CROW BUTTE RESOURCES, INC.

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November 27, 2007

Mr. Steven J. Cohen, PG, Hydrogeologist
U.S. Nuclear Regulatory Commission
Office of Federal and State Materials and Environmental Management Program
Mail Stop T7E18
Washington, D.C. 20555-0001

Dear Mr. Cohen:

Enclosed are three copies of the Application for Renewal of Source Materials License No. SUA-1534, copies of the submittal letter for the Application and the NRC Form 313. An electronic copy of the License Renewal Application will follow under separate cover.

Should you have any questions concerning any of the enclosures please don't hesitate to call. I can be reached by telephone at (308) 665-2234 ext. 115 or by email at rgrantham@bbc.net.

Sincerely,

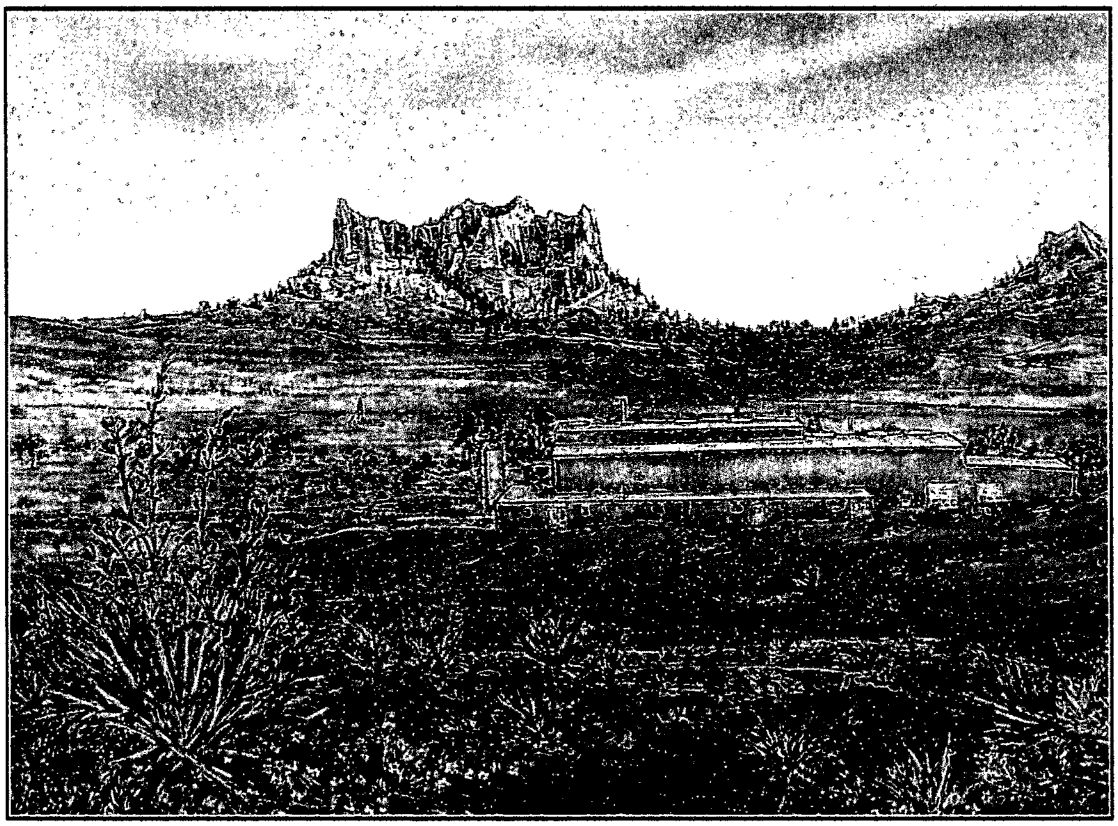
Rhonda Grantham, Supervisor
Radiation Safety and Regulatory Affairs

Enclosure

Application for 2007 License Renewal

USNRC Source Materials License SUA-1534

Crow Butte License Area



Prepared by:

Crow Butte Resources, Inc.

86 Crow Butte Road

Crawford Nebraska 69339

and

ARCADIS U.S., Inc.

630 Plaza Drive #100

Highlands Ranch Colorado 80129

November 2007

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FIGURES

TABLES

APPENDIX

ACRONYMS

ALARA	As low as reasonably achievable
Amsl	Above mean sea level
BLM	Bureau of Land Management
BPT	Best Practicable Technology
bgs	Below ground surface
BNSF	Burlington Northern Santa Fe
BMP	Best Management Practice
CAD	Computer Aided Design
CBR	Crow Butte Resources, Inc.
CDP	Census Designated Places
CFR	Code of Federal Regulations
CSA	Commercial Study Area
cfs	Cubic feet per second
cm	Centimeter
cm/sec	Centimeter per second
CDP	Census Designated Places
CESQG	Conditionally Exempt Small Quantity Generator
CO_2	Carbon Dioxide
DAC	Derived Air Concentration
DLG	Digital line graphic
DEM	Digital elevation model
dBA	A-weighted decibel
DOT	Department of Transportation
DQO	Data Quality Objective
ER	Environmental Report
EA	Environmental Assessment
USEPA	Environmental Protection Agency
EHSMS	Environmetnal, Health and Safety Management System
ESRI	Environmental System Research Institute
EDR	Electro Dialysis Reversal
FEMA	Federal Emergency Management Act
GNIS	Geographical Names Information System
gpm	Gallons per minute
gpd	Gallons per day
gpdpp	Gallons per day per person
GIS	Geographic Information System
GPS	Geographic Positioning System
HP	Horse Power
HPRCC	High Plains Regional Climatic Center
HSMS	Health and Safety Management SYstems
in	Inch
ISL	In-situ leach
km	Kilometer
LRA	License Renewal Application
mg/L	Milligrams per liter
m/s	Meters per second

mph	Miles per hour
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols Manual
MCL	Maximum contaminant level
MeV	Mega electronvolt
MIT	Mechanical integrity test
mREM	Miliroentgen equivalent, man
msl	Mean sea level
MWL	Maximum working levels
NUREG-1569	Standard Review Plan for In Situ Leach Uranium Extraction License Application
NGS	National Geodetic Survey
NDEQ	Nebraska Department of Envrionmental Quality
NDNR	Nebraska Department of Natural Resources
NRCS	Natural Resources Conservation Service
NASS	National Agricultural Statistics Service
NDED	Nebraska Department of Economic Development
NGPC	Nebraska Game and Parks Commission
NOU	Nebraska Ornithologists' Union's
NOAA	National Oceanic Atmospheric Association
NAAQS	National Ambient Air Quality Standards
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NOI	Notice of Intent
pCi/g	Pico curies per gram
ppe	Personal protective equipment
ppm	Parts per million
PVC	Polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QAM	Quality Assurance Manual
R&D	Research and development
REM	Roentgen equivalent, man
RMP	Risk Management Program
RO	Reverse osmosis
ROI	Radius of Influence
RWP	Radiation Work Permit
RCRA	Resource Conservation and Recovery Act
SH	State Highway
SHPO	State Historic Preservation Office
SOP	Standard Operating Practice
SPCC	Spill Prevention, Control, and Countermeasure
SWPPP	Stormwater Pollution Prevention Plan
S.U.	Standard units
SERP	Safety and Environmental Review Panel
SRWP	Standing radiation work permits
TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
TR	Technical report
TSP	Total suspended particulates

U_3O_8	Triuranium octoxide
UIC	Underground injection control
USCB	United States Census Bureau
USEPA	United States National Environmental Policy Act
USGS	United States Geologic Survey
USDA	United States Department of Agriculture
USNRC	United States Nuclear Regulatory Commission
USFWS	United States Fish and Wildlife Service
UCL	Upper Control Limits
USDW	Underground source of drinking water
$\mu g/m^3$	Micrograms per cubic meter
VRM	Visual Resource Management
WFC	Wyoming Fuel Company
ww	Water well
WL	Working Levels

1 PROPOSED ACTIVITIES

1.1 LICENSING ACTION REQUESTED

Crow Butte Resources, Inc. (CBR) submits this combined Technical Report (TR) and Environmental Report (ER) in support of a license renewal application (LRA) of the Radioactive Source Materials License SUA-1534 for submittal to the United States Nuclear Regulatory Commission (USNRC). At the request of the USNRC, the ER and TR have been combined into one document, referred to from here on as the LRA, and incorporates applicable USNRC guidance regulations for both the TR and ER. This LRA concerns the continued commercial operation of uranium leach in-situ (ISL) mining resources located in Dawes County, Nebraska.

This LRA is prepared to supplement and update the information presented to the USNRC in support of issuance of Source Materials License SUA-1534 in 1989 and the subsequent renewal in 1997, and provides the supplemental information necessary to determine the environmental impacts of continuing uranium leach activities in the Crow Butte License Area under SUA-1534. This LRA is submitted in accordance with the licensing requirements contained in 10 Code of Federal Regulations (CFR) Part 40 and provides the USNRC staff with the necessary information to support the preparation of an Environmental Assessment (EA) as required in 10 CFR Part 51.

This LRA has been prepared using suggested guidelines and standard formats from both state and federal agencies. The application is presented primarily in the USNRC format found in Regulatory Guide 3.46, "*Standard Format and Content of License Applications, Including Environmental Reports, For In Situ Uranium Solution Mining*" (June 1982). USNRC document NUREG-1569, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications* (June 2003) was used to ensure that all information is provided to allow USNRC Staff to complete their review of this amendment application. NUREG-1748, *Environmental Review Guidance for Licensing Actions Associated with NMSS Programs* (August 2003) was also used to ensure information typically found in the ER was appropriately incorporated into this LRA.

1.2 CROW BUTTE PROJECT BACKGROUND

What is now the Crow Butte Project was originally developed by Wyoming Fuel Corporation, which constructed a 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. Only the name of the company changed, not its ownership. CBR is the current owner and operator of the Crow Butte Project.

The 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.

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.

1.3 SITE LOCATION AND DESCRIPTION

The location of the Crow Butte License Area (License 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 (**Figure 1.3-1**). The plant site is situated approximately 4.0 miles southeast of the City of Crawford. The current production and planned wellfields are located within the License Area as shown in **Figure 1.3-2**. The process plant is located in Section 19, Township 31 North, Range 51 West, Dawes County, Nebraska. This original License Area occupies approximately 3,300 acres, and the surface area affected over the estimated life of the project is approximately 1,100 acres.

Approximately 100 percent of the minerals leased in the License Area are on private lands. Surface landownership includes federal, state/local government, and private ownership as shown in **Table 1.3-1. Figure 1.3-3** shows the land ownership within the License Area.

Table 1.3-1: Land Ownership within the Crow Butte License Area

Owner	Percent Ownership
Federal Government	4
State/Local Government	9
Private	89

Note: Percent ownership rounded up to the nearest whole percent.

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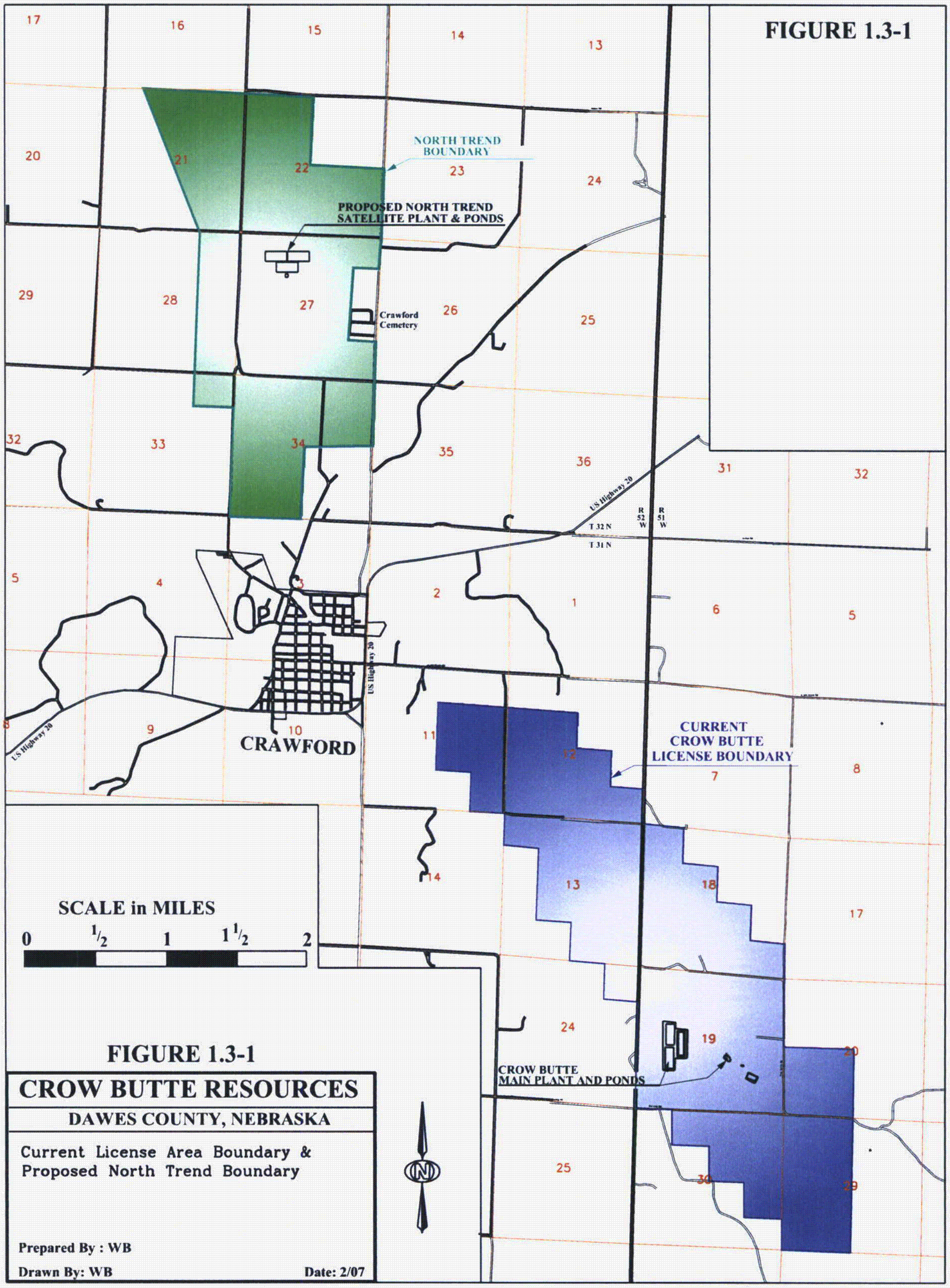
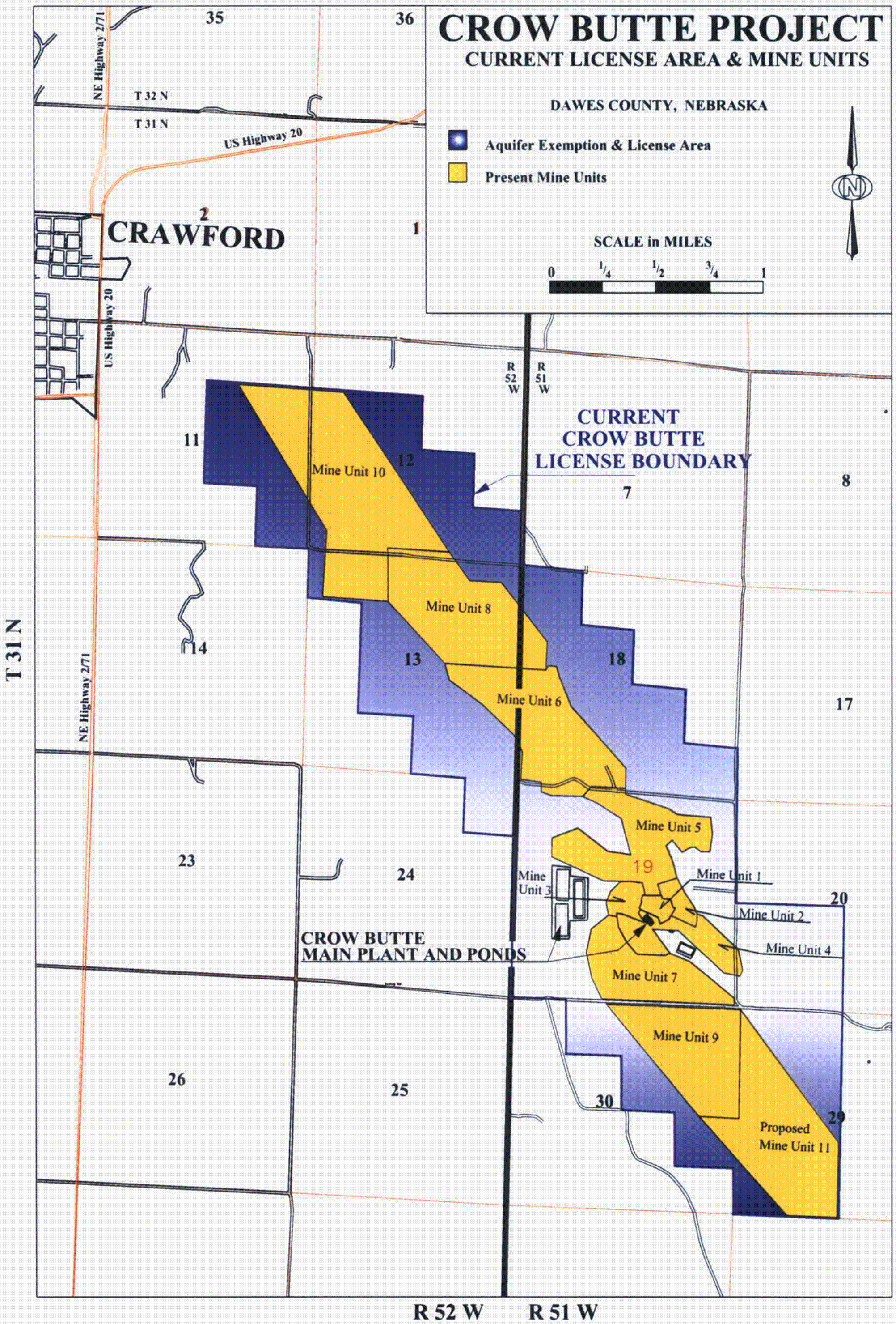


FIGURE 1.3-1
NORTH TREND BOUNDARY
PROPOSED NORTH TREND SATELLITE PLANT & PONDS
Crawford Cemetery
US Highway 20
T 32 N
T 31 N
R 52 W
R 51 W
CRAWFORD
CURRENT CROW BUTTE LICENSE BOUNDARY
CROW BUTTE MAIN PLANT AND PONDS
SCALE in MILES
0 1/2 1 1 1/2 2
FIGURE 1.3-1
CROW BUTTE RESOURCES
DAWES COUNTY, NEBRASKA
Current License Area Boundary & Proposed North Trend Boundary
Prepared By : WB
Drawn By: WB
Date: 2/07

FIGURE 1.3-2



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
CRAWFORD
US Highway 20
NE Highway 2/71
T 32 N
T 31 N
CURRENT
CROW BUTTE
LICENSE BOUNDARY
Mine Unit 10
Mine Unit 8
Mine Unit 6
Mine Unit 5
Mine Unit 1
Mine Unit 3
Mine Unit 2
Mine Unit 4
Mine Unit 7
Mine Unit 9
Proposed
Mine Unit 11
CROW BUTTE
MAIN PLANT AND PONDS
R 52 W
R 51 W
35
36
2
1
11
12
7
8
14
13
18
17
23
24
19
20
26
25
30
29
T 31 N
R 52 W R 51 W

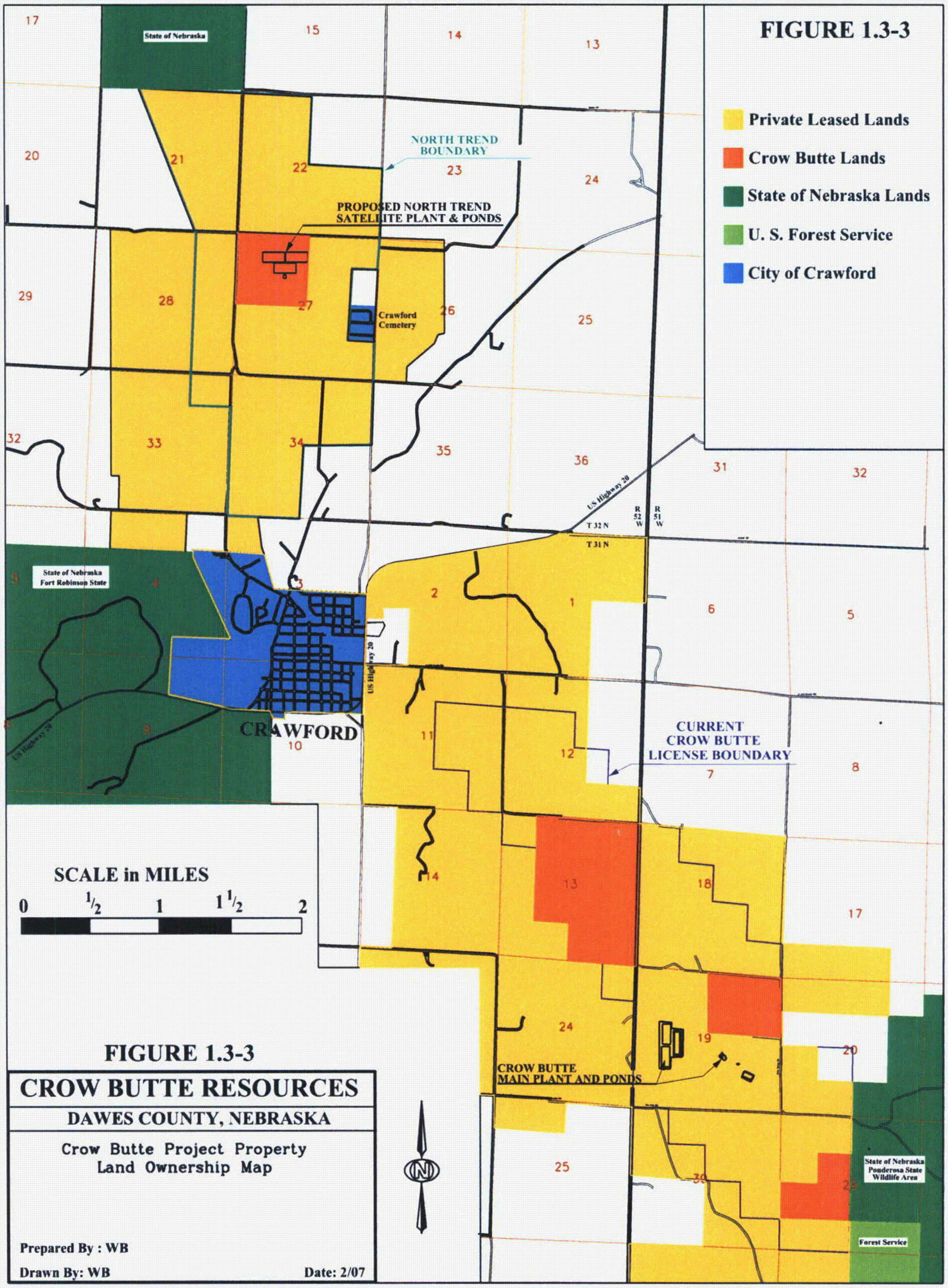


FIGURE 1.3-3
Private Leased Lands
Crow Butte Lands
State of Nebraska Lands
U. S. Forest Service
City of Crawford
State of Nebraska
NORTH TREND BOUNDARY
PROPOSED NORTH TREND SATELLITE PLANT & PONDS
Crawford Cemetery
US Highway 20
T 32 N
T 31 N
R 52 W
R 51 W
State of Nebraska Fort Robinson State
CRAWFORD
CURRENT CROW BUTTE LICENSE BOUNDARY
SCALE in MILES
0 1/2 1 1 1/2 2
CROW BUTTE MAIN PLANT AND PONDS
State of Nebraska Ponderosa State Wildlife Area
Forest Service
FIGURE 1.3-3
CROW BUTTE RESOURCES
DAWES COUNTY, NEBRASKA
Crow Butte Project Property
Land Ownership Map
Prepared By : WB
Drawn By: WB
Date: 2/07

1.4 ORE BODY DESCRIPTION

In the current license area, uranium is recovered by ISL from the Chadron Sandstone at a depth that varies from 400 feet to 900 feet. The overall width of the mineralized area varies from 1000 feet to 5000 feet. The ore body ranges from less than 0.05 percent to greater than 0.5 percent triuranium octoxide (U_3O_8), with an average grade estimated at 0.26 percent equivalent U_3O_8, with an estimated at 0.27 percent U_3O_8.

1.5 SOLUTION MINING METHOD AND RECOVERY PROCESS

The ISL process for uranium recovery consists of an oxidation step and a dissolution step. Gaseous oxygen or hydrogen peroxide is used to oxidize the uranium, and bicarbonate is used for dissolution. The uranium bearing solution that results from the leaching of uranium underground is recovered from the wellfield and the uranium extracted in the process plant. The plant process uses the following steps:

- Loading of uranium complexes onto ion exchange resin;
- Reconstitution of the solution by the addition of carbonate and an oxidizer;
- Elution of the uranium complexes from the resin; and
- Drying and packaging of the uranium.

Section 3.0 (Description of Proposed Facility) provides a detailed description of the solution mining process and equipment.

1.5.1 Advantages of ISL Uranium Mining

ISL uranium mining is a proven technology that has been successfully demonstrated commercially in Wyoming, Texas, and at the Crow Butte Project in Nebraska. ISL mining of uranium is environmentally superior to conventional open pit and underground uranium mining as evidenced by the following:

- ISL mining results in significantly less surface disturbance since mine pits, waste dumps, haul roads, and tailings ponds are not needed;
- ISL mining requires much less water demand than conventional mining and milling, avoiding the water usage associated with pit dewatering, conventional milling, and tailings transport;
- The lack of heavy equipment, haul roads, waste dumps, etc. result in very little air quality degradation at ISL mines;
- Fewer employees are needed at ISL mines, thereby reducing transportation and socioeconomic concerns;
- Aquifers are not excavated, but remain intact during and after ISL mining;
- Tailings ponds are not used, thereby eliminating a major groundwater pollution concern. State of the art lined evaporation ponds may be used to manage liquid waste streams; and
- ISL uranium mining results in leaving the majority of other contaminants (e.g., heavy metals) where they naturally occur instead of moving them to waste dumps and tailings ponds where their presence is of more environmental concern.

1.5.2 Ore Amenability to the ISL Mining Method

Amenability of the uranium deposits in the License Area to ISL mining was demonstrated initially through core studies. Results of the core studies were confirmed in the R&D project at the Crow Butte site using bicarbonate/carbonate leaching solutions with oxygen. Reports concerning the results of the R&D activities, including restoration of affected groundwater, were previously submitted to USNRC and the Nebraska Department of Environmental Quality (NDEQ).

The information and experience gained during these pilot programs formed the basis for the commercial uranium ISL mining operations. CBR believes that the current commercial project, including the successful restoration of groundwater in Mine Unit 1, demonstrates that such a program can be implemented with minimal short-term environmental impacts and with no significant risk to the public health or safety. The remainder of this application describes the Mining and Reclamation Plans for this project and the concurrent environmental monitoring programs employed to ensure that any impact to the environment or public is minimal.

1.6 OPERATING PLANS, DESIGN THROUGHPUT, AND PRODUCTION

The current Crow Butte Central Plant is licensed for a process flow rate of 5,000 gallons per minute (gpm), excluding restoration flow, under SUA-1534. Total annual production is limited to 2 million pounds of yellowcake. On October 16, 2006, CBR submitted a request to the USNRC for a license amendment to increase the plant throughput from 5,000 to 9,000 gpm. USNRC approval is pending.

The uranium-bearing solution extracted from the subsurface of the Crow Butte License Area is transported via pipeline to the Crow Butte Central Plant for elution, drying, and packaging. This cycle will continue until the ore zone is depleted or leach of the uranium is no longer economically viable.

1.7 PROPOSED OPERATING SCHEDULE

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. Completion of groundwater restoration in the current License Area is scheduled for 2023.

Projected production and restoration schedules for the current production area are shown in **Figure 1.7-1**. Status of the current mine unit operations is shown in **Table 1.7-1**. The layout of the current and planned mine units in the License Area is shown in **Figure 1.7-2**.

Table 1.7-1: Current Crow Butte 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	Groundwater restoration
Mine Unit 6	March 1998	Production
Mine Unit 7	July 1999	Production
Mine Unit 8	July 2002	Production
Mine Unit 9	October 2003	Production
Mine Unit 10	August 2007	Production
Mine Unit 11	Pending	Under construction

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Figure 1.7-1 Current Production Area Mine Unit Schedule

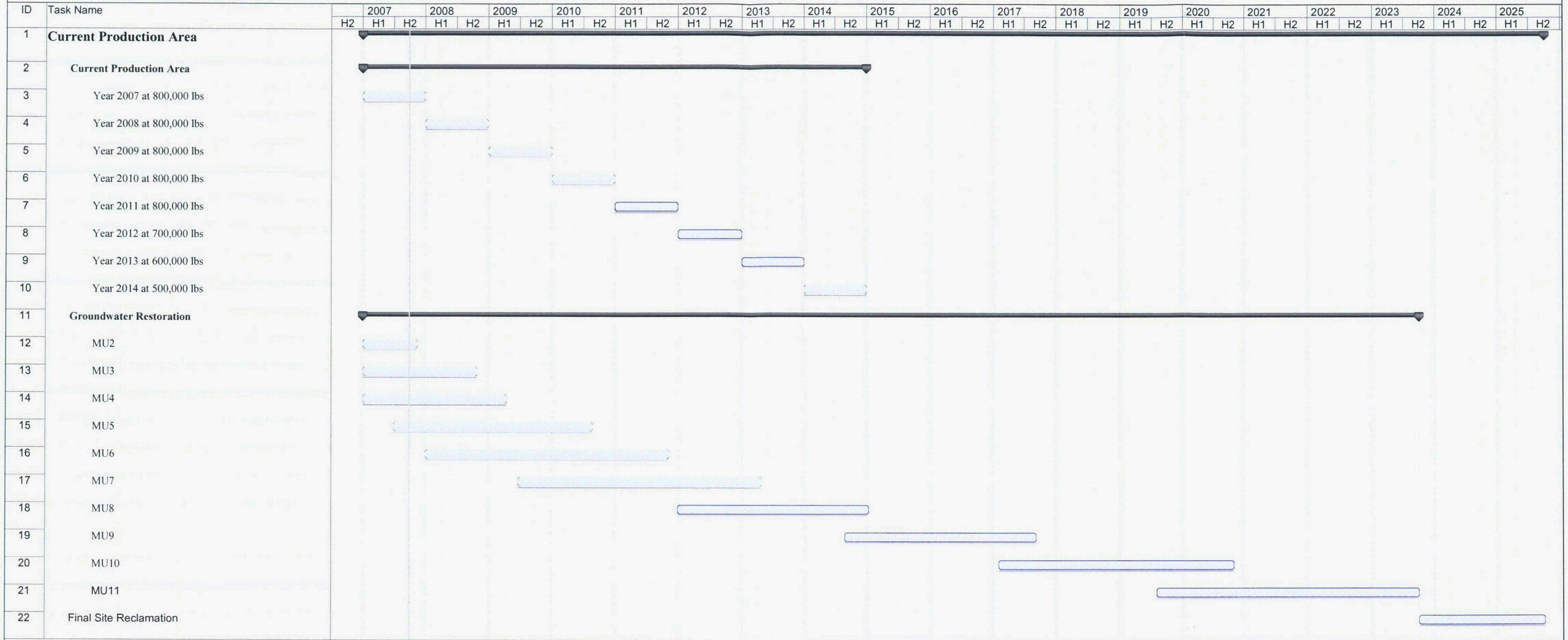
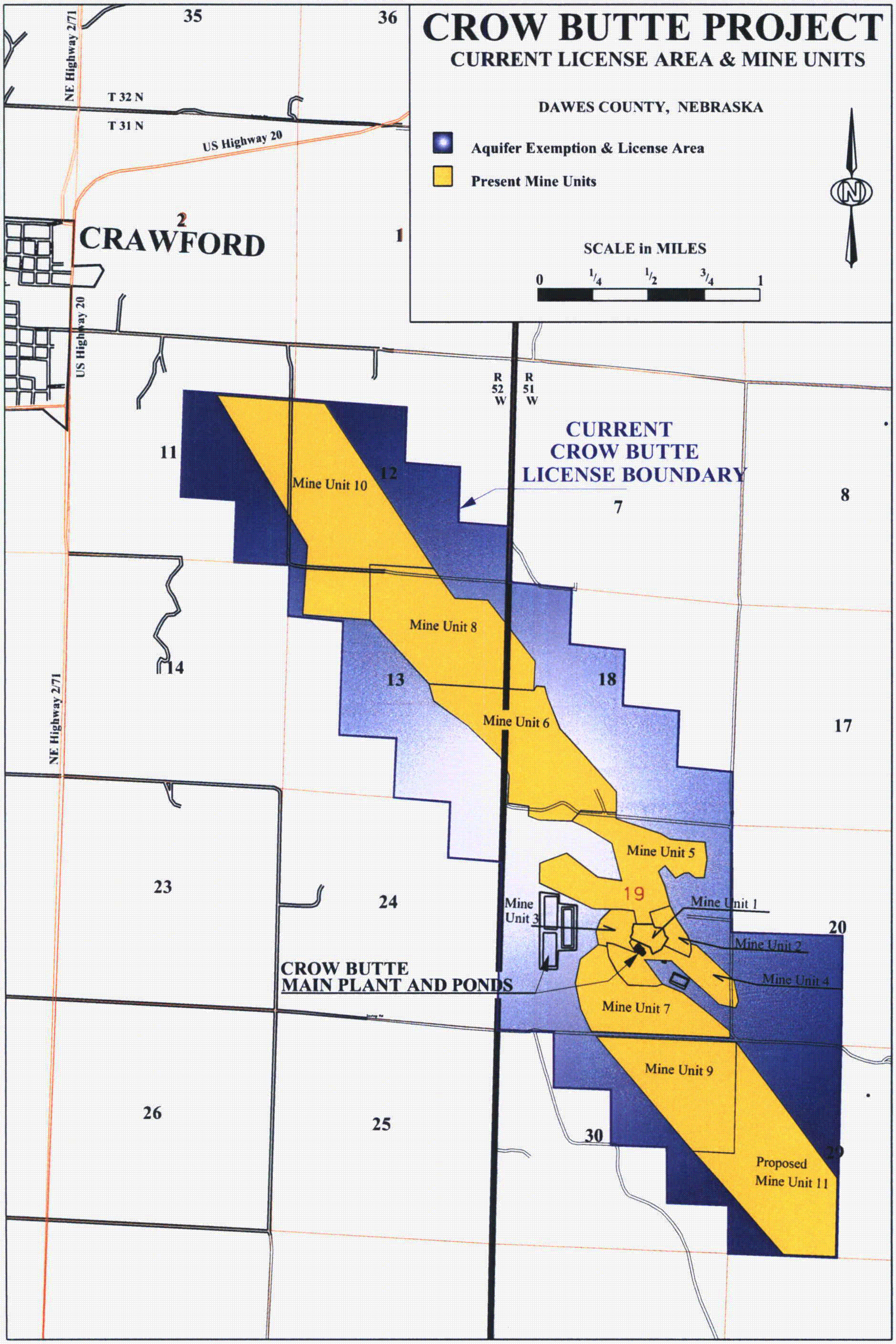


FIGURE 1.7-2



T 31 N

R 52 W R 51 W

1.8 WASTE MANAGEMENT AND DISPOSAL

1.8.1 Gaseous and Airborne Particulates

The only radioactive airborne effluent at the Crow Butte Project is radon-222 gas. As yellowcake drying and packaging is carried out using a vacuum dryer, there are no airborne effluents from that system.

The radon-222 is contained in the pregnant lixiviant that comes from the wellfield to the process plant. The majority of this radon is released in the ion exchange columns and process tanks. These vessels are covered and vented to a manifold, which are in turn exhausted to atmosphere outside the building through stacks. The manifolds are equipped with an exhausting fan.

1.8.2 Liquid Waste

There are currently three wastewater disposal options for the Crow Butte Project: evaporation in solar evaporation ponds, deep well injection, and land application. The specific method utilized depends upon the volume and characterization of the waste stream.

The operation of the process facility results in three sources of water that are collected on the site. They include the following:

- **Water generated during well development** - This water is recovered groundwater that has not been exposed to any mining process or chemicals. The water is discharged directly to one of the solar evaporation ponds and silt, fines and other natural suspended matter collected during well development is settled out. This water may be used in plant processing, disposed of in a deep disposal well, or land applied following treatment.
- **Liquid process waste** - The operation of the process plant results in two primary sources of liquid waste, an eluant bleed and a production bleed. This water is also routed to the evaporation ponds or injected into the deep disposal well.
- **Aquifer restoration** - Following mining operations, restoration of the affected aquifer commences which results in the production of wastewater. The restoration waste is primarily brine from the reverse osmosis unit, which is sent to the waste disposal system. The permeate is either reinjected into the wellfield or sent to the waste disposal system.

1.8.3 Solid Waste

Solid wastes generated at the site consist of spent resin, resin fines, filters, empty reagent containers, miscellaneous pipe and fittings, and domestic waste. These wastes are classified as contaminated or non-contaminated waste according to their radiological survey results. Contaminated byproduct waste that cannot be decontaminated is packaged and stored until it can be shipped to a licensed waste disposal site or licensed mill tailings facility. Non-contaminated solid waste is collected on the site on a regular basis and disposed of in a sanitary landfill permitted by the NDEQ. Domestic waste is disposed of in an approved septic system.

1.8.4 Contaminated Equipment

Materials and equipment that become contaminated as a result of normal operations are decontaminated if possible and disposed of by conventional methods. Equipment and materials that cannot be decontaminated are treated in the same manner as other contaminated solid waste.

Section 4.0 (Effluent Control Systems) presents a detailed discussion of the effluent control systems for the current CBR project operations.

1.9 GROUNDWATER RESTORATION

Restoration activities will be carried out at the License Area concurrent with mining activities. The restoration process will be similar to that used to restore Wellfield No. 2 at the Crow Butte R&D site and Mine Unit 1 of the current commercial production area, and consist of four basic activities:

- **Groundwater transfer-** groundwater is transferred between the mining unit commencing restoration and a mine unit commencing production or another water source.
- **Groundwater sweep-** water is pumped from the wellfield, which results in an influx of baseline quality water from the wellfield perimeter.
- **Groundwater treatment-** water from injection wells is pumped to the restoration plant where ion exchange, reverse osmosis, filtration or other treatment methods take place.
- **Wellfield recirculation-** water is recirculated by pumping from the production wells and reinjecting the recovered solution. This will act to homogenize the quality of the aquifer.

Following these restoration phases, a groundwater stabilization monitoring program is initiated. Once the restoration values are reached and maintained, restoration is deemed complete. Results are documented in a restoration report and submitted to the NDEQ and the USNRC for approval. Groundwater restoration is described in more detail in **Section 6** (Groundwater Quality Restoration, Surface Reclamation and Facility Decommissioning).

1.10 DECOMMISSIONING AND RECLAMATION

At the completion of mine life and after groundwater restoration has been completed, all injection and recovery wells will be plugged and the site decommissioned. Decommissioning will include plant disassembly and disposal, pond reclamation and land reclamation of all disturbed areas. Appropriate USNRC Regulatory Guidelines will be followed as required. Decommissioning and reclamation are discussed in more detail in **Section 6** (Groundwater Quality Restoration, Surface Reclamation and Facility Decommissioning).

1.11 SURETY ARRANGEMENTS

CBR maintains a USNRC-approved financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover the estimated costs of reclamation activities. Crow Butte maintains an Irrevocable Standby Letter of Credit issued by the Royal Bank of Canada in favor of the State of Nebraska in the present amount of $22,980,913. The surety amount will be revised annually in accordance with the requirements of SUA-1534.

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2 SITE CHARACTERISTICS

2.1 SITE LOCATION AND LAYOUT

The location of the current license area of the Crow Butte project is in 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 maps used in this section and other sections of this amendment application are Vector 7.5 minute quad maps. These are computer-aided design (CAD) and geographi information systems (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, United States Geological Survey (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 2.1-1 shows the general area surrounding the License Area. **Figure 2.1-1** also shows the original Commercial Study Area (CSA) and the 3.2-kilometer (km) (2.0-mile) review area.

Figure 2.1-2 shows the general project site layout and Restricted Areas for the License Area including the Central Processing 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 2.1-3 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.

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Figure 2.1-1

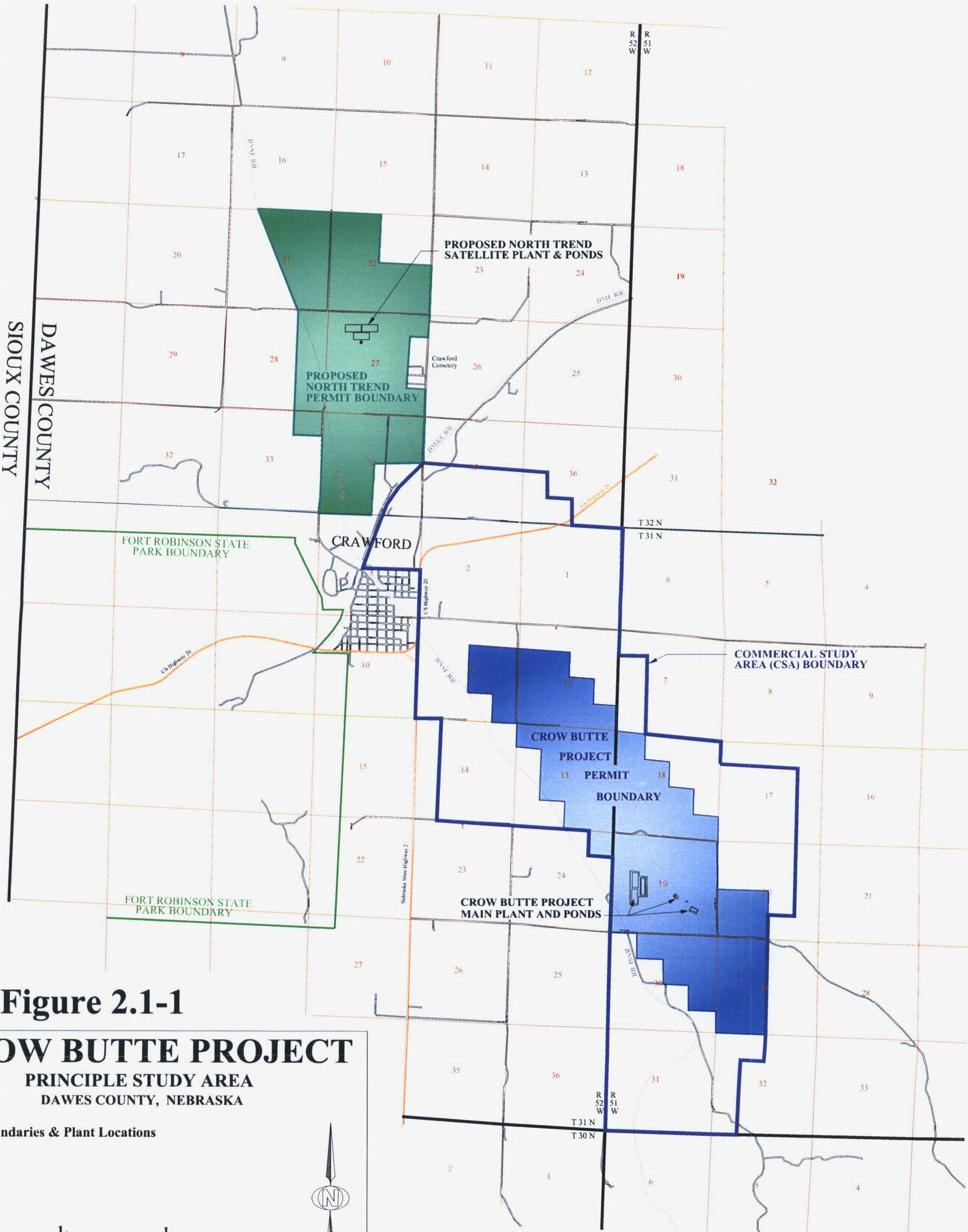


Figure 2.1-1

CROW BUTTE PROJECT

PRINCIPLE STUDY AREA

DAWES COUNTY, NEBRASKA

Permit Boundaries & Plant Locations

SCALE 0 ½ 1 1½ 2 MILE

FIGURE2.1-2

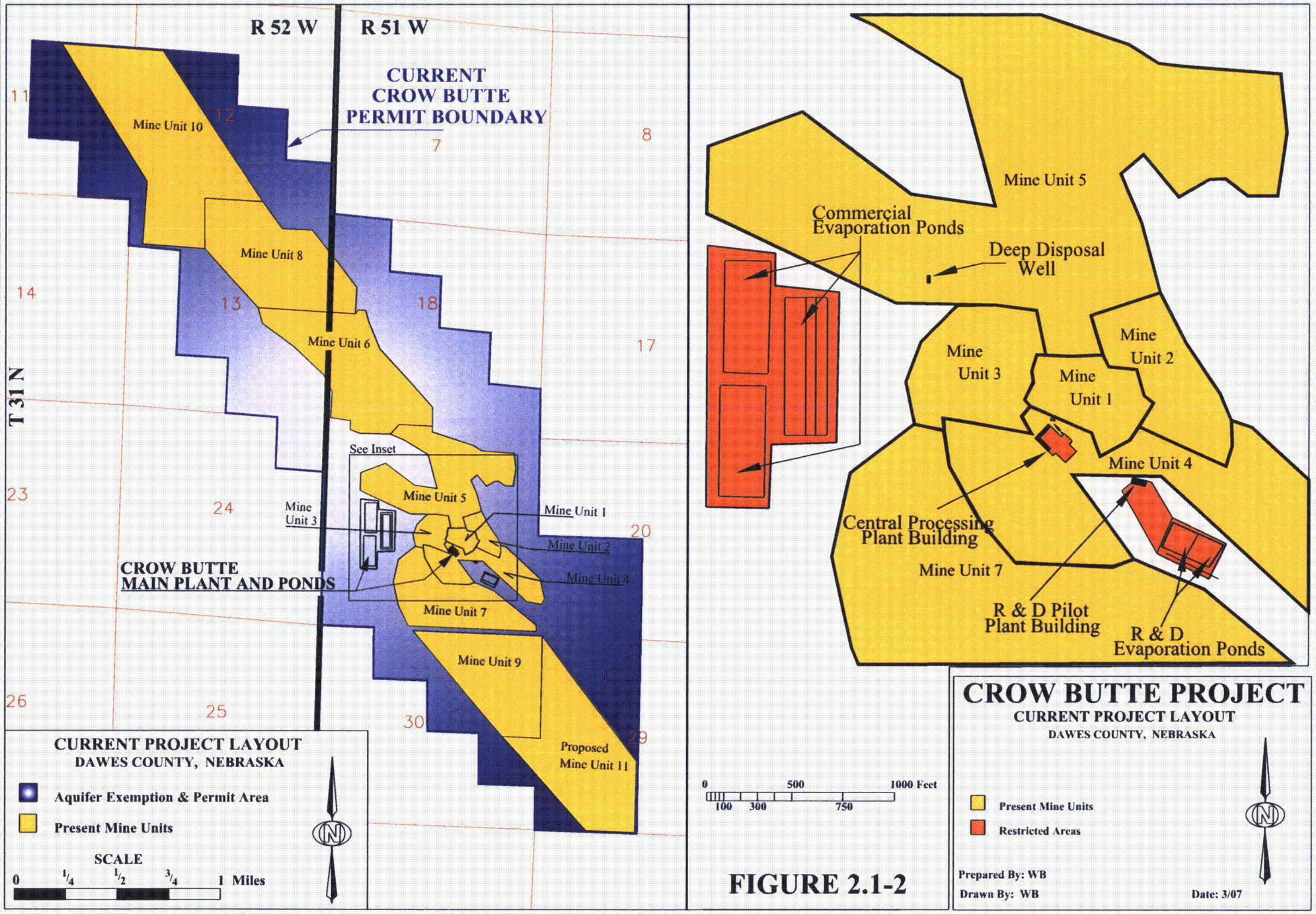
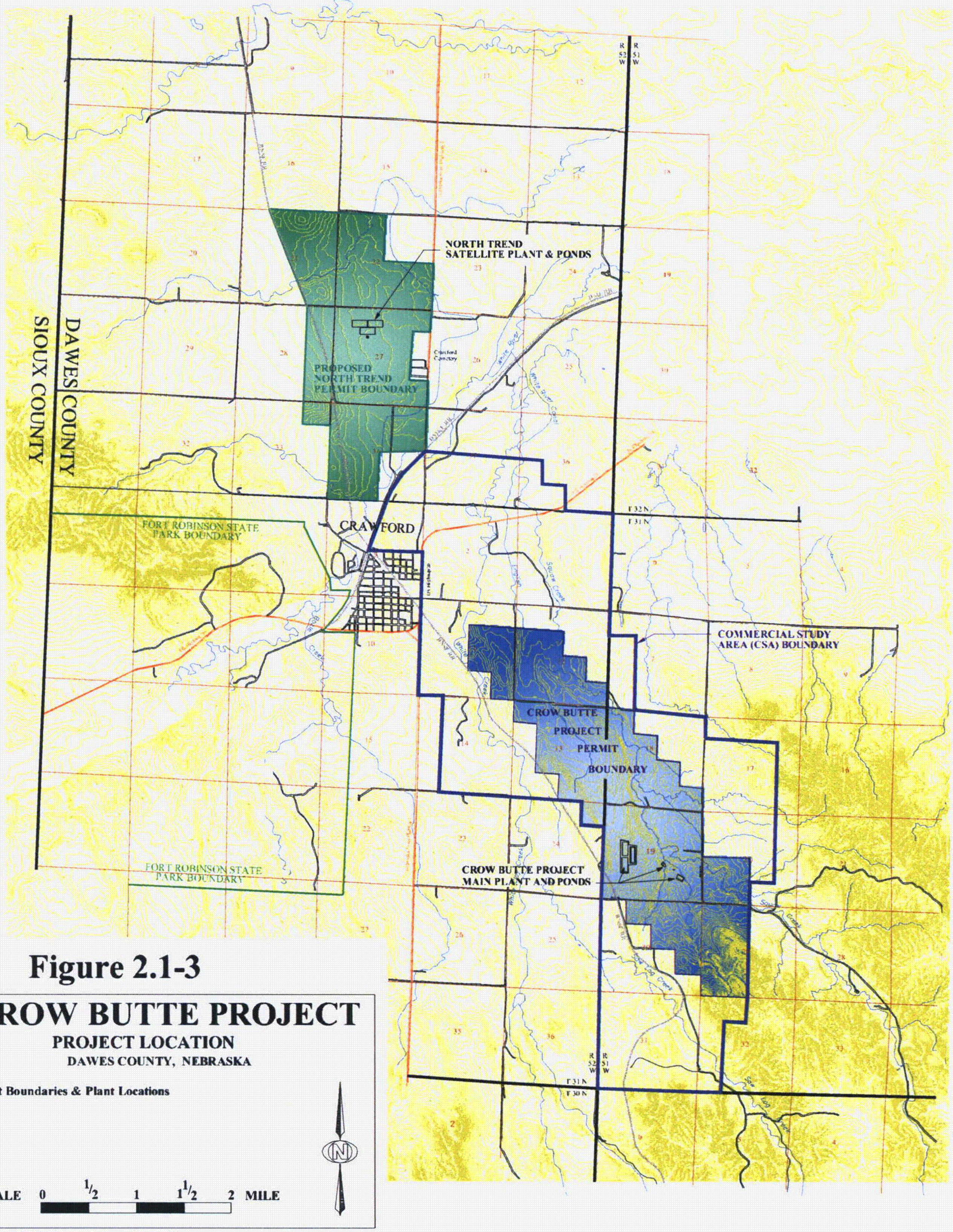


FIGURE 2.1-2

Figure 2.1-3



NORTH TREND
SATELLITE PLANT & PONDS
PROPOSED
NORTH TREND
PERMIT BOUNDARY
DAWES COUNTY
SIOUX COUNTY
CRAWFORD
FORT ROBINSON STATE
PARK BOUNDARY
COMMERCIAL STUDY
AREA (CSA) BOUNDARY
CROW BUTTE
PROJECT
PERMIT
BOUNDARY
FORT ROBINSON STATE
PARK BOUNDARY
CROW BUTTE PROJECT
MAIN PLANT AND PONDS
Figure 2.1-3
CROW BUTTE PROJECT
PROJECT LOCATION
DAWES COUNTY, NEBRASKA
Permit Boundaries & Plant Locations
N
SCALE 0 1/2 1 1 1/2 2 MILE

2.2 USES OF ADJACENT LANDS AND WATERS

The information in this section provides relevant data concerning the physical, ecological and social characteristics of the commercial study area and 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 LRA. 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 3.2 km (2.0-mile) radius surrounding the License Area. Because previous historical studies were performed assuming a 3.6-km (2.25-mile) review area, some data in this section are based on a 3.6-km (2.25-mile) radius. A 3.6-km (2.25-mile) radius was used rather than the required 3.2 km (2.0-mile) radius to remain consistent with other resource descriptions. For water resources, oil and gas resources and well locations, the standard 3.2 km (2.0-mile) review area is used.

2.2.1 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 2.1-1** shows the general location of the proposed project site. The Crow Butte Project site is about 4.0 miles southeast of the City of Crawford via Squaw Creek Road. State Highway 71 provides access to the License Area from points north and south of Crawford. U.S. Highway 20 provides access to Crawford and the License Area from points east and west.

Approximately 4 percent of the area within an 8-km (5-mile) radius of the License Area is located within the Nebraska National Forest. Also identified as the Pine Ridge, this area is covered with mixed evergreens and Ponderosa pines. The predominant land use in Dawes County, as well as the License Area, is livestock production. An annual average of 56,833 cattle valued at approximately $21.35 million was reported on Dawes County farms for the years 1978, 1979 and 1980 (Nebraska Crop and Livestock Reporting Service 1980, 1981). Cropland is used primarily for the production of winter wheat, alfalfa, and oats. Native grasslands are used for grazing or for cut hay. Livestock values and agricultural uses in 1987 have not changed appreciably in Dawes County in the last five years (Huls 1987, SCS 1987).

Recreational lands are also prevalent in Dawes County (**Figure 2.2-1** and **Table 2.2-1**). Fort Robinson State Park, the largest State Park in Nebraska, is located just outside the Crow Butte 8-km (5-mile) radius. Facilities at the park consist of lodging, showers, electrical hookups, pit toilets, ski and snowmobile trails, a rodeo arena, and museum. Visitors to the park may go hunting, fishing, hiking, swimming, or horseback riding. Other recreational facilities in Dawes County include the Ponderosa Wildlife Area, Chadron State Park, Soldier Creek Management Unit, Cochran Wayside Area, and the Red Cloud Picnic Area and associated trails in the Nebraska National Forest (Nebraska Game and Parks Commission 1982).

Urban land uses in the county are concentrated within the city limits of Crawford and Chadron. Approximately 73 rural occupied dwellings are located within the 8-km radius (USGS 1980, EH&A 1982).

2.2.2 Land and Mineral Ownership

Approximately 4.0 percent of land within the 8-km (5-mile) radius is owned by the federal government, while another 9.0 percent is owned by the state or local government (Bump Abstract, 1979). Except for lands within the City of Crawford, private land is predominantly owned by ranching families. Approximately 90 percent of all minerals leased in Dawes County are on private lands (Mathis, 1982). No Indian lands are present in the 8-km (5 mile) radius of the License Area.

2.2.3 Land Use

The Crow Butte License Area is located in west central Dawes County, Nebraska, just north and west of the Pine Ridge area (**Figure 2.2-1**). The License Area is approximately 4 miles southeast of the City of Crawford on Squaw Creek Road. State Highway 2/71 provides access to the License Area from points north and south of Crawford. U.S. Highway 20 provides access to Crawford and the License Area from points east and west.

Land uses found within the License Area and 3.6-km (2.25-mile) review area are depicted in **Figure 2.2-1. Table 2.2-1** explains each of the land use types. **Table 2.2-2** presents land uses in 22 1/2° sectors centered on each of the 16 compass points within the License Area and 3.6-km (2.25-mile) review area. These sectors radiate out from the geographic center of the License Area. The total areas of the sectors vary because of the irregular site boundary.

Pastureland comprises the greatest portion of land use within the License Area and surrounding 3.6-km (2.25-mile) area (43 percent) and is used for the production of hay. Cropland (29 percent), forest land (12 percent), and wildlife habitat (15 percent) are the other significant land uses.

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THAT CAN BE VIEWED AT THE RECORD TITLED: "LAND USE MAP Figure 2.2-1."

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D-01

Table 2.2-1: Land Use Definitions

Land Use	Definition
Croplands (C)	Harvested cropland, including grasslands cut for hay, cultivated summer-fallow, and idle cropland.
Commercial and Services (C/S)	Those areas that 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 persistently covered with water.
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.

Table 2.2-2: Land Use of the Crow Butte Review Area 3.6-km (2.25-mile) Radius, By Sector and Category (in acres)

	N[b]	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Subtotal
C[a]	394.6	155.0	94.6	119.1	92.0		33.4		74.5	95.2	306.3	366.1	332.6	174.8	349.4	274.0	2,869.6
F	0.9	58.9	230.4	364.1	0.9	10.8	109.8	313.1	53.0	11.7		0.9	6.3	3.6	9.4	18.6	1,192.4
H				67.9	491.1	529.3	377.4	1.8									1,467.5
M										3.6			3.6		5.7		12.9
P	233.0	412.8	229.0	69.5	55.6	88.5	106.3	232.0	501.2	518.2	316.8	261.6	286.3	450.3	261.4	336.1	4,347.6
R		1.8	74.7				1.8	81.6									159.9
W											5.6				2.8		8.4
Total[b]	**628.5**	**628.5**	**628.7**	**620.6**	**639.6**	**628.6**	**628.7**	**628.5**	**628.7**	**628.7**	**628.7**	**628.6**	**628.8**	**628.7**	**628.7**	**628.7**	**10,058.3[c]**

Notes:

[a] See **Table 2.2-1** for land-use definitions.

[b] Calculations used in this Table for each of the 22-1/2 degree compass points:
0-1.8 km = 157.158 acres
1.8-3.6 km = 471.747 acres
Total 3.6 km = 628.91 acres

[c] Actual area of the 3.6-km radius is equal to 10,058.3 acres. However, multiplying the total acreage used for each compass point (628.91) by 16 equals 10,062.48 acres. Differences between these total as well as other subtotals are due to rounding.

Cropland is the second largest land use found within the License Area and is primarily used for the production of wheat. A small amount of cropland within the License 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.

Rangeland accounts for 4.2 percent of the total land acreage within the License Area. In 2006, an average of 52,000 head of livestock was reported in Dawes County (NASS 2007a). 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.

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.

2.2.3.1 Recreation

Recreational lands also are present in Dawes County (**Table 2.2-3**). 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 3.6-km (2.25-mile) review area. Approximately 9 percent of the area within an 80-km (50-mile) radius of the License Area 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 (NGPC 2007).

Table 2.2-3: Recreational Facilities within 80-km (50-Mile) of the Crow Butte License Area

Name of Recreational Facility	Distance From Current Crow Butte License Area (km)
Red Cloud Campground	30.58
Pine Ridge National Recreation Area	20.92
Roberts Trailhead and Campground	17.70
Museum of the Fur Trade	38.62
Toadstool Park	28.97
Warbonnet Battlefield	38.62
Hudson-Meng Bison Kill Site	27.36

Table 2.2-3: Recreational Facilities within 80-km (50-Mile) of the Crow Butte License Area

Name of Recreational Facility	Distance From Current Crow Butte License Area (km)
Crawford City Park	3.22
Whitney Lake	16.09
Legend Buttes Golf Course	3.22
Box Butte Reservoir	38.62
Ponderosa Wildlife Area	3.22
Peterson Wildlife Area	17.70
Walgren Lake State Recreation Area	61.15
Soldier Creek Wilderness	11.27
Chadron State Park	27.36
Agate Fossil Beds National Monument	43.45

Source: Nebraska Department of Travel and Tourism 2004.
DeLorme Maps 2006.

2.2.3.2 Agriculture

Several of the soil types found in the vicinity of the License Area are classified as prime farmland (NRCS 2007). However, in Dawes County, soils are classified by the Natural Resources Conservation Service (NRCS 2007) as prime farmland only if irrigated. According to 2004 Nebraska State Agricultural Statistics, only 2 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 (NASS 2007b).

Table 2.2-4 through **Table 2.2-6** show agricultural productivity within Dawes County and the License Area. Wheat and hay are the major crops grown on croplands within the License Area. Most of these crops are used for livestock feed, while the remaining crops are commercially sold. Data for the acres of land planted and harvested, and production for beans, sunflowers, and sugar beets, were last reported by the National Agricultural Statistics Service (NASS) for the years 2001 and 2002. These crops are not produced in the License Area and surrounding 3.2 km (2.0-mile) review area. 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.

2.2.3.3 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, which is south and adjacent to the License Area as shown in **Figure 2.2-1**. 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 3.6-km (2.25-mile) review area.

Table 2.2-4: 2006 Agricultural Yields for Croplands in Dawes County

Commodity	Planted		Harvested		Yield		Production
	Acres[a]	km²	Acres[a]	km²	Per acre	Per km²	
Wheat Winter All	37,000	150	35,300	143	38 bu	9,291 bu	1,325,900 bu
Corn For Grain	2,500	10	700	3	161 bu	39,784 bu	112,700 bu
Corn For Silage	na	na	1,700	7	11 ton	2,743 ton	18,900 ton
Oats	4,000	16	500	2	16 bu	3,954 bu	8,000 bu
Hay Alfalfa (Dry) [b]	na	na	32,500	132	2 ton	381 ton	49,900 ton
Hay Other (Dry)	na	na	24,000	97	1 ton	198 ton	19,200 ton
Hay All (Dry)	na	na	56,500	229	1 ton	301 ton	69,100 ton

Notes:

bu bushels

[a] 1 acre = 0.0040469 square kilometer (km^2)

[b] Includes wild and tame alfalfa.

Na Not available

Source: National Agricultural Statistics Service 2007b.

Table 2.2-5: Potential Agricultural Production for Cropland in the License Area and the 3.2 km (2.0-Mile) Review Area

	Percent of Total Planted[a]	Total Cropland (acres)[b]	Percent of Planted/ Harvested[c]	Harvested (acres)	Harvested (km^2)	Production[d] (bushels)
Wheat	33.3	9,718.6	95.4	9,271.54	120,530.02	352,318.52

Notes:

[a] Same as for Dawes County.

[b] 1 acre = .0040469 km^2.

[c] assume 95.4 percent is harvested

[d] assume 38 bushels per acre

Source: National Agricultural Statistics Service 2007b.

Table 2.2-6: Livestock Inventory for Dawes County, 2002

Livestock Type	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	<1	148	<1
Hogs	305	<1	67.1	<1
Sheep	1,740	<1	348	<1
Chickens	431	<1	2.2	<1
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: Nebraska Department of Economic Development 2007

2.2.3.4 Residential

According to 1980 USGS 7.5 minute quadrangle maps, on-site field investigations, and USGS aerial photos flown in 2006, there are 73 occupied dwelling units located in the rural area outside of Crawford in the Crow Butte License Area 8-km (5-mile) radius (**Table 2.2-7**). According to U.S. Census 2000, the average persons per household estimate for Dawes County of 2.28 people per housing unit results in an estimated 166 persons who reside in the 8-km (5-mile) radius, a decrease from the 1982 estimate of 181 persons. An additional 1,035 persons reside in Crawford, approximately 4 miles from the site center point (U.S. Bureau of the Census 2006). Two dwelling units are within 0.62 mile, and another five dwelling units are within 1.24 miles of the center point of the License Area.

Table 2.2-7 shows the distance to the nearest residence and to the nearest site boundary of residences within the 8-km (5-mile) review area from the center of the License Area for each 22 1/2° sector centered on each compass point. There are no dwelling units within 0.62 mile of the center point of the proposed License Area. Four dwelling units are within 1.24 miles.

Table 2.2-7: Residence Count and Distance within the 8-km (5-mile) Radius of License Area Center Point

Sector [c]	Structure Count [a]	Nearest Residence (km)	Nearest Vegetable Garden (km)	Nearest Project Boundary (km)
North	2	5.7	--	2.4
North-Northeast	1	4.0	--	2.0
Northeast	3	4.3	--	2.5
East-Northeast	6	0.6	0.6	2.1
East	0	--	--	2.1
East-Southeast	5	0.6	--	1.4
Southeast	1	4.5	--	2.9
South-Southeast	1	4.5	--	2.9
South	3	3.8	--	4.0
South-Southwest	2	5.0	--	2.3
Southwest	3	1.6	--	1.5
West-Southwest	3	3.1	--	1.3
West	3	2.5	--	1.3
West-Northwest	27[b]	4.4	--	1.3
Northwest	510[b]	3.1	--	5.4
North-Northwest	10	1.1	1.1	2.4

Notes:
[a] Residences.
[b] U.S. Census 2000 reported 537 housing units within the City of Crawford. As with the sectorial population, housing units for Crawford are allocated as 5 percent for the WNW sector and 95 percent for the NW sector.
[c] 22 1/2 ° sectors centered on each of the 16 compass points.
-- Not present
Sources: USDA FSA 2006; U.S. Bureau of the Census 2000.

2.2.3.5 Industrial and Mining

There are six gravel pits within the 8-km (5-mile) radius of the License Area (**Figure 2.2-2**). Most of the pits are inactive, although a few are mined periodically for local road construction purposes. Besides Crow Butte Resources, Conoco, Amoco Minerals, Sante Fe Mining, and Union Carbide have also drilled exploratory testing holes in the area for a variety of natural resources. Other industrial facilities within the 8-km (5-mile) radius include the railroad station and maintenance yard at the City of Crawford.

There are no other 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.

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Figure 2.2-2

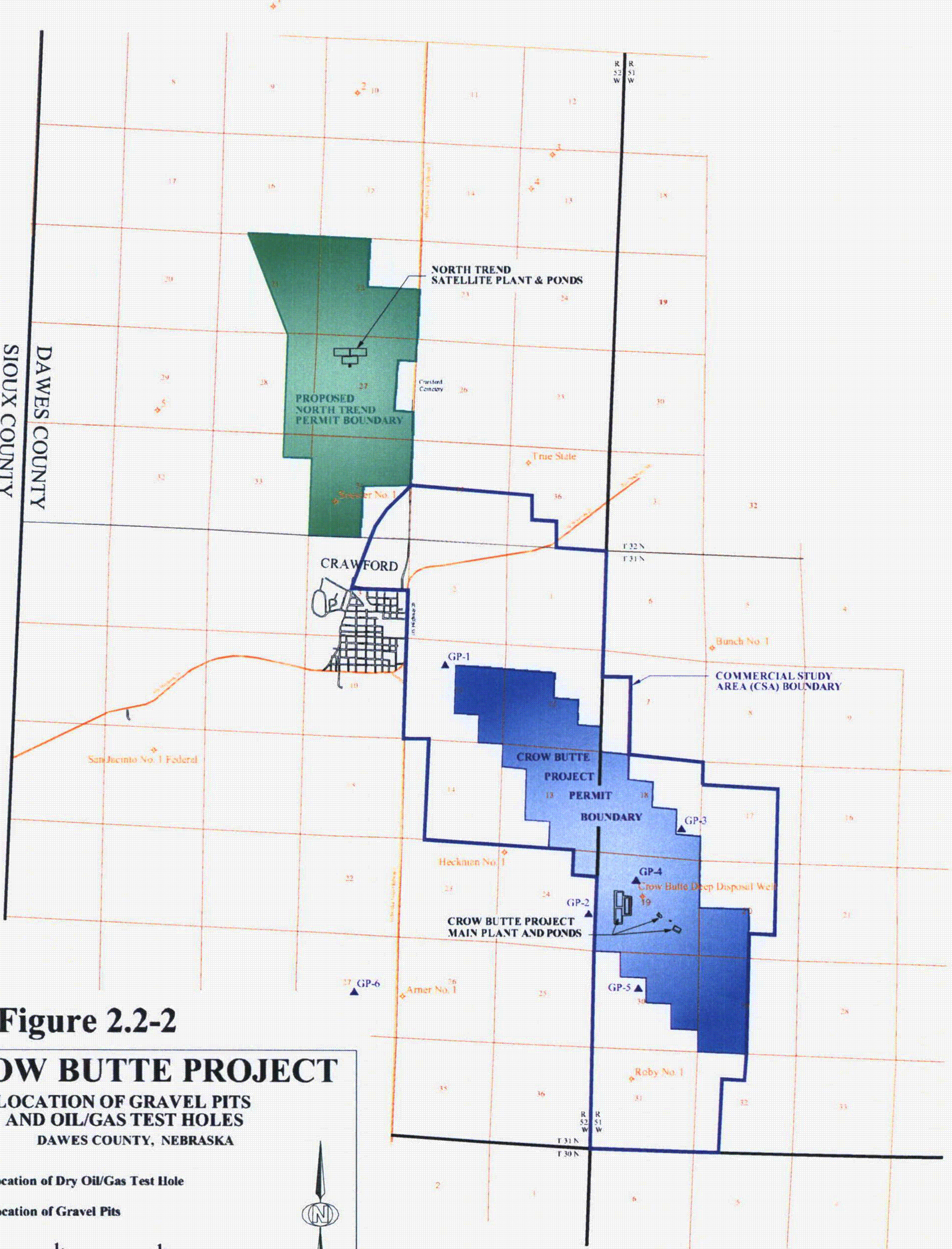

Figure 2.2-2

CROW BUTTE PROJECT

LOCATION OF GRAVEL PITS AND OIL/GAS TEST HOLES

DAWES COUNTY, NEBRASKA

Name — Location of Dry Oil/Gas Test Hole

GP-X — Location of Gravel Pits

SCALE 0 ½ 1 1½ 2 MILE

N

2.2.3.6 Transportation

Nebraska Highway 2/71 and U.S. Highway 20 converge in Crawford. The annual average daily traffic counts for 2004 range between 1,195 south of Crawford and 540 north of Crawford on Nebraska Highway 2, and 1,795 on U.S. Highway 20 north of the License Area (Nebraska Department of Roads 2007). Although unpaved, Squaw Creek Road provides access to the License Area. A Burlington Northern Railroad runs in a northwesterly direction approximately 0.75 miles west of the site. Several transmission lines traverse the License Area, including one less than 1 km west of the designated center point.

2.2.4 Water Use

The Crow Butte License Area is drained by Squaw Creek and is within the White River Watershed. Squaw Creek is used by local landowners for irrigation, livestock watering, and domestic purposes, and by fish and wildlife habitat. Warm-water fishing and hunting also occur downstream from the Crow Butte project.

The White River supports agricultural production, wildlife habitat, and both warm- and cold-water fish. Within 6.2 miles upstream of the License Area, the White River supplies drinking water to the citizens of Crawford. In 1981, average daily usage ranged from a low of 199 gallons per day per person (gpdpp) in February to a high of 508 gpdpp in July. The maximum recorded daily water usage in Crawford was nearly 1 million gallons.

Lake Crawford, as well as approximately 20 unnamed reservoirs ranging from 1 to 17 acres of surface area, is also located within a 10-km (6.2-mile) radius.

Groundwater within the 8-km (5-mile) License Area is supplied by either the Brule or Chadron Formations (Williams 1982). A water well survey conducted by Wyoming Fuel Company (WFC) indicates that most of the groundwater pumped from 123 wells surveyed within the 3.6-km (2.25-miles) radius of the proposed commercial License Area is used either to water livestock or for domestic purposes. A spring, located in Fort Robinson State Park, produces an average of 972,000 gallons per day (gpd) (Storbeck 1987).

Eight surface water impoundments are located within or adjacent to the License Area (**Figure 2.2-3**). These eight impoundments are identified as I-1 through I-8. Impoundments I-1, I-2, I-7, and I-8 are located outside the License Area, while impoundments I-3 through I-6 are located inside the License Area.

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Figure 2.2-3

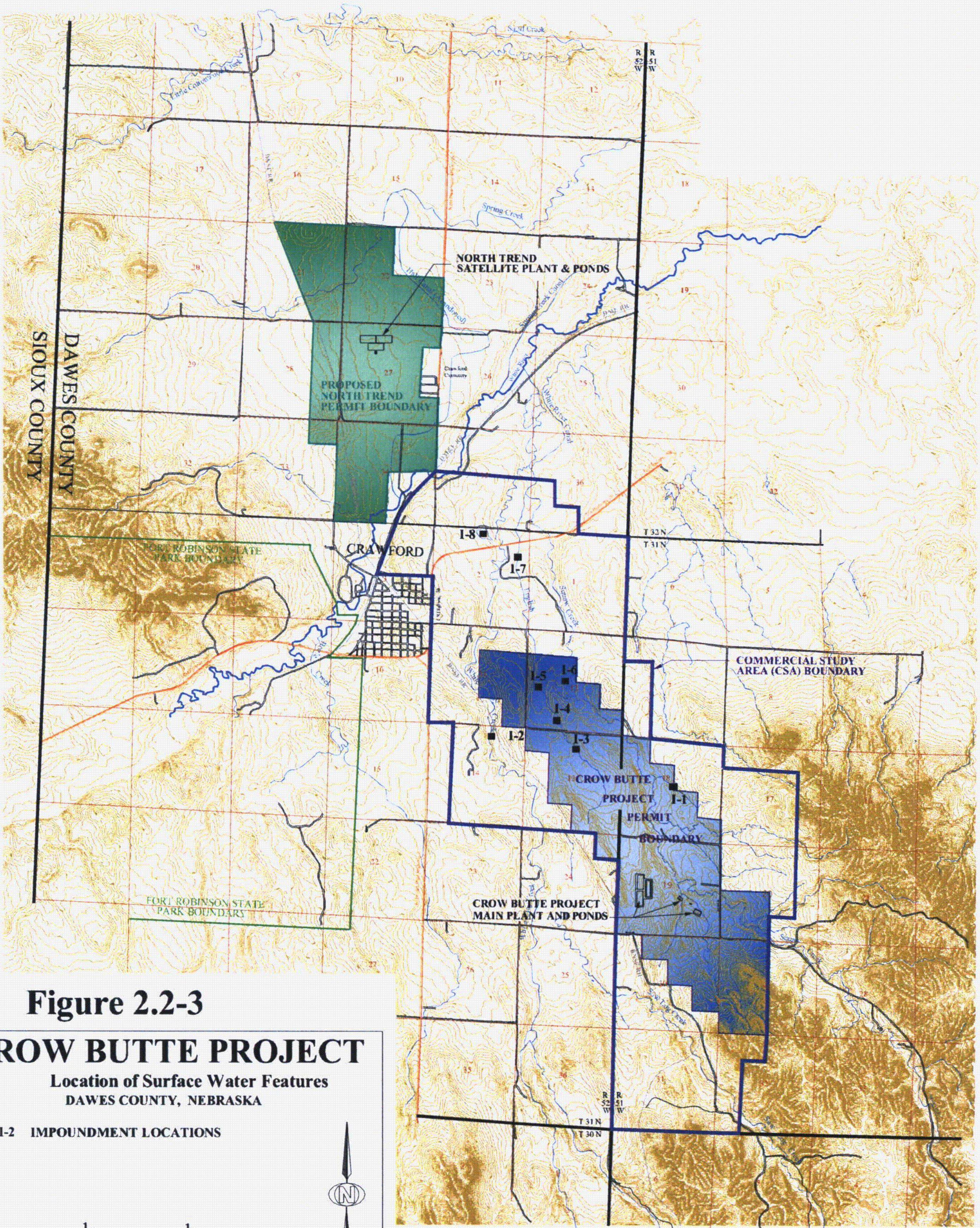

Figure 2.2-3

CROW BUTTE PROJECT

Location of Surface Water Features

DAWES COUNTY, NEBRASKA

■ 1-2 IMPOUNDMENT LOCATIONS

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

Impoundment I-1 consists of a low earthen berm constructed across an unnamed ephemeral drainage course, which is tributary to Squaw Creek. This berm forms a small seasonal pond which is used for livestock watering. Impoundment I-2 is formed by a small earthen dam on White Clay Creek. Water from this pond is used for livestock watering and crop irrigation. Impoundments I-3, I-4, I-5, and I-7 are formed by small earthen dams across English Creek. Water from these ponds is used for livestock watering. Impoundment I-6 is formed by an earthen dam across Squaw Creek. Water from this pond is used for livestock watering. Impoundment I-8 is located in the alluvial valley of White Clay Creek and is also used for livestock watering.

The White River and associated tributaries indirectly supply some of the drinking water to the citizens of Crawford. The city system, which serves a population of 1,115 (Nebraska Department of Health & Human Services 2004), is supplied by three infiltration galleries (located along the White River, Dead Man's Creek, and Soldier Creek) and two wells which produce "groundwater under the influence of surface water" (University of Nebraska, Lincoln undated).

Based on the Crawford Municipal Water Conservation Plan (Spring 2003), the average per capita water use in 2002 (including residential and business customers, public facilities including parks, and water lost to system leaks) was 323 gallons per day. Information regarding the City of Crawford water system is summarized in **Table 2.2-8** (CBR 2007).

Table 2.2-8: Summary of City of Crawford Water System

Description	Capacity
Raw Water Storage Capacity	500,000 gallons
Treated Water Capacity West Tank East Tank	 1,000,000 gallons 750,000 gallons
Average Daily Use (2006)	419,181 gallons
Maximum Daily Use	1,000,000 gallons
Supply Wells South Well #1 (100 feet deep); Reg: G-93533 NW1/4 SW1/4 Sec. 15, T31N, R52W West Well #2 (100 feet deep); Reg: G-93532 NW1/4 SW1/4 Sec. 15, T31N, R52W	 104 gpm 54 gpm
Infiltration Gallery Pump #1; 27 feet; Reg: G-93551 SE1/4 SW1/4 Sec. 8 T31N R52W Pump #2; 27 feet; Reg: G-93551 SE1/4 SW1/4 Sec. 8 T31N R52W	 420 gpm 420 gpm
Dewatering Wells; 20 to 26 feet deep SE1/4 SW1/4 Sec. 8 T31N R52W Reg Nos: 93528, 93529, 93530	33 gpm (each)

Source: CBR 2007

Alternate supplies of stock water are provided by the underlying Basal Chadron Sandstone (400 to 900 feet). However, because of greater depth and inferior water quality, the Basal Chadron is not used for a domestic supply within the License Area. In this regard, Gosselin et al. (1996) state that (1) "the sands near the bottom of the Chadron Formation yield sodium-sulfate water with high total dissolved solids", and (2) "near uranium deposits in the Crawford area, groundwater from the Chadron Formation is not suitable for domestic or livestock purposes because of high radium concentrations". Because of artesian pressure, most Chadron wells in the vicinity of the License Area either flow at the surface, or have water levels very close to surface elevation.

A summary of groundwater quality data collected from 1982 to 1987 to establish background conditions in the vicinity of the Crow Butte Project follows (**Table 2.2-9**). The data are presented for three hydrogeologic units: (1) the Chadron Sandstone (mining zone), the Brule Formation, which supplies the majority of groundwater in the project area, and (3) the Brule Alluvium. It is noted that supplies of Brule Alluvium are limited, and few wells produce from this interval, none of which are located in the License Area.

Table 2.2-9: Summary of Groundwater Quality Data – Crow Butte Vicinity

Constituent[1]	Brule Formation		Chadron Formation		Brule Alluvium	
	Range	Mean	Range	Mean	Range	Mean
Calcium	7.1 - 98	48	11 - 41	20	67 - 74	70.6
Magnesium	0.3 - 16	6.6	0.8 - 7.2	3.2	6.4 - 10	8.7
Sodium	12 - 340	104	340 - 540	411	34 - 41	36.5
Potassium	4.1 - 15.9	9.9	7.0 - 19.8	12.4	10.3 - 13	11.1
Bicarbonate	137 - 627	364	308 - 411	368	299 - 364	321
Sulfate	1 - 23	10	254 - 620	407	11 - 20	16.3
Chloride	1.6 - 192	48	134 - 250	176	5 - 10	6.7
Specific Conductance (μmhos)	246 - 1481	714	1500 - 2500	1932	507 - 614	548
PH (pH units)	6.80 - 8.50	7.80	7.60 - 8.70	8.20	7.10 - 8.40	7.70
Uranium (mg/L)	0.001 - 0.021	0.0064	<0.001 - 2.40	0.092	0.006 - 0.022	0.015
Radium-226 (pCi/l)	0.1 - 3.0	0.7	0.1 - 619	53	0.4 - 18.3	2.5

[1] Concentrations in mg/L, unless otherwise noted.

Future water use within the 2-mile review area will likely be a continuation of present use. Detailed surface and groundwater analysis is provided in **Section 2.7**.

2.2.5 References

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2.3 POPULATION DISTRIBUTION

Information presented in this section concerns those demographic and social characteristics of the environs that may be affected by the proposed expansion of the Crow Butte Project to include operations in the License Area. Data were obtained through the 1980, 1990, and 2000 U.S. Census of Population and various State of Nebraska government agencies.

2.3.1 Demography

2.3.1.1 Regional Population

The area within an 80-km (50-mile) radius of the License Area includes portions of six counties in northwestern Nebraska, two counties in southwestern South Dakota, and two counties in eastern Wyoming. Because the 80-km radius extends only slightly into two very rural counties in Wyoming (with populations of less than 2,000 persons), the regional demography in Wyoming is not discussed in detail beyond that summarized in **Tables 2.3-1** through **Table 2.3-3**. **Figure 2.3-1** depicts significant population centers within an 80-km radius of the License Area.

Historical and current population trends in the License Area counties and communities are contained in **Table 2.3-1**. Between 1960 and 1980, Box Butte County exhibited the fastest rate of growth with more than a 17 percent population increase, largely occurring in the latter half of the 1970s. Box Butte County lost population between 1980 and 2000, with the greater population losses occurring during the 1990s.

All of the Nebraska counties comprising the License Area experienced slight growth or actual population decline between 1960 and 1980 and population decline between 1980 and 1990. The state experienced its fastest growth since the 1920s during the years between 1990 and 2000. The total state population in 2000 was 1.7 million, which was an 8.4-percent increase over the 1990 population of 1.6 million. The Nebraska counties in the License Area experienced little of the state's growth spurt. However, with the exception of Box Butte, the counties experienced a reversal of the downward trends of the 1980s. In general, population trends for the last decade show that population in urban areas is increasing, while population in rural areas is declining. Areas within 80-km of the License Area that are defined as urban (all territory, population, and housing units in urbanized areas and in places of more than 2,500 persons outside of urbanized areas) by the U.S. Census 2000 are the cities of Chadron in Nebraska, and Hot Springs and Pine Ridge in South Dakota.

Table 2.3-1: Historical and Current Population Change for Counties and Towns within 80-km (50-mile) Radius of the License Area, 1960-2000

STATE County City	Population					Average Annual Percent Change			
	1960	1970	1980	1990	2000	1960/1970	1970/1980	1980/1990	1990/2000
NEBRASKA									
Dawes	9,536	9,761	9,609	9,021	9,060	2.4	-1.6	-6.1	0.4
Chadron	5,079	5,921	5,933	5,588	5,634	16.6	0.2	-5.8	0.8
Crawford	1,588	1,291	1,315	1,115	1,107	-18.7	1.9	-15.2	-0.7
Box Butte	11,688	10,094	13,696	13,130	12,158	-13.6	35.7	-4.1	-7.4
Alliance	7,845	6,862	9,869	9,765	8,959	-12.6	43.8	-1.1	-8.3
Hemingford	904	734	1,023	953	993	-18.8	39.4	-6.8	4.2
Sheridan	9,049	7,285	7,544	6,750	6,198	-19.5	3.6	-10.5	-8.2
Hay Springs	823	682	794	693	652	-17.1	16.4	-12.7	-5.9
Rushville	1,228	1,137	1,217	1,127	999	-7.4	7.0	-7.4	-11.4
Sioux	2,575	2,034	1,845	1,549	1,475	-21.0	-9.3	-16.0	-4.8
Harrison	448	377	361	241	279	-15.8	-4.2	-33.2	15.8
SOUTH DAKOTA									
Fall River	10,688	7,505	8,439	7,353	7,453	-29.8	12.4	-12.9	1.4
Hot Springs	4,943	4,434	4,742	4,325	4,129	-10.3	6.9	-8.8	-4.5
Oelrichs	132	94	124	138	145	-28.8	31.9	11.3	5.1
Ardmore	73	14	16	N/A	N/A	-80.8	14.3	N/A	N/A
Shannon	6,000	8,198	11,323	9,902	12,466	36.6	38.1	-12.6	25.9
Pine Ridge CDP	N/A	N/A	N/A	422	1,229	N/A	N/A	N/A	191.2
WYOMING	1,256	2,768	3,059	2,596	3,171	120.4	10.5	-15.1	22.1
Goshen	11,941	10,885	12,040	12,373	12,538	-8.8	10.6	2.8	1.3
Niobrara	3,750	2,924	2,924	2,499	2,407	-22.0	0.0	-14.5	-3.7
Lusk	1,890	1,495	1,650	1,504	1,447	-20.9	10.4	-8.8	-3.8

Note – CDP (Census Designated Place) is a statistical entity defined for each decennial census according to Census Bureau guidelines, comprising a densely-settled concentration of population that is not within an incorporated place, but is locally identified by a name.
N/A = Not Available
Sources: U.S. Bureau of the Census, 1972a, 1972b, 1972c, 1979, 1981, 1990a, 1990b, 1990c, 2003

Dawes County grew slightly between 1990 and 2000, gaining 0.4 percent in population. Most of this growth occurred in the City of Chadron. The Dawes County communities of Chadron and Crawford are the nearest communities to the License Area. Chadron is located approximately 25 miles northeast of the License Area with a 2000 population of 5,634, an increase of 0.8 percent from 1990. The community of Crawford, within 6.2 miles of the site, had a 2000 population of 1,107. Chadron experienced a small population gain between 1990 and 2000, while Crawford lost population.

Table 2.3-2: Population by Age and Sex for Counties within 80-km (50-mile) Radius of the License Area, 2000

State County	Age	Male	Female	Total	Total Percent Breakdown
South Dakota					
Fall River	Under 5	214	145	359	4.8
	5 – 19	847	661	1,508	20.2
	20 – 34	397	406	803	10.8
	35 – 64	1,596	1,513	3,109	41.7
	65+	846	828	1,674	22.6
	Total	3,900	3,553	7,453	100.0
Shannon	Under 5	676	684	1,360	10.9
	5 – 19	2,460	2,294	4,754	38.1
	20 – 34	1,205	1,297	2,502	20.1
	35 – 64	1,614	1,642	3,256	26.1
	65+	265	329	594	4.8
	Total	6,220	6,246	12,466	100.0
Wyoming					
Goshen	Under 5	378	349	727	5.8
	5 – 19	1,460	1,322	2,782	22.2
	20 – 34	1,001	946	1,947	15.5
	35 – 64	2,459	2,451	4,910	39.2
	65+	936	1,236	2,172	17.3
	Total	6,234	6,304	12,538	100.0
Niobrara	Under 5	60	55	115	4.8
	5 - 19	268	219	487	20.2
	20 - 34	134	180	314	13.0
	35 - 64	507	533	1,040	43.2
	65+	205	246	451	18.7
	Total	1,174	1,233	2,407	100.0

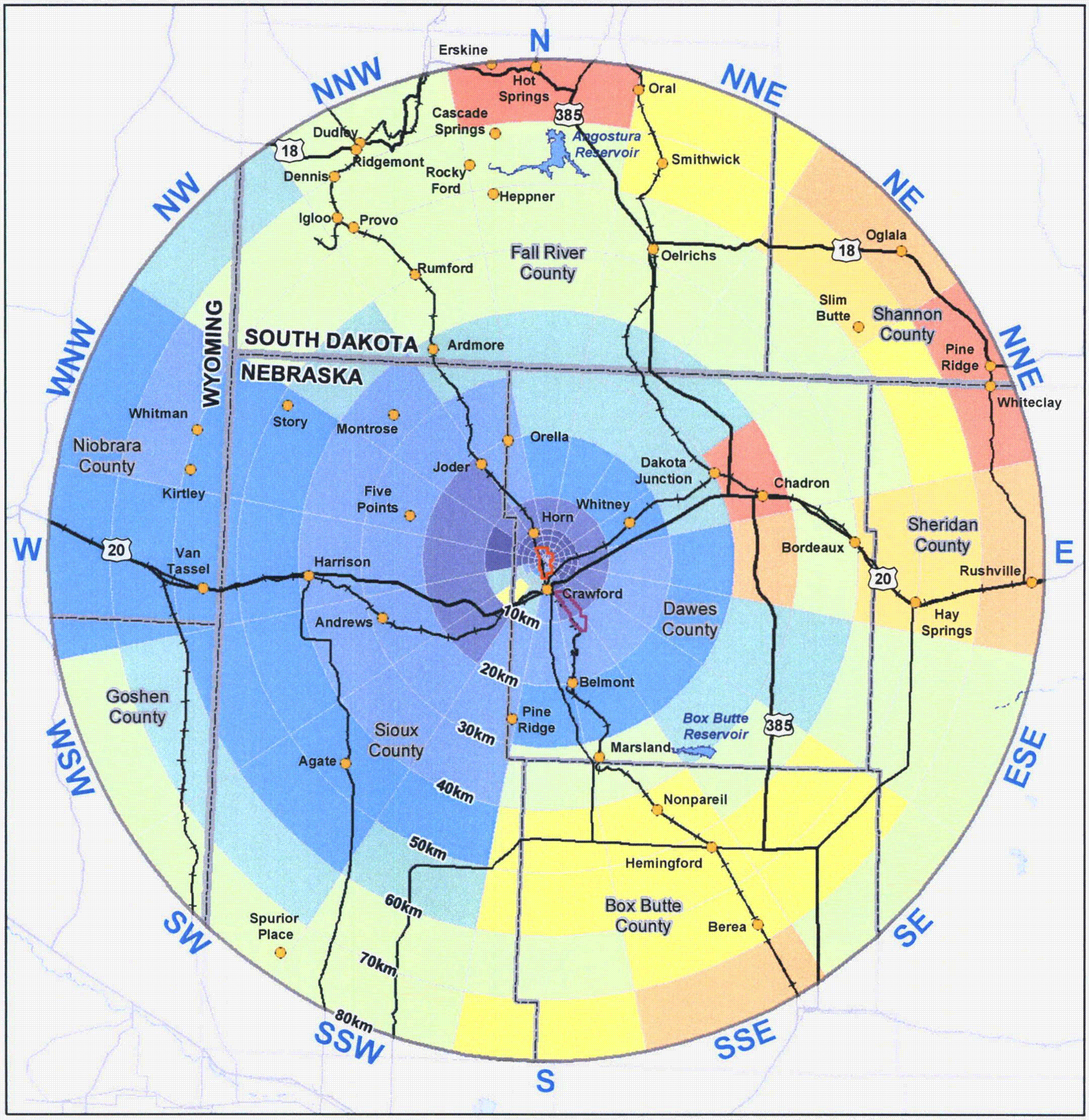
Source: U.S. Bureau of the Census 2003

Table 2.3-3: Population Projections for Counties within an 80-km (50-mile) Radius of the License Area, 2000-2020

County	Census 2000	Projected 2005	Projected 2010	Projected 2015	Projected 2020
Box Butte	12,158	11,759	11,387	11,048	10,662
Dawes	9,060	9,168	9,273	9,339	9,368
Sheridan	6,198	5,962	5,732	5,540	5,368
Sioux	1,475	1,424	1,364	1,294	1,215
Fall River	7,453	N/A	N/A	N/A	N/A
Shannon	12,466	N/A	N/A	N/A	N/A
Goshen	12,538	12,401	12,429	N/A	N/A
Niobrara	2,407	2,399	2,399	N/A	N/A

N/A = not available

Sources: University of South Dakota, Bureau of Business Research 2004. University of Nebraska-Lincoln, Bureau of Business Research 2004. Wyoming Department of Administration and Information 2004.



Legend

Population

- 0 - 4
- 4 - 16
- 16 - 33
- 33 - 53
- 53 - 98
- North Trend
- CBR License Area
- 98 - 179
- 179 - 303
- 303 - 679
- 679 - 1701
- 1701 - 5040

0 2.5 5 10 15 20 Miles

CROW BUTTE PROJECT

REGIONAL AREA BASE MAP

DAWES & SIOUX COUNTIES, NEBRASKA

FIGURE 2.3-1
SIGNIFICANT POPULATION CENTERS WITHIN 80 KILOMETERS

Sioux County lost population at a slower rate in the years between 1980 and 1990 than in the previous decade. The slower decline of the county population occurred in part because the town of Harrison gained nearly 16 percent, which is a reversal of a trend that shows a decline in population since 1960. Between 1980 and 1985, the downward trend continued in Sioux and Morrill Counties, with Sheridan County exhibiting a slight turnaround. Between 1985 and 1990, the downward trend continued in the Nebraska counties, with the exception of Morrill County, which experienced an increase of 6.3 percent. However, this growth is a decrease from the 1980 population.

Sheridan County has experienced an overall decline of nearly 32 percent since 1960. Population has declined in the towns of Hay Springs and Rushville between 1980 and 2000, despite earlier gains in the 1980s. Scotts Bluff County experienced gradual population growth over the two-decade period between 1960 and 1980.

The two South Dakota counties in the 80-km (50-mile) study area include Fall River and Shannon. Fall River County experienced an overall population decline by more than 30 percent between 1960 and 2000; however, between 1990 and 2000, there was a small increase of 1.4 percent. The town of Ardmore lost more than 80 percent of its population between 1960 and 1980, and was disincorporated in 1984 (U.S. Census 1990e). Shannon County, on the other hand, grew by 25.9 percent between 1990 and 2000; more than double the 1960 population. Much of the growth occurred in the Pine Ridge and Oglala Census Designated Places (CDP), which are urban areas as defined by the U.S. Census, but are not incorporated municipalities. Most of Fall River County is included within the 80-km (50-mile) radius of the License Area; however, only the southwest portion of Shannon County is within the 80-km (50-mile) radius of the License Area.

The population declines in the counties within the 80-km (50-mile) radius reflect trends in the overall region, where declines have been attributed to the declines in the rural farming based economy and limited economic opportunities for youth. Persistent drought conditions have also contributed to the shrinking of the agriculture-based economy. Rural residents have been migrating to larger cities, depopulating the largely rural Great Plains states. Many of the people migrating out of the state are young adults and families, which results in fewer people of childbearing age, and therefore, fewer children. This trend also contributes to the increasing proportion of the elderly population in the state.

2.3.1.2 Population Characteristics

The 2000 population by age and sex for counties within 80-km of the License Area is shown in **Table 2.3-2**. Overall, 67.7 percent of the population in the region is more than 20 years old. Fall River and Niobrara Counties reported the highest percentage of persons older than 18 with 75.0 percent. About 6.7 percent of the population was less than 5 years old in 2000. Shannon County reported the youngest population, with 10.9 percent less than 5 years old and slightly more than half (51.0 percent) at 18 years of age and under. Females slightly outnumbered males in most counties, with an overall population of 50.1 percent female to 49.9 percent male.

In 2000 slightly more than 75 percent of the ten-county population was classified as white. American Indians and persons of Hispanic origin comprised 21.2 percent and 4.3 percent, respectively, of the total population. Nearly 80 percent of the American Indians were Sioux living on the Pine Ridge Reservation in Shannon County, South Dakota.

2.3.1.3 Population Projections

The projected population for selected years by county within the 80-km radius of the License Area is shown in **Table 2.3-3**. The population is expected to decrease in the Nebraska Counties of Box Butte, Sheridan, and Sioux. These counties are primarily rural, with agriculture-based economies. It is anticipated that the declining population trends of the last two decades will continue into the foreseeable future for these counties. The projected population for Dawes County is expected to increase at an annual rate of less than 1 percent over the next 20 years. This rate reflects recent increases in the population of Chadron that are expected to continue. In addition, Dawes County provides a scenic setting for a variety of outdoor recreation activities. The Pine Ridge region will probably increase in popularity with visitors and recreationists from outside of the region, as participation in outdoor recreational activities is expected to increase nationwide. An increase in visitor utilization of recreation facilities in Dawes County would revitalize the local economy, adding to the overall attractiveness of the region to potential residents.

2.3.1.4 Seasonal Population and Visitors

According to the Final Environmental Impact Statement for the Northern Great Plains Management Plans Revision (USFS 2001), the various state parks in northwest Nebraska, the Pine Ridge Ranger District and the Oglala National Grassland, are increasingly becoming regional tourist destinations.

Approximately 358,000 people visited Fort Robinson State Park in 2002. This number represents a 4.8-percent increase from 2001, but a decrease of 5.1 percent from the 1981 visitation of 377,000 people and a slight decrease of less than 1 percent from the 359,000 visitors in 1984 (Nebraska Department of Economic Development 2003). Visitor Figures were up slightly for 2005, with a total of 361,230 visitors to the park (Nebraska Department of Economic Development 2007). Approximately 50 percent of the visitors in 2002 were from other states, which is an increase in the number of out-of-state visitors from 1981, as the majority of 1981 visitors were Nebraskan families. It is likely that the decline of visitors from Nebraska has resulted from the overall decline of population in rural counties within a few hours commuting distance of the park.

There were 55,000 visitors to the Pine Ridge District of the Nebraska National Forest in 2001. Camping and motorized travel/viewing scenery are the two most popular recreation categories on the Pine Ridge Ranger District and the Oglala National Grassland.

The forest provides a wide range of other undeveloped backcountry recreation opportunities such as hunting, hiking, backpacking, fishing and wildlife observation. The district provides the greatest number of miles of mountain biking trails in the state.

District trails also attract horseback riders and off-highway motorized vehicle use. The Pine Ridge is an important destination for deer hunting, and provides the most popular turkey hunting area in Nebraska.

One source of seasonal population in this region is Chadron State College, located approximately 21.6 miles from the site. During the 2001 fall semester, enrollment was 2,804, an increase of 25 percent over the fall 1986 enrollment of 2,240 (Nebraska Department of Economic Development 2002; Schmiedt 1987). In the 1994 fall semester, a total of 3,296 students were enrolled at the college (Taylor 1995).

2.3.1.5 Schools

Crawford is served by the Crawford Public School District. The Crawford High School and grade school are presently under capacity. Total enrollment in these two schools as of fall 2001 was 146 in the high school and 140 in the elementary school with maximum capacities of 545 and 185, respectively (National Center for Educational Statistics 2004; Crawford High School 1995, Crawford Elementary School 1995). Current enrollment numbers are 134 in the grade school and 134 in the high school (Crawford Public Schools 2007) and are comparable to annual enrollments since 1987 for both schools. The grade school currently has a student to teacher ratio of 13 to 1 and the high school has a ratio of 8 to 1. No historical high enrollment was given for the grade school. However, it was estimated in 1995 that the high school historical high enrollment was more than 200 pupils.

There is one rural school supporting grades one through eight within the Crawford district. The Belmont School is a two-room schoolhouse. Students living in the rural district attend Crawford High School. There were 6 pupils as of fall 2007 at the Belmont School from which Crawford High School draws, a decline from the 1995 enrollment of an estimated 100 pupils in seven rural school districts.

Families moving into the Crawford district as a result of the Crow Butte Project would not stress the current school system because it is presently under capacity.

2.3.1.6 Sectorial Population

Existing population, as determined for the original analysis in the CBR commercial license application prepared in 1987 for the 80-km (50-mile) radius, was estimated for 16 compass sectors, by concentric circles of 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70 and 80-km from the site (a total of 208 sectors). Sectorial population for this LRA was updated with data from the 2000 U.S. Census. Subtotals by sector and compass points as well as the total population are shown in **Table 2.3-4**.

Table 2.3-4: 2000 Population within an 80-km (50-mile) Radius of the License Area[a]

	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Total
N	0	0	0	0	1	9	38	63	87	112	137	161	3,682	4,292
NNE	0	0	0	0	1	9	38	63	88	112	147	205	223	886
NE	0	0	0	0	1	9	38	63	88	109	116	624	679	1,728
ENE	0	0	0	0	1	9	37	58	5,039	113	132	224	3,139	8,754
E	0	0	0	0	1	9	29	48	1,007	113	587	435	1,207	3,436
ESE	0	0	0	0	1	7	29	48	69	91	117	131	107	601
SE	0	0	0	0	0	7	29	48	68	146	263	303	153	1,016
SSE	0	11	21	9	2	7	29	48	125	242	273	194	1,701	2,663
S	0	16	41	58	72	27	29	48	136	190	188	164	179	1,149
SSW	0	14	41	58	74	75	21	25	30	38	67	115	133	690
SW	0	4	39	58	74	291	13	21	29	38	46	70	112	794
WSW	0	0	6	33	60	75	13	21	29	38	53	83	98	509
W	0	0	0	0	1	3	13	21	29	38	33	39	49	226
WNW	0	0	0	0	1	4	13	21	29	38	38	32	37	212
NW	0	0	0	0	1	6	13	21	30	71	110	113	78	444
NNW	0	0	0	0	1	9	28	26	65	112	136	148	164	691
Total	0	46	148	214	293	560	409	645	6,950	1,601	2,443	3,041	11,741	28,092

Notes:

a Current population living between 10 and 80 km of the mine site were estimated using 2000 census data. Field reconnaissance was conducted in 2004 to verify data collected within 2.25 miles (3.6 km). See Section 2.3.1. for a detailed description of the methodology.

Population within the 80-km (50-mile) radius was estimated using the following techniques:

- U.S. Census 2000 data were used to estimate the total population within an 80-km (50-mile) radius, measured from the center of the License Area site. The data were created by Geographic Data Technology, Inc., a division of Environmental System Research Institute (ESRI) Inc., from Census 2000 boundary and demographic information for block groups within the United States.
- ArcInfo GIS was used to extract data from U.S. Census 2000 population estimates for 40 Census Tract Block Groups located wholly or partially within the 80-km (50-mile) radius from the approximate center of the License Area. Urban areas within each county were generally assigned their own block group.
- To assign a population to each sector, a percentage area of each sector within one or more block groups was calculated for all of the block groups.
- 2000 U.S. Census of population estimates for cities and counties in Nebraska, South Dakota and Wyoming were used to determine total urban population.

2.3.2 Local Socioeconomic Characteristics

2.3.2.1 Major Economic Sectors

In 2002, average annual unemployment rates in Dawes and Box Butte Counties decreased from the 1994 rates. **Table 2.3-5** summarizes unemployment rates and employment in the License Area counties. Dawes and Box Butte Counties exhibited unemployment rates at 3.8 percent in Dawes County and 5.0 percent in Box Butte County. Unemployment rates for both counties increased between 1994 and 2002. In 1994, unemployment levels declined from February 1987 levels. These rates were a little higher than the statewide rate of 3.5 percent. Dawes County was close to the state unemployment rate, while the Box Butte rate was higher.

Table 2.3-5: Annual Average Labor Force and Employment Economic Sectors* for Dawes and Box Butte Counties, 1994 and 2002

Employment Economic Sectors	Dawes		Box Butte	
	1994	2002	1994	2002
Labor Force	4,490	4,663	6,156	5,670
Unemployment	149	175	235	282
Unemployment Rate	3.3	3.8	3.8	5.0
Employment	4,341	4,489	5,921	5,387
Farm Employment	564	550	763	760
Non-Farm Employment Total	3,479	3,903	5,446	5,241
Manufacturing	165	201	402	465
Construction and Mining	136	179	80	0
Transportation, Communication, and Utilities	N/A	N/A	1,909	1,288
Trade	952	N/A	1,106	825

Table 2.3-5: Annual Average Labor Force and Employment Economic Sectors* for Dawes and Box Butte Counties, 1994 and 2002

Employment Economic Sectors	Dawes		Box Butte	
	1994	2002	1994	2002
Retail	824	636	840	539
Wholesale	128	N/A	265	286
Financial, Insurance, and Real Estate	77	117	215	205
Services	548	N/A	779	N/A
Information	N/A	0	N/A	110
Professional and Business Services	N/A	N/A	N/A	219
Education and Health Services	N/A	358	N/A	424
Leisure and Hospitality	N/A	533	N/A	372
Other Services	N/A	133	N/A	203
Government	1,384	1,450	955	1,130
Federal	144	161	65	67
State	721	719	67	62
Local	519	571	824	1,001

* Industry employment estimates are based on the Standard Industry Classification System before 2001, and on the North American Industry Classification System after 2001.
N/A = not available

The major economic sectors in the License Area have changed little in recent years, although individual sectors have shifted in their relative proportion in the overall economy. The area continues to depend on trades, government, and services. Economic activities in the Crawford area include farming, ranching, cattle feed lots, tourism, and retail sales.

Agriculture accounts for slightly more than 1 percent of the total employed labor force in Dawes County, while farm employment was 14 percent of total employment in Box Butte County. Government employment in Dawes County makes up 37 percent of total non-farm employment, followed by trade (16 percent), leisure and hospitality services (14 percent), and education and health services (9 percent). Construction and mining account for 5 percent. In Box Butte County, the largest four non-farm employment sectors are transportation (25 percent), government (22 percent), trade (16 percent), and manufacturing (9 percent).

Agriculture employment has a small share of total employment in both counties. However, agriculture provides the economic base for the counties, as other economic sectors support the agricultural industry. Events that affect agriculture are generally felt throughout rural economies. According to the Nebraska Department of Economic Development (2002), Farm employment in Nebraska is expected to decline by nearly 14,000 jobs (20 percent) between 2000 and 2045, while overall non-farm employment will increase by nearly 26 percent. The decrease in jobs in the agricultural sector could continue to fuel migration from rural counties to urban areas, resulting in overall declines in other sectors of the local economy as dollars spent from personal income and agricultural business expenditures move out of the counties.

Per capita personal income is the income that is received by persons from all sources, including wages and other income over the course of 1 year. In 2002, personal income in Dawes County was $19,760, which was 68 percent of the state average of $29,182. The county ranks 84th out of 93 counties in the state (BEA 2004).

2.3.2.2 Housing

Between 1970 and 1980, total housing units increased by 17 percent in Dawes County from 3,388 to 3,965 units. By 2002, the growth of the preceding decades had slowed, and total housing units increased by 2.4 percent to 4,004 units from 3,909 units in 1990. Chadron, the largest community in Dawes County and within 25 miles of the License Area, experienced a 25 percent increase in housing stock between 1970 and 1980, and a 5 percent increase between 1990 and 2000. Crawford housing stock decreased by nearly 7 percent from 576 units in 1990. By 2000, there were 2,441 housing units in Chadron and 537 units in Crawford. Alliance, in Box Butte County (approximately 72 km [45 miles] from the License Area) exhibited a 1 percent loss in total housing units between 1990 and 2000. In 2000, there were 4,062 housing units in Box Butte County (USCB 1981a, 1990d, 2004).

In 2000, Dawes and Box Butte Counties had homeowner vacancy rates of 1.7 and 1.4 percent, respectively. A June 2004 listing of property for sale revealed two ranch properties near Crawford. Housing prices averaged $53,915 in 1999. According to the Dawes County Tax Assessor, no new houses are being built, as current housing needs are being met.

A local Crawford realtor indicated in 1999 that rental property in Crawford was scarce. The rental housing stock has not increased in 2000, as rental vacancy rates were 4.4 percent in Dawes County and 4.7 percent in Box Butte County (USCB 2004), compared with rental vacancy rates in 1990, which were 12.6 percent in Dawes County and 14.9 percent in Box Butte County (USCB 1990a).

High interest rates and tax rates were the major deterrents for potential homebuyers in the License Area in the past. Current deterrents are economic uncertainty and unemployment. Recent interest rates on most home mortgages have ranged between 5 and 7 percent.

Population projections for Dawes County indicate an average annual growth rate of 10 percent between 2000 and 2020. Most of this growth is likely to occur in Chadron, as suggested by population growth between 1990 and 2000, rather than Crawford, which lost population. The majority of housing demand expected over the next two decades is most likely to occur in Chadron. However, housing stock in Crawford has decreased so that homeowner vacancy rates have also decreased. In the event that the various scenic and recreational amenities of the region stimulate the local tourist economy, it is likely that both population and housing stock would increase in Crawford.

The purchase of homes by Crow Butte employees provides the town of Crawford with ad valorem property taxes. The town of Crawford levies taxes at a dollar per hundred of valuation. In 2001, the total levy was 0.43346, which would result in taxes on a $50,000 property of approximately $217 per year (Nebraska Department of Property Assessment and Taxation 2001).

2.3.3 Environmental Justice

The 2000 Census provides population characteristics for Census Tracts, which contain Block Groups that are further divided into Blocks. The Blocks are the smallest Census area that contains the race characteristics of the population in Dawes County. The CSA contains all or a portion of 68 Blocks within Census Tract 9506. Block Groups are the smallest Census area that contains poverty level information. There is no poverty data for individual Blocks within each Block. There are three Block Groups that are located partially within the CSA; however, the Block Groups area includes most of the north portion of Dawes County.

The affected area selected for the Environmental Justice analysis includes the race characteristics of the population within the City of Crawford and the surrounding Census Tract Blocks within the CSA. The population with an annual income below the poverty level was determined from Block Group characteristics.

According to the 2000 Census and summarized in **Table 2.3-6**, the combined population of the city of Crawford and the surrounding Census Blocks within the CSA was 1,265. Minority populations accounted for a small percentage of the total population. The majority of minority populations resided within Crawford.

The state of Nebraska was selected to be the geographic area to compare the demographic data for the population in the affected Blocks. This determination was based on the need for a larger geographic area encompassing affected area Block Groups in which equivalent quantitative resource information is provided. The population characteristics of the CSA are compared with Nebraska population characteristics to determine whether there are concentrations of minority or low income populations in the CSA relative to the state.

The data in **Table 2.3-6** shows that minority populations in the affected Blocks account for considerably smaller proportion of the total CSA population than the proportion of minority populations at the state level. No concentrations of minority populations were identified as residing near the proposed Project facilities, as residents nearest to the License Area rural populations, while most of the minority population lives in Crawford.

Table 2.3-6: Race and Poverty Level Characteristics of the Population in the State of Nebraska, Dawes County, and the CSA

	Nebraska	Percent of Nebraska Pop.	Dawes County	Percent of Dawes County Pop.	Crawford City	Total Block Pop.	Crawford & Block Pop. (CSA)	Percent of Crawford & Block Pop.	Block Group 1	Block Group 2	Block Group 3
Total Population	1,711,263	100.0%	9,060	100.00%	1,107	158	1,265	100.0%	1,111	1,137	890
White alone	1,533,261	89.6%	8,457	93.34%	1,037	151	1,188	93.9%	-	-	-
Black or African American	68,541	4.0%	73	0.81%	1	0	1	0.1%	-	-	-
American Indian and Alaska Native	14,896	0.9%	261	2.88%	38	6	44	3.5%	-	-	-
Asian alone	21,931	1.3%	28	0.31%	0	0	0	0.0%	-	-	-
Native Hawaiian and Other Pacific Islander	836	0.0%	5	0.06%	0	0	0	0.0%	-	-	-
Some other race	47,845	2.8%	93	1.03%	10	1	11	0.9%	-	-	-
Two or more races	23,953	1.4%	143	1.58%	21	0	21	1.7%	-	-	-
Hispanic or Latino	94,425	5.5%	220	2.43%	22	3	25	2.0%	-	-	-
Percent below poverty level:	9.4%	-	17.1%	-	14.4%	-	-	-	21.3%	14.0%	8.3%

Source: USCB 2000

With the exception of Block Group 3, the populations within the Block Groups have higher rates of people living below the poverty level than the state. However, lower income levels are characteristic of predominantly rural populations and small communities that serve as a local center of agricultural activity. No adverse environmental impacts would occur to the population within the CSA as a result of project activities; therefore there would be no disproportionate adverse impact to populations living below the poverty level in these Block Groups.

2.3.4 References

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2.4 REGIONAL HISTORIC, ARCHEOLOGICAL, ARCHITECTURAL, SCENIC AND NATURAL LANDMARKS

2.4.1 Historic, Archeological, and Cultural Resources

Identification and assessment of cultural resources within the Crow Butte License Area have involved two separate field investigations. The R&D stage of cultural resources investigation within the project was carried out during March and April 1982 by the University of Nebraska. Further investigations were completed for the remaining CSA lands during April and May 1987 by the Nebraska State Historical Society.

This section summarizes the results and recommendations of both studies. For detailed descriptions of each identified resource, please refer to the original 1987 license application.

Preliminary background and archival research were initiated in conjunction with intensive field surveys to obtain data required for preparation of both R&D and commercial applications. This work established a basis for addressing potential effects of the project on identified cultural resources. Preliminary literature and records research indicated that systematic investigations had not been previously conducted within the CSA and that no National Register of Historic Places (National Register) eligible properties had been recorded within or immediately adjacent to the survey unit.

Limited previous studies in surrounding areas provided evidence that a wide range of paleontological, prehistoric and historic resources of potential significance to regional studies are present in the near vicinity and could likely be encountered within the CSA. Registered National Historic Landmarks representing military and Native American reservation period use of the CSA are located near the Crow Butte License Area.

Intensive (100 percent coverage) pedestrian inspection of the R&D area (in 1982) and the full CSA survey unit (in 1987) resulted in identification of 21 newly recorded resource locations (**Table 2.4-1** and **Figure 2.4-1**) including eight sites representing Native American components, 12 Euro-American locations, and a buried bone deposit of undetermined cultural association.

Fifteen of these newly identified resources contained limited observed evidence of scientifically important cultural remains or were not determined to be of significant historic value based on the archival research. These sites do not warrant further National Register consideration.

Table 2.4-1: Summary of Cultural Resources Identified During the 1982 and 1987 Investigations Crow Butte Project, Dawes County, Nebraska

Site Number	Description and Temporal Assignment	Topographical Location	Area (m^2)	Field Investigation
1982				
25DW111 (Harvey Homestead)	surface; glass, ceramic, metal; bone debris; Euro-American; late 19th century (?)	top and slope of small knoll	1,000	survey, sketch map, photographs
25DW112/00-17 (Wulf/Daniels Place)	surface/buried; abandoned farmstead (house, depression, 11 outbuildings); Euro-American late 19th/early 20th century	broad terrace; Squaw Creek	6,000	survey, sketch plan, photographs
25DW113 (Fiandt Homestead)	surface/buried; glass, ceramic, metal, wood, leather debris (25 to 40 cm S.D.); 4 depressions; Euro-American; late 19th century (?)	broad terrace; Squaw Creek	9,000	survey, transit map, soil probe/shovel test, photographs
25DW114	surface; chipped stone tools, flaking debris, trade goods, bone, primary component is Middle Archaic, although Paleo-Indian, Late Archaic, Late Prehistoric and Historic components are also present.	broad terrace; Squaw Creek	150,000	survey, transit map, controlled surface collection, photographs
25DW115 (School Dist. 25)	surface; glass, brick debris; former location of First Presbyterian Church and public school; Euro-American; late 19th century	small rise on upper slope	900	survey, sketch map
25DW116	Surface; chipped stone flaking debris; unassigned Native American	terrace slope; Squaw Creek	2	survey, sketch map, photographs
25DW117 (Fleming Homestead)	surface; windmill, cistern, stock tank complex; Euro-American (possibly associated with Fleming homestead); late 19th century (?)	terrace slope; Squaw Creek	250	survey, sketch plan, photographs
FN-1	1 chipped stone flake; unassigned Native American	terrace slope; Squaw Creek	1	survey
FN-2	buried; bone, charcoal; unknown cultural association	eroding cutbank; Squaw Creek	50 (length)	survey, bank profile, collection, sketch map, photographs
FN-3	Crow Butte Cemetery; Euro-American; 1880 through 1971	level ridge top	2,700	survey, sketch plan, photographs
1987				
25DW191 (Dougherty/Smith)	surface/buried; outbuilding; 2 depressions; farm machinery; Euro-American; late 19th century	foot of Pine Ridge colluvial slope	50,000	survey, sketch map, photographs
25DW192	surface/buried; glass and metal debris; 2 depressions, 2	top and slope of small	1,000	survey, sketch map, uncontrolled surface

Table 2.4-1: Summary of Cultural Resources Identified During the 1982 and 1987 Investigations Crow Butte Project, Dawes County, Nebraska

Site Number	Description and Temporal Assignment	Topographical Location	Area (m^2)	Field Investigation
(Stetson/Roby)	foundations; Euro-American; late 19th century	knoll overlooking Squaw Creek tributary		collection, photographs
25DW193	surface/buried; school, foundations, debris, and artifacts; Euro-American early 20th century through 1970s	upland ridge west of Squaw Creek	2,500	survey, sketch map, photographs
25DW194	surface/buried; human burial, chipped stone tools, flaking debris, bone; Plains Equestrian and unassigned Native American	ridge slope west of Squaw Creek	1,600	survey, sketch map, photographs, collected, tested
25DW195	surface; chipped stone tools, flaking debris, fire-cracked rock; unassigned Native American, possibly Archaic	ridge slope east of English Creek	1,000	survey, sketch map, photographs, shovel test
25DW196	surface; chipped stone tool, flaking debris, bone; unassigned Native American	upland ridge divide between Squaw and English Creeks	80,000	survey, transit map, uncontrolled surface collection, controlled test (4), photographs
25DW197	surface; chipped stone tools, flaking debris, bone; unassigned Native American	upland ridge divide between Squaw and English Creeks	150,000	survey, sketch map, uncontrolled surface collection, photographs
25DW198	surface/buried (plow zone only); chipped stone tools and flaking debris; unassigned Native American	saddle and adjacent knolls on divide between English and White Clay Creeks	30,000	survey, transit map, uncontrolled surface collection, controlled test (3), photographs; controlled test 2003
25DW199 (Crawford Ice House)	surface/buried; foundation, pond; Euro-American; early to mid 20th century	narrow terrace, White Clay Creek	2,000	survey, sketch map, photographs
25DW00-25 (Stetson Place)	surface/buried; occupied farmstead (house, 8 outbuildings, corral); Euro-American late 19th century to present	broad terrace, Squaw Creek	18,000	survey, sketch plan, photographs
25DW00-26 (Gibbons/Ehlers Place)	surface/buried; occupied farmstead (house, 11 outbuildings, corral); Euro-American; early 20th century to present	broad terrace, Squaw Creek	25,000	survey, sketch plan, photographs

The remaining six sites are of potential archeological data recovery importance (25DW114, 25DW192, 25DW194, and 25DW198) or possible architectural interest (25DW112 and 25DW00-25). These six sites are potentially eligible for the National Register, but fully assessing the eligibility of these sites was not within the scope of this work.

Field observation in August of 1995 confirmed that the current commercial operation has not directly affected any of the six potentially significant sites. Additionally, there are no properties within the CSA listed in the National Register or registered as natural or historic landmarks. Project development staff has detailed location maps of these properties, and there is coordination with the Nebraska State Historical Society before any development occurs in the immediate vicinity of the six potentially eligible sites.

2.4.2 Visual/Scenic Resources

2.4.2.1 Introduction

The Crow Butte License Area is on private land that is not managed to protect scenic quality by any public agency. However, it is located in scenic landscape of the Pine Ridge area of northwestern Nebraska and is visible from sensitive viewing areas. The existing landscape and the visual effect of the facilities have been inventoried and assessed for the License Area using the United States Department of Interior (USDOI), Bureau of Land Management (BLM) Visual Resource Management (VRM) system.

2.4.2.2 Methods

The VRM system is the basic tool used by the BLM to inventory and manage visual resources on public lands and is used in this analysis. The VRM inventory process involves rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points.

The scenic quality inventory was based on methods provided in BLM Manual 8410 – *Visual Resource Inventory* (BLM 1986). The key factors of landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modifications were evaluated according to the rating criteria and provided with a score for each key factor. The criteria for each key factor ranged from high to moderate to low quality based on the variety of line, form, color, texture, and scale of the factor within the landscape. A score was associated with each rating criteria, with a higher score applied to greater complexity and variety for each factor in the landscape. The results of the inventory and the associated score for each key factor are summarized in **Table 2.4-2**. According to NUREG-1569, 2.4.3(7), if the visual resource evaluation rating is 19 or lower, no further evaluation is required. The total score of the scenic quality inventory is 14; therefore, the visual effect of the Crow Butte Project on the local visual resources was not further analyzed.

Table 2.4-2: Scenic Quality Inventory and Evaluation for the Crow Butte License Area

Key Factor	Rating Criteria	Score
Landform	Flat to rolling terrain with no interesting landscape features	1
Vegetation	Some variety of vegetation; cropland, range, riparian	3
Water	Water is present, but not evident as viewed from residences and roads	0
Color	Some variety in colors and contrasts with vegetation and soil	3
Influence of adjacent scenery	Adjacent scenery is very similar to Crow Butte License Area and provides little contrast	1
Scarcity	Landscape is common for the region	1
Cultural modifications	Existing modifications consist of Crow Butte Project facilities.	5
	Total Score	**14**

U.S.D.I. Bureau of Land Management (BLM). 1986. Visual Resource Inventory. BLM Manual Handbook 8410-1.

2.5 METEOROLOGY, CLIMATOLOGY, AND AIR QUALITY

2.5.1 Introduction

This section describes the meteorological conditions in the region surrounding the License Area. The data presented in this section were used to determine the effect of the local climate on the development area. The joint frequency data can be used to assess the atmospheric dispersion characteristics present in the region.

Data sources for the meteorological conditions used for this report come from the High Plains Regional Climatic Center (HPRCC) for a site located in Chadron, Nebraska (HPRCC 2004) and from an on-site monitoring station near the Crow Butte facility. The period of record for the HPRCC data covers 56 years of observation between 1948 and 2003. The on-site monitoring data were collected between May 1982 and April 1984, and include temperature, precipitation, evaporation, wind speed, and wind direction. Data are also included from the National Weather Service Stations in Scottsbluff, Nebraska and Rapid City, South Dakota.

The License Area is located in Dawes County (in the north central portion of the Nebraska panhandle), which shares its northern border with South Dakota. The weather patterns are typical of a semi-arid, continental climate. This climate is characterized by warm summers, cold winters, light precipitation, and frequent changes in the weather.

The Rocky Mountains, located to the west of the site, and the Black Hills, located to the north, effectively block moisture from these directions, while moisture from the south is directed eastward by a plateau south of the region. As a result of this topography, the License Area is generally drier than the rest of the panhandle.

The HPRCC data were collected at the Chadron 1 NW site (latitude 42° 50' north, longitude 103° 01') west with a ground elevation of 1021 meters (3350 feet) above mean sea level (amsl). The monitor is 0.9 miles west northwest of Chadron, 23 miles east northeast of Crawford, and 22 miles east northeast of the License Area.

2.5.2 Temperature

Table 2.5-1 summarizes mean daily maximum and minimum and mean monthly temperature data for Chadron, Nebraska from 1948 to 2003. The months of November through March all have mean daily minimum temperatures below freezing, with January as the coldest month. December, January, and February all have monthly mean temperatures below freezing.

Table 2.5-1: Mean Daily Maximum and Minimum and Mean Monthly Temperature Data for Chadron, Nebraska

Month	Mean Daily Maximum (°C)	Mean Daily Minimum (°C)	Mean Monthly (°C)	Record High		Record Low	
				(°C)	Year	(°C)	Year
Jan	2.0	-11.8	-4.9	21.1	1989	-33.9	1949
Feb	5.0	-9.2	-2.1	24.4	1982	-32.8	1982
Mar	8.9	-5.4	1.8	28.3	1967	-32.2	1989
Apr	15.1	0.2	7.7	33.9	1989	-23.9	1975
May	20.9	6.3	13.6	36.7	1969	-8.9	1954
June	27.1	11.6	19.3	41.7	1989	-3.3	1969
July	31.8	15.2	23.5	43.3	1954	3.3	1971
Aug	31.3	14.3	22.8	42.2	1980	2.2	1962
Sept	25.3	8.1	16.7	40.0	1978	-8.3	1984
Oct	18.2	1.3	9.7	34.4	1953	-21.7	1991
Nov	8.9	-5.4	1.8	27.2	1999	-27.8	1959
Dec	3.6	-10.1	-3.3	22.2	1980	-40.0	1989
Year	**16.5**	**1.2**	**8.9**	**43.3**	**Jul-54**	**-40.0**	**Dec-89**

Notes: °C = degrees Celsius
Source: HPRCC 2004

The warmest months are July and August. The mean yearly temperature is 8.9°C (48.0°F).

The temperature extremes for the period of record are also given in **Table 2.5-1**, along with the year of occurrence. These data show that temperatures can exceed 38°C (100°F), and freezing or near-freezing temperatures can occur throughout the year.

Table 2.5-2 lists the mean number of days per month with temperatures above or below selected values. The average date of the last yearly 0°C (32°F) temperature is May 18 while the first fall freeze is expected on September 18. The average growing season is 120 to 130 days long (USDA 1981). These are average values, and the exact occurrence of freezing temperatures depends on exposure.

Table 2.5-2: Temperature Occurrences for Chadron, Nebraska (From 1948 to 2003)

Month	Mean Number of Days with Maximum Temperatures		Mean Number of Days with Minimum Temperatures	
	> 32.2°C	< 0°C	< 0°C	< -17.8°C
January	0.0	11.4	30.1	7.5
February	0.0	7.8	26.7	4.3
March	0.0	4.7	26.2	1.7
April	0.1	0.8	15.4	0.0
May	0.9	0.0	2.9	0.0
June	6.0	0.0	0.1	0.0
July	15.9	0.0	0.0	0.0
August	15.6	0.0	0.0	0.0
September	5.6	0.0	1.9	0.0
October	0.3	0.5	12.4	0.1
November	0.0	4.5	25.6	1.0
December	0.0	9.1	29.6	4.7
Year	**44.3**	**38.7**	**170.8**	**19.3**

Source: HPRCC 2004

2.5.3 Precipitation

Precipitation in the region is generally light, with the heaviest occurrences in the spring and summer. **Table 2.5-3** lists the monthly precipitation totals for the period of record along with the maximum 24-hour precipitation events. May has the heaviest precipitation, with good precipitation occurring through July. The driest months are November through February. The mean yearly precipitation is 40.79 centimeters (cm) (16.06 inches (in)).

The monthly mean and maximum snowfalls for the period of record are listed in **Table 2.5-3**. The mean annual snowfall is 107.44 cm (42.30 in). July and August are the only two months without a reported snowfall. The maximum mean monthly snowfall occurred in March.

Precipitation data from the National Oceanic and Atmospheric Administration (NOAA) was also reviewed. The site in Scottsbluff, Nebraska is 60.9 miles south of the License Area and the site in Rapid City, South Dakota is 98.2 miles north of the License Area. These data indicate that precipitation in excess of 0.03 cm (0.01 in) can be expected on an average of 91 and 96 days per year, respectively. These data are listed in **Table 2.5-4**.

Table 2.5-3: Mean and Maximum Precipitation Data for Chadron, Nebraska (From 1948 to 2003)

Month	Water Equivalent		Snow Fall	
	Mean (cm)	Maximum 24-Hour (cm)	Mean (cm)	Maximum Monthly (cm)
January	1.12	2.72	16.51	88.14
February	1.17	3.81	16.51	59.69
March	2.16	3.51	21.84	88.14
April	4.47	6.22	13.21	49.28
May	7.52	6.50	1.52	23.62
June	7.14	5.38	0.00	3.05
July	5.41	5.08	0.00	0.00
August	3.48	4.62	0.00	0.00
September	3.66	11.18	0.76	25.40
October	2.36	3.81	5.59	28.45
November	1.24	1.78	13.21	42.93
December	1.04	1.80	17.78	46.99
Year	**40.79**	**11.18**	**107.44**	**196.85**

Source: HPRCC 2004

Table 2.5-4: Precipitation Events (1982 - 1990)

Month	Mean Number of Days with Precipitation	
	Scottsbluff, NE	Rapid City SD
January	5.4	5.4
February	5.4	6.2
March	7.3	9.2
April	9.2	8.0
May	12.0	10.8
June	9.2	11.3
July	8.6	8.3
August	8.2	8.6
September	8.0	8.3
October	5.3	6.6
November	6.6	6.2
December	6.2	6.8
Year	91.4	95.7
Period of Record (years)	9	9

Source: NOAA 1993

Tornadoes are rare. In the USNRC, "Draft Generic Environmental Impact Statement on Uranium Milling", (USNRC 1979) the authors calculated a mean annual frequency of 0.6 for tornadoes in intensity Category I at Rapid City. The annual probability of occurrence at this location is 4.8×10^{-4}. A tornado in intensity Category I has a rotational speed of 134 meters per second (m/s) and a translational speed of 26 m/s.

2.5.4 Humidity

Relative percent humidity at the Scottsbluff and Rapid City weather stations is given in **Table 2.5-5**. The humidity at 0500, 1100, 1700, and 2300 hours is listed. Both locations have about the same humidity during the night; but in the early morning, Scottsbluff is slightly more humid. By noon and throughout the afternoon, Scottsbluff becomes less humid than Rapid City. These data indicate that humidity differences are slight and the humidity within the License Area can be expected to be similar to these locations.

Table 2.5-5: Percent Relative Humidity Data (From 1982 - 1990)

Month	0500 Hours		1100 Hours		1700 Hours		2300 Hours	
	NE[a]	SD[b]	NE	SD	NE	SD	NE	SD
January	72.0	67.7	54.3	55.7	53.4	61.0	68.3	67.0
February	75.0	71.0	52.6	54.8	47.6	56.1	70.0	70.0
March	76.0	76.2	50.9	56.3	44.1	54.9	68.4	73.7
April	75.3	70.6	42.9	44.9	39.1	43.2	65.0	65.1
May	80.3	75.4	44.4	49.2	41.2	47.5	68.8	70.8
June	80.0	77.0	43.0	49.8	38.4	46.1	66.8	71.3
July	81.1	72.3	40.7	41.3	35.1	37.8	65.4	62.8
August	82.6	73.4	42.6	41.3	37.2	36.8	69.2	64.7
September	79.5	71.9	42.7	44.1	37.8	42.0	68.0	65.8
October	76.6	69.7	43.4	45.2	40.9	48.2	67.6	66.4
November	76.2	72.3	51.2	54.3	53.9	60.5	71.3	70.9
December	76.1	69.1	57.4	56.6	59.6	63.3	73.4	68.1
Year	77.6	72.2	47.2	49.5	44.0	49.8	68.5	68.1
Period of Record (years)	9	9	9	9	9	9	9	9

Source: NOAA 1993
[a] Scottsbluff, NE
[b] Rapid City, SD

2.5.5 Winds

Figure 2.5-1 and **Figure 2.5-2** are the wind roses for Scottsbluff, Nebraska and Rapid City, South Dakota, respectively. These Figures show predominant wind patterns that are similar; however, the finer details are greatly influenced by the local topography. Rapid City has a predominant wind from the north-northwest while Scottsbluff has a slightly bimodal distribution with the predominant winds from the west-northwest and the east-southeast. The least prevalent wind direction at Scottsbluff and Rapid City is from the southwest.

As shown by the wind rose for the License Area in **Figure 2.5-3**, the predominant air pollutant dispersion would be towards the north to northeast. The next most common directions would be towards the southwest to south-southwest.

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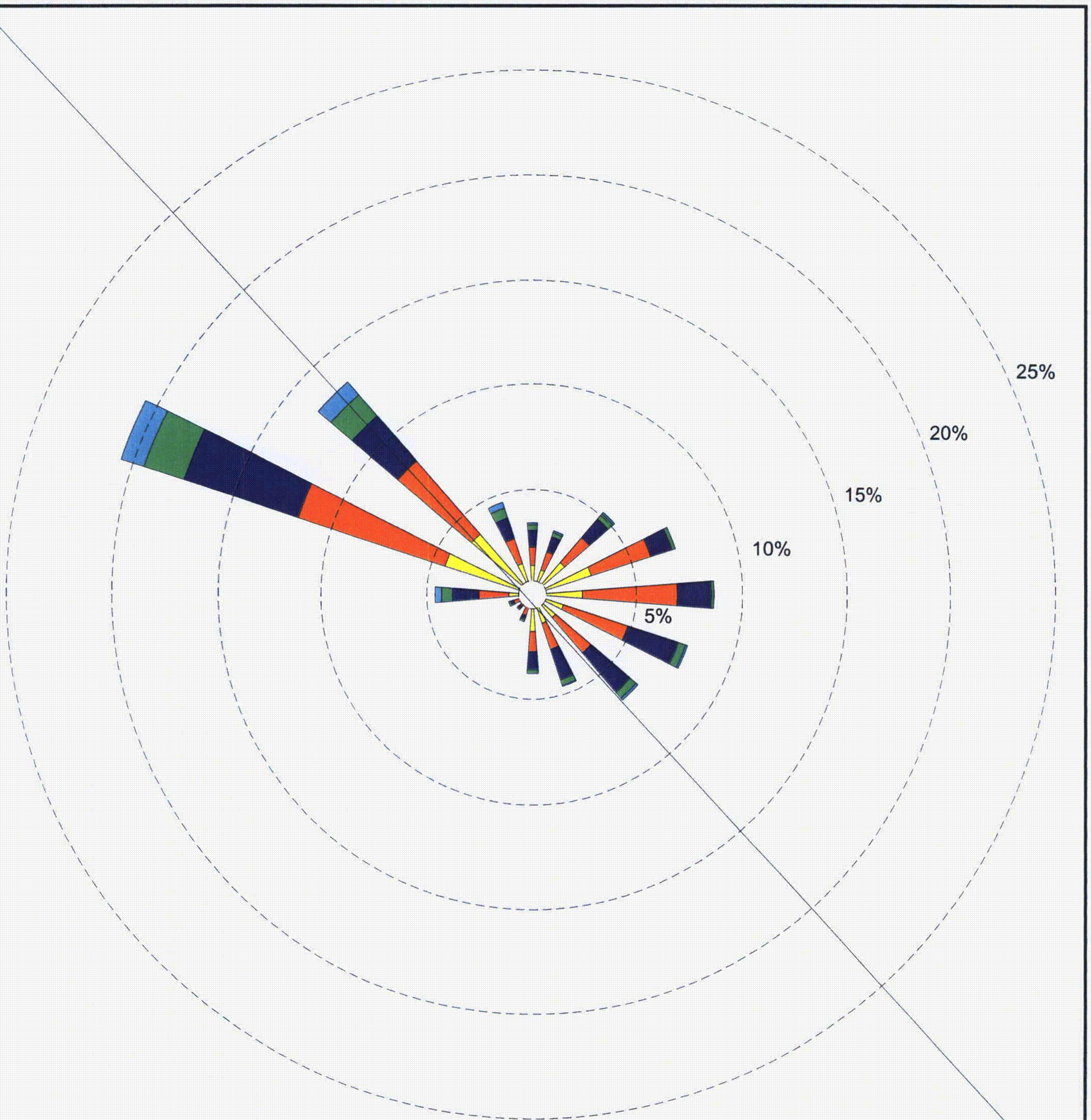


Source: Greystone

Wind Speed (Knots)

- >21
- 17-21
- 11-16
- 7-10
- 4-6
- 1-3

Station: 24028 Scottsbluff, Nebraska

Avg. Wind Speed	9.69	knots
Percent Calm Winds	3.2	percent
Wind Direction	Blowing From	
Years	1984 - 1990	

CROW BUTTE PROJECT

DAWES & SIOUX COUNTIES, NEBRASKA

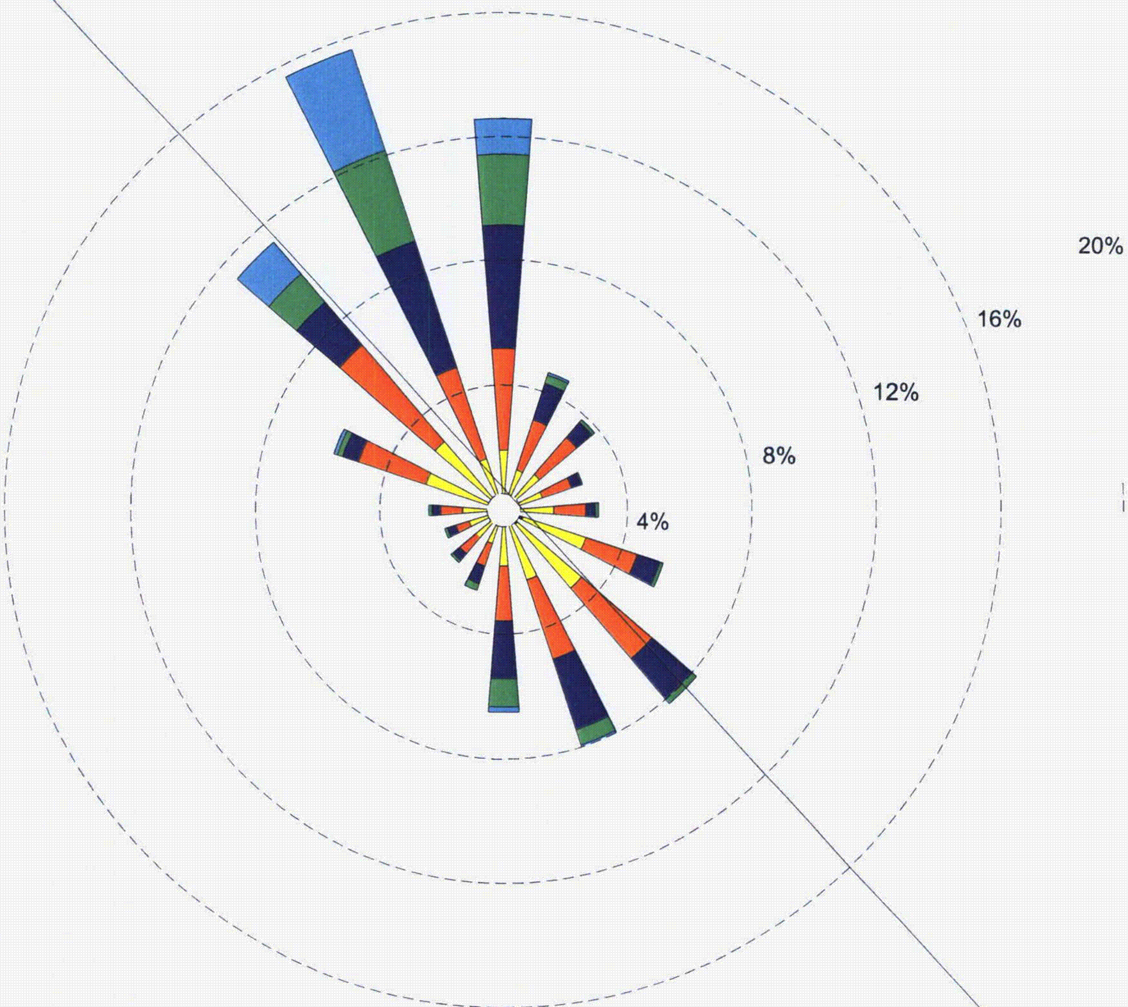
FIGURE 2.5-1
SCOTTSBLUFF SURFACE WINDS

N

NEBRASKA

Date: 06/01/04 | Drawn: ETC | Fig. 2-5-1

1711-04 cb-wind-rose.dwg



Source: Greystone

Wind Speed (Knots)

- >21
- 17-21
- 11-16
- 7-10
- 4-6
- 1-3

Station: 27090 Rapid City, South Dakota		
Avg. Wind Speed	10.49	knots
Percent Calm Winds	2.88	percent
Wind Direction	Blowing From	
Years	1984 - 1990	

CROW BUTTE PROJECT

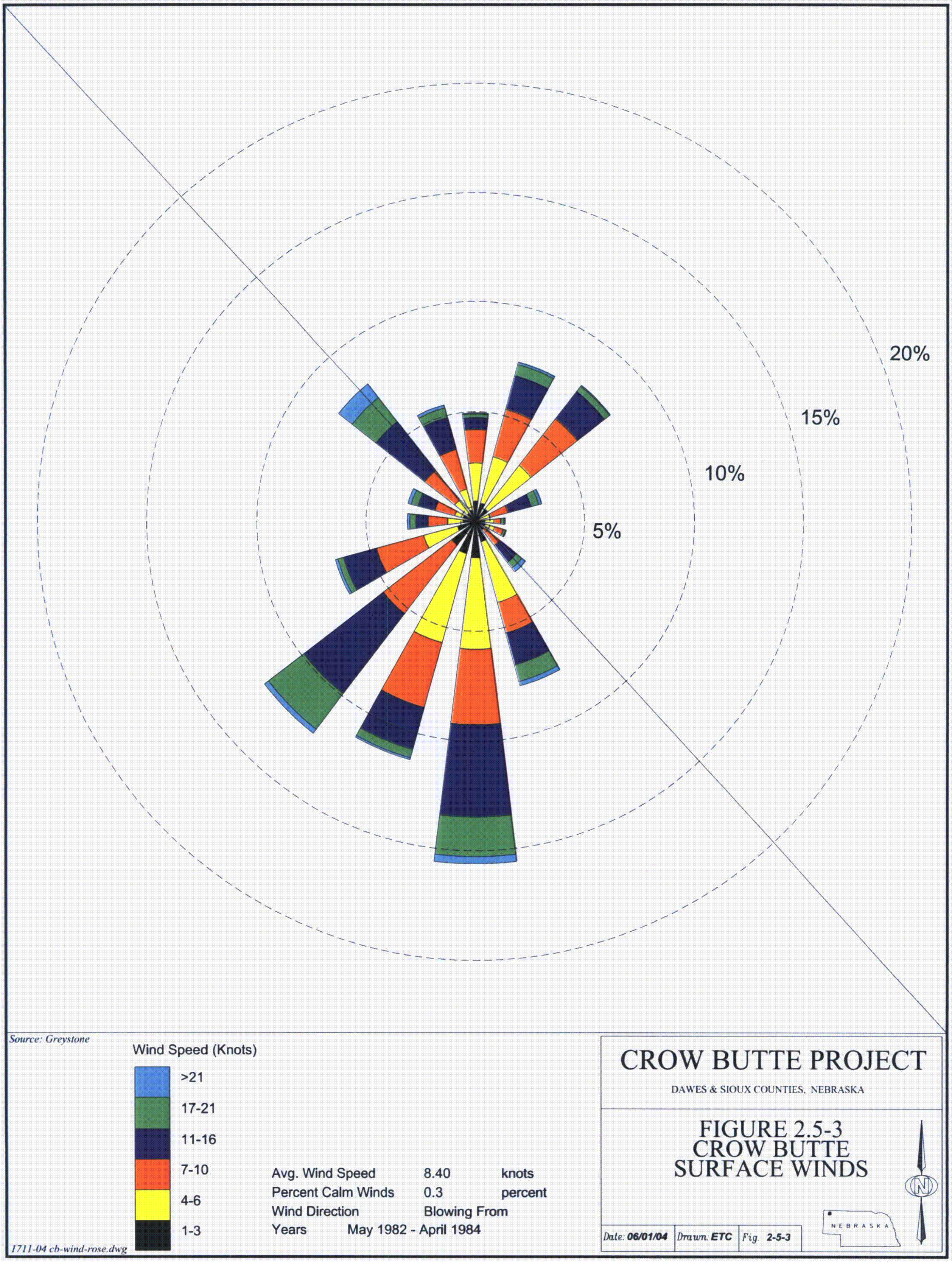
DAWES & SIOUX COUNTIES, NEBRASKA

FIGURE 2.5-2
RAPID CITY SURFACE WINDS

NEBRASKA

Date: 06/01/04 | Drawn: ETC | Fig. 2-5-2

1711-04 cb-wind-rose.dwg



Source: Greystone

CROW BUTTE PROJECT

DAWES & SIOUX COUNTIES, NEBRASKA

FIGURE 2.5-3
CROW BUTTE
SURFACE WINDS

Date: 06/01/04 | Drawn: ETC | Fig. 2-5-3

1711-04 cb-wind-rose.dwg

Local terrain will have a significant influence on the wind patterns in a given area. Because of this, a meteorological station was installed within the License Area. This station was capable of measuring wind speed, direction, and the standard deviation of the wind direction. Joint frequency data was compiled from this information. **Figure 2.5-3** exhibits the wind rose that was identified for the site and **Table 2.5-6** through **Table 2.5-12** shows the frequency of winds by direction and speed for the six stability classes. As shown on **Figure 2.5-3**, the predominant wind direction of the site is from a south-southwest direction approximately 45 percent of the time. Because of the differences among the site, Rapid City, and Scottsbluff, the two-year Crow Butte site wind record is considered the most representative.

Table 2.5-6: Frequency of Winds by Direction and Speed (Stability A)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.98	8.63	2.62	0.11	0.00	0.00	12.34	4.90
NNE	2.61	8.74	2.95	0.11	0.00	0.00	14.31	4.60
NE	1.64	8.52	1.31	0.00	0.00	0.00	11.47	4.50
ENE	0.66	4.37	0.55	0.00	0.00	0.00	5.58	4.40
E	1.20	1.97	0.77	0.00	0.00	0.00	3.94	4.40
ESE	0.33	0.87	0.22	0.00	0.00	0.00	1.42	4.00
SE	0.98	1.75	1.64	0.00	0.00	0.00	4.37	5.10
SSE	0.44	2.61	1.64	0.11	0.00	0.00	4.70	5.30
S	0.98	3.72	1.53	0.00	0.00	0.00	6.23	5.00
SSW	0.55	1.97	2.08	0.22	0.00	0.00	4.82	6.00
SW	0.77	3.72	1.53	0.00	0.00	0.00	6.02	5.00
WSW	0.66	2.08	1.53	0.00	0.00	0.00	4.27	5.30
W	0.66	1.75	1.75	0.11	0.00	0.00	4.27	5.50
WNW	0.77	1.42	0.98	0.44	0.00	0.00	3.61	5.70
NW	0.66	2.30	1.53	0.11	0.00	0.00	4.60	5.50
NNW	1.53	3.93	1.86	0.44	0.00	0.00	7.76	5.30
ALL	**15.32**	**58.25**	**24.49**	**1.65**	**0.00**	**0.00**	**99.71**	**5.00**

Stability Class A
Data Recorded between May 1982 and April 1984
Crow Butte Project Site, Nebraska
Calm (less than one knot) = 0.3 %
Period mean wind speed = 5.0 knots
Percent occurrence for A stability class=5.6%

Precipitation was also recorded at the station with a heated tipping bucket rain gauge. Evaporation was measured using a 48-inch evaporation pan and an evaporation gauge with analog output. The air temperature was also recorded using a precision linear thermistor and fan-aspirated radiation shield. All of the information was recorded on strip chart recorders. In addition, the information was run through a microprocessor and recorded on magnetic tape. The information from the tape was transferred to a computer and then verified by comparison from the strip charts and from visual observation records.

Table 2.5-7: Frequency of Winds by Direction and Speed (Stability B)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	1.01	2.68	5.53	0.67	0.00	0.00	9.89	6.40
NNE	1.34	3.52	3.77	0.34	0.00	0.00	8.97	5.70
NE	0.92	5.28	5.45	0.50	0.00	0.00	12.15	6.00
ENE	0.84	1.76	2.85	0.25	0.00	0.00	5.70	6.00
E	0.17	0.84	0.75	0.08	0.00	0.00	1.84	6.00
ESE	0.59	0.59	1.09	0.00	0.00	0.00	2.27	5.80
SE	0.08	1.26	2.26	0.25	0.00	0.00	3.85	6.90
SSE	0.67	1.17	2.43	0.50	0.00	0.00	4.77	6.50
S	1.09	1.01	4.02	0.92	0.00	0.00	7.04	7.00
SSW	1.01	2.01	2.26	0.75	0.00	0.00	6.03	6.30
SW	0.92	3.19	2.61	0.59	0.00	0.00	7.21	6.10
WSW	0.59	2.01	2.60	0.84	0.08	0.00	6.12	6.90
W	0.42	1.34	2.35	0.42	0.08	0.00	4.61	7.20
WNW	0.67	1.09	2.10	0.34	0.00	0.00	4.20	6.60
NW	0.25	1.09	4.02	1.09	0.08	0.00	6.53	7.80
NNW	0.42	1.51	4.95	1.68	0.08	0.00	8.64	7.80
ALL	**10.99**	**30.35**	**48.94**	**9.22**	**0.32**	**0.00**	**99.82**	**6.60**

Stability Class B
Data Recorded between May 1982 and April 1984
Crow Butte Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 6.5 knots
Percent occurrence for B stability class = 7.4%

Table 2.5-8: Frequency of Winds by Direction and Speed (Stability C)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.74	1.54	2.68	0.74	0.00	0.00	5.70	6.70
NNE	0.63	2.62	2.90	0.85	0.00	0.00	7.00	6.60
NE	0.91	2.28	5.69	1.20	0.00	0.00	10.08	7.00
ENE	0.46	1.03	2.96	0.97	0.00	0.00	5.42	7.30
E	0.00	0.57	0.74	0.28	0.00	0.00	1.59	7.60
ESE	0.23	0.34	0.91	0.23	0.00	0.00	1.71	7.00
SE	0.17	0.68	1.82	0.74	0.00	0.00	3.41	7.70
SSE	0.46	0.74	2.22	1.48	0.00	0.00	4.90	8.00
S	0.97	1.65	5.30	2.28	0.00	0.00	10.20	7.70
SSW	1.14	3.02	3.93	0.97	0.00	0.00	9.06	6.60
SW	1.03	3.36	4.67	1.14	0.11	0.00	10.31	6.80
WSW	0.97	3.02	3.59	1.14	0.06	0.06	8.84	6.80
W	0.11	0.91	1.99	1.03	0.11	0.00	4.15	8.40

Table 2.5-8: Frequency of Winds by Direction and Speed (Stability C)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
WNW	0.17	0.51	1.03	1.25	0.06	0.00	3.02	9.10
NW	0.40	0.74	3.70	2.22	0.06	0.00	7.12	8.70
NNW	0.40	1.42	3.42	2.11	0.00	0.00	7.35	8.20
ALL	**8.79**	**24.43**	**47.55**	**18.63**	**0.40**	**0.06**	**99.86**	**7.40**

Stability Class C
Data Recorded between May 1982 and April 1984
Crow Butte Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 7.4 knots
Percent occurrence for C stability class = 10.8%

Table 2.5-9: Frequency of Winds by Direction and Speed (Stability D)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.17	0.52	1.14	0.83	0.20	0.02	2.88	9.20
NNE	0.16	1.12	2.34	2.90	0.89	0.19	7.60	10.70
NE	0.13	1.53	2.65	2.72	0.46	0.08	7.47	9.80
ENE	0.04	0.47	0.79	0.50	0.06	0.00	1.86	8.30
E	0.02	0.06	0.28	0.22	0.04	0.00	0.62	9.50
ESE	0.01	0.25	0.35	0.13	0.00	0.00	0.74	7.40
SE	0.06	0.42	0.71	0.52	0.18	0.01	1.90	9.50
SSE	0.13	1.78	1.50	2.60	1.21	0.34	7.56	11.10
S	0.34	1.67	3.58	7.77	3.57	0.58	17.51	12.40
SSW	0.22	1.37	3.82	3.60	0.76	0.12	9.89	10.00
SW	0.17	2.11	5.80	3.80	0.29	0.02	12.19	8.80
WSW	0.17	0.61	2.28	2.74	0.54	0.16	6.50	10.70
W	0.10	0.20	0.64	1.03	0.47	0.19	2.63	12.60
WNW	0.05	0.17	0.91	1.39	0.66	0.28	3.46	13.20
NW	0.05	0.31	1.60	5.13	2.68	1.55	11.32	15.00
NNW	0.04	0.49	1.80	2.34	0.90	0.20	5.77	11.90
ALL	**1.86**	**13.08**	**30.09**	**38.22**	**12.91**	**3.74**	**99.90**	**11.20**

Stability Class D
Data Recorded between May 1982 and April 1984
Crow Butte Project Site, Nebraska
Calm (less than one knot) = 0.1%
Period mean wind speed = 11.2 knots
Percent occurrence for D stability class = 51.3%

Table 2.5-10: Frequency of Winds by Direction and Speed (Stability E)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.85	2.92	0.65	0.04	0.00	0.00	4.46	4.60
NNE	0.97	2.80	1.82	0.00	0.00	0.00	5.59	5.20
NE	0.97	3.32	1.90	0.08	0.00	0.00	6.27	5.10
ENE	0.45	1.26	0.73	0.00	0.00	0.00	2.44	5.10
E	0.16	0.73	0.20	0.00	0.00	0.00	1.09	4.70
ESE	0.28	0.65	0.45	0.00	0.00	0.00	1.38	4.80
SE	0.49	1.82	0.85	0.12	0.00	0.00	3.28	5.10
SSE	1.70	7.62	1.05	0.08	0.00	0.00	10.45	4.40
S	2.23	11.06	4.34	0.16	0.00	0.00	17.79	5.00
SSW	2.11	10.53	2.80	0.04	0.00	0.00	15.48	4.70
SW	1.78	8.18	5.67	0.12	0.04	0.00	15.79	5.50
WSW	1.05	2.88	2.47	0.04	0.00	0.00	6.44	5.40
W	0.65	0.97	0.36	0.04	0.00	0.00	2.02	4.30
WNW	0.36	0.97	0.81	0.00	0.00	0.00	2.14	5.50
NW	0.45	1.18	0.85	0.20	0.00	0.00	2.68	5.70
NNW	0.61	1.34	0.49	0.00	0.00	0.00	2.44	4.50
ALL	**15.11**	**58.23**	**25.44**	**0.92**	**0.04**	**0.00**	**99.74**	**5.00**

Stability Class E
Data Recorded between May 1982 and April 1984
Crow Butte Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 5.0 knots
Percent occurrence for E stability class = 15.2%

Table 2.5-11: Frequency of Winds by Direction and Speed (Stability F)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	3.30	1.65	0.00	0.00	0.00	0.00	4.95	2.80
NNE	1.65	1.33	0.00	0.00	0.00	0.00	2.98	3.00
NE	0.95	1.40	0.00	0.00	0.00	0.00	2.35	3.10
ENE	1.40	0.76	0.00	0.00	0.00	0.00	2.16	2.80
E	1.27	0.44	0.00	0.00	0.00	0.00	1.71	2.80
ESE	1.78	1.02	0.00	0.00	0.00	0.00	2.80	2.60
SE	1.72	1.78	0.00	0.00	0.00	0.00	3.50	3.00
SSE	3.75	4.76	0.00	0.00	0.00	0.00	8.51	3.10
S	7.50	12.07	0.00	0.00	0.00	0.00	19.57	3.30
SSW	7.24	13.15	0.00	0.00	0.00	0.00	20.39	3.30
SW	6.48	8.01	0.00	0.00	0.00	0.00	14.49	3.20
WSW	2.73	2.60	0.00	0.00	0.00	0.00	5.33	3.00

Table 2.5-11: Frequency of Winds by Direction and Speed (Stability F)

Wind Direction	Speed Class Intervals (Knots) 1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
W	1.78	1.46	0.00	0.00	0.00	0.00	3.24	2.90
WNW	0.83	0.95	0.00	0.00	0.00	0.00	1.78	3.00
NW	1.33	1.21	0.00	0.00	0.00	0.00	2.64	3.00
NNW	1.33	0.51	0.00	0.00	0.00	0.00	1.84	2.60
ALL	**45.04**	**53.10**	**0.00**	**0.00**	**0.00**	**0.00**	**98.14**	**3.10**

Stability Class F
Data Recorded between May 1982 and April 1984
Crow Butte Project Site, Nebraska
Calm (less than one knot) = 1.8%
Period mean wind speed = 3.1 knots
Percent occurrence for F stability class = 9.7%

Table 2.5-12: Frequency of Winds by Direction and Speed (All Stabilities)

Wind Direction	Speed Class Intervals (Knots) 1 – 3	3 – 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.75	1.72	1.53	0.57	0.10	0.01	4.68	6.50
NNE	0.70	2.16	2.24	1.61	0.46	0.10	7.27	8.20
NE	0.57	2.64	2.69	1.57	0.23	0.04	7.64	7.70
ENE	0.37	0.99	1.08	0.38	0.03	0.00	2.85	6.50
E	0.24	0.42	0.35	0.15	0.02	0.00	1.18	6.20
ESE	0.31	0.46	0.44	0.09	0.00	0.00	1.30	5.50
SE	0.35	0.93	0.95	0.38	0.09	0.01	2.71	7.00
SSE	0.81	2.84	1.44	1.55	0.62	0.17	7.43	8.20
S	1.48	4.17	3.45	4.33	1.83	0.30	15.56	9.30
SSW	1.36	4.17	3.09	2.03	0.39	0.06	11.10	7.20
SW	1.21	3.91	4.62	2.13	0.17	0.01	12.05	7.10
WSW	0.70	1.60	2.21	1.60	0.29	0.09	6.49	8.20
W	0.40	0.69	0.87	0.68	0.26	0.10	3.00	8.90
WNW	0.27	0.54	0.91	0.90	0.35	0.14	3.11	10.20
NW	0.32	0.75	1.73	2.99	1.39	0.79	7.97	12.80
NNW	0.40	0.99	1.84	1.58	0.47	0.10	5.38	9.50
ALL	**10.24**	**28.88**	**29.44**	**22.64**	**6.70**	**1.92**	**99.72**	**8.40**

Stability Class All
Data Recorded between May 1982 and April 1984
Crow Butte Project Site, Nebraska
Calm (less than one knot) = 0.3%
Period mean wind speed = 8.4 knots
Percent occurrence for A stability class = 100.0%

2.5.6 Air Quality

Although there are no ambient air quality monitoring data for non-radiological pollutants within the License Area, PM10[1] concentrations have been measured in Rapid City, South Dakota and Badlands National Park in South Dakota. Both locations are geographically similar to the License Area.

The Rapid City data were collected at the National Guard Camp Armory site about 2 mile west of the city. This area is classified as suburban. The Badlands data were collected in an area classified as rural. Because of the degree of urbanization, the air quality at the License Area would probably fall somewhere between the air quality at these two locations. These data were obtained from the United States Environmental Protection Agency (USEPA) air quality monitoring database (USEPA 2007), and are presented in **Table 2.5-13**.

Table 2.5-13: PM_{10} Monitoring Summary (micrograms per cubic meter)

	Maximum 24-hr Average		Annual Average	
Year	Black Hills, SD	Rapid City, SD	Black Hills, SD	Rapid City, SD
1998	NA	87.4	NA	30.7
1999	NA	116.9	NA	28.2
2000	38.5	97.4	12.0	31.3
2001	47.9	81.5	12.6	34.6
2002	26.0	104.7	9.9	34.9
2003	74.4	91.8	16.3	36.2
2004	24.0	72.0	10.0	30.0
2005	40.0	94.00	9.0	27.0
2006	30.0	124.0	10.0	29.0

Notes: NA = Not Available

The National Ambient Air Quality Standards (NAAQS) for PM_{10} are 150 micrograms per cubic meter (24-hour average), and 50 micrograms per cubic meter (annual average). All counties within the 80-km radius or the project are in attainment of NAAQS.

2.5.7 Noise

Noise standards and sound measurement equipment have been designed to account for the sensitivity of human hearing to different frequencies. This varying sensitivity is accommodated by applying "A-Weighted" correction factors. This correction de-emphasizes the very low and very high frequencies of sound in a manner similar to the response of the human ear. The primary assumption is that the A-weighted decibel (dBA) is a good correlation to a human's subjective reaction to noise. In general, a residential area at night is 40 dBA; a residential area during the day is 50 dBA; a rural

[1] Particulate matter with a diameter less than or equal to 10 microns.

area during the day is 40 dBA and a typical construction site is 80 dBA (USEPA 1974). As a comparison, a normal conversation at 5 feet is 60 dBA (USEPA 1974).

The nearest noise receptor (residence) to the License Area is on State Highway (SH) 2/71 along the eastern License Area boundary. This residence is located approximately 0.5 mile from the satellite plant. The next closet residence is located along the southern License Area boundary at a distance of approximately 1.5 miles south of the satellite plant.

According to Sandy Seidel, Crawford City Clerk, the City of Crawford does not have a noise ordinance. A review of the City of Crawford Municipal Code revealed a noise ordinance related to industrial equipment. Section 2-103, Excessive Noise Control (Crawford 2007) reports that it is "unlawful to operate industrial equipment, heavy machinery, jack hammer and other industrial equipment emitting loud noise or to race automobile engines within the City between the hours of 8:00 P.M. and 7:00 A.M., in such a manner so as to disturb the .... peace .... unless such activity has been approved in advance by the City Council." Construction activities associated with the License Area would be conducted outside of the City of Crawford limits. The Dawes County Clerk's office did not know of a noise ordinance for Dawes County.

The License Area is bounded on the west by the Burlington Northern Santa Fe (BNSF) rail line and on the east by Nebraska SH 2/71. Therefore, the existing ambient noise in the vicinity of the License Area is dominated by the traffic noise from SH 2/71 and trains on the BNSF rail line.

The State of Nebraska, Department of Roads, reports that the annual 24-hour average number of total vehicles to travel SH 2/71 along the eastern project boundary in 2004 was 965 (Nebraska 2007a). Thirty-five of these vehicles were reported to be heavy commercial vehicles. **Table 2.5-14** (USDOT 1995) presents typical noise levels for automobiles at a distance of 15 meters (45 feet) at speeds ranging from 50-miles per hour (mph) to 70 mph.

Table 2.5-14: Typical Automobile Noise Levels

Speed (mph)	Noise Level at 45 Feet (dBA)
50	62
55	64
60	65
65	66.5
70	68

Traffic noise is a combination of traffic density and vehicle speed. According to the Nebraska Department of Roads (NDOR), the speed limit along SH 2/71 near the License Area is 60 miles per hour (NDOR 2007). The closest noise receptor (residence) to SH 2/71 is located adjacent to the road. Therefore, the existing noise level at that receptor due to existing traffic noise alone would be expected to be 65 dBA.

The precise noise levels caused by trains is a complex calculation that considers the train speed, the train length, the conditions of the wheels, and the condition of the track (Harris 1991). Noise from trains has been measured (Harris 1991) to range from 87 to 96 dBA at 100 feet from a track. The BNSF rail line runs through the town of Crawford. Assuming that a resident may live as close as 100 feet from the track, the existing noise for that receptor would be expected to be at least 87 dBA due to train noise alone.

The propagation of noise depends on many factors including atmospheric conditions, ground cover, and the presence of any natural or man-made barriers. As a general rule, noise decreases by approximately 6 dBA with every doubling of the distance from the source (Bell 1982). Therefore, noise levels at various distances can be predicted. The closest noise receptor, residence along SH 2/71, is located approximately 1.2 miles east of the BNSF. Using the doubling rule, the train noise at the residence would be 51 dBA, assuming a distance of 6400 feet. Because the effect of multiple noise sources is not a simple addition, but rather is a logarithmic addition, the existing noise levels at the closest receptor, based on noise from highway traffic and the BNSF, is likely to be 65 dBA or greater.

2.5.8 References

Bell, Lewis H. 1982. *Industrial Noise Control: Fundamentals and Applications*, New York, M. Dekker 1982. 91 Pages.

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2.6 GEOLOGY SOILS AND SEISMOLOGY

This section describes the regional and local geology and seismology related to the current License Area and CSA. In this regard, discussion of the geology of the License Area and CSA, in particular, has been presented in previous reports (WFC 1983; Ferret Exploration of Nebraska 1987). Information contained in these reports include 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. These data, in addition to new information from exploratory drilling/logging activities within the License Area, are used to describe the geology and seismology in this section.

2.6.1 Regional Setting

The Crow Butte Project is in Dawes County in northwestern Nebraska. Crawford is the principal town in the area and lies approximately 4 miles northwest of the proposed plant site. Crawford is 25 miles west of Chadron 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 (**Figure 2.6-1**). The topography consists of low rolling hills dominated by the Pine Ridge south and west of the project area.

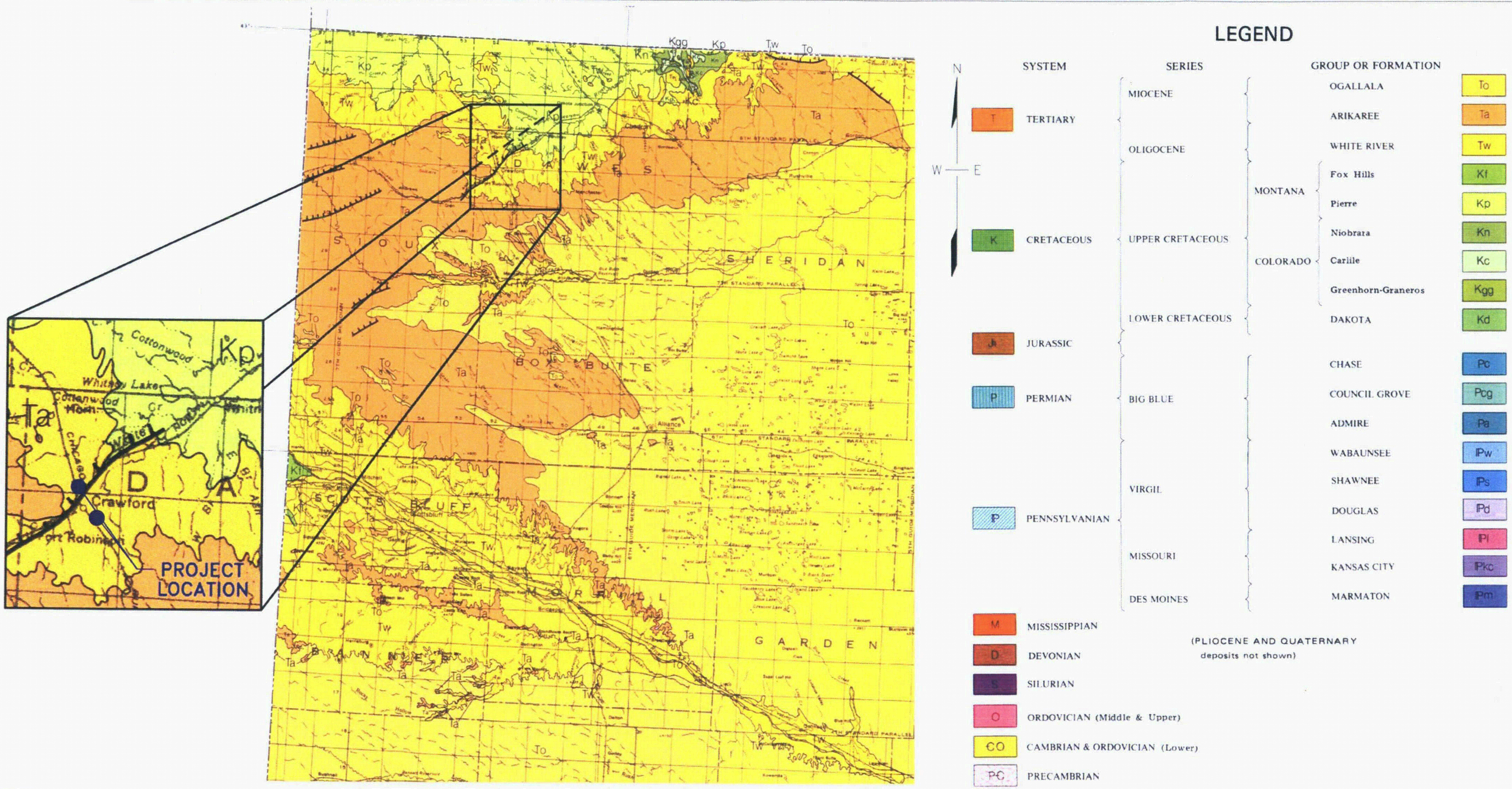
2.6.1.1 General Stratigraphy

Sedimentary strata ranging from late Cretaceous through Tertiary are exposed throughout northwest Nebraska. Pleistocene alluvial-colluvial material is abundant along the north slope of the Pine Ridge. **Table 2.6-1** is a generalized stratigraphic chart for the region.

2.6.1.2 Pre-Pierre Shale Stratigraphy

Formations older than the Cretaceous Pierre Shale are listed on the general stratigraphic chart (**Table 2.6-1**). 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.

The principal water bearing rocks below the Pierre Shale are the G Sand, J Sand, and the Dakota, Morrison and Sundance Formations. The Total Dissolved Solids (TDS) of the water below the Pierre Shale has been interpreted from deep oil and gas exploration logs. The Dakota Sandstone is at a depth of 2972 to 3020 feet in the Bunch No. 1 hole (Section 5, T31N, R51W). The minimum TDS of the water in the Dakota Sandstone calculated from the spontaneous potential and sonic logs is estimated to range from 14,000 to 26,000 ppm.



Source: Nebraska Geological Survey

CROW BUTTE RESOURCES, INC.

FIGURE 2.6-1
BEDROCK GEOLOGY MAP, DAWES COUNTY

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

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Table 2.6-1: General Stratigraphic Chart for Northwest Nebraska

System	Series	Formation or Group	Rock Types	Thickness (feet)
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/	Ls, Sh	130
		Cherokee		
	Atoka	Upper/Lower	Ls, Sh	200
Mississippian	Lower	Lower	Ls, Sh	30
Pre-Cambrian			Granite	

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

2.6.1.3 Pierre Shale

The Pierre Shale of Cretaceous age is the oldest formation of interest for the Crow Butte project since it is the lower confining formation for the uranium mineralization. All company test holes are terminated as soon as the Pierre Shale is intersected. The Pierre is a widespread dark gray to black marine shale, with relatively uniform composition throughout. The Pierre outcrops extensively in Dawes and Sioux Counties along the South Dakota boundary north of the area of review.

The Pierre is essentially impermeable. In areas of outcropping Pierre, water for domestic and agricultural needs is piped in from wells from other formations. A number of shallow wells are reported as having the Pierre Shale as the bedrock unit (Spalding, 1982) in Township 32 North, Range 51-52 West. These wells range in depth from 18 to 100 feet with an average depth of 44 feet. These wells are in an area with considerable alluvium along Sand Creek, Cottonwood Creek, Spring Creek, and the White River between Crawford and Whitney Lake. These wells are probably producing water from a few tens of feet of Quaternary alluvium overlying the Pierre Shale. The bottom few tens of feet in those wells provide storage. It is recognized in this report that (Spalding, 1982, p.18) "In very shallow wells (a few tens of feet) significant amounts of water utilized may be contained in the thin Quaternary sediments overlying the designated hydrogeologic unit. This situation is particularly true for those wells noted as completed in the Pierre Shale". In the geologic summary of the Spalding report the groundwater potential of the Pierre Shale is discussed by Marvin Carlson on page 14, "The oldest bedrock unit in the area, the Pierre Shale of Cretaceous Age, is not considered as a potential aquifer. It is, however, included in the discussion of completion horizons and hydrogeologic units. A few of the shallow wells produce from the Quaternary sediments immediately overlying the Pierre Shale".

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. Aerial exposure and subsequent erosion greatly reduced the vertical thicknesses of the Pierre prior to Oligocene 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 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, p.24) and is readily observed in certain outcrop exposures.

2.6.1.4 White River Group

The White River Group is Oligocene in age and consists of the Chadron and Brule Formations. The White River Group outcrops as a band at the base of the Pine Ridge in northwest Nebraska.

2.6.1.5 Chadron Formation

The Chadron is the oldest Tertiary Formation in northwest Nebraska. The Chadron lies with marked regional unconformity on top of the Pierre Shale. The Chadron Formation frequently has a sandstone and conglomerate at the base with overlying siltstone, mudstone, and claystone that is typically green hued (Singler and Picard 1980). Ash beds and limestone lenses have also been recognized. Occasionally the lower portion of the Chadron Sandstone is a very coarse, very poorly sorted conglomerate. Where present the conglomerate consists of well rounded, predominantly quartz and chalcedony cobbles ranging up to 6 inches across. Regionally, the vertical thickness of the Chadron Formation varies greatly. On outcrop the Chadron Formation has been noted to vary 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). These differences are attributed to the variable thickness of the Chadron Sandstone.

The 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 (approximately 36 to 40 million years before present) (Swinehart et al. 1985). Regionally, the Chadron Sandstone thickness has been estimated in company drill holes to range from 0 to 350 feet.

The upper part of the Chadron represents a distinct and rapid facies change from the underlying sandstone. The Chadron above the sandstone unit 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.

2.6.1.6 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). The Brule had previously been subdivided into two separate members, the Orella and the Whitney (Schultz and Stout 1938). More recently, the maximum thickness of the Brule Formation has been described as 1150 feet. This is due to the inclusion of the newly recognized 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).

The Whitney Member of the Brule is comprised of fairly massive buff to brown siltstones, dominantly 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.

Recently, 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.

Arikaree Group

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

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, p.50).

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, p. 53.).

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, p.55).

Ogallala Group

The Miocene Ogallala Group overlies the Arikaree Group and is the outcropping unit south of the Pine Ridge. The Ogallala Group rocks are primarily sandstone and are coarser grained, more poorly sorted and contain only small amounts of volcanic material as compared to the underlying Arikaree Group rocks (Souders 1981). Some siltstone and mudstone is complexly 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.

2.6.1.7 Regional Structure

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 2.6-1), 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, p.18). The Crow Butte 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 that is about 50 miles long in an east-west direction and about 25-30 miles wide at Crawford.

The geologic map of northwest Nebraska reproduced from the State Geologic Map, Figure 2.6-1, illustrates the recognized faulting in northwest Nebraska. Six northeast trending faults are present in Sioux and Dawes Counties. 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 discovered 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 Bordeaux Fault, Pine Ridge Fault, and Toadstool Park Fault were proposed by DeGraw (1969) but have not been included 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). Other smaller faults may be present.

The Cochran Arch was also proposed by DeGraw (1969, p.36) 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 Area of Review (**Figure 2.6-2**) (Collings and Knode 1984). The Inner Crawford Basin is characterized by an increase in the thickness of the Chadron Sandstone.

2.6.2 Crow Butte License Area Geology

An Area of Review Stratigraphic Column for the Crow Butte License Area has been prepared and is shown as **Figure 2.6-2**. The stratigraphic nomenclature of Swinehart, et al (1985) and Crow Butte Resources are shown on the column.

A series of seven east-west cross sections have been constructed through the proposed wellfield area and the Area of Review to demonstrate the geology of the Basal Chadron Sandstone and its relationship to the confining horizons (**Figure 2.6-3** to **Figure 2.6-10**). One northwest-southeast cross section is included to show the continuity of the geology (**Figure 2.6-11**). Reduced electric geophysical logs from representative CBR exploration holes were used in the cross sections. These logs consist of two curves, single point resistance on the right and either neutron-neutron or spontaneous potential on the left. The Pierre Shale, Chadron Formation, Brule Formation, and Arikaree Group, if present, are subdivided on these cross sections based on log characteristics that are the most important consideration in a solution mining project. These sections demonstrate the continuity of the Chadron Sandstone and the excellent confinement provided by the overlying Chadron and Brule Formations and the underlying Pierre Shale (**Figure 2.6-3** to **Figure 2.6-10**).

2.6.2.1 Pierre Shale - Lower Confinement

The Pierre Shale is a black marine shale and is the oldest formation encountered in any CBR test holes within the Area of Review (**Figure 2.6-1** to **Figure 2.6-9**). The Pierre Shale is the confining bed below the Chadron Sandstone that is the host for uranium mineralization (**Figure 2.6-1** to **Figure 2.6-9**). The description provided under General Stratigraphy also describes the Pierre Shale within the Area of Review.

The ancient soil horizon known as the Interior Paleosol has been scoured away by the overlying Chadron Sandstone throughout most of the Area of Review.

Figure 2.6-2: Area of Review, Stratigraphic Column

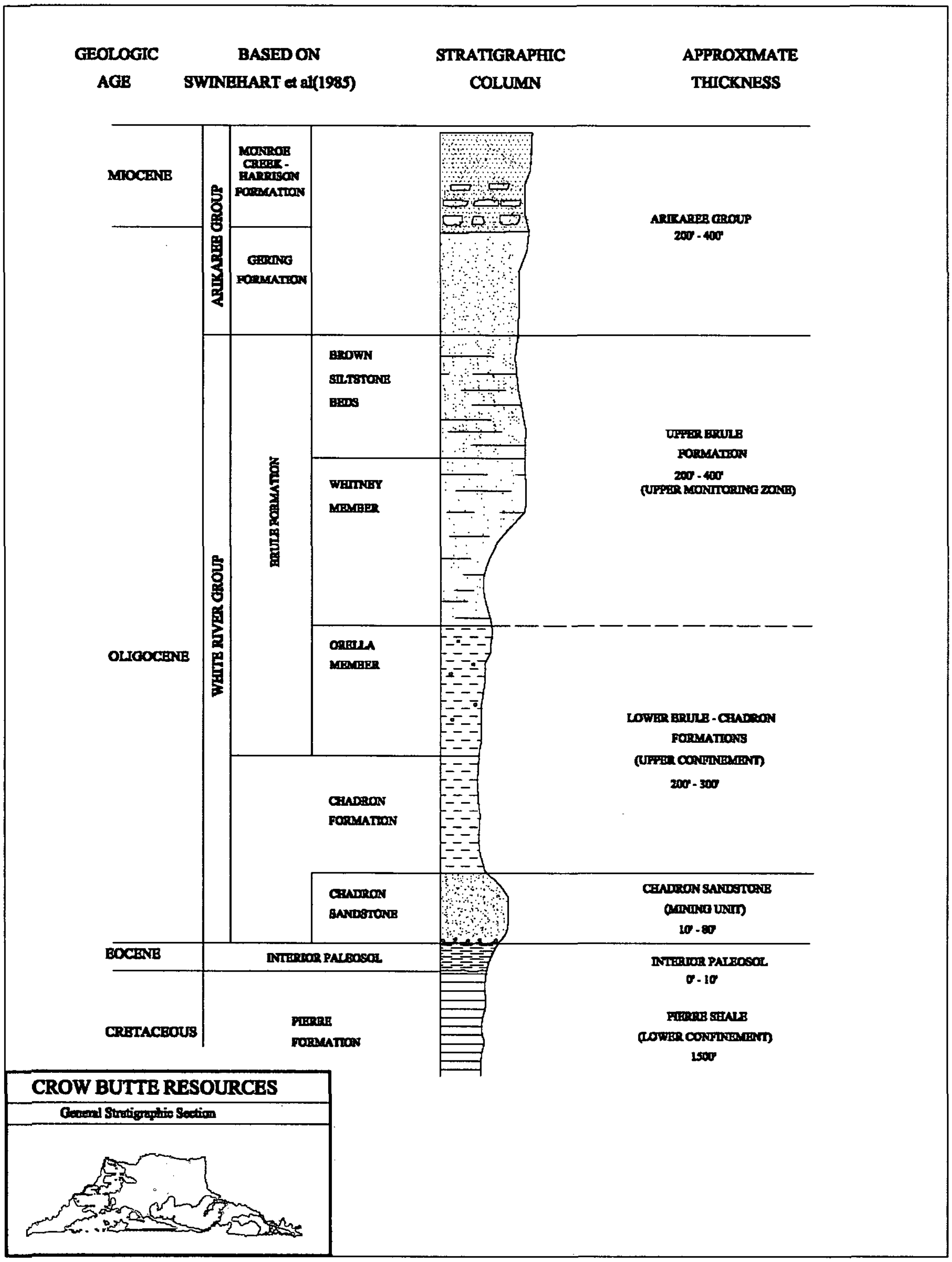


Figure 2.6-3: Cross Section Location

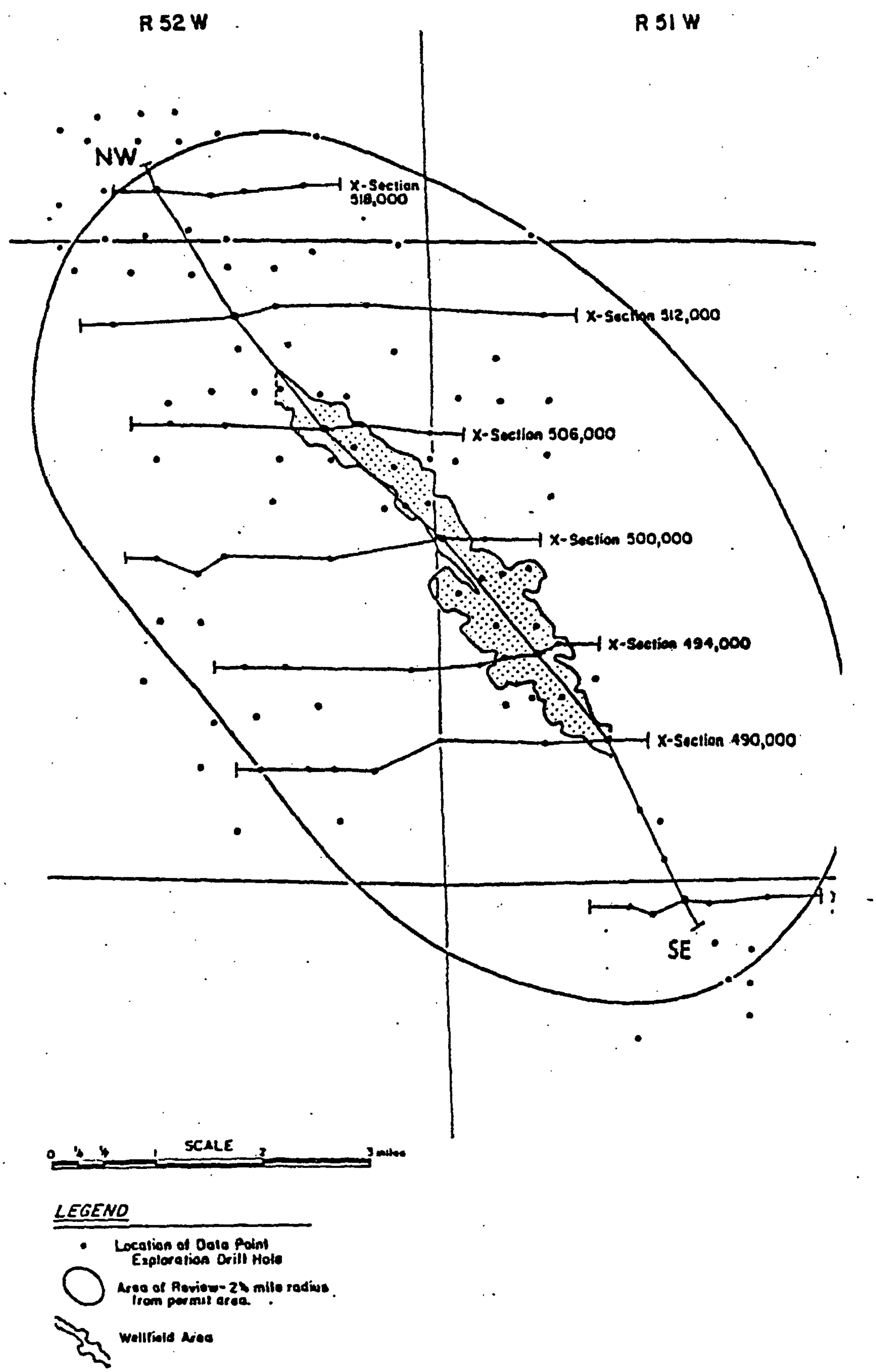


Figure 2.6-4: Cross Section 518,000 E-W

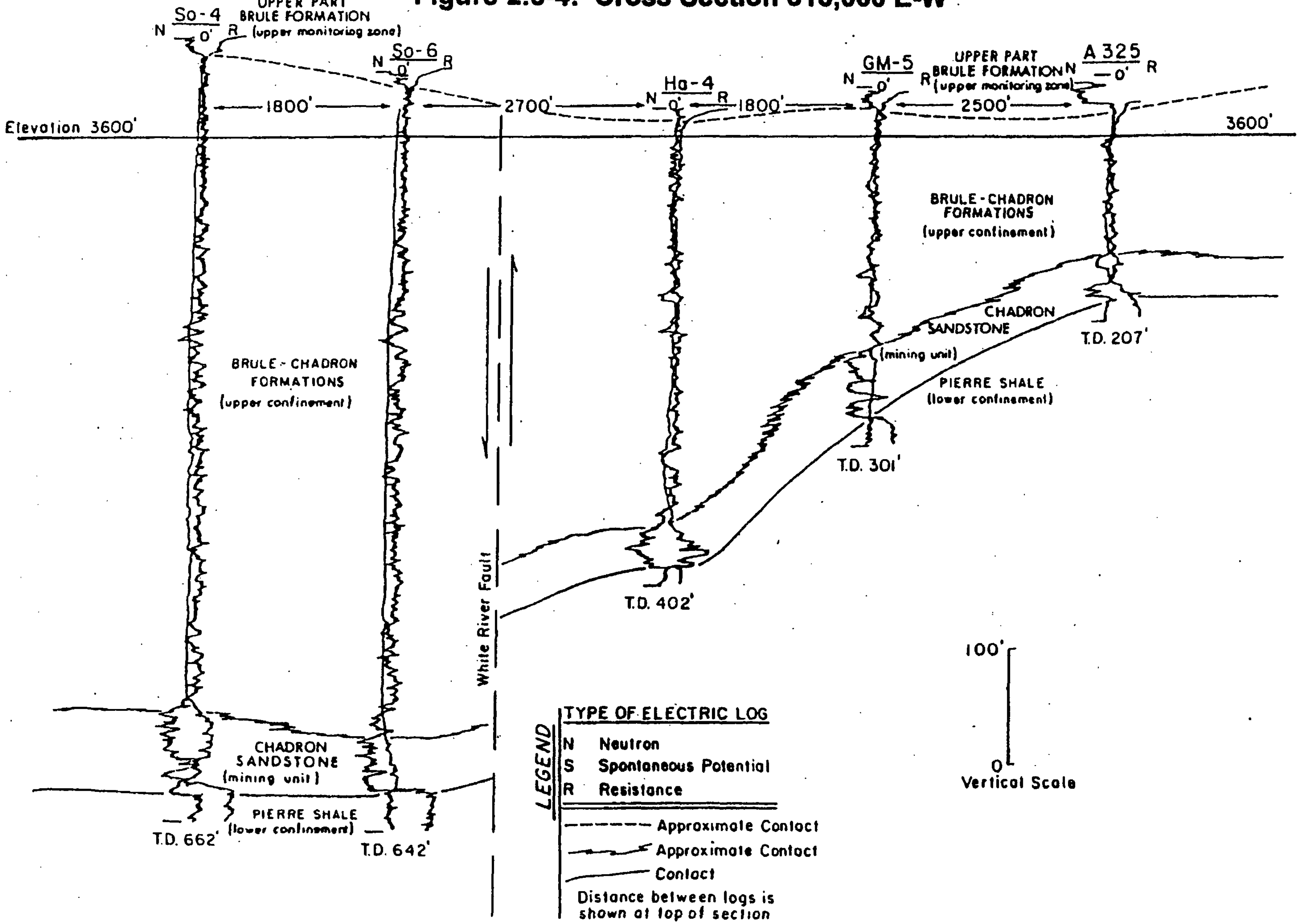


Figure 2.6-5: Cross Section 512,000 E-W

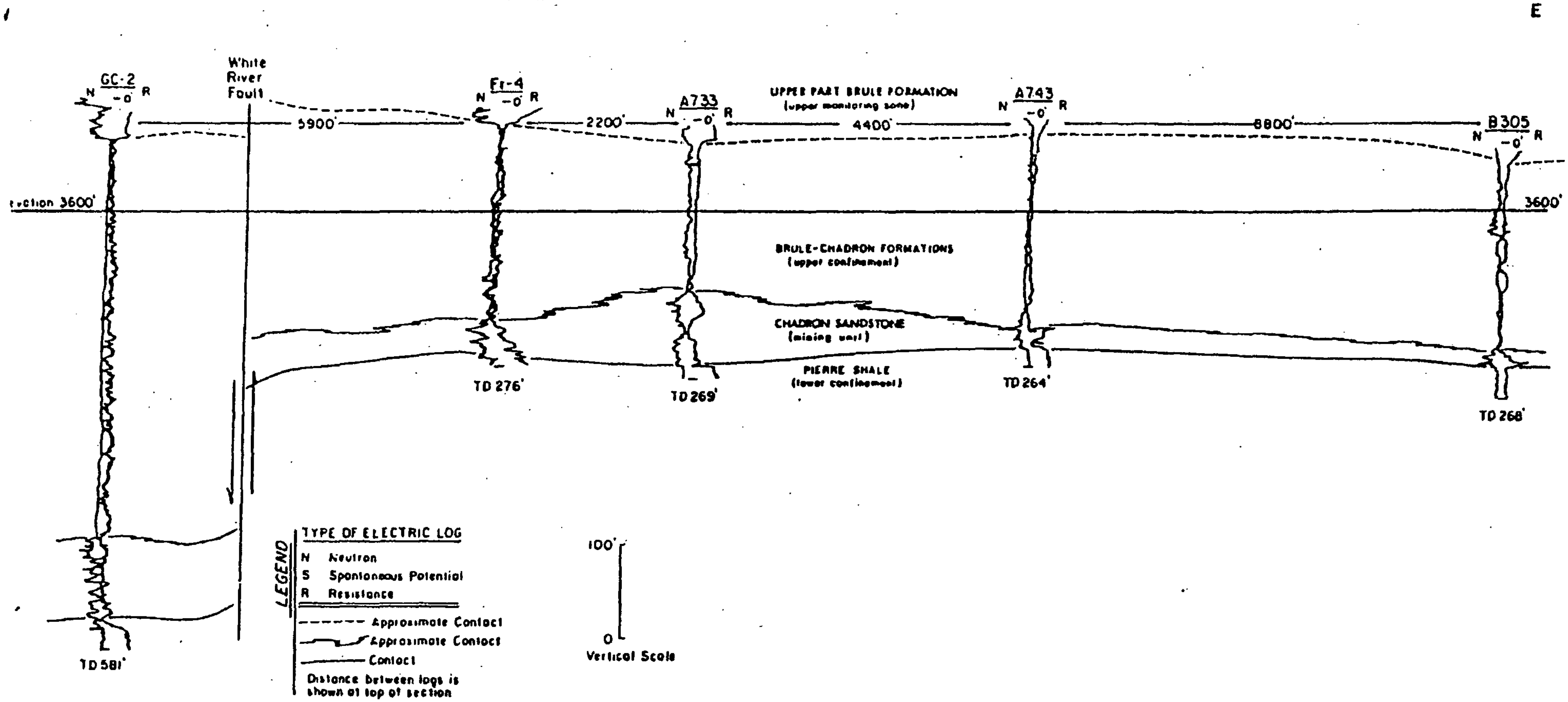


Figure 2.6-6: Cross Section 506,000 E-W

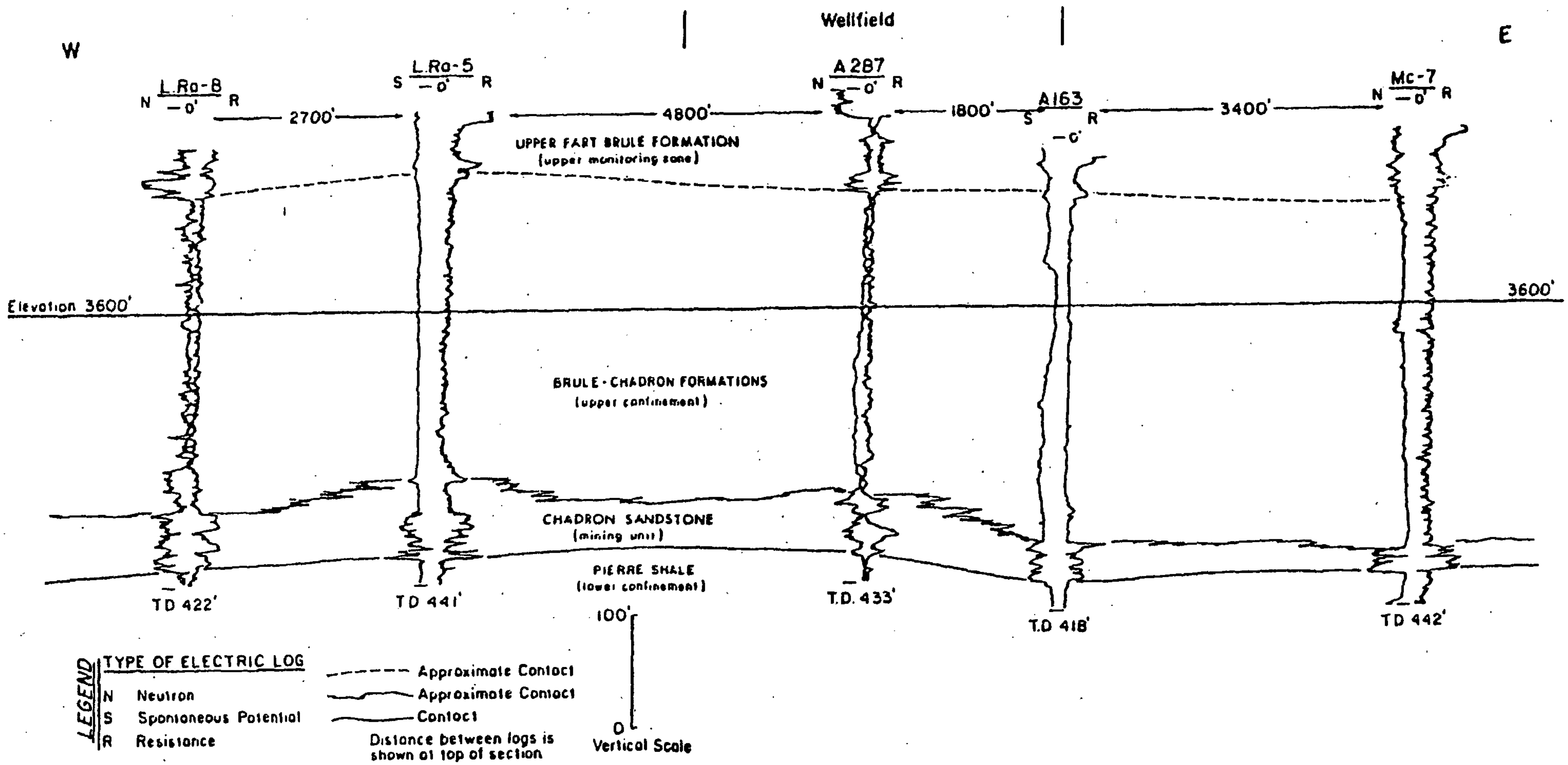


Figure 2.6-7: Cross Section 500,000 E-W

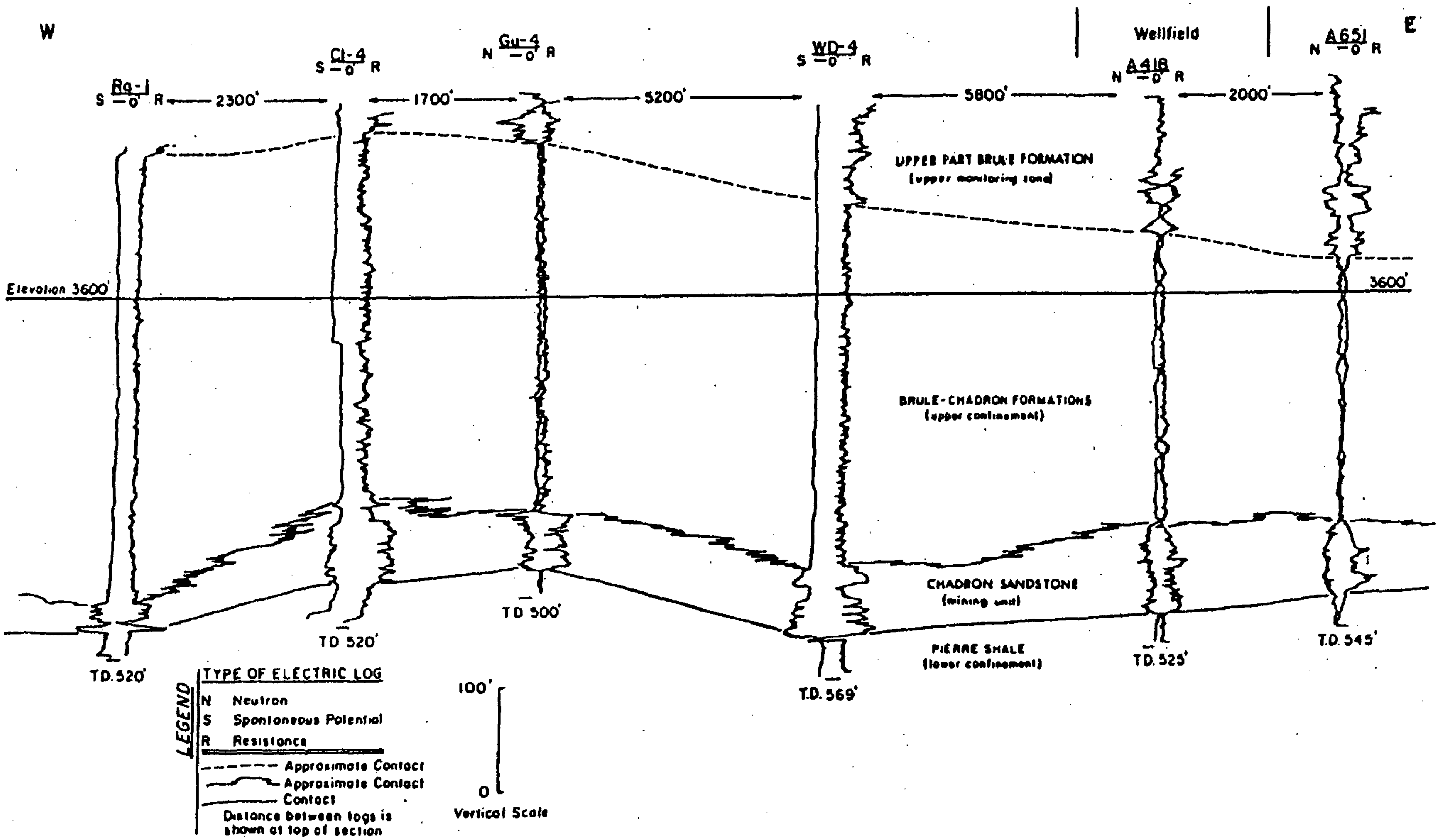


Figure 2.6-8: Cross Section 494,000 E-W

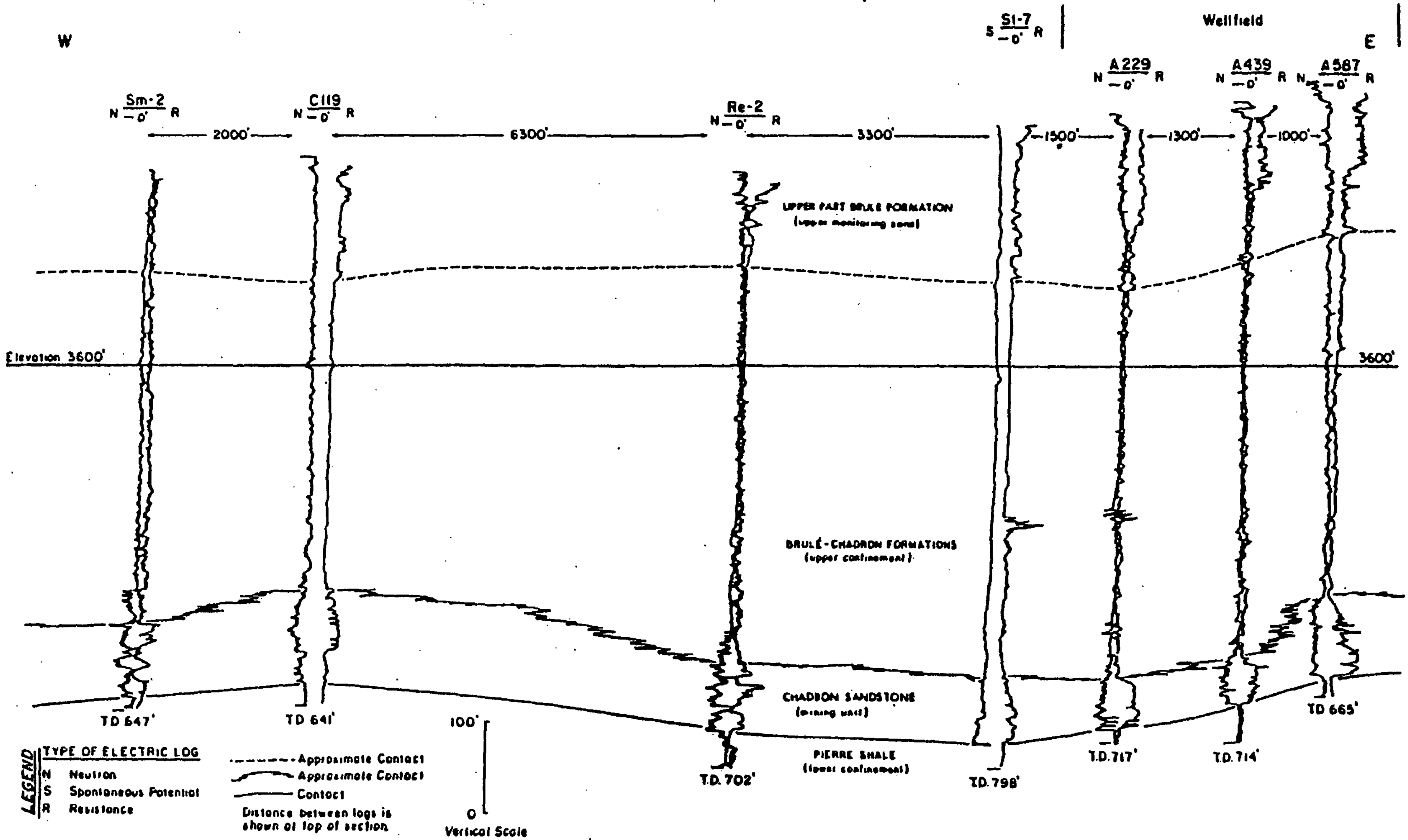


Figure 2.6-9: Cross Section 490,000 E-W

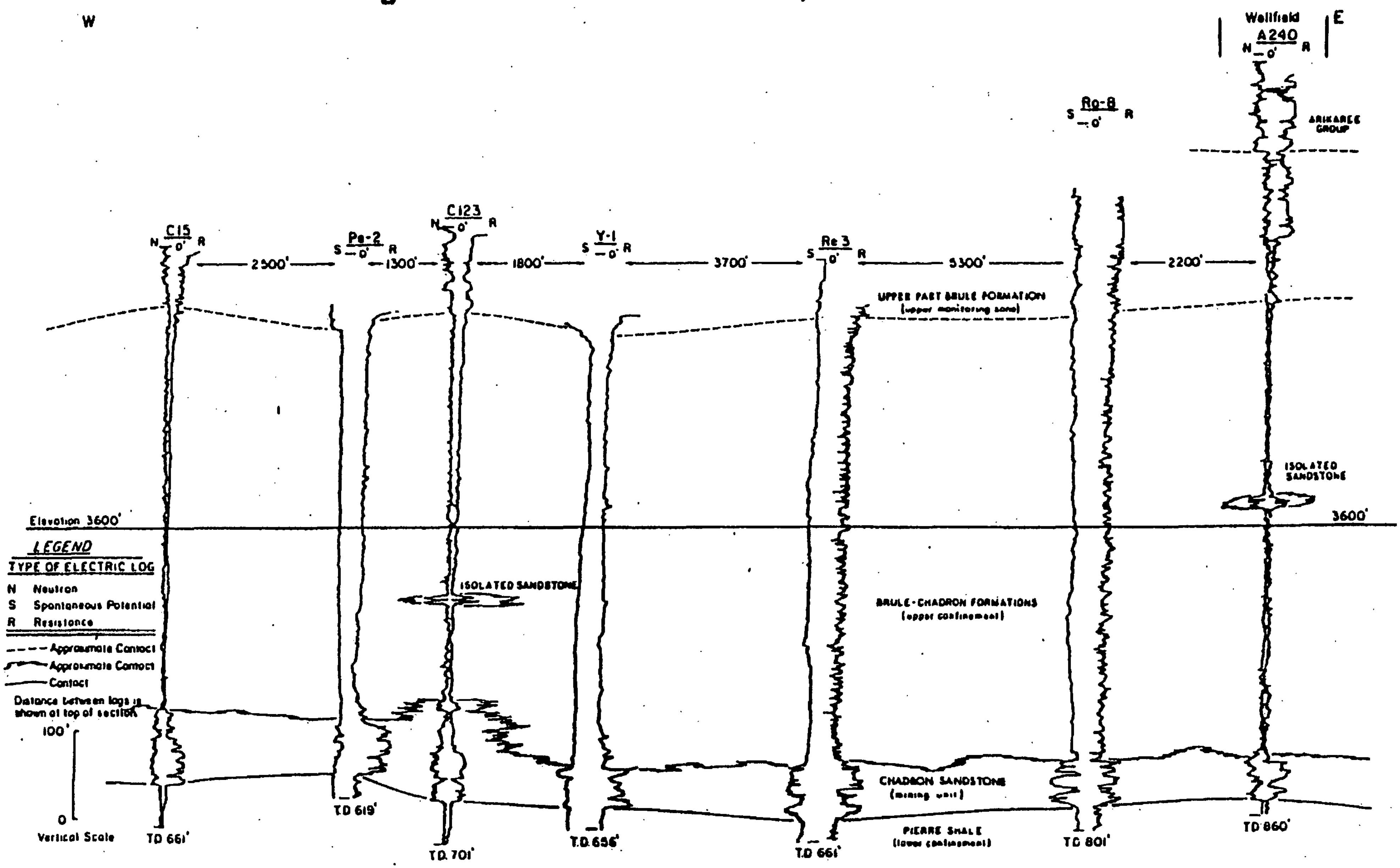


Figure 2.6-10: Cross Section 482,000 E-W

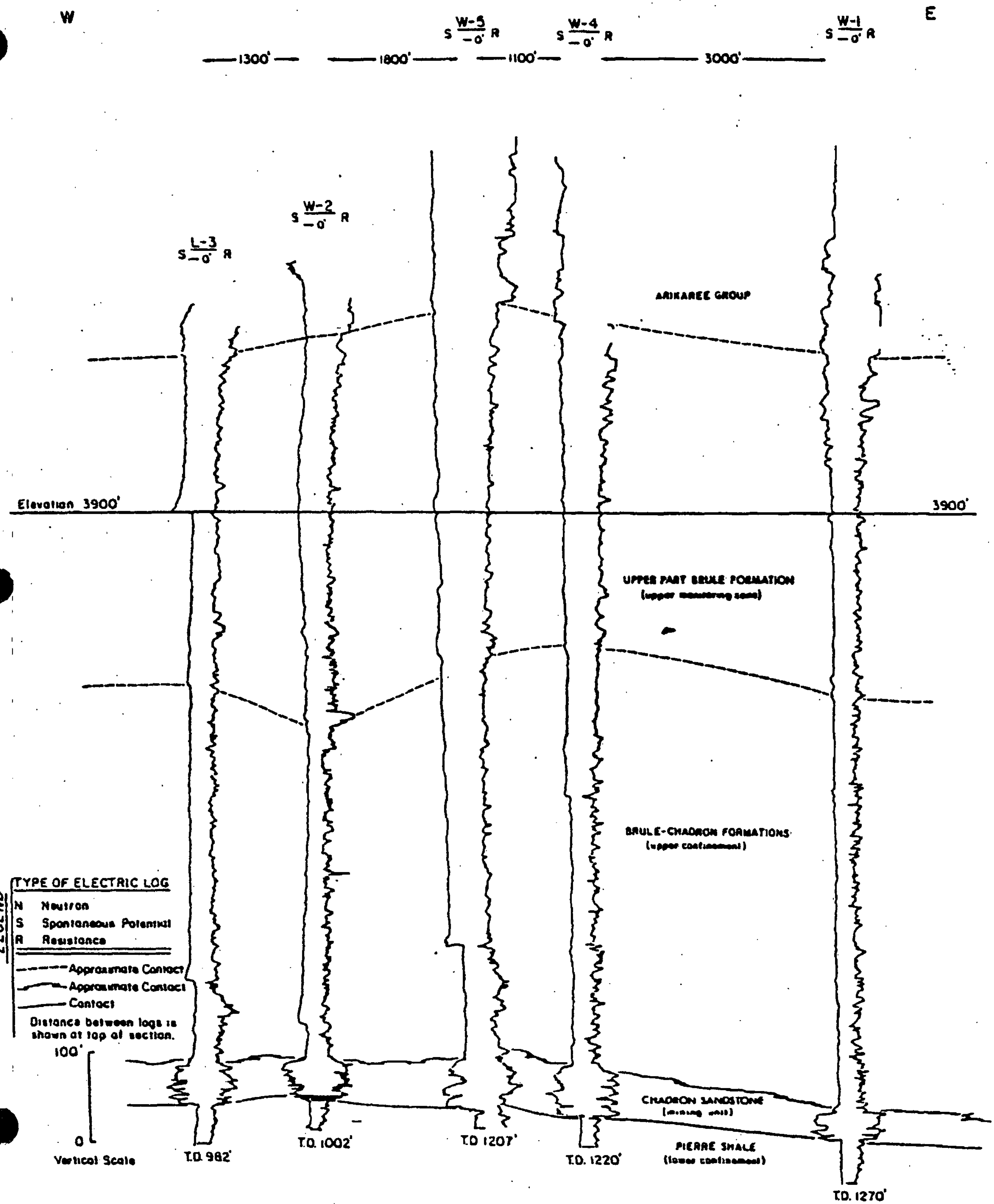
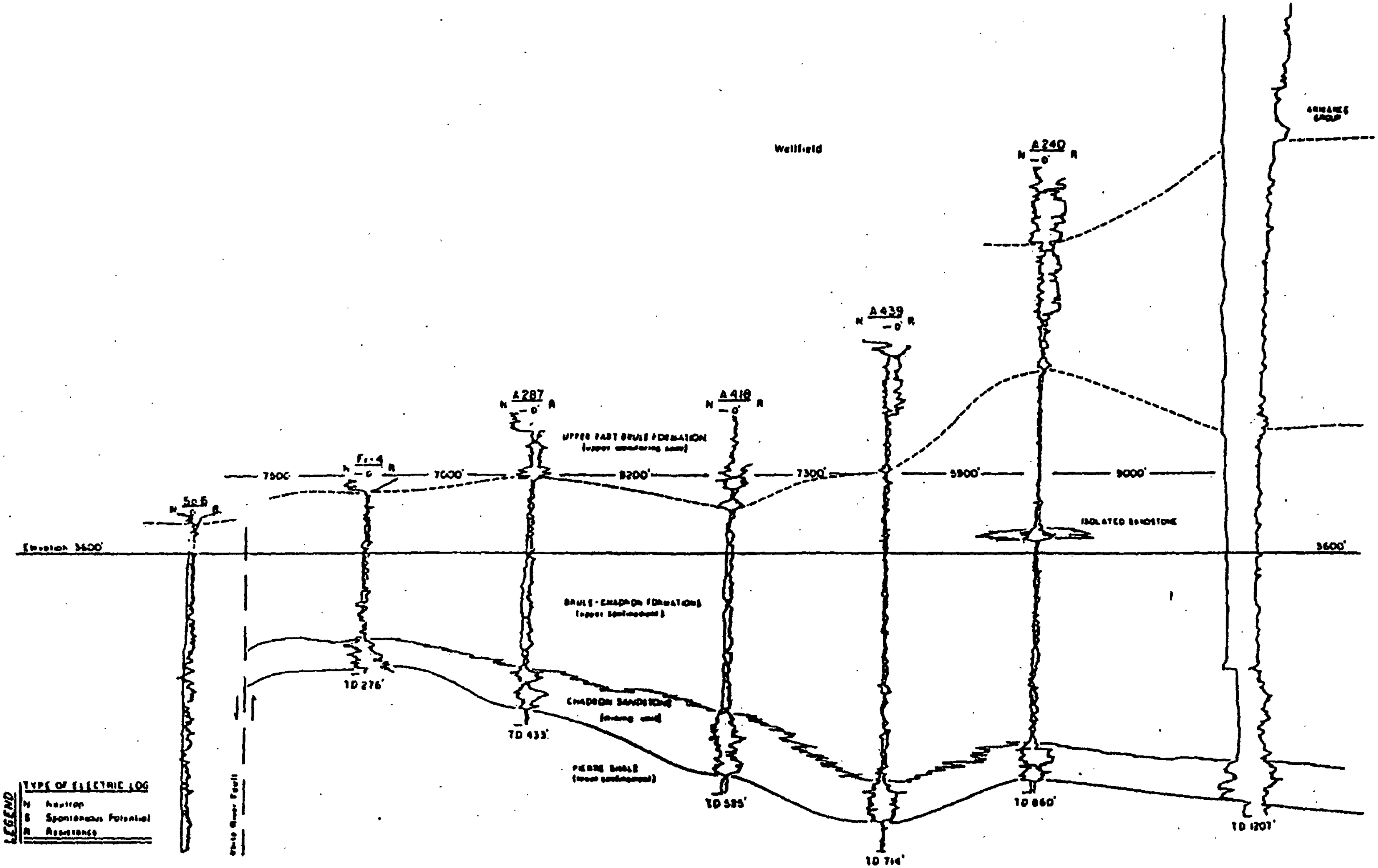


Figure 2.6-11: Cross Section NW-SE



The character of the entire Pierre Shale can be observed in a nearby oil and gas geophysical log, Heckman No. 1. This hole is about 1 mile west (Section 24, T31N, R52W) of the wellfield area. The log from Heckman No. 1 is believed to be representative of the Pierre Shale within the Area of Review. At the location of Heckman No. 1 the base of the Chadron Formation is at a depth of 525 feet. The Pierre Shale is 1565 feet thick and rests on the Niobrara Formation at 2090 feet. The spontaneous potential and resistivity curves of this hole indicate there are no permeable zones within the Pierre Shale. Based on several additional oil and gas holes within the Area of Review the Pierre Shale ranges from about 1250 to 1565 feet in thickness.

X-ray diffraction analyses of two core samples indicate that the Pierre Shale is primarily comprised of quartz and montmorillonite with minor kaolinite-chlorite and mica illite (**Table 2.6-2**). The black marine shale is an ideal confining bed with measured vertical hydraulic conductivity in the Area of Review of less than 2.0×10^{-9} centimeters per second (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.

Table 2.6-2: 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**

Notes: -- = Not encountered

2.6.2.2 Chadron Sandstone - Mining Unit

The Chadron Sandstone is generally present at the base of the Chadron Formation and is coarse grained arkosic sandstone with frequent interbedded thin clay beds and clay galls. Occasionally the Chadron Sandstone grades upward to fine grained sandstone containing varying amounts of interstitial clay material and persistent clay interbeds.

The Chadron Sandstone is the host member and mining unit of the Crow Butte ore deposit and no other uranium mineralization is present in overlying units.

The vertical thickness of the Chadron Sandstone within the Area of Review averages about 60 feet. An isopach of the Chadron Sandstone in the Area of Review indicates a range in thickness of 0 feet on the northeast to nearly 100 feet on the west (**Figure 2.6-12**).

A persistent clay horizon typically brick red in color generally marks the upper limit of the Chadron Sandstone. Occasionally younger sandstone immediately overlies the red clay and is well enough developed to be included in the Chadron Sandstone unit. This upper sandstone is similar in appearance to the rest of the Chadron Sandstone, and is typically very fine to fine grained, well sorted, poorly cemented sandstone.

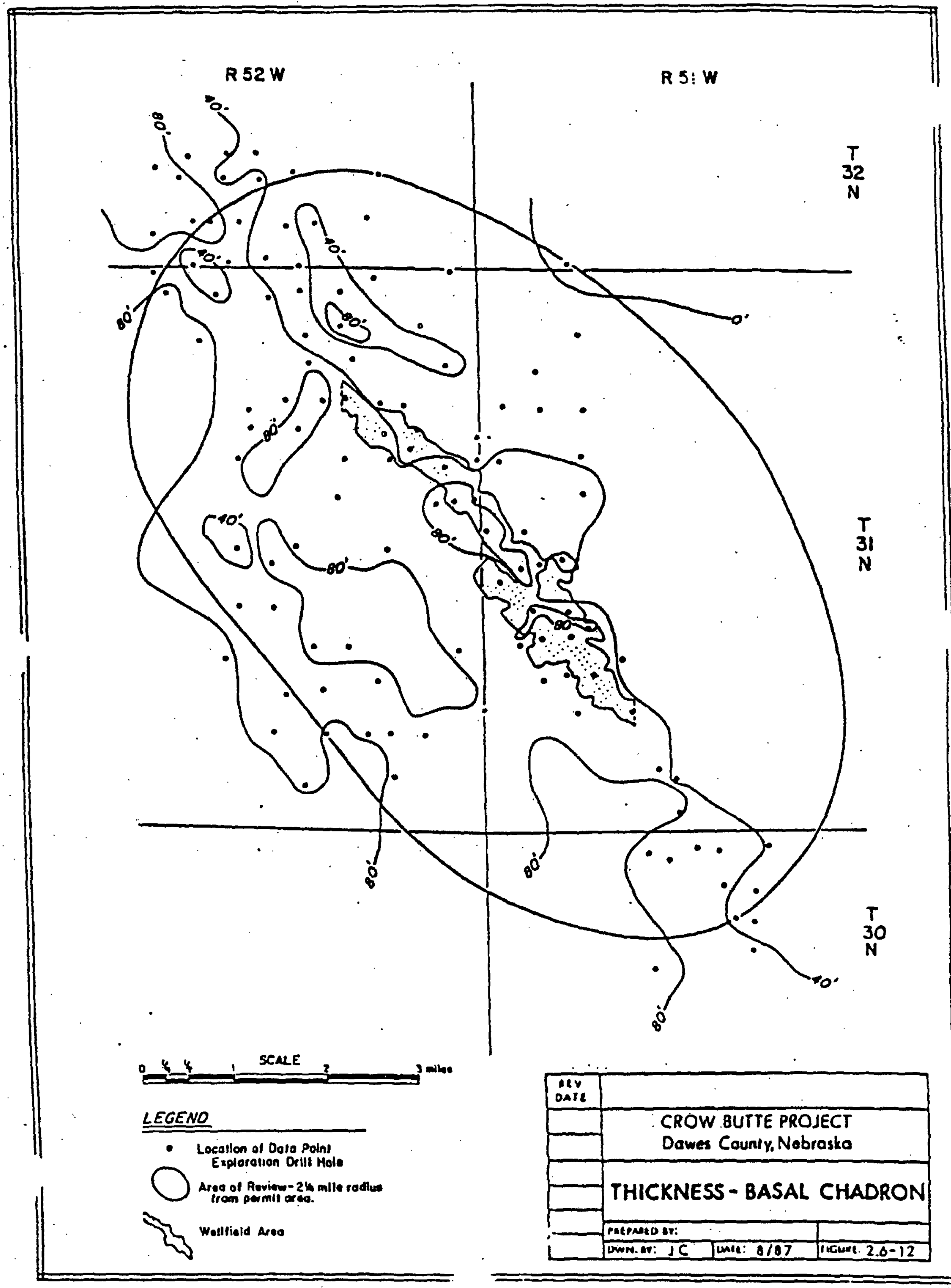
Thin section examination of the Chadron Sandstone reveals its composition to be 50 percent monocrystalline quartz, 30 to 40 percent undifferentiated feldspar, plagioclase feldspar and microcline feldspar. The remainder includes polycrystalline quartz, chert, chalcedonic quartz, various heavy minerals and pyrite. X-ray diffraction analyses indicate that the Chadron Sandstone is 75 percent quartz with the remainder K-feldspar and plagioclase (**Table 2.6-2**).

Core samples and outcrops of the 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 that normally occur during fluvial sedimentation. Within the License Area varying thicknesses of clay beds and lenses often separate the Chadron Sandstone into fairly distinct subunits as shown on the electric logs. Drill holes A-287 (**Figure 2.6-6**), and WD-4 (**Figure 2.6-7**), and Re-2 (**Figure 2.6-8**) illustrate the subunits.

2.6.2.3 Chadron-Brule Formations-Upper Confinement

The upper part of the Chadron Formation and the Brule Formation are the upper confinement overlying the Chadron Sandstone. This is observable by the epigenetic occurrence of the uranium mineralization, which is strictly confined to the Chadron Sandstone. The upper part of the Chadron represents a distinct and rapid facies change from the underlying sandstone unit. The upper part of the Chadron Formation is 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 2.6-2**).

Figure 2.6-12: Thickness- Basal Chadron



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 Area of Review. The measured vertical hydraulic conductivity of the upper confinement is less than $1.0x10^{-10}$ cm/sec. The contact with the overlying Brule Formation is gradational and cannot be consistently picked accurately in drill cuttings or on electric logs. Therefore, the upper part of the Chadron Formation and the lower part of the Brule Formation are combined within the Area of Review.

The Brule Formation lies conformably on top of the Chadron Formation. The Brule Formation is the outcropping formation throughout most of the Area of Review. 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.

2.6.2.4 Upper Part of the Brule Formation - Upper Monitoring Unit

The upper part of the Brule Formation is primarily buff to brown siltstones that 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 (**Figure 2.6-3** to **Figure 2.6-11**). 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).

2.6.2.5 Area of Review Structure

The structure of the Area of Review is illustrated on **Figure 2.6-13**. Elevation contours of the contact between the Cretaceous Pierre Shale and the Tertiary Chadron Formation demonstrate the regional structure. The features present in the Area of Review are a result of the erosional paleotopographic surface of the Pierre Shale prior to deposition of the Chadron Formation and some amount of structural folding and faulting that occurred after deposition of the Chadron Formation. Regionally and within the Area of Review, the White River Group, Chadron and Brule Formations in general dip gently to the south at about 0.5 to 1 degree.

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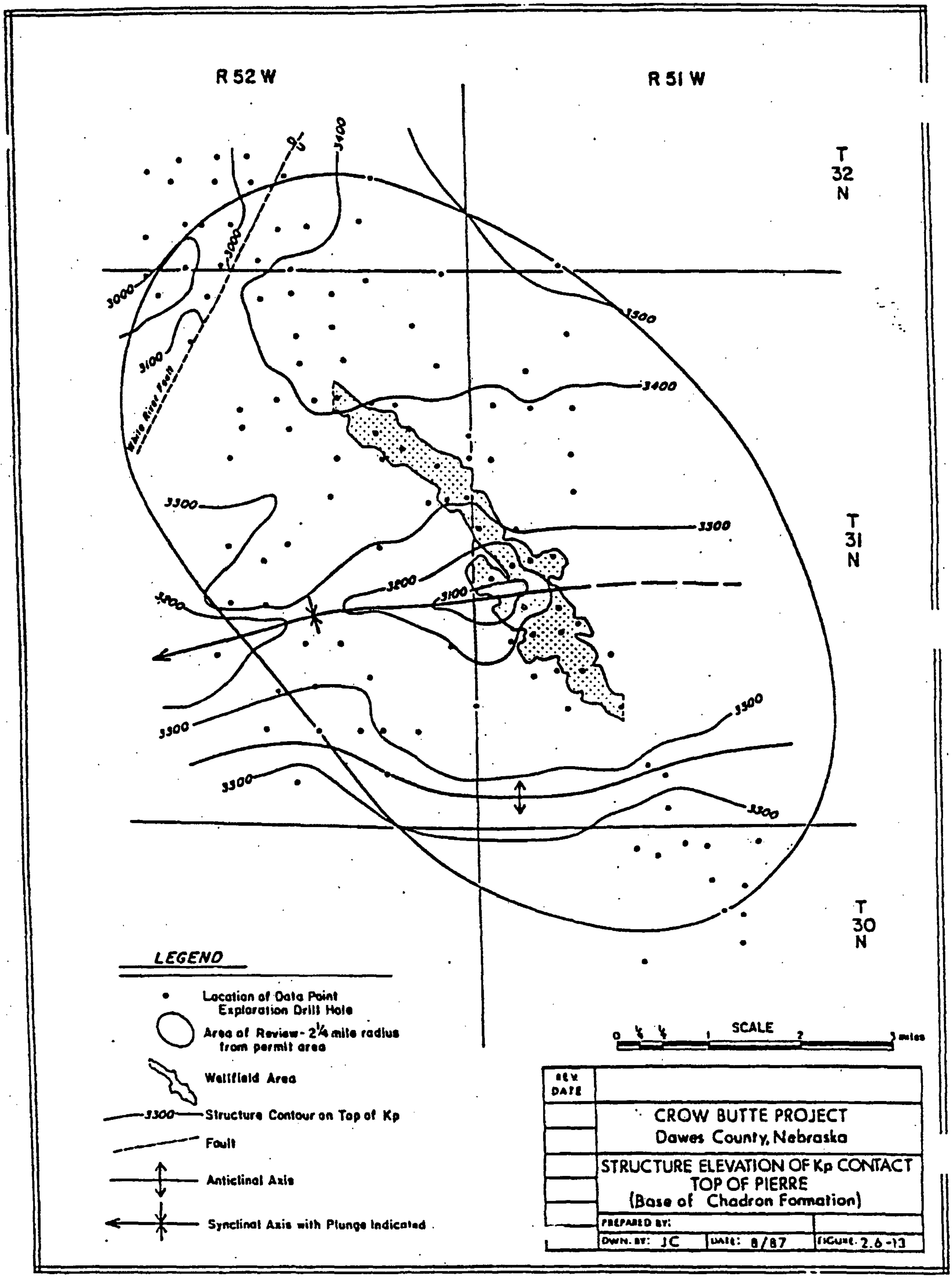
Figure 2.6-13: Structure Elevation of Kp Contact Top of Pierre (Base of Chadron Formation)



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 White River drainage at the extreme northwest edge of the Area of Review. Historical drill data suggested a total vertical displacement of 200 to 400 feet with the up thrown side on the south. Previous reports and maps by CBR and others show the White River Fault to transect the Chadron and Brule Formations, suggesting that the fault displacement occurred post-depositionally.

Recent close spaced drilling activity in this area demonstrates that cross-section correlations are readily made without showing the fault to transect the Chadron and overlying units. While structure contour maps clearly indicate the presence of a feature in the area, the data does not mandate that contouring reflect the presence of a fault in this location, but may instead be interpreted as a monocline or fold. Current drilling and logging data suggests that while this fault likely occurs at depth, it does not continue up-section through the Pierre into and through the Chadron and Brule Formations. 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 up-section in the Pierre, Chadron and Brule Formations as a fold. The White River Fault/Fold is located approximately one and one half miles northwest of the proposed northern extent of the wellfield area.

Close spaced drill data throughout the Area of Review indicate that no other significant faulting is present in the wellfield area. Small faults have been identified in and near the Area of Review (personal communication, Vern Souders and Jim Swinehart, Conservation Survey Division, University of Nebraska, 1988) which have offsets of a few feet. However, these faults do not effect the confinement of the Chadron Sandstone based on hydrologic testing in the area.

A synclinal feature trends east-west and plunges west through the Area of Review. An associated east-west trending anticlinal feature is present along the southern part of the Area of Review. This anticlinal axis is subparallel to the Cochran Arch proposed by DeGraw (1969) and is probably a related feature.

2.6.2.6 Discussion of Confining Strata

The Crow Butte ore body represents a situation favorable for in-situ mining of uranium. The lower confining bed is the Pierre Shale and is over 1,000 feet in thickness. The Pierre Shale is 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 Chadron Formation above the Chadron Sandstone and that portion of the Brule Formation underlying the intermittent Brule sandstones (**Figure 2.6-3** to **Figure 2.6-11**). This part of the Chadron Formation is impermeable clay grading upward into several hundred feet of siltstones and claystones of the Brule Formation. These units separate the zone of injection

(Chadron Sandstone) from the nearest overlying water bearing unit with several hundred feet of clay and siltstones. The Chadron Formation clays also have a large lateral extent and have been observed in all holes within the Area of Review.

From **Table 2.6-2** one can see that the upper and lower confining beds (the Chadron-Brule Formation clay 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.

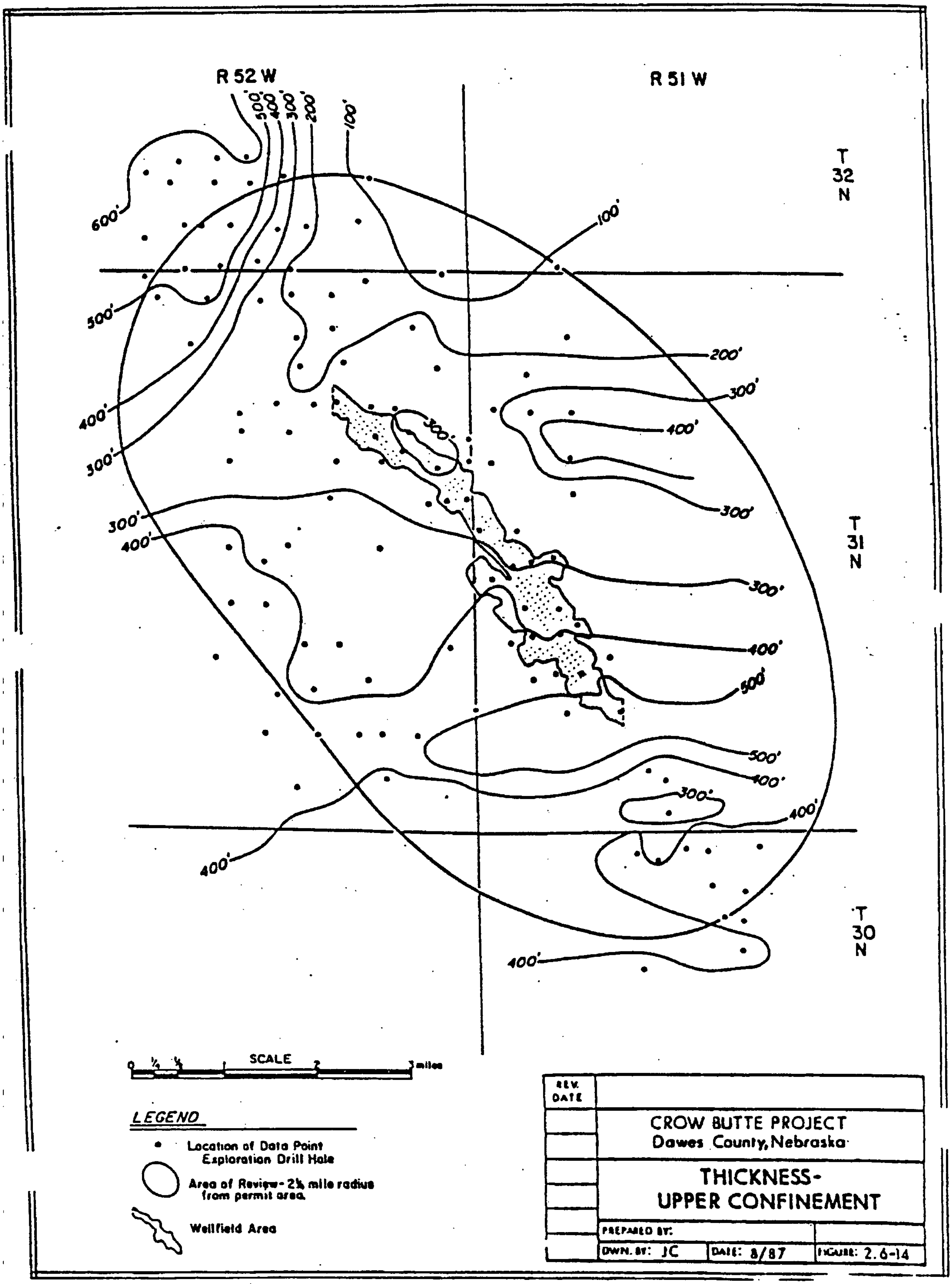
It is recognized that small faults and fractures may occur in the sediments overlying the Chadron Sandstone unit. Additionally, there may be areas of secondary permeability within isolated areas of the Brule Formation. However, two pump tests conducted in the Area of Review indicate no faulting or fracturing which affects the confinement of the Chadron Sandstone or which would affect in-situ mining of the uranium mineralization (see **Section 2.7**). The thickness of the upper confinement ranges from approximately 100 feet along the northeast boundary of the Area of Review to over 500 feet locally (**Figure 2.6-14**). Stratigraphically above the wellfield area the upper confinement ranges from 200 feet on the north to 500 feet on the south (**Figure 2.6-14**). This variation in thickness is primarily due to erosion of the rocks overlaying the Chadron Sandstone during Pleistocene time.

2.6.3 Seismology

The Crow Butte License Area in northwest Nebraska is within the Stable Interior of the United States. The project area along with most of Nebraska is in seismic risk Zone 1 on the Seismic Risk Map for the United States compiled by Algermissen (1969). Most of the central United States is within seismic risk Zone 1 and only minor damage is expected from earthquakes that occur within this area. The nearest area to the project area of higher seismic risk is in the southeastern part of Nebraska within the eastern part of the central Nebraska Basin (Burchett 1979) about 300 miles from the project area.

Although the License 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, considered complete to 1966, 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 2.6-14: Thickness- Upper Confinement



REV. DATE	
	CROW BUTTE PROJECT Dawes County, Nebraska
	THICKNESS- UPPER CONFINEMENT
	PREPARED BY:
	DWN. BY: JC | DATE: 8/87 | FIGURE: 2.6-14

Figure 2.6-15 is a seismic hazards map of Nebraska (USGS 2007). **Figure 2.6-16** illustrates earthquake epicenters, shown as orange circles, and seismicity in Nebraska (Burchett 1979, USGS 2007). The location of the Chadron and Cambridge Arches areshown on this map. The earthquakes that have been recorded along these two structural features are tabulated in **Table 2.6-3**.

Table 2.6-3: Earthquakes in Nebraska

Date	Central Standard Time	Locality	Latitude Degrees North	Longitude Degrees West	Modified Mercalli (MM) Intensity	Source
March 17, 1984	14:00	North Platte	41.133	100.75	IV	A
December 16, 1916	-----	Stapleton	41.55	100.467	II-III	A
September 24, 1924	5:00	Gothenburg	40.95	100.133	IV	A
August 8, 1933	-----	Scottsbluff	41.867	103.667	IV-V	A
July 30, 1934	1:20	Chadron	42.85	103	VI	A
March 24, 1938	7:11	Fort Robinson	42.683	103.417	IV	A
March 9, 1963	9:25	Chadron	42.85	103	II-III	A
March 28, 1964	4:21	Merriman	42.8	101.667	VII	A
May 7, 1978	10:06	SW Cherry County	42.26	101.95	V	B
May 6, 1983	0:15	NE Sheridan County	42.96	102.2	III	B
January 1, 1987	2:02	Crawford	42.79	103.48	III	B
February 8, 1989	23.16	Merriman	42.8	101.6	IV	B

Sources: A = Docekal 1970
B = National Earthquake Information Service 2004

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. 25 occurred on March 24, 1938 near Fort Robinson. This earthquake had an intensity of VI and 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. 29 occurred on March 9, 1962. 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. 31 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. 34) with Intensity V occurred in southwestern Cherry County, also near the Chadron Arch. No major damage was reported from this earthquake.

Figure 2.6-15: Seismic Hazard Map for Nebraska

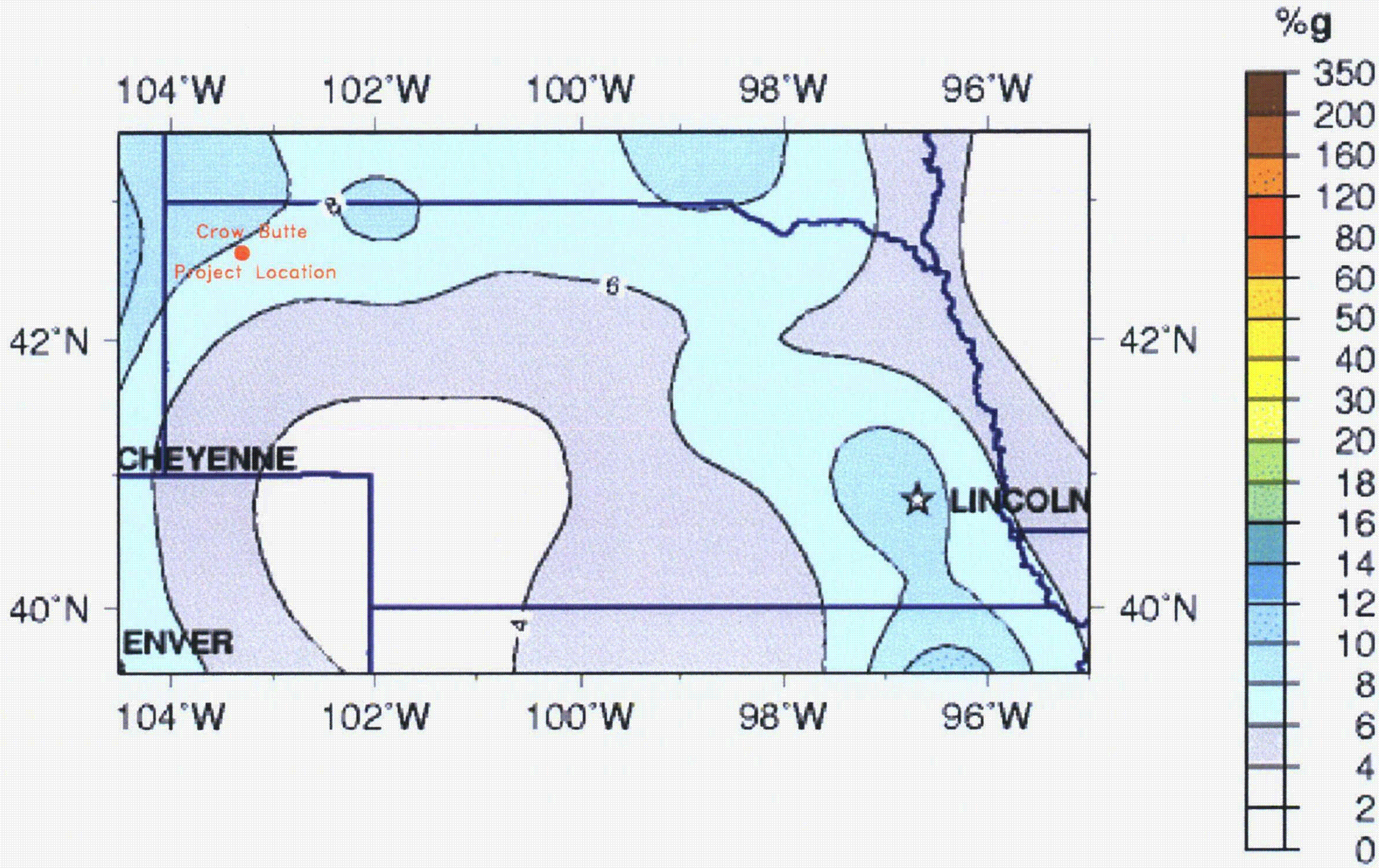
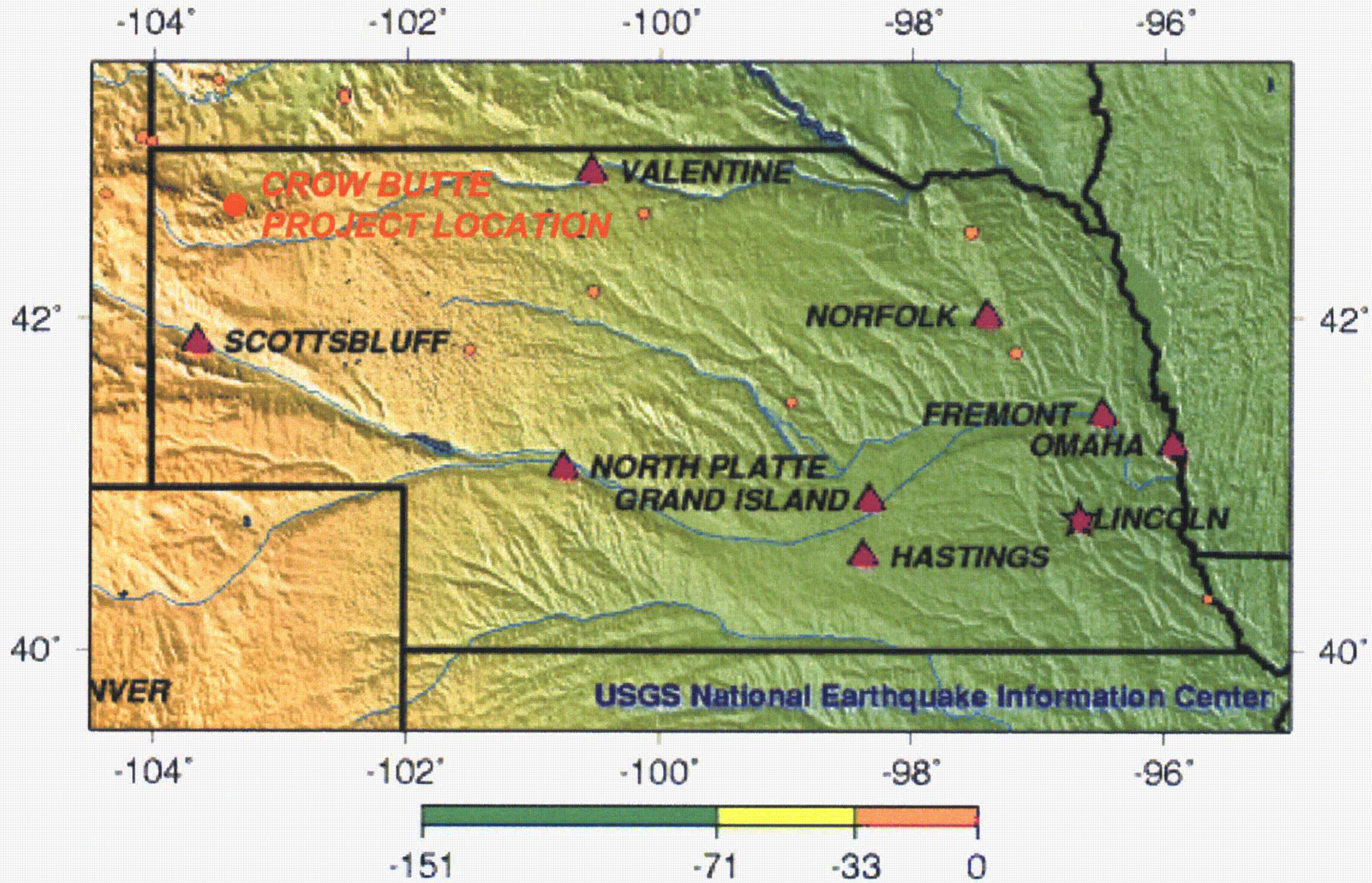


Figure 2.6-16: Epicenter Locations (orange circles) and Seismicity Map of Nebraska



Although the risk of major earthquakes in Nebraska is slight (Burchett 1979, p.14), some low to moderate tectonic activity is occurring (Rothe 1981). This tectonic movement is also suggested by geomorphic and sedimentation patterns during the Pleistocene (Rothe 1981). 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.

The most recent earthquake recorded in Nebraska occurred April 16, 2007. The epicenter was about 45 miles north-northwest of McCook, Nebraska, and was about 180 miles southeast of Crawford. This earthquake had a recorded magnitude of 3.0, but was not felt at Crawford or the License Area. According to the USGS, no earthquakes have been felt in Nebraska since the April 16, 2007 event (USGS 2007).

2.6.4 Soils

The License Area is located in the semiarid west-central portion of Dawes County, Nebraska, southeast of the City of Crawford. The local soils were investigated for the proposed project. Soils data for the License Area were obtained from the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Soil Survey of Dawes County, Nebraska, published in February 1977, and field sampling for radionuclide, physical, and chemical properties was conducted (USDA 2006, NRCS 1977).

The License Area is situated in the White River watershed along the Squaw Creek tributary. The terrain is gently rolling to hilly. The terrain is generally flat with gentle rolling hills. To the south lies the Pine Ridge, an area of rough steep terrain dissected by steep drainageways. Vegetative cover is typically mixed grass and ponderosa pine trees, but they have been largely replaced by agricultural crops within the License 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. The 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.

A 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 License 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 License Area. Approximate percentages of soils in this association are Kadoka at 28 percent, Keith at 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 are 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, 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".

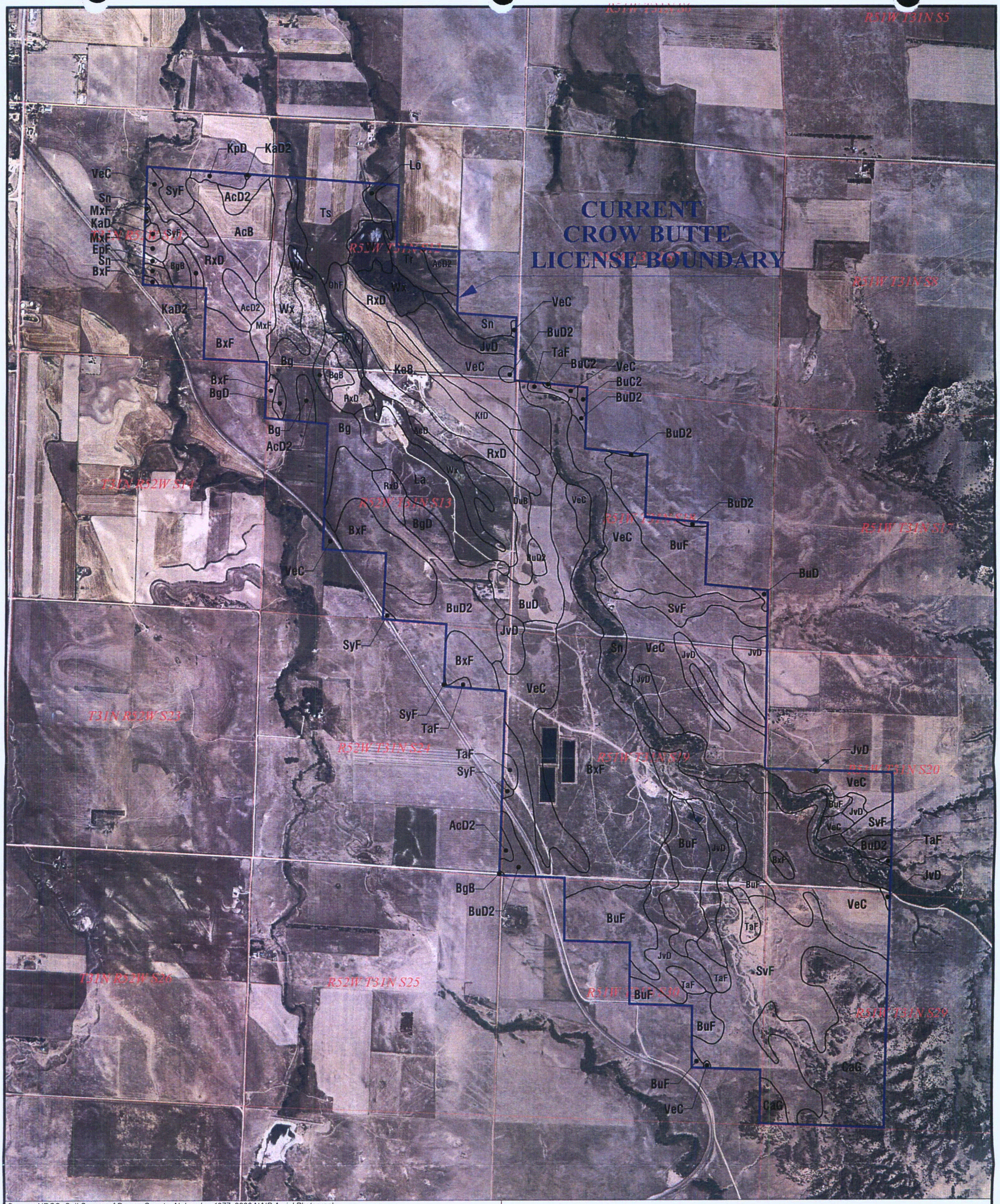
2.6.4.1 Soils Mapping Unit Descriptions

Table 2.6-4 summarizes those soils found within License Area. The first capital letter is the initial 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 2.6-17.**

Table 2.6-4: Summary of Soil Resources within the License Area

Map Unit	Map Unit Name	Percent of License Area
AcB	Alliance silt loam, 1 to 3 percent slopes	1.6
AcD	Alliance silt loam, 3 to 9 percent slopes	0.2
AcD2	Alliance silt loam, 3 to 9 percent slopes, eroded	1.5
Bg	Bridget silt loam, 0 to 1 percent slopes	1.9
BgB	Bridget silt loam, 1 to 3 percent slopes	0.5
BgD	Bridget silt loam, 3 to 9 percent slopes	1.3
BuC2	Busher loamy very fine sand, 1 to 5 percent slopes, eroded	0.2
BuD	Busher loamy very fine sand, 5 to 9 percent slopes	2.1
BuD2	Busher loamy very fine sand, 5 to 9 percent slopes, eroded	3.9
BuF	Busher loamy very fine sand, 9 to 20 percent slopes	7.0
BxF	Busher and tassel loamy very fine sands, 5 to 20 percent slopes	13.0
CaG	Canyon-Bridget-Rock outcrop association, steep	5.4
DuB	Duroc very fine sandy loam, 1 to 3 percent slopes	0.8
EpF	Epping silt loam, 3 to 30 percent slopes	0.0
JvD	Jayem and Vetal loamy very fine sands, 5 to 9 percent slopes	5.4
KaB	Kadoka silt loam, deep variant, 1 to 3 percent slopes	0.0
KaD	Kadoka silt loam, deep variant, 3 to 9 percent slopes	0.1
KaD2	Kadoka silt loam, deep variant, 3 to 9 percent slopes, eroded	0.2
KeB	Keith silt loam, 1 to 3 percent slopes	1.9
KfD	Keith and Ulysses silt loams, 3 to 9 percent slopes	0.8
KpD	Keota-Epping silt loams, 3 to 9 percent slopes	0.2
La	Las Animas soils, 0 to 2 percent slopes	3.3
Lo	Loamy alluvial land	0.2
MxF	Mitchell-Epping complex, 9 to 30 percent slopes	1.2
OhF	Oglala-Canyon loams, 9 to 20 percent slopes	0.4
RxD	Rosebud-Canyon loams, 3 to 9 percent slopes	4.6
Sn	Sandy alluvial land	5.9
SvF	Sarben and Vetal loamy very fine sands, 9 to 30 percent slopes	9.2
SyF	Schamber soils, 3 to 30 percent slopes	0.7
TaF	Tassel soils, 3 to 30 percent slopes	1.1
Tr	Tripp silt loam, 0 to 1 percent slopes	0.9
Ts	Tripp silt loam, saline-alkali, 0 to 2 percent slopes	1.8
VeC	Vetal and Bayard soils, 1 to 5 percent slopes	18.5
W	Water	0.9
Wx	Wet alluvial land	3.1

Source: USDA 2006, NRCS 1977



Source: NRCS, Soil Survey of Dawes County, Nebraska, 1977, 2006 NAIP Aerial Photograph.

LEGEND

SrF MAP UNIT ID

MAP UNIT BOUNDARY

2000 0 1000 2000 3000 Feet

G:\AProject\Crow Butte Resources\CO001269.0001\ACAD\Figure 2.6-17.dwg

CROW BUTTE PROJECT

REGIONAL AREA BASE MAP

DAWES & SIOUX COUNTIES, NEBRASKA

FIGURE 2.6-17 CROW BUTTE LICENSE AREA SOILS MAP

Date:3/7/07 | Drawn:PBE | Fig. 2.6-29

NEBRASKA

BuF Busher loamy very fine sand, 9 to 20 percent slopes

This soil is on uplands, occurring in areas up to 200 acres in size. The Busher soil series consists of deep, well drained to somewhat excessively drained soils that formed in material weathered from sandstone. The soil profile is typical of that for the series. The 3- to 7-inch-thick surface layer is described as grayish brown or dark grayish brown when wet; weak, fine granular structure; soft, very friable; neutral; with a gradual smooth boundary. Lime occurs at a depth of less than 46 cm (18 in) in some areas. The A horizon ranges from 7 to 20 inches in thickness and is neutral to mildly alkaline. The AC horizon is from 8 to 21 inches thick. It is fine sandy loam or loamy very fine sand. Lower horizons become progressively coarser with sandstone fragments typical in the C horizon.

Permeability of Busher series soils is moderately rapid, and water capacity is moderate. Conservation of soil moisture is a major concern in management for control of blowing soil. Runoff is medium.

Natural fertility is medium to low, and organic matter content is moderate. This supports a growth of native grasses, which are used for grazing or hay. The hazard of erosion and steepness of slope make this soil unsuited to cultivation. Classification is sandy range site.

BxF Busher and Tassel loamy very fine sands, 5 to 20 percent slopes

The majority of occurrences of this uplands soil are 9 to 20 percent slope, but range from 5 to 20 percent. The soil covers areas up to 100 acres in size. The group is composed of about 60 percent Busher loamy very fine sand and 40 percent Tassel loamy very fine sand; however, any mapped area may contain either or both soils. Busher soils are found on middle and lower slope areas, and Tassel soils are on ridgetops, knolls, and sides of small drainageways.

The brown to light gray surface layer may be less than 7 inches thick in places. Bedrock occurs at depths of 20 to 36 inches in certain areas. Small areas of outcropping sandstone are also included.

This mapping area may be vegetated in native grass, used for grazing or cut for hay. Cultivation is not suitable, as serious soil blowing and water erosion may occur if cover is removed. Runoff is medium. Classification of Busher soil is sandy range site, and Tassel soil is shallow limy range site.

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

This unit is on uplands and foot slopes in areas up to 300 acres in size. Jayem soils are found on upper parts of side slopes and on ridgetops. Each soil may comprise 50 percent of the unit. Soils of the Jayem series are deep, soldiering to somewhat excessively drained that formed in eolian sands. The representative surface layer is very friable, loamy very fine sand about 13 inches thick underlain by a transitional layer 7 inches thick. The A horizon ranges from 14 to 20 inches, and the AC horizon from 8 to 20 inches in thickness.

Permeability of both soils is moderately rapid, and available water capacity is moderate. Natural fertility is medium, and organic matter content is moderate. Water erosion and soil blowing may be hazards in cultivated or unprotected areas. Runoff is slow to medium. Most areas are in native grasses; however, small acreages may be cultivated by dry land or irrigated methods. Classification is sandy range site.

Sn Sandy alluvial land, 0 to 3 percent slopes

Calcareous alluvial material make up this land type on bottom lands and the short, steep sides of intermittent drainageways. The surface material is fine sandy loam to very fine sandy loam with small rounded fragments of sandstone interspersed. Gravel is common below a depth of 40 inches. Material on the steep sides of drainages ranges from fine sand to fine sandy loam.

Bottomlands are subject to periodic short-duration flooding, especially in the spring. Permeability is moderately rapid, and available water capacity is low to moderate. Runoff is slow on low slope bottomlands and rapid on steep drainageway sides. The water table is below a depth of 10 feet in most places.

Most areas are vegetated in native grass, as they are generally unsuited to cultivation due to flooding hazards. Classification is sandy lowland range site.

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

This mapping unit consists of deep, well-drained soils that formed in wind-deposited sands. This soil is found on uplands and foot slopes in areas up to 300 acres in size. Sarben soils are 60 to 80 percent, and Vetal soils are 20 to 40 percent of the unit.

Upper portions of side slopes and ridgetops are generally Sarben. The surface layer on A horizon is loamy very fine sand about 6 inches thick, but ranges from 3 to 10 inches in thickness. Underlying material, C horizon, is fine sandy loam, with no AC horizon development present. Lime may occur at a depth of 24 inches. Vetal soils occur in swales and on lower portions of foot slopes. The Vetal soils are typically deep and well-drained. The A horizon may be up to 31 inches thick with lime occasionally at less than 24 inches deep.

Permeability is moderately rapid, and available water capacity is moderate. Runoff is medium. Natural fertility is medium to low, and organic matter content is low. Moisture conservation is by a cover of native grass. This prevents water erosion and soil blowing. Slopes are too steep for cultivation; thus, the classification is sandy range site.

VeC Vetal and Bayard soils, 1 to 5 percent slopes

The soils of this mapping unit are deep, well drained and formed in sandy alluvium and colluvium. They occur on foot slopes and stream terraces in areas up to 300 acres in size. Vetal soils make up 55 to 75 percent of the total acreage and Bayard soils 25 to 46 percent.

Both soils are loamy very fine sand, neutral to mildly alkaline and very friable. The surface layer includes very fine sandy loam, fine sandy loam, and loamy very fine sand. In some areas the A horizon is less than 7 inches thick, and in other areas silty material is below a depth of 2 feet. Buried soils are common.

Permeability is moderately rapid, and available water capacity is moderate. Runoff is slow. Natural fertility is medium, and organic matter content is moderate. Approximately half the acreage is cultivated in crops such as wheat, alfalfa, oats, and seeded grasses. The other half is range. Conservation of soil moisture and prevention of wind and water erosion are important in farmed areas. Classification is sandy range site.

Plant cover depends on the site condition. A climax population for sandy alluvial land (Sn) consists of 40 percent sand bluestem, little bluestem, switchgrass, and Canada wild rye. About 60 percent is other grasses and forbs such as prairie sandreed, needleandthread, blue grama, Scribner panicum, sand dropseed, western wheatgrass, and members of the sedge family. Plant communities common in poor condition sites are blue grama, sand dropseed, Scribner panicum, and western ragweed.

The shallow limy range site classification in which Tassel soils of BxF fall contains more alkaline soils as the name implies. Approximately 75 percent of climax plant cover is a mixture of decreaser grasses such as little bluestem, sand bluestem, side-oats grama, needleandthread, prairie sandreed, plains muhly, and western wheatgrass. Perennial grasses, forbs, and shrubs make up the remaining 25 percent. These increasers include blue grama, hairy grama, threadleaf sedge, fringed sagewort, common prickly pear, broom snakeweed, skunkbush sumac, and western snowberry. These sites are less commonly in poor condition due to their terrain.

The BuF, part of BxF, JvD, and VeC mapping units are classified as sandy range sites. The vegetation that occurs on these soils is influenced by the moderately rapid to rapid permeability of the soils. A typical climax plant community is about a 50 percent mixture of decreaser plants such as sand bluestem, little bluestem, and prairie junegrass. The remaining 50 percent is perennial grass, forbs, and shrubs. The principal increasers are blue grama, threadleaf sedge, prairie sandreed, needleandthread, sand dropseed, western wheatgrass, fringed sagewort, and small soapweed. A site in poor condition will commonly have blue grama, threadleaf sage, sand dropseed, and western ragweed.

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Oil and Gas Logs in the Area of Review
Bunch No. 1, Section 5, Township 31 North, Range 51 West
Heckman No. 1, Section 24, Township 31 North, Range 52 West
Arner No. 1, Section 26, Township 31 North, Range 52 West
Roby No. 1, Section 31, Township 31 North, Range 51 West
Soester 1, Section 34, Township 32 North, Range 52 West
True State, Section 36, Township 32 North, Range 52 West
CBR Deep Disposal Well, Section 19, Township 31 North, Range 51 West

2.7 HYDROLOGY

NUREG 1569 Section 2.7 states: "Characterization of the hydrology at *in situ* leach uranium extraction facilities must be sufficient to establish the potential effects of *in situ* operations on the adjacent surface-water and groundwater resources and the potential effects of surface-water flooding on the *in situ* leach facility." To meet these requirements, this section addresses surface water features (**Section 2.7.1**), groundwater characteristics (**Section 2.7.2**), and surface water and groundwater quality (**Section 2.7.2.3**).

2.7.1 Surface Water

The License Area is located within the watershed of Squaw Creek and English Creek, which are small tributaries to the major regional water course, the White River. As a part of the preoperational environmental study, flow measurements and water quality samples were taken from Squaw Creek in the vicinity of the study area.

2.7.1.1 Location

The License Area is located in Sections 18, 19, 20, 29, and 30 of T31N, R51W and Sections 11, 12, and 13 of T31N and R52W within the drainage basin of the White River. The White River heads in Sioux County and flows northeasterly across Dawes County into South Dakota. Northern tributaries in the Crawford area cross upland portions of the Pierre Shale, an impermeable formation. These streams are dry except for runoff flow. The southern tributaries originate in the Pine Ridge escarpment, and flow primarily over forest, range, and agricultural land. These streams are generally ephemeral except where they are spring-fed.

Squaw Creek is one of the southern tributaries of the White River. This creek heads in the Pine Ridge southeast of the License Area. From the headwaters, it flows northwest over range and agricultural land to the White River. Contributions to flow come from springs in the Arikaree Formation, snowmelt, runoff, and the shallow Brule sands. The latter may receive inflow from the creek during periods of high flow. Due to the time-variable nature of these water sources, discharge rates at various points along the creek may experience wide fluctuations monthly and yearly.

Squaw Creek enters the License Area on the southeast corner, travels through the entire length of the License Area approximately paralleling its long axis, and exits to the north. Two branches of an unnamed tributary enter along the southern boundary, join just north of the Mine Unit 1 wellfield, and exit the northern boundary before converging with Squaw Creek.

Figure 2.7-1 illustrates the location of the License Area with respect to the Squaw Creek and English Creek watercourses and the locations of the commercial evaporation ponds.

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Figure 2.7-1

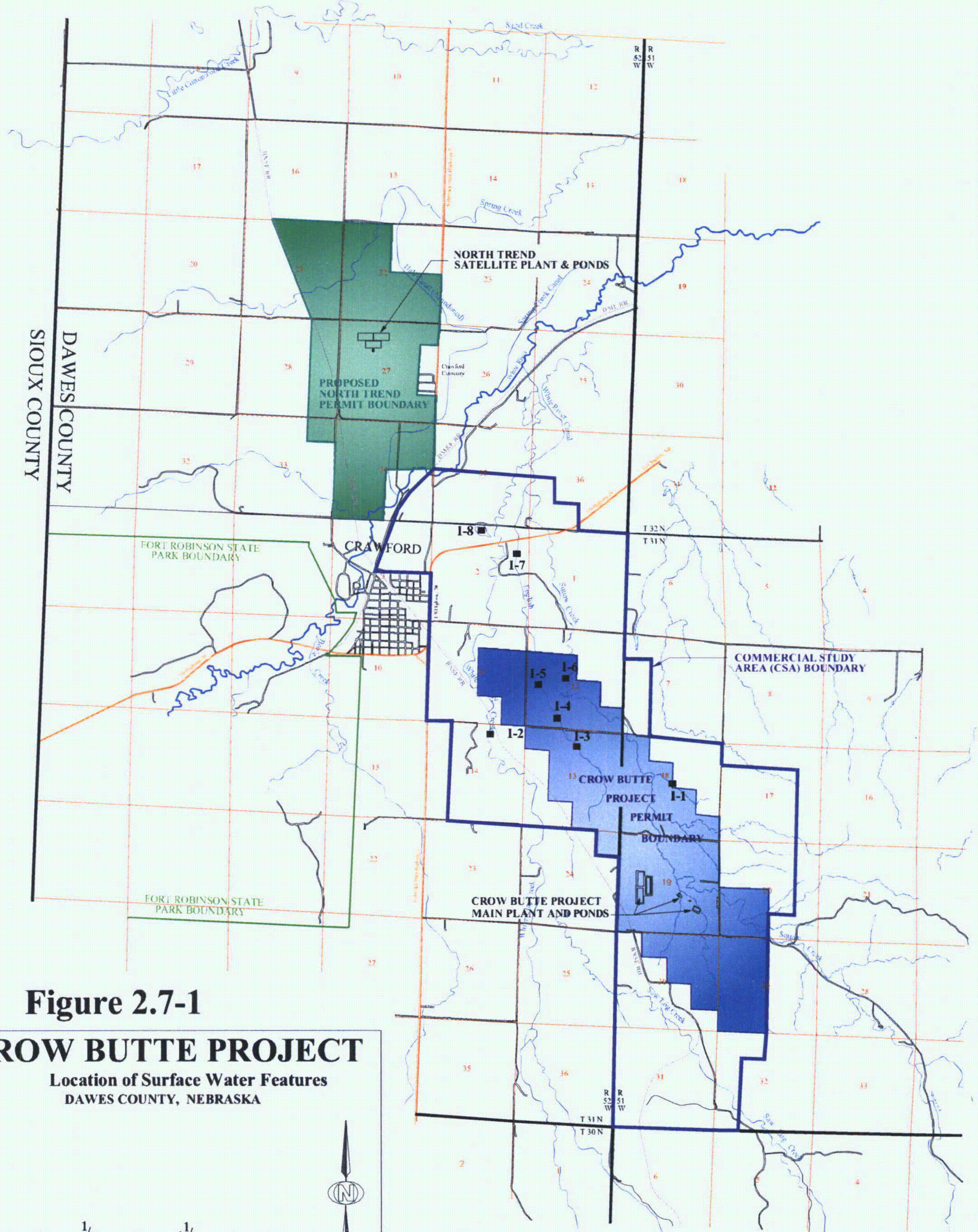


Figure 2.7-1

CROW BUTTE PROJECT

Location of Surface Water Features

DAWES COUNTY, NEBRASKA

2.7.1.2 Stream Flow

Table 2.7-1 shows the mean monthly discharge of the White River as compared to the mean monthly precipitation over several years. These extended data show that a general correlation can be made between the direct precipitation and discharge. Higher flows are recorded in spring and early summer with lowest flow rates in late summer to early fall, reflecting seasonal changes related to precipitation. Between 1931 and 2004, the average normal annual mean discharge at the White River Station at Crawford was 20.3 cubic feet per second (cfs) with a standard deviation of 2.8 cfs. The maximum was 27 cfs and the minimum was 13 cfs.

Table 2.7-1: Comparison of Mean Monthly Precipitation with Normal Mean Monthly Discharge of the White River at Crawford, Nebraska

Month	Mean Precipitation [a]		Mean Discharge [b]	
	inches	centimeters	ft^3/sec	m^3/sec
January	0.61	1.55	21	0.59
February	0.76	1.93	23	0.65
March	1.74	4.42	27	0.76
April	2.65	6.73	25	0.71
May	3.11	7.9	27	0.76
June	2.42	6.15	22	0.62
July	2.77	7.04	16	0.45
August	1.21	3.07	13	0.37
September	1.38	3.51	14	0.4
October	1.66	4.22	17	0.48
November	0.82	2.08	19	0.54
December	0.79	2.01	20	0.57

Notes:
[a] - Climatology of the US No. 81, 1971-2000, NOAA, 25-Nebraska
[b] – USGS National Water Information System for USGS gaging station 06444000
m^3/sec = cubic meters per second

Peak rainfall at Harrison and Scottsbluff, Nebraska occurs in May and June (NOAA 1976 and 1980), and this precipitation pattern appears to be representative of the Crawford area. **Table 2.7-2** provides mean monthly discharge information for the White River for 1992 through 1995, as well as data for 2004 and 2005. The recent data for the White River are comparable to the stream flow data shown in **Table 2.7-2**.

Table 2.7-2: Normal Mean Monthly Discharge of the White River at Crawford, Nebraska, 1992 – 1995, part of 2003 and 2004

Month	1992 (ft^3/sec)	1993 (ft^3/sec)	1994 (ft^3/sec)	1995 (ft^3/sec)	2003 (ft^3/sec)	2004 (ft^3/sec)
January	21.4	20.7	21.4	20.3	no data	23
February	22.5	23.5	23	21.5	no data	24.8
March	22.3	31.2	23.3	19.7	no data	25.9
April	20	26.1	21.3	22.1	no data	22.7
May	18.8	19.7	19.6	27	no data	21.1
June	18.1	30.6	14	29.8	no data	17.1
July	15.6	25.3	12.3	18.5	no data	17.4
August	12.4	16.4	9.87	12.9	no data	11.3
September	12.4	17.8	11.1	13.6	no data	17.8
October	16	20.9	16.3	18.8	17.5	no data
November	18.8	21.2	17.9	19.8	22.6	no data
December	22.9	26.4	18.8	19.7	23.1	no data
Average	18.4	23.3	17.4	20.3	21.1	20.1

Note: data not available from 1995 through 2003
Source: USGS National Water Information System for USGS gaging station 06444000

2.7.1.3 Surface Water Impoundments

Eight surface water impoundments are located near or within the boundaries of the commercial License Area. **Figure 2.7-1** shows the locations of these impoundments. These eight impoundments are identified as I-1 through I-8. Impoundments I-1, I-2, I-7, and I-8 are outside the License Area, while impoundments I-3 through I-6 are inside the License Area.

Impoundment I-1 consists of a low earthen berm constructed across an unnamed ephemeral drainage course, which is tributary to Squaw Creek. This berm forms a small seasonal pond which is used for livestock watering. Impoundment I-2 is formed by a small earthen dam on White Clay Creek. Water from this pond is used for livestock watering and crop irrigation. Impoundments I-3, I-4, I-5, and I-7 are formed by small earthen dams across English Creek. Water from these ponds is used for livestock watering. Impoundment I-6 is formed by an earthen dam across Squaw Creek. Water from this pond is used for livestock watering. Impoundment I-8 is located in the alluvial valley of White Clay Creek and is also used for livestock watering.

2.7.1.4 Assessment of Surface Water Features

As shown in **Table 2.7-1** and **Table 2.7-2**, the average monthly stream flow of the White River at the Crawford gauge station is about 20 cfs. The highest discharge and gauge height on record between 1920 and 2004 occurred on May 10, 1991. On that date, severe thunderstorms resulted in significant rainfall, the gauge height was 16.32

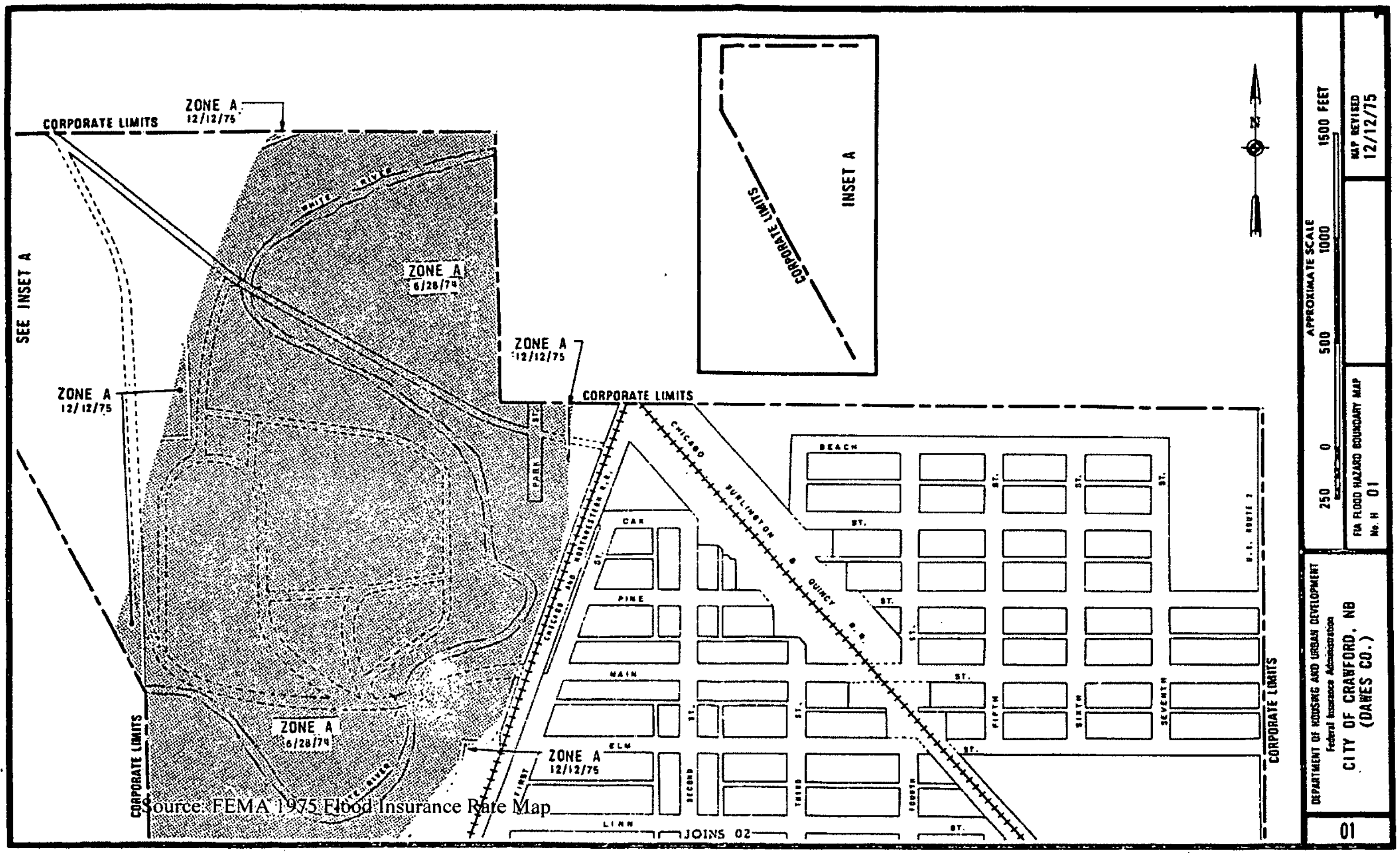
feet, and the stream flow exceeded 13,300 cfs (State of Nebraska Department of Natural Resources 2004). Several city facilities were damaged by floodwaters and hail, including the local golf course and fish hatchery, and the event was considered a "100-year" flood. The Rocky Mountain News (May 12, 1991) reported that mobile homes were swept away and the town's water system was knocked out of service. However, it is noted that, while there are certainly historical extremes, the average gauge height on the White River at Crawford is less than 5 feet, with an average annual stream flow of 20.2 cfs.

The potential for flooding or erosion that could impact the in-situ mining processing facilities and surface impoundments have been assessed based on data from the Federal Emergency Management Agency (FEMA 2007). FEMA has not mapped unincorporated Dawes County north of Crawford, Nebraska; however, FEMA maps are available for the City of Crawford, which depict the flooding potential of the White River in Crawford. As shown in **Figure 2.7-2**, FEMA has classified the portion of Crawford between the D M & E Railroad (immediately west of First Street) as Zone A (i.e., an area that could be impacted by a 100-year flood) (FEMA 1995). All surface facilities within the License Area occur outside of the 100-year flood plain of the White River, and are not likely to be within a "flood-prone" area. Therefore, consistent with NUREG-1623, erosion modeling was not considered necessary or performed. Existing Crow Butte surface facilities are located in Section 19, approximately 3 miles southeast of White River (river segment in Crawford), and more than 150 feet topographically above the common river elevation. All existing and planned surface facilities are least 50 feet above the White River elevation.

2.7.1.5 Water Quality

Samples were collected from Squaw Creek and all surface bodies of water within the commercial License Area. This schedule was begun in 1982 and continued into 1987 for specified locations. The data and sampling methodology are found in the 1997 LRA White River water quality data were assembled by the USEPA for various years between 1969 and 1994. These data, as well as groundwater quality sampling results, are presented in **Section 6.1.3.**

Figure 2.7-2: FEMA Zone A Flood Map



Source: FEMA 1975 Flood Insurance Rate Map

2.7.2 Groundwater

This section provides a summary of the regional and local groundwater hydrology including local and regional hydraulic gradient and hydrostratigraphy, hydraulic parameters, baseline water quality conditions, and local groundwater use including well locations related to the License Area. The discussion is based on information from investigations performed within the License Area, data presented in previous applications and reports for the CSA where ISL mining is being conducted, and the geologic information presented in **Section 2.6**.

The hydrostratigraphic section of interest for the License Area includes the following (presented in descending order):

- Alluvium
- Brule Formation (including the first "aquifer" in the Brule sand/clay)
- Chadron Formation (Upper Confining Unit including the Upper Chadron confining layer, Middle/Upper Chadron sand [aquifer, where present], and Middle Chadron confining layer)
- Basal Chadron Sandstone (Mining Unit)
- Pierre Shale (Lower Confining Unit)

With regard to the Crow Butte Project, two groundwater sources are of interest in the Crawford and the License Area. These are the Brule sand and the Basal Chadron Sandstone. The Basal Chadron Sandstone contains the uranium mineralization in the CSA.

2.7.2.1 Regional Groundwater Hydrology

A map prepared by Souders (2004) indicates that the water table configuration in the region trends north-northeast. No published regional water level maps are available for the Basal Chadron Sandstone or the local Brule sands. Souders (2004) states that aquifers within the White River Basin, which encompasses the northern half of Dawes County, are "nearly nonexistent". He indicates that a groundwater divide occurs to the south of the CSA along the Pine Ridge; groundwater north of this divide in the CSA and License Area flows to the north, northwest, and northeast, depending on location with respect to the White River. The Brule, Chadron, and Pierre Shale outcrop progressively northward from the Pine Ridge divide through the White River Basin, and Souder states that none of these formations "are considered major sources of groundwater".

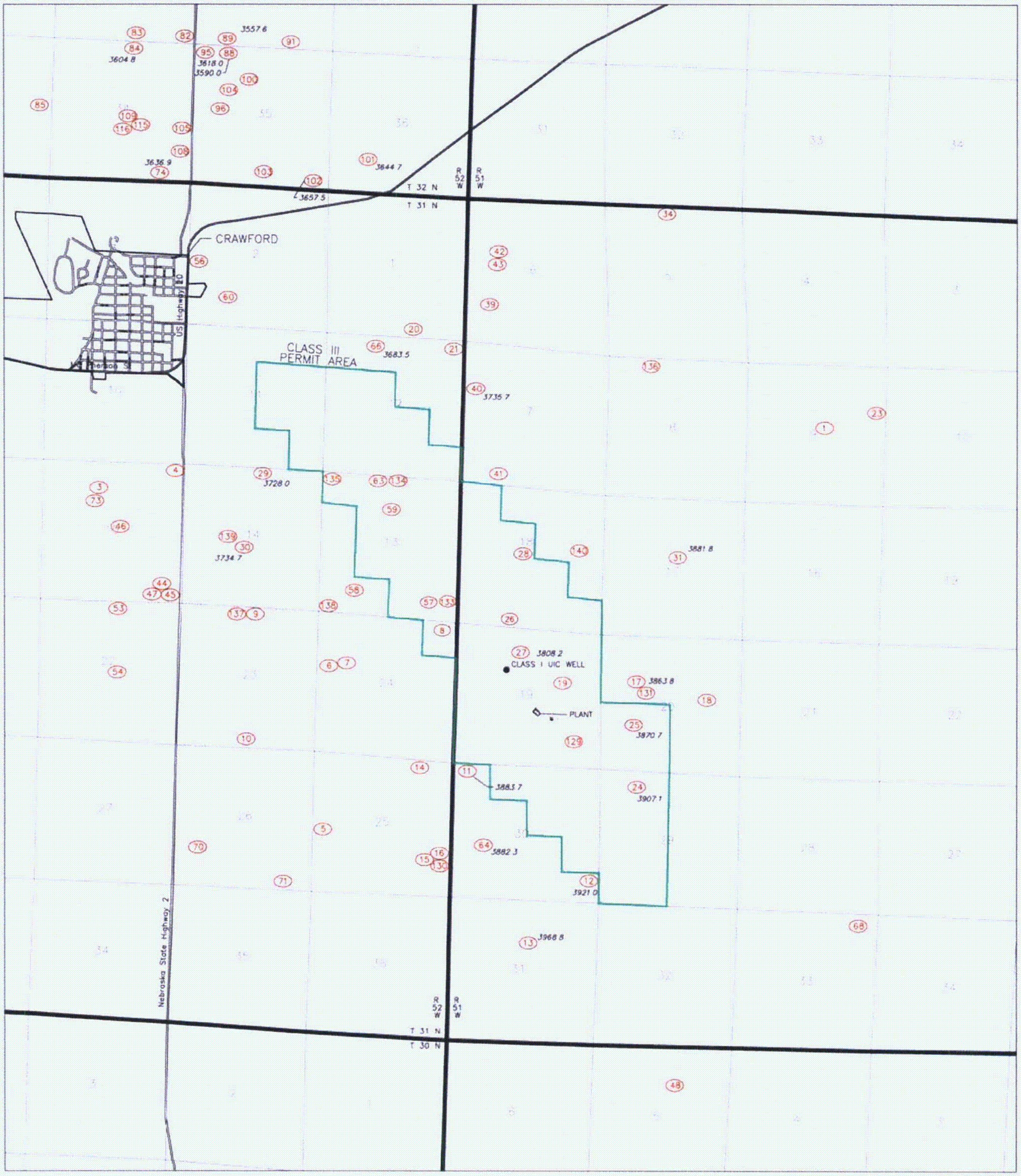
Souder indicates that the Brule is a tight formation with a minimal hydraulic conductivity of less than 25 feet per day (feet/day), although in a few areas, there may be a significant saturated thickness, presumably where sandier intervals are present. The Chadron is described as consisting of claystones with extensive volcanic ash that is tight with low hydraulic conductivity comparable to the Brule, except where fractured, although the coarse Basal Chadron Sandstone is present at the bottom of the formation. The Pierre is described by Souders (2004) as a dark grey, bentonitic shale that is "very tight and is not considered to hold any extractable groundwater" except where fractured. Fractures may increase Brule and Chadron permeability in localized areas (Souders 2004). It is noted that CBR operations in the CSA to date do not support evidence of fracturing in the Pierre to a degree such that it would impact the designation of the Pierre as a lower confining unit below the Basal Chadron Sandstone.

Prior to mining in the CSA, water levels were measured in existing wells throughout the Crawford-Crow Butte area for the local Brule sand and the Basal Chadron Sandstone. Maps showing the potentiometric surfaces for these two aquifers are included as **Figure 2.7-3** and **Figure 2.7-4**. Based on these figures, the local direction of groundwater flow (e.g., in the vicinity of the CSA) in the Brule sand appears to be to the north-northwest.

The Basal Chadron Sandstone is an artesian (confined) aquifer, and wells completed in it may flow to the surface near the White River. The direction of Chadron groundwater migration in the region is to the north-northwest in southern areas near the White River. Farther to the south, the potentiometric surface is almost flat.

Because these data presented in **Figure 2.7-2** and **Figure 2.7-3** are over 10 years old and limited in extent, no potentiometric contours are presented. Further, because the regional flow in the Brule and Basal Chadron differ depending on location (e.g., south versus north of the White River), a regional potentiometric map with data from the CSA is not presented. Historical water level data for a one-year period from wells located in the CSA are included on **Tables 2.7-3** (Brule wells) and **Table 2.7-4** (Basal Chadron wells).

Regionally, the principal water bearing rocks below the Pierre Shale are the G Sand, J Sand, and the Dakota, Morrison and Sundance Formations. The Total Dissolved Solids (TDS) concentrations of the water below the Pierre Shale have been interpreted from deep oil and gas exploration logs. The Dakota Sandstone is at a depth of 2,972 to 3,020 feet in the Bunch No. 1 hole (Section 5, T31N, R52W). The minimum TDS of the water in the Dakota Sandstone, calculated from the spontaneous potential and sonic logs, is estimated to range from 14,000 to 26,000 mg/L (as NaCl). Based on samples collected during the installation and testing of the Crow Butte deep disposal well (DW #1, Section 19, T31N, R51W) TDS levels in the Morrison Formation (3,580 feet midpoint depth) and Sundance Formation (3,784 feet) are approximately 24,000 and 40,000 mg/L, respectively.



LEGEND

(129) Brule Formation Water Level Elevation (amsl)
3968.8

0 0.5 1.0 2.0

SCALE IN FEET 1" = 1 MILE

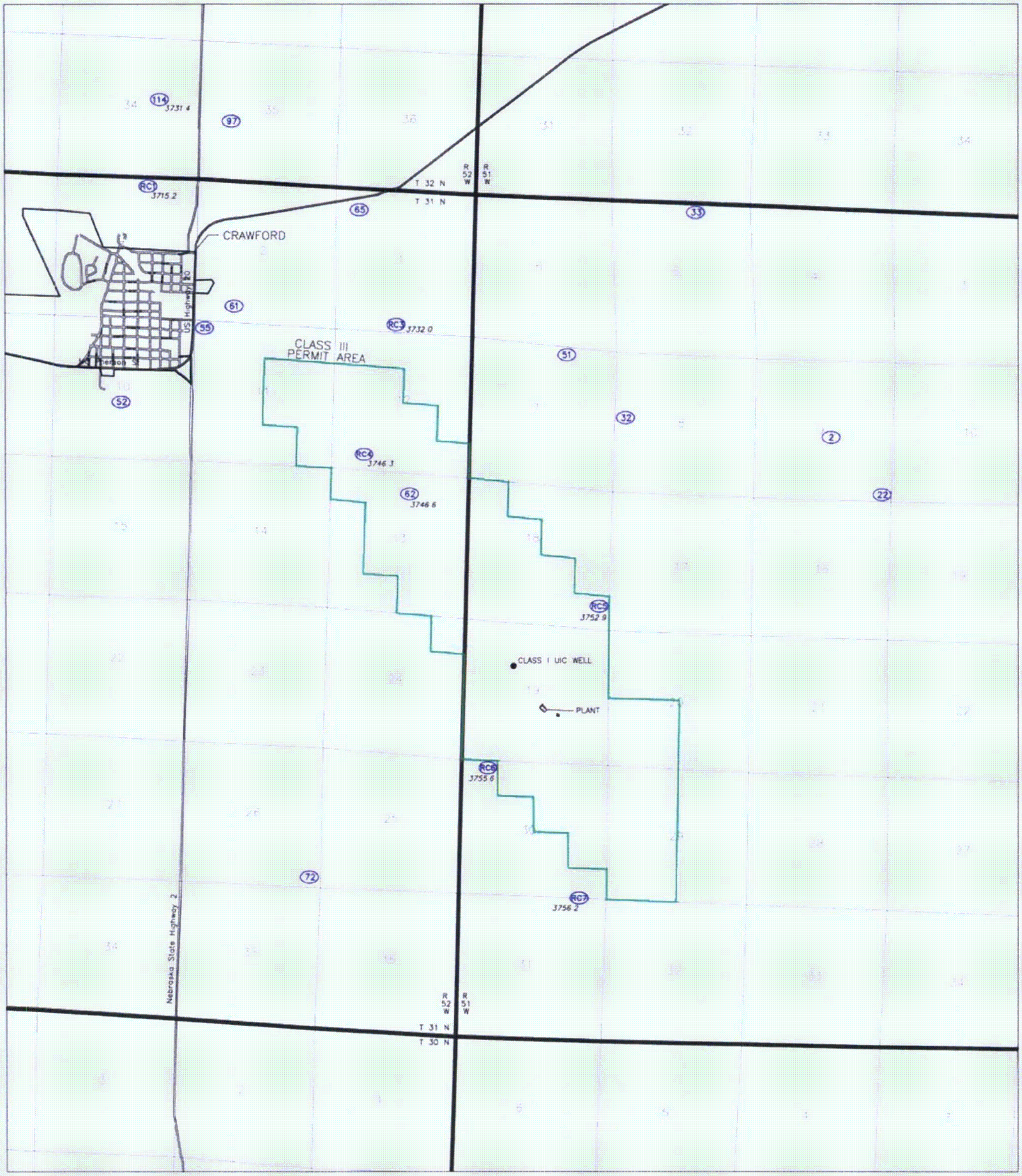
N
W — E

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-3
REGIONAL WATER LEVEL MAP
BRULE SANDSTONE 1982-1983

PROJECT: 223-37	DATE: MARCH 2007
NTAAFig2.7-2&3.dwg	BY: KRS CHECKED: HPD

Petrotek



LEGEND

(129) Chadron Formation Water Level Elevation (amsl)
3968.8

0 0.5 1.0 2.0

SCALE IN FEET 1" = 1 MILE

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-4

REGIONAL WATER LEVEL MAP
BASAL CHADRON SANDSTONE 1982-1983

PROJECT: 223-37	DATE: MARCH 2007
NTAAFig2.7-2&3.dwg	BY: KRS CHECKED: HPD

Petrotek

Table 2.7-3: Brule Water Levels (in feet above mean sea level)

	1982												1993	1993
Well	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	April	July
11**	3831.7	3831.5	3831.8	3833	3833	3833.6	3833	3832.6	3831.5	3830.6	3830.3	3830.3	3843.5*	3837
12**	3928	3924	3923	3922.7	3923.7	3921.1	3922.1	3921.5	3922.2	3921.3	3903.3*	3918.7	3922.9	3920
13	3968.5	3968.7	3968.8	3969.4	3969.6	3969.2	3969.5	3968.9	3968.1	3967.5	3968.1	3968.4	3969	3970
17	3865	3863.5	3863.3	3862.6	3863.6	3864.8	3863.3	3862.8	3863.5	3863.8	3865.3	3864.6	3864.8	3862.8
24**	3902	3910.5	3909	3903	3910.9	3910.5	3910.5	3910	3904.7	3901.5	3895.7*	3910.1	3910.4	3911
25	3870	3870.8	3870	3871	3871	3871.3	3869.5	3870.9	3870.6	3870.5	3870.8	3870.9	3870.1	3871.6
31**	3883.1	3883.1	3883.2	3883.1	3883.3	3883	3882.6	3882.3	3882.6	3880	3882.3	3882.5	3882.5*	3872.3*
64	3882	3882.9	3882.6	3883.5	3883.6	3883.8	3881.4	3880.8	3881.5	3880	3880.4	3882	3884.3	3883.5
	1982				1983									
	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Sept	
RA-2	3737.1	3737	3738.5	3737.9	3739.2	3739.1	3739.7	3740.2	3740.9	3741	3739.9	3739.2	3738.1	
RB-3	3962.6	3961.2	3963.5	3963.6	3963.8	3963.8	3963.3	3969.7*	3963.7	3963.7	3964.2	3964.1	3964.2	
PM-6	------	3844.9	3844.9	------	3843.5*	3844.5	3844.9	3845.3	3845.5	3846	3845.9	3945.9	3845.7	
PM-7	------	3845.7	3845.5	------	3845.9	3845.8	3845.7	3846.1	3846.3	3846.9	3846.7	3846.7	3846.6	

Notes:
* Suspect Data
** Well may have been pumped prior to water level reading.
------ = measurement not taken

Table 2.7-4: Basal Chadron Water Levels (in feet above mean sea level)

	1982				1983								
Well	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Sept
62	3748.4	3748	3747.2	3746.6	------	------	3746.1	3746.2	------	------	3746.1	3745.8	3745.4
RC-4	------	------	------	3746.7	------	------	------	3746.2	------	------	3746.2	3746.2	3746.3
RC-5	3753.6	3753.4	3753.4	3753.2	3753	3752.6	3752.7	3752.9	3752.8	3752.9	3752.7	3752.5	3752.4
RC-6	3755.2	3755.2	3755.7	3756.8	3757.5	3754.7	3754.9	3755.7	3755.6	3755.6	3755.4	3755.2	3754.7
RC-7	3755.2	3756.8	3756.3	3756.2	3756.4	3755.8	3756	3756.4	3756.5	3756.7	3756.2	3756.1	3755.9
PM-1	------	3754.5	3754.4	3754.1	3754.3	3754	3753.8	3754	3754.2	3754.1	3753.8	3753.5	3753.5
PM-4	------	3755.2	3755.2	3754.4	3754.4	3754.1	3754.2	3754.4	3754.8	3754.6	3754.3	3753.9	3754.6
PT-2	------	3747.1*	3747.1*	3754	3754.6	3754.3	3754.1	3754.3	3754.5	3754.7	3754.3	3753.9	3753.7
PT-7	------	3755.1	3755	3754.2	3754.2	3754	3754	3754.1	3754.8	3754.6	3754.3	3754.1	3753.9
PT-8	------	3755.5	3755.6	3754.6	3754.4	3754.4	3755.7	3754.4	3754.5	3754.6	3754.2	3753.8	3753.7
PT-9	------	3753.5	3753.5	3754.9	3754.6	3754.6	3754.6	3754.8	3854.8	3754.9	3754.5	3754.3	3754.1

Notes:

* Suspect Data

------ = measurement not taken

The Pierre is essentially impermeable which precludes its use as a water supply. A number of shallow wells are reported as having the Pierre Shale as the bedrock unit (Spalding, 1982) in Township 32 North, Range 51-52 West. These wells range in depth from 18 to 100 feet with an average depth of 44 feet, and were drilled in areas that have considerable alluvium atop the Pierre, including locations along Spring Creek and the White River between Crawford and Whitney Lake. These wells produce water from a few tens of feet of Quaternary Alluvium overlying the Pierre Shale, with the bottom few tens of feet in those wells providing storage. Spalding (1982) states that, *"In very shallow wells (a few tens of feet) significant amounts of water utilized may be contained in the thin Quaternary sediments overlying the designated hydrogeologic unit. This situation is particularly true for those wells noted as completed in the Pierre Shale"*. In the geologic summary of the Spalding report, the groundwater potential of the Pierre Shale is discussed as (page 14), *"The oldest bedrock unit in the area, the Pierre Shale of Cretaceous Age, is not considered as a potential aquifer. It is, however, included in the discussion of completion horizons and hydrogeologic units. A few of the shallow wells produce from the Quaternary sediments immediately overlying the Pierre Shale"*.

2.7.2.2 Crow Butte Area Groundwater Hydrology

The hydrogeologic system within and surrounding the Crow Butte CSA is similar to that found regionally. Alluvial deposits occur intermittently in ephemeral drainages, but are not considered to be a reliable water source. Over most of the Crow Butte License Area, the Brule Formation outcrops, and is underlain by the Chadron Formation (including the Basal Chadron Sandstone) and the Pierre Shale. The occurrence and thickness of these geologic units within the License Area have been confirmed during exploratory drilling and logging activities. Based on these data, the relationship of the hydrostratigraphic units within the License Area is shown on a cross-section location map (**Figure 2.7-5**) and two cross-sections (**Figures 2.7-6** and **2.7-7**).

The Basal Chadron Sandstone, the aquifer which is host to the uranium mineralization, is bounded above and below by strata which form aquicludes. The term "aquiclude" is used to describe strata capable of transmitting only minor amounts of fluid either vertically or horizontally. Typical values for vertical and horizontal permeability of "aquicludes" are in the range of 10^{-4} to 10^{-5} darcys (Todd 1980), which is equivalent to a hydraulic conductivity of 10^{-7} to 10^{-8} centimeters per second (cm/sec). The vertical hydraulic conductivities of the aquicludes calculated from pumping tests conducted in the CSA are on the order of 10^{-11} cm/sec (Ferret Exploration of Nebraska 1987). Laboratory analysis of cores from wells in the CSA indicates vertical hydraulic conductivities on the order of 10^{-10} to 10^{-11} cm/sec (Ferret Exploration of Nebraska 1987). Local groundwater flow within the Basal Chadron is to the east, with a gradient of 0.0016 feet per feet (ft/ft) or 8.5 feet per mile (ft/mile).

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Figure 2.7-5: Hydrostratigraphic Cross Section Location Map

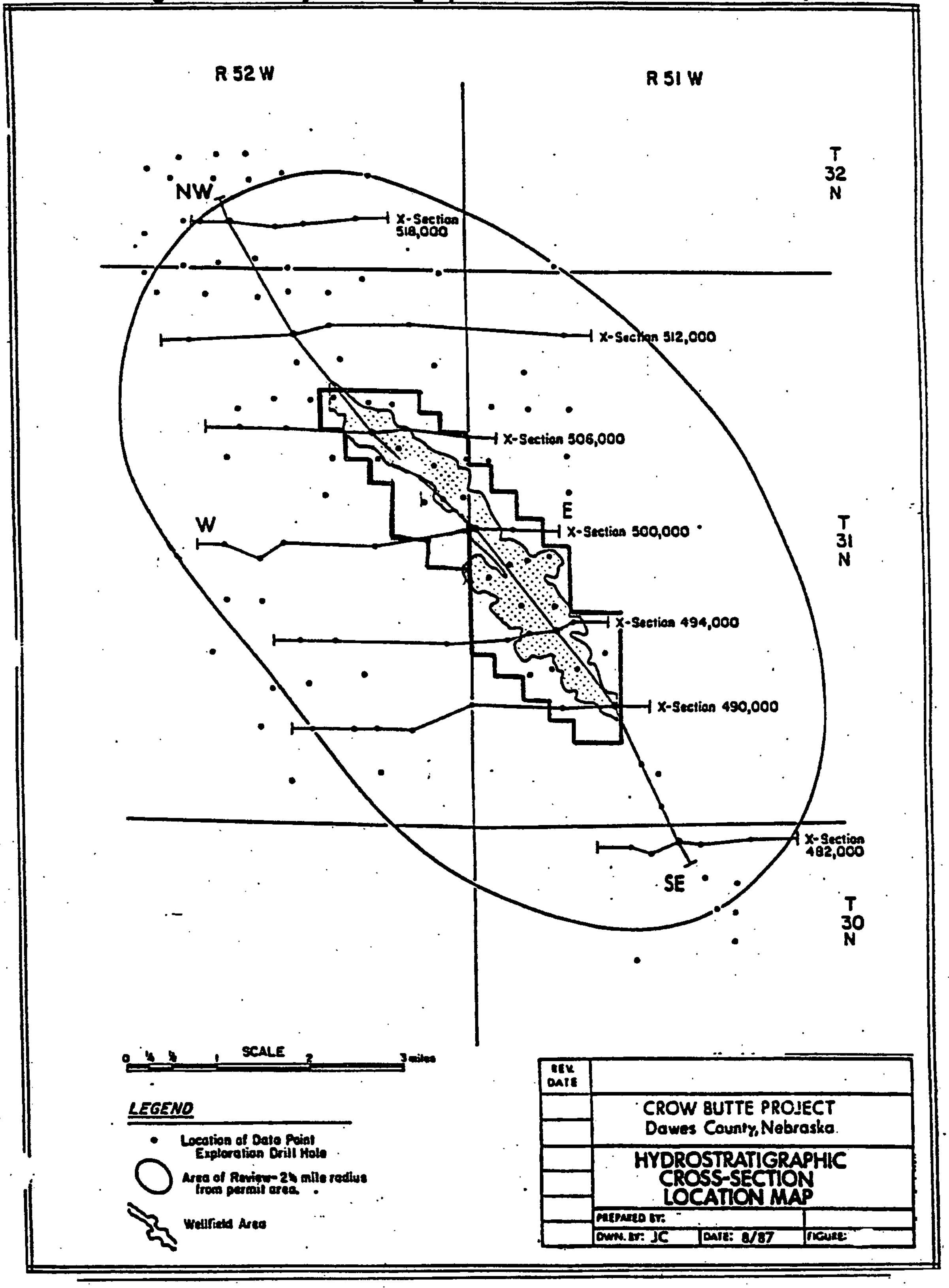


Figure 2.7-6: Northwest-Southeast Hydrostratigraphic Cross Section

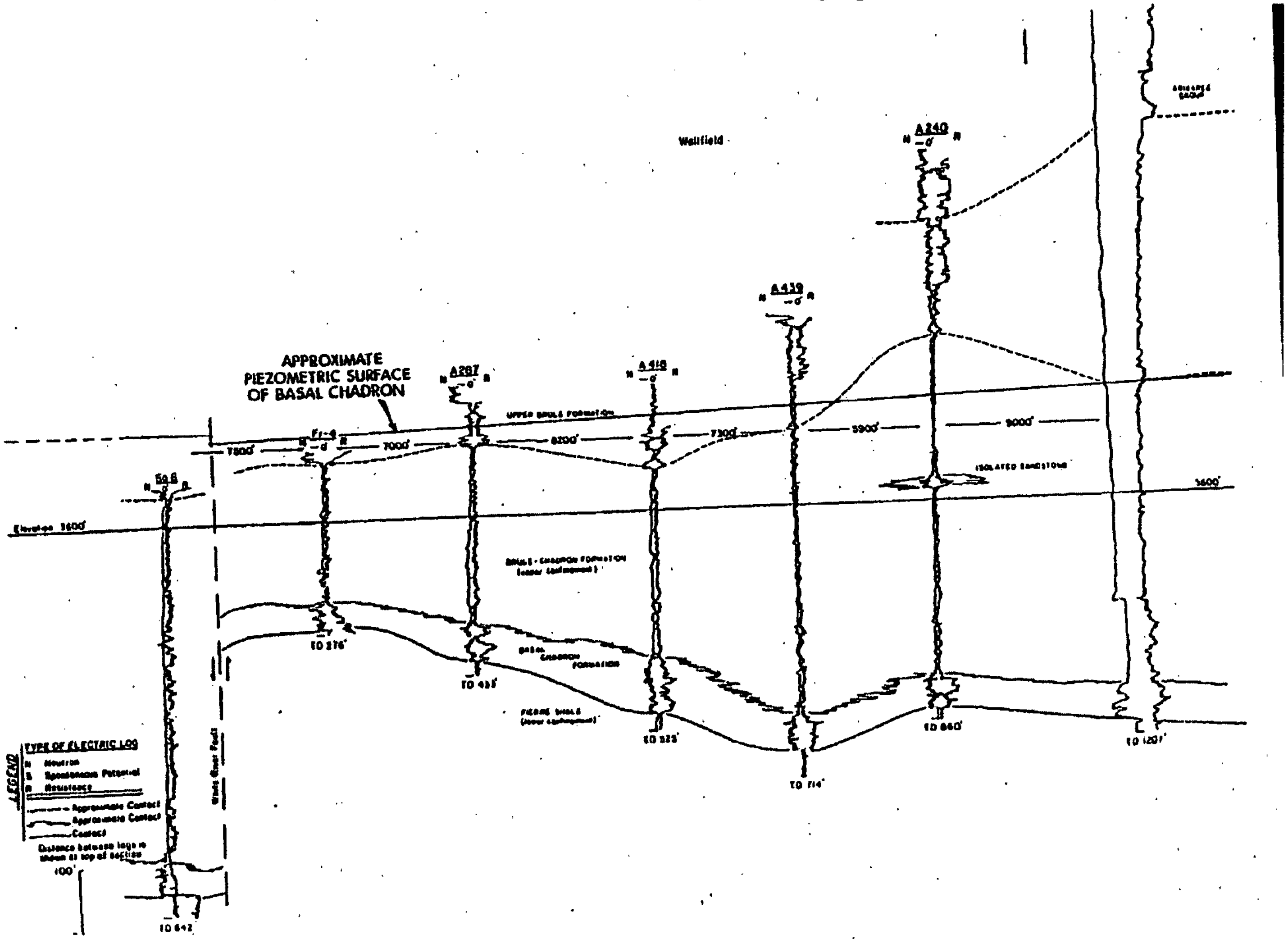
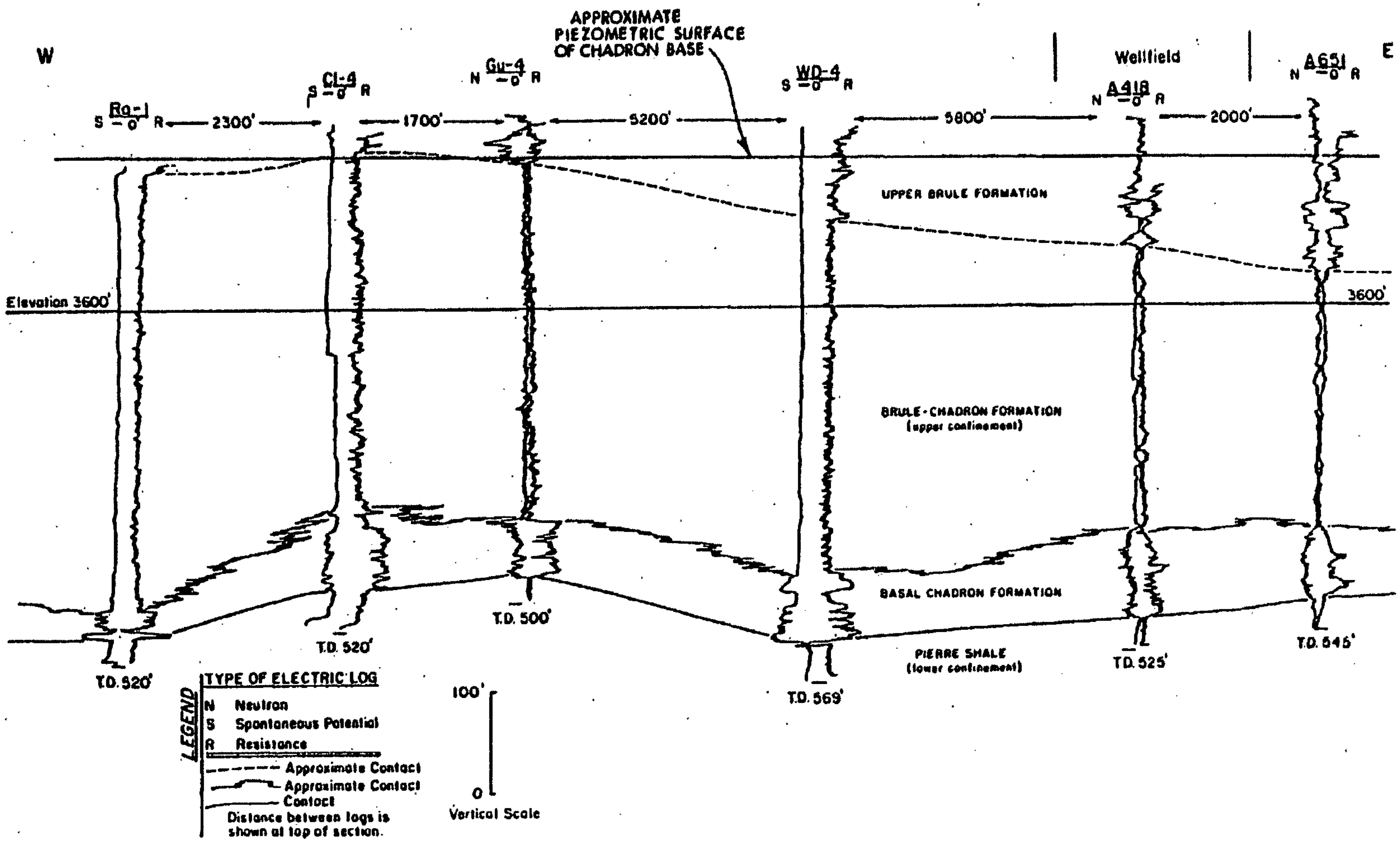


Figure 2.7-7: East-West Hydrostratigraphic Cross Section



The sandstones and sandy siltstones in the upper part of the Brule Formation may be water-bearing locally. However, these sandstones, siltstones, and clay stringers are difficult to correlate over any large distance and are discontinuous lenses rather than laterally continuous strata. As stated previously, these different sand lenses may exhibit different water levels. Brule wells PM-6 and PM-7, monitor wells in the R&D wellfield, exhibit differences in water levels which average 1 foot and range from 0.7 to 2.4 feet. In addition, recharge capacity is low in these lenses as evidenced by the low productivity of these wells and the difficulty in developing these wells. Based on only four data points, flow in the Brule is to the east/northeast at 0.005 ft/ft or 26.4 ft/mile.

Water level data support hydrologic isolation of the Basal Chadron Sandstone with respect to the other water-bearing intervals of interest in the CSA. Groundwater production rates within the Brule and Upper/Middle Chadron sands are low to exceptionally low.

The geochemical groundwater characteristics of the Brule and Chadron further indicate that the two zones are not naturally interconnected.

2.7.2.3 Aquifer Testing

CBR operates an in-situ uranium mine in Dawes County, Nebraska, southeast of the City of Crawford (**Figure 1.3-2**). The mine area spans portions of Sections 11, 12, and 13 of Township 31 North, Range 51 West and Sections 7, 19, 20, 29, and 30 of Township 31 North, Range 52 West. The NDEQ authorized CBR to operate the mine according to Underground Injection Control (UIC) regulations via UIC Permit Number NE 0122611. This permit requires CBR to complete aquifer pumping tests to demonstrate the integrity of the confining layer above the mining zone prior to mine development within the License Area. Data collected and analyzed as part of these aquifer pumping tests included pumping rate, test duration, formation characteristics, transmissivity, hydraulic conductivity, storativity, and radius of influence (ROI) so the hydraulic characteristics of the aquifer and the integrity of the confining layers near the mining sites can be evaluated.

In general, aquifer pumping tests are field experiments performed to evaluate an aquifer's recovery to the induced stress of pumping. Typically, aquifer pump tests involve the design and construction of multiple wells, both a pump well and observation wells, to monitor the aquifer's response to pumping. During the pump test, groundwater is pumped from pump wells at determined rate and for a fixed time, and water levels are measured in the surrounding observation wells throughout the test to determine the effect of pumping on the aquifer and adjacent water bearing formations. Aquifer pump tests usually involve monitoring water levels during the pumping phase, as well as after pumping has stopped, in order to determine the aquifer's recovery time. The well data are then analyzed to compute hydraulic properties of the aquifer including hydraulic conductivity, transmissivity, storativity, and ROI (Heath 1982).

CBR performed four groundwater pumping tests within the License Area boundary between 1982 and 2002 in order to comply with the requirements of the UIC permit. **Figure 2.7-8** illustrates the locations of the four pumping tests within the License Area. This section of the report summarizes the hydrogeologic characteristics of the License Area and the methods used in the aquifer pumping tests, test results, and conclusions regarding the aquifer and integrity of the confining layer within the License Area.

Purpose & Objectives of Aquifer Testing

The objectives of the aquifer pumping tests are to assess the integrity of the confining layer above the mining zone and characterize the hydrogeology of the ore-bearing aquifer in order to comply with NDEQ and USNRC permit requirements. The hydrogeologic investigation was also designed to address environmental and operational questions pertinent to ISL uranium mining at the site raised by the USNRC. Specifically, these tests address requirements are outlined by the USNRC in Regulatory Guide 3.46, Section 2.7.1 and Draft Staff Technical Position Paper WM-8203, Section 3.1.2. In general, the hydrogeologic investigation was oriented toward the characterization of the hydraulic properties of the ore-bearing aquifer and the hydraulic relationship of the aquifer to the overlying and underlying confining strata.

In addition to its use in the commercial permit application, the information gathered from the aquifer pump tests may be used for:

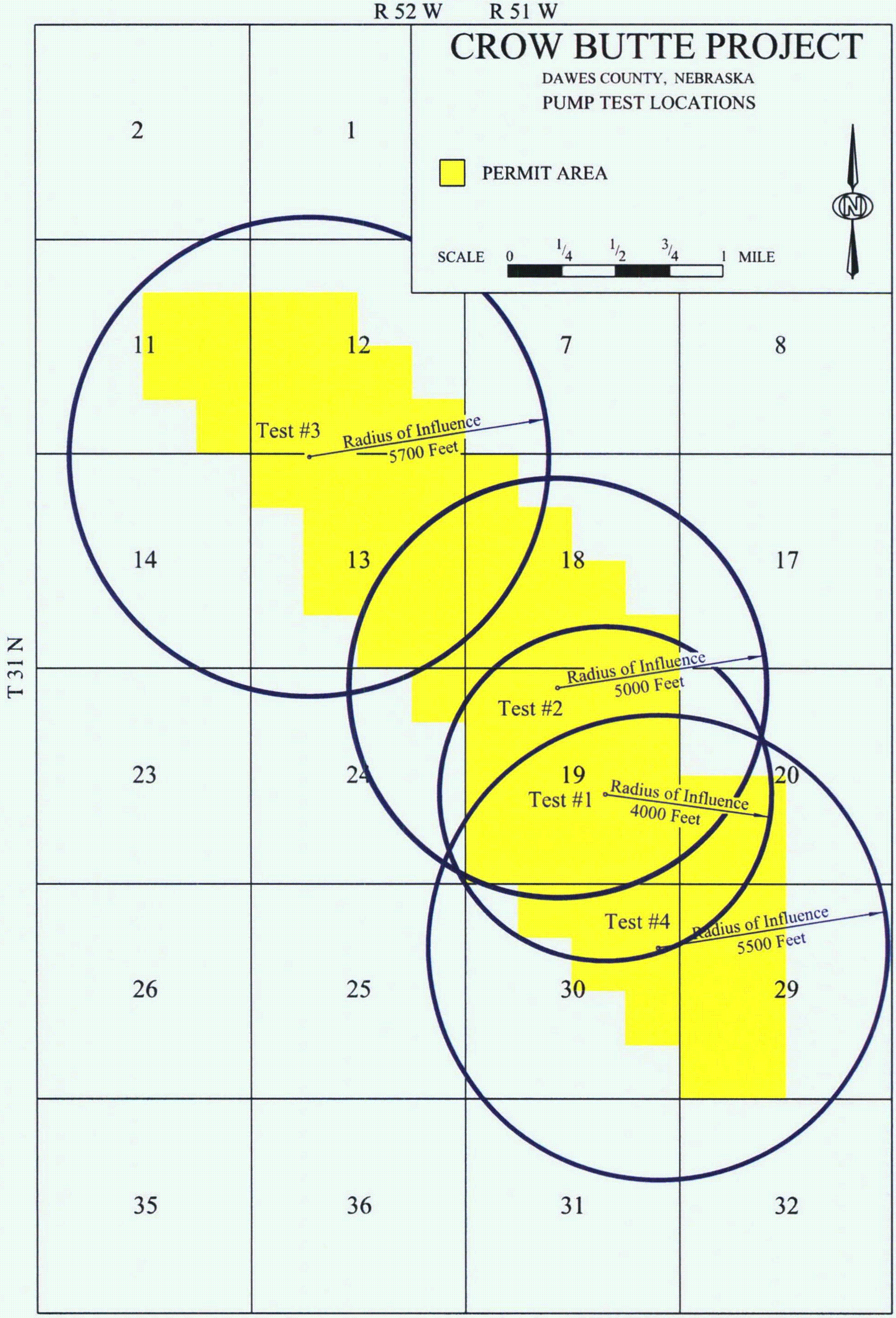
- design of the commercial wellfield,
- selection of commercial production parameters,
- design of the groundwater monitoring system, and
- prediction of the mining and restoration efficiency.

Site Characterization

CBR developed the mine to recover uranium from the Chadron Sandstone Formation. The uranium-bearing aquifer is formed by coarse-grained arkosic sandstone which is locally known as the Basal Sandstone Member of the Chadron Formation. The Basal Sandstone is believed to be the depositional product of a large, vigorous, braided-stream system which occurred during the early Oligocene age (approximately 36 to 40 million years before present).

Ore-grade uranium deposits underlying the CBR site are predominantly located in the Chadron Sandstone Formation, which occurs at depths ranging from 400 to 1,200 feet and averages 50 feet in thickness, of which 35 feet are net sand. A confining layer exists above the Chadron Sandstone Formation that is composed of the Upper Chadron and Brule Formations, which averages 300 feet thick across the site. The general stratigraphy

FIGURE 2.7-8


R 52 W
R 51 W
T 31 N
CROW BUTTE PROJECT
DAWES COUNTY, NEBRASKA
PUMP TEST LOCATIONS
PERMIT AREA
SCALE 0 1/4 1/2 3/4 1 MILE
N
2
1
11
12
7
8
14
13
18
17
23
24
19
20
26
25
30
29
35
36
31
32
Test #3
Radius of Influence
5700 Feet
Test #2
Radius of Influence
5000 Feet
Test #1
Radius of Influence
4000 Feet
Test #4
Radius of Influence
5500 Feet

of the site in both the northern and southern portions of the License Area is summarized in **Section 2.6**.

The Pierre Shale of late Cretaceous age forms the underlying confining layer for the Basal Chadron Sandstone. The Pierre Shale is a widespread dark gray to black marine shale which is essentially impermeable. Regionally, the Pierre Shale is up to 5,000 feet thick. In Dawes County, deep oil test holes have encountered thicknesses of 1,200 to 1,500 feet of Pierre Shale. The clays, claystones, and siltstones of the Middle and Upper Members of the Chadron Formation and the Lower Brule Formation form the overlying confining layer for the Basal Chadron Sandstone.

Further geologic characterization of the general area surrounding the CBR project site is available in "Application and Supporting Environmental Report for the State of Nebraska Underground Injection Control Program Commercial Permit" (Ferret of Nebraska 1987).

Aquifer Pumping Tests

Four aquifer pumping tests were performed at the CBR mine area between November 1982 and August 2002 in order to evaluate hydraulic characteristics of the Chadron Sandstone in the License Area, assess the integrity of the confining layer above the mining zone, and to comply with requirements outlined in the UIC permit.

The methods, results and conclusions regarding the hydrogeologic properties of the aquifer and confining layer above the mining zone are discussed below.

Methods

In general, the four aquifer tests employed the following methodology.

- Review of existing geologic and hydrogeologic data for the area,
- Design of appropriate aquifer test,
- Design and construction of appropriate well array for aquifer test,
- Laboratory tests of core samples from confining layers,
- Performance of aquifer test,
- Analysis of data from aquifer test, and
- Interpretation of results of test.

Aquifer pump test data collected as part of this investigation were analyzed using a variety of the following methods.

- Theis' Non-Equilibrium Method (Theis 1935) for analyzing non-equilibrium pumping test data.

- Theis' Recovery Method (Theis 1935) for analyzing recovery test data.
- Jacob's Modified Non-Equilibrium Method (Cooper and Jacob 1946) for analyzing non-equilibrium pumping test data.
- Cooper and Jacob's Distance-Drawdown Method (Cooper and Jacob 1946) for determining radius of influence.
- Hantush's Method (Hantush 1966) for determining the magnitude and direction of the major the minor horizontal axes of transmissivity in an anisotropic aquifer.
- Neuman and Witherspoon's Method (Neuman and Witherspoon 1972) for determining the hydraulic diffusivity and vertical hydraulic conductivity of confining layers.
- Darcy's Law (Darcy 1856) to determine the average pore velocity and the groundwater flux across the aquifer test site.
- Standard Consolidation Test (ASTM 1985) to determine the coefficient of consolidation, compression index, coefficient of compressibility, and vertical hydraulic conductivity of the confining layer.

The locations of each of the four aquifer tests within the CBR License Area are illustrated in **Figure 2.7-8**. Tests numbers 1 and 2 were carried out in the central portion of the License Area within Section 19 of Township 31 North, Range 51 West. Test number 3 was performed in the northwestern portion of the License Area on the border between Sections 12 and 13 of Township 31 North, Range 52 West. Test number 4 was performed in the southeastern section of the License Area within Section 30 of Township 31 North, Range 51 West.

First Aquifer Test

The first multiple-well aquifer test (Test #1) was conducted in the R&D wellfield in November 1982. The pumping period of this test was 50.75 hours and the recovery period was 27.6 hours. During this test, water levels were measured in four production zone observation wells and two shallow Brule monitor wells were measured. The data from the first aquifer test were analyzed using the Theis Non-Equilibrium Method (1935), the Jacob Modified Non-Equilibrium Method (1946) and the Theis Recovery Method (1935). The results of these analyses show that the Basal Chadron Sandstone, which is the ore-bearing aquifer at the Crow Butte site, is a non-leaky, confined, anisotropic aquifer. The effective transmissivity of the Basal Chadron Sandstone ranged from 2,453 gpd/ft (327 ft^2/day) to 3,863 gpd/ft (516 ft^2/day). The average thickness of the aquifer at the test site was about 40 feet. Average hydraulic conductivity ranged from about 61 gpd/ft^2 (8.2 ft/day) to about 97 gpd/ft^2 (13 ft/day). The average coefficient of storage ranged from 9.66×10^{-5} to 1.75×10^{-4}. The azimuth and magnitude of the major axis of transmissivity were about 2° and 3,000 gpd/ft (401 ft^2/day), respectively. The azimuth and magnitude of the minor axis of transmissivity were about 92° and 2169 gpd/ft (290 ft^2/day), respectively. Evidence from the test showed that the Basal Chadron Sandstone is not hydraulically connected to the overlying aquifer in the Brule Sand.

Results from Test #1 imply that aquicludes which overlie and underlie the Basal Chadron Sandstone probably yielded some small amount of water as recharge (or leakage) to the aquifer during the pump test. However, the amount of this recharge or leakage was extremely small as evidenced by the results of the laboratory test of the core samples and the drawdown analysis of the Basal Chadron Sandstone. The lack of substantial leakage was the result of the extremely low vertical hydraulic conductivity of the confining layers. The vertical hydraulic conductivity of the overlying confining layer, as determined from the laboratory tests of core samples, was about 7.8×10^{-7} ft/day (2.8×10^{-10} cm/sec), and that of the underlying confining layer was about 9.6×10^{-8} ft/day (3.4×10^{-11} cm/sec). Confining layers with vertical hydraulic conductivities this low are, by definition, called aquicludes rather than aquitards.

The integrity of confinement of the ore-zone aquifer (Basal Chadron Sandstone) may be characterized by the hydraulic resistance factor, c. The hydraulic resistance of the overlying aquiclude is about 53,000 years and that of the underlying aquiclude is about 34,000,000 years. The times needed for a water molecule to travel through the entire thicknesses of the aquicludes, assuming an effective porosity of 2.0 percent, under unit gradient (1 foot of head loss per foot of movement in the direction of flow) were about 1,050 years for the overlying aquiclude and about 685,000 years for the underlying aquiclude.

The piezometric surface of the Basal Chadron Sandstone dips toward the north at a gradient of about 0.04 percent (0.0004) which is equal to 1 foot per 2500 feet. Using a directional hydraulic conductivity of 10 ft/day, a gradient of 4×10^{-4} and a porosity of 29 percent, the average pore velocity across the R&D site was computed to be 5.0 ft/year. The groundwater flux across the site was computed to be 0.16 ft^3/day per unit width of the aquifer.

Second Aquifer Test

A second multiple-well aquifer test (Test #2) was performed between 10 June and 3 July 1987 in the mineralized area near the northern boundary of Section 19, Township 31 North, Range 51 West and approximately 2,800 feet north of the R&D site. The second aquifer pumping test was performed in order to characterize the hydrogeology of the mining area developed in 1987. At the Test #2 site, the Basal Sandstone is approximately 550 to 600 feet below ground surface and averages 40 feet in thickness. The Chadron Formation lies with marked unconformity on top of the Pierre Shale.

The well array used for Test #2 consisted of five wells and two high-sensitivity piezometers. One pumping well (CPW-1) and three observation wells (COW-1, COW-2, COW-3) were completed in the ore-bearing aquifer (Basal Chadron Sandstone). The three observation wells were located in an equiangular arrangement around the central pumping well. This configuration provided the data needed to define the magnitude and direction of the major and minor axes of transmissivity, the effective transmissivity, the hydraulic conductivity and the storativity of the ore-bearing aquifer. One monitor well (BMW-1) was completed in the first overlying sand of the Brule Formation. This well was used to monitor the water level in the first overlying sand during the aquifer test. Two piezometers (UCP-1, LCP-1) were completed in the confining layers which overlie and underlie the ore-bearing aquifer to provide data to calculate the vertical hydraulic conductivities of these confining layers under in-situ field conditions.

During Test #2, the pumped well (CPW-1) was equipped with a 7.5 HP submersible pump which was set at a depth of about 500 feet. Discharge pumped from the well was measured with an electronic pressure transducer and was recorded by the data-logger throughout the course of the test. The pumping phase of the aquifer test endured 72 hours between June 30, 1987 and July 3, 1987. Prior to the start of the pumping, static water levels of all the wells were measured and recorded. The recovery phase of the test lasted 72.5 hours between July 3, 1987 and July 6, 1987.

The average discharge rate during the pumping phase of the test was 47.74 gpm, and the total volume of water discharged was 206,288 gallons. Throughout the pumping phase, the discharge rate was regularly monitored to ensure that it remained constant. The static water level in the pumped well was approximately 484 feet above the top of the aquifer.

The calculated maximum drawdown in the pumped well was 36.86 feet, which is approximately 447 feet above the top of the aquifer. Barometric pressure did vary considerably during the 6-day test, which was likely the result of the passage of a low pressure system and a cold front with associated thunderstorms and subsequent high pressure.

The Jacob Non-Equilibrium Method, the Theis Non-Equilibrium Method and the Theis Recovery Method were used to analyze the aquifer test data from the three Basal Chadron Sandstone wells. A confined non-leaky type of analysis was made because leakage effects were not apparent in the test data and the piezometric surface is well above the top of the aquifer. Inspection of the results of the analyses verifies that these assumptions are valid. The Neuman-Witherspoon Method (1972) to determine the vertical hydraulic conductivity of both the over- and underlying confining area of the ore-bearing aquifer under in-situ conditions.

The transmissivities calculated from the drawdown data from the three Basal Chadron Sandstone observation wells (COW-1, COW-2, COW-3), ranged from 2682 gpd/ft (359 ft^2/day) to 2795 gpd/ft (374 ft^2/day). The storage coefficients for these wells, calculated from the same analyses, ranges from 8.44×10^{-5} to 1.31×10^{-4}. The transmissivities calculated from the recovery data from the three observation wells are slightly lower, ranging from 2604 gpd/ft (348 ft^2/day) to 2659 gpd/ft (355 ft^2/day). The average thickness of the aquifer at the test site is 40 feet. Therefore, the hydraulic conductivities calculated from the drawdown data ranged from approximately 67 gpd/ft^2 (8.96 ft/day) to 70 gpd/ft^2 (9.34 ft/day). The hydraulic conductivities calculated from the recovery data ranged from approximately 65 gpd/ft^2 (8.7 ft/day) to about 66 gpd/ft^2 (8.89 ft/day).

The Hantush Method was used to determine the direction and magnitude of the major and minor axes of transmissivity of the Basal Chadron Sandstone. The major axis of transmissivity in the Basal Chadron Sandstone lies along an azimuth of about 51° and has a magnitude of 2760 gpd/ft (369 ft^2/day). The minor axis of transmissivity has an azimuth of about 141° and a magnitude of 2692 gpd/ft 360 ft^2/day.

The overlying confining layer piezometer (UCP-1) showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test. However, this piezometer did respond to the rapid changes in barometric pressure from the low pressure weather front. Because UCP-1 did not respond to pumping, laboratory data from the consolidation tests of core samples from UCP-1 were used to calculate the hydraulic properties of the overlying confining layer. The calculated average coefficient of compressibility, a_v, of the red clay portion of the overlying confining layer, is 3.99 x 10^{-7} cm^2/g, and the calculated average vertical hydraulic conductivity is 3.49 x 10^{-11} cm/sec. Using these consolidation test data, the calculated specific storage of the red clay portion of the overlying confining layer is 3.08 x 10^{-7} cm^{-1}, and the calculated hydraulic diffusivity is 1.13 X 10^{-4} cm^2/sec. Given that the red clay is approximately 30 feet thick and the total overlying confining layer is approximately 325 feet thick, the hydraulic resistance, c, (Kruseman and de Ridder 1979) is about 830,200 years for the red clay and 9,000,000 years for the entire confining layer. Assuming an average effective porosity of the overlying confining layer of 2.0 percent, the travel time through the red clay portion of the upper confining layer would be about 16,600,000 years and that of the entire upper confining layer would be about 180,000 years under unit gradient.

Because the vertical hydraulic conductivity of the underlying confining layer (Pierre Shale), as determined from the laboratory consolidation tests, is of the same order of magnitude as the vertical hydraulic conductivity of the upper confining layers (10 to 11 cm/sec) little drawdown of LCP-1 resulted. The calculated average coefficient of compressibility, a_v, of the Pierre Shale is 5.13 x 10^{-7} cm^2/g, and the calculated average vertical permeability is 3.63 x 10^{-11} cm/sec. Using these consolidation test data, the calculated specific storage of the top 5 feet of the underlying confining layer (Pierre Shale) is 2.78 x 10^{-7} cm^{-1}, and the calculated hydraulic diffusivity is 5.22 x 10^{-3} cm^2/sec. Applying the Neuman-Witherspoon Method to the data from the aquifer test and the consolidation test produces a field vertical hydraulic conductivity of 1.45 x 10^{-9} cm/sec. Oil test holes have shown that the Pierre Shale is approximately 1,200 feet thick in the vicinity of the aquifer test site. Therefore, the calculated hydraulic resistance, c, using field measured vertical hydraulic conductivity, is about 799,900 years. The calculated hydraulic resistance using the vertical hydraulic conductivity calculated from the laboratory consolidation tests is about 31,919,000 years. The average effective porosity of the Pierre Shale is estimated to be 2.0 percent. Therefore, the travel time through the Pierre Shale would be about 16,000 years using field determined vertical hydraulic conductivity and about 638,000 years using laboratory determined vertical hydraulic conductivity under unit gradient.

The overlying aquifer monitor well, BMW-1, showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test. However, this well did respond to barometric changes that occurred during the aquifer test. Because BMW-1 did not respond to pumping, it is evident that the overlying aquifer is not in hydraulic communication with the Basal Chadron Sandstone. Therefore, the test data from BMW-1 were not further analyzed. Further, the piezometric surface of the Basal Chadron Sandstone is approximately 495 feet above the top of the aquifer, and the piezometric surface of the overlying aquifer is about 204 feet above the top of the Brule Sand. The difference between the piezometric surfaces of the two aquifers is about 59 feet. This also supports the theory that the Basal Chadron Sandstone is confined and that it is not hydraulically connected to the overlying aquifer.

The results of Test #2 indicate the Basal Chadron Sandstone, which is the ore-bearing aquifer, is a non-leaky, confined, slightly anisotropic aquifer. The effective transmissivity of the Basal Chadron Sandstone is 2726 gpd/ft. The average thickness of the aquifer at the test site is about 40 feet. Therefore, the average hydraulic conductivity is about 68 gpd/ft^2 (9.10 ft/day). The average storativity is 1.04 x 10^{-4}. The azimuth and magnitude of the major axis of transmissivity are about 51° and 2760 gpd/ft (369 ft^2/day). The azimuth and magnitude of the minor axis of transmissivity are about 141° and 2692 gpd/ft (360 ft^2/day).

The aquiclude which overlie and underlie the Basal Chadron Sandstone probably yielded some small amount of water as recharge (leakage) to the aquifer during the pumping of the aquifer test. However, the amount of this recharge or leakage was extremely small, as evidenced by the piezometer responses and the drawdown analysis of the Basal Chadron Sandstone. The overlying confining layer piezometer did not show any response attributable to the pumping. The underlying confining layer piezometer did show a maximum drawdown of 0.06 foot about 4300 minutes after pumping began. However, it is suspected that this small amount of drawdown is attributable to leakage at the annulus of the packer and borehole rather than to leakage from the confining layer.

The lack of substantial drawdown in the confining layer piezometers is attributable to the extremely low vertical hydraulic conductivity of the confining layers. The vertical hydraulic conductivity of the overlying confining layer is about 3.49 x 10^{-11} cm/sec, and that of the underlying confining layer is about 1.45 x 10^{-9} to 3.63 x 10^{-11} cm/sec, evident of an aquiclude. The calculated hydraulic resistance (c) of the entire thickness of the overlying aquiclude is about 9,000,000 years and that of the underlying aquiclude is between 799,900 years and 31,919,000 years. The times needed for a given water molecule to travel through the entire thicknesses of the aquiclude under unit gradient (one foot of head loss per foot of movement in the direction of flow) are about 180,000 years for the upper aquiclude and about 16,000 years to 638,000 years for the lower. Because the gradients would be much smaller during mining, actual travel times would be much longer than those stated above.

The piezometric surface of the Basal Chadron Sandstone dips approximately to the north at a gradient of 7.84×10^{-4}, which is equal to 1 foot per 1,275 feet. Using a directional hydraulic conductivity of 9.11 ft/day, a gradient of 7.84×10^{-4}, and a porosity of 29 percent, the average pore velocity across this part of the commercial study area was about 9.00 ft/year. The groundwater flux across the test site was computed to be about 0.29 ft^3/day per unit width of the aquifer (Darcy 1856).

Using the Cooper-Jacob Distance-Drawdown Method (Cooper and Jacob 1946), the ROI of the aquifer test in the Basal Chadron Sandstone was calculated to be about 5,000 feet. Therefore, the area investigated and characterized by Test #2 was approximately 1,803 acres.

Third Aquifer Test

A third groundwater pumping test (Test #3) was conducted in Sections 12 and 13, Township 31 North, Range 51 West, Dawes County, Nebraska between September 11, 1996 and September 13, 1996 for a duration of 55 hours. The recovery period monitoring was conducted between September 13, 1996 and September 15, 1996 and endured 44 hours. This test consisted of pumping one well (CPW96.1) completed in the Chadron Sandstone and monitoring groundwater levels in three wells (COW96.1, RC-4, A251/62) in the Chadron Sandstone, and in one well (BOW96.1) in the overlying Brule Formation. The pump test was performed using a 5 HP electrical submersible pump powered by a portable generator, which was set at a depth of 200 feet in well CPW96.1. Discharge pumped from the well was measured and recorded using a digital flow meter, and water levels were measured manually with a battery-powered level meter. Water levels in each observation well were digitally measured with a pressure transducer and recorded using a data-logger.

Aquifer pump test data were analyzed using conventional techniques including, log-log, semi-log, and distance drawdown methods developed by Theis, Jacob, and Cooper and Cooper and Jacob, respectively, using the Aquifer Test software package (Waterloo Hydrogeologic, Inc.). Data were analyzed to determine aquifer response to pumping and assess the hydraulic properties of the Chadron Sandstone.

The average pumping rate was determined to be 51.2 gallons per minute (gpm), and the drawdown of the pumping well (CPW96.1) was 65 feet. The drawdowns measured in the observation wells COW96.1, RC-4, A251/62 were 11.3 ft, 9.2 ft, and 4.5 ft, respectively. Average transmissivity (T) ranged from 300 to 350 ft^2/day. Average hydraulic conductivity (k) ranged from 8.9 to 10.3 ft/day, and average storativity ranged from 1.1×10^{-4} to 7.0×10^{-5}. Results of T, k, and storativity analyses are based on type-curve match points derived from late-time data during both pumping and recovery periods. No response to pumping or recovery period was observed in the well completed in the Brule Formation (BOW96.1). Minor fluctuations, however, in water level were observed in the Brule well, which may be attributed to barometric variations and changes in ambient temperature. The ROI was determined to be approximately 5,700 ft and to span the entire portion of the northern License Area.

Test results demonstrate the integrity of the confining layer above the mining zone and the homogeneity and isotropy of the Chadron Sandstone in the northern portion of the CBR License Area. Therefore, results confirm the integrity of the confining layer between the Chadron Sandstone and the Brule Formation.

Fourth Aquifer Test

A fourth aquifer test (Test #4) was performed in the areas of new mining development in the southeastern portion of the CBR License Area, Township 31 North, Range 52 West, between August 19, 2002 and August 25, 2002. The pump test endured 64.5 hours and recovery monitoring was completed between 22 and 26 August. Test #4 involved the installation of one new pumping well (CPW2002) at a depth of 740 ft and four new observation wells (COW2002, CM9-04, CM9-13 and CM9-14) at depths ranging from 740 to 840 ft in the Chadron Sandstone. Also, one new monitoring well (SM9-10) was installed in the Brule Formation at a depth of 250 ft.

Test #4 was performed using a 7.5 HP electrical submersible pump powered by a portable generator and set to an approximate depth of 440 ft in well CPW2002. Water levels in each well were measured using pressure transducers and recorded using data loggers for the duration of the test. The average pumping rate was 50.2 gpm. The drawdown in the pumping well at the end of the pumping period was 45.3 ft. Drawdown in the Chadron observation wells (CM9-04, CM9-13, CM9-14, and COW2002) were 4.9 ft, 5.8 ft, 5.2 ft, and 2.4 ft, respectively. No drawdown was observed in the Brule Formation observation well (SM9-10).

Similar to Test #3, aquifer pump data for Test #4 were analyzed using conventional techniques including, log-log, semi-log, and distance drawdown methods developed by Theis, Jacob, and Cooper and Cooper and Jacob, respectively, using the Aquifer Test software package (Waterloo Hydrogeologic, Inc.) and based on an average aquifer thickness of 40 ft. Analyses of T, k, and storativity are based on type-curve match points derived from middle-time data during both pumping and recovery periods. Assumptions made in the analyses included a constant flow rate in an infinite, homogeneous, and isotropic aquifer. ROI was determined based on distance-drawdown analysis of data from pumping well COW2002 and observation wells CM9-04, CM9-13, and CM9-14, as well as a minimum drawdown of 1.0 ft.

T values for the observation wells in the Chadron Sandstone ranged from 658 ft^2/day (CM9-14) to 1,261 ft^2/day (COW2002) and averaged 826 ft^2/day. Hydraulic conductivity (k) values ranged from 16.4 ft/day (CM9-14) to 31.5 ft/day (COW2002) and averaged 20.6 ft/day. Storativity values ranged from 4.8 x 10^{-5} to 8.2 x 10^{-5}. Distance-drawdown analysis of observation well data produced a T value of 747 ft^2/day and a storativity of 8.1 x 10^{-5}. No significant response to pumping or recovery period was observed in the Brule Formation observation well. The ROI was found to be approximately 5,500 ft and to encompass the entire southern portion of the License Area.

Analysis of pumping well COW2002 data produced the highest T and k values. Storativity values imply a highly confined aquifer. Minor water level fluctuations observed in the wells during the test may be attributed to mining operations occurring in Mine Units 5 and 7 as well as barometric effects.

Results

Table 2.7-5 summarizes the results of the four aquifer tests performed at the CBR in-situ uranium mine site between 1982 and 2002. Duration of the four pump tests ranged from 51 to 72 hours and averaged 61 hours. Test pumping rates ranged from abut 24 to 51 gpm and averaged 43 gpm. Minimum transmissivity was 330 ft^2/day (Test #2) and maximum transmissivity was 836 ft^2/day (Test #4). Average transmissivity was 479 ft^2/day. Hydraulic Conductivities ranged from 9.0 ft/day to 20.6 ft/day and averaged 12.13 ft/day. Average storativity was calculated to be 8.8 x 10^{-5} and ranged from 9.0 x 10^{-5} to 1.0 x 10^{-4}. Average ROI was 5,050 ft and ranged from 4,000 (Test #1) to 5,700 ft (Test #3).

Table 2.7-5: Summary of Aquifer Pumping Tests Performed within the CBR License Area

Test Number	1	2	3	4	Arithmetic Average
Date Conducted (month, year)	November, 1982	June, 1987	September, 1996	August, 2002	
Test Duration (hours)	51	72	55	64.5	61
Pumping Rate (gpm)	23.8	47.2	51.2	50.2	43.1
Transmissivity (ft^2/day)	400	360	330	826	479
Hydraulic Conductivity (ft/day)	9.0	9.1	9.8	20.6	12.13
Storativity	1.0 X 10^{-4}	1.0 X 10^{-4}	9.0 X 10^{-5}	6.2 X 10^{-5}	8.8 X 10^{-5}
Radius of Influence (ft)	4000	5000	5700	5500	5050

Analysis of Results

The increase in transmissivity from Test #1 to Test #4 is expected as average aquifer thickness is about 33 ft in the northern License Area and 45 ft in the southern License Area. Tests #1 and #2 characterized the aquifer as anisotropic to slightly anisotropic, whereas Tests #3 and #4 characterized the aquifer as isotropic. The differences in isotropy may be attributed to more variability in hydraulic conductivities in the central portion of the License Area (sites of Test #1 and #2) compared to the northern (site of Test #3) and southern portions (site of Test #4) of the License Area. Higher k values found in Test #4 may indicate that higher quality sand is found in the southern portion of the License Area compared to the northern portions of the property. Even though the k value was determined to be higher for Test #4 than the other tests, they are all the same order of magnitude, which indicate a homogeneous aquifer. Low storativity values from all tests indicate a confined aquifer. Decreasing storativity values from north to south within the License Area may imply a more deeply confined aquifer in the south. Test results also indicated a non-leaky aquifer.

Conclusions

In general, pump test results indicate that the Chadron Sandstone is relatively homogeneous within the CBR License Area. Results demonstrate the integrity of the confining layer above the mining zone throughout the CBR License Area. Due to the stability of the confining layer above the mining zone, it is likely that the mining development at the site will not significantly impact the aquifer.

2.7.3 Surface Water and Groundwater Quality

Historical surface water quality data for the White River (assembled by USEPA) and historical groundwater quality data from the CSA for the Brule Alluvium, Brule Formation, and Basal Chadron Formation are presented in **Section 6**.

Monitoring was conducted to establish baseline groundwater quality conditions in the License Area. The program was conducted in 1996 and 1997, and includes samples from a Basal Chadron well (Well 81) and Brule well (Well 78) in the License Area. The radiological results of baseline sampling for these wells and a detailed analysis are included in **Section 6**. These data establish the groundwater conditions associated with the mineralized Basal Chadron sandstone and Brule in the CSA at a location immediately outside and northeast of the License Area.

Table 2.7-6 through **Table 2.7-16** are the Baseline and Restoration Values for Mine Units 1 through 5 in the CSA area. The License Area ore body is considered a zone of distinct water quality characteristics primarily due to the presence of relatively concentrated uranium and radium in the zone when compared to the concentration of these parameters outside of the zone.

Table 2.7-6: Baseline and Restoration Values for Mine Unit 1

Parameter	Groundwater Standard	MU-1 Baseline	MU-1 Standard Deviation	MU-1 NDEQ Restoration Value
Ammonium (mg/L)	10.0	<0.372		10.0
Arsenic (mg/L)	0.05	<0.00214		0.05
Barium (mg/L)	1.0	<0.1		1.0
Cadmium (mg/L)[1]	0.01	<0.00644		0.005[1]
Chloride (mg/L)	250.0	203.9	38	250.0
Copper (mg/L)	1.0	<0.017		1.0
Fluoride (mg/L)	4.0	0.686	0.04	4.0
Iron (mg/L)	0.3	<0.0441		0.3
Mercury (mg/L)	0.002	<0.001		0.002
Manganese (mg/L)	0.05	<0.011		0.05
Molybdenum (mg/L)	1.0	<0.0689		1.0
Nickel (mg/L)	0.15	<0.0340		0.15
Nitrate (mg/L)	10.0	<0.050		10.0
Lead (mg/L)	0.05	0.0315		0.05
Radium (pCi/L)	5.0	229.7	177.1	584.0
Selenium (mg/L)	0.01	<0.00323		0.05
Sodium (mg/L)	N/A	412	19.2	4120
Sulfate (mg/L)	250.0	356.2	9.4	375
Uranium (mg/L)	5.0	0.0922	0.089	5.0
Vanadium (mg/L)	0.2	<0.0663		0.2
Zinc (mg/L)	5.0	<0.036		5.0
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/L)	N/A	12.5	3.2	125.0
Total Carbonate (mg/L)	N/A	351	31.1	585
Potassium (mg/L)	N/A	12.5	1.5	125.0
Magnesium (mg/L)	N/A	3.2	0.8	32.0
TDS (mg/L)	N/A	1170.2	47.6	1170.2

[1] Standard for Cadmium lowered in modification to UIC permit dated March 9, 2001 following NDEQ approval of Mine Unit 1 restoration.

Table 2.7-7: Baseline and Restoration Values for Mine Unit 2

Parameter	Groundwater Standard	MU-2 Baseline	MU-2 Standard Deviation	MU-2 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.37	0.07	10.0
Arsenic (mg/L)	0.05	<0.001		0.05
Barium (mg/L)	1.0	<0.1		1.0
Cadmium (mg/L)	0.005	<0.007		0.005
Chloride (mg/L)	250.0	208.6	30.8	250.0
Copper (mg/L)	1.0	<0.013		1.0
Fluoride (mg/L)	4.0	0.67	0.04	4.0
Iron (mg/L)	0.3	<0.045		0.3
Mercury (mg/L)	0.002	<0.001		0.002
Manganese (mg/L)	0.05	<0.01		0.05
Molybdenum (mg/L)	1.0	<0.073		1.0
Nickel (mg/L)	0.15	<0.037		0.15
Nitrate (mg/L)	10.0	<0.039		10.0
Lead (mg/L)	0.05	<0.035		0.05
Radium (pCi/L)	5.0	234.5	411.8	1058.0
Selenium (mg/L)	0.05	<0.001		0.05
Sodium (mg/L)	N/A	410.8	18.2	4108
Sulfate (mg/L)	250.0	348.2	10.3	369.0
Uranium (mg/L)	5.0	0.046	0.037	5.0
Vanadium (mg/L)	0.2	<0.07		0.2
Zinc (mg/L)	5.0	<0.026		5.0
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/L)	N/A	13.4	2.4	134.0
Total Carbonate (mg/L)	N/A	366.9	13.3	585.0
Potassium (mg/L)	N/A	12.6	2.5	126.0
Magnesium (mg/L)	N/A	3.5	0.4	35.0
TDS (mg/L)	N/A	1170.4	41	1170.4

Table 2.7-8: Baseline and Restoration Values for Mine Unit 3

Parameter	Groundwater Standard	MU-3 Baseline	MU-3 Standard Deviation	MU-3 NDEQ Restoration Value
Ammonium (mg/L)	10.0	<0.329		10.0
Arsenic (mg/L)	0.05	<0.001		0.05
Barium (mg/L)	1.0	<0.1		1.0
Cadmium (mg/L)	0.005	<0.01		0.005
Chloride (mg/L)	250.0	197.6	16.7	250.0
Copper (mg/L)	1.0	<0.0108		1.0
Fluoride (mg/L)	4.0	0.719	0.05	4.0
Iron (mg/L)	0.3	<0.05		0.3
Mercury (mg/L)	0.002	<0.001		0.002
Manganese (mg/L)	0.05	<0.01		0.05
Molybdenum (mg/L)	1.0	<0.1		1.0
Nickel (mg/L)	0.15	<0.05		0.15
Nitrate (mg/L)	10.0	<0.0728		10.0
Lead (mg/L)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	165	222.5	611.0
Selenium (mg/L)	0.05	<0.00115		0.05
Sodium (mg/L)	N/A	428	27.6	4280
Sulfate (mg/L)	250.0	377.0	13.4	404.0
Uranium (mg/L)	5.0	0.115	0.158	5.0
Vanadium (mg/L)	0.2	<0.1		0.2
Zinc (mg/L)	5.0	<0.0131		5.0
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/L)	N/A	13.3	3.1	133.0
Total Carbonate (mg/L)	N/A	358.7	24.8	592.0
Potassium (mg/L)	N/A	13.9	4.0	139.0
Magnesium (mg/L)	N/A	3.5	0.9	35.0
TDS (mg/L)	N/A	1183.0	47.4	1183.0

Table 2.7-9: Baseline and Restoration Values for Mine Unit 4

Parameter	Groundwater Standard	MU-4 Baseline	MU-4 Standard Deviation	MU-4 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.288	0.08	10.0
Arsenic (mg/L)	0.05	<0.00209		0.05
Barium (mg/L)	1.0	<0.1		1.0
Cadmium (mg/L)	0.005	<0.01		0.005
Chloride (mg/L)	250.0	217.5	34.9	250.0
Copper (mg/L)	1.0	<0.0114		1.0
Fluoride (mg/L)	4.0	0.745	0.05	4.0
Iron (mg/L)	0.3	<0.0504		0.3
Mercury (mg/L)	0.002	<0.001		0.002
Manganese (mg/L)	0.05	<0.01		0.05
Molybdenum (mg/L)	1.0	<0.1		1.0
Nickel (mg/L)	0.15	<0.05		0.15
Nitrate (mg/L)	10.0	<0.114		10.0
Lead (mg/L)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	154.3	171.5	496.0
Selenium (mg/L)	0.05	<0.00244		0.05
Sodium (mg/L)	N/A	416.6	27.8	4166
Sulfate (mg/L)	250.0	337.2	19.3	375.0
Uranium (mg/L)	5.0	<0.122		5.0
Vanadium (mg/L)	0.2	<0.0984		0.2
Zinc (mg/L)	5.0	<0.0143		5.0
pH (Std. Units)	6.5 - 8.5	8.68	0.3	6.5 – 9.28
Calcium (mg/L)	N/A	11.2	2.9	112.0
Total Carbonate (mg/L)	N/A	374.4	28	610.0
Potassium (mg/L)	N/A	16.7	4.7	167.0
Magnesium (mg/L)	N/A	2.8	0.8	28.0
TDS (mg/L)	N/A	1221.1	73.5	1221.1

Table 2.7-10: Baseline and Restoration Values for Mine Unit 5

Parameter	Groundwater Standard	MU-5 Baseline	MU-5 Standard Deviation	MU-5 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.28	0.05	10.0
Arsenic (mg/L)	0.05	<0.001		0.05
Barium (mg/L)	1.0	<0.10		1.0
Cadmium (mg/L)	0.005	<0.01		0.005
Chloride (mg/L)	250.0	191.9	7.9	250.0
Copper (mg/L)	1.0	<0.01		1.0
Fluoride (mg/L)	4.0	0.64	0.07	4.0
Iron (mg/L)	0.3	<0.05		0.3
Mercury (mg/L)	0.002	<0.001		0.002
Manganese (mg/L)	0.05	<0.01		0.05
Molybdenum (mg/L)	1.0	<0.10		1.0
Nickel (mg/L)	0.15	<0.05		0.15
Nitrate (mg/L)	10.0	<0.1		10.0
Lead (mg/L)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	166.0	184.6	535.0
Selenium (mg/L)	0.05	<0.002		0.05
Sodium (mg/L)	N/A	397.6	14.4	3976
Sulfate (mg/L)	250.0	364.5	10.5	385.0
Uranium (mg/L)	5.0	0.072	0.056	5.0
Vanadium (mg/L)	0.2	<0.10		0.2
Zinc (mg/L)	5.0	<0.02		5.0
pH (Std. Units)	6.5 - 8.5	8.5	0.1	6.5 – 8.5
Calcium (mg/L)	N/A	12.6	1.8	126.0
Total Carbonate (mg/L)	N/A	372	13.0	590.0
Potassium (mg/L)	N/A	11.5	1.2	115.0
Magnesium (mg/L)	N/A	3.4	0.4	34.0
TDS (mg/L)	N/A	1179.5	22.5	1202.0

Table 2.7-11: Baseline and Restoration Values for Mine Unit 6

Parameter	Groundwater Standard	MU-6 Baseline	MU-6 Standard Deviation	MU-6 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.32	0.05	10.0
Arsenic (mg/L)	0.05	0.002		0.05
Barium (mg/L)	1.0	0.100		1.0
Cadmium (mg/L)	0.005	0.009		0.005
Chloride (mg/L)	250.0	206	15.4	250.0
Copper (mg/L)	1.0	0.012		1.0
Fluoride (mg/L)	4.0	0.65	0.03	4.0
Iron (mg/L)	0.3	0.050		0.3
Mercury (mg/L)	0.002	0.001		0.002
Manganese (mg/L)	0.05	0.010		0.05
Molybdenum (mg/L)	1.0	0.102		1.0
Nickel (mg/L)	0.15	0.050		0.15
Nitrate (mg/L)	10.0	0.1		10.0
Lead (mg/L)	0.05	0.050		0.05
Radium (pCi/L)	5.0	80.6	121.9	325
Selenium (mg/L)	0.05	0.001		0.05
Sodium (mg/L)	N/A	400	12.8	4000
Sulfate (mg/L)	250.0	361	14.6	390
Uranium (mg/L)	5.0	0.133	0.212	5.0
Vanadium (mg/L)	0.2	0.098		0.2
Zinc (mg/L)	5.0	0.011		5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.2	6.5 – 9.0
Calcium (mg/L)	N/A	12.8	2.3	128
Total Carbonate (mg/L)	N/A	367.1	22.9	596
Potassium (mg/L)	N/A	11.9	1.7	119
Magnesium (mg/L)	N/A	3.2	0.7	32
TDS (mg/L)	N/A	1192	28.1	1220

Table 2.7-12: Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.42	0.08	10.0
Arsenic (mg/L)	0.05	0.001		0.05
Barium (mg/L)	1.0	0.10		1.0
Cadmium (mg/L)	0.005	0.007		0.005
Chloride (mg/L)	250.0	198	22.6	250.0
Copper (mg/L)	1.0	0.01		1.0
Fluoride (mg/L)	4.0	0.70	0.05	4.0
Iron (mg/L)	0.30	0.05		0.30
Mercury (mg/L)	0.002	0.001		0.002
Manganese (mg/L)	0.05	0.01		0.05
Molybdenum (mg/L)	1.00	0.10		1.00
Nickel (mg/L)	0.15	0.05		0.15
Nitrate (mg/L)	10.0	0.1		10.0
Lead (mg/L)	0.05	0.05		0.05
Radium (pCi/L)	5.0	142	148.0	438
Selenium (mg/L)	0.05	0.004		0.05
Sodium (mg/L)	N/A	387	21.6	3,870
Sulfate (mg/L)	250.0	346	20.1	386
Uranium (mg/L)	5.0	0.110	0.138	5.0
Vanadium (mg/L)	0.2	0.10		0.2
Zinc (mg/L)	5.0	0.01		5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.3	6.5 – 9.2
Calcium (mg/L)	N/A	12.2	2.6	122
Total Carbonate (mg/L)	N/A	356		588
Potassium (mg/L)	N/A	12.9	3.0	129
Magnesium (mg/L)	N/A	3.2	0.7	32
TDS (mg/L)	N/A	1,176	40.7	1,217

Table 2.7-13: Baseline and Restoration Values for Mine Unit 8

Parameter	Groundwater Standard	MU-8 Baseline	MU-8 Standard Deviation	MU-8 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.682	0.222	10.0
Arsenic (mg/L)	0.05	0.002	0.001	0.05
Barium (mg/L)	1.0	0.099	0.005	1.0
Cadmium (mg/L)	0.005	0.005		0.005
Chloride (mg/L)	250	196	53.8	250
Copper (mg/L)	1.0	0.01		1.0
Fluoride (mg/L)	4.0	0.638	0.048	4.0
Iron (mg/L)	0.30	0.135	0.086	0.30
Mercury (mg/L)	0.002	0.001		0.002
Manganese (mg/L)	0.05	0.01		0.05
Molybdenum (mg/L)	1.0	0.093	0.023	1.00
Nickel (mg/L)	0.15	0.049	0.003	0.15
Nitrate (mg/L)	10.0	0.2		10.0
Lead (mg/L)	0.05	0.049	0.003	0.05
Radium (pCi/L)	5.0	124.4	151.8	428
Selenium (mg/L)	0.05	0.004		0.05
Sodium (mg/L)	N/A	416.8	41.8	4,168
Sulfate (mg/L)	250	312	33	378
Uranium (mg/L)	5.0	0.188	0.140	5.0
Vanadium (mg/L)	0.2	0.127	0.122	0.2
Zinc (mg/L)	5.0	0.013	0.008	5.0
pH (Std. Units)	6.5 - 8.5	8.67	0.37	6.5 – 9.41
Calcium (mg/L)	N/A	12.3	3.5	123
Total Carbonate (mg/L)	N/A	377	15.6	569
Potassium (mg/L)	N/A	11.8	3.2	117.8
Magnesium (mg/L)	N/A	2.7	0.92	27.1
TDS (mg/L)	N/A	1,137	97.4	1,234

Table 2.7-14: Baseline and Restoration Values for Mine Unit 9

Parameter	Groundwater Standard	MU-9 Baseline	MU-9 Standard Deviation	MU-9 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.40	0.05	10.0
Arsenic (mg/L)	0.05	0.001	0.000	0.05
Barium (mg/L)	1.0	0.1	0.0	1.0
Cadmium (mg/L)	0.005	0.005	0.000	0.005
Chloride (mg/L)	250	203	13	250
Copper (mg/L)	1.0	0.01	0.00	1.0
Fluoride (mg/L)	4.0	0.8	0.0	4.0
Iron (mg/L)	0.3	0.04	0.01	0.3
Mercury (mg/L)	0.002	0.001	0.000	0.002
Manganese (mg/L)	0.05	0.01	0.00	0.05
Molybdenum (mg/L)	1.0	0.1	0.0	1.0
Nickel (mg/L)	0.15	0.05	0.00	0.15
Nitrate (mg/L)	10.0	0.06	0.01	10.0
Lead (mg/L)	0.05	0.05	0.00	0.05
Radium (pCi/L)	5.0	164	238	640
Selenium (mg/L)	0.05	0.003	0.001	0.05
Sodium (mg/L)	N/A	380	11	3,800
Sulfate (mg/L)	250	320	15	350
Uranium (mg/L)	5.0	0.1	0.24	5.0
Vanadium (mg/L)	0.2	0.1	0.0	0.2
Zinc (mg/L)	5.0	0.01	0.00	5.0
pH (Std. Units)	6.5 - 8.5	8.35	0.30	6.5 – 9.41
Calcium (mg/L)	N/A	13.6	4.6	136
Total Carbonate (mg/L)	N/A	383	14	595
Potassium (mg/L)	N/A	13.9	3.0	139
Magnesium (mg/L)	N/A	3.5	1.2	35.0
TDS (mg/L)	N/A	1,152	38	1,190

Table 2.7-15: Baseline Well Restoration Table Mine Unit 10

Parameter	Units	Groundwater Standard	Wellfield Average	Standard Deviation	NDEQ Restoration Value
Ammonia (NH_4 as N)	mg/L	10.0	0.34	0.07	10.0
Arsenic (As)	mg/L	0.010	0.001	0.001	0.010
Barium (Ba)	mg/L	2.0	0.1	0.0	2.0
Cadmium (Cd)	mg/L	0.005	0.005	0.000	0.005
Calcium (Ca)	mg/L	---	11.8	2.6	118.0
Chloride (Cl)	mg/L	250	185	14	250
Copper (Cu)	mg/L	1.3	0.01	0.01	1.3
Fluoride (F)	mg/L	4.0	0.72	0.10	4.0
Iron (Fe)	mg/L	0.3	0.03	0.01	0.3
Lead (Pb)	mg/L	0.015	0.001	0.0	0.015
Magnesium (Mg)	mg/L	---	3.4	0.7	34.0
Managanese (Mn)	mg/L	0.05	0.01	0.0	0.05
Mercury (Hg)	mg/L	0.002	0.001	0.0	0.002
Molybdenum (Mo)	mg/L	1.0	0.1	0.0	1.0
Nickel (Ni)	mg/L	0.15	0.05	0.0	0.15
Nitrite + Nitrate as N ($NO_3 + NO_2$)[1]	mg/L	10.0	0.1	0.0	10.0
pH	Std. Units	6.5 - 8.5	8.51	0.19	6.5 - 8.89
Potassium (K)	mg/L	---	10.1	1.6	101
Radium-226	pCi/L	5.0	87.3	161.0	409.3
Selenium (Se)	mg/L	0.05	0.003	0.002	0.05
Sodium (Na)	mg/L	---	388	12	3880
Sulfate (SO4)	mg/L	250.0	329	25	379
Total Carbonate ($CO_3 + HCO_3$)[2]	mg/L	---	394	15	550.5
Total Dissolved Solids	mg/L	---	1101	26	1127
Uranium (U)	mg/L	0.03	0.0378	0.0351	0.108
Vanadium (V)	mg/L	0.2	0.1	0.0	0.2
Zinc (Zn)	mg/L	5.0	0.01	0.01	5.0

1 Nitrate was reported by the lab as $NO_3 + NO_2$ instead of NO_3 as required in the permit. However, only two samples, well 4024 collected 6/09/06 and well CM8-6 collected 5/02/02, were above the detection limits. The restoration value is 10.0 mg/L while the average is 0.1 mg/L. Therefore, including NO_2 has no bearing on determining the restoration value. Nitrite, NO_2, was also analyzed for and all samples were below the detection limit of 0.10 mg/L.

2 Total carbonate = alkalinity as $CaCO_3$ x 1.2

Standard formulas were used to calculate the average and standard deviation but the true values, especially for the standard deviation, are most likely significantly smaller than shown. This results in a conservative estimate of the standard deviation.

--- no NDEQ standard

Available groundwater data for both the Brule and Chadron do not indicate that there are any documented flow rate variations or recharge issues that would impact groundwater quality. There are no surface water ponds within the area, and only limited stream flow (**Section 2.7.1**). The Brule, while considered an overlying aquifer, is not an extensive or exceptionally productive system. The available monitoring data do not indicate any seasonality or pumping effects by domestic wells within this zone. With respect to the Basal Chadron sandstone, there are no domestic wells completed within this interval in the immediate License Area, and there is no information to indicate that there are recharge or flow rate issues associated with the Basal Chadron sandstone that would affect groundwater quality.

During the course of mining, the water quality is expected to change as outlined in **Table 2.7-16.** The chemicals used in the mining and recovery process will include sodium bicarbonate, an oxidizer (such as oxygen), carbon dioxide, and chloride for elution. As a result, the greatest changes in water quality are expected to be in alkalinity, bicarbonate, chloride, sodium, conductivity, and TDS. Significant increases are also likely to occur in calcium concentrations as a result of ion exchange with clays. The oxidant will cause significant increases in uranium, vanadium, and radium and minor increases in trace metals such as copper, arsenic, molybdenum, and selenium. Historic restoration activities at the CSA have demonstrated the ability to successfully restore groundwater to established restoration standards.

Table 2.7-16: Changes in Water Quality during Mining

Average Ore Zone Water Quality			
Analyte	**Units**	**MU 1-10 Pre-Mining Average**	**Typical Water Quality During Mining at CSA**
Total Carbonate ($HCO_3 + CO_3$)	mg/L	370	1,920
Calcium	mg/L	12.6	77
Chloride	mg/L	201	600
Fluoride	mg/L	0.697	0.6
Magnesium	mg/L	3.2	23
Ammonia as N	mg/L	0.38	<0.05
Nitrate+Nitrite as N	mg/L	0.094	0.46
Potassium	mg/L	12.8	35
Sodium	mg/L	404	1,310
Sulfate	mg/L	345	900
pH	s.u.	8.51	7.8
TDS	mg/L	1,168	4,080
Arsenic	mg/L	0.001	0.06
Barium	mg/L	0.10	<0.1
Cadmium	mg/L	0.007	<0.005
Copper	mg/L	0.011	0.04
Iron	mg/L	0.054	<0.030
Lead	mg/L	0.042	<0.05
Manganese	mg/L	0.01	0.05

Table 2.7-16: Changes in Water Quality during Mining

Average Ore Zone Water Quality			
Analyte	**Units**	**MU 1-10 Pre-Mining Average**	**Typical Water Quality During Mining at CSA**
Mercury	mg/L	0.001	<0.001
Molybdenum	mg/L	0.094	0.5
Nickel	mg/L	0.047	<0.05
Selenium	mg/L	0.002	0.07
Uranium	mg/L	0.102	44
Vanadium	mg/L	0.096	2.5
Zinc	mg/L	0.016	0.02
Radium 226	pCi/L	155	1,090

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2.8 ECOLOGICAL RESOURCES

2.8.1 Introduction

During 1982, an ecological study was performed specifically for the Crow Butte Project. Data was collected to fulfill the objectives specified in USNRC's permit application guide (USNRC 1982). A review and update to the original study was conducted in 1987, 1995, and 1997.

There have been no documented changes to ecological resources within the License Area since the 1997 LRA. The original analysis consisted of a review of documents, databases, and reports in conjunction with a biological reconnaissance field survey to determine the potential impacts, if any, to the habitats for special-status plant and wildlife species in the License Area. Agency coordination included telephone and written correspondence among Greystone (now ARCADIS) biologists, U.S. Fish and Wildlife Service (USFWS), and Nebraska Game and Parks Commission (NGPC) management and staff. This coordination is ongoing. The purpose of these consultations and associated correspondence was to help identify biological issues and potential occurrences and distribution of special-status plants, wildlife, and their habitats.

2.8.2 Regional Setting

The License Area occurs at the confluence of two Nebraska ecoregions – the Western High Plains and the Northwestern Great Plains (Chapman et al. 2001). The transition from Central Great Plains in the eastern part of the state to Western High Plains westward is primarily a factor of the reduction in effective precipitation associated with the Western High Plains. There is a general conformity in the composition of the plant cover, as many species are common to both ecoregions. Physiographically, this area comprises smooth to slightly irregular plains that support native communities, croplands or grazing.

The Western High Plains ecoregion is characterized by a semi-arid to arid climate, with annual precipitation ranging between 13 to 20 inches. Higher and drier than the Central Great Plains to the east, much of the Western High Plains comprises a smooth to slightly irregular plain with a high percentage of dryland agriculture. Natural vegetation is dominated by drought-tolerant, short-grass prairie and large areas of mixed-grass prairie in the northwest portion of the state.

The Northwestern Great Plains ecoregion encompasses the Missouri Plateau portion of the Great Plains. It is a semi-arid rolling plain of shale and sandstone punctuated by occasional buttes. Native grasslands persist in areas of steep or broken topography, but they have been largely replaced by spring wheat and alfalfa over most of this ecoregion. Agriculture exists on level to rolling hills and is generally limited by erratic precipitation patterns and limited opportunities for irrigation.

Nearly 470 plant species are described in the Chadron State College herbarium contains for Dawes County (WFC 1983). The Institute of Agriculture and Natural Resources lists 603 native and 123 introduced species that occur in Dawes County. During the 1982 baseline study, more than 400 species of plants were collected (WFC 1983).

2.8.3 Local Setting - License Area

The License Area is located in west-central Dawes County, Nebraska, just southeast of Crawford. The License Area is located within 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. **Figure 1.3-1** shows the general location of the current License Area.

2.8.4 Climate

The climate of the region is characterized by wide seasonal and day-to-day variations in temperature and precipitation. Dawes County is usually warm in the summer, with frequent spells of hot weather and occasional cool days interspersed, although sporadically, throughout the summer. These changes in weather can generate thunderstorms, which deliver a majority of the total annual precipitation. Annual average minimum and maximum temperatures are 34°F and 62°F, respectively, with a mean monthly average of 48°F (High Plains Regional Climate Center [HPRCC] 2004). Average total precipitation is 16.07 inches (HPRCC 2004). Precipitation occurs throughout the year, with yearly averages ranging from a low of 0.41 inches in December to a high of 2.96 inches in May (HPRCC 2004). Winter precipitation is typically relegated to storms with snow and the occasional blizzard. In this portion of Nebraska, the average annual seasonal snowfall is approximately 42 inches (HPRCC 2004).

2.8.5 Baseline Data

An ecological study was performed for a commercial CBR Uranium Project application in 1982 (Radioactive Source Materials License SUA-1534). Baseline flora and fauna data were collected to fulfill the objectives specified in USNRC Regulatory Guide 3.46, *Standard Format and Content of License Applications, Including Environmental Reports, For In Situ Uranium Solution Mining.* The 1982 baseline study focused on conducting intensive research within the principal License Area, which included both the commercial License Area and the five-mile adjacent area, and less intensive research within the 50-mile outer area. Additional baseline data was collected within the three areas in 1987, 1995, 1996, and 1997.

For more detailed descriptions of the data, please refer to the *Crow Butte Uranium Project Application and Supporting Environmental Report for USNRC Research and Development Source Material License* (WFC 1983) or the *Crow Butte Uranium*

Project Application and Supporting Environmental Report for USNRC Commercial Source Material License (FEN, 1987).

2.8.6 Terrestrial Ecology

The information presented in this section summarizes the findings of the ecological baseline studies conducted in support of the Crow Butte project in 1982, 1987, 1995, 1996, and 1997.

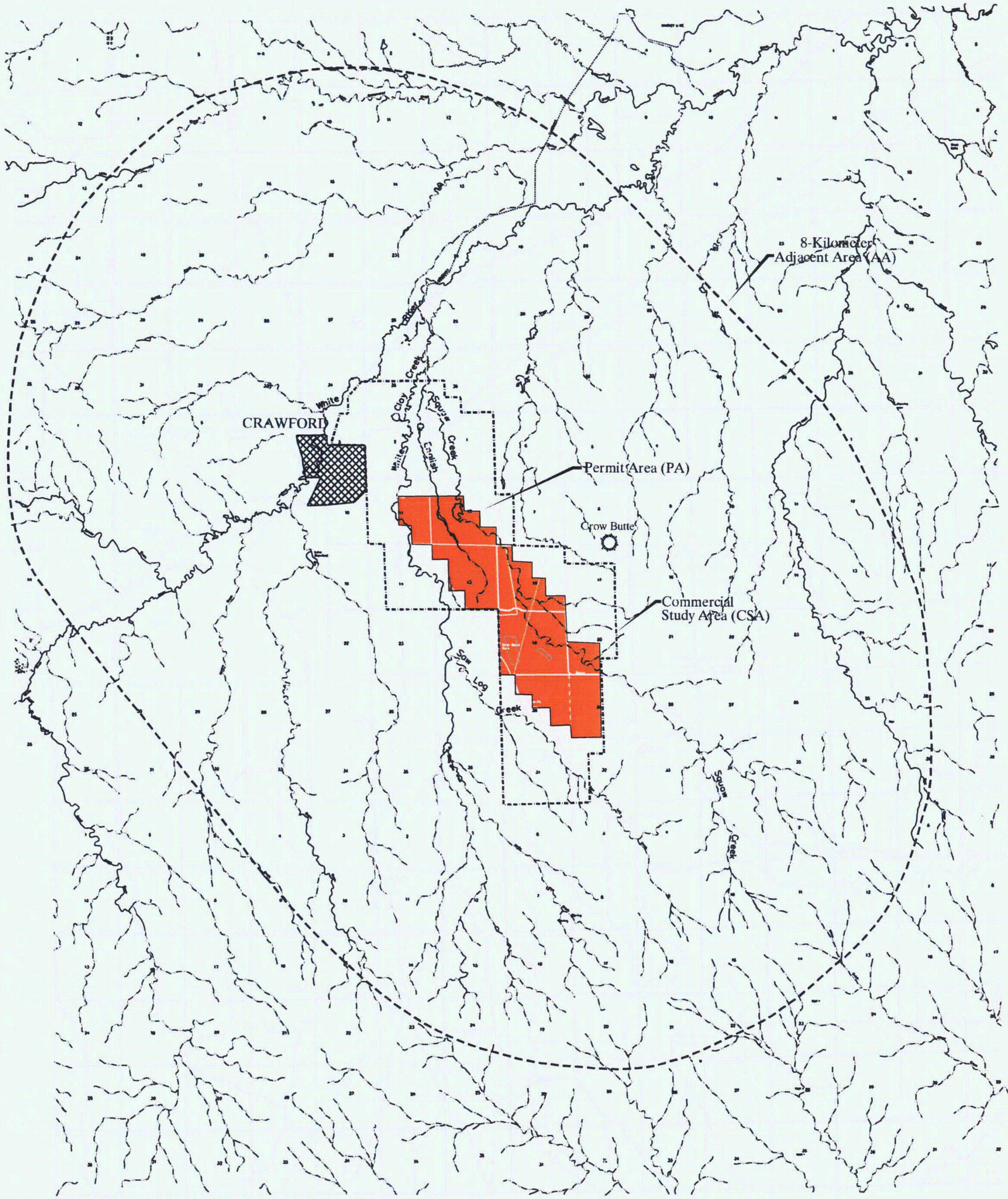
A one-year ecological baseline study was initiated in January 1982. The principal study area **Figure 2.8-1** includes both the Commercial Study Area (CSA) and the Adjacent Area (AA). Intensive studies were conducted on the CSA. Comparable but less intense studies were conducted within the 8 km (5 mi) AA, to assess the ecological importance of the CSA in relation to the adjacent environments. Additional investigations were conducted within an 80-km (50 mi) Outer Area (OA) centered on Section 19, drawing primarily upon published sources of information.

2.8.6.1 Methods

Methods of investigation were chosen to describe the principal floral and faunal species of the area. Whenever possible, methods were used that would provide continuity and compatibility with ongoing investigations in the state and the region.

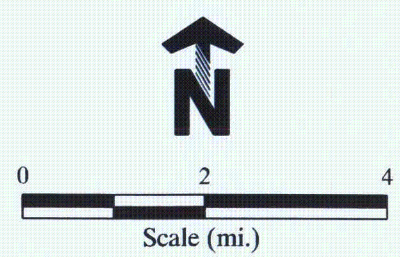
Plant collections were conducted throughout the growing season to prepare a comprehensive voucher of plant species within the study area. Vegetation communities mapping was completed at a scale of 1:12,000 for the CSA, and 1:24,000 for the AA. Vegetation/Habitat types were chosen according to the system developed by the Montana Agriculture Experiment Station (Coenenberg et al. 1977), modified to conform to the ecological characteristics of the Crow Butte area. The system was deemed appropriate to describe floristic characteristics and to describe wildlife habitat affinities.

General observation was used to generate a species list for the study area and to obtain information on faunal distribution. In addition to routine sightings, time was devoted specifically for 1) aircraft raptor nest surveys, 2) aircraft big game surveys, 3) movement and migration route delineation, 4) game bird winter concentrations, 5) game bird brood counts, 6) grouse strutting ground "lek" surveys, 7) waterfowl breeding pair counts, 8) waterfowl brood surveys and production counts, 9) prairie dog colony surveys, 10) small mammal trapping, 11) carnivore spotlight surveys, and 11) reptile and amphibian surveys. Refer to WFC (1983) for detailed descriptions of these methodologies.



LEGEND

- Permit Area (PA)
- Commercial Study Area (CSA)
- Adjacent Area (AA)



GREYSTONE®

ECOLOGICAL STUDY AREA

CROW BUTTE PROJECT
Dawes County, Nebraska

Scale: 1"=2 miles	Date: 10/95	**Figure 2.8-1**

2.8.6.2 Existing Disturbance

The agricultural value of the two ecoregions has tremendously impacted mixed-grass prairie grasslands and the resulting landscape has been substantially altered since settlement in the late 1800s. Economic incentives to convert natural landscapes to agriculture have been intensive and resulted in the loss of significant areas of mixed-grass prairie grassland. Agriculture, intensive grazing, haying, sand and gravel mining, road and railroad construction, and rural and urban development are the primary sources of surface disturbance to native vegetation communities.

2.8.6.3 Vegetation

Study Area General Vegetation Description

The Pine Ridge area of Nebraska, as with the adjacent Black Hills of South Dakota, is represented by two principal vegetation regions (Van Bruggen 1977). These are described briefly below:

- **Plains and Prairie Flora** - The main features that describe this vegetation region are a dominance of grasses, absence of trees, rolling topography, and a characteristic xerophytic flora. Species occurring on the study area include big bluestem, little bluestem, Canada wild rye, Kentucky bluegrass, sage, purple cornflower, breadrood scurf pea, golden rod and related species.
- **Rocky Mountain Forest Flora (Black Hills Montane Element)** - Although geographically separated from the Rocky Mountains, the Pine Ridge and Black Hills have affinities to this region, which lies principally 200 km to the west. Floral species suggest that the two areas were contiguous during Pleistocene times. Species on the study area typical of this region include Oregon grape, Rocky Mountain juniper, ponderosa pine and Mariposa lily.

Many non-native plant species occur in the study area. The 1982 study estimated that 30 percent of species and more than 50 percent of plant cover consists of non-native plant species that are conspicuously successful and include smooth brome, cheatgrass, white sweetclover, yellow sweetclover and several Brassicaciae, including the species tumble mustard, tansy mustard, pennycress charlock, and Shephard's purse. Cultivated species include wheat, oats, rye, corn, milo and alfalfa.

Plants

According to the Great Plains Flora Association (1977), about 1,020 species of plants should be expected to occur within 80-km of the CSA. During the baseline study between March and Mid-July, 1982, more than 400 species of plant were collected within the study area (CSA and AA). Of that number, 163 species were recorded within a specific Section 19 study (**Table 2.8-1**).

Table 2.8-1: Plant Species List

Scientific Name	Common Name
EQUISETACEAE	
Equisetum laevigatum	Smooth horsetail
PINACEAE	
Pinus ponderosa	Ponderosa pine
RANUNCULACEAE	
Anemone patens	Pasque-flower
Clematis ligusticifolia	Western clematis
Ranunculus abortivus	Early wood buttercup
Thalictrum dasycarpum	Purple meadowrue
PAPAVERACEAE	
Argemone polyanthemos	Prickle poppy
FUMARIACEAE	
Corydalis aurea	Golden corydalis
ULMACEAE	
Ulmus americana	American elm
Ulmus pumila	Siberian elm
CANNABACEAE	
Humulus lupulus	Common hop
URTICACEAE	
Urtica dioica	Stinging nettle
CACTACEAE	
Coryphantha vivipara	Pincushion cactus
Opuntia fragilis	Brittle prickly pear
CARYOPHYLLACEAE	
Arenaria hookeri	Hooker sandwort
Cerastium arvense	Prairie chickweed
Paronychia jamesii	James nailwort
Stellaria media	Common chickweed
CHENOPODIACEAE	
Chenopodium album	Lamb's-quarters
Chenopodium fremontii	Fremont goosefoot
Chenopodium leptophyllum	Maple-leaved goosefoot
CHENOPODIACEAE	
Kochia scoparia	Kochia
Salsola iberica	Russian thistle
AMARANTHACEAE	
Amaranthus graecizans	Tumbleweed
Amaranthus retroflexus	Rough pigweed
POLYGONACEAE	
Polygonum convolvulus	Wild buckwheat
Polygonum ramosissimum	Bushy knotweed
MALVACEAE	
Malva rotundifolia	Common mallow
Sphaeralcea coccinea	Red false mallow
VIOLACEAE	
Viola canadensis	Canada violet
Viola nuttallii	Yellow prairie violet
SALICACEAE	
Populus deltoids	Plains cottonwood
Salix exigua	Coyote willow

Table 2.8-1: Plant Species List

Scientific Name	Common Name
CAPPARACEAE	
Cleome serrulata	Rocky mountain beeplant
BRASSICACEAE	
Arabis holboellii	Rockcress
Brassica kaber	Charlock
Capsella bursa-pastoris	Shepherd's purse
Chorispora tenella	Blue mustard
Descurainia pinnata	Tansy mustard
Descurainia sophia	Flixweed
Draba reptans	White whitlowwort
Erysimum asperum	Western wallflower
Erysimum repandum	Bushy wallflower
Lesquerella ludoviciana	Bladderpod
Sisymbrium altissimum	Tumbling mustard
Thlaspi arvense	Penny cress
PRIMULACEAE	
Androsace occidentalis	Western rock jasmine
SAXIFRAGACEAE	
Ribes odoratum	Buffalo currant
ROSACEAE	
Prunus americana	Wild plum
Prunus virginiana	Chokecherry
Rosa acicularis	Prickly wild rose
Rosa arkansana	Prairie wild rose
Rosa woodsii	Western wild rose
FABACEAE	
Astragalus gracilis	Slender milkvetch
Astragalus missouriensis	Missouri milkvetch
Lupinus argentus	Silvery lupine
Medicago falcata	Yellow lupine
Medicago sativa	Alfalfa
Melilotus alba	White sweetclover
Melilotus officinalis	Yellow sweetclover
Oxytropis lambertii	Purple locoweed
Psoralea argophylla	Silver-leaf scurf pea
Psoralea esculenta	Breadroot scurf pea
Psoralea lanceolata	Lemon scurf pea
Vicia americana	American vetch
ONAGRACEAE	
Gaura coccinea	Velvety gaura
Oenothera caespitosa	Gumbo lily
Oenothera nuttallii	White-stemmed evening primrose
CORNACEAE	
Comandra umbellata	Bastard toadflax
EUPHORBIACEAE	
Croton texensis	
Euphorbia podperae	
VITACEAE	
Parthenocissus vitacea	Woodbine
ACERACEAE	

Table 2.8-1: Plant Species List

Scientific Name	Common Name
Acer negundo	Box elder
ANACARDIACEAE	
Rhus amomatica	Aromatic sumac
Toxicodendron rydbergii	Poison ivy
ZYGOPHYLLACEAE	
Tribulus terrestris	Puncture vine
LINACEAE	
Linum perenne	Blue flax
Linum rigidum	Stiffstem flax
POLYGALACEAE	
Polygala alba	White milkwort
APIACEAE	
Lomatium nuttallii	Wild parsley
APOCYNACEAE	
Apocynum cannabinum	Hemp dogbane
ASCLEPIADACEAE	
Asclepias speciosa	Showy milkweed
SOLANACEAE	
Solanum rostratum	Buffalo bur
CONVOLVULACEAE	
Convolvulus arvensis	Field bindweed
Convolvulus sepium	Hedge bindweed
POLEMONIACEAE	
Phlox andicola	Moss phlox
BORAGINACEAE	
Cryptantha jamesii	James' cryptantha
Lappula redowskii	Low stickseed
Lithospermum incisum	Narrow-leaved puccoon
LAMIACEAE	
Mentha arvensis	Field mint
Monarda pectinata	Spotted beebalm
PLANTAGINACEAE	
Plantago patagonica	Buckhorn
OLEACEAE	
Fraxinus pennsylvanica	Green ash
SCROPHULARIACEAE	
Penstemon albidus	White beardtongue
Penstemon angustifolius	Narrow beardtongue
Penstemon glaber	Smooth beardtongue
Penstemon grandiflorus	Large beardtongue
Verbascum thapsus	Common mullein
CAMPANULACEAE	
Campanula rotundifolia	Harebell
RUBIACEAE	
Galium aparine	Catchweed bedstraw
CAPRIFOLIACEAE	
Symphoricarpos occidentalis	Western snowberry
ASTERACEAE	
Achillea millefolium	Yarrow
Agoseris glauca	False dandelion

Table 2.8-1: Plant Species List

Scientific Name	Common Name
Antennaria rosea	Rose pussytoes
Artemisia campestris	Western sagebrush
Artemisia frigida	Fringed sagebrush
Artemisia ludoviciana	White sage
Chrysopsis villosa	Golden aster
Cirsium undulatum	Wavyleaf thistle
Cirsium vulgare	Bull thistle
Crepis runcinata	Hawk's-beard
Echinacea angustifolia	Purple coneflower
Erigeron pumilus	Low fleabane
Grindelia squarrosa	Curly-top gumweed
Gutierrezia sarothrae	Broom snakeweed
Helianthus annuus	Common sunflower
Helianthus petiolaris	Plains sunflower
Lygodesmia juncea	Skeleton-weed
Ratibida columnifera	Prairie coneflower
Ridbeckia hirta	Black-eyed susan
Senecio plattensis	Prairie ragwort
Taraxacum officinale	Dandelion
Townsendia exscapa	Easter daisy
Tragopogon dubius	Goatsbeard
COMMELINACEAE	
Tradescantia occidentalis	Prairie spiderwort
JUNCACEAE	
Juncus balticus	Baltic rush
CYPERACEAE	
Carex filifolia	Thread-leaved sedge
Carex hystericina	Bottlebrush sedge
Carex lanuginose	Wooly-headed sedge
Carex nebraskensis	Nebraska sedge
Carex rossii	Ross' sedge
POACEAE	
Agropyron cristatum	Crested wheatgrass
Agropyron intermedium	Intermediate wheatgrass
Agropyron pectiniforme	Smooth crested wheatgrass
Agropyron smithii	Western wheatgrass
Agropogon scoparius	Little bluestem
Aristida longiseta	Red threeawn
Bouteloua gracilis	Blue grama
Bromus inermis	Smooth brome
Bromus japonicus	Japanese brome
Bromus tectorum	Cheatgrass
Buchloe dactyloides	Buffalo-grass
Cenchrus longispinus	Field sandbur
Elymus canadensis	Canada wild rye
Festuca octoflora	Six-weeks fescue
Hordeum jubatum	Foxtail barley
Hordeum pusillum	Little barley
Koeleria pyramidata	Junegrass
Oryzopsis hymenoides	Indian ricegrass

Table 2.8-1: Plant Species List

Scientific Name	Common Name
Panicum capillare	Witchgrass
Poa compressa	Canada bluegrass
Poa pratensis	Kentucky bluegrass
Poa sandbergii = (*P. secunda*)	Sandberg bluegrass
Setaria glauca	Yellow foxtail
Setaria viridis	Green foxtail
Sitanion hystrix	Squirreltail
Stipa comata	Needle-and-thread
Stipa viridula	Green needlegrass
Triticum aestivum	Wheat
LILIACEAE	
Allium textile	White wild onion
Calochortus nuttallii	Mariposa lily
Leucocrinum montanum	Mountain lily
Smilacina stellata	Spikenard
Yucca glauca	Yucca
Zigadenus venenosus	Death camass
IRIDACEAE	
Sisyrinchium montanum	Blue-eyed grass

2.8.6.4 Habitat Types

A habitat classification system (**Table 2.8-2**) was derived for the study area, sufficient to include the flora within the 80-km radius, with particular reference to generating a system useful in identifying faunal habitat affinities. **Table 2.8-3** summarizes the habitat types and amounts of each that comprise the CSA. Specific descriptions of each habitat classification are given in 1983 WFC.

Table 2.8-2: Habitat Classification System

Habitat Classification
000 - Wetlands (Closed Basin Features)
001 - Class I Wetland (Mixed Grass Prairie)
002 - Class II Wetland (Wet Meadow)
003 - Class III Wetland (Shallow Marsh Flora)
004 - Class IV Wetland (Deep Marsh Flora)
005 - Class V Wetland (Permanent Marsh)
006 - Class VI Wetland (Alkaline Lake)
007 - Class VII Wetland (Fen/Bog)
008 - Dugout
009 - Excavated Wetland
010 - Special Features
011 - Cliff
012 - Talus Slope, Scree
013 - Caves
014 - Marl Formation ("Badlands")
050 - Riverine Habitats (Open Basin and Drainage Features)

Table 2.8-2: Habitat Classification System

Habitat Classification
050 - Complex Riparian
051 - Mixed Grass Prairie Riparian
052 - Wet Meadow Riparian
053 - Shallow Marsh Riparian
054 - Deep Marsh Riparian
055 - Permanent Water - Streams and Rivers
056 - Alkaline Streambank
057 - Streamside Bog
058 - Stream Dugout
059 - Impoundments - Lakes and Ponds
100 - Woodlands
110 - Deciduous Streambank Forest
111 - Deciduous Basin Forest
120 - Deciduous "Wooded Draw" - Intermittent Drainages
130 - Tree Plantings - Orchards, Shelterbelts, Plantations
140 - Ponderosa Pine Forest
141 - Ponderosa Pine/Juniper
142 - Ponderosa Pine/Deciduous Woodland
143 - Ponderosa Pine/Grassland
144 - Ponderosa Pine/Shrubland
150 - Juniper
160 - Aspen
200 - Xerophytic Shrublands
211 - Big Sagebrush
212 - Big Sagebrush/Grassland
221 - Sand Sagebrush
222 - Sand Sagebrush/Grassland
231 - Sumac/Grassland
240 - Mixed Shrub/Half Shrub
300 - Mesophytic Shrublands
311 - Upland Drainage Seep
320 - Chionophilous Copse
330 - Flood Plain/Mud Flat Shrubland
400 - Grasslands
405 - Shortgrass Prairie
410 - Mixed Grass Prairie
420 - Range Rehabilitation
500 - Cultivated
510 - Grains
520 - Hay
530 - Root Crops
540 - Vegetables
550 - Fallow
551 - Bare Ground/Summer Fallow
552 - Annual Weed Complex

Table 2.8-2: Habitat Classification System

Habitat Classification
600 - Structure Biotopes
610 - Surface Disturbance Unreclaimed
611 - Surface Disturbance Reclaimed
630 - Human Biotopes - Towns, Buildings, Farmyards
640 - Cemeteries, Parks
650 - Roads and Roadside/Fencerow Complex

Sixteen habitat types were originally identified in the License Area as described in the 1983 report. These have remained relatively unchanged and include; wet meadow, mixed prairie–riparian, wet meadow–riparian, deep marsh–riparian, riverine, impoundment, deciduous streambank forest, shelterbelts and tree plantings, ponderosa pine, mixed grass prairie, range rehabilitation, cultivated, surface disturbance, human biotopes, cemeteries, and roads and roadside complex (**Figure 2.8-2**). These broad categories often represent several vegetation community types that are generally defined by both species composition and relative abundance. The acres of occurrence and relative distribution of habitat types within the License Area are presented in **Table 2.8-3**. Detailed descriptions of each habitat classification are given in the 1983 WFC.

Table 2.8-3: License Area Habitat Types

Habitat Classification		Acreage	Hectares	Percent
002	Wet Meadow	4.07	1.65	0.05
051	Mixed Prairie - Riparian	119.65	48.42	1.38
052	Wet Meadow - Riparian	47.27	19.13	0.55
054	Deep Marsh - Riparian	23.50	9.51	0.27
055	Riverine	32.86	13.34	0.38
059	Impoundment	46.57	18.84	0.54
110	Deciduous Streambank Forest	510.43	206.56	5.89
130	Shelterbelts, Tree Plantings	27.27	11.04	0.31
140	Ponderosa Pine	325.85	131.86	3.76
410	Mixed Grass Prairie	2840.18	1149.42	32.74
420	Range Rehabilitation	1370.77	554.74	15.80
500	Cultivated	2856.08	1155.86	32.92
610	Surface Disturbance	2.58	1.04	0.03
630	Human Biotopes	105.05	42.51	1.21
640	Cemeteries	5.02	2.03	0.06
650	Roads and Roadside Complex	356.55	144.30	4.11
Totals		**8,673.70**	**3,510.25**	**100.00**

Source: WFC 1983

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Wetlands perform many important hydrologic functions such as floodwater storage, regulating stream flows, streambank stabilization, nutrient removal and uptake, and groundwater recharge. Wetlands and/or waterbodies (classification numbers 002, 051, 052, 054, 055, and 059) make up only 3.17 percent (273.92 acres) of the habitat within the License Area.

Woodlands are generally defined as vegetation communities that contain structure dominated by trees where canopy foliage covers 10 to 30 percent of the ground area (Butler et al. 1997). Forested habitat (classification numbers 110, 130, and 140) makes up 9.96 percent (863.55 acres) of the License Area.

Grasslands are characterized by grasses and other erect herbs, usually without trees or shrubs (Butler et al. 1997). The mixed-grass prairie vegetation community is dominated by cool- and warm-season midgrasses, short-grasses, and sedges. Mixed grass prairie (classification number 410) is a large habitat component of the License Area and accounts for 32.74 percent (2,840.18 acres).

Range rehabilitation areas (classification number 420) are previously cultivated fields subjected to intensive grazing or seasonal haying and account for 15.80 percent (1,370.77 acres) of habitat. Cultivated areas (classification number 500) consist mostly of domesticated cereal crops such as spring wheat, oats, and barley, making up 32.92 percent (2,856.08 acres), the largest component at the site.

The remaining land use within the License Area (classification numbers 610, 630, 640, and 650) includes farmsteads and associated buildings, gravel and dirt roads, and highways and associated rights-of-way. Urban or developed land includes areas of intensive use with much of the land covered by structures (e.g., houses and farm outbuildings). Human disturbed lands account for only 5.41 percent (189.88 acres) of the land use.

2.8.6.5 Mammals

Thirty-six species of wild mammals were documented during the 1982 baseline study, and another 28 species, mostly bats, insectivores, and small rodents, were deemed likely to occur in the region (**Table 2.8-4**).

Table 2.8-4: Mammal Species List

Order/Common Name	Scientific Name	Documented Status[1]
CARNIVORES		
Carnivora		
Raccoon	*Procyon lotor*	D
Long-tailed weasel	*Mustela frenata*	D
Mink	*Mustela vison*	D
Black-footed ferret	*Mustela nigripes*	E
Badger	*Taxidea taxus*	D
Spotted skunk	*Spilogale putorius*	E

Table 2.8-4: Mammal Species List

Order/Common Name	Scientific Name	Documented Status[1]
Striped skunk	*Mephitis mephitis*	D
Coyote	*Canis latrans*	D
Swift fox	*Vulpes velox*	R
Red fox	*Vulpes fulva*	D
Bobcat	*Lynx rufus*	D
Mountain lion	*Felis concolor*	R
BIG GAME MAMMALS		
Artiodactyla		
Mule deer	*Odocoileus hemionus*	D
White-tailed deer	*Odocoileus virginianus*	D
Pronghorn	*Antilocapra americana*	D
Elk	*Cervus elaphus*	D
Bighorn sheep	*Ovis canadensis*	D
Bison	*Bison bison*	D
Moose	*Alces alces*	R
Mule deer/White-tailed deer hybrid	*O. hemionus x virginianus*	D
SMALL MAMMALS		
Chiroptera		
Keen myotis	*Myotis keeni*	E
Little brown myotis	*Myotis lucifugus*	E
Fringed myotis	*Myotis thysanodes*	E
Long-eared myotis	*Myotis evotis*	E
Long-legged myotis	*Myotis volans*	E
Small-footed myotis	*Myotis subulatus*	E
Silver-haired bat	*Lasionycteris noctivagans*	E
Red bat	*Lasiurus borealis*	E
Big brown bat	*Eptesicus fuscus*	E
Hoary bat	*Lasiurus cinereus*	E
Western big-eared bat	*Plecotus townsendi*	E
Insectivora		
Masked shrew	*Sorex cinereus*	E
Dwarf shrew	*Sorex nanus*	E
Merriam shrew	*Sorex merriami*	E
Least shrew	*Cryptotis parva*	E
Eastern mole	*Scalopus aquaticus*	D
Lagomorpha		
White-tailed jackrabbit	*Lepus townsendi*	D
Black-tailed jackrabbit	*Lepus californicus*	D
Eastern cottontail	*Sylvilagus floridanus*	D
Desert cottontail	*Sylvilagus auduboni*	D
Rodentia		
Black-tailed prairie dog	*Cynomys ludovicianus*	D
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	D
Spotted ground squirrel	*Citellus spilosoma*	D
Least chipmunk	*Eutamias minimus*	D

Table 2.8-4: Mammal Species List

Order/Common Name	Scientific Name	Documented Status[1]
Eastern fox squirrel	*Sciurus niger*	D
Northern pocket squirrel	*Thomomys talpoides*	D
Plains pocket gopher	*Geomys bursarius*	E
Wyoming pocket mouse	*Perognathus fasciatus*	E
Plains pocket mouse	*Perognathus flavescens*	E
Silky pocket mouse	*Perognathus flavus*	E
Hispid pocket mouse	*Perognathus hispidus*	E
Ord kangaroo rat	*Dipodomys ordii*	D
Beaver	*Castor canadensis*	D
Plains harvest mouse	*Reithrodontomys montanus*	E
Western harvest mouse	*Reithrodontomys megalotis*	E
White-footed mouse	*Peromyscus leucopus*	D
Deer mouse	*Peromyscus maniculatus*	D
Northern grasshopper mouse	*Onychomys leucogaster*	E
Eastern woodrat	*Neotoma floridana*	E
Bushy-tailed woodrat	*Neotoma cinerea*	E
Brown rat	*Rattus norvegicus*	E
House mouse	*Mus musculus*	D
Meadow vole	*Microtus pennsylvanicus*	D
Prairie vole	*Microtus ochrogaster*	D
Muskrat	*Ondatra zibethicus*	D
Meadow jumping mouse	*Zapus hudsonicus*	D
Porcupine	*Erethizon dorsatum*	D

[1] D Documented in the 1982 baseline study.
E Expected to occur - historical or recent evidence.
R Reported by knowledgeable individual(s).

Big Game Mammals

Big game species that may occur in suitable habitats throughout the project area include pronghorn antelope (*Antilocapra americana*), white-tailed deer (*Odocoileus virginianus*), and mule deer (*Odocoileus hemionus*). Elk (*Cervus elaphus*) and bighorn sheep (*Ovis canadensis*) may occur as transient species because of their known distribution in the Pine Ridge area (Nordeen 2004).

Pronghorn Antelope

Pronghorn typically inhabit grasslands and semi-desert shrublands of the western and southwestern United States. This species is most abundant in short- and mixed-grass habitats and is less abundant in more xeric habitats. Typically, daily movement does not exceed 6 miles. Some pronghorn migrate seasonally between summer and winter habitats, but these migrations are often triggered by availability of succulent plants and not local weather conditions (Fitzgerald et al. 1994).

Nebraska is on the eastern fringe of the pronghorn's range, and there are large areas within the range boundary where pronghorns do not occur. According to Nordeen (2004), a large herd of approximately 60 to 100 antelope may use the area north of Crawford as winter range.

Mule Deer

In Nebraska, mule deer occur in foothills, broken hill country, prairie grasslands, and shrublands. Browse is an important component of the mule deer's diet throughout the year, making up as much as 60 percent of total intake during autumn, while forbs and grasses typically make up the rest of their diet (Fitzgerald et al. 1994). This species tends to be more migratory than white-tailed deer, traveling from higher elevations in the summer to winter ranges that provide more food and cover.

Mule deer are distributed primarily along the foothills and escarpments, ranging outward into mixed-grass prairie and cultivated land. However, the distribution and abundance of mule deer varies by vegetation type in the project area. According to Nordeen (2004), approximately 100 to 200 mule deer and white-tailed deer may occupy a 1 to 2 square-mile area within the project area.

White-tailed Deer

White-tailed deer are found throughout the state of Nebraska, typically concentrated in riparian woodlands, mixed shrubs riparian, and associated irrigated agricultural lands, and are generally absent from dry grasslands and coniferous forests (Clark and Stromberg 1987).

In the License Area, white-tailed deer are expected to be more widely distributed than mule deer. However, because of the high amount of cultivated land, white-tailed deer distributions may be primarily associated with riparian habitats along the White River and associated intermittent and ephemeral stream drainages. In addition, white-tailed deer may be absent from large expanses of mixed-grass prairie and shrub land habitats because they lack sufficient cover and browse.

Elk

In Nebraska, this species occurs primarily in the northwestern region in a variety of habitats, including coniferous forests, meadows, short- and mixed-grass prairies, and sagebrush and other shrub lands.

Elk ranges are concentrated in the Pine Ridge area and associated habitats in the Bordeaux and Hat Creek units. There are an estimated 200 to 250 elk in the state, with most of the herd concentrated in the Pine Ridge area (Nordeen 2004). Occasionally, elk may occur within the project area as transients primarily between the summer and winter range movements.

Bighorn Sheep

Prior to the 1900s, the Audubon bighorn sheep inhabited parts of western Nebraska including the Wildcat Hills, the Pine Ridge, along the North Platte River to eastern Lincoln County, and along the Niobrara River. It is thought that the Audubon bighorn probably became extinct in the early 1900s with its last stronghold being the South Dakota badlands.

In 1981, the Nebraska Game and Parks Commission began introducing bighorn sheep in the Pine Ridge area. A dozen bighorns were released into a 500-acre enclosure at Fort Robinson State Park near Crawford. In December 1988, 21 sheep were released from the pen and in January 1993, the remaining 23 sheep were released. Nebraska's bighorn sheep population is now estimated to be between 80 and 140 animals (Nordeen 2004). A few bighorn sheep are known to have ranged from the Fort Robinson area as far east as the Bordeaux Creek drainage southeast of Chadron, south near Belmont, west near the Gilbert-Baker Wildlife Management Area, and north into the Oglala grasslands (Nordeen 2004). No bighorn sheep are expected to occur within the License Area because of in sufficient habitia.

Carnivores

The coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and long-tailed weasel (*Mustela frenata*) are expected to range freely and widely throughout the project area. Bobcat (*Lynx rufus*), badger (*Taxidea taxus*), and striped skunk (*Mephitis mephitis*) may also occur in the License Area, but they are less common.

Small Mammals

The deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), meadow jumping mouse (*Zapus hudsonius),* northern pocket gopher (*Thomomys talpoides*), and meadow vole (*Microtus pennsylvanicus*) are expected to occur in the highest abundances. The highest densities of these small mammals are expected to occur in the deciduous forest areas, whereas the lowest abundance of small mammals would most likely occur in the cultivated fields. According to results of the 1982 baseline study (WFC 1983), the greatest diversity of small mammals was detected in the mixed- and short-grass community, and the lowest diversity was observed in the non-wooded riparian and lower deciduous forest areas.

Muskrat (*Ondatra zibethicus*) may occur along watercourses, and beaver (*Castor canadensis*) may occur in the White River Basin. Porcupine (*Erethizon dorsatum*), fox squirrel (*Sciurus niger*), white-tailed jackrabbit (*Lepus townsendii*), black-tailed jackrabbit (*Lepus californicus*), and eastern cottontail (*Sylvilagus floridanus*) are also expected to occur throughout the License Area.

Domestic Mammals

Domestic livestock within the CSA include cattle, horses, and swine. Cattle management includes cow-calf operations on native range and range rehabilitation areas, winter pasturing and feedlots. Cattle numbers on the CSA range from about 600 to 900 seasonally. In addition, 30 horses and 80 swine are pastured and fed year-round (WFC 1983).

2.8.6.6 Birds

The Nebraska Ornithologists' Union's (NOU) "Official" list 434 birds (including two extinct species – passenger pigeon and Carolina parakeet) occurring in Nebraska (NOU 1997). Accordingly, Johnsgard (1979) lists 430 species, including 54 apparently "accidental" (vagrant) species, and nine extinct, extirpated, or probably extirpated species. In addition, Johnsgard (1979) lists 27 "hypothetical" species, and four unsuccessfully introduced species. Researchers documented 201 species during the 1982 baseline study (**Table 2.8-5**).

Table 2.8-5: Bird Species List

Common Name	Scientific Name	Status[1]
GAVIIFORMES		
Common loon	*Gavia immer*	R
Arctic loon	*Gavia arctica*	R
PODICIPEDIFORMES		
Red-necked grebe	*Podiceps grisegena*	R
Horned grebe	*Podiceps auritus*	D
Eared grebe	*Podiceps caspicus*	D
Western grebe	*Aechmophorus occidentalis*	D
Pied-billed grebe	*Podilymbus podiceps*	
PELECANIFORMES		
White pelican**	*Pelicanus erythrorhynchos*	D
Double-crested cormorant**	*Phalacrocorax auritus*	D
CICONIFORMES		
Great blue heron	*Ardea herodias*	D
Green heron	*Butorides virescens*	R
Cattle egret	*Bubulcus ibis*	R
Great egret	*Casmerodius albus*	R
Snowy egret	*Leucophoyx thula*	R
Black-crowned night heron**	*Nycticorax nycticorax*	D
Yellow-crowned night heron	*Nyctanassa violacea*	R
American bittern**	*Botaurus lentiginosus*	D
White-faced ibis	*Plegadia chihi*	R
ANSERIFORMES		
Whistling swan	*Olor columbianus*	R
Trumpeter swan	*Olor buccinator*	D
Canada goose	*Branta canadensis*	D
Brant	*Branta bernicla*	R

Table 2.8-5: Bird Species List

Common Name	Scientific Name	Status[1]
White-fronted goose	*Anser albifrons*	D
Snow goose	*Chen hyperborea*	D
Mallard*	*Anas plantyrhynchos*	D
Black duck	*Anas rubripes*	R
Gadwall**	*Anas strepera*	D
Pintail**	*Anas acuta*	D
Green-winged teal**	*Anas carolinensis*	D
Blue-winged teal**	*Anas discors*	D
Cinnamon teal	*Anas cyanoptera*	D
American wigeon	*Mareca americana*	D
Northern shoveler	*Spatula clypeata*	D
Wood duck	*Aix sponsa*	D
Redhead	*Aythya americana*	D
Ring-necked duck	*Aythya collaris*	D
Canvasback	*Aythya valisineria*	D
Lesser scaup	*Aythya affinis*	D
Common goldeneye	*Bucephala clangula*	D
Barrow's goldeneye	*Bucephala islandica*	R
Bufflehead	*Bucephala albeola*	D
Oldsquaw	*Clangula hyemalis*	R
White-winged scoter	*Melanitta deglandi*	R
Surf scoter	*Melanitta perspicillata*	R
Black scoter	*Oidemia nigra*	R
Ruddy duck	*Oxyura jamaicensis*	D
Hooded merganser	*Lophodytes cucullatus*	D
Common merganser	*Mergus merganser*	D
Red-breasted merganser	*Mergus serrator*	R
FALCONIFORMES		
Turkey vulture	*Cathartes aura*	D
Goshawk	*Accipiter gentilis*	D
Sharped-shinned hawk	*Accipiter striatis*	D
Cooper's hawk	*Accipiter cooperi*	D
Red-tailed hawk	*Buteo jamaicensis*	
Red-shouldered hawk	*Buteo lineatus*	R
Broad-winged hawk	*Buteo platypterus*	R
Swainson's hawk	*Buteo swainsoni*	R
Rough-legged hawk	*Buteo lagopus*	D
Ferruginous hawk	*Buteo regalis*	D
Golden eagle	*Aquila chrysaetos*	D
Bald eagles	*Haliaeetus leucocephalus*	D
Northern harrier	*Circus cyaneus*	D
Osprey	*Pandion haliaetus*	R
Gyrfalcon	*Falco rusticolus*	D
Prairie falcon	*Falco mexicanus*	D
Peregrine falcon	*Falco peregrinus*	R

Table 2.8-5: Bird Species List

Common Name	Scientific Name	Status[1]
Merlin	*Falco columbarius*	D
American kestrel	*Falco sparverius*	D
GALLIFORMES		
Sharp-tailed grouse*	*Pedioecetes phasianellus*	D
Bobwhite	*Colinus virginianus*	R
Ring-necked pheasant*	*Phasianus colchicus*	D
Turkey*	*Meleagris gallopavo*	D
Gray partridge**	*Perdix perdix*	D
GRUIFORMES		
Sandhill crane	*Grus canadensis*	D
Virginia rail**	*Rallus limicola*	D
Sora rail**	*Porzana carolina*	D
American coot**	*Fulica americana*	D
CHARADRIIFORMES		
Semipalmated plover	*Charadrius semipalmatus*	R
Mountain plover	*Charadrius montainus*	E
Piping plover	*Charadrius melodus*	R
Snowy plover	*Charadrius alexandrinus*	R
Killdeer*	*Charadrius vociferus*	D
American golden plover	*Pluvialis dominica*	R
Black-bellied plover	*Squatarola squatarola*	D
Marbled godwit	*Lemosa fedoa*	D
Whimbrel	*Numenius phaeopus*	R
Long-billed curlew**	*Numenius americanus*	D
Upland sandpiper**	*Bartramia longicauda*	D
Greater yellowlegs	*Totanus melanoleucus*	D
Lesser yellowlegs	*Totanus flavipes*	D
Solitary sandpiper	*Tringa solitaria*	D
Willet**	*Catoptrophorus semipalmatus*	D
Spotted sandpiper**	*Actitis macularia*	D
Common snipe*	*Capella gallinago*	D
Short-billed dowitcher	*Limnodromus griseus*	R
Long-billed dowitcher	*Limnodromus scolopaceus*	D
Red knot	*Calidris canutus*	R
Sanderling	*Calidris alba*	D
Semipalmated sandpiper	*Ereunetes pusillus*	D
Western sandpiper	*Ereunetes mauri*	R
Least sandpiper	*Eriola minutilla*	D
White-rumped sandpiper	*Eriola fuscicollis*	R
Baird's sandpiper	*Eriola bairdii*	D
Pectoral sandpiper	*Eriola melanotos*	R
Stilt sandpiper	*Micropalama himantopus*	D
CHARADRIIFORMES		
Buff-breasted sandpiper	*Tryngites subrufficollis*	R
American avocet**	*Recurvirostra americana*	D

Table 2.8-5: Bird Species List

Common Name	Scientific Name	Status[1]
Wilson's phalarope**	*Steganopus tricolor*	D
Northern phalarope	*Lobipes lobatus*	D
Parasitic jaeger	*Stercorarius parasiticus*	R
Herring gull	*Larus argentatus*	R
California gull	*Larus californicus*	R
Ring-billed gull	*Larus delawarensis*	D
Black-headed gull	*Larus ridibundus*	R
Franklin's gull	*Larus pipixcan*	D
Bonaparte's gull	*Larus philadelphia*	R
Forster's tern	*Sterna forsteri*	D
Common tern	*Sterna hirundo*	R
Least (Least interior) tern	*Sterna albifrons*	R
Black tern**	*Chlidonias niger*	D
COLUMBIFORMES		
Mourning dove*	*Zenaidura macroura*	D
Rock dove*	*Columba livia*	D
CUCULIFORMES		
Yellow-billed cuckoo**	*Coccyzus americanus*	D
Black-billed cuckoo**	*Coccyzus erythropthalmus*	D
STRIGIFORMES		
Barn owl**	*Tyto alba*	D
Screech owl**	*Otus asio*	D
Great horned owl*	*Bubo virginianus*	D
Snowy owl	*Nyctea scandiaca*	R
Burrowing owl*	*Speotyto cunicularia*	D
Barred owl	*Strix varia*	R
Long-eared owl	*Asio otus*	R
Short-eared owl**	*Asio flammeus*	D
Saw-whet owl**	*Aegolius acadicus*	D
CAPRIMULGIFORES		
Common poor-will**	*Phalaenoptilus nuttallii*	D
Common nighthawk**	*Chordeiles minor*	D
APODIFORMES		
Chimney swift**	*Chaetura pelagica*	D
White-throated swift**	*Aeronautes saxatalis*	D
Broad-tailed hummingbird	*Selasphorus platycercus*	R
Rufous hummingbird	*Selasphorus rufus*	R
CORACIIFORMES		
Belted kingfisher**	*Megaceryle alcyon*	D
PICIFORMES		
Common flicker*	*Colaptes auratus*	D
Red-bellied woodpecker	*Centurus carolinus*	R
Red-headed woodpecker*	*Melanerpes erythrocephalus*	D
Lewis' woodpecker**	*Asyndesmus lewis*	D
Yellow-bellied sapsucker	*Sphyrapicus varius*	R

Table 2.8-5: Bird Species List

Common Name	Scientific Name	Status[1]
Hairy woodpecker**	*Dendrocopos villosus*	D
Downy woodpecker**	*Dendrocopos pubescens*	D
PASSERIFORMES		
Eastern kingbird*	*Tyrannus tyrannus*	D
Western kingbird*	*Tyrannus verticalis*	D
Cassin's kingbird	*Tyrannus vociferans*	R
Scissor-tailed flycatcher	*Muscivora forfic*	R
Great crested flycatcher**	*Myiarchus crinitus*	D
Eastern phoebe**	*Sayornis phoebe*	D
Say's phoebe**	*Sayornis saya*	D
Black phoebe	*Sayornis nigricans*	D
Willow flycatcher**	*Empidonax traillii*	D
Least flycatcher	*Empidonax minimus*	D
Hammond's flycatcher	*Empidonax hammondii*	R
Western flycatcher	*Empidonax difficilis*	R
Eastern pewee**	*Contopus virens*	D
Western pewee*	*Contopus sordidulus*	D
Olive-sided flycatcher	*Nuttalornis borealis*	R
Horned lark*	*Eremophila alpestris*	D
Violet-green swallow**	*Tachycineta thallassina*	D
Tree swallow**	*Iridoprocne bicolor*	D
Bank swallow*	*Riparia riparia*	D
Rough-winged swallow**	*Stelgidopteryx ruficollis*	D
Barn swallow*	*Hirundo rustica*	D
Cliff swallow*	*Petrochelidon pyrrhonota*	D
Purple martin	*Progne subis*	R
Gray jay	*Perisoreus canadensis*	R
Blue jay**	*Cyanocitta cristata*	R
Stellar's jay	*Cyanocitta stelleri*	R
Black-billed magpie*	*Pica pica*	D
American crow*	*Corvus branchyrhynchos*	D
Pinyon jay**	*Gymnorhinus cyanocephalus*	D
Clark's nutcracker	*Nucifraga columbiana*	R
Black-capped chickadee**	*Parus atricapillus*	D
Tufted titmouse	*Parus bicolor*	R
White-breasted nuthatch**	*Sitta carolinensis*	D
Red-breasted nuthatch**	*Sitta canadensis*	D
Pygmy nuthatch**	*Sitta pygmaea*	D
Brown creeper**	*Certha familiaris*	D
Dipper	*Cinclus mexicanus*	R
Northern house wren**	*Troglodytes aedon*	D
Winter wren	*Troglodytes troglodytes*	R
Bewick's wren	*Thryomanes bewickii*	R
Carolina wren	*Thryothorus ludovicianus*	R
Marsh wren**	*Telmatodytes palustris*	D

Table 2.8-5: Bird Species List

Common Name	Scientific Name	Status[1]
Canyon wren	*Catherpes mexicanus*	R
Rock wren**	*Salpinctes obsoletus*	D
Mockingbird	*Mimus polyglottos*	R
Gray catbird**	*Dumetella carolinensis*	D
Brown thrasher**	*Toxostoma rufum*	D
Sage thrasher	*Orescoptes montanus*	R
American robin*	*Turdus migratorius*	D
Wood thrush	*Hylocichla mustelina*	D
Hermit thrush	*Hylocichla guttata*	D
Swainson's thrush	*Hylocichla ustalata*	D
Gray-cheeked thrush	*Hylocichla ustalata*	D
Veery	*Hylocichla fuscenscens*	D
Eastern bluebird	*Sialia sialis*	R
Mountain bluebird**	*Sialia currucoides*	D
Townsend's solitaire**	*Myadestes townsendi*	D
Blue-gray gnatcatcher	*Polioptila caerulea*	R
Golden-crowned kinglet	*Rugulus satrapa*	R
Ruby-crowned kinglet	*Rugulus calendula*	D
Water pipit	*Anthus spinoletta*	D
Bohemian waxwing	*Bombycilla garrulus*	D
Cedar waxwing**	*Bombycilla cedrorum*	D
Northern shrike	*Lanius excubitor*	D
Loggerhead shrike**	*Lanius ludovicianus*	D
European starling*	*Sturnus vulgaris*	D
White-eyed vireo	*Vireo griseus*	R
Bell's vireo**	*Vireo bellii*	D
Yellow-throated vireo	*Vireo flavifrons*	R
Solitary vireo	*Vireo solitarius*	R
Red-eyed vireo**	*Vireo olivaceus*	D
Philadelphia vireo	*Vireo philadelphicus*	R
Warbling vireo**	*Vireo gilvus*	D
Black and white warbler	*Mniotilta varia*	D
Prothonotary warbler	*Protonotaria citrea*	R
Tennessee warbler	*Vermivora peregrina*	D
Orange-crowned warbler	*Vermivora celata*	D
Nashville warbler	*Vermivora ruficapilla*	D
Northern parula	*Parula americana*	R
Yellow warbler**	*Dendroica petechia*	D
Magnolia warbler	*Dendroica magnolia*	R
Cape May warbler	*Dendroica tigrina*	R
Yellow-rumped warbler	*Dendroica coronata*	
(Audubon race)**	*Dendroica coronata*	D
(Myrtle race)	*Dendroica coronata*	D
Townsend's warbler	*Dendroica townsendi*	R
Black-throated green warbler	*Dendroica virens*	R

Table 2.8-5: Bird Species List

Common Name	Scientific Name	Status[1]
Cerulean warbler	*Dendroica cerulea*	R
Blackburnian warbler	*Dendroica fusca*	R
Chestnut-sided warbler	*Dendroica pensylvanica*	R
Blackpoll warbler	*Dendroica striata*	D
Palm warbler	*Dendroica palmarum*	R
Ovenbird**	*Seiurus aurocapillus*	D
Northern waterthrush	*Seiurus noveboracensis*	D
PARULIDAE		
Mourning warbler	*Oporornis philadelphia*	R
MacGillivray's warbler	*Oporornis tolmiei*	R
Common yellowthroat**	*Geothlypis trichas*	D
Yellow-breasted chat**	*Icteria virens*	D
Hooded warbler	*Wilsonia citrina*	R
Wilson's warbler	*Wilsonia pusilla*	D
American redstart**	*Setophaga ruticilla*	D
House sparrow*	*Passer domesticus*	D
Bobolink**	*Dolichonyx oryzivorus*	D
Eastern meadowlark**	*Sturnella magna*	D
Western meadowlark*	*Sturnella neglecta*	D
Yellow-headed blackbird**	*Xanthocephalus xanthocephalus*	D
Red-winged blackbird*	*Agelaius phoeniceus*	D
Orchard oriole**	*Icterus spurius*	D
Northern (Bullock) oriole**	*Icterus galbula*	D
Rusty blackbird	*Euphagus carolinus*	R
Brewer's blackbird**	*Euphagus cyanocephalus*	D
Common grackle**	*Quiscalus quiscula*	D
Brown-headed cowbird**	*Molothrus ater*	D
Western tanager**	*Piranga ludoviciana*	D
Scarlet tanager	*Piranga olivacea*	R
Cardinal	*Richmondena cardinalis*	R
Rose-breasted grosbeak	*Pheucticus ludovicianus*	R
Blue grosbeak**	*Guiraca caerulea*	D
Indigo bunting**	*Passerina cyanea*	D
Lazuli bunting**	*Passerina amoena*	D
Indigo x lazuli hybrid**	*P. cyanea x amoena*	D
FRINGILLIDAE		
Dickcissel	*Spiza americana*	R
Evening grosbeak	*Herperiphona vespertina*	D
Purple finch	*Carpodacus purpureus*	R
Cassin's finch	*Carpodacus cassinii*	R
House finch	*Carpodacus mexicanus*	D
Pine grosbeak	*Pinicola enucleator*	R
Gray-crowned rosy finch	*Leucosticte tephrocotis*	R
Common redpoll	*Acanthis flammea*	R
Pine siskin**	*Spinus pinus*	D

Table 2.8-5: Bird Species List

Common Name	Scientific Name	Status[1]
American goldfinch**	*Spinus tristis*	D
Red crossbill**	*Loxia curvirostra*	D
White-winged crossbill	*Loxia leucoptera*	R
Green-tailed towhee	*Chlorura chlorura*	R
Rufous-sided towhee**	*Pipilo erythrophthalmus*	D
Lark bunting**	*Calamospiza melanocoryx*	D
Savannah sparrow	*Passerculus sandwichensis*	D
Grasshopper sparrow	*Ammodramus savannarum*	D
Vesper sparrow**	*Pooecetes gramineus*	D
Lark sparrow*	*Chondestes grammacus*	D
Black-throated sparrow	*Amphispiza bilineata*	R
Dark-eyed junco	*Junco hyemalis*	
(White-winged race)**	*Junco hyemalis*	D
(Slate-colored race)	*Junco hyemalis*	D
(Oregon race)	*Junco hyemalis*	D
(Gray-headed race)	*Junco hyemalis*	D
Tree sparrow	*Spizella arborea*	D
Chipping sparrow**	*Spizella passerina*	D
Clay-colored sparrow**	*Spizella pallida*	D
Brewer's sparrow**	*Spizella breweri*	D
Field sparrow	*Spizella pusilla*	R
Harris' sparrow	*Zonotrichia querula*	R
White-crowned sparrow	*Zonotrichia leucophrys*	D
White-throated sparrow	*Zonotrichia albicollis*	R
Fox sparrow	*Passerella iliaca*	R
Lincoln's sparrow	*Melospiza lincolnii*	D
Swamp sparrow	*Melospiza georgiana*	R
Song sparrow	*Melospiza melodia*	D
McCown's longspur**	*Rhynchophanes mccownii*	D
Lapland longspur	*Calcarius lapponicus*	D
Chestnut-collared longspur**	*Calcarius ornatus*	D
Snow bunting	*Plectyrophenax nivalis*	D

1 - Documentation:
D Documented in the 1982 study.
E Expected to occur - historical or recent evidence.
R Reported by knowledgeable individual(s).
*confirmed breeder
**suspected breeder

Of the NOU 434 birds sighted in Nebraska, approximately 200 species nest in the state. The largest single component is arboreal species adapted to living in trees, woodlands, and forests which make up approximately 45 percent of the state's total species, while aquatic and shoreline adapted species make up the second largest component or 32 percent of the state's total avifauna (Johnsgard 1979). Species primarily associated with grasslands comprise a still smaller breeding component, or approximately 10 percent of the state's total avifauna. Bird species associated with semi-desert scrub are the least numerous.

Common birds likely to occur within the cultivated fields include the American robin (*Turdus migratorius*), red-winged blackbird (*Agelaius phoeniceus*), mourning dove (*Zenaida macroura*), house wren (*Troglodytes aedon*), violet-green swallow, (*Tachycineta thalassina*), and horned lark (*Eremophila alpestris*). Birds associated with riparian and woodland habitats include pine siskin (*Carduelis pinus*), red crossbill (*Loxia curvirostra*), black-capped chickadee (*Poecile atricapillus*), rufous-sided towhee (*Pipilo erythrophthalmus*), yellow warbler (*Dendroica petechia*), and house wren (*Troglodytes aedon*).

Upland game birds such as wild turkey (*Meleagris gallopavo*), ring-necked pheasants (*Phasianus colchicus*), and sharp-tailed grouse (*Tympanuchus phasianellus*) may occur in the area as well. Waterfowl may occur throughout the region primarily during both the spring and fall migrations. However, because there are only a few low productivity wetlands and waterbodies (approximately 274 acres, or 3 percent), the diversity and abundance of waterfowl is extremely low in the project area.

Several raptor species are expected to occur in the project area, a reflection of the diversity in habitat types and the existence of many suitable nesting sites, such as tall trees. Golden eagles are permanent residents of the area, occurring in a variety of habitats. The most common permanent resident raptors occurring in the cultivated fields and mixed-grass prairies may include red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), northern harrier (*Circus cyaneus*), prairie falcon (*Falco mexicanus*), turkey vulture (*Cathartes aura*), and great horned owl (*Bubo virginianus*). In addition, rough-legged hawks (*Buteo lagopus*) are common winter residents of the Pine Ridge area (WFC 1983).

2.8.6.7 Reptiles and Amphibians

Of the 22 species of reptiles and amphibians recorded in Dawes and Sioux Counties (Ferraro 2004) (**Table 2.8-6**), 13 were documented during the 1982 baseline investigation. Documented toads and frogs included Woodhouse's toad (*Bufo woodhousii*), great plains toad (*Bufo cognatus*), plains spadefoot (*Spea bombifrons*), western striped chorus frog (*Pseudacris triseriata*), northern leopard frog (*Rana pipiens*), and bullfrog (*Rana catesbeiana*). Two species of turtles observed were the snapping turtle (*Chelydra serpentina*) and painted turtle (*Chrysemys picta*). Snakes identified included the bullsnake (*Pituophis catenifer*), plains garter snake (*Thamnophis radix*), red-sided garter snake (*Thamnophis sirtalis*), and racer (*Coluber constrictor*).

Table 2.8-6: Reptile and Amphibian List

Common Name	Scientific Name	Status
AMPHIBIANS		
Eastern tiger salamander	*Ambystoma tigrinum*	
Great plains toad	*Bufo cognatus*	
Woodhouse's toad	*Bufo woodhousii*	
Western chorus frog	*Pseudacris triseriata*	
Plains spadefoot	*Spea bombifrons*	
Northern leopard frog	*Rana pipiens*	
Bullfrog	*Rana catesbeiana*	
REPTILES		
Lesser earless lizard	*Holbrookia maculata*	
Short-horned lizard	*Phrynosoma hernandesi*	
Prairie lizard	*Sceloporus undulatus*	
Many-lined skink	*Eumeces multivirgatus*	R
Bullsnake	*Pituophis catenifer*	
Yellow-bellied racer	*Coluber constrictor*	
Plains garter snake	*Thamnophis radix*	
Red-sided/Common garter snake	*Thamnophis sirtalis*	
Plains hognose snake	*Heterodon nasicus*	
Prairie rattlesnake	*Crotalus viridis*	
W. terrestrial garter snake	*Thamnophis elegans*	R
Plains milk snake	*Lampropeltis triangulum*	R
Northern water snake	*Nerodia sipedon*	R
Common snapping turtle	*Chelydra serpentina*	
Painted turtle	*Chrysemys picta*	

R = Rare

2.8.7 Threatened, Endangered, or Candidate Species

Several species that could potentially occur within the License Area are designated as "threatened or endangered" because of their recognized rarity or vulnerability to various causes of habitat loss or population decline. These designated species receive specific protection defined in the federal Endangered Species Act of 1973, as amended, and the Nongame and Endangered Species Conservation Act (Neb. Rev. Stat. §37-430 et seq.). Other species have been designated as "candidate or sensitive" on the basis of adopted policies and expertise of state resource agencies or organizations with acknowledged expertise. A list of potentially occurring special-status species, along with specific occurrence records, was developed from an original list of target species based on records of the NGPC and the USFWS. **Table 2.8-7** summarizes the potential occurrence of each species within the vicinity of the License Area.

Table 2.8-7: Federal and State Threatened, Endangered, and Candidate Species with the Potential to Occur within the Vicinity of the License Area

Species	Federal/State Listing Status		Habitat	Critical Habitat
	Federal	State		
Swift fox (*Valpesvelox*)	Not Listed	Endangered	Large tracts of short- and mid-grass prairie habitats.	None designated
Bald eagle (*Haliaeetus leucocephalus*)	Delisted	Threatened	Migrates spring and fall statewide, but primarily along the major river courses.	None designated
Black-Footed Ferret (*Mustela nigripes*)	Endangered	Endangered	Closely associated with prairie dogs found in short and mid-grass prairies	None designated
Whooping Crane (*Grus Americana*)	Endangered	Endangered	Slow-moving rivers/streams with sandbars/islands; nearby wet meadows, croplands and marshlands	None designated

Source: NGPC 2007. USFWS 2006.

2.8.7.1 Swift Fox

The swift fox (*Vulpes velox*) is listed as endangered by the NGCP. The USFWS does not list the species as endangered, threatened or as a candidate species. The USFWS notes the swift fox has the potential to occur in Dawes County. The swift fox is widely distributed throughout the Great Plains and there are small, disjunct populations in western Nebraska and Kansas (USFWS 1995). There is high quality swift fox habitat in the Oglala National Grassland immediately northwest of the project area. The swift fox is closely associated with lagomorph populations, prairie dog colonies, ground squirrels, and other small mammals, which exist in varying densities and abundance throughout the License Area.

2.8.7.2 Bald Eagle

On June 28, 2007, the USFWS removed the bald eagle (*Haliaeetus leucocephalus*) from the list of threatened and endangered species (USFWS 2007). Even though the bald eagle has been delisted, it is still protected by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. The Nebraska Game and Parks Commission currently lists the bald eagle as threatened. Any changes in the status of the bald eagle in the state will have to have approval of the Commission, following public hearings. It is anticipated that a decision as to the state delisting of the bald eagle will occur during the next 6 to 12 months (Fritz 2007).

Nebraska's wintering bald eagle population is highly variable, ranging from 409 in 1984 to 1,292 in 1992, with an average of 714 bald eagles counted in Nebraska during the annual midwinter surveys between 1980 and 1993 (NGPC 2007). Most of the wintering bald eagle population is found in close association with open water. Bald eagles are known to occasionally occur in this region, primarily during the winter months (November through March). No bald eagle nests are known to occur within the project area. Moreover, no winter concentration areas or winter roosts have been documented within the project area (Fritz, 2004).

2.8.7.3 Black-footed Ferret

The black-footed ferret (*Mustela nigripes*) is listed as endangered by the USFWS and NGPC, and has the potential to occur in Dawes County (NGPC 2007, USFWS 2006). However, no recent confirmed populations of the black-footed ferret have been observed in the state of Nebraska. The last known specimen was an individual killed on a road near Overton in Dawson County in 1949, and no wild ferrets have been verified in Nebraska since the 1940s (NGPC 2007). Therefore, the black-footed ferret is not expected to occur in the project area.

2.8.7.4 Whooping Crane

The whooping crane (*Grus americana*) is listed as endangered by the USFWS and NGPC, with the potential to occur in Dawes County (NGPC 2007, USFWS 2006). The whooping crane is an occasional spring and fall migrant along the Platte Valley in the state, which accounts for approximately 90 percent of the sitings in Nebraska. The Platte Valley is located in central Nebraska, a considerable distance from the License Area. Any presence of whooping cranes on the project site and immediate area would be expected to be infrequent and transient. There is a lack of suitable habitat within the License Area, e.g., rivers and streams with associated sandbars and islands, marshlands, wet meadows and croplands.

2.8.8 Aquatic Resources

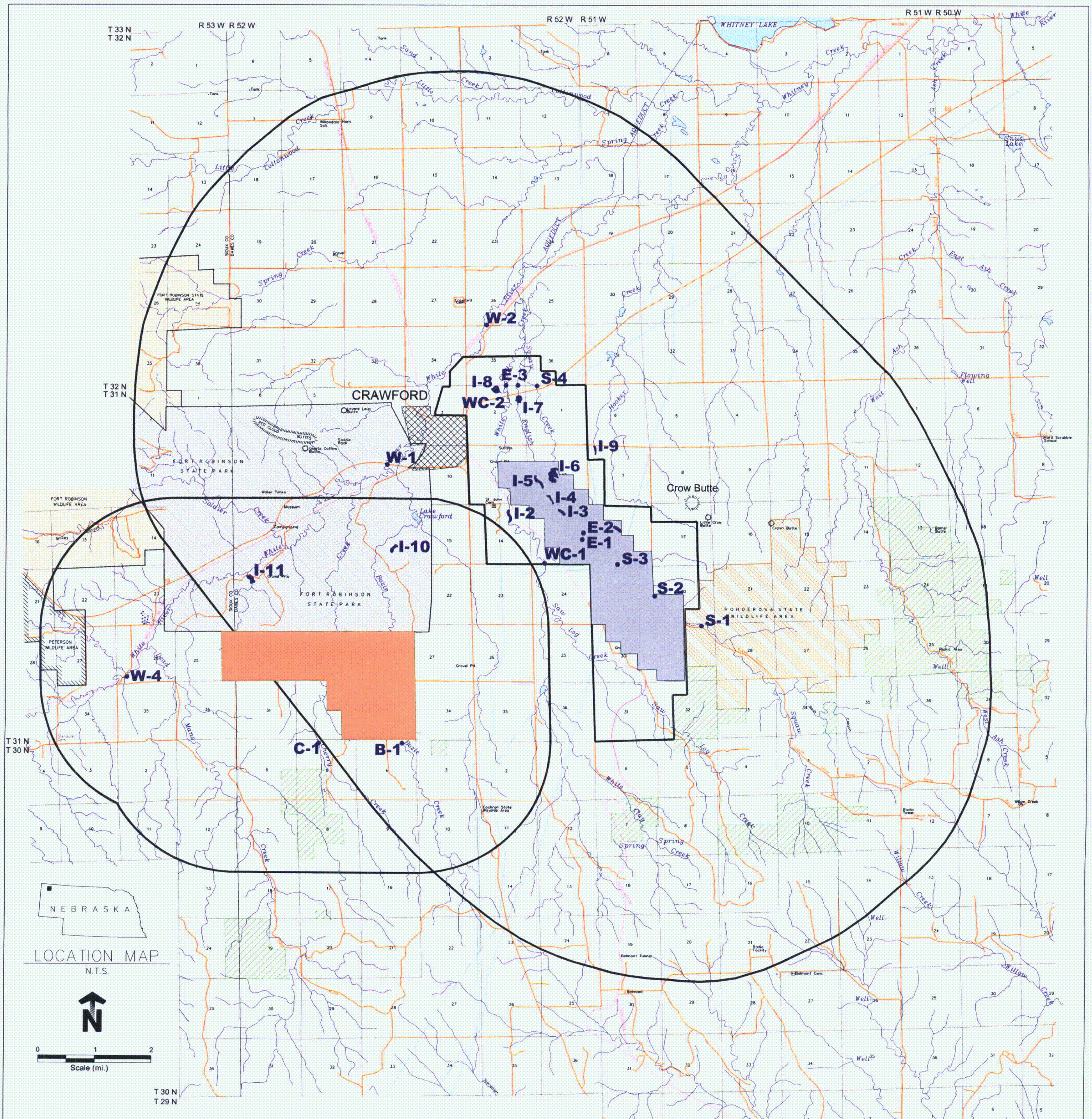
Objectives of the aquatic ecology baseline data collections conducted in 1982 were to provide information to assess the aquatic resources occurring within the CSA. The data results are summarized below. For more detailed information, please refer to the 1983 WFC.

2.8.8.1 Aquatic Study Area Description

Aquatic habitats on the CSA consist of three streams and eight impoundments. English Creek, Squaw Creek, and White Clay Creek are first-order streams that form the drainage basin within the CSA (**Figure 2.8-3**). Four of the impoundments are on English Creek, two on White Clay Creek, and one on Squaw Creek. The remaining impoundment is a stock pond created by a dam on a small drainage area.

In general, the aquatic habitats on the CSA suffer from ongoing environmental stresses. Naturally occurring stresses include unstable substrates and banks, low flows, and periodic flooding. Overgrazing on adjacent rangelands and in riparian areas, and farming practices along the stream courses further compound these problems. Commercial baitfish practices such as poisoning, dewatering, and introducing bait minnows have affected many of the impoundments. Livestock grazing and watering add to impoundment problems. These stresses are reflected in a fishery mostly consisting of non-game, tolerant species. Periodic stocking by the NGPC has created some put-and-take sport fisheries in the area but these are not self-sustaining due to environmental factors.

- English Creek is entirely within the CSA originating from springs and flowing northerly for about 5.6-km where it empties into Squaw Creek. Low flow and a vegetation-choked stream channel provide little suitable fish habitat. On-stream impoundments and pools created by washouts below culverts provide about the only suitable fish habitat.
- Squaw Creek originates in the Nebraska National Forest and the Ponderosa State Wildlife Area and flows through the CSA to its confluence with White Clay Creek. Squaw Creek changes dramatically from the upstream areas to the lower reaches. Much of the upper watershed is forested, mainly because it is within the Ponderosa Wildlife Area where livestock grazing and cultivation is prohibited. In contrast, the middle and lower watershed consists of heavily grazed rangeland or cultivated small grains.
- At the upper sampling station (S-1) the pine and grass-covered slopes, and thick, undisturbed riparian zone provide a relatively stable watershed. Substrates in this area consist of hardpan, gravel riffle areas, and some silted-in pools. Streambanks are relatively stable with overhanging vegetation and with some undercutting. Log jams, undercut banks, and pools up to 1.5 m deep provide cover and probable overwintering areas for fish.
- From station S-2 downstream to I-6, Squaw Creek looks entirely different. The understory in this lower section has virtually been eliminated by livestock grazing. Stream banks are degraded and unstable and the substrate is mostly sand. Few gravel riffle areas are present and most of the pools are heavily silted. Aquatic vegetation is relatively sparse in this section of stream with some Cladophora growing in shallow fast-flowing areas. The watershed in this lower area is unstable and, as evidenced by high-water debris, is subjected to periodic severe flooding (WFC 1983).
- White Clay Creek drains from the national forest to the south and flows northerly through the CSA and empties into the White River. At WC-1, the creek flows through a riparian grass area and has relatively stable stream banks. Habitat consists of mud and sand substrates and no well defined pools or riffles. At station WC-2 the creek flows through pasture land. In this section the substrate consists of sand, gravel and rubble with some silted pools. The stream banks appear to be relatively stable.



LEGEND

- Original Permit Area (PA)
- Three Crow Permit Area (TC)
- Fort Robinson State Park
- Fort Robinson State Wildlife Area
- Ponderosa State Wildlife Area
- Nebraska National Forest
- Peterson Wildlife Area

- Original Commercial Study Area (CSA)
- Original Adjacent Area (AA)
- Expansion Study Area (ESA)
- Rail Road
- Gravel Roads
- Paved Roads
- Perennial Stream
- Intermittent Stream
- Transmission Line

SAMPLING SITE KEY

B	**Bozle Creek**
C	**Cherry Creek**
E	**English Creek**
I	**Impoundment**
S	**Squaw Creek**
SL	**Saw Log Creek**
W	**White River**
WC	**White Clay Creek**

CROW BUTTE RESOURCES, INC.

1982 AND 1996
AQUATIC SAMPLING
SITE LOCATIONS

CROW BUTTE PROJECT
Dawes County, Nebraska

Scaleas shown | **Date: 5/14/97** | Figure 2.8-3

- Impoundments range in size from 0.4 ha (I-1) to 7.7 ha (I-6). Impoundments I-4, 5, 6, 7, and 8 have been or are now being, managed for raising baitfish. Impoundment I-9 has been stocked with brook trout for recreational fishing and serves for stock watering.

2.8.8.2 Methods

Fish were collected at each location to document their occurrence and to determine their relative abundance. The sampling effort was not standardized due to differences in the types of habitats sampled, sampling equipment, and abundance of fish present at each location.

Quantitative triplicate samples of benthic macroinvertebrates were collected from the stream and impoundment sample locations. Soft substances were sampled with a Ponar Dredge ($0.22m^2$) and gravel riffle substrates with a Surber sampler ($0.0093m^2$). Shannon-Weaver diversity indices were calculated from all samples.

Single qualitative samples of periphyton were collected at each sampling location by scraping the surface of several rocks, sticks, plant or other substrate material with a pocket knife. Diatom proportional counts were performed at the generic level. Green and blue-green algae were identified and their occurrence noted for each sampling location.

Fish

The status and distribution of fish species for the study area are presented in **Table 2.8-8**. Fourteen species of fish were collected from the CSA streams and impoundments (**Table 2.8-9**). Game fish collected included black bullheads, rainbow trout, brown trout, and brook trout.

Brook trout, which are not stocked, were collected in low numbers from Squaw Creek at several locations (**Table 2.8-10**). Although rainbow trout are periodically stocked by the NGPC in the upstream section, none were sampled at either S-1 or S-2. Periodic severe flooding is probably the most important factor limiting the effectiveness of stocking and reducing the trout population in Squaw Creek.

Table 2.8-8: Fish Species List

Family/Common Name	Scientific Name	Status[1]
	CATOSTOMIDAE	
River sucker	*Carpiodes carpio*	R
Longnose sucker	*Catostomus catostomus*	R
White sucker	*Catostomus commersoni*	D
	CENTRARCHIDAE	
Green sunfish	*Lepomis cyanellus*	D
Bluegill	*Lepomis macrochirus*	D
Smallmouth bass	*Micropterus dolomieui*	R
Largemouth bass	*Micropterus salmoides*	D

Table 2.8-8: Fish Species List

Family/Common Name	Scientific Name	Status[1]
Rock Bass	*Amblo plites rupestrinis*	D
Black crappie	*Pomoxis nigromaculatus*	D
CYPRINIDAE		
Carp	*Cyprinus carpio*	D
Plains minnow	*Hybognathus placitus*	D
Flathead chub	*Hybopsis gracilis*	R
Common shiner	*Luxilus cornutus*	D
Golden shiner	*Notemigonus crysoleucas*	D
Red shiner	*Notropis lutrensis*	R
Sand shiner	*Notropis stramineus*	D
Flathead minnow	*Pimephales promelas*	D
Longnose dace	*Rhinichthys cataractae*	D
Creek chub	*Semotilus atromaculatus*	D
CYPRINODONTIDAE		
Plains topminnow	*Fundulus sciadicus*	D
ESOCIDAE		
Northern pike	*Esox lucius*	R
HIODONTIDAE		
Goldeye	*Hiodon alosoides*	R
ICTALURIDAE		
Black bullhead	*Ictalurus melas*	D
Channel catfish	*Ictalurus punctatus*	R
Stonecat	*Noturus flavus*	R
PERCICHTHYIDAE		
White bass	*Morone chrysops*	D
PERCIDAE		
Walleye	*Stizostedion vitreum*	D
SALMONIDAE		
Rainbow trout	*Oncorhynchus mykiss*	D
Brown trout	*Salmo trutta*	D
Brook trout	*Salvelinus fontinalis*	D

Notes

[1] Documentation:

D Documented in the course of the present study.

E Expected to occur - historical or recent evidence.

R Reported by knowledgeable individual(s).

Table 2.8-9: Occurrence of Fish Species by Habitat

FISH SPECIES	STREAMS					IMPOUNDMENTS								
	English Creek	Squaw Creek	White Clay Creek	White River		1	2	3	4	5	6	7	8	9
SALMONIDAE														
Brook trout		X												X
Brown trout				X										
Rainbow trout				X										
CYPRINIDAE														
Creek chub	X		X	X			X							
Fathead minnow	X	X	X	X						X	X	X		
Longnose dace		X	X	X										
Plains minnow			X											
Sand shiner				X			X							
Golden shiner	X		X							X	X			
CATOSTOMIDAE														
White sucker			X	X			X							
ICTALURIDAE														
Black bullhead			X											
Stone Cat				X										
CYPRINODONTIDAE														
Plains topminnow	X		X											
CENTRARCHIDAE														
Green sunfish	X		X	X			X			X				
NUMBER OF SPECIES	5	3	9	9		0	4	0	0	3	2	1	0	1
SAMPLING METHOD														
Electrofishing	X	X	X	X			X			X				X
Gill Netting														
Pond Netting														
Minnow Trapping	X	X	X	X			X			X				X
Rod and Reel Angling														X

Table 2.8-10: Relative Abundance (Percent Occurrence) of Fish Collected at Each Sampling Location (1982)

	STREAMS									IMPOUNDMENTS								
FISH SPECIES	**E-3**	**S-1**	**S-2S-3**	**S-4**	**WC-1**	**WC-2**	**W-1**	**W-2**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
SALMONIDAE																		
Brook trout		5.7	1.2															100
Brown trout							18.5	3.2										
Rainbow trout							3.7											
CYPRINIDAE																		
Creek chub	0.3				44.8	1.1												
Fathead minnow	71.1	11.3	65.5	100	30.6	64.1								89.0	100	100		
Longnose dace		83.0	33.3		6.0	11.1	59.3	76.3										
Plains minnow						0.3												
Sand shiner																		
Golden shiner	3.9					0.6								2.4				
CATOSTOMIDAE																		
White sucker					2.2	1.1	18.5	20.4										
Black bullhead						0.9												
CYPRINODONTIDAE																		
Plains topminnow						0.3												
CENTRARCHIDAE																		
Green sunfish	24.7				16.4	20.5					100		100	8.6				
Electrofishing Total	55	106	174	18	112	335	27	93						193	126			
Minnow Trap Total	249			31	71	16					3		21	52	21	5		
Angling Total																		6
GRAND TOTAL	304	106	174	49	183	351	27	93			3		21	245	147	5		6

Brown trout and rainbow trout were collected in the White River at station W-1 and brown trout were collected at W-2. A regionally important put-and-take fishery exists in the White River around the Fort Robinson State Park area. Longnose dace were captured at all White River stations. Fluctuating flows, periodic flooding, sand and silt substrates, and warm water temperatures are probably the most important factors limiting natural trout production in the White River.

Impoundment I-9 has been stocked with brook trout but is not a public area and therefore provides only a limited amount of recreational fishing. The other impoundments have been or are now managed for baitfish production.

Macroinvertebrates

Macroinvertebrate analyses of the samples indicate that, in general, the study streams and impoundments have stressed environments. More than 90 percent of the total abundance of all stations consisted of organisms considered tolerant. The most abundant groups of these tolerant species were: chironomidae – 34 percent, simulidae - 20 percent, oligochaeta - 19 percent, and ceratopogonidae - 15 percent. Exceptions occurred at the upper Squaw Creek stations (S-1 and S-2), where caddisflies and mayflies dominated the riffle habitat. These two taxa typically represent less stressed environments than the above listed organisms.

Macroinvertebrate density and diversity values for the aquatic stations are presented in **Table 2.8-11**. Additionally, percent contributions of the dominant macroinvertebrate taxa are given. Although densities were high at most sampling stations, diversity values were low. Healthy streams usually have diversity values between 3.0 and 4.0, but many forms of stress reduce diversity by making the environment unsuitable for some species or by giving other species a competitive advantage. The upper Squaw Creek station (S-1) was the only station that had diversity values within this range indicating relatively higher quality and a more stable habitat.

Periphyton

The Periphyton communities at the aquatic sample stations were composed of 21 diatoms, 8 green algae, and one blue-green alga genera. Diatom percent occurrence and general occurrence of other algae are presented in **Table 2.8-12**. *Cymbella, Navicula, Nitzschia, Surirella, and Synedra*, were the most common diatom genera and were found in every sample. Green algae were found in all sampling locations, with greatest development occurring in the impoundments (WFC 1983). Cladophora was the most common and abundant green algae found in the streams and at some locations formed thick mats.

Table 2.8-11: Benthic Macroinvertebrate Community Values for Study Area Streams and Impoundments Derived from Samples Taken in April 1982

	Sampling Locations																					
	Streams													Impoundments								
Parameter/sample	E-1	E-2	E-3	S-1	S-2	S-2	S-3	S-4	WC-1	WC-2	W-1	W-2		1	2	3	4	5	6	7	8	9
Sampling Method*	D	D	D	S	D	S	S	D	D	D	D	D		D	D	D	D	D	D	D	D	D
Density (Org./m²)																						
1	5695	3766	3674	549	8451	377	8468	4777	322	459	505	3261		0	6992	6155	4731	5190	138	965	505	12998
2	15387	1378	2251	785	6071	1754	3325	1883	9186	367	276	5741		0	1288	6063	7165	8543		1010	138	10151
3	18188	92	4271	785	2664	560	5896	2526	6798	459	276	8451		46	13432	14698	2480	459		965	184	7578
Ö	13090	1745	3399	706	5729	897	5896	3062	5435	428	352	5818		15	7237	8972	4792	4731	138	980	276	10242
Diversity (d)																						
1	0.75	1.40	0.71	3.07	0.10	1.59	1.09	1.44	1.38	0.72	1.24	1.28			1.07	0.96	0.85	1.06	0	1.37	0	1.48
2	0.48	1.60	1.33	3.07	0.13	1.22	1.24	2.00	1.95	1.41	0.92	1.37			1.09	1.17	1.31	0.17		1.37	0	2.10
3	0.24	0	1.01	3.41	0.34	1.20	1.13	2.09	0.65	1.36	0.92	0.78		0	0.64	0.66	1.47	1.96		2.07	0	1.49
Ö	0.49	1.0	1.02	3.18	0.19	1.34	1.15	1.84	1.33	1.16	1.03	1.14		0	0.93	0.93	1.21	1.06	0	1.60	0	1.69
No. of Taxa	11	9	7	22	5	8	16	9	8	4	3	7		1	8	8	9	6	1	7	1	13
Community Structure (% Occurrence)																						
Taxon																						
Chironomidae	0.9	17.5	82.0	10.7	98.1	18.0	14.1	45.5	71.8	42.9	47.8	72.4			3.8	19.2	12.3	87.7	48.4	100	37.4	33.6
Oligochaeta		1.8	5.0	3.6	0.8	3.2	0.2	36.0	14.4	50.0	47.8	19.7		100	89.8	78.3	81.3	3.6	39.1		39.5	19.1
Ephemeroptera				20.3		65.2	6.8					7.9					0.9		4.7		16.6	7.0
Trichoptera			0.5	37.1	0.5	0.4	0.5				4.3	0.5										1.4
Ceratopogonidae	94.5	56.1		0.5		0.4	0.2	1.0	8.7	7.1		0.3			1.7	0.6					4.2	14.5
Simulidae				8.6		11.6	76.8															20.0

*D = Ponar Dredge Sample; S = Surber Sample

Table 2.8-12: Diatom Proportional Counts (Percent Occurrence) and Occurrence of Other Algae by Sample Location (April 1982)

	STREAMS											IMPOUNDMENTS							
	E-1	E-2	E-3	S-1	S-2	S-3	S-4	WC-1	WC-2	W-1	W-2	1	2	3	4	5	7	8	9
DIATOMS																			
Acnanthes	17.9	1.2	0.3	76.7		14.3	19.7	22.3	2.0	40.3			2.8				4.3	2.6	2.1
Amphora	0.5			0.5				0.3									0.3	1.8	
Cocconeis			0.3	2.4	0.7	4.8	1.7	1.2	11.3	1.9	0.3	1.1			0.4	0.6	0.3	1.4	0.7
Cyclotella			2.1		2.2	1.0	8.2	7.6		0.6				0.3		6.6	6.0	1.0	0.9
Cymatopleura							0.4												
Cymbella	6.3	0.3	0.3	1.9	6.1	2.9	8.2	25.9	7.0	7.8	1.8		7.1	1.3	11.8	3.9	1.4	8.5	13.7
Diatoma		0.6		1.9				6.4	1.0	0.9	21.6		0.7						17.9
Epithemia	1.1						1.3		0.4					12.6	2.1	1.7	2.6	4.4	
Fragilaria	3.3	66.5	0.3	0.5	2.9			0.3					0.7		9.3		0.6		0.2
Gomphonema	14.4	0.3	80.5	3.4	4.3			0.3			7.5		17.3	0.3	1.7	5.8	2.3	9.9	0.7
Gyrosigma									0.4							0.3			
Hantzschia													0.4	0.5	0.4		0.3		
Melosira																	0.6		
Meridion	0.8		0.3				2.1												
Navicula	3.8	2.6	8.2	5.3	15.8	16.2	13.7	9.8	58.6	33.4	47.7		3.2	6.2	5.5	2.5	18.2	21.0	1.2
Nedium	0.3																		
Nitzschia	13.0	6.6	3.8	5.3	65.9	58.1	13.7	15.2	10.6	11.3	19.1		6.0	12.9	7.6	3.6	30.4	12.1	34.4
Rhopalodia									0.4					3.2		0.3	1.4	0.2	
Stauroneia	0.3													0.3				0.4	
Surirella	0.5	0.3	1.0	0.5	0.4	1.9	3.9	1.2	6.6	3.4	0.5		0.7	0.3	2.5	5.8	12.5	1.0	0.2
Synedra	37.8	22.0	2.7	1.5	1.8	1.0	27.0	9.5	2.0	0.3	1.5		60.1	62.2	58.6	69.1	19.0	35.6	27.9
GREEN ALGAE																			
Ceratophylum															x				
Chara															x	x			
Cladophora			x	x	x	x	X	x	x	x	x								
Mougeotia	x	x												x					
Oedigonium															x		x		
Rhizoclonium							X												
Spirogyra	x	x					X	x							x		x		
Zygnema	x	x					X								x		x		
BLUE-GREEN ALGAE																			
Anabaena																	x		

2.8.9 References

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2.9 BACKGROUND NONRADIOLOGICAL CHARACTERISTICS

In order to establish baseline conditions of the commercial scale site and surrounding areas, a preoperational monitoring program was conducted for nonradiological characteristics. Categories chosen for sampling included water, sediment and soils. Wherever possible, sites for radiological and nonradiological samples were the same. **Table 2.9-1** provides a summary of the preoperational monitoring program implemented for the Crow Butte Project.

During the year of 1982 and continuing into 1983, a preoperational nonradiological environmental monitoring program was conducted for the Crow Butte Project. This program was designed to collect baseline environmental data for both the R&D and the commercial scale operations simultaneously. Coordination of these two programs allowed more comprehensive surveys plus availability of regional data for the R&D phase. The results of the R&D project preoperational monitoring are presented in this section. The R&D operational monitoring and the commercial preoperational data that were collected from 1985 through 1987 are also presented in this section.

The nonradiological monitoring program was adapted from the monitoring recommended in USNRC Regulatory Guide 4.14 to provide companion data to the Crow Butte preoperational radiological monitoring program described in **Section 2.10** of this report. Site specific data have been collected from monitor and baseline wells, Squaw Creek that passes through the restricted area, and soils. Other groundwater and impoundment samples were obtained within the License Area. Soils reported here were collected within the License Area and at a greater frequency in Section 19 that contains the present restricted area. All preoperational nonradiological sample points identified in this section are shown in **Figure 2.9-1**.

2.9.1 Groundwater

Investigations of the groundwater quality and usage for the License Area were made for this report.

The first step was to identify the aquifers present on a regional basis between the White River to the north and the Pine Ridge escarpment to the south. Geologic literature and maps were consulted to determine boundaries of outcropping formations and the local stratigraphy. Electric logs were examined and sand units within the formations identified. The water user survey provided information on which aquifers are currently being tapped for potable water. In some cases potentiometric data were also available.

Existing hydrologic studies were then compared with these findings. A thorough discussion of the groundwater hydrology is found in **Section 2.7.2** of this document.

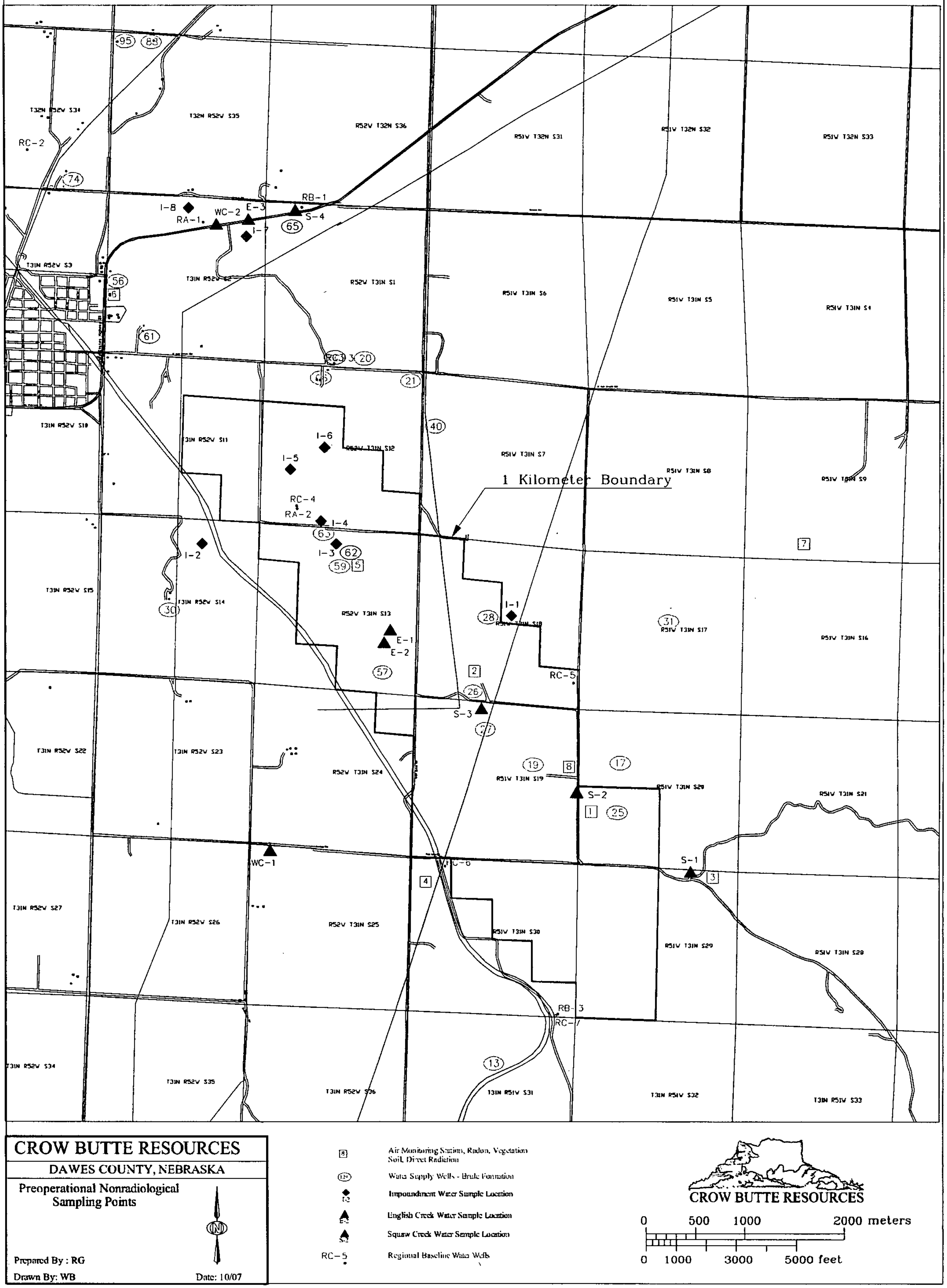
Table 2.9-1: Non-Radiological Preoperational Monitoring Program

Sample Collection					Sample Analysis	
Type of sample	**Number**	**Location**	**Method**	**Frequency**	**Frequency**	**Type of Analysis**
WATER						
Ground Water						
	One from each water supply well	All wells within 1 km of restricted are boundary	Grab	3 Times	Each Sample	Complete Table 5.7-19 list
	One from each well	Selected Regional wells	Grab	3 Times	Each Sample	Same
	One from each DEQ baseline & monitor well	As required by DEQ	Grab	Quarterly	Quarterly	Complete Table 5.7-19 list once; common ions only other quarters
Surface Water						
	One from each pond or impoundment		Grab	Once	Once	Complete Table 5.7-19 list
	Two from Squaw Creek	One up-stream, one down stream of restricted area	Grab	Quarterly	Quarterly	Complete Table 5.7-19 list once; common ions only other quarters
	Two from White Clay Creek	Upstream and down stream of License Area.	Grab	Four Times	Quarterly	Complete Table 5.7-19 list once; common ions other quarters
	Two from English Creek	Upstream and down stream of License Area	Grab	Four Times	Quarterly	Complete Table 5.7-19 once; common ions other quarters
	Two from Squaw Creek	One upstream and one down stream of restricted area	Grab	Quarterly	Quarterly	Suspended sediment
Water Levels						
	One from each monitor	Surrounding and within	Electric line	Monthly	Monthly	Map

Table 2.9-1: Non-Radiological Preoperational Monitoring Program

Sample Collection					Sample Analysis	
Type of sample	**Number**	**Location**	**Method**	**Frequency**	**Frequency**	**Type of Analysis**
	well, baseline well, and selected private wells	wellfield				
Flow						
	Two from Squaw Creek	One upstream and one down stream of restricted area	Flow	Monthly through 1982; then quarterly	Monthly	Tabular
SOILS						
Surface						
	One each	Six locations in Section 19	Grab	Once	Once	Arsenic, Selenium
	One each	Nine locations in License Area	Grab	Once	Once	Arsenic, Selenium
	One each	Seven Locations In restricted area	Grab	Once	Once	Vanadium

Figure 2.9-1



T32N R52W S34
T32N R52W S35
R52W T32N S36
R51W T32N S31
R51W T32N S32
R51W T32N S33
RC-2
RB-1
I-8
E-3
WC-2
RA-1
S-4
I-7
T31N R52W S3
T31N R52W S2
R52W T31N S1
R51W T31N S6
R51W T31N S5
R51W T31N S4
T31N R52W S10
T31N R52W S11
R52W T31N S12
R51W T31N S7
R51W T31N S8
R51W T31N S9
I-6
I-5
RC-4
RA-2
I-4
I-3
I-2
I-1
1 Kilometer Boundary
T31N R52W S15
T31N R52W S14
R52W T31N S13
R51W T31N S18
R51W T31N S17
R51W T31N S16
E-1
E-2
RC-5
S-3
T31N R52W S22
T31N R52W S23
R52W T31N S24
R51W T31N S19
R51W T31N S20
R51W T31N S21
S-2
S-1
WC-1
T31N R52W S27
T31N R52W S26
R52W T31N S25
R51W T31N S30
R51W T31N S29
R51W T31N S28
RB-3
RC-7
T31N R52W S34
T31N R52W S35
T31N R52W S36
T31N R51W S31
T31N R51W S32
T31N R51W S33
CROW BUTTE RESOURCES
DAWES COUNTY, NEBRASKA
Preoperational Nonradiological Sampling Points
Prepared By : RG
Drawn By: WB
Date: 10/07
Air Monitoring Station, Radon, Vegetation Soil, Direct Radiation
Water Supply Wells - Brule Formation
Impoundment Water Sample Location
English Creek Water Sample Location
Squaw Creek Water Sample Location
RC-5
Regional Baseline Water Wells
CROW BUTTE RESOURCES
0 500 1000 2000 meters
0 1000 3000 5000 feet

Water samples were taken from selected representative wells within the License Area and surrounding areas. The objective of this sampling was to characterize the water quality in the mineralized production zone and any overlying aquifer(s). This was accomplished in several ways. Eighteen of the nearby private wells identified in the water user survey were chosen for quarterly sampling during 1982. Sampling continued on a quarterly basis from 1982 and 1983 went to semiannual in 1984 and annual in 1985 and 1986. Their selection was to provide information supplemental to that from wells installed by Wyoming Fuel Company and since taken over by CBR. A majority of the local private wells and all but three of those sampled are completed in shallow Brule sands due to the lower drilling costs and more desirable quality water than that of the deeper Chadron Formation aquifer. **Table 2.9-2** lists the private wells that were sampled to evaluate the local water quality.

Table 2.9-2: Private Wells Sampled within and around the License Area

Well Number	Formation	Estimated Depth (ft)	Use
13	Brule	---	Stock
17	Brule	80	Domestic, Stock
19	Brule	80	Stock
25	Brule	75	Domestic, Stock
26	Brule	80	Domestic, Stock
27	Brule	80	Stock
30	Brule	55	Stock
40	Brule	60	Stock
56	Brule	200	Domestic, Stock
57	Brule	25	Domestic, Stock
61	Chadron	280	Domestic, Stock
62	Chadron	470	Industrial Well
63	Brule	100	Domestic
65	Chadron	260	Stock
66	Brule	60	Domestic, Stock
74	Brule	60	Stock
88	Brule	60	Domestic, Stock
95	Brule	100	Domestic, Stock

Notes:
--- = unknown

Eleven wells originally drilled by WFC and since taken over by CBR expressly for baseline determination were sampled. The well screening interval, total depth and formation in which the baseline wells were completed are listed in **Table 2.9-3**. Four are completed in the Brule Formation and seven in the Chadron Sandstone (production zone).

Table 2.9-3: Baseline Wells Originally Drilled by WFC

Well Number	Formation	Screen Interval (ft)	Depth (ft) to Bottom of Screen Assembly
RA-1	Brule	7 - 27	32
RA-2	Brule	7 - 27	32
RB-1	Brule	100 - 110	115
RB-3	Brule	95 - 115	120
RC-1	Chadron	330 - 350	355
RC-2	Chadron	572 - 592	597
RC-3	Chadron	260 - 270	275
RC-4	Chadron	340 - 360	365
RC-5	Chadron	672 - 692	697
RC-6	Chadron	713 - 733	738
RC-7	Chadron	708 - 718	723

Sample collection and preservation were performed using standard USEPA methods. Prior to sampling, all field pH and conductivity meters were calibrated using known standards. In some cases, a backup meter was also used to verify readings from the primary instrument. Also prior to sampling 1 to 1.25 casing volumes are removed from the well by pumping. The type pumping systems (submersible, pump jack, etc.) is determined by the depth and recharge characteristics of the well. The specific conductance, pH and temperature are measured periodically during pumping and samples are taken after these parameters have stabilized (typically 1 to 1.25 casing volumes). The preservatives as specified by Handbook for Sampling and Sample Preservation of Water and Wastewater (Report No. USEPA-600/4-82-029) are added to the samples and samples are transported to the lab for analysis.

2.9.2 R&D Area Groundwater Quality

Initial baseline and operational samples have been collected from the R&D wellfield and selected monitor wells. **Figure 2.9-2** illustrates the locations of the production zone baseline and overlying aquifer baseline wells, and the monitor wells used during mining. **Table 2.9-3** lists the depth and geologic unit for each baseline well. A summary of the analytical results (Brule and Chadron formations) for the eleven baseline wells drilled by WFC is given in **Table 2.9-4**.

2.9.3 Water Levels

Monthly water level measurements were made on 23 representative wells within the License Area. Of these wells, 12 are completed in the Brule Formation and 11 in the Chadron Formation aquifer. The objective was to determine if seasonal or periodic fluctuation in the piezometric surfaces occurs in the License Area.

Figure 2.9-2: R & D Wellfield Water Quality Wells

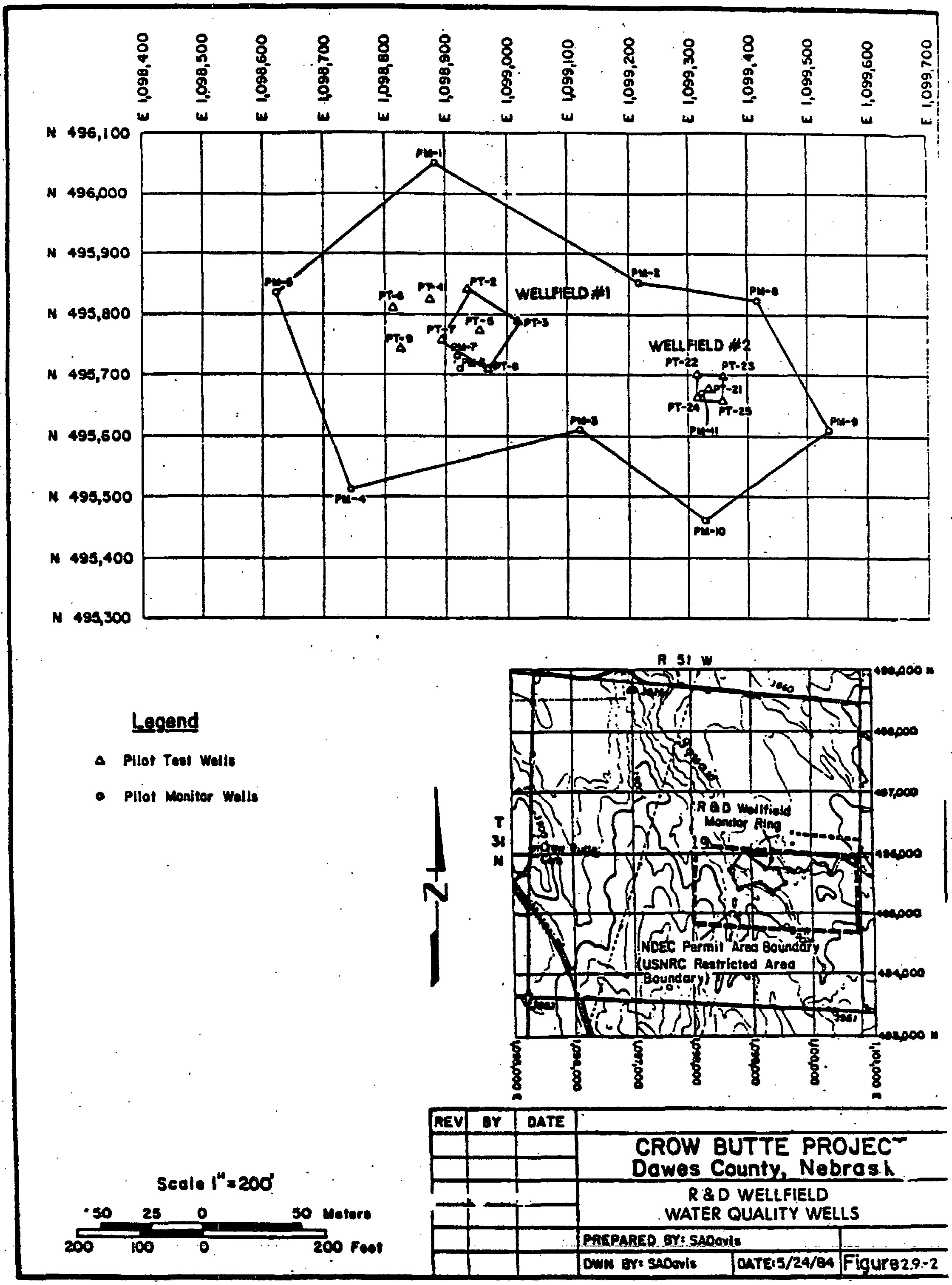


Table 2.9-4: Aquifer Water Quality Summary

	Range	Mean
Brule Formation*		
Calcium	7.1 - 98	48
Magnesium	0.3 - 16	6.6
Sodium	12 - 340	104
Potassium	4.1 - 15.9	9.9
Bicarbonate	137 - 627	364
Sulfate	1 - 23	10
Chloride	1.6 - 192	48
Conductance	246 - 1481	714
pH	6.8 - 8.5	7.8
Uranium	0.001 - 0.021	0.0064
Radium-226	0.1 - 3.0	0.7
Chadron Formation*		
Calcium	11 - 41	20
Magnesium	0.8 - 7.2	3.2
Sodium	340 - 540	411
Potassium	7.0 - 19.8	12.4
Bicarbonate	308 - 411	368
Sulfate	254 - 620	407
Chloride	134 - 250	176
Conductance	1500 - 2500	1932
pH	7.6 - 8.7	8.2
Uranium	<0.001 - 2.40	0.092
Radium-226	0.1 - 619	53

* Summary of average values for baseline wells drilled by WFC listed in **Table 2.9-3**.
In mg/L, except pH (units), Ra-226 (pCi/l), and Conductance (umhos).

Seasonal fluctuations in water level are commonly observed in shallow unconfined aquifers where effects of the hydrologic cycle are more immediate. Decreases occur in response to aquifer discharge to surface water systems during dry periods. Infiltration of precipitation, runoff and excess stream flow will serve to recharge the aquifer. Confined aquifers should exhibit little fluctuation in the piezometric surface except where groundwater withdrawal rates are high and/or seasonal.

Water levels were determined using battery operated instruments. Measurements were recorded together with the date and name of individual taking the readings. Values were then corrected to mean sea level (msl). Selected results are presented in **Figure 2.9-3** and **Figure 2.9-4. Table 2.9-5** lists the depth (screen interval and total well depth) and geologic unit for each baseline well. All of the water level results are listed in **Table 2.9-6** and **Table 2.9-7**.

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Figure 2.9-3: Seasonal Water Level Fluctuations

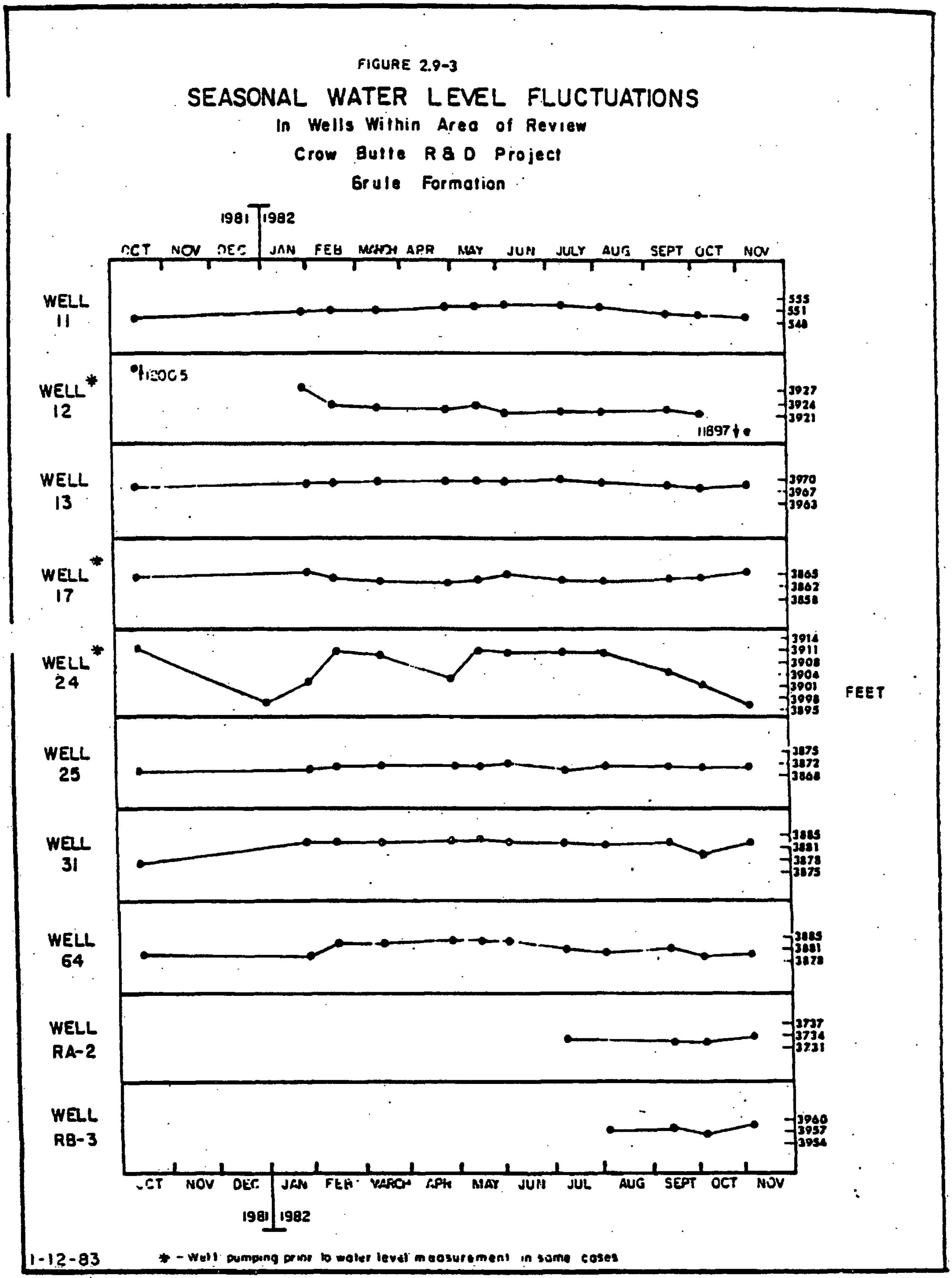

Figure 2.9-4: Seasonal Water Level Fluctuations

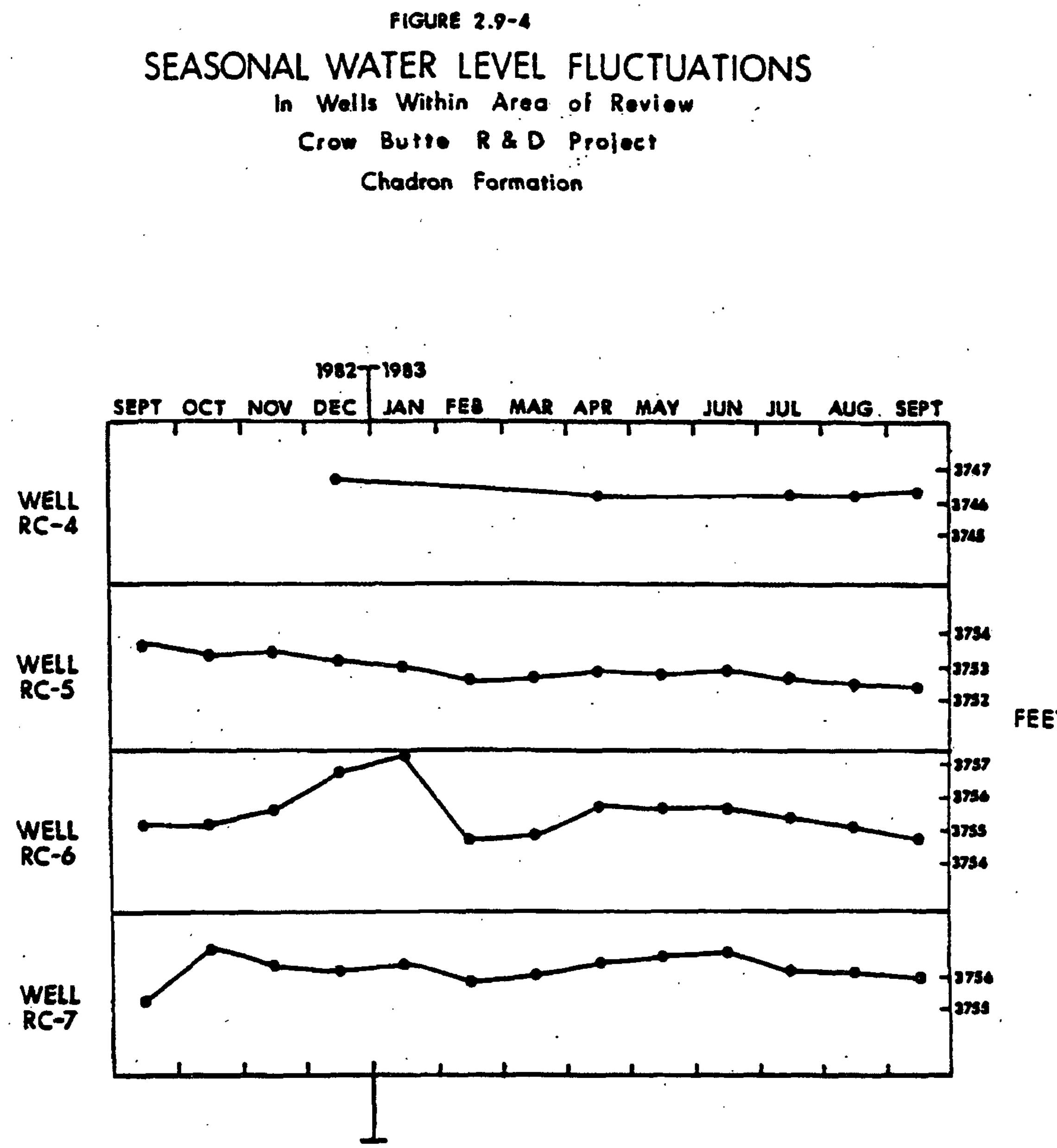

Table 2.9-5: Water Quality Wells Used for Preoperational and Operational Data

Well Number	Formation	Screen Interval (ft)	Depth to Bottom of Screen Assembly (ft)
OB-1 (PT-4)	Chadron	637.1-647.1; 652.1-657.1	662.1
OB-2 (PT-6)	Chadron	652 - 667	667
Wellfield Domestic	Brule	20 - 60	60
PT-2	Chadron	641 - 656	661
PT-3	Chadron	638 - 648	653
PT-5	Chadron	638 - 653	670
PT-7	Chadron	649 - 664	669
PT-8	Chadron	653 - 668	673
PT-9	Chadron	659 - 674	680.2
PT-21	Chadron	652 - 657	660
PT-22	Chadron	652.5 - 657.5	662.5
PT-23	Chadron	655.5 - 660.5	665.5
PT-24	Chadron	647.1 - 652.1	654.1
PT-25	Chadron	650 - 655	659
PM-1	Chadron	649.5 - 669.5	674.5
PM-2	Chadron	641-651; 661-671	676
PM-3	Chadron	616-626; 631-641; 464-656	661
PM-4	Chadron	641.5-646.5; 654.5-669.5	674.5
PM-5	Chadron	648-658; 668-678; 683-688	693
PM-6	Brule	196 - 211	216
PM-7	Brule	89.5-94.5; 99.5-104.5;	
		109-114; 119.5-124.5	129.5
PM-8	Chadron	631-641; 651-661	666
PM-9	Chadron	633-643; 698-658	663
PM-10	Chadron	619-629; 635-645; 651-661	666
PM-11	Brule	252 - 267	272

2.9.4 Surface Water Quality

Samples were collected from Squaw Creek, English Creek, White Clay Creek, the White River and all surface bodies of water within the License Area during preoperational sampling. **Table 2.9-1** outlines the preoperational sampling schedule and the parameters for analysis. This schedule was begun in 1982 and continued.

Squaw Creek passes through the License Area as it flows towards the White River. Four sampling points located on Squaw Creek were utilized. Locations W-1, W-2 and W-3 on the White River were also part of the commercial preoperational monitoring program.

Table 2.9-6: Brule Water Levels (in feet above mean sea level)

Well	1982												1993	
	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	April	July
11**	3831.7	3831.5	3831.8	3833.0	3833.0	3833.6	3833.0	3832.6	3831.5	3830.6	3830.3	3830.3	3843.5*	3837.0
12**	3928.0	3924.0	3923.0	3922.7	3923.7	3921.1	3922.1	3921.5	3922.2	3921.3	3903.3*	3918.7	3922.9	3920.0
13	3968.5	3968.7	3968.8	3969.4	3969.6	3969.2	3969.5	3968.9	3968.1	3967.5	3968.1	3968.4	3969.0	3970.0
17	3865.0	3863.5	3863.3	3862.6	3863.6	3864.8	3863.3	3862.8	3863.5	3863.8	3865.3	3864.6	3864.8	3862.8
24**	3902.0	3910.5	3909.0	3903.0	3910.9	3910.5	3910.5	3910.0	3904.7	3901.5	3895.7*	3910.1	3910.4	3911.0
25	3870.0	3870.8	3870.0	3871.0	3871.0	3871.3	3869.5	3870.9	3870.6	3870.5	3870.8	3870.9	3870.1	3871.6
31**	3883.1	3883.1	3883.2	3883.1	3883.3	3883.0	3882.6	3882.3	3882.6	3880.0	3882.3	3882.5	3882.5	3872.3*
64	3882.0	3882.9	3882.6	3883.5	3883.6	3883.8	3881.4	3880.8	3881.5	3880.0	3880.4	3882.0	3884.3	3883.5
	1982				1983									
	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Sept	
RA-2	3737.1	3737.0	3738.5	3737.9	3739.2	3739.1	3739.7	3740.2	3740.9	3741.0	3739.9	3739.2	3738.1	
RB-3	3962.6	3961.2	3963.5	3963.6	3963.8	3963.8	3963.3	3969.7*	3963.7	3963.7	3964.2	3964.1	3964.2	
PM-6	------	3844.9	3844.9	------	3843.5*	3844.5	3844.9	3845.3	3845.5	3846.0	3845.9	3945.9	3845.7	
PM-7	------	3845.7	3845.5	------	3845.9	3845.8	3845.7	3846.1	3846.3	3846.9	3846.7	3846.7	3846.6	

Notes:

* Suspect data

** Well may have been pumping prior to water level measurement

------ = not measured

Table 2.9-7: Chadron Water Levels (in feet above mean sea level)

	1982				1983								
Well	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Sept
62	3748.4	3748.0	3747.2	3746.6	------	------	3746.1	3746.2	------	------	3746.1	3745.8	3745.4
RC-4	------	------	------	3746.7	------	------	------	3746.2	------	------	3746.2	3746.2	3746.3
RC-5	3753.6	3753.4	3753.4	3753.2	3753.0	3752.6	3752.7	3752.9	3752.8	3752.9	3752.7	3752.5	3752.4
RC-6	3755.2	3755.2	3755.7	3756.8	3757.5	3754.7	3754.9	3755.7	3755.6	3755.6	3755.4	3755.2	3754.7
RC-7	3755.2	3756.8	3756.3	3756.2	3756.4	3755.8	3756.0	3756.4	3756.5	3756.7	3756.2	3756.1	3755.9
PM-1	------	3754.5	3754.4	3754.1	3754.3	3754.0	3753.8	3754.0	3754.2	3754.1	3753.8	3753.5	3753.5
PM-4	------	3755.2	3755.2	3754.4	3754.4	3754.1	3754.2	3754.4	3754.8	3754.6	3754.3	3753.9	3754.6
PT-2	------	3747.1*	3747.1*	3754.0	3754.6	3754.3	3754.1	3754.3	3754.5	3754.7	3754.3	3753.9	3753.7
PT-7	------	3755.1	3755.0	3754.2	3754.2	3754.0	3754.0	3754.1	3754.8	3754.6	3754.3	3754.1	3753.9
PT-8	------	3755.5	3755.6	3754.6	3754.4	3754.4	3755.7	3754.4	3754.5	3754.6	3754.2	3753.8	3753.7
PT-9	------	3753.5	3753.5	3754.9	3754.6	3754.6	3754.6	3754.8	3854.8	3754.9	3754.5	3754.3	3754.1

Notes:
* Suspect data
------ = not measured

The stream and river samples were also analyzed for suspended sediment content. Sampling was initiated in 1982 and samples were taken from sites S-1, S-2, S-3 and W-2 (White River) for four quarters in 1982. Sampling continued at sites S-2 and S-3 from 1982 through 1987. Results of the suspended sediment sampling are found in **Table 2.9-8**. Average Squaw Creek suspended sediment ranges from 5.6 to 29.1 mg/L with site S-3 consistently higher in suspended sediments than sites S-1 and S-2.

Table 2.9-8: Suspended Sediment in Flowing Waters of Squaw Creek and White River

	Time Period	Range	Average	Std. Dev.
S-1	1982	5-36	13.5	15.1
S-2	1982 - 1987	<1-24	5.6	5.6
S-3	1982 - 1987	2.7-76	29.1	24.4
W-2	1982	7-190	73.8	80.0

Notes: Results given as Total Suspended Solids in mg/L.

The White River suspended sediment was an average of 74 mg/L for the year period.

Eight impoundments are located within the CSA; I-1 through I-8. Samples were collected and handled in the same manner as described above. Sampling sites were also used for obtaining sediment material for radiometric determinations discussed in **Section 2.10**.

Total suspended solids measurements have not been collected since 1982 and there are no plans to sample in the future.

2.9.5 Stream Flow

Squaw Creek flows through the Crow Butte License Area from east to northwest. The flow rate of this perennial stream was monitored at two locations according to the schedule given in **Table 2.9-1**. In addition, discharge rates of the Squaw Creek above the License Area and the White River were monitored.

Flow was determined using a water current meter. This instrument operated utilizing a propeller driven photo-optical device to measure water velocity. It is a broad range, low threshold instrument. Measurement range is 0-6.1 m/sec (0-20 ft/sec) with an accuracy of ± 1 percent.

Flow rates were determined as follows. First the height of the water at the deepest point and width of water were measured and drawn on the cross-section. Next, the numbers of flow measurements to be taken were determined. If the stream width was less than one meter, then one measurement was taken at a point 0.5 times the width. The depth of measurement was 0.6 times the depth, down from the surface. If the width was greater than one meter, then three sets of measurements were made at two depths each (USDI, 1981). Data were then analyzed by determining the cross-sectional area of the water and the average flow velocity.

Table 2.9-9 lists the flow rates measured during 1982. An upstream station, S-1 and a White River station, W-2, are included for comparison. The data are shown graphically in **Figure 2.9-5**.

Table 2.9-9: 1982 Stream Discharge Rates (m^3/sec)

Station	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Squaw Creek 1 (S-1)	.812	1.34	1.38	2.26	2.40	1.34	.918	.106	.600	1.17
Squaw Creek 2 (S-2)	.247	1.02	1.06	1.45	4.52	.282	.247	.071	.282	.459
Squaw Creek 3 (S-3)	.953	1.80	1.62	3.28	1.41	.812	.071	.000	.706	1.34
White River 2 (W-2)	25.0	27.6	31.8	29.8	26.9	21.0	16.3	11.1	28.5	20.2

2.9.6 Soils

Soils samples were collected to determine baseline concentrations of selected elements in the different soil types. Nine samples were collected in the License Area. Six locations were chosen within and nearby Section 19 to provide background information on where the commercial process facility will be located and where maximum surface disturbance will occur **(Figure 2.9-6)**. Seven sites were also sampled in the proposed restricted area **(Figure 2.9-7)**. At the plant and pond locations, another set of samples were obtained before commercial construction and also after topsoil removal and excavation is complete.

Material collected for nonradiological analysis was in the form of surface samples. These were collected as follows: A two-meter transect was laid out in either a north-south or east-west direction at the desired location. Points along this line were situated at 0, 0.67, 1.33 and 2 meters. At each point soil was removed from a 5 to 7.6 cm (2 to 3 in.) diameter circular area to a depth of 5 cm (2 in.).

Three trace elements were chosen for consideration in this sampling. Arsenic, selenium and vanadium are commonly associated with uranium ore deposits. This is especially true in roll-front type deposits where halos of metal sulfides and other reduced compounds occur at the "nose" or in front of the uranium mineralization. When leaching takes place during mining, varying concentrations of companion compounds will be solubilized. Thus, a surface spill of leach solution might contain small amounts of these three elements. The leach solution will also contain uranium and radium-226. The baseline uranium and radium-226 levels in the soil are found in **Section 2.10**.

Samples from the License Area and the specific samples from Section 19 **(Figure 2.9-6)** were analyzed for arsenic and selenium and the samples from the proposed restricted area **(Figure 2.9-7)** were analyzed for vanadium.

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Figure 2.9-5: Stream Discharge Rates

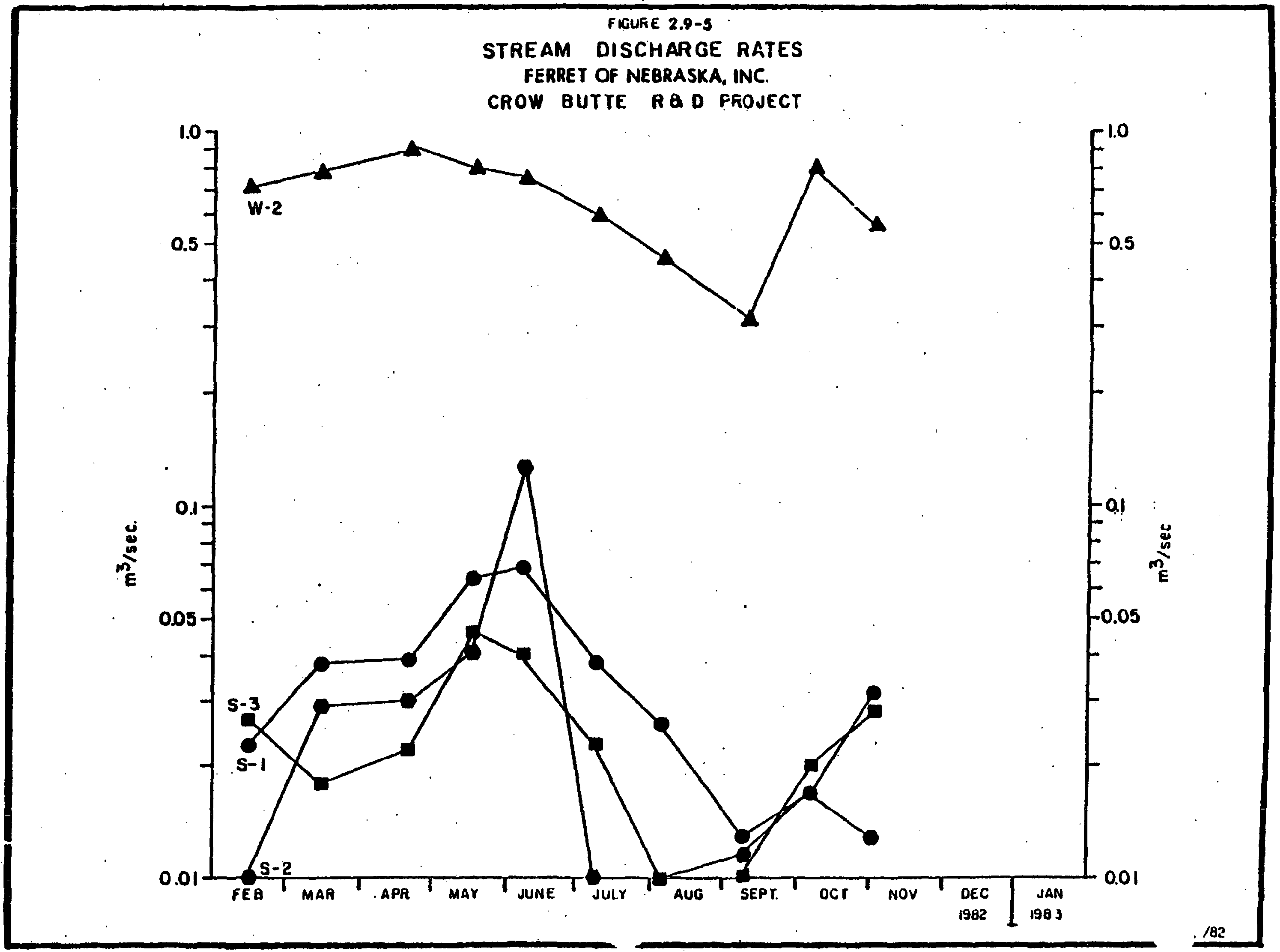
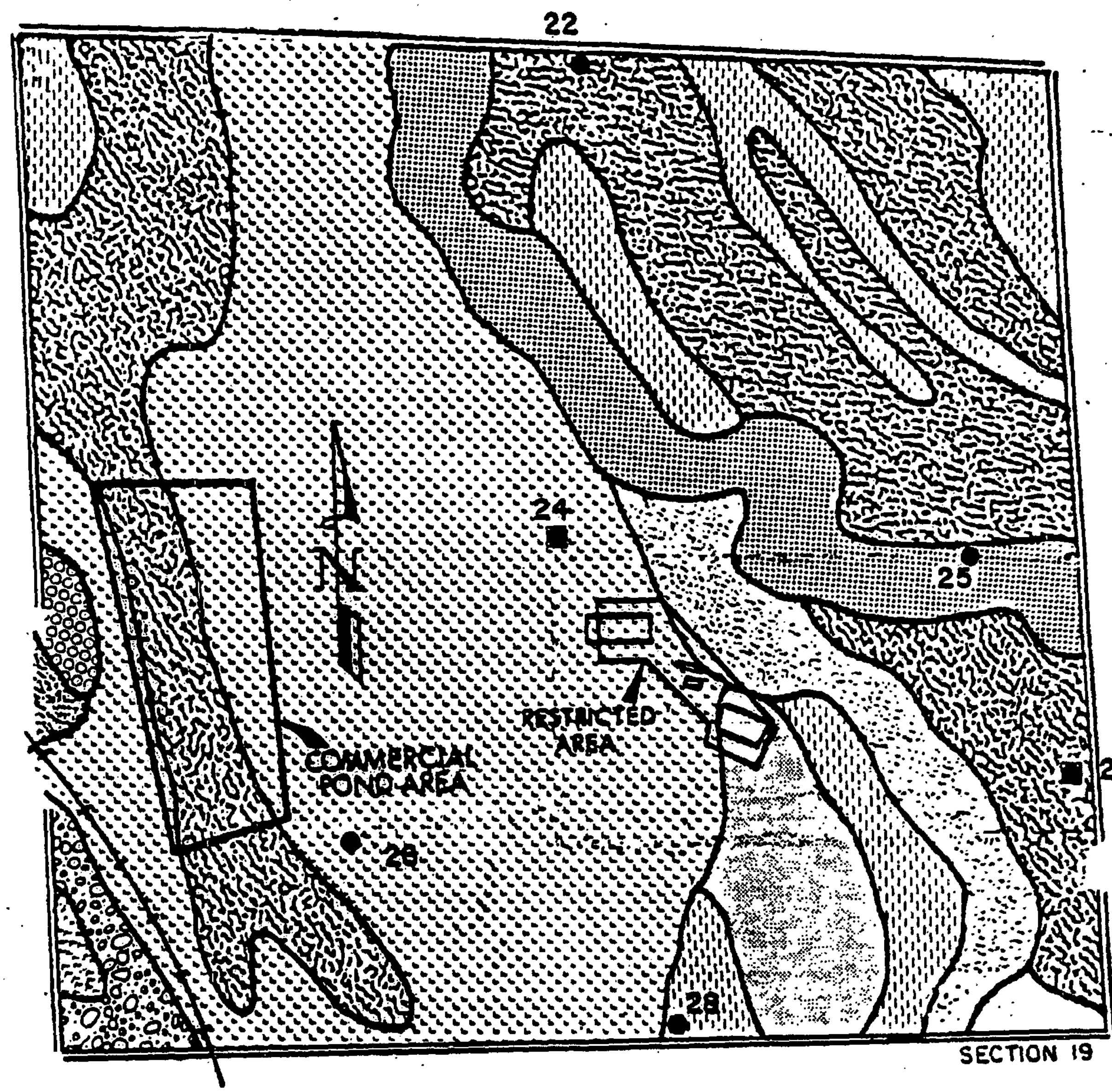


Figure 2.9-6: Soil Sample Location



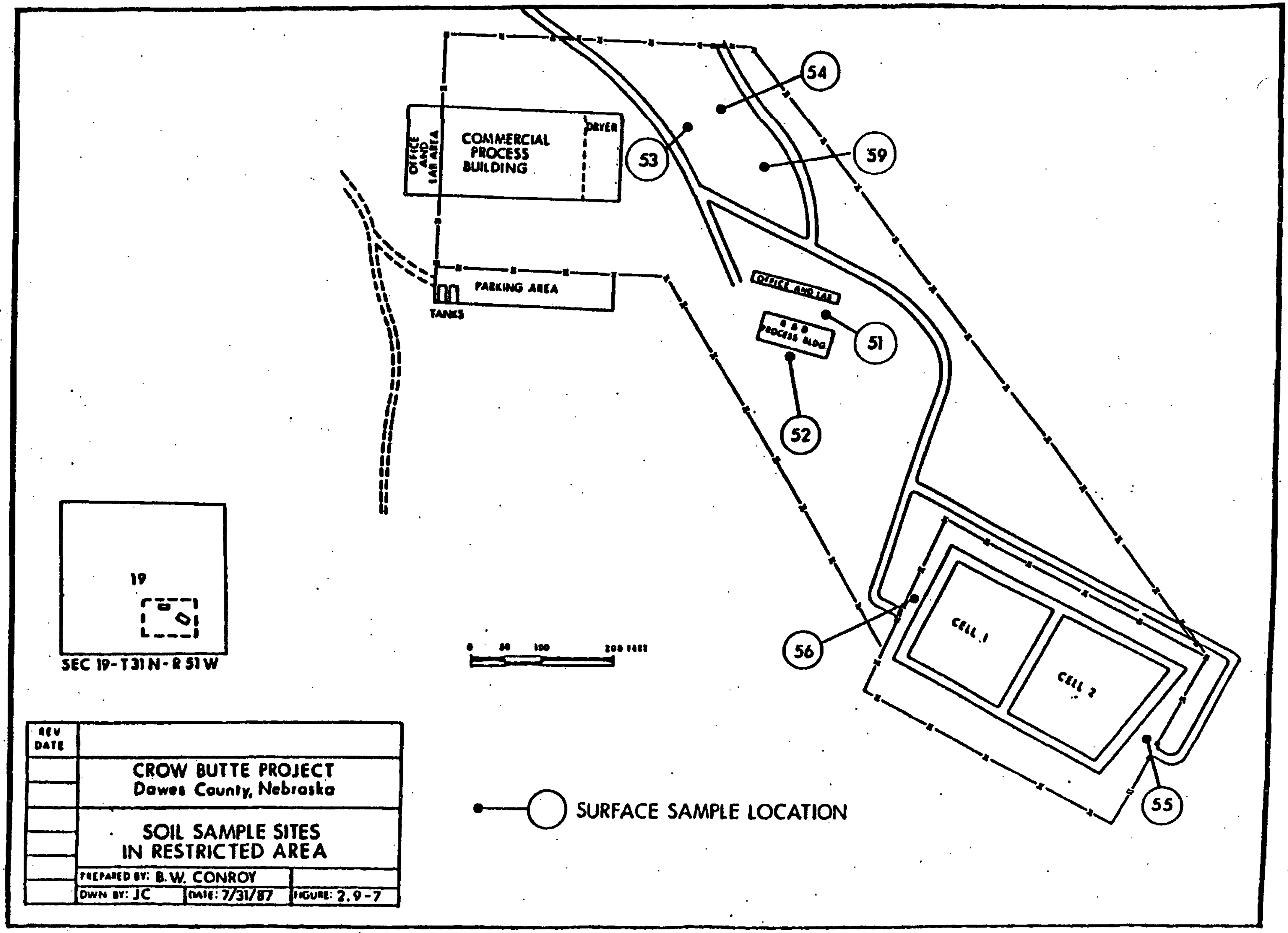
AcD2 Alliance silt loam, 3 to 9% slopes, eroded
BuD2 Busher loamy very fine sand, 5 to 9% slopes, eroded
BuF Busher loamy very fine sand, 9 to 20% slopes
BxF Busher and Tassel loamy very fine sands, 5 to 20% slopes
JvD Jayem and Vetal loamy very fine sands, 5 to 9% slopes
Sn Sandy alluvial land
SvF Sarben and Vetal loamy very fine sands, 9 to 30% slopes
SyF Schamber soils, 3 to 30%
TaF Tassel soils, 3 to 30% slopes
VeC Vetal and Bayard soils, 1 to 5% slopes

● - Surface Sample Site

METERS: 400 200 0 400
FEET: 1250 750 250 0 1250

REV	BY	DATE	FERRET OF NEBRASKA, INC. CROW BUTTE PROJECT Dawes County, Nebraska
			SOIL SAMPLE LOCATION
			PREPARED BY: F.E.N.
			DWN BY: JC · DATE: 8/87 · FIGURE 2.9-6

Figure 2.9-7: Soil Sample Sites in Restricted Area



Results of the soil sampling are found in **Table 2.9-10** and **Table 2.9-11**. As can be seen from the data in **Table 2.9-10** the arsenic concentration ranges from 0.59 μg/g to 3.30 μg/g and the selenium concentration ranges from <0.01 μg/g to 0.06 μg/g. There does not appear to be any relationship between the soil type and the levels of these elements. The vanadium analyses shown in **Table 2.9-11** indicates that the vanadium levels in the restricted area are very consistent with a range of 22 to 29 μg/g.

Table 2.9-10: Soils Analysis Results License Area and Section 19

Sample Site	Soils Map Unit	Sample Date	Arsenic (μg/g)	Selenium (μg/g)
2	Sarben	7/24/82	0.59	<0.01
5	Keith	7/23/82	1.10	0.04
6	Keith	7/23/82	1.00	0.03
10	Rosebud	7/23/82	1.00	0.03
11	Rosebud	7/24/82	0.80	0.03
13	Jayem	7/23/82	0.80	0.03
15	Duroc	7/24/82	0.70	0.06
19	Sarben	7/24/82	0.88	0.03
22	Vetal	7/24/82	0.88	<0.01
24	Busher	7/24/82	1.00	0.03
24	Sandy Alluvial	7/24/82	0.64	0.04
26	Busher	7/24/82	0.99	0.01
27	Vetal	7/24/82	0.72	0.05
28	Jayem	7/24/82	0.94	0.03
49	Sarben	7/23/82	3.30	0.04

Notes: See soils map in Section 2.7 for further information on soils map unit.

Table 2.9-11: Soils Analysis Results in Restricted Area

Sample Site	Sample Date	Vanadium (μg/g)
51	12/15/82	22
52	12/15/82	28
53	12/15/82	22
54	12/15/82	27
55	12/15/82	27
56	12/15/82	29
59	12/15/82	26

Soils develop over long periods of time and contain elements that are in equilibrium with the established chemical environment. Several factors govern solubility and stability of elements in soils. These include pH, drainage status, organic content, sulfate content, etc. In addition, many studies have pointed out there is no absolute correlation between the total concentration of an element in the soil and its uptake by plants. However, uptake of arsenic, selenium, and vanadium by plants depends highly on the chemical form and availability of the elements and upon the plant species.

2.9.7 References

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