CROW BUTTE URANIUM PROJECT
Dawes County, Nebraska

Application and Supporting Environmental Report for State of Nebraska Underground Injection Control Program Commercial Permit

Submitted to:
Nebraska Department of Environmental Control
Lincoln, Nebraska

November, 1987

Prepared and Submitted by:
Ferret of Nebraska, Inc.
1800 Glenarm Pl., Suite 400
Denver, CO 80202

5/23/88

ERRATA SHEET

Attached please find corrected replacement pages for the Application and Supporting Environmental Report for the State of Nebraska Underground Injection Control Program Commercial Permit. Please replace the original pages with the corrected pages.

4.2(3)	Revised Commercial Pond Area.
4.5(5)*	Basal Member changed to Chadron Sandstone.
4.5(9)*	Bordeaux Fault and Toadstool Park Fault in singular tense.
4.5(26)*	University misspelled and illustrate instead of illustrates.
5.0(1)	An alternative 7 spot hexagon pattern is included.
5.0(3)	Figure 5.1-1 revised Commercial Pond Area and individual ponds shown.
5.0(4)	An alternative 7 spot hexagon pattern is included on Figure 5.1-2.
5.0(10)	The alkalinity range for the lixiviant is added to the table and the less than sign deleted from pH.
5.1-2	An alternative 7 spot hexagon pattern is included.
9.0(2)	An alternative 7 spot hexagon pattern is included.
11.0(10)*	Post Mining NO_2 as N is 0.043 not 0.43.

* Indicates a typographical error, so the date on the page is not changed.

2/29/88

ERRATA SHEET
DEC Completeness Review

Attached please find corrected replacement pages for the Application and Supporting Environmental Report for the State of Nebraska Underground Injection Control Program Commercial Permit. Please replace the original pages with the corrected pages.

DDC	1.	FEN response
	2.	Correction page 4.4(66) attached
	3.	FEN submitted raw data
	4.	FEN response
	5.	FEN response
	6.	FEN response
SW	1.	Appendix 4.9(A) and Appendix 4.9(B) attached
	2.	Correction page 4.9(110) attached
	3.	Correction page 4.9(94) attached
	4.	Correction page 4.9(106) attached; Page 4.9(127) attached to add reference for page 4.9(106).
PSF	1.	Correction page 3.0(1) attached and page 1 of Introduction
	2.	Corrected Figure 4.4-1 attached
	3.*	Corrected page 4.4(14) attached
	4.	Corrected Figure 4.4-7 attached
	5.	Section 4.5 replaced
	6.	Section 4.5 replaced
	7.*	Corrected page 4.7(15) attached
	8.*	Corrected page 4.8(3) attached
	9.	Corrected page 4.8(53) attached
	10.	FEN response
	11.	Corrected page 5.0(6) attached
	12.	Corrected page 5.0(10) attached
	13.	FEN submitted NRC Attachment A
	14.	Section 4.8 Appendices A and B provided
	15.	Section 4.5 replaced
	16.	See page 4.6(3) and page 1 of Introduction
JA	1.	Figures 4.2-1 replaced earlier; Figures 4.4-1 and 4.4-7 replaced by PSF #2 and PSF #4; Corrected Figure 4.5-15 attached
	2.	FEN response
	3.	Corrected page 4.4(50) attached and Appendix 4.4(C)
	4.	FEN response
	5.	Corrected page 4.4(56) and 4.4(56A) attached.
DC	1.	Corrected page 4.4(65) and 4.4(65A) attached
	2.	FEN response
	3.1	Appendices A and B provided by FEN
	3.2	Appendices A and B provided by FEN
	3.3	Appendices A and B provided by FEN
	3.4	Appendices A and B provided by FEN

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ERRATA SHEET - Continued

DC	4.	FEN response
	5.	See PSF #14
	6.	See PSF #14
	7.	FEN response
	8.	Corrected page 4.9(123) attached
	9.	Answered on page 5.0(10), See response to PSF #12
	10.	Corrected page 8.0(1) and Figure 10.2-1 and 10.2-2 attached
	11.	FEN response
	12.	Corrected page 11.0(4) attached
	13.	Corrected page 11.0(29) attached
	14.	Corrected page 4.4(28) attached
	15.	Corrected page 4.4(28) attached
	16.*	Corrected page 4.4(51) attached
	17.*	Corrected page 4.4(55) attached
	18.	Corrected in JA #5
	19.	Corrected page 4.4(80) attached
	20.*	Corrected page 4.4B(20) attached
	21.	FEN response
	22.*	Corrected page 4.9(119) attached
	23.	Corrected page 4.9(122) attached
	24.	Corrected page 10.0(7) attached
	25.	FEN response
CSD	1.	Corrected page 4.4(5) attached
	2.	Subsection 4.5 revised

* Indicates a typographical error, so the date on the page is not changed.

7/28/88

ERRATA SHEET

Attached please find corrected replacement pages for the Application and Supporting Environmental Report for the State of Nebraska Underground Injection Control Program Commercial Permit. Please replace the original pages with the corrected pages.

11.0(6)	Addition of words "(a total of 69 individual analysis)" at bottom of page.
11.0(7)-(7A)	Addition of 6 paragraphs to explain the statistical basis for one well per acre for establishing restoration criteria.
13.0(2)	Table 13.0-1 - Delet D (domestic usage) from Well 65 to reflect correct usage.

FEN Responses to DEC Staff Comments

DDC

1. Is the one additional pumping test performed sufficient for the entire permit area?

   The 1987 pumping test had a radius of influence of about 5000 feet. The 1982 pumping test was within this area of influence and extended the radius of influence further south. The proposed ten year mine plan is entirely within the area of influence of both tests. At the time mine plans are prepared for areas outside of the radius of influence of these two pumping tests, additional pumping tests will be conducted for these areas. Present plans indicate that it is 10 to 15 years before additional pumping tests are necessary to be conducted. FEN believes it would not be effective to conduct pumping tests far in advance of proposed mining.

2. Table 4.4-15 (Page 4.4(66)) contains some errors. The first column titled "USEPA NDEC MCL" should be changed to "NDEC MCL", as confirmed by footnote "A" (page 4.4 (67)). The MCL list omitted our standards for chloride and sulfate (both 250 mg/l) and for chromium (0.05 mg/l). In addition, the MCL for fluoride should be 4.0 mg/l, for iron 0.3 mg/l, for manganese 0.05 mg/l, for pH 6.5-8.5.

   These comments have been added to the table as requested.

3. Does DEC have all the raw water-quality data that appendix 4.4(A) summarizes? If so, where? If not, it needs to be supplied.

   Enclosed is a computer print out of the individual data for each well that is summarized in Appendix 4.4 (A). This data is supplied as support data to the permit application.

4. FEN reports some isolated sandstones in the upper confining layers (middle/upper Chadron-lower Brule). Will these be monitored as the first overlying permeable units?

   These isolated sandstones are very rare. See Cross Sections 4.5-1 to 4.5-11. None of these sandstones have been identified in the ten year mine plan. No one, to our knowledge, is using water from these isolated sandstones. If any of these isolated sands are encountered, they could be monitored if the NDEC desires. FEN would suggest that most of the monitor wells be placed in sands of the upper part of the Brule since these sands are more continuous and more likely to be used for domestic use.

5. Ferret's application states that we will establish restoration values (page 11.0(6)), but it later outlines a procedure that will be used to determine restoration values (page 11.0(7)). This procedure is different than what DEC used for the R&D permit. It would be more appropriate (and less controversial) for the application to simply state that we will establish the restoration values or make it clear the procedure discussed by FEN is only a proposal subject to DEC approval.

   The procedure proposed by FEN to establish restoration values is a proposal based on the R&D experience, and other commercial operations. During the R&D application review it was recognized that more data would be collected during the R&D restoration demonstration than was appropriate during commercial restoration.

DDC Comments Continued

6. The discussion of the R&D restoration in Section 11.3 is important, but the restoration process has not been completed. Can DEC say the commercial application is complete without this information?

FEN believes that restoration of Wellfield #2 was achieved in August, 1987. FEN has been sampling the representative well for a six month period to demonstrate stabilization. All of the wells were sampled on February 24, 1988 to demonstrate the stability of the wellfield. This data will be submitted as soon as it is available.

FEN believes that review of the commercial application should proceed on a timely basis in parallel with review of the R&D restoration.

SW

1. Fish population estimate data collected at Stations W-1 and W-3 on November 2, 1983, have not been included in the application. At the top of Page 4.9(113), the fish population estimate data collected on November 2, 1983, is stated to be in Appendix 4.9(B) of the application. Appendix 4.9(B) needs to be added to the application.

   Appendix 4.9(B) is included in this submittal for inclusion in the permit application.

2. The fish population estimate data from November 2, 1983, should also be incorporated into the text on Page 4.9(110), Page 2 in discussions of the numbers and sizes of brown trout collected in the White River at Station W-1.

   A statement has been added to page 4.9(110) to include this data.

3. On Page 4.9(94) p.2, last sentence, the statement, "as such, fish were collected at each location to document their occurrence and to determine their relative abundance, but no attempt was made to determine absolute "densities," is also not accurate as a result of the fish population estimate data collected on November 3, 1983. It should be stated that this paragraph refers only to the fisheries data collected in 1982. Additional statements should be added which discuss the fish population estimates made in 1983.

   A statement has been added to page 4.9(94) to address these comments.

4. On Page 4.9(106), last paragraph, first sentence, the statement "brook trout were collected from Squaw Creek, which is not stocked, at several locations," is somewhat misleading. "Currently" should be added before the "stocked". Statements should be added that describe Squaw Creek in the Ponderosa State Wildlife area as a self-reproducing brook trout fishery created as a result of original stockings by the Nebraska Game and Parks Commission. The most recent stocking records of brok trout in Squaw Creek by the Nebraska Game and Parks Commission should also be included.

   Additional information has been added to page 4.9(106) to address these comments.

PSF

1. The following permits or construction letters must be added on Page 1 of the introduction:
   Class V 5W-11
   Septic Tank
   Pond Permit
   Water Resources Permit
2. Page 4.4(3); Figure 4.4-1, no scale.
3. Page 4.4(14); toward is misspelled.
4. Page 4.4(16); Figure 4.4-7, no scale.
5. Page 4.5(22); typing error; should read "the".
6. Page 4.5(25); P. 3 L4-5, are there some words missing?
7. Page 4.7(15); local economy has misplaced comma.
8. Page 4.8(3); L2-3 should read "published" instead of "publisted?"
9. Page 4.8(53); P.2 L1 featire number is missing.

   Items 1-9 have been added or corrected on the appropriate pages.

10. Page 4.8; P. 1 L9 suggests an old well at 25DW193. Is there a plugging record? If so, please supply.

    The abandoned well is listed in the Water User Survey 4.3-4 as Well 35 along with the location. There are no plugging records for abandoned wells. A discussion of corrective actions to be taken for abandoned wells is included in Section 13.0.

11. Page 5.0(6); what are the highest flow values anticipated?

    A clarification of the highest flow values has been added to the text.

12. Page 5.0(10); less than or equal to signs need to be corrected.

    This table has been corrected.

13. Page 11.0(28); pleae supply a copy of USNRC Attachment A.

    A copy of USNRC Attachment A (Attachment 1) is enclosed as support data to the application.

14. The DEC must have the appendices referred to in Section 4.8.

    A copy of the appendices is enclosed. These appendices contain specific locations and information of a conidential nature and are requested by the Nebraska State Historical Society to be available only for professional review. The Nebraska State Historical Society believes that Section 9 of the Archeological Resources Protection Act of 1979 and other state laws make this document confidential.

    The appendices are supplied as support data to the permit application.

PSF - Continued

15. Paul Roberts noted that the legal description for #1 arner is wrong. The township should be 52W.

    This correction has been made.

16. Need statement on indian lands statement.

    A statement has been added to indicate that there are no Indian lands within the area.

Jon Atkinson

1. The scale specification is missing for Figures 4.2-1, 4.4-1, 4.4-7 and 4.5-15.

   Scales have been added to these Figures.

2. To complete well information, I would suggest adding legal description locations for wells listed in Tables 4.3-1 an 4.3-6.

   The wells are shown on Figure 4.3-1. The Section, Township and Range can be determined from this map.

3. For sake of completeness and ease of verification, the governing equations and calculations for travel times through the underlying and overlying aquicludes (p.4.4(14)) should be presented.

   The governing equations and calculations are added as an Appendix.

4. To complete information contained in Table 4.4-2, I suggest adding radial separation distances from the pumping wells.

   This information is provided on Table 4.4-3 on the next page.

5. The description of sample collection and preservation methods (p.4.4(56)) is incomplete, in my evaluation. For example, well purging methodology(ies) should be described briefly.

   An additional description has been added to page 4.4(56).

David Charlton

Section 4.0

1. Subsection 4.4, Hydrology
p.4.4(65) need to define SAR

A definition of SAR has been included in the text.

2. Subsection 4.5, Geology
p.4.5(2), Figure 4.5-1. Figure has been reduced to a point where it is unreadable. Needs to be redone.

A copy of the State Geologic Map of Nebraska is enclosed for reference.

p.4.5(8) to 4.5(10) Regional Structure. FEN's interpretation of the regional structure needs to be shown on a map. Figure 4.5-1 is inadequate. The map should include features such as (1) Crawford Basin, (2) Inner Crawford Basin, (3) White River Fault, (4) Cochran Arch, (5) Toadstool Park Fault, (6) Bordeaux Fault, (7) Pine Ridge Fault, (8) Chadron Arch, etc.

FEN has included the State Geologic Map of Nebraska as Figure 4.5-1 as the accepted regional structure.

3. Subsection 4.8, Historical
3.1 p.4.8(5) para 1: Appendix B was not found. If in Fenneman (1931), it is improperly presented.
3.2 p.4.8(37) para 2: Appendix C was not found.
3.3 p.4.8(40) Table 48-4: Appendix B not found.
3.4 p.4.8(61) para 1 and 4: Appendix B not found

A copy of the Appendices is enclosed. The reference to Appendix C on page 4.8(37) is a typographical error. This is Appendix B. A corrected page is enclosed for page 4.8(37). These appendices contain specific location and information about cultural resources and are requested by the Nebraska State Historical Society to be available only for professional review. These appendices are supplied as support data to the permit application.

4. Subsection 4.9, Ecology
Who did the studies? Need to identify and discuss

Studies were done by Greystone and Fred Harrington and Associates as noted in the Acknowledgements.

5. Appendixes A and B are missing.

Appendix A and B are enclosed to be added to the permit application.

6. p.4.9(113): Reference to Appendix 4.9(B)

Appendix 4.9(B) has been included to be added to the permit application.

David Charlton - Continued

7. p.4.9(122), Big Game Animals: If deer hunting will take place on property, what will happen if a wellhead is shot at by a hunter? Need to discuss here.

   The wellfield area is a limited access area in which no hunting will be permitted. Therefore, it is not anticipated that wellheads will be shot at. The impact on operations should be minimal if wellheads were shot, since pitless adaptors are used and the pipe is buried.

8. p.4.9(123), Raptors: Should bald eagles be included?

   A clarification has been added to paragraph 2 on page 4.9(123).

9. Section 5.0, Operation Data
   p.5.0(10) Table 5.1-2: From the text, it is not clear if this is barren lixiviant, pregnant lixiviant or both. (See page 12.0(1), which identifies this table as the "injection fluid").

   A footnote has been added to Table 5.1-2 to clarify this.

10. Section 10.0, Construction
    p.10.0(1) to 10.0(4): Method No. 1, description does not include how sand packing (gravel packing) will be done. It is necessary to explain when or why Method No. 1 (with sand pack) or Method No. 2 (without sand pack) will be used.

    This is natural sand packing that is developed during well clean-up. A clarification has been added to the text in 8.0 and on the Figures 10.2-1 and 10.2-2.

11. Section 11.0, Contingency Plan
    p.11.0(2), para 1: If selective screening of sandstone intervals, between clay beds, is planned, it will be of no use without a sand pack through sandstone intervals and bentonite through clay intervals (See comments for p.10.0(1) to 10.0(4) above).

    Both wellfields at the Crow Butte Project were selectively screened using the methods described. Performance of these wells has been satisfactory.

12. p.11.0(4) para 2: Need to explain what a "liquid seal" is.

    A clarification has been added to page 11.0(4).

13. p.11.0(26) to 11.0(29): No mention made of plans to remove (or leave) buried piping to and from each wellhead.

    The piping is buried below plow depth at 5 feet. FEN plans to remove buried piping to the wells if it is cost effective to reuse the piping for new wellfields. If it can not be reused, FEN will leave the piping buried pending USNRC approval. A clarification has been added to page 11.0(29).

David Charlton - Continued

14. p.4.4(28) para. 3: Times for beginning or ending of pump test are not consistent with a test of 4322 minutes. Times given yield 4320, not 4322.

    A correction has been made to page 4.4(28).

15. p.4.4(28), para. 4: The last sentence needs clarification. Why does a calculated maximum drawdown of 38.86 feet show confined conditions?

    A clarification has been added to page 4.4(28).

16. p.4.4(51), Table 4.4-9: Diffusively symbol missing.
17. p.4.4(55), para. 3: "were", not "was".
18. p.4.4(65), para. 3: typos for "presence" and "physiological".
19. p.4.4(80): "U.S. Dept. of Interior, 1981" listed twice.
20. p.4.4B(20), para. 3: typo "anistrophy".

    Corrected pages enclosed.

21. p.4.5(28), Figure 4.5-13: Should the structure map (Top Pierre) show anticlinal and synclinal axes? Are these actually folds or erosional highs and lows not related to folding?

    FEN believes these axes are folds rather than erosional features since they do not control the deposition of Chadron sandstone.

22. p.4.9(119): page misnumbered.

    A corrected page is enclosed for addition to the application.

23. p.4.9(122), Birds - General: Are bald eagles not designated threatened or endangered? If so, first sentence is incorrect.

    The first sentence has been deleted to this paragraph on page 4.9(122) to eliminate the confusion.

24. p.10.0(7), para. second from bottom, line 4: Should it read: "...where air pressure will be equal to the maximum operating..."?

    A clarification hs been added to this sentence.

25. p.10.0(7), No. 3: If a loss of pressure of 10% or less acceptable for MIT? What is basis of 10% figure? This is not consistent with your Class III MIT Procedures for Nebraska, Solution Mining Research Institute, Fall 1987.

    This loss of pressure is consistent with the UIC permit for the R&D project and has proved workable for detection of casing leaks. Pressure losses below 10% can not be detected accurately with existing instrumentation. It is FEN's understanding that the 5% figure listed in the cited reference is a typographical error (P. French, personal communication).

Conservation and Survey Division

1. Subsection 4.4

   A short discussion of Squaw Creek discharge rates was included on page 4.4(5).

2. Subsection 4.5

   Subsection 4.5 has been revised in accordance with CSD's suggestions on stratigraphic nomenclature and editorial changes.

8/30/88

ERRATA SHEET

Enclosed please find corrected replacement pages for the Application and Supporting Environmental Report for the State of Nebraska Underground Injection Control Program Commercial Permit. Please replace the original page with the corrected page.

Introduction (1)	Addition of "NPDES Permit" to Item IV.
3.0(1)	Addition of last paragraph.

10/88

ERRATA SHEET

Enclosed please find corrected replacement pages for the Application and Supporting Environmental Report for the State of Nebraska Underground Injection Controlk Program Commercial Permit. Please replace the original pages with the corrected pages.

5.0(1)	Revised second paragraph under 5.1-1, Wellfield Operation
10.0(1)	Revised paragraph under 10.1, Surface and Subsurface Injection System Details
10.0(2)	Revised Figure 10.1-1
12.0(8)	Revised first paragraph under 12.4-3, Wellfield Surface Monitoring

REVISION

02-16-89

Attached please find revised Section 1.0 for the Application and Supporting Environmental Report for the State of Nebraska Underground Injection Control Program Commercial Permit. Please replace the original pages with this revision. This section was revised to include additional information required by Chapter 11 of Title 122, Amended January 2, 1989.

Also attached is replacement for page 4.7(17). A typographical error of "4.7 children/family" was changed to "2.3 children/family" in the second paragraph.

Also attached are replacement pages for 11.0(30-32). A revision has also been made to correct a math error for the cost to treat two pore volumes. A misspelling of "plant" was also corrected on page 11.0(32).

ERRATA SHEET
2-21-89

Enclosed please find corrected replacement pages for the Application and Supporting Environmental Report for the State of Nebraska Underground Injection Control Program Commercial Permit. Please replace the original pages with the corrected pages.

11.0(30-32)	Correct total for Site and Plant Decommissioning and Well Plugging and Abandonment. Correct several typographical errors.

TABLE OF CONTENTS

Application Number CBR014

Year	Mo.	Day	

FOR OFFICE USE ONLY

NEBRASKA DEPARTMENT OF ENVIRONMENTAL CONTROL

UNDERGROUND INJECTION CONTROL PROGRAM
Application for Permit to Inject

I. APPLICANT INFORMATION

Company Name Ferret Exploration Company of Nebraska, Inc.
Nebraska Address 315 Second Street, Crawford, Nebraska 69339
Nebraska Telephone Number (308) 665-2132
Company Headquarters Name Ferret Exploration Company of Nebraska, Inc.
Company Headquarters Address Suite 400, 1800 Glenarm Place
Denver, Colorado 80202
Company Headquarters Telephone Number (303) 295-0238
Contact Person Steve Collings
Ownership Status (check one) ( ) owned, (x) leased, ( ) other
Entity Status (check one) ( ) Federal, ( ) State, (x) Private, ( ) Public,
( ) Other
There are no Indian lands within the Area of Review

II. NATURE OF BUSINESS

Standard Industrial Classification (SIC) Codes:
(1) 1094 (2) ______ (3) ______ (4) ______
Describe reason for application and nature of business:

FEN is required to obtain a permit to inject and operate Mineral Production and Class III injection wells as required by the Nebraska Underground Injection Control Program. FEN will be operating a commercial scale in-situ uranium leach facility. This facility will concentrate U_3O_8. The U_3O_8 will be sold as fuel for nuclear reactors.

III. OTHER ENVIRONMENTAL PERMITS (check any of the following which have been applied for and/or received)

( ) Hazardous waste program
( ) Underground Injection Control
( ) National Pollutant Discharge Elimination System (NPDES)
( ) Prevention of Significant Deterioration (PSD)
( ) Nonattainment Program
( ) National Emission Standards for Hazardous Pollutants
( ) Dredge or Fill Permit (404)
(x) Other relevant Federal/State permit or license
Explain: USNRC Source Material License for a commercial scale facility; facility permit for operation and maintenance of wastewater treatment works, Title 123 NDEC; septic tank permit; Class V 5W-11 permit; Industrial Groundwater Regulatory Act permit, NPDES Permit

IV. FACILITY LOCATION AND INFORMATION

A. Legal Description: county Dawes, township ____, range ____, section ____, quarter/quarters see Section 4.1, Legal Description.

B. A map of the injection well(s) for which a permit is sought is to be attached to this application packet and labeled "IVB". All information as specified in Chapter 11., 006.06 is to be noted on a 7½ min. topographic map. (See Subsections 4.2 and 4.3).

C. A tabulation of data on all wells within the area of review as specified in Chapter 11., 006.07 should be attached and identified as "IVC". (See Subsection 4.3)

D. Maps and cross sections delineating the water resources should be included as "IVD". See Chapter 11., 006.08. (See Subsection 4.4)

E. Maps and cross sections of the local and regional geology should be attached and labeled "IVE". See Chapter 11., 006.09. (See Subsection 4.5)

F. A narrative describing the geology and hydrology of the well site and the surrounding area is to be attached and labeled "IVF". See Chapter 11., 006.11. (See Subsections 4.4 and 4.5)

G. A narrative describing the local topography industry, agriculture, population densities, culture, wildlife and fish and other aquatic life within the area of the proposed injection project should be included and labeled "IVG". See Chapter 11., 006.12. (See Subsections 4.6, 4.7, 4.8, 4.9)

V. PROPOSED OPERATING DATA

A. Description of Injected Fluids:

1) Chemical Characteristics

dissolved constitutents Na^+, Ca^{++} K^+, Mg^{++}, $SO_4^=$, Cl^-, U_3O_8, V_2O_5, HCO_3^-, Ra-226, Rn-222, Trace As, Se

pH 6.5 - 10.5

stability good

reactivity (a) with system components none

(b) with formation waters none

(c) with formation minerals dissolves U_3O_8, ion exchange with clays

toxicity chemical due to minor U_3O_8; radiological due to Ra-226, Rn-222

other comments injected with up to 1500 ppm dissolved oxygen

2) Physical Characteristics

density 1.00 - 1.05 g/cc — color none

viscosity 1 cp — odor none

temperature 60° - 80° F — foamability slight

gas content 1500 ppm O_2; CO_2 saturated at pH — corrosiveness slight

specific conductivity 100 - 18000 umho/cm

radiologic 0 - 5000 pCi/l Radium-226

suspended solids content 5 ppm

other comments

3) Biological Characteristics

biochemical oxygen demand NIL

bacteria NIL

other comments NIL

B. Projected Volume and Rate of Injection (include units of measurement)

average daily rate 2500 gpm — average daily volume 3,600,000 gal.

maximum daily rate 3000 gpm — maximum daily volume 4,320,000 gal.

C. Injection Pressure

average pressure 100 p.s.i.

maximum pressure 0.63 p.s.i./ft. of well depth

INTRODUCTION

Ferret Exploration Company of Nebraska, Inc. (FEN) is pleased to submit this Application for a permit to inject to the Nebraska Department of Environmental Control (NDEC) for their consideration. This application is being submitted as part of the regulatory requirements for FEN to operate a Commercial Scale in-situ uranium mining facility in Dawes County, Nebraska. FEN acquired a major interest from Wyoming Fuel Company (WFC) in June, 1986 and is now the operator of the Crow Butte Project. The Crow Butte R & D was constructed by WFC and operated by FEN. All commitments and activities conducted by WFC on the Crow Butte Project were assumed by FEN.

This application was prepared in accordance with the Rules and Regulations for Underground Injection Control, Title 122, Nebraska Department of Environmental Control effective February 16, 1982, as amended September 4, 1986. Specifically, this application addresses the requirements of Chapter 11-Permit Application: Information and Requirements, of the aforementioned rules and regulations for underground injection, and seeks an Area Permit as defined in Chapter 21 of Title 122.

This application was formulated according to the Application Form provided by the NDEC personnel to FEN. This application contains information consistent with the information provided to the U.S. Nuclear Regulatory Commission by application on October 7, 1987. Much of the information in this application was collected and submitted to the NDEC in March of 1983 in the R & D application. It was noted at that time that the R & D application contained much of the data necessary for a commercial scale application. The data submitted in 1983 were updated to 1987 in the preparation of the commercial application.

FEN generally followed Chapter 11 of Title 122 and the Application for Permit to Inject in the preparation of this document. In the preparation of the sections on Hydrology and Geology, FEN deviated from the instructions found in Section IV D, E, and F of the Application for Permit to Inject. Those instructions call for the figures, maps, and cross sections to be located in a separate section from the narrative. FEN is of the opinion that this makes these sections very difficult to read and evaluate. FEN has integrated the figures, maps, and cross sections with the narrative for the benefit of the reviewer.

ACKNOWLEDGMENTS

FEN acknowledges Resource Technologies Group, Inc. (RTG) of Lakewood, Colorado for providing the overall project management in the preparative of this application, for their work in the hydrologic test and evaluation area, and the facilities area. FEN would also like to acknowledge Greystone Development Consultants Inc. of Englewood, Colorado for their updating of the Ecological Section, the Land Use Section, and the Population Distribution Section; the Nebraska State Historical Society of Lincoln, Nebraska for their updating of the Regional Historic, Archeological, Architectural, Scenic and Natural Landmarks Section; and the staff of FEN for the preparation of the Geology Section and for their assistance in the collection of operational data, restoration data, and baseline data.

FEN would also like to acknowledge all of the contributors who worked on the preparation of the R & D Permit Application.

SECTION 1.0

APPLICANT INFORMATION

1.0 Applicant Information

The applicant and operator of the proposed project is Ferret Exploration Company of Nebraska, Inc. (FEN), a Nebraska Corporation. The company's Nebraska address and corporate headquarters are:

Ferret Exploration Company of
Nebraska, Inc.
315 Second Street
Crawford, Nebraska 69339
(308) 665-2132

Ferret Exploration Company of
Nebraska, Inc.
1800 Glenarm Place, Suite 400
Denver, Colorado 80202
(303) 295-0238

The permit area described in the application covers private lands which are leased or owned by Crow Butte Land Company, a Nebraska Corporation. Crow Butte Land Company is a wholly owned subsidiary of Ferret Exploration Company of Nebraska, Inc. and has the same addresses listed above.

The Standard Industrial Classification (SIC) Code for the proposed activity is 1094 - Mining and Milling - Uranium.

FEN has operated the Crow Butte pilot plant in Dawes County, Nebraska, which is included in the permit area applied for, since its start-up in July, 1986. During the over two and one-half years of operation to date, FEN has demonstrated the recovery of uranium from two wellfields under the close regulatory scrutiny of the Nebraska Department of Environmental Control and the U.S. Nuclear Regulatory Commission. During these operations, there have been no adverse environmental impacts or health and safety problems. The mining solutions were well controlled, as there were no groundwater excursions. Restoration of the groundwater was successfully demonstrated following mining of Wellfield No. 2. The restoration of Wellfield No. 2 was approved by the Nuclear Regulatory Commission in April, 1988 and the Nebraska Department of Environmental Control in December, 1988.

The management and technical staff of FEN have engineering degrees in mining, geology, metallurgy, and degrees in geology and biology. The management and technical staff of FEN have over ten years direct experience in developing the Crow Butte Project. The staff initiated the project and drilled, properly abandoned and reclaimed over 2,500 exploration holes during this period. The staff also constructed and operated

the Crow Butte pilot plant, including the restoration of Wellfield No. 2 from 1985 to present. During the construction of the wellfield, the staff demonstrated its ability to properly close, plug, or abandon and reclaim several wells which did not meet mechanical integrity requirements.

In addition to direct experience on Crow Butte, the staff has extensive experience on other mining and exploration projects that are directly applicable to operation of the proposed Crow Butte facility.

FEN has not been involved as the operator of any other underground injection projects except the Crow Butte pilot plant in Dawes County, Nebraska. That project is included in the permit area applied for in this application and is regulated by the Department of Environmental Control and U.S. Nuclear Regulatory Agency.

SECTION 2.0

NATURE OF BUSINESS

2.0 NATURE OF BUSINESS

Please refer to Section II of Application Form "Underground Injection Control Program, Application for Permit to Inject".

Ferret Exploration Company of Nebraska (FEN) will be operating a commercial in-situ uranium leach facility. This facility will concentrate U_3O_8. The U_3O_8 will be sold as fuel for nuclear reactors.

SECTION 3.0

OTHER ENVIRONMENTAL PERMITS

3.0 OTHER ENVIRONMENTAL PERMITS

Please refer to Section III of Application Form "Underground Injection Control Program, Application for Permit to Inject".

Source Material License for a commercial production plant is required from U.S. Nuclear Regulatory Commission. Application for the license was filed with the U.S. Nuclear Regulatory Commission on October 7, 1987.

FEN plans to apply for a permit for Operation and Maintenance of Wastewater Treatment Works under Title 123 of the NDEC Rules and Regulations prior to construction of the evaporation ponds.

On July 22, 1983 WFC applied for an Aquifer Exemption under Title 122 of the NDEC Rules and Regulations. An Aquifer Exemption covering 3000 acres which includes the Area Permit was granted by the NDEC and an Aquifer Exemption for the R&D Area was authorized by the EPA. The EPA Aquifer Exemption for the remainder of the Area Permit is pending.

FEN plans to apply for a permit under the Industrial Groundwater Regulatory Act prior to expanding the project to the extent that it meets the requirements of this Act.

FEN plans to apply for a septic tank permit and a Class V 5W-11 permit for the septic tank system for the commercial plant.

FEN has proposed land irrigation of treated wastewater in accordance with NDEC Guidelines for Treated Wastewater Irrigation System, February, 1986. The proposal was submitted July 27, 1988. FEN plans to apply for a NPDES permit to conduct this activity.

SECTION 4.0

FACILITY LOCATION AND INFORMATION

SUBSECTION 4.1

LEGAL DESCRIPTION

4.1 LEGAL DESCRIPTION

A legal description of the area proposed for the Area Permit follows:

Township	Range	Section
31 N	52 W	11 - S1/2NE1/4, N1/2 SE1/4, SE1/4SE1/4
31 N	52 W	12 - SW1/4, S1/2NW1/4, NW1/4SE1/4, S1/2SE1/4
31 N	52 W	13 - NE1/4, NW1/4NW1/4
31 N	51 W	18 - SW1/4, S1/2NW1/4, NW1/4NW1/4, S1/2SE1/4, NW1/4SE1/4
31 N	51 W	19 - ALL
31 N	51 W	20 - SW1/4
31 N	51 W	30 - NE1/4, NE1/4SE1/4, NE1/4NW1/4
31 N	51 W	29 - W1/2

The Injection Facility and the evaporation ponds will be located in T31N, R51W, Section 19.

SUBSECTION 4.2

INJECTION FACILITY AND AREA OF REVIEW

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4.2 INJECTION FACILITY AND AREA OF REVIEW

This section contains information as required in Chapter 11, Subsection 006.06 of the Nebraska UIC Rules and Regulations. Figure 4.2-1 shows the area permit boundary (which is identical to the commercial permit area), the commercial study area, and the area of review. Figure 4.2-2 shows the injection facility Site Layout and Figure 4.2-3 shows the Process Facility. The Commercial Pond Area shown in Figure 4.2-2 will contain the evaporation ponds which will be permitted and constructed to meet the requirements of Title 123 of the NDEC Rules and Regulations.

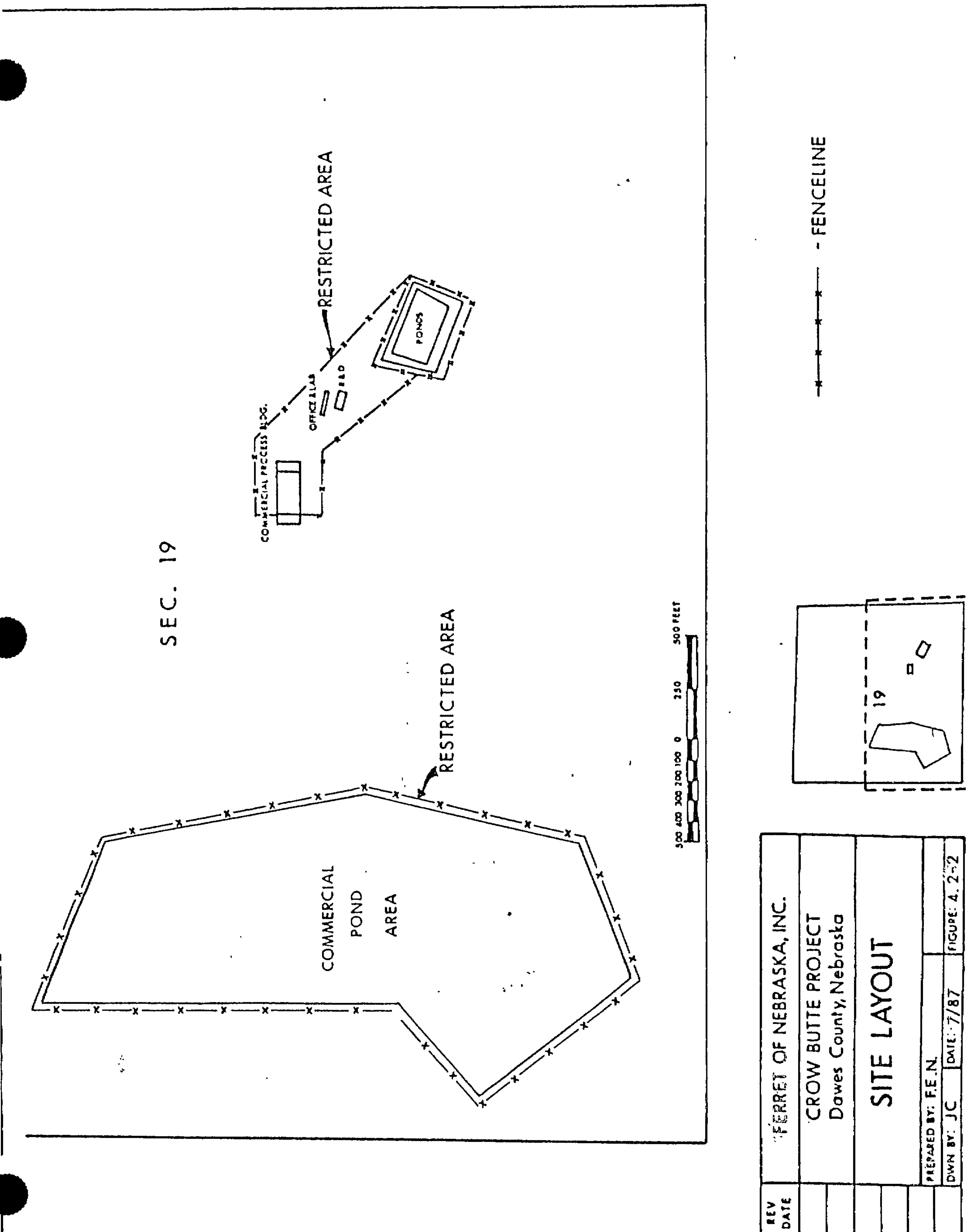
The Area of Review as shown in Figure 4.2-1 is a 2-1/4 mile measured distance from the outline of the Area Permit Boundary. The Area Permit Boundary describes the area in which injection and production wells may be installed.

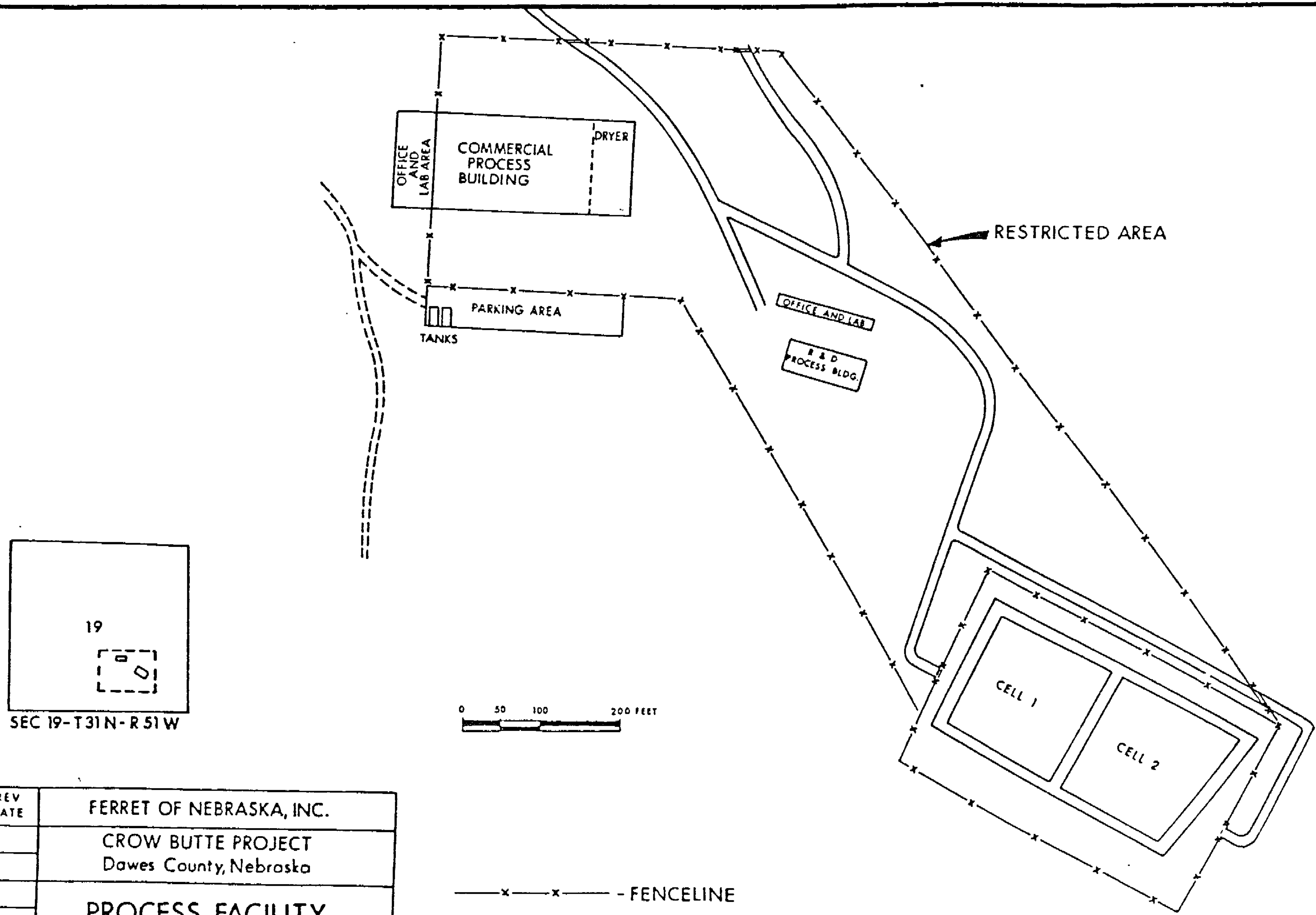
Within the Area of Review, FEN identified water wells, abandoned wells, injection, recovery and monitoring wells installed by WFC/FEN, oil and gas test holes, gravel pits, springs and impoundments. The Tables and Maps showing the above are found in Section 4.3 ***Area of Review Water User Survey.***

The only known mineral exploration holes in the Area of Review are those drilled by WFC and FEN. All WFC and FEN exploration holes within the Area of Review have been plugged in accordance with Nebraska Oil and Gas Conservation Standards prior to 1983 and NDEC Title 135 Rules and Regulations since 1983. Maps of WFC/FEN plugged test holes and/or mineral exploration holes within the Area of Review have been submitted to the NDEC under separate cover as confidential information in accordance with Chapter 25, Section 002 of the NDEC Rules and Regulations for Underground Injection Control, Title 122.

One fault within the Area of Review, the White River Fault, was identified during the exploration drilling. This fault follows the White River north of Crawford and is located within the area of review approximately 1.5 miles northwest of the Area Permit Boundary. The location of the fault is shown on Figure 4.5-13 in Section 4.5, ***Geology.***

CBR-014


RESTRICTED AREA
PONDS
R&D
OFFICE & LAB
COMMERCIAL PROCESS BLDG.
SEC. 19
RESTRICTED AREA
COMMERCIAL
POND
AREA
500 400 300 200 100 0 250 500 FEET
- FENCELINE
19
SEC. 19 - T31N - R51W
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
SITE LAYOUT
PREPARED BY: F.E.N.
DWN BY: JC
DATE: 7/87
FIGURE: 4. 2-2
REV
DATE



REV DATE	
	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	PROCESS FACILITY
	PREPARED BY: F.E.N.
	DW[illegible] C. DATE: 7/31/87 FIGURE: 4.2-3

SUBSECTION 4.3

AREA OF REVIEW
SURVEY DATA

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4.3 AREA OF REVIEW SURVEY DATA

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4.3 AREA OF REVIEW SURVEY DATA

This Section contains available data on water wells, injection, recovery and monitoring wells installed by WFC/FEN, abandoned wells, surface bodies of water, gravel pits, oil and gas test holes and springs within the area of review as required by Title 122, Chapter 11, Subsections 006.06 and 006.07. This tabulation of data resulted from FEN's water user and area survey. The location of the water wells can be found in Figure 4.3-1 and a listing of the water wells can be found in Table 4.3-1. Water wells and abandoned wells within the Town of Crawford are listed in Tables 4.3-2 and 4.3-3. It should be noted that the wells and abandoned wells within the Town of Crawford are within the Area of Review. They have been listed separately in this document because of the large number of wells within the Town. Abandoned wells and the six oil and gas test holes in the Area of Review are listed in Table 4.3-4 and Table 4.3-5 and shown in Figure 4.3-2.

During the R&D operation, WFC/FEN installed regional monitoring, injection, recovery, monitoring and aquifer test wells. The regional monitoring wells are listed in Table 4.3-6 and shown in Figure 4.3-3. The wells and piezometers used for aquifer testing are listed in Table 4.3-8 and shown in Figure 4.3-3. The injection, recovery and monitoring wells used in the R&D test fields are listed in Table 4.3-8 and shown in Figure 4.3-4, entitled ***R & D Wellfield Water Quality Wells.***

Impoundments within the Area of Review are listed in Table 4.3-9 and shown in Figure 4.3-5. Springs and streams within the Area of Review are listed in Table 4.3-10 and the locations of the springs are shown in Figure 4.3-5. Six gravel pits were identified in the Area of Review and these are listed in Table 4.3-10 and shown in Figure 4.3-5.

To FEN's knowledge, no mineral exploration holes other than those by WFC/FEN have been drilled in the Area of Review. As stated in Subsection 4.2, maps showing the location of the mineral exploration holes have been submitted by FEN to the NDEC as confidential information. As noted earlier, six oil and gas test holes were drilled within the Area of

TABLE 4.3-1

WATER USER SURVEY WELLS
(WITHIN THE AREA OF REVIEW)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft.)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
1	E.A.Faney	-----	200	-----	-----	-----	Brule Fm	D, L
2	E.A.Faney	1966	650	Steel	590-650	-----	Chadron Fm	D, L
3	L. Raben	1970	100	Steel	50-100	16.2	Brule Fm	L
4	L. Raben	1970	100	Steel	50-100	-----	Brule Fm	D, L
5	Fern Bass	1900	80	Steel	60-80	-----	Brule Fm	D, L
6	Mike Dyer	1950	75	Steel	50-75	20.9	Brule Fm	D
7	Mike Dyer	1954	75	Steel	50-75	-----	Brule Fm	L
8	Mike Dyer	1954	75	Steel	50-75	-----	Brule Fm	L
9	Mike Dyer	1920	70	Steel	60-70	51.2	Brule Fm	L
10	Mike Dyer	-----	------	-----	-----	-----	Brule Fm	L
11	Mike Dyer	-----	110	-----	-----	64.7	Brule Fm	L
12	Mike Dyer	-----	135	-----	-----	75.7	Brule Fm	L
13	Mike Dyer	-----	------	-----	-----	52.0	Brule Fm	L

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available.

TABLE 4.3-1 (Continued)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft.)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
14	John Paris	1960	80	Galvanized	60-80	43.3	Brule Fm	L
15	John Paris	1960	75	Galvanized	30-75	34.4	Brule Fm	L
16	John Paris	1960	80	Galvanized	60-80	-----	Brule Fm	D, L
17	H. Gibbons	1946	80	Steel	40-80	46.5	Brule Fm	D, L
18	H. Gibbons	1960	120	Steel	80-120	-----	Brule Fm	L
19	H. Gibbons	-----	80	Steel	40-80	-----	Brule Fm	L
20	L. Tagart	-----	50	Plastic	-----	-----	Brule Fm	D, L
21	L. Tagart	-----	100	Galvanized	70-100	59.8	Brule Fm	L
22	R.Hageman	1960	400	Plastic	300-400	-----	Chadron Fm	D, L
23	R.Hageman	-----	30	Galvanized	-----	-----	Brule Fm	L
24	F. Ehlers	-----	80	Steel	60-80	59.2	Brule Fm	L
25	F. Ehlers	-----	75	Steel	55-75	36.1	Brule Fm	D, L
26	O. Stetson	1890	80	Steel	19-80	-----	Brule Fm	D, L

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available

TABLE 4.3-1 (Continued)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft.)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
27	O. Stetson	1930	80	Galvanized	35-80	-----	Brule Fm	L
28	O. Stetson	1981	80	Plastic	60-80	-----	Brule Fm	L
29	Bill Dodd	-----	-----	Steel	-----	58.8	Brule Fm	D
30	Bill Dodd	-----	55	Galvanized	-----	26.5	Brule Fm	L
31	H. Bunch	1955	135	Galvanized	30-135	93.2	Brule Fm	L
32	H. Bunch	1947	400	Steel	-----	39.8	Chadron Fm	D, L
33	Jim Bunch	1979	212	Plastic	-----	-----	Chadron	L
34	Jim Bunch	-----	90	-----	-----	43.3	Brule	D
35	State of NE	-----	300	Galvanized	280-300	-----	Gering Fm	L
36	State of NE	-----	500	-----	30-500	83.5	Gering Fm	L
37	State of NE	-----	-----	-----	-----	-----	Brule Fm	D, L
38	State of NE	-----	80	Galvanized	60-80	-----	Brule Fm	L
39	M. Franey	1920	50	Galvanized	-----	9.8	Brule	D, L
40	M. Franey	-----	60	Galvanized	-----	19.8	Brule Fm	L
41	M. Franey	1900	100	-----	-----	-----	Brule Fm	L
42	W. Fry	1910	45	Galvanized	5-45	25.0	Brule Fm	D

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available

TABLE 4.3-1 (Continued)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft.)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
43	W. Fry	1960	20	Galvanized	5-20	17.0	Brule Fm	L
44	C.J.Guggenmos	1979	90	Plastic	70-90	-----	Brule Fm	D
45	C.J.Guggenmos	1977	90	Plastic	20-90	28.0	Brule Fm	D
46	C.J.Guggenmos	1981	125	Plastic	105-125	30.0	Brule Fm	N
47	C.J.Guggenmos	1946	50	Steel	20-50	48.6	Brule Fm	D, L
48	Gerald Lux	1953	120	Steel	40-120	33.0	Brule Fm	D
49	Gerald Lux	1920	80	Galvanized	-----	72.4	Brule Fm	L
50	Gerald Lux	1973	180	Steel	20-180	80.0	Brule Fm	L
51	Gordon Moore	1979	300	Plastic	-----	-----	Chadron Fm	L
52	L.Bauersachs	1956	420	Steel	-----	-----	Chadron Fm	L
53	M. Jones	-----	80	Plastic	40-80	-----	Brule Fm	D, L
54	M. Jones	1970	80	Plastic	-----	-----	Brule Fm	L
55	K. Welling	-----	320	Plastic	-----	-----	Chadron Fm	N
56	D.Zeilinger	1929	200	Steel	-----	-----	Brule Fm	D
57	Tom Brott	1920	25	Galvanized	-----	-----	Brule Fm	D, L

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available.

TABLE 4.3-1 (Continued)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft.)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
58	Tom Brott	1980	35	Galvanized	16-35	-----	Brule Fm	L
59	Tom Brott	1970	35	Plastic	-----	-----	Brule Fm	L
60	F. Anders	1962	312	Steel	-----	-----	Chadron Fm	N
61	F. Anders	1980	280	-----	-----	-----	Chadron	D, L, C
62	FEN	1981	470	Plastic	430-470	35.2	Chadron Fm	C
63	FEN	-----	-----	-----	-----	-----	Brule Fm	D
64	O. Davis	1946	30	Galvanized	15-30	19.7	Brule Fm	D, L
65	R.McDowell	1980	260	Plastic	240-260	-----	Chadron	L
66	R.McDowell	1960	60	Steel	-----	18.6	Brule Fm	D, L
68	H. Snyder	1930	30	Galvanized	-----	18.2	Brule Fm	D
70	Sam Pedrick	------	125	Galvanized	30-125	74.8	Brule Fm	L
71	Sam Pedrick	-----	100	-----	-----	50.0	Brule Fm	L
72	Sam Pedrick	-----	450	-----	-----	82.2	Chadron Fm	N
73	City/Crawford	1981	120	Plastic	-----	16.8	Brule Fm	N

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available

TABLE 4.3-1 (Continued)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft.)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
74	W. Mader	1976	60	-----	-----	-----	Brule Fm	D, L
85	G.Eschenbrenner	1930	80	Plastic	60-80	-----	Brule Fm	D
86	State of NE	1960	300	Steel	280-300	-----	Brule	N
88	Ed Trucks	1958	60	Galvanized	20-60	19.5	Brule Fm	D, L
95	Gene Nixon	1972	100	Plastic	80-100	34.5	Brule Fm	D
96	Gary Fisher	1930	86	Plastic	46-86	-----	Brule Fm	D
97	Gary Fisher	1976	380	Plastic	-----	-----	Chadron Fm	L
100	M. Beaver	-----	35	Galvanized	25-35	-----	Brule Fm	D, L
101	G. Moore	1974	75	Plastic	55-75	-----	Brule Fm	D
102	G. Moore	1920	100	Steel	80-100	-----	Brule Fm	D, L
103	G. Moore	1955	125	Galvanized	115-125	-----	Brule Fm	L
104	L. Howard	1940	23	Galvanized	10-23	-----	Brule Fm	D, L
105	R.Hagemeister	1961	70	Steel	50-60	-----	Brule Fm	L
106	G. Moody	1950	100	Galvanized	80-100	-----	Brule Fm	D, L

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available

TABLE 4.3-1 (Concluded)

Well Number	Well Owner	Date Drilled	Bottom Depth (ft.)	Type of Completion	Probable Screen or Open Interval (ft)	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage*
107	Ody Knoell	-----	45	-----	-----	-----	Brule Fm	D
108	R.Hagemeister	1970	75	Plastic	55-75	43.3	Brule Fm	N
109	G. Hedberg	1975	55	Plastic	35-55	-----	Brule Fm	D, L
112	L. Chubb	-----	110	-----	-----	-----	Brule Fm	D
113	L. Chubb	-----	110	-----	-----	-----	Brule Fm	D
114	V. Norgard	1970	470	Plastic	50-470	-----	Chadron Fm	D, L
115	V. Norgard	1970	90	Plastic	70-90	-----	Brule Fm	D
116	Fred Raben	1981	80	Plastic	15-80	-----	Brule Fm	N
119	Ronnie Dyer	1981	330	Plastic	310-330	-----	Arikaree	D, L
120	Ronnie Dyer	1965	240	Galvanized	30-240	-----	Arikaree	L
122	M. Rising	1940	60	-----	40-60	-----	Brule Fm	L
123	G. Moore	1979	280	-----	-----	-----	Chadron Fm	L
124	M. Franey	1984	520	Plastic	500-520	-----	Chadron Fm	L
125	FEN	1985	60	Plastic	40-60	-----	Brule Fm	D, C
127	G. Moody	1987	105	Plastic	45-65	-----	Brule Fm	L, I
128	R. Lemmon	-----	60	Galvanized	-----	-----	Brule Fm	D, L

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available

TABLE 4.3-2

WATER USER SURVEY WELLS WITHIN THE TOWN OF CRAWFORD

Well Owner	Date Drilled	Bottom Depth (ft)	Type of Completion	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage
Chubb	1972	280	Plastic	Artesian	Chadron	C
Garner	----	25	Galvanized	----	Brule	I
Courtain	1964	280	Steel	Artesian	Chadron	I
Limbach	----	85	----	45	Brule	I
Lathrop	----	40	Galvanized	-----	Brule	D
Thomas	1960	100	Galvanized	----	Brule	D
Ball	1900	50	Galvanized	20	Brule	D
Peterson	1977	48	Plastic	24	Brule	I
Scoggan	1979	60	Plastic	22	Brule	D
Hartman	1927	30	Steel	12	Brule	N
Hiner	1960	110	Steel	27	Brule	I
Avey	1981	80	Plastic	40	Brule	I

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available

TABLE 4.3-2 (Continued)

Well Owner	Date Drilled	Bottom Depth (ft)	Type of Completion	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage
Avey	1983	45	Plastic	18.5	Brule	I
Mason	1970	50	None	14	Brule	I
Rhoads	----	50	Galvanized	----	Brule	I,D
Piper	----	38	Galvanized	18	Brule	I
Anderson	1974	60	Plastic	19	Brule	I
Moffet	1960	40	Galvanized	28	Brule	I
Welling	1978	60	Plastic	30	Brule	D
Benson	----	100	Galvanized	----	Brule	D
Prosser	1980	50	Plastic	30	Brule	I
Rice	----	50	Galvanized	25	Brule	N
Hallsted	1931	50	Galvanized	30	Brule	D

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available

TABLE 4.3-2 (Continued)

Well Owner	Date Drilled	Bottom Depth (ft)	Type of Completion	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage
Leetch	1979	40	Plastic	30	Brule	I
McNett	----	60	----	----	Brule	N
Pipher	----	65	Galvanized	20	Brule	D
City of Crawford	1977	60	Plastic	--	Brule	I
Hanson	----	36	----	10	Brule	N
Bell	1968	80	Galvanized	30	Brule	I
Corbin	1980	50	Plastic	30	Brule	I
Bacon	----	----	----	----	----	I
Soester	1950	114	Galvanized	32	Brule	D
Zeller	----	46	Galvanized	11	Brule	I
Snyder	1910	55	----	45	Brule	I
Johnson	1980	285	Plastic	Artesian	Chadron	I,L
Pisaka	----	26	Steel	----	Brule	N

* D = Domestic, L = Livestock, I = Irrigation, C = Commercial, N = Seldom Used

----- Indicates information not available

TABLE 4.3-2 (Concluded)

Well Owner	Date Drilled	Bottom Depth (ft)	Type of Completion	Water Level Below Land Surface (ft)	Probable Aquifer Unit	Usage
Garner	----	63	----	----	Brule	I,D
Bell	1968	105	Galvanized	----	Brule	N
Liebentritt	----	50	Steel	12	Brule	N
Blaylock	----	----	----	----	Brule (?)	D
Leeling	1975	90	Plastic	20	Brule	I
Bass	----	60	Galvanized	----	Brule	N
Mansfield	1965	400	Steel	17.9	Chadron	N
Garvin	----	50	Galvanized	17	Brule	N
Neff	----	24	Galvanized	12	Brule	N
Topham	1952	140	Galvanized	30	Brule	D
Britton	----	40	----	15	Alluvium	N
Carnahan	1981	50	----	----	Alluvium	I,D
Hamaker	----	40	Galvanized	15	Alluvium	I
Hamaker	1964	50	Galvanized	17	Alluvium	N

* D=Domestic, L-Livestock, I-Irrigation, C- Commercial, N-Seldom Used

----Indicates information not available

TABLE 4.3-3

**ABANDONED WELLS WITHIN
THE TOWN OF CRAWFORD**

1121 1st Street
233 Reed
708 Annin
702 Annin
5th & Linn
Sam Schmidt Place - intersection of Elm and 4th St.
228 Ash - gasoline in water
Old Creamery - 2 wells - 3rd and Pine
5th & Main
311 Annin
410 Pine
5th & Oak
704 Annin
320 Annin
End of Fremont Street (south end)
325 Elm Street
1018 3rd Street
100 ft. South of Townline Motel - intersection Highway 20 and Main St.
100 ft. North of Townline Motel - intersection Highway 20 and Main St.

TABLE 4.3-4

ABANDONED WELLS WITHIN THE AREA OF REVIEW

Well I.D.	Location		
1	32N 52W Sec. 28	300 N	300 E
2	32N 52W Sec. 28	2800 N	4950 E
3	32N 52W Sec. 27	100 N	2700 E
4	32N 52W Sec. 27	3800 N	5100 E
5	32N 52W Sec. 26	1000 N	1100 E
6	32N 52W Sec. 26	1800 N	5200 E
7	32N 52W Sec. 25	2400 N	5200 E
8	32N 52W Sec. 25	2750 N	5200 E
9	32N 52W Sec. 25	2900 N	5100 E
10	32N 52W Sec. 34	2300 N	2900 E
11	32N 52W Sec. 34	2000 N	3500 E
12	32N 52W Sec. 34	2200 N	4250 E
13	32N 52W Sec. 35	5100 N	100 E
14	32N 52W Sec. 35	3200 N	400 E
15	32N 52W Sec. 35	4850 N	700 E
16	32N 51W Sec. 31	3250 N	2000 E
17	31N 52W Sec. 3	4600 N	2000 E
18	31N 52W Sec. 2	1150 N	100 E
19	31N 52W Sec. 2	450 N	3150 E
20	31N 52W Sec. 2	4750 N	3950 E
21	31N 51W Sec. 6	800 N	700 E
22	31N 51W Sec. 6	1500 N	1200 E
23	31N 51W Sec. 5	600 N	500 E
24	31N 52W Sec. 11	1100 N	400 E
25	31N 52W Sec. 11	4900 N	1900 E
26	31N 52W Sec. 11	5100 N	1900 E
27	31N 52W Sec. 12	5000 N	1900 E
28	31N 52W Sec. 14	550 N	1900 E
29	31N 52W Sec. 22	4400 N	4200 E
30	31N 52W Sec. 26	4800 N	1400 E
31	31N 51W Sec. 28	800 N	3300 E
32	31N 51W Sec. 31	400 N	300 E
33	30N 51W Sec. 6	4200 N	2050 E
34	30N 51W Sec. 5	5200 N	2450 E
35	31N 51W Sec. 18	100 N	200 E
36	31N 51W Sec. 17	1400 N	400 E
37	31N 52W Sec. 24	4800 N	900 E
38	31N 52W Sec. 24	500 N	1300 E
39	31N 52W Sec. 24	350 N	2200 E
40	31N 51W Sec. 20	3500 N	300 E
41	31N 52W Sec. 26	4550 N	4900 E
42	31N 51W Sec. 29	4900 N	2500 E
43	31N 51W Sec. 14	5000 N	1900 E
44	31N 51W Sec. 13	1700 N	600 E

* Location coordinates are referenced in units of feet from the Southwest Section corner.

TABLE 4.3-5

I.D.#

OIL AND GAS TEST HOLES IN AREA OF REVIEW

1	Bunch No. 1,	Section 5, Township 31 North, Range 51 West
2	Heckman No. 1,	Section 24, Township 31 North, Range 52 West
3	Arner No. 1,	Section 26, Township 31 North, Range 51 West
4	Roby No. 1,	Section 31, Township 31 North, Range 51 West
5	Soester No. 1,	Section 34, Township 32 North, Range 52 West
6	True State	Section 36, Township 32 North, Range 52 West

TABLE 4.3-6

REGIONAL BASELINE WELLS ORIGINALLY DRILLED BY WFC

Well No.	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

TABLE 4.3-7

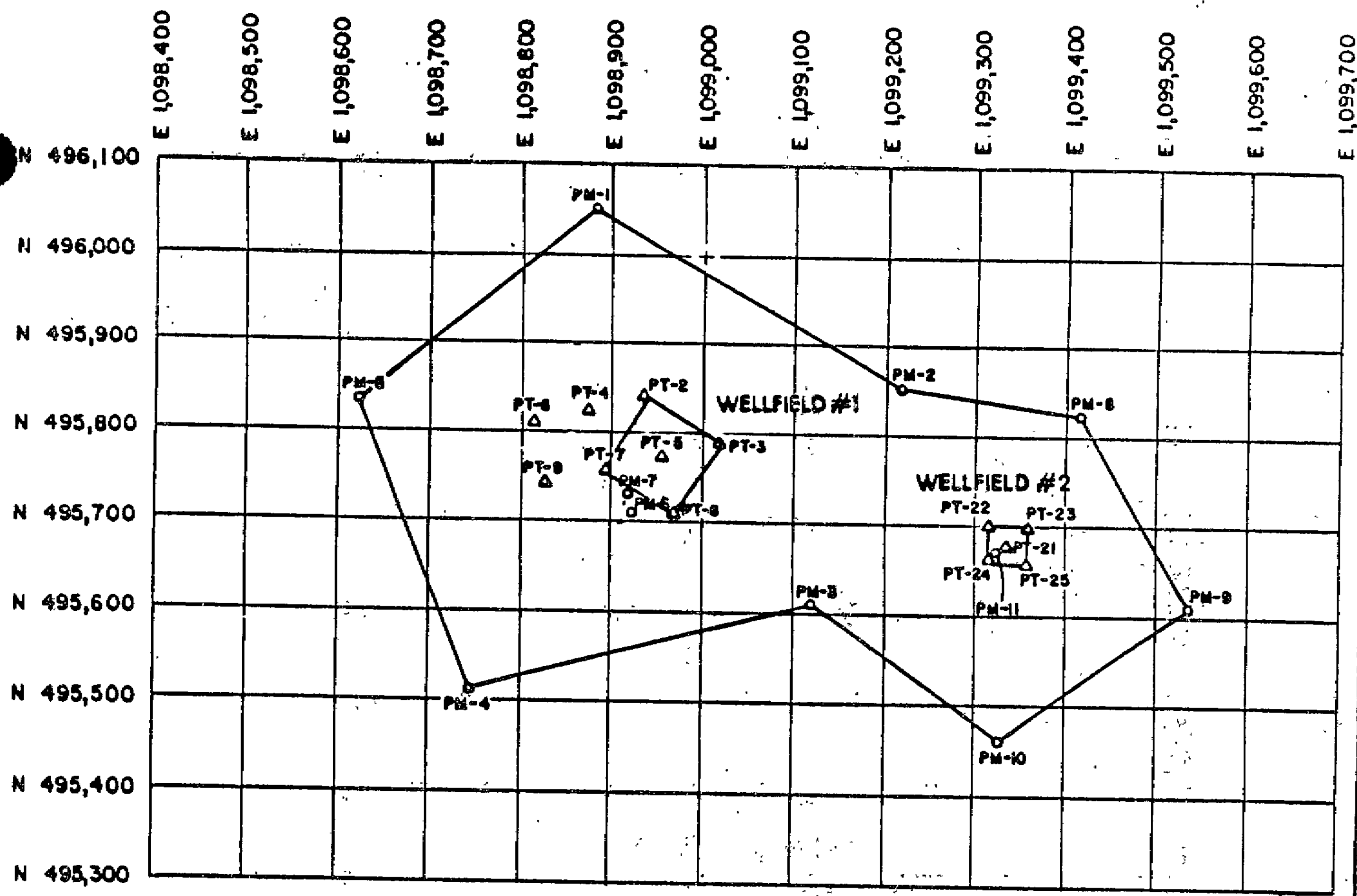
AQUIFER TEST #2 WELLS

Well No.	Formation	Screen Interval (ft)	Depth to Bottom of Screen Assembly (feet)
CPW-1	Chadron	572 - 612	617
COW-1	Chadron	585 - 625	630
COW-2	Chadron	565 - 610	615
COW-3	Chadron	575 - 615	620
BMW-1	Brule	235 - 260	265
UCP-1	Chadron (Upper Aquiclude)	555 - 557	557
LCP-1	Pierre (Lower Aquiclude)	618 - 620	620

TABLE 4.3-8

INJECTION, RECOVERY AND MONITOR WELLS INSTALLED AT CROW BUTTE R & D

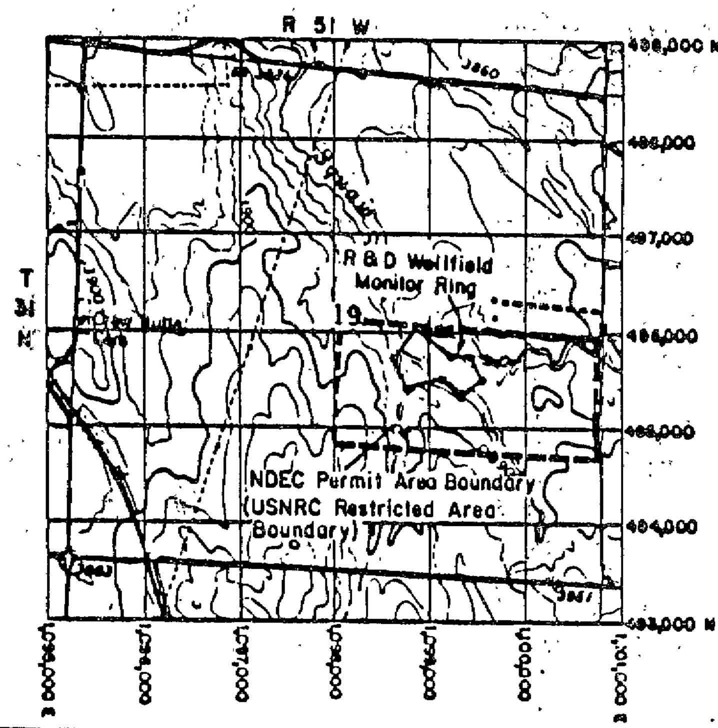
Well No.	Formation	Screen Interval (ft)	Depth to Bottom of Screen Assembly(ft)
OB-1 (PT-4)	Chadron	637.1-647.1, 652.1-657.1	662.1
OB-2 (PT-6)	Chadron	652 - 667	667
PT-2	Chadron	641 - 656	661
PT-3	Chadron	638 - 648	653
PT-5	Chadron	638 - 653	670
PT-7	Chadron	649 - 664	669
PT-8	Chadron	653 - 668	673
PT-9	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



Legend

△ Pilot Test Wells

○ Pilot Monitor Wells



Scale 1" = 200'

50 25 0 50 Meters

200 100 0 200 Feet

REV	BY	DATE	FERRET OF NEBRASKA, INC.	
			CROW BUTTE PROJECT Dawes County, Nebraska	
			R & D WELLFIELD WATER QUALITY WELLS	
			PREPARED BY: F. E. N.	
			DWN BY: J C / DATE: 8/87	Figure 4.3-4

TABLE 4.3-9

IMPOUNDMENTS WITHIN THE AREA OF REVIEW

Impoundment I.D.#	Location
I- 1	31N 51W Sec. 18
I- 2	31N 52W Sec. 14
I- 3	31N 52W Sec. 13
I- 4	31N 52W Sec. 12
I- 5	31N 52W Sec. 12
I- 6	31N 52W Sec. 12
I- 7	31N 52W Sec. 2
I- 8	31N 52W Sec. 2
I- 9	32N 51W Sec. 31
I-10	32N 51W Sec. 31
I-11	31N 51W Sec. 5
I-12	31N 51W Sec. 5
I-13	31N 52W Sec. 10
I-14	31N 51W Sec. 7
I-15	31N 51W Sec. 8
I-16	31N 51W Sec. 9
I-17	31N 51W Sec. 9
I-18	31N 51W Sec. 9
I-19	31N 52W Sec. 15
I-20	31N 51W Sec. 17
I-21	31N 52W Sec. 22
I-22	31N 52W Sec. 36
I-23	31N 52W Sec. 32
I-24	30N 51W Sec. 5
I-25	31N 52W Sec. 25
I-26	31N 52W Sec. 25

TABLE 4.3-10

SPRINGS, STREAMS AND GRAVEL PITS WITHIN THE AREA OF REVIEW

Spring I.D.	Location
SP- 1	32N 51W Sec. 31
SP- 2	31N 51W Sec. 7
SP- 3	31N 51W Sec. 16
SP- 4	31N 51W Sec. 20
SP- 5	31N 51W Sec. 21
SP- 6	31N 52W Sec. 13
SP- 7	31N 51W Sec. 7
SP- 8	31N 51W Sec. 6
SP- 9	31N 51W Sec. 6
SP-10	31N 51W Sec. 6
SP-11	31N 51W Sec. 5
SP-12	31N 51W Sec. 5

STREAMS

White River
White Clay Creek
Squaw Creek
English Creek
Saw Log Creek

GRAVEL PITS

I.D.	Location
GP-1	31N 52W Sec. 11
GP-2	31N 52W Sec. 24
GP-3	31N 51W Sec. 18
GP-4	31N 51W Sec. 19
GP-5	31N 51W Sec. 30
GP-6	31N 52W Sec. 27

Review and these are listed in Table 4.3-5. To FEN's knowledge, these holes have been plugged in accordance with Nebraska Oil and Gas Conservation Commission standards.

All FEN/WFC exploration holes within the area of review have been plugged in accordance with applicable standards. From 1979 through 1983, exploration drill holes were plugged using Nebraska Oil and Gas Conservation Commission standards. Beginning in November 1983, Nebraska Department of Environmental Control assumed jurisdiction over mineral exploration activities within the state. Exploration holes have been plugged in accordance with NDEC standards since that time.

During 1979 and 1980, exploration holes were plugged with cement grout. Beginning in 1981 and continuing through the present, all exploration holes were plugged with an approved abandonment material which is a non-toxic, high grade bentonite with small amounts of non-fermenting organic polymer and soda ash.

SUBSECTION 4.4

HYDROLOGY AND WATER QUALITY

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TABLE OF CONTENTS (Continued)

LIST OF FIGURES

FIGURE No.

TABLE OF CONTENTS (Concluded)

4.4 HYDROLOGY

4.4-1 Surface Water

The Crow Butte permit area lies 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 have been taken from Squaw Creek in the vicinity of the study area.

Eight surface water impoundments occur within or near the commercial restricted area boundaries.

Location.

The Crow Butte permit area lies 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 spring-fed.

Squaw Creek is one of the southern tributaries of the White River. This creek heads in the Pine Ridge sourtheast of the permit 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 on a month to month and yearly basis.

Squaw Creek enters the commercial permit area on the southeast corner, travels through the entire length of permit 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 wellfield and exit the northern boundary before converging with Squaw Creek. This tributary is ephemeral, only flowing when precipitation exceeds infiltration, storage and evaporation. This rarely occurs.

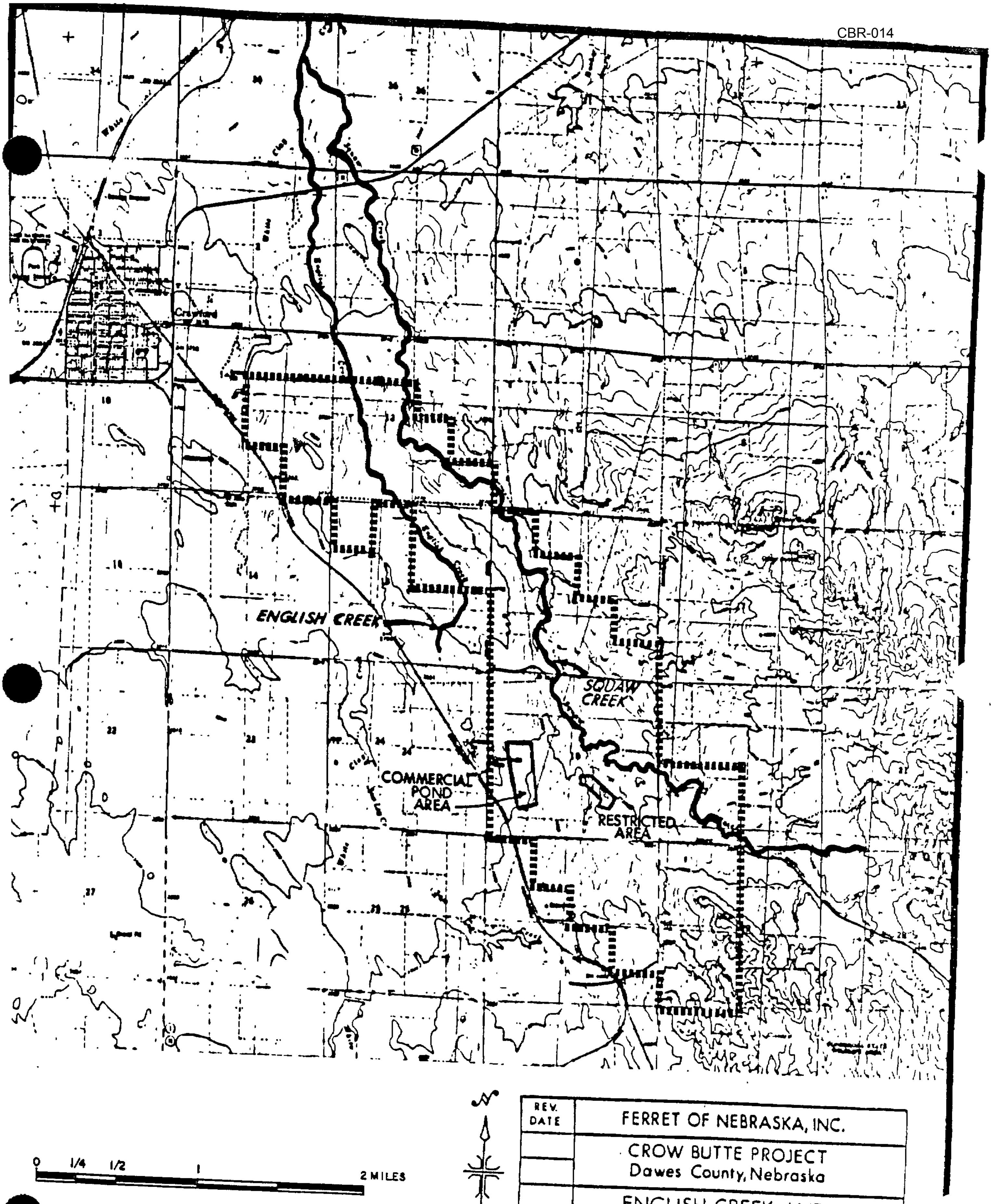
Figure 4.4-1 illustrates the location of the Crow Butte Permit Area with respect to the Squaw Creek and English Creek watercourses and the proposed location of the restricted area and the commercial evaporation ponds.

<u>Stream Flow</u>. Flow rates were measured on Squaw Creek and these data and the methodology used is found in Section 4.4-4.

Table 4.4-1 shows the mean monthly discharge of the White River as compared to the mean monthly precipitation over several years (NOAA, 1981). These extended data show that a loose 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. For the period of 1931 to 1980 the average normal annual mean discharge at the White River Station at Crawford was 20.1 cfs (0.57 cms) with a standard deviation of 2.8 cfs (0.08 cms). The maximum was 29.7 cfs (0.84 cms) and minimum 16.6 cfs (0.47 cms). Peak rainfall at Harrison and Scottsbluff, Nebraska occurs in May and June (NOAA, 1976 and 1980). This is typically true for the Crawford area also.

<u>Surface Water Impoundments</u>. Eight surface water impoundments are located near or within the boundaries of the commercial permit area. Figure 4.4-22 (See Section 4.4-4) shows the location 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 permit area while impoundments I-3 through I-6 are inside the permit area.

CBR-014



REV. DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	ENGLISH CREEK AND SQUAW CREEK WATERCOURSES		
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/87	FIGURE. 4.4-1

4.4(3)01/15/88

TABLE 4.4-1

COMPARISON OF MEAN MONTHLY PRECIPITATION WITH NORMAL MEAN MONTHLY DISCHARGE OF THE WHITE RIVER AT CRAWFORD, NEBRASKA

	Mean[1] Precipitation		Mean[2] Discharge	
	Inches	(cm)	cfs	(cms)
January	0.41	1.04	21.0	0.59
February	0.37	0.94	23.4	0.66
March	0.70	1.78	27.2	0.77
April	1.67	4.24	25.3	0.72
May	2.98	7.57	25.3	0.72
June	3.32	8.43	22.2	0.63
July	2.16	5.49	15.4	0.44
August	0.97	2.46	12.6	0.36
September	1.33	3.38	13.3	0.38
October	0.83	2.11	16.6	0.47
November	0.43	1.09	19.4	0.55
December	0.39	0.99	20.2	0.57

(1) U.S. Department of Commerce, 1982, Period of Record 1941-1970.

(2) U.S. Department of the Interior, 1981, Period of Record 1931-1980.

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. Samples of impoundments I-1 through I-8 were collected and handled as described in Section 4.4-4. Results of the baseline and operational analyses are given in Appendix 4.4(A).

Water Quality. Samples were collected from Squaw Creek and all surface bodies of water within the commercial permit area. This schedule was begun in 1982 and continued into 1987 for specified locations. The data and sampling methodology are found in Section 4.4-4.

4.4-2 Groundwater

With regard to the Crow Butte Project, two groundwater sources are of interest in the Crawford and Crow Butte area. These are the local Brule sands and the Chadron aquifer. The Chadron aquifer contains the uranium mineralization of interest to this project. This section describes the regional and local hydrology of the groundwater, including physical and chemical characteristics.

An aquifer test was performed in the R&D wellfield in November, 1982. A second aquifer test was performed in June, 1987 at a site which is approximately 2800 feet north of the R&D wellfield. The purpose of these two tests was to determine the hydrogeologic characteristics of the Chadron aquifer. The following discussion includes the results of these tests and

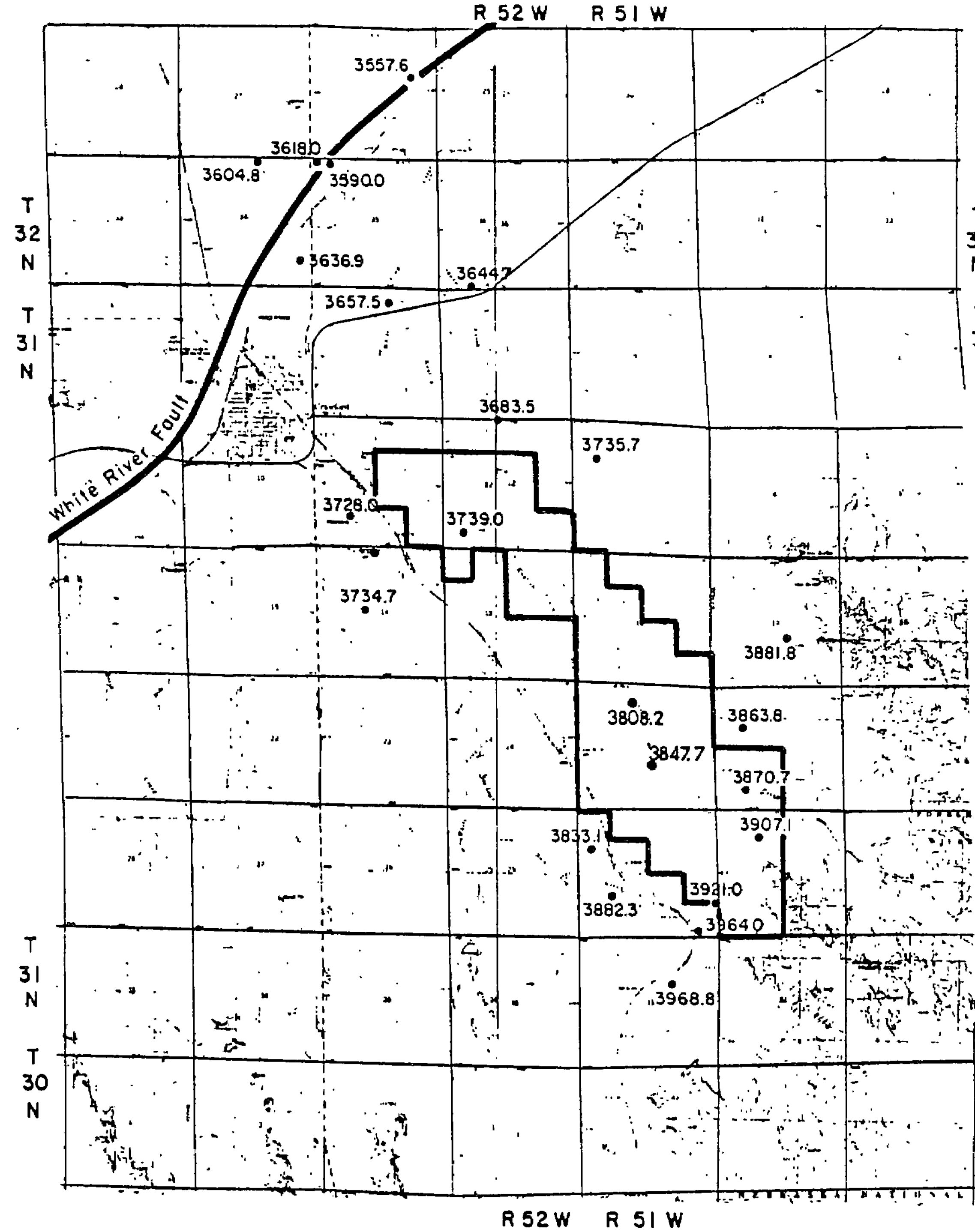
the conclusions which can be drawn concerning transmissivities, storage coefficients, vertical permeability of the confining layers and boundary conditions. Tabulated data for the first aquifer test is included in Appendix 4.4(A).

Regional Hydrology. A map prepared by Souders and Freethey (1975) indicates that the water table configuration in the region trends north-northeast. No published regional water level maps are available for the Chadron aquifer or the local Brule sands.

Water level data have been gathered from existing and specifically drilled wells throughout the Crawford-Crow Butte area for the local Brule sands and the Chadron aquifer. Maps showing the piezometric surfaces are included as Figures 4.4-2 and 4.4-3 for these two aquifers. The direction of flow in the local Brule sands appears to be to the north-northwest. However, the extreme variation in the piezometric surface from the Pine Ridge to the White River (south to north) would indicate separate, hydraulically isolated Brule sands.

The Chadron aquifer is artesian (confined) and wells completed in it may flow to the surface near the White River Fault and to about 1.5 miles south of the fault. The direction of groundwater migration in that area is north-northwest. Farther to the south, the piezometric surface is almost flat.

Commercial Area Hydrology. The hydrogeologic system within and surrounding the Crow Butte commercial permit area is essentially the same as found regionally. The outcropping Brule Formation is underlain by the Chadron Formation and Pierre Shale. Figures 4.4-4 and 4.4-5 are cross-sectional representations of these strata indicating their hydrologic properties. These cross sections are based on lithologic descriptions and geophysical logs from exploration drilling, core samples and baseline wells. Figure 4.4-6 shows the location of these sections.



•3742.1 Water Level - MSL (feet)

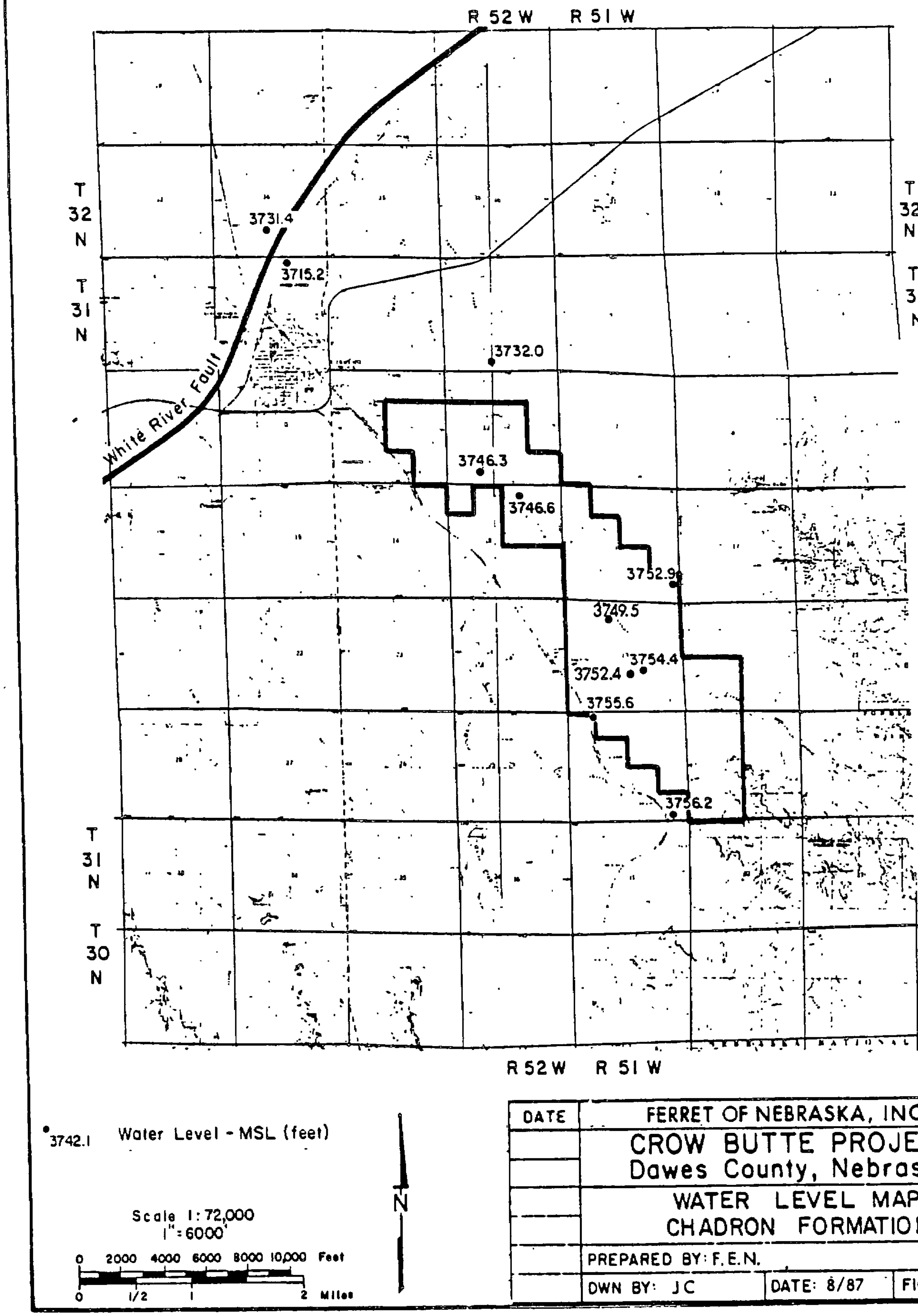
Scale 1:72,000
1" = 6000'

0 2000 4000 6000 8000 10,000 Feet

0 1/2 1 2 Miles

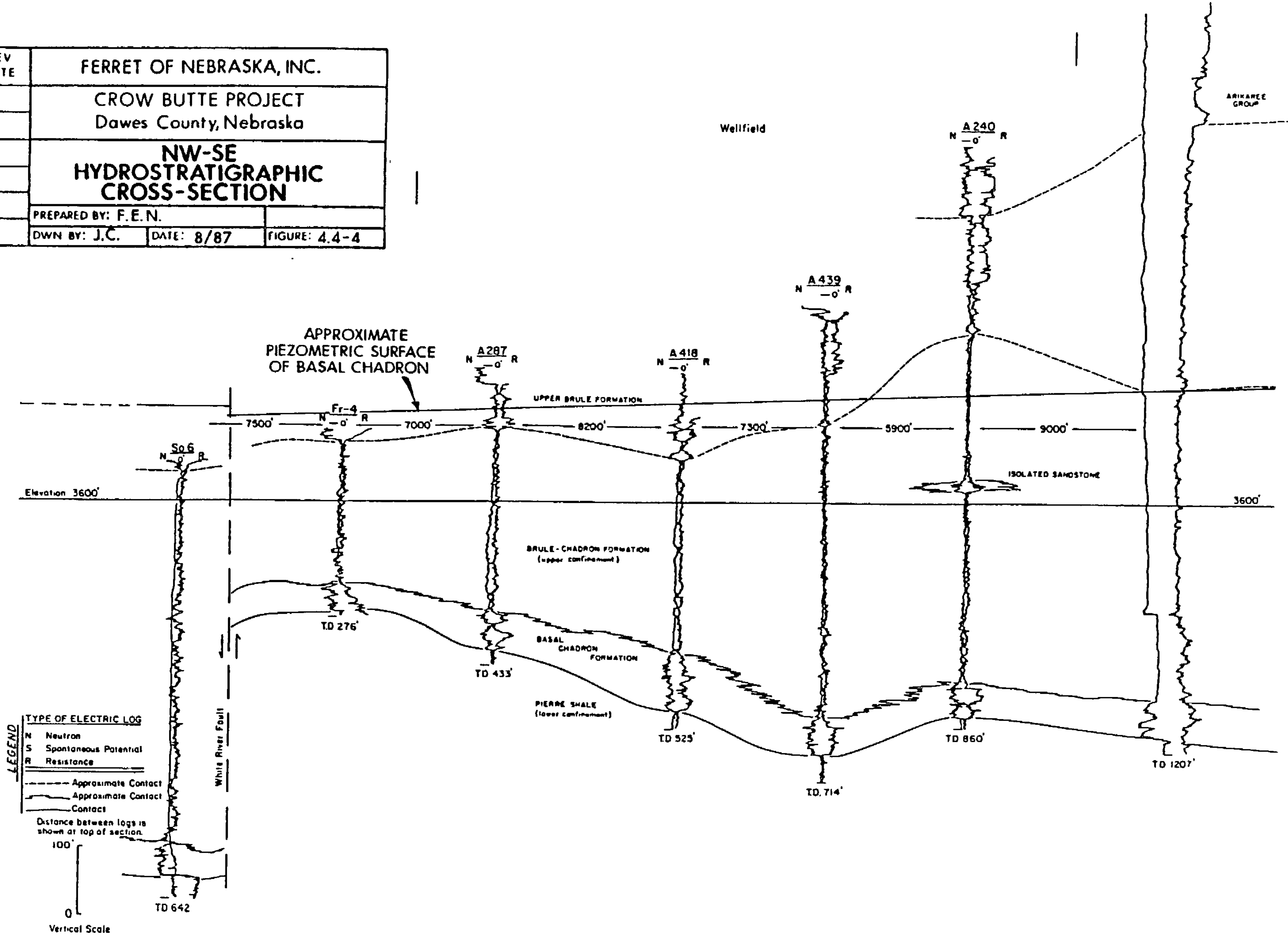
N

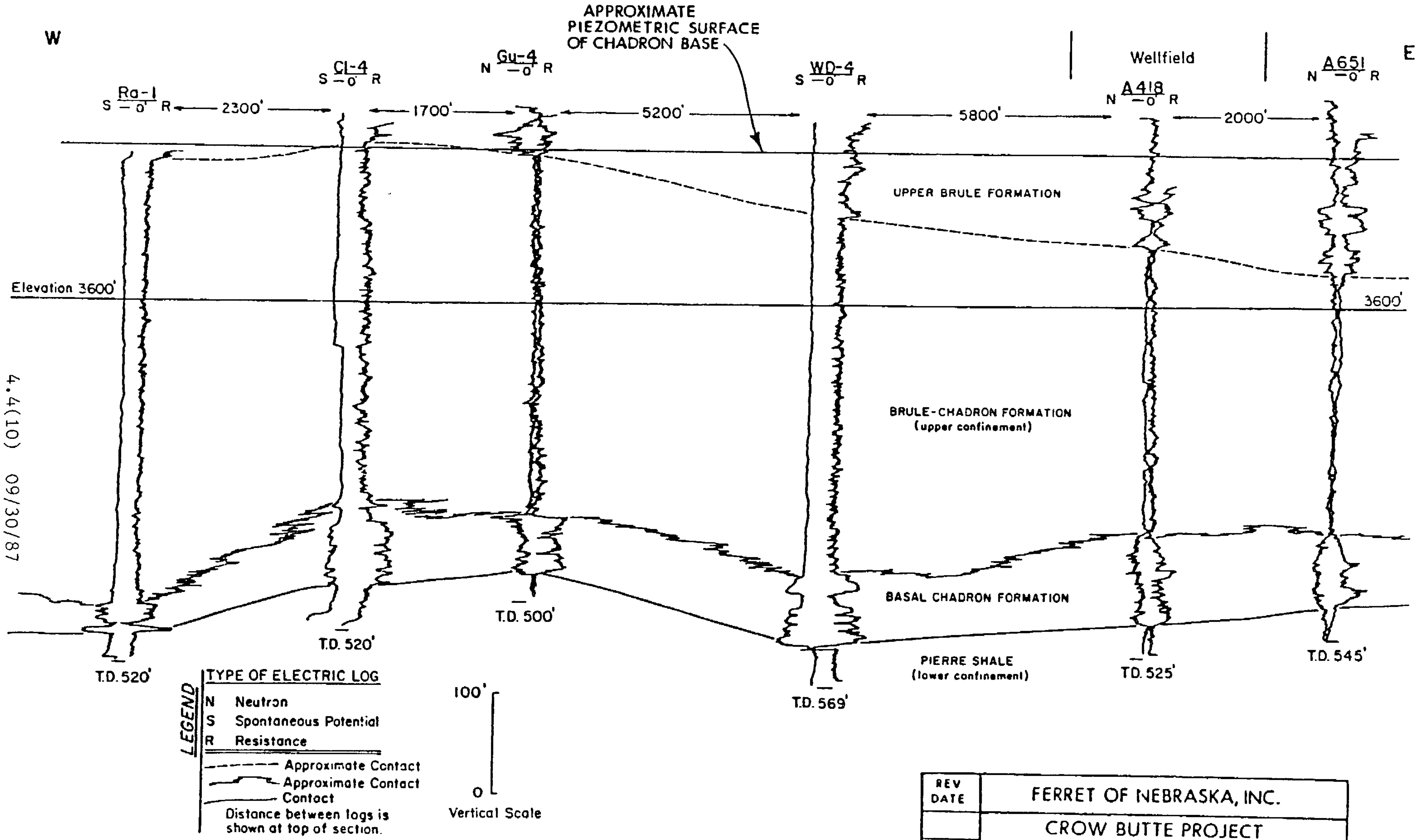
DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	WATER LEVEL MAP BRULE FORMATION	
	PREPARED BY: F.E.N.	
	DWN BY: J.C.	DATE: 8/87	FIGURE 4.4-2



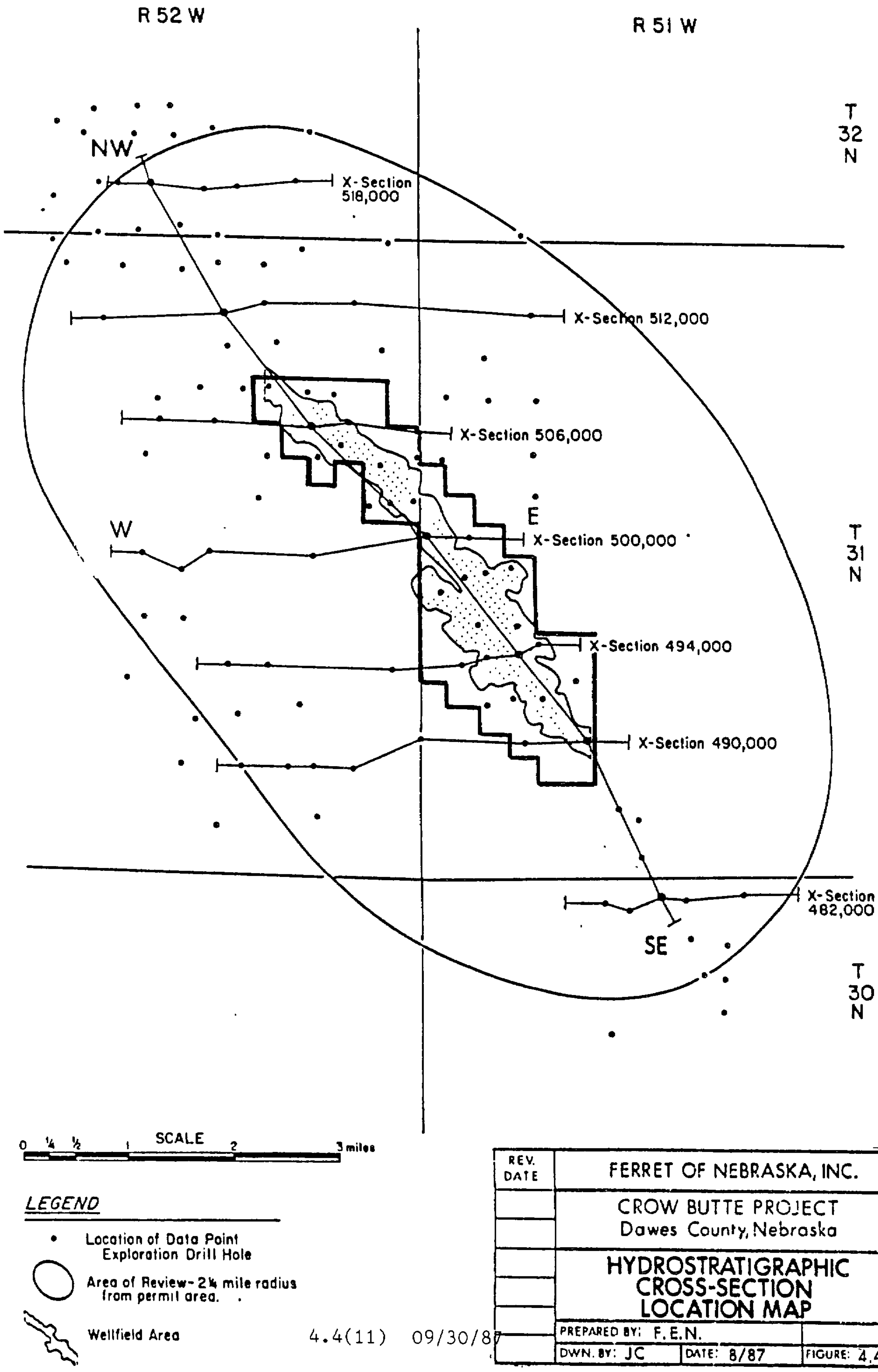
DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	WATER LEVEL MAP CHADRON FORMATION	
	PREPARED BY: F.E.N.	
	DWN BY: JC	DATE: 8/87	FIGURE 4.4-3

REV DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	NW-SE HYDROSTRATIGRAPHIC CROSS-SECTION		
	PREPARED BY: F.E.N.		
	DWN BY: J.C.	DATE: 8/87	FIGURE: 4.4-4





REV DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	E-W HYDROSTRATIGRAPHIC CROSS-SECTION		
	PREPARED BY: F.E.N.		
	DWN BY: JC	DATE: 8/87	FIGURE: 4.4-5



REV. DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	HYDROSTRATIGRAPHIC CROSS-SECTION LOCATION MAP	
	PREPARED BY: F.E.N.	
	DWN. BY: JC	DATE: 8/87	FIGURE: 4.4-6

4.4(11) 09/30/87

The Basal Chadron Sand, 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 mean a strata capable of transmitting only minor amounts of fluid either vertically or horizontally. Typical values for the permeability of "aquicludes" are in the range of 10^{-4} to 10^{-5} darcys for vertical and horizontal permeabilities (Todd, 1980). The measured vertical permeabilities of the aquicludes are presented in Table 4.4-4 and 4.4-9.

In the upper part of the Brule Formation, sandstones and sandy siltstones are present which locally may be water bearing. 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 1.0 foot (0.30 m) and range from 0.7 feet (0.21 m) to 2.4 feet (0.73 m). 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.

Water Quality. A monitoring program was conducted to establish baseline groundwater and surface water quality conditions on the commercial permit area and surrounding areas. A detailed description of this program and all data is found in Section 4.4-4.

4.4-3 Aquifer Testing

To evaluate the hydraulic properties of the uranium bearing sand and the confining strata within the permit area, an aquifer testing program was conducted. The aquifer testing program consisted of two aquifer tests. The first test was conducted within the R&D wellfield in November, 1982. The second test was conducted in June, 1987 at a site located approximately 2800 feet north of the first test.

First Aquifer Test:

The first multiple-well aquifer test 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 in four production zone observation wells and two shallow Brule monitor wells were measured.

Aquifer Response to Pumping:

The data from the first aquifer test were analyzed by five different methods. The results of these five 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 as determined from the five analytical methods, ranged from 2453 gpd/ft (327 ft^2/day) to 3863 gpd/ft (516 ft^2/day). The average thickness of the aquifer at the test site is about 40 feet. Therefore, the average hydraulic conductivity ranges from about 61 gpd/ft^2 (8.2ft/day) to about 97 gpd/ft^2 (13 ft/day). The average coefficient of storage, as determined from the five analysis, ranged from $9.66x10^{-5}$ to $1.75x10^{-4}$. The azimuth and magnitude of the major axis of transmissivity are about 2^0 and 3000 gpd/ft. (401 ft^2/day). The azimuth and magnitude of the minor axis of transmissivity are about 92^0 and 2169 gpd/ft (290 ft^2/day). Evidence from the test show that the Basal Chadron Sandstone is not hydraulically connected to the overlying aquifer in the Brule Sand.

Integrity of Confinement:

The 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 aquifer-test pumping. 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 is 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, is about 7.8×10^{-7} ft/day (2.8×10^{-10} cm/sec), and that of the underlying confining layer is about 9.6×10^{-8} ft./day (3.4×10^{-11} cm/sec). Confining layers with vertical hydraulic conductivies 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 most graphically 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 a porosity of 22 percent, under unit gradient (one foot of head loss per foot of movement in the direction of flow) are about 12,000 years for the overlying aquiclude and about 7,500,000 years for the underlying aquiclude.

Movement of Groundwater:

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 one 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.

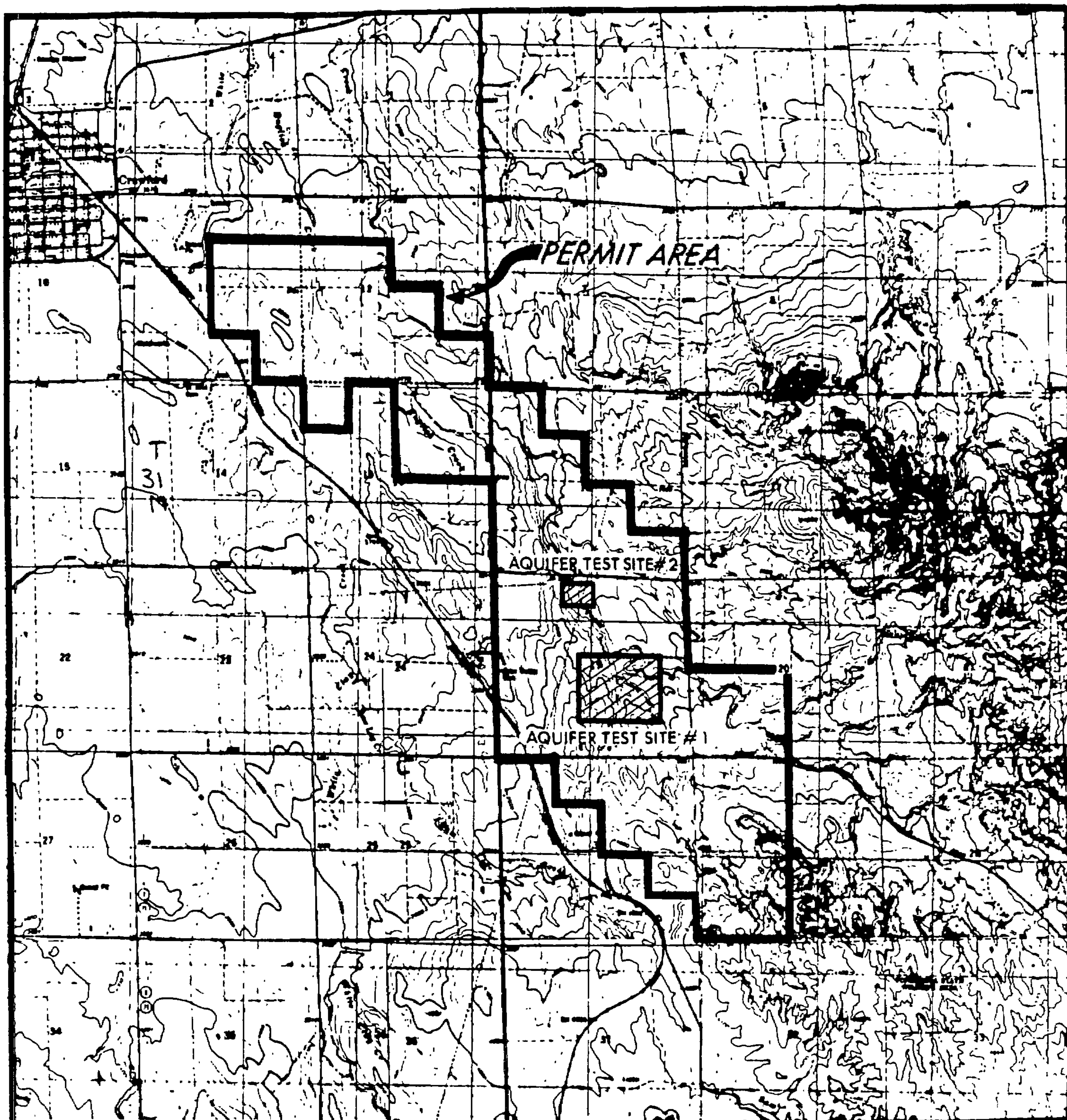
The details of the first aquifer test, including a description of the test, test data, as well as analysis and intepretation of the data are presented in Appendix 4.4(B).

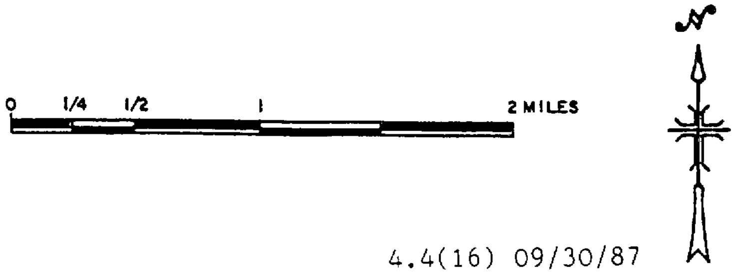
<u>Second Aquifer Test:</u>

A second multiple-well aquifer test was performed in the mineralized area near the northern boundary of Section 19. This test was part of a hydrogeogeologic investigation of the commercial permit area north of the R&D site. This investigation consisted of: (1) a review of exisiting geologic and hydrogeologic data; (2) design of an appropriate aquifer test; (3) design and construction of an appropriate well array for the aquifer test; (4) laboratory testing of core samples from confining layers; (5) conducting the aquifer test, (6) analyzing the aquifer test data, and (7) interpreting the results. This hydrogeologic investigation was structured to address environmental and operational questions pertinent to ISL uranium mining at the site. Specifically, the requirements outlined by the Nuclear Regulatory Commission (NRC) in Regulatory Guide 3.46, Section 2.7.1 and Draft Staff Technical Position Paper WM-8203, Section 3.1.2. Therefore, this 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 and the overlying aquifer. The aquifer test site is located near the north boundary of Section 19, T 31 N, R51 W, Dawes County, Nebraska. This site is approximately 2800 feet north of the R & D site (Figure 4.4-7).

<u>Site Hydrostratigraphy:</u>

The uranium-bearing aquifer is formed by a 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). Regionally, the thickness of the Basal Sandstone ranges from 0 to 350 feet. Exploration drilling in the vicinity of the test site shows that the average thickness of Basal Sandstone is approximately 40 feet. At the test site, the Basal Sandstone is approximately 550 to 600 feet below ground surface. The Chadron Formation lies with marked unconformity on top of the Pierre Shale.





4.4(16) 09/30/87

REV. DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	LOCATION MAP		
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/5/87	FIGURE: 4.4-7

The Pierre Shale of late Cretaceous age forms the underlying confining layer for the Basal Chadron Sandstone. The Pierre is a wide-spread dark-gray to black marine shale which is essentially impermeable. Regionally, the Pierre Shale is up to 5000 feet thick. In Dawes County, deep oil test holes have encountered thicknesses of 1200 to 1500 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. At the test site, the overlying confining layer is approximately 315 to 325 feet thick.

Purpose of Investigation:

The purpose of this hydrogeologic investigation was to accurately characterize the hydrogeologic regime of the commercial permit area north of the R&D site as it pertains to ISL uranium mining. The specific objectives of this investigation were to:

- confirm confinement of the ore-bearing aquifer,
- determine the transmissivity, hydraulic conductivity, and storativity of the ore-bearing aquifer,
- determine the azimuth and magnitude of the major and minor axes of transmissivity in the ore-bearing aquifer,
- use the Neuman-Witherspoon Method to determine the vertical hydraulic conductivity under in situ conditions, of the confining layers which overlie and underlie the ore-bearing aquifer.

In addition to its use in the commercial permit application, the information gathered during this investigation may be used for:

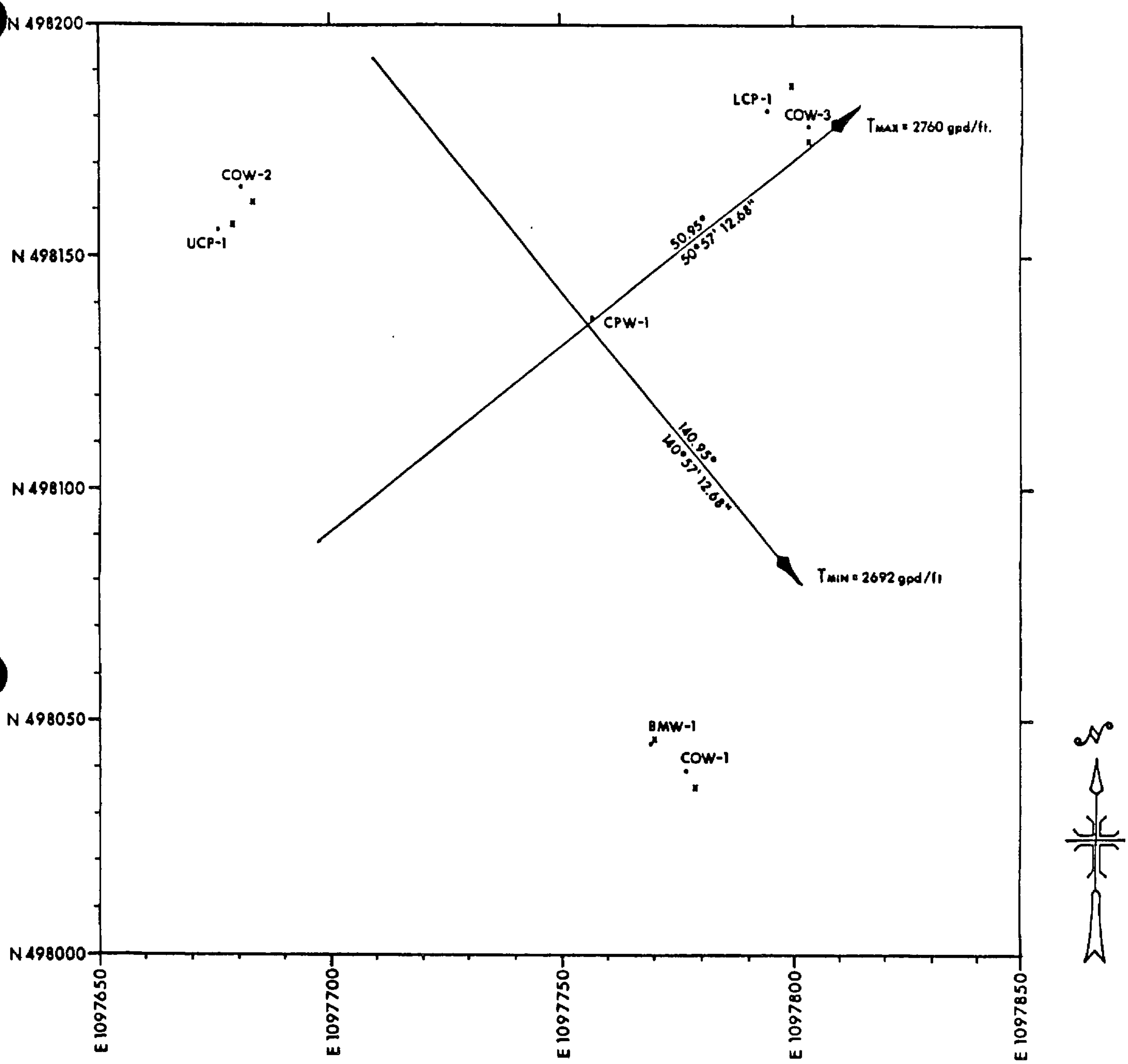
- o design of the commercial wellfield,
- o selection of commercial production parameters,
- o design of the groundwater monitoring system,
- o predictive analysis of the mining and restoration efficiency.

AQUIFER TESTING PROGRAM

The aquifer test program was designed to quantify the hydrogeologic parameters recommended by the NRC in Regulatory Guide 3.46, Section 4.4.1, and Draft Staff Technical Position Paper WM-8203. Specifically, this test was designed to allow analysis of the confining layers by the Neuman/Witherspoon Method (1972) which is currently considered by the NRC to be the most applicable to aquifer-aquitard systems commonly associated with uranium deposits.

Configuration of Well Array:

The well array used for the aquifer test consisted of five wells and two high-sensitivity piezometers configured as shown in Figure 4.4-8. All of the wells and piezometers used to perform this test were constructed during April and May, 1987 specifically for use in this test. The location and completion details of these wells and piezometers are shown on Tables 4.4-2 and 4.4-3. 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). These wells were screened through the entire thickness of the aquifer (fully penetrating), (Figure 4.4-9). The three observation wells were located in an equiangular arrangement around the central pumping well (Figure 4.4-8). 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.



EXPLANATION:

- SURFACE LOCATION OF WELL
- BOTTOMHOLE LOCATION OF WELL

DIRECTION AND MAGNITUDE OF MAJOR AND MINOR AXIS OF TRANSMISSIVITY OF BASAL CHADRON SANDSTONE.

0 — 50 FEET

REV. DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	AQUIFER TEST WELL ARRAY	
	PREPARED BY: F.E.N.	
	DWN. BY: JC	DATE: 8/5/87 — FIGURE: 4.4-8

TABLE 4.4-2

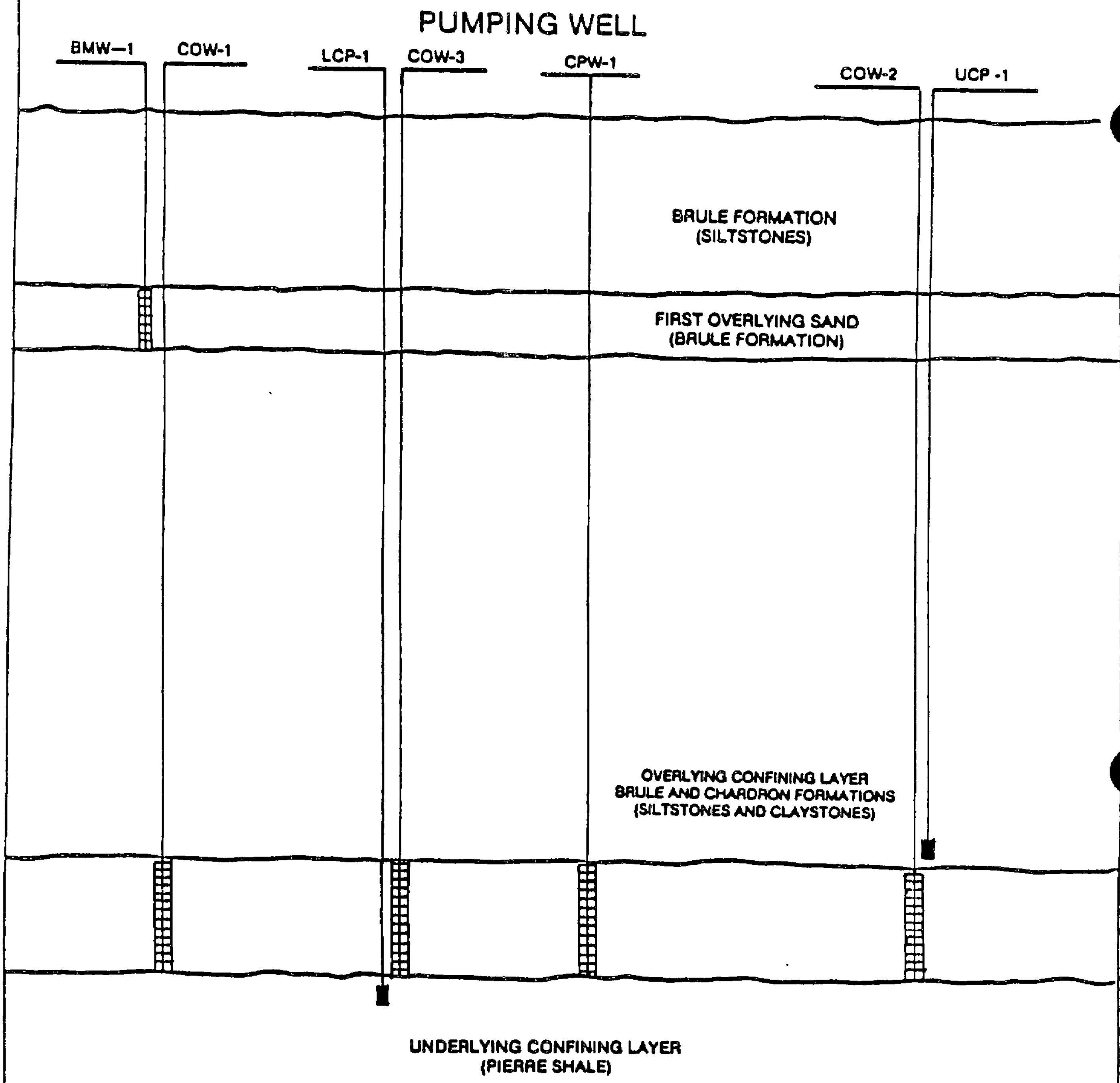
WELL LOCATIONS

Well	Surface Coordinates (ft)		Deviation (ft)		Bottom-hole Coordinates (ft)		Ground Surface Elevation (ft)	Top of Casing Elevation (ft)
	E	N	E	N	E	N		
CPW-1	1,097,757.20	498,137.28	- .64	-1.02	1,097,756.56	498,136.26	3837.55	3838.75
COW-1	1,097,774.33	498,039.39	+3.02	-2.62	1,097,777.35	498,036.77	3840.21	3842.25
COW-2	1,097,681.13	498,164.90	+1.89	-2.33	1,097,683.02	498,162.57	3833.61	3835.57
COW-3	1,097,803.23	498,177.05	- .19	-1.39	1,097,803.04	498,175.66	3840.40	3842.36
BMW-1	1,097,768.97	498,045.32	+1.63	+ .76	1,097,770.60	498,046.08	3839.85	3841.82
UCP-1	1,097,676.19	498,156.47	+2.33	+ .58	1,097,678.52	498,157.05	3834.16	3836.82
LCP-1	1,097,794.73	498,181.79	+4.41	+6.07	1,097,799.14	498,187.86	3840.02	3840.98

TABLE 4.4-3

WELL COMPLETION DETAILS

Well	Open Interval Depth (ft)	Completion Stratum	Casing Size I.D.(in)	Total Depth (ft)	From CPW-1 (bottomhole) Distance (ft)	From CPW-1 (bottomhole) Azimuth	Elevation of Piezometric Surface in ft above MSL (6/28/87)
CPW-1	572-612	Basal Chadron	4.5	617	----	----	3749.3
COW-1	585-625	Basal Chadron	4.5	630	101.64	168.20°	3749.4
COW-2	565-610	Basal Chadron	4.5	615	78.10	289.69°	3749.3
COW-3	575-615	Basal Chadron	4.5	620	60.93	49.71°	3749.4
BMW-1	235-260	Upper Aquifer	4.5	265	91.27	171.15°	3808.0
UCP-1	555-557	Upper Aquiclude	2.0	557	80.76	284.92°	3750.7
LCP-1	618-620	Lower Aquiclude	2.0	620	66.90	39.53	3748.8



NOT TO SCALE

REV DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	SCHEMATIC OF WELL COMPLETION INTERVALS	
	PREPARED BY: F.E.N.	
	DWN. BY: JC	DATE: 8/5/87 · FIGURE: 4.4-9

One monitor well (BMW-1) was completed in the first overlying sand of the Brule Formation (Figure 4.4-9). Well BMW-1 is also screened through the entire thickness of the aquifer (fully penetrating). This well was used to monitor the water level in the first overlying sand during the aquifer test.

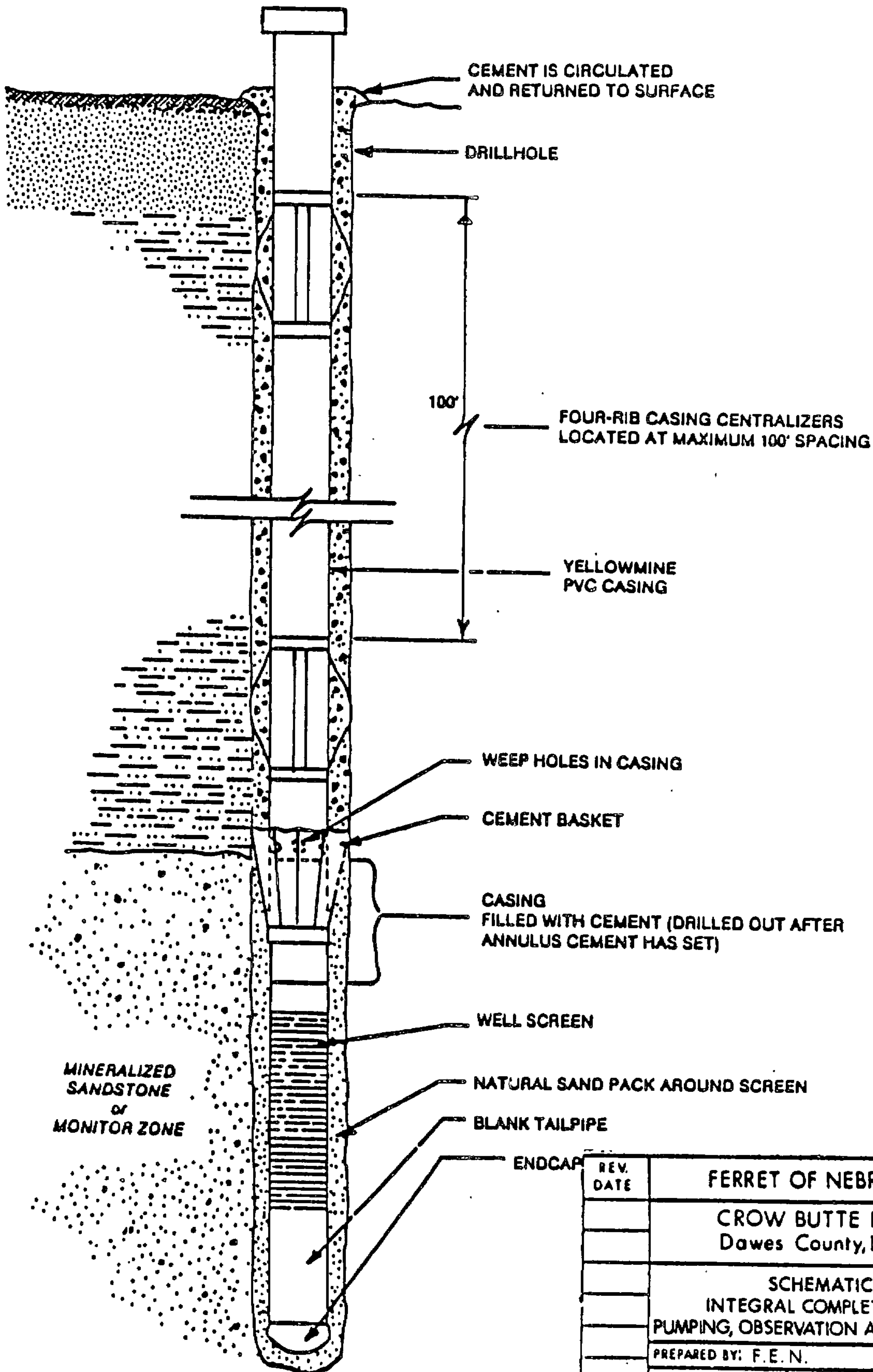
Two small-diameter, high-sensitivity piezometers (UCP-1, LCP-1) were completed in the confining layers which overlie and underlie the ore-bearing aquifer (Figure 4.4-9). These piezometers provided the data to calculate the vertical hydraulic conductivities of these confining layers under in-situ field conditions.

Well Construction and Completion Techniques

All well and piezometer boreholes were drilled with a conventional rotary drill rig using a bentonite based drilling fluid. The borehole was drilled to the appropriate depth and was geophysically logged. The log suite consisted of a gamma log, a resistivity log, a neutron log and a deviation survey. The geophysical logs were then used to determine the exact completion interval of each well or piezometer.

The pumping, observation and monitor wells were completed by a single stage or integral completion method. Figure 4.4-10 is a schematic of this completion method. This method consisted of drilling a nominal 8-inch borehole to the desired depth. Next, a string of 4.5-inch diameter Yelomine casing with the desired length of screen attached to the lower end was placed in the hole. A cement basket was attached to the blank casing just above the screen to exclude cement from the screen interval during cementing. The cement was then pumped down the inside of the casing to a plug set just below the cement basket. The cement passed out through weep holes in the casing above the cement basket and was directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement had cured sufficiently, the residual cement and plug were drilled out. The completed wells were then developed by air-lifting. The confining layer piezometers were cased with two-inch I.D. Yelomine casing and a porous stone tip. The porous stone tip was two feet

WELL COMPLETION METHOD



REV. DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	SCHEMATIC OF INTEGRAL COMPLETION METHOD FOR PUMPING, OBSERVATION AND MONITOR WELLS		
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/5/87	FIGURE: 4.4-10

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long, 1.5 inches in diameter, with 50 micron pores. These piezometers were grouted through a tremie line from the top of the completion interval to ground surface with cement slurry. The cement was excluded from the completion interval by an inflatable packer. Figure 4.4-11 is a generalized diagram of the drilling and completion procedures for the piezometers. The completed piezometers were then cleaned and developed by inserting a one-inch pipe to the bottom of the piezometer and circulating clean water. During the construction of the confining layer piezometers, cores were cut from the completion intervals. These cores were sealed in nitrogen purged containers made of PVC pipe to preserve in situ moisture content and to prevent oxidation during transportation to the testing laboratory.

Standard consolidation tests were performed on samples of these cores to determine the coefficient of consolidation, c_v, compression index, C_c, coefficient of compressibility, a_v, and vertical hydraulic conductivity, k_v, of the confining layers (Table 4.4-4). Laboratory determination of these parameters allowed calculation of the specific storage of the confining layers and their vertical hydraulic conductivity.

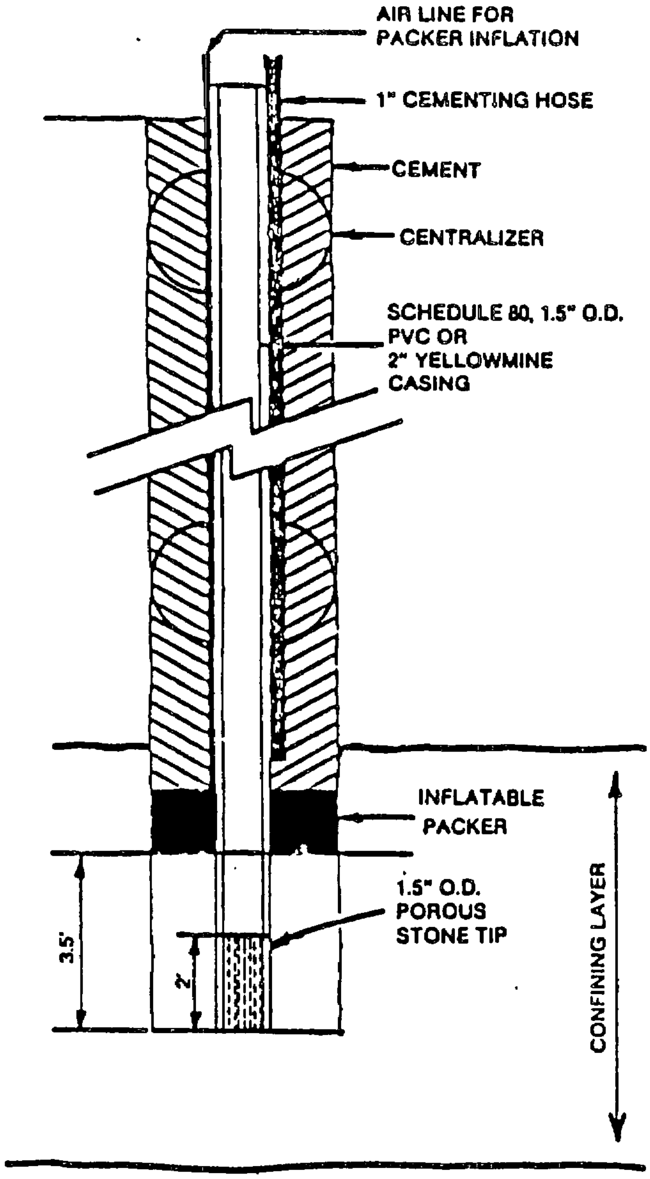
Pre-Test Monitoring

Construction and development of the five wells and two piezometers in the well array was completed on May 28, 1987. For the next 33 days, the well array was allowed to stabilize. During this time, the water levels in all the wells and piezometers and the barometric pressure were measured and recorded daily. These data were used to ensure that the wells and piezometers had reached a true static water level.

Aquifer Test Equipment and Instrumentation

During the aquifer test, the pumped well (CPW-1) was equipped with a 7.5 HP submersible pump which was set at a depth of about 500 feet. A two-inch I.D. discharge pipe conveyed the pumped water to the surface. Electrical power for the pump was supplied by a diesel-powered portable generator which ran continuously throughout the pumping phase of the test. A one-inch diaphragm valve was used to control the discharge rate. Two

DRILLING AND COMPLETION PROCEDURES



1. Drill pilot hole to top of completion interval.
2. Core (2" minimum diameter) through completion interval.
3. Run geophysical logs.
4. Set casing with an inflatable packer at top of completion interval. Porous stone piezometer will be used in the completion interval.
5. Inflate the packer.
6. Cement the annulus through 1" cementing line and shut the well in.
7. Top off annulus with cement after setting has occurred.

SCHEMATIC
NOT TO SCALE

REV. DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	SCHEMATIC OF COMPLETION METHOD FOR CONFINING LAYER PIEZOMETERS		
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/5/87	FIGURE: 4.4-11

TABLE 4.4-4

RESULTS OF CONSOLIDATION TESTS OF CONFINING LAYER CORE SAMPLES

Borehole	Depth (ft)	Lithology	Porosity	Coefficient of Consolidation, c_v (cm^2/sec.)	Compression Index, Cc	Coefficient of Compressibility, a_v (cm^2/g)	Vertical Hydraulic Conductivity, k[1] (cm/sec.)
UCP-1	546.5	red clay	.341	6.65×10^{-5}	2.75×10^{-2}	4.46×10^{-7}	2.22×10^{-11}
UCP-1	550.6	red clay	.328	1.13×10^{-4}	2.69×10^{-2}	4.37×10^{-7}	3.78×10^{-11}
UCP-1	555.6	red clay	.284	1.78×10^{-4}	1.94×10^{-2}	3.15×10^{-7}	4.46×10^{-11}
UCP-1	Average		.318	1.19×10^{-4}	2.46×10^{-2}	3.99×10^{-7}	3.49×10^{-11}
LCP-1	617.0	shale	.317	1.04×10^{-4}	2.28×10^{-2}	3.70×10^{-7}	2.89×10^{-11}
LCP-1	621.8	shale	.333	9.10×10^{-5}	4.04×10^{-2}	6.56×10^{-7}	4.36×10^{-11}
LCP-1	Average		.325	9.70×10^{-5}	3.16×10^{-2}	5.13×10^{-7}	3.63×10^{-11}

(1) Calculated for 600 psi effective overburden pressure from consolidation test data.

Haliburton meters which measured both flow rate and volume were installed in the discharge line to measure instantaneous discharge rate and cumulative discharge volume. Only one meter was used at any one time, keeping the second in reserve as a backup.

The discharge line extended about 400 feet from the wellhead to prevent discharged water from leaking downward and recharging the shallow overlying aquifer. The three Chadron observation wells (COW-1, COW-2, and COW-3), the overlying monitor well (BMW-1), and the two confining layer piezometers (UCP-1 and LCP-1) were equipped with electronic pressure transducers. These six pressure transducers were connected to a computer-controlled datalogger which automatically recorded the water levels in each well at specified time intervals. A seventh electronic pressure transducer was used to measure barometric pressure which was also recorded by the datalogger each time the water levels were recorded.

Aquifer Test

The pumping phase of the aquifer test began at 12:47 on June 30, 1987 and concluded at approximately 12:47 on July 3, 1987. Thus, the length of the pumping phase of the test was 4320 minutes, or about 72 hours. Just prior to the start of the pumping, static water levels of all the wells were measured and recorded (Table 4.4-5). The recovery phase of the test began at 12:47 on July 3, 1987 and concluded at 13:17 on July 6, 1987, which is a period of 4350 minutes, or 72.5 hours.

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 insure that it remained constant. Tables 4.4-6 and 4.4-7 present the recorded drawdown and recovery data corrected for changes in barometric pressure. 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 during the test was 36.86 feet, which is approximately 447 feet above the top of the the aquifer. Therefore, the aquifer was under confined conditions throughout the test.

TABLE 4.4-5

STATIC WATER LEVELS

Well	Static Water Level 6/30/87 (ft. above MSL)
CPW-1	---- *
COW-1	3749.5
COW-2	3749.5
COW-3	3749.5
BMW-1	3808.2
UCP-1	3751.3
LCP-1	3749.4

* Could not measure water level because pump was in well.

TABLE 4.4-6
DRAWDOWN DATA

	REAL TIME										ELAPSED TIME			
	DATE	HH:MM	SEC	COW-1	COW-2	COW-3	LCP-1	UCP-1	BMW-1	BAROM	HOURS	MIN.	SEC	TOTAL MIN.
1	181	1247	34.750	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.000	0.00
2	181	1247	43.750	0.02	0.06	0.00	-0.00	0.00	-0.00	0.00	0.0	0.0	9.875	0.16
3	181	1247	52.750	0.04	0.18	-0.02	-0.00	-0.00	-0.00	0.00	0.0	0.0	19.750	0.33
4	181	1248	1.750	0.09	0.36	0.05	-0.00	-0.00	-0.01	0.00	0.0	0.0	29.625	0.49
5	181	1248	10.750	0.17	0.57	0.06	-0.00	-0.00	-0.00	0.00	0.0	0.0	39.500	0.66
6	181	1248	19.750	0.27	0.75	0.10	0.00	-0.00	-0.00	0.00	0.0	0.0	49.375	0.82
7	181	1248	28.750	0.38	0.96	0.14	-0.01	-0.00	-0.00	0.00	0.0	0.0	59.250	0.99
8	181	1248	39.750	0.53	1.17	0.15	-0.01	0.00	-0.00	0.00	0.0	1.0	11.125	1.18
9	181	1248	50.750	0.68	1.37	0.22	-0.00	-0.01	-0.01	0.00	0.0	1.0	23.000	1.38
10	181	1249	1.750	0.84	1.57	0.32	-0.00	-0.00	-0.00	0.00	0.0	1.0	34.875	1.58
11	181	1249	12.750	0.99	1.75	0.44	-0.00	-0.00	-0.01	0.00	0.0	1.0	46.750	1.78
12	181	1249	23.750	1.14	1.89	0.51	-0.01	0.00	-0.00	0.00	0.0	1.0	58.625	1.98
13	181	1249	34.750	1.28	2.05	0.59	-0.00	0.00	-0.00	0.00	0.0	2.0	10.500	2.17
14	181	1249	45.750	1.41	2.19	0.64	-0.00	-0.00	-0.01	0.00	0.0	2.0	22.375	2.37
15	181	1249	56.750	1.54	2.32	0.76	-0.00	-0.00	-0.00	0.00	0.0	2.0	34.250	2.57
16	181	1250	7.750	1.67	2.41	0.78	-0.00	0.00	0.00	0.00	0.0	2.0	46.125	2.77
17	181	1250	18.750	1.79	2.52	0.89	-0.00	0.01	-0.00	0.00	0.0	2.0	58.000	2.97
18	181	1250	32.750	1.93	2.66	0.98	-0.00	0.00	-0.00	0.00	0.0	3.0	12.875	3.21
19	181	1250	46.750	2.07	2.76	1.15	0.00	0.00	0.00	0.00	0.0	3.0	27.750	3.46
20	181	1251	0.750	2.20	2.86	1.20	-0.00	-0.00	-0.00	0.00	0.0	3.0	42.625	3.71
21	181	1251	14.750	2.31	2.99	1.30	-0.00	0.00	-0.00	0.00	0.0	3.0	57.500	3.96
22	181	1251	28.750	2.42	3.06	1.48	0.00	0.00	-0.00	0.00	0.0	4.0	12.375	4.21
23	181	1251	42.750	2.52	3.16	1.54	0.00	-0.00	-0.00	0.00	0.0	4.0	27.125	4.45
24	181	1251	56.750	2.61	3.22	1.66	-0.00	0.00	-0.00	0.00	0.0	4.0	42.000	4.70
25	181	1252	10.750	2.71	3.30	1.76	-0.00	0.00	0.00	0.00	0.0	4.0	56.875	4.95
26	181	1252	29.750	2.82	3.40	1.95	-0.00	-0.00	-0.00	0.00	0.0	5.0	16.750	5.28
27	181	1252	48.750	2.93	3.52	2.01	-0.00	0.00	-0.00	0.00	0.0	5.0	36.625	5.61
28	181	1253	7.750	3.03	3.60	2.24	0.00	0.00	0.00	0.00	0.0	5.0	56.500	5.94
29	181	1253	26.750	3.13	3.69	2.36	0.00	-0.00	0.00	0.00	0.0	6.0	16.375	6.27
30	181	1253	45.750	3.22	3.81	2.42	-0.00	-0.00	0.00	0.00	0.0	6.0	36.250	6.60
31	181	1254	4.750	3.32	3.87	2.58	-0.00	0.00	-0.00	0.00	0.0	6.0	56.125	6.93
32	181	1254	23.750	3.42	3.98	2.77	-0.00	0.00	-0.00	0.00	0.0	7.0	16.000	7.27
33	181	1254	42.750	3.49	4.06	2.81	0.00	0.00	-0.00	0.00	0.0	7.0	35.875	7.60
34	181	1255	1.750	3.57	4.13	2.97	-0.00	-0.00	-0.00	0.00	0.0	7.0	55.750	7.93
35	181	1255	20.750	3.64	4.19	3.09	-0.00	0.00	-0.00	0.00	0.0	8.0	15.625	8.26
36	181	1255	39.750	3.72	4.24	3.18	-0.00	0.00	0.01	0.00	0.0	8.0	35.500	8.59
37	181	1255	58.750	3.80	4.34	3.32	0.00	0.00	0.01	0.00	0.0	8.0	55.375	8.92
38	181	1256	17.750	3.86	4.38	3.48	-0.00	0.00	0.01	0.00	0.0	9.0	15.250	9.25
39	181	1256	36.750	3.92	4.44	3.55	0.00	0.00	0.01	0.00	0.0	9.0	35.125	9.58
40	181	1256	55.750	3.99	4.53	3.71	0.00	0.01	0.00	0.00	0.0	9.0	55.000	9.92
41	181	1257	54.750	4.16	4.68	3.94	-0.01	-0.01	-0.01	0.01	0.0	10.0	54.875	10.91
42	181	1258	53.750	4.33	4.83	4.23	0.00	0.00	0.00	0.00	0.0	11.0	54.750	11.91
43	181	1259	52.750	4.47	4.97	4.57	0.00	0.00	0.01	0.00	0.0	12.0	54.625	12.91
44	181	1300	51.750	4.60	5.12	4.78	0.00	0.00	0.01	0.00	0.0	13.0	54.500	13.91
45	181	1301	50.750	4.72	5.23	4.99	-0.00	0.00	0.01	0.00	0.0	14.0	54.375	14.91
46	181	1302	49.750	4.85	5.34	5.22	-0.00	0.01	0.00	0.00	0.0	15.0	54.250	15.90
47	181	1303	48.750	4.95	5.45	5.37	-0.00	0.01	0.00	0.00	0.0	16.0	54.125	16.90
48	181	1304	47.750	5.05	5.55	5.61	0.00	0.00	0.01	0.00	0.0	17.0	54.000	17.90
49	181	1305	46.750	5.15	5.62	5.69	0.00	0.00	0.01	0.00	0.0	18.0	53.875	18.90
50	181	1306	45.750	5.23	5.73	5.92	0.00	0.00	0.01	0.00	0.0	19.0	53.750	19.90
51	181	1308	44.750	5.41	5.88	6.12	0.00	0.00	0.01	0.00	0.0	21.0	53.625	21.89
52	181	1310	43.750	5.56	6.05	6.43	0.00	0.00	0.01	0.00	0.0	23.0	53.500	23.89

Table 4.4-6 (Cont'd)

53	181	1312	42.750	5.72	6.18	6.61	0.00	0.01	0.01	0.00	0.0	25.0	53.375	25.89
54	181	1314	41.750	5.85	6.31	6.85	0.01	0.01	0.00	0.00	0.0	27.0	53.250	27.89
55	181	1316	40.750	5.97	6.44	6.97	-0.01	-0.00	-0.00	0.01	0.0	29.0	53.125	29.88
56	181	1318	39.750	6.11	6.58	7.20	0.00	0.01	0.00	0.00	0.0	31.0	53.000	31.88
57	181	1320	38.750	6.21	6.70	7.30	-0.00	0.01	0.01	0.00	0.0	33.0	52.875	33.88
58	181	1322	37.750	6.33	6.79	7.52	0.00	0.00	0.01	0.00	0.0	35.0	52.750	35.88
59	181	1324	36.750	6.43	6.92	7.64	0.00	0.01	0.01	0.00	0.0	37.0	52.625	37.88
60	181	1326	35.750	6.54	7.02	7.73	0.00	0.00	0.01	0.00	0.0	39.0	52.500	39.87
61	181	1328	34.750	6.63	7.10	7.83	-0.00	0.01	0.01	0.00	0.0	41.0	52.375	41.87
62	181	1330	33.750	6.72	7.20	8.00	0.00	0.00	0.01	0.00	0.0	43.0	52.250	43.87
63	181	1332	32.750	6.81	7.29	8.10	0.00	0.01	0.01	0.00	0.0	45.0	52.125	45.87
64	181	1334	31.750	6.88	7.36	8.11	0.00	-0.00	-0.00	0.01	0.0	47.0	52.000	47.87
65	181	1336	30.750	6.96	7.46	8.26	-0.00	-0.01	-0.00	0.01	0.0	49.0	51.875	49.86
66	181	1339	29.750	7.08	7.57	8.40	0.00	0.00	0.00	0.01	0.0	52.0	51.750	52.86
67	181	1342	28.750	7.19	7.69	8.48	0.00	-0.00	0.00	0.01	0.0	55.0	51.625	55.86
68	181	1345	27.750	7.29	7.81	8.64	0.00	-0.00	0.00	0.01	0.0	58.0	51.500	58.86
69	181	1348	26.750	7.39	7.90	8.75	-0.00	0.00	0.01	0.01	1.0	1.0	51.375	61.86
70	181	1351	25.750	7.48	7.99	8.84	0.00	0.00	0.00	0.02	1.0	4.0	51.250	64.85
71	181	1354	24.750	7.58	8.11	8.89	0.01	0.00	0.01	0.01	1.0	7.0	51.125	67.85
72	181	1357	23.750	7.68	8.20	8.99	0.01	0.01	-0.00	0.01	1.0	10.0	51.000	70.85
73	181	1400	22.750	7.77	8.32	9.17	0.01	0.01	0.01	0.01	1.0	13.0	50.875	73.85
74	181	1403	21.750	7.83	8.38	9.26	-0.00	-0.01	-0.01	0.02	1.0	16.0	50.750	76.85
75	181	1406	20.750	7.92	8.48	9.27	0.01	0.01	0.00	0.01	1.0	19.0	50.625	79.84
76	181	1411	19.750	8.06	8.60	9.46	-0.00	-0.00	-0.01	0.02	1.0	24.0	50.500	84.84
77	181	1416	18.750	8.19	8.74	9.62	0.00	0.00	-0.01	0.02	1.0	29.0	50.375	89.84
78	181	1421	17.750	8.32	8.86	9.70	0.00	0.01	-0.01	0.02	1.0	34.0	50.250	94.84
79	181	1426	16.750	8.42	8.98	9.81	0.01	0.01	-0.01	0.02	1.0	39.0	50.125	99.83
80	181	1436	15.750	8.63	9.18	10.10	0.01	0.01	-0.00	0.02	1.0	49.0	50.000	109.83
81	181	1446	14.750	8.80	9.36	10.23	-0.00	0.00	-0.01	0.03	1.0	59.0	49.875	119.83
82	181	1456	13.750	8.98	9.55	10.45	0.00	0.00	-0.01	0.03	2.0	9.0	49.750	129.83
83	181	1506	12.750	9.14	9.70	10.61	0.01	0.01	-0.01	0.03	2.0	19.0	49.625	139.83
84	181	1516	11.750	9.29	9.86	10.78	0.01	0.01	-0.02	0.03	2.0	29.0	49.500	149.82
85	181	1526	10.750	9.43	9.99	10.95	0.01	0.01	-0.01	0.03	2.0	39.0	49.375	159.82
86	181	1536	9.750	9.55	10.11	11.06	0.00	0.00	-0.01	0.04	2.0	49.0	49.250	169.82
87	181	1546	8.750	9.68	10.24	11.15	0.00	0.00	-0.02	0.05	2.0	59.0	49.125	179.82
88	181	1556	7.750	9.79	10.37	11.33	0.01	0.01	-0.02	0.05	3.0	9.0	49.000	189.82
89	181	1606	6.750	9.91	10.48	11.43	0.01	0.01	-0.01	0.05	3.0	19.0	48.875	199.81
90	181	1626	5.750	10.11	10.68	11.59	0.01	0.00	-0.01	0.06	3.0	39.0	48.750	219.81
91	181	1646	4.750	10.29	10.85	11.80	0.01	-0.00	-0.02	0.06	3.0	59.0	48.625	239.81
92	181	1706	3.750	10.47	11.04	11.94	0.01	0.00	-0.02	0.06	4.0	19.0	48.500	259.81
93	181	1726	2.750	10.64	11.21	12.17	0.00	-0.00	-0.03	0.07	4.0	39.0	48.375	279.81
94	181	1746	1.750	10.80	11.38	12.30	0.01	-0.00	-0.00	0.07	4.0	59.0	48.250	299.80
95	181	1806	0.750	10.93	11.50	12.50	0.00	-0.01	-0.04	0.08	5.0	19.0	48.125	319.80
96	181	1825	59.750	11.05	11.62	12.59	0.02	0.00	-0.03	0.08	5.0	39.0	48.000	339.80
97	181	1845	58.750	11.16	11.71	12.67	0.01	0.00	-0.03	0.08	5.0	59.0	47.875	359.80
98	181	1905	57.750	11.26	11.83	12.77	0.01	-0.01	-0.04	0.09	6.0	19.0	47.750	379.80
99	181	1925	56.750	11.38	11.94	12.95	0.02	-0.00	-0.04	0.08	6.0	39.0	47.625	399.79
100	181	1955	55.750	11.52	12.10	13.09	0.01	-0.01	-0.05	0.09	7.0	9.0	47.500	429.79
101	181	2025	54.750	11.65	12.22	13.17	0.01	-0.01	-0.05	0.09	7.0	39.0	47.375	459.79
102	181	2055	53.750	11.76	12.33	13.28	0.01	-0.01	-0.06	0.09	8.0	9.0	47.250	489.79
103	181	2125	52.750	11.91	12.48	13.47	0.01	-0.01	-0.06	0.08	8.0	39.0	47.125	519.78
104	181	2155	51.750	12.02	12.60	13.58	0.02	0.00	-0.05	0.07	9.0	9.0	47.000	549.78
105	181	2225	50.750	12.13	12.69	13.67	0.02	0.00	-0.06	0.07	9.0	39.0	46.875	579.78
106	181	2255	49.750	12.23	12.81	13.73	0.02	-0.00	-0.07	0.08	10.0	9.0	46.750	609.78
107	181	2325	48.750	12.32	12.91	13.86	0.02	-0.01	-0.06	0.08	10.0	39.0	46.625	639.78
108	181	2355	47.750	12.41	12.98	13.94	0.01	-0.01	-0.07	0.09	11.0	9.0	46.500	669.77
109	182	25	46.750	12.51	13.08	14.07	0.02	-0.01	-0.06	0.08	11.0	39.0	46.375	699.77
110	182	125	45.750	12.67	13.23	14.16	0.02	-0.01	-0.07	0.09	12.0	39.0	46.250	759.77
111	182	225	44.750	12.82	13.40	14.38	0.02	-0.01	-0.06	0.09	13.0	39.0	46.125	819.77
112	182	325	43.750	12.94	13.50	14.47	0.02	-0.01	-0.06	0.09	14.0	39.0	46.000	879.77
113	182	425	42.750	13.05	13.61	14.56	0.02	-0.02	-0.07	0.10	15.0	39.0	45.875	939.76
114	182	525	41.750	13.16	13.72	14.69	0.02	-0.01	-0.08	0.10	16.0	39.0	45.750	999.76

Table 4.4-6 (Concluded)

115	182	625	40.750	13.27	13.82	14.81	0.02	-0.01	-0.07	0.09	17.0	39.0	45.625	1059.76
116	182	725	39.750	13.39	13.94	14.93	0.03	-0.01	-0.07	0.08	18.0	39.0	45.500	1119.76
117	182	825	38.750	13.49	14.06	15.00	0.03	-0.01	-0.07	0.08	19.0	39.0	45.375	1179.76
118	182	925	37.750	13.60	14.16	15.17	0.03	-0.01	-0.06	0.07	20.0	39.0	45.250	1239.75
119	182	1025	36.750	13.66	14.21	15.18	0.02	-0.02	-0.07	0.07	21.0	39.0	45.125	1299.75
120	182	1125	35.750	13.76	14.31	15.30	0.03	-0.01	-0.07	0.07	22.0	39.0	45.000	1359.75
121	182	1225	34.750	13.85	14.41	15.39	0.03	-0.01	-0.07	0.08	23.0	39.0	44.875	1419.75
122	182	1325	33.750	13.93	14.50	15.42	0.03	-0.02	-0.07	0.09	24.0	39.0	44.750	1479.75
123	182	1425	32.750	14.00	14.56	15.51	0.03	-0.02	-0.06	0.10	25.0	39.0	44.625	1539.74
124	182	1525	31.750	14.08	14.64	15.61	0.03	-0.02	-0.06	0.09	26.0	39.0	44.500	1599.74
125	182	1625	30.750	14.16	14.71	15.70	0.03	-0.01	-0.06	0.08	27.0	39.0	44.375	1659.74
126	182	1705	29.750	14.22	14.78	15.74	0.02	-0.02	-0.05	0.08	28.0	19.0	44.250	1699.74
127	182	2025	28.750	14.38	14.94	15.87	0.03	-0.02	-0.07	0.07	31.0	39.0	44.875	1899.75
128	182	2345	27.750	14.59	15.15	16.13	0.03	-0.03	-0.07	0.05	34.0	59.0	45.500	2099.76
129	183	305	26.750	14.72	15.28	16.22	0.04	-0.03	-0.06	0.05	38.0	19.0	46.125	2299.77
130	183	625	25.750	14.92	15.49	16.43	0.04	-0.03	-0.05	0.02	41.0	39.0	46.750	2499.78
131	183	945	24.750	15.11	15.64	16.57	0.04	-0.03	-0.05	0.02	44.0	59.0	47.375	2699.79
132	183	1305	23.750	15.40	15.91	16.85	0.05	-0.03	-0.04	0.02	48.0	19.0	48.000	2899.80
133	183	1625	22.750	15.52	16.06	17.02	0.05	-0.04	-0.06	0.09	51.0	39.0	48.625	3099.81
134	183	1945	21.750	15.61	16.14	17.11	0.05	-0.04	-0.06	0.07	54.0	59.0	49.250	3299.82
135	183	2305	20.750	15.66	16.19	17.13	0.06	-0.04	-0.05	0.03	58.0	19.0	49.875	3499.83
136	184	225	19.750	15.77	16.28	17.19	0.06	-0.05	-0.05	0.03	61.0	39.0	50.500	3699.84
137	184	545	18.750	15.88	16.38	17.31	0.05	-0.06	-0.04	0.03	64.0	59.0	51.125	3899.85
138	184	905	17.750	15.92	16.43	17.39	0.06	-0.05	-0.06	0.08	68.0	19.0	51.750	4099.86
139	184	1225	16.750	16.01	16.51	17.48	0.06	-0.05	-0.06	0.10	71.0	39.0	52.375	4299.87

LEGEND:

DATE: Julian calendar day of the year.

HH:MM Hours and minutes.

SEC. Seconds

Drawdown units for all wells are feet from the initial water level.

Barometer units are feet of water changes from initial pressure at start of test.

TABLE 4.4-7

RECOVERY DATA

		REAL TIME										ELAPSED TIME			
	DATE	HH:MM	SEC	COW-1	COW-2	COW-3	LCP-1	UCP-1	BMW-1	BAROM	HOURS	MIN.	SEC	TOTAL MIN.	t/t'
1	184	1246	48.750	16.01	16.50	17.44	0.06	-0.06	-0.07	0.11	0.0	0.0	0.000	0.00	--------
2	184	1246	57.750	16.00	16.44	17.46	0.06	-0.05	-0.07	0.11	0.0	0.0	9.875	0.16	26191.34
3	184	1247	6.750	15.98	16.32	17.42	0.06	-0.06	-0.07	0.11	0.0	0.0	19.750	0.33	13135.97
4	184	1247	15.750	15.93	16.11	17.37	0.06	-0.05	-0.07	0.11	0.0	0.0	29.625	0.49	8748.79
5	184	1247	24.750	15.85	15.88	17.24	0.06	-0.05	-0.07	0.11	0.0	0.0	39.500	0.66	6568.49
6	184	1247	33.750	15.75	15.66	17.22	0.06	-0.05	-0.07	0.11	0.0	0.0	49.375	0.82	5251.80
7	184	1247	42.750	15.62	15.43	17.14	0.06	-0.05	-0.07	0.11	0.0	0.0	59.250	0.99	4379.32
8	184	1247	53.750	15.46	15.15	17.03	0.06	-0.05	-0.07	0.11	0.0	1.0	11.125	1.18	3647.76
9	184	1248	4.750	15.28	14.92	16.86	0.06	-0.05	-0.07	0.11	0.0	1.0	23.000	1.38	3125.66
10	184	1248	15.750	15.11	14.73	16.71	0.06	-0.05	-0.07	0.11	0.0	1.0	34.875	1.58	2734.34
11	184	1248	26.750	14.95	14.54	16.60	0.06	-0.05	-0.08	0.11	0.0	1.0	46.750	1.78	2430.12
12	184	1248	37.750	14.79	14.40	16.44	0.06	-0.04	-0.07	0.11	0.0	1.0	58.625	1.98	2186.84
13	184	1248	48.750	14.64	14.25	16.29	0.06	-0.05	-0.08	0.11	0.0	2.0	10.500	2.17	1987.85
14	184	1248	59.750	14.50	14.13	16.18	0.06	-0.05	-0.07	0.11	0.0	2.0	22.375	2.37	1822.07
15	184	1249	10.750	14.37	14.03	16.01	0.06	-0.05	-0.08	0.11	0.0	2.0	34.250	2.57	1681.83
16	184	1249	21.750	14.25	13.92	15.80	0.06	-0.06	-0.08	0.11	0.0	2.0	46.125	2.77	1561.64
17	184	1249	32.750	14.14	13.83	15.61	0.06	-0.04	-0.07	0.11	0.0	2.0	58.000	2.97	1457.49
18	184	1249	46.750	14.00	13.71	15.41	0.06	-0.05	-0.08	0.11	0.0	3.0	12.875	3.21	1345.14
19	184	1250	0.750	13.88	13.60	15.26	0.06	-0.05	-0.07	0.11	0.0	3.0	27.750	3.46	1249.24
20	184	1250	14.750	13.76	13.50	15.07	0.06	-0.05	-0.07	0.11	0.0	3.0	42.625	3.71	1165.80
21	184	1250	28.750	13.65	13.41	14.84	0.06	-0.05	-0.07	0.11	0.0	3.0	57.500	3.96	1092.82
22	184	1250	42.750	13.55	13.32	14.74	0.06	-0.05	-0.08	0.11	0.0	4.0	12.375	4.21	1028.44
23	184	1250	56.750	13.45	13.24	14.55	0.06	-0.05	-0.08	0.11	0.0	4.0	27.250	4.45	971.23
24	184	1251	10.750	13.36	13.15	14.33	0.06	-0.05	-0.08	0.11	0.0	4.0	42.125	4.70	920.06
25	184	1251	24.750	13.27	13.07	14.25	0.06	-0.05	-0.07	0.11	0.0	4.0	57.000	4.95	874.01
26	184	1251	43.750	13.15	12.98	13.99	0.06	-0.05	-0.08	0.11	0.0	5.0	16.875	5.28	819.29
27	184	1252	2.750	13.05	12.89	13.82	0.06	-0.06	-0.07	0.11	0.0	5.0	36.750	5.61	771.03
28	184	1252	21.750	12.94	12.80	13.63	0.06	-0.05	-0.07	0.11	0.0	5.0	56.625	5.94	728.02
29	184	1252	40.750	12.85	12.71	13.55	0.06	-0.04	-0.07	0.11	0.0	6.0	16.500	6.27	689.67
30	184	1252	59.750	12.76	12.61	13.34	0.06	-0.05	-0.07	0.11	0.0	6.0	36.375	6.61	655.16
31	184	1253	18.750	12.67	12.54	13.19	0.06	-0.05	-0.07	0.11	0.0	6.0	56.250	6.94	623.86
32	184	1253	37.750	12.59	12.46	13.11	0.06	-0.05	-0.07	0.11	0.0	7.0	16.125	7.27	595.50
33	184	1253	56.750	12.51	12.40	12.96	0.06	-0.05	-0.07	0.11	0.0	7.0	36.000	7.60	569.61
34	184	1254	15.750	12.44	12.32	12.84	0.06	-0.05	-0.07	0.11	0.0	7.0	55.875	7.93	545.88
35	184	1254	34.750	12.37	12.26	12.81	0.06	-0.05	-0.07	0.11	0.0	8.0	15.750	8.26	524.05
36	184	1254	53.750	12.31	12.21	12.67	0.06	-0.05	-0.07	0.11	0.0	8.0	35.625	8.59	503.84
37	184	1255	12.750	12.23	12.13	12.56	0.06	-0.05	-0.07	0.11	0.0	8.0	55.500	8.92	485.19
38	184	1255	31.750	12.18	12.07	12.46	0.06	-0.05	-0.07	0.11	0.0	9.0	15.375	9.26	467.88
39	184	1255	50.750	12.11	11.99	12.44	0.06	-0.05	-0.07	0.11	0.0	9.0	35.250	9.59	451.76
40	184	1256	9.750	12.05	11.94	12.37	0.06	-0.05	-0.07	0.11	0.0	9.0	55.125	9.92	436.67
41	184	1257	8.750	11.88	11.77	12.09	0.06	-0.05	-0.07	0.11	0.0	10.0	55.000	10.92	396.84
42	184	1258	7.750	11.73	11.62	11.91	0.06	-0.06	-0.07	0.11	0.0	11.0	54.875	11.91	363.69
43	184	1259	6.750	11.58	11.50	11.73	0.06	-0.05	-0.07	0.11	0.0	12.0	54.750	12.91	335.68
44	184	1300	5.750	11.45	11.36	11.62	0.06	-0.06	-0.07	0.11	0.0	13.0	54.625	13.91	311.67
45	184	1301	4.750	11.32	11.26	11.46	0.06	-0.05	-0.07	0.11	0.0	14.0	54.500	14.91	290.87
46	184	1302	3.750	11.21	11.12	11.29	0.06	-0.05	-0.07	0.11	0.0	15.0	54.375	15.91	272.68
47	184	1303	2.750	11.10	11.02	11.21	0.06	-0.05	-0.07	0.11	0.0	16.0	54.250	16.90	256.64
48	184	1304	1.750	11.00	10.92	11.12	0.06	-0.05	-0.07	0.11	0.0	17.0	54.125	17.90	242.39
49	184	1305	0.750	10.91	10.82	11.01	0.06	-0.05	-0.07	0.11	0.0	18.0	54.000	18.90	229.65
50	184	1305	59.750	10.82	10.73	10.88	0.06	-0.04	-0.07	0.11	0.0	19.0	53.875	19.90	218.18
51	184	1307	58.750	10.64	10.56	10.71	0.06	-0.05	-0.07	0.11	0.0	21.0	53.750	21.90	198.36
52	184	1309	57.750	10.48	10.41	10.50	0.06	-0.05	-0.07	0.11	0.0	23.0	53.625	23.89	181.86

Table 4.4-7 (Cont'd)

53	184	1311	56.750	10.33	10.28	10.33	0.06	-0.05	-0.07	0.11	0.0	25.0	53.500	25.89	167.90
54	184	1313	55.750	10.19	10.13	10.23	0.06	-0.05	-0.07	0.11	0.0	27.0	53.375	27.89	155.94
55	184	1315	54.750	10.06	10.00	10.05	0.06	-0.05	-0.07	0.11	0.0	29.0	53.250	29.89	145.59
56	104	1317	53.750	9.93	9.86	9.96	0.06	-0.06	-0.07	0.12	0.0	31.0	53.125	31.88	136.53
57	184	1319	52.750	9.82	9.76	9.83	0.06	-0.05	-0.06	0.11	0.0	33.0	53.000	33.88	128.54
58	184	1321	51.750	9.70	9.64	9.72	0.06	-0.05	-0.07	0.12	0.0	35.0	52.875	35.88	121.44
59	184	1323	50.750	9.60	9.53	9.58	0.06	-0.06	-0.07	0.12	0.0	37.0	52.750	37.88	115.08
60	184	1325	49.750	9.50	9.42	9.51	0.06	-0.06	-0.07	0.12	0.0	39.0	52.625	39.88	109.37
61	184	1327	48.750	9.41	9.34	9.40	0.06	-0.05	-0.07	0.12	0.0	41.0	52.500	41.88	104.20
62	184	1329	47.750	9.32	9.24	9.30	0.06	-0.04	-0.06	0.12	0.0	43.0	52.375	43.87	99.50
63	184	1331	46.750	9.23	9.15	9.21	0.05	-0.05	-0.07	0.13	0.0	45.0	52.250	45.87	95.21
64	184	1333	45.750	9.15	9.07	9.08	0.06	-0.05	-0.06	0.12	0.0	47.0	52.125	47.87	91.28
65	184	1335	44.750	9.06	8.98	8.99	0.06	-0.06	-0.07	0.13	0.0	49.0	52.000	49.87	87.66
66	184	1341	42.625	8.84	8.73	8.77	0.05	-0.05	-0.07	0.13	0.0	52.0	57.250	52.95	82.61
67	184	1344	23.625	8.74	8.65	8.67	0.06	-0.05	-0.07	0.13	0.0	55.0	49.625	55.83	78.41
68	184	1347	14.625	8.64	8.54	8.59	0.06	-0.05	-0.07	0.13	0.0	58.0	48.500	58.81	74.48
69	184	1350	7.625	8.56	8.46	8.48	0.06	-0.05	-0.06	0.13	1.0	1.0	47.625	61.79	70.93
70	184	1353	4.625	8.47	8.36	8.35	0.06	-0.05	-0.06	0.13	1.0	4.0	47.250	64.79	67.70
71	184	1356	1.625	8.38	8.27	8.30	0.06	-0.05	-0.06	0.13	1.0	7.0	46.875	67.78	64.76
72	184	1358	58.625	8.29	8.19	8.23	0.06	-0.05	-0.06	0.13	1.0	10.0	46.500	70.77	62.06
73	184	1404	55.625	8.13	8.02	8.00	0.06	-0.05	-0.06	0.13	1.0	16.0	46.125	76.77	57.29
74	184	1408	53.625	8.03	7.91	7.89	0.05	-0.06	-0.06	0.13	1.0	20.0	45.875	80.76	54.51
75	184	1412	51.625	7.93	7.83	7.86	0.06	-0.05	-0.06	0.13	1.0	24.0	45.625	84.76	51.98
76	184	1418	48.625	7.80	7.68	7.67	0.06	-0.05	-0.06	0.13	1.0	30.0	45.250	90.75	48.62
77	184	1422	46.625	7.70	7.57	7.60	0.05	-0.06	-0.07	0.14	1.0	34.0	45.000	94.75	46.61
78	184	1428	43.625	7.58	7.45	7.46	0.05	-0.05	-0.06	0.14	1.0	40.0	44.625	100.74	43.89
79	184	1437	40.625	7.40	7.26	7.31	0.06	-0.05	-0.06	0.15	1.0	49.0	44.250	109.74	40.38
80	184	1446	37.625	7.24	7.11	7.10	0.06	-0.05	-0.05	0.15	1.0	58.0	43.875	118.73	37.40
81	184	1458	33.625	7.04	6.90	6.91	0.06	-0.05	-0.05	0.15	2.0	10.0	43.375	130.72	34.06
82	184	1508	31.625	6.89	6.75	6.74	0.06	-0.05	-0.05	0.15	2.0	20.0	43.125	140.72	31.71
83	184	1518	29.625	6.75	6.61	6.62	0.05	-0.06	-0.06	0.15	2.0	30.0	42.875	150.71	29.67
84	184	1528	28.625	6.63	6.48	6.44	0.06	-0.05	-0.05	0.13	2.0	40.0	42.750	160.71	27.89
85	184	1538	27.625	6.50	6.37	6.34	0.06	-0.05	-0.05	0.13	2.0	50.0	42.625	170.71	26.31
86	184	1548	26.625	6.37	6.25	6.21	0.06	-0.05	-0.05	0.14	3.0	0.0	42.500	180.71	24.91
87	184	1558	25.625	6.25	6.11	6.09	0.05	-0.06	-0.05	0.16	3.0	10.0	42.375	190.71	23.66
88	184	1608	24.625	6.15	6.03	5.95	0.05	-0.06	-0.04	0.17	3.0	20.0	42.250	200.70	22.53
89	184	1628	22.625	5.95	5.82	5.77	0.05	-0.06	-0.04	0.18	3.0	40.0	42.000	220.70	20.58
90	184	1648	20.625	5.79	5.66	5.61	0.06	-0.06	-0.04	0.18	4.0	0.0	41.750	240.70	18.95
91	184	1718	18.625	5.55	5.41	5.35	0.06	-0.05	-0.03	0.05	4.0	30.0	41.500	270.69	16.96
92	184	1738	17.625	5.55	5.42	5.34	0.22	0.10	0.12	-0.09	4.0	50.0	41.375	290.69	15.87
93	184	1758	16.625	5.41	5.30	5.28	0.22	0.11	0.12	-0.09	5.0	10.0	41.250	310.69	14.91
94	184	1818	15.625	5.26	5.15	5.08	0.20	0.09	0.08	-0.05	5.0	30.0	41.125	330.68	14.07
95	184	1838	14.625	5.15	5.03	4.98	0.21	0.09	0.09	-0.08	5.0	50.0	41.000	350.68	13.32
96	184	1858	13.625	5.04	4.94	4.85	0.21	0.10	0.10	-0.08	6.0	10.0	40.875	370.68	12.66
97	184	1938	11.625	4.85	4.74	4.69	0.24	0.11	0.11	-0.09	6.0	50.0	40.625	410.68	11.52
98	184	1958	10.625	4.77	4.68	4.58	0.25	0.14	0.13	-0.08	7.0	10.0	40.500	430.67	11.03
99	184	2018	9.625	4.64	4.54	4.45	0.22	0.11	0.09	-0.02	7.0	30.0	40.375	450.67	10.59
100	184	2048	8.625	4.51	4.39	4.39	0.21	0.10	0.08	-0.03	8.0	0.0	40.250	480.67	9.99
101	184	2118	7.625	4.39	4.29	4.27	0.20	0.08	0.07	-0.05	8.0	30.0	40.125	510.67	9.46
102	184	2148	6.625	4.29	4.16	4.10	0.21	0.09	0.08	-0.06	9.0	0.0	40.000	540.67	8.99
103	184	2218	5.625	4.21	4.10	4.03	0.22	0.11	0.10	-0.06	9.0	30.0	39.875	570.66	8.57
104	184	2248	4.625	4.12	4.02	4.00	0.23	0.11	0.10	-0.06	10.0	0.0	39.750	600.66	8.19
105	184	2318	3.625	4.03	3.91	3.89	0.22	0.10	0.09	-0.07	10.0	30.0	39.625	630.66	7.85
106	184	2348	2.625	3.96	3.85	3.78	0.23	0.12	0.10	-0.07	11.0	0.0	39.500	660.66	7.54
107	185	18	1.625	3.89	3.78	3.74	0.23	0.11	0.10	-0.08	11.0	30.0	39.375	690.66	7.26
108	185	48	0.625	3.80	3.70	3.63	0.22	0.10	0.08	-0.04	12.0	0.0	39.250	720.65	7.00
109	185	117	59.625	3.74	3.63	3.58	0.22	0.11	0.09	-0.04	12.0	30.0	39.125	750.65	6.76
110	185	217	58.625	3.62	3.49	3.50	0.22	0.10	0.09	-0.04	13.0	30.0	39.000	810.65	6.33
111	185	317	57.625	3.51	3.39	3.40	0.22	0.11	0.09	-0.03	14.0	30.0	38.875	870.65	5.96
112	185	417	56.625	3.39	3.29	3.22	0.21	0.10	0.08	-0.01	15.0	30.0	38.750	930.65	5.64
113	185	517	55.625	3.31	3.19	3.14	0.23	0.11	0.10	-0.02	16.0	30.0	38.625	990.64	5.36
114	185	617	54.625	3.20	3.10	3.10	0.21	0.09	0.08	-0.02	17.0	30.0	38.500	1050.64	5.11

Table 4.4-7 (Concluded)

115	185	717	53.625	3.12	3.02	3.01	0.21	0.09	0.09	-0.03	18.0	30.0	38.375	1110.64	4.89
116	185	817	52.625	3.06	2.93	2.93	0.22	0.11	0.11	-0.03	19.0	30.0	38.250	1170.64	4.69
117	185	917	51.625	2.98	2.86	2.81	0.22	0.11	0.11	-0.02	20.0	30.0	38.125	1230.63	4.51
118	185	1017	50.625	2.91	2.81	2.76	0.21	0.09	0.09	0.00	21.0	30.0	38.000	1290.63	4.35
119	185	1117	49.625	2.85	2.73	2.70	0.21	0.10	0.10	0.00	22.0	30.0	37.875	1350.63	4.20
120	185	1217	48.625	2.79	2.69	2.63	0.21	0.10	0.10	0.01	23.0	30.0	37.750	1410.63	4.06
121	185	1317	47.625	2.74	2.64	2.59	0.22	0.10	0.11	0.02	24.0	30.0	37.625	1470.63	3.94
122	185	1417	46.625	2.69	2.58	2.53	0.22	0.11	0.10	0.04	25.0	30.0	37.500	1530.62	3.82
123	185	1517	45.625	2.65	2.52	2.55	0.23	0.12	0.11	0.05	26.0	30.0	37.375	1590.62	3.72
124	185	1617	44.625	2.60	2.47	2.46	0.21	0.10	0.10	0.07	27.0	30.0	37.250	1650.62	3.62
125	185	1717	43.625	2.59	2.45	2.47	0.21	0.11	0.10	0.08	28.0	30.0	37.125	1710.62	3.53
126	185	1757	42.625	2.57	2.43	2.44	0.21	0.10	0.10	0.08	29.0	10.0	37.000	1750.62	3.47
127	185	2117	41.625	2.43	2.30	2.24	0.18	0.07	0.06	0.03	32.0	30.0	37.625	1950.63	3.22
128	186	37	40.625	2.32	2.21	2.19	0.18	0.07	0.07	0.01	35.0	50.0	38.250	2150.64	3.01
129	186	357	39.625	2.24	2.12	2.13	0.18	0.08	0.08	0.01	39.0	10.0	38.875	2350.65	2.84
130	186	717	38.625	2.15	2.03	2.00	0.17	0.07	0.08	0.01	42.0	30.0	39.500	2550.66	2.69
131	186	1037	37.625	2.06	1.93	1.88	0.16	0.07	0.08	0.01	45.0	50.0	40.125	2750.67	2.57
132	186	1357	36.625	1.97	1.84	1.82	0.18	0.08	0.10	0.01	49.0	10.0	40.750	2950.68	2.46
133	186	1717	35.625	1.94	1.82	1.76	0.20	0.11	0.13	0.01	52.0	30.0	41.375	3150.69	2.37
134	186	2037	34.625	1.88	1.76	1.77	0.19	0.09	0.12	0.02	55.0	50.0	42.000	3350.70	2.29
135	186	2357	33.625	1.82	1.69	1.70	0.18	0.09	0.12	0.03	59.0	10.0	42.625	3550.71	2.22
136	187	317	32.625	1.79	1.68	1.66	0.21	0.12	0.14	0.04	62.0	30.0	43.250	3750.72	2.15
137	187	637	31.625	1.71	1.58	1.58	0.15	0.06	0.10	0.05	65.0	50.0	43.875	3950.73	2.09
138	187	957	30.625	1.62	1.49	1.48	0.08	-0.01	0.07	0.05	69.0	10.0	44.500	4150.74	2.04
139	187	1317	29.625	1.56	1.44	1.36	0.07	-0.02	0.05	0.06	72.0	30.0	45.125	4350.75	1.99

No equipment failures or interruptions occurred during the aquifer test. However, barometric pressure did vary considerably during the six-day test as the result of the passage of a low pressure system and a cold front with associated thunderstorms and subsequent high pressure.

ANALYSIS OF DATA

Analytical Methods

To accomplish the goals of this investigation, the following methods of analysis were used:

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

- o Standard Consolidation Test (ASTM 1985) to determine the coefficient of consolidation, compression index, coefficient of compressibility, and vertical hydraulic conductivity of the confining layer.

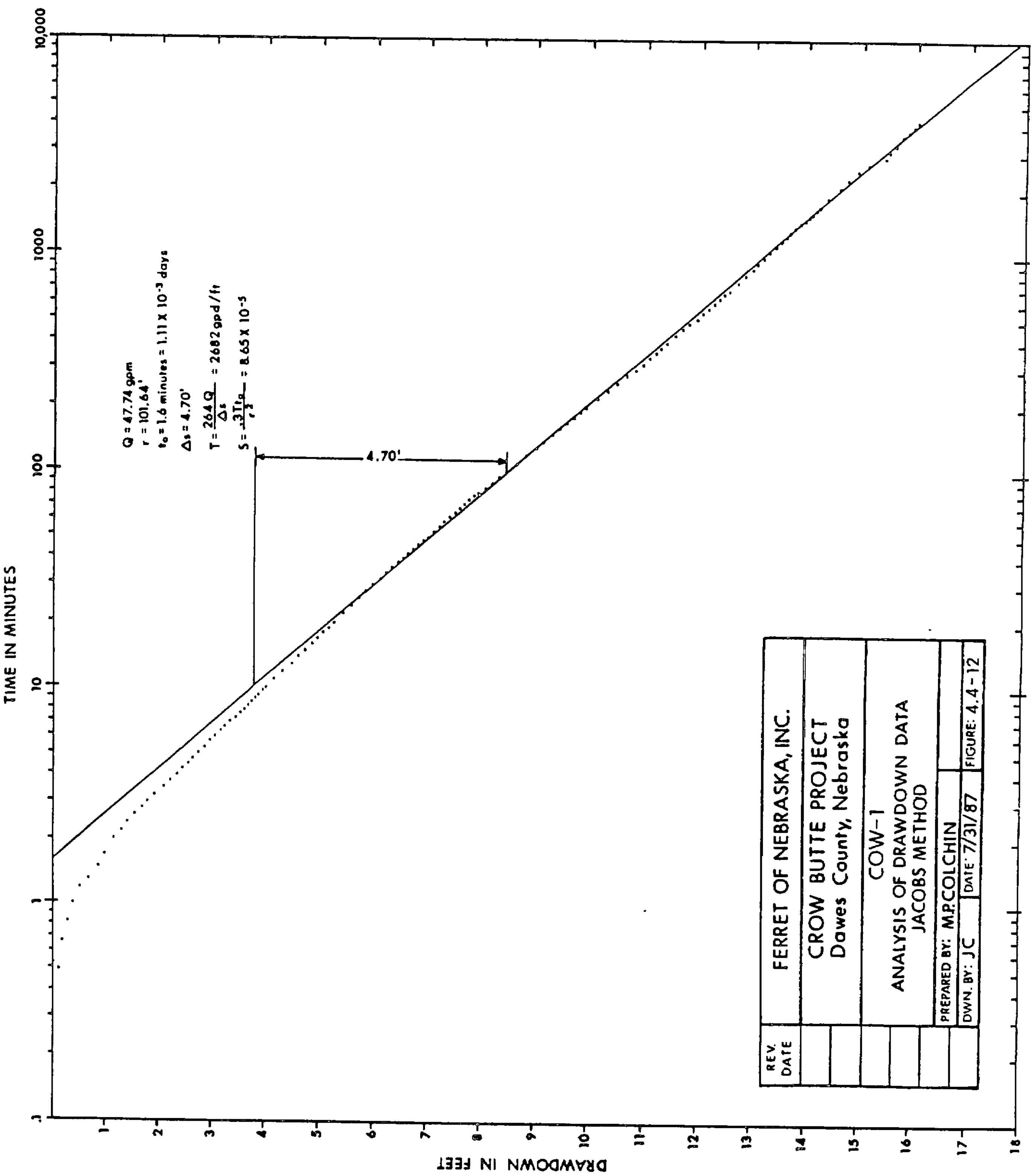
From a practical viewpoint, the field conditions at the test site met all the assumptions and conditions necessary for these analytical methods to be applicable and valid.

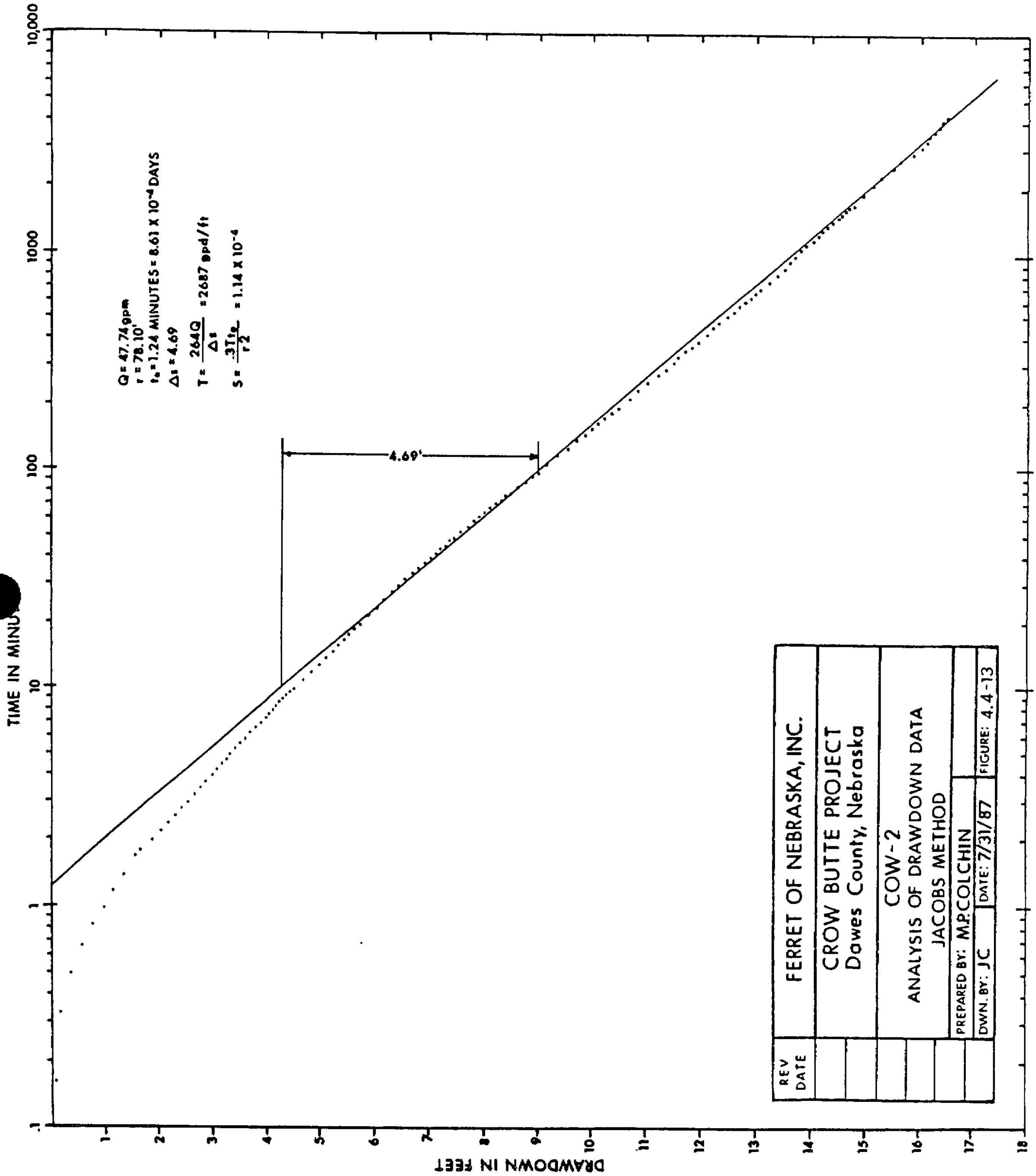
Results of Analysis

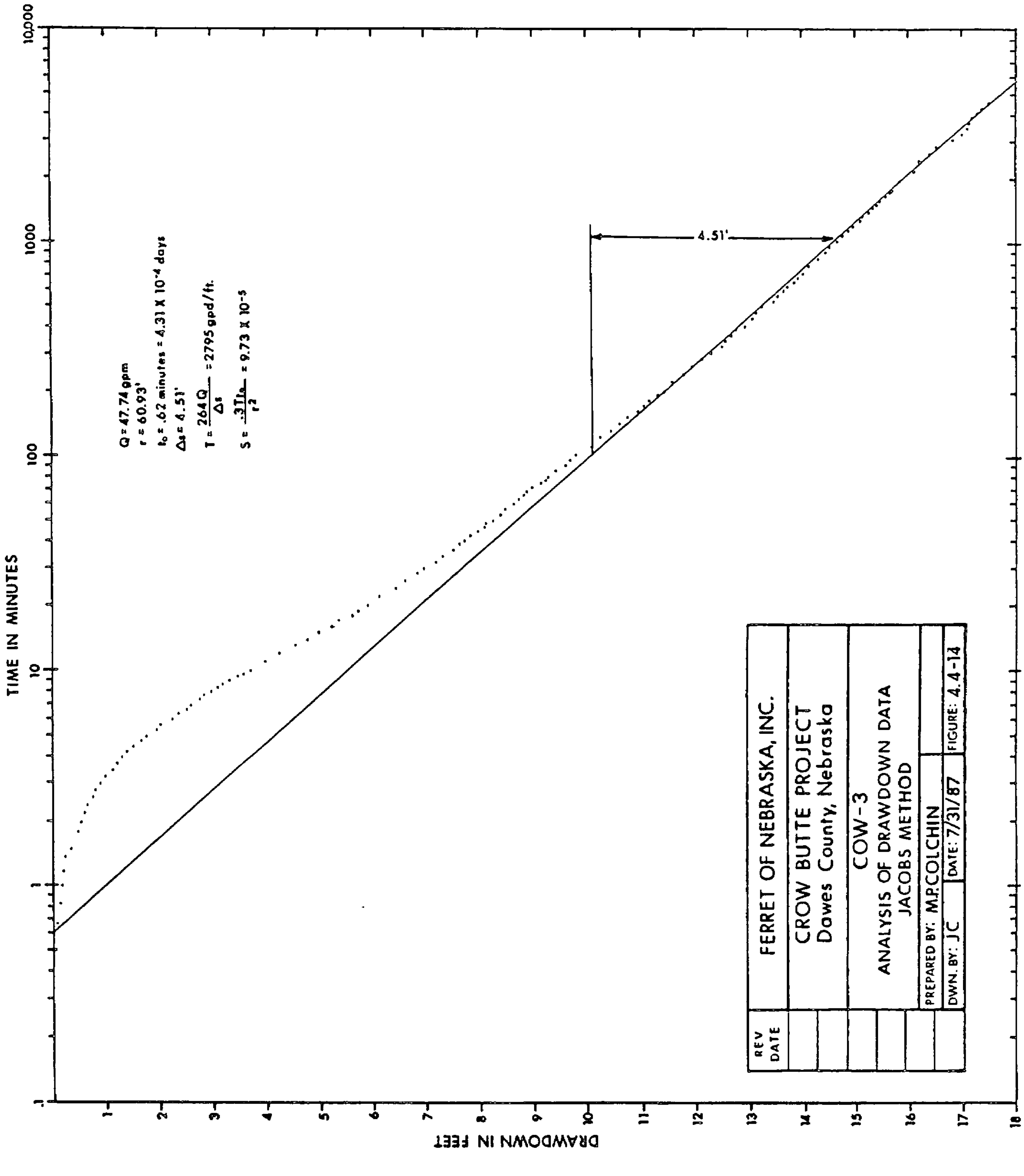
Basal Chadron Sandstone

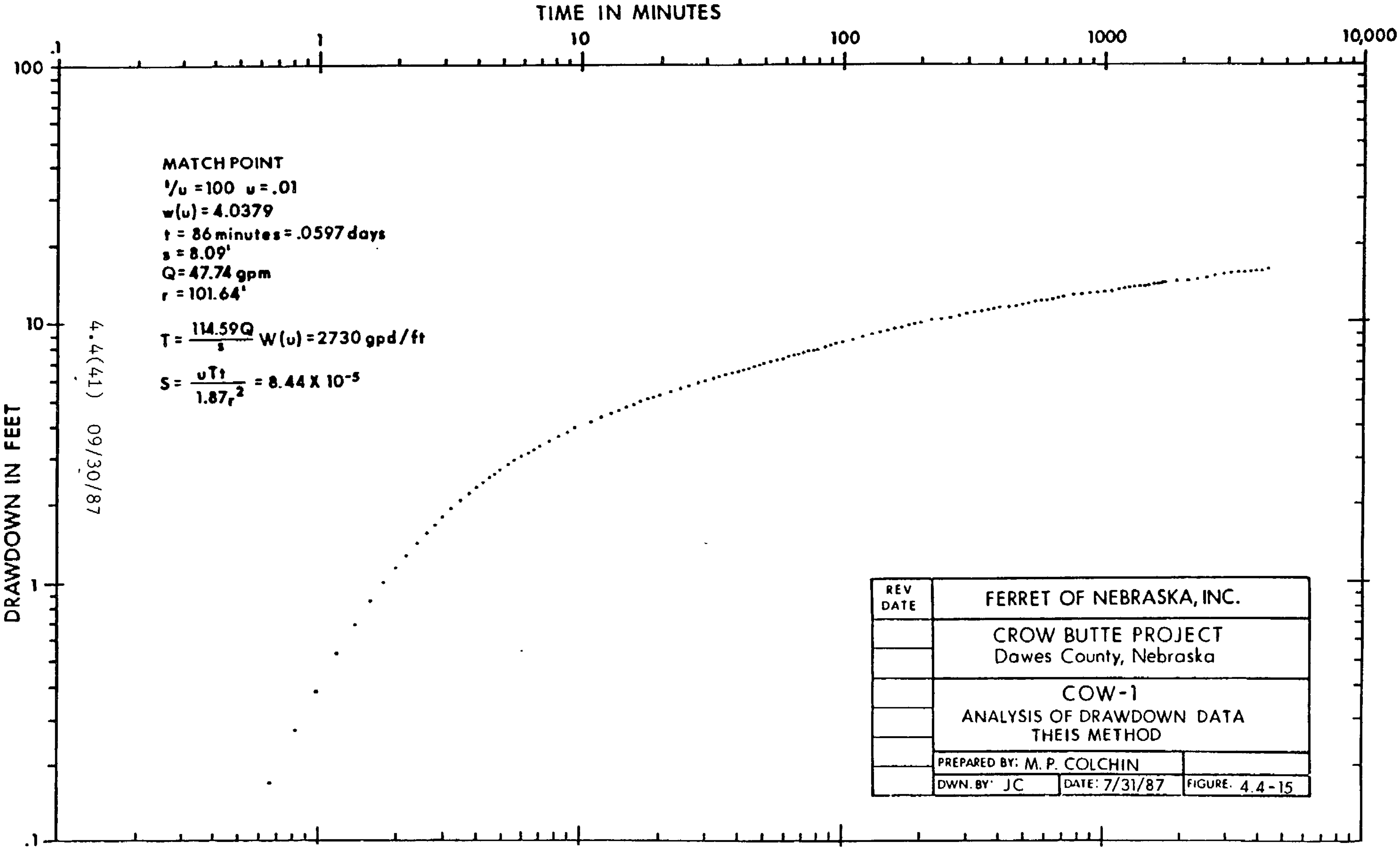
The Jacob Non-Equilibrium Method, the Theis Non-Equilibrium Method and the Theis Recovery Method were used to analyze the aquifer test data from the three Basal Chadron Sandstone wells (Figures 4.4-12 to 4.4-20). A confined non-leaky type of analysis was made because leakage effects were not apparent 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.

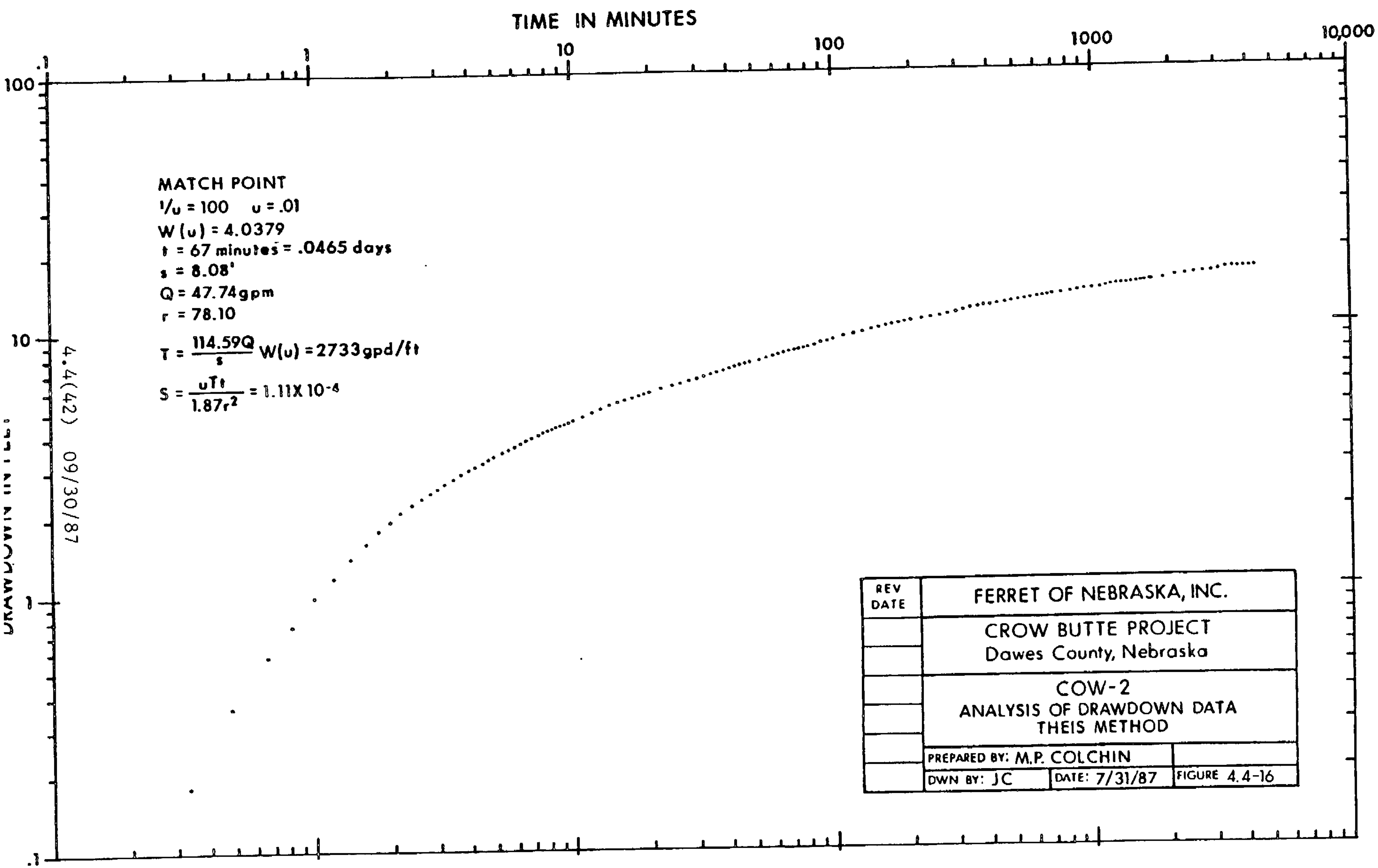
The transmissivities calculated from the drawdown data from the three Basal Chadron Sandstone observation wells ((COW-1, COW-2, COW-3), ranged from 2682 gpd/ft (359 ft^2/day) to 2795 gpd/ft (374 ft^2/day). The storage coefficients for these wells, calculated from the same analyses, ranges from 8.44×10^{-5} 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 lower transmissivity values calculated from the recovery data are probably the result of the variation in the storage coefficient during pumping and recovery. In theory, the storage coefficient is assumed to be constant during both the pumping and the recovery phases of an aquifer test. This assumption is true if the aquifer is perfectly elastic. In practice, however, a confined aquifer is usually not perfectly elastic. Therefore, it will not rebound vertically during recovery of water levels (recovery of pressure) at the same rate that it consolidates or compresses when pressure is decreased during the preceeding pumping. Therefore, the storage

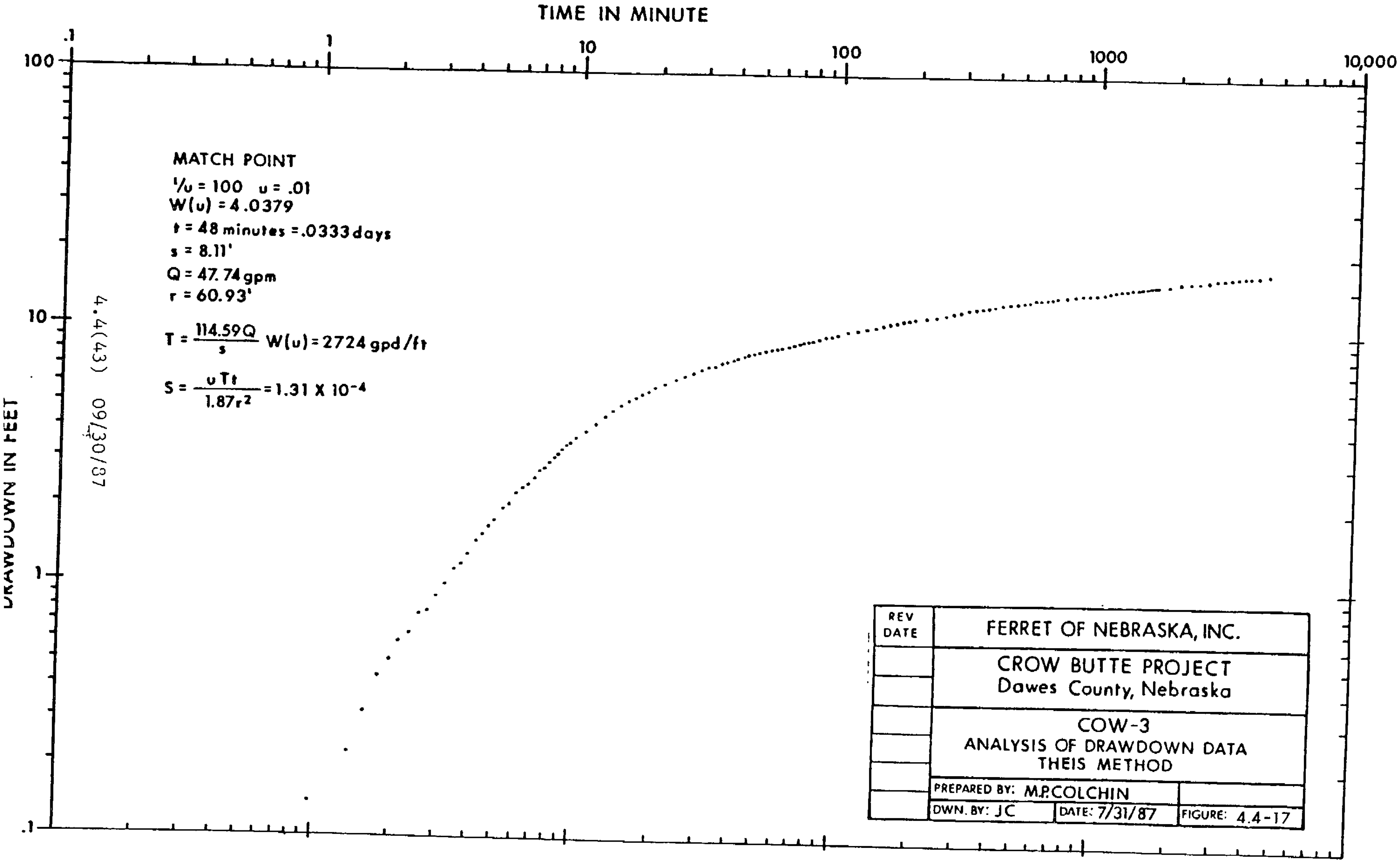

TIME IN MINUTES
DRAWDOWN IN FEET
Q = 47.74 gpm
r = 101.64'
t0 = 1.6 minutes = 1.11 X 10-3 days
Δs = 4.70'
T = 264Q/Δs = 2682 gpd/ft
S = .3Tt0/r2 = 8.65 X 10-5
4.70'
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-1
ANALYSIS OF DRAWDOWN DATA
JACOBS METHOD
PREPARED BY: M.P.COLCHIN
DWN. BY: JC
DATE: 7/31/87
FIGURE: 4.4-12
REV. DATE

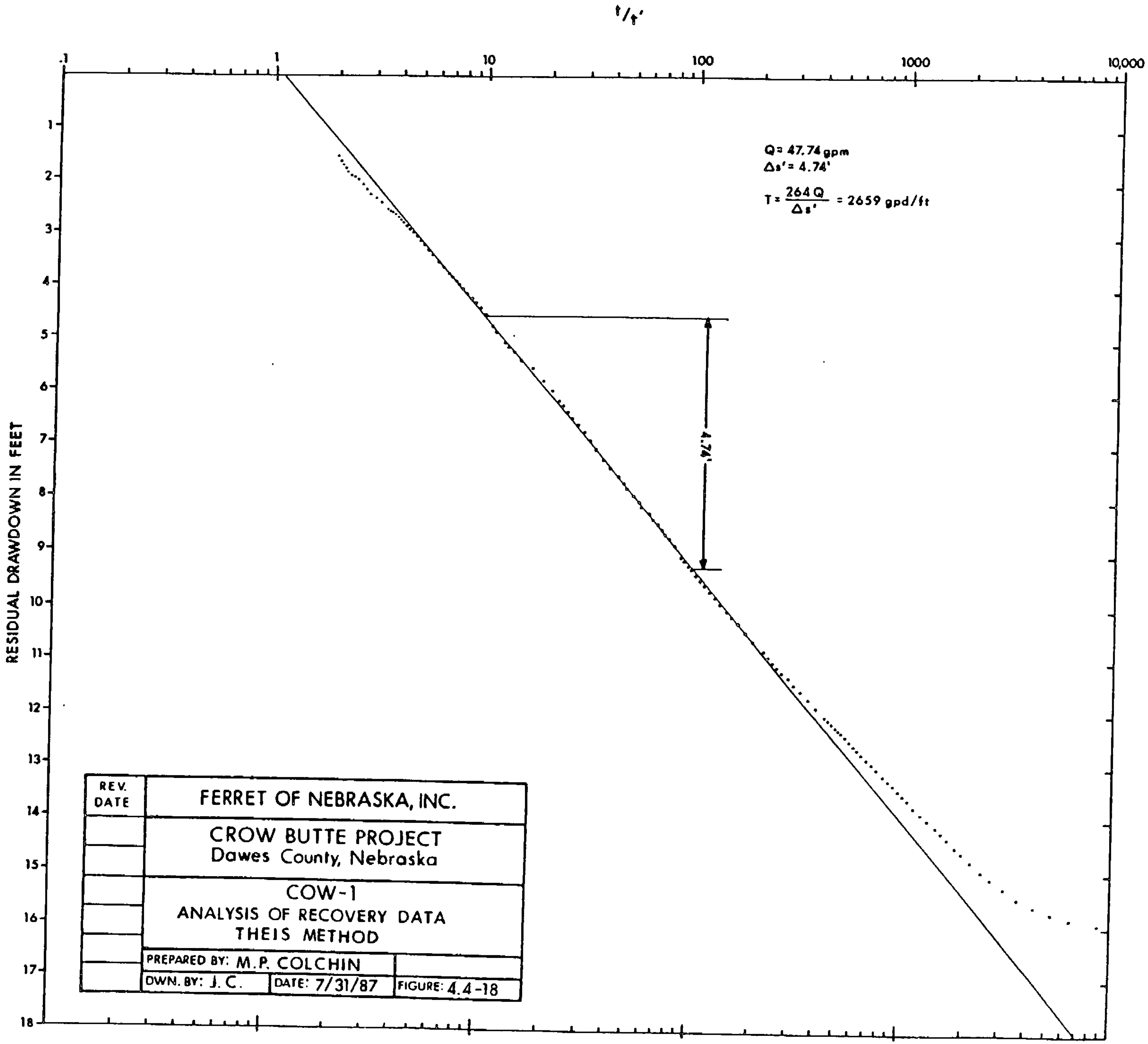

Q= 47.74 gpm
r = 78.10'
t₀ = 1.24 MINUTES = 8.61 X 10⁻⁴ DAYS
Δs = 4.69
T = 264Q / Δs = 2687 gpd/ft
S = .3Tt₀ / r2 = 1.14 X 10⁻⁴
4.69'
TIME IN MINUTES
DRAWDOWN IN FEET
.1
1
10
100
1000
10,000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-2
ANALYSIS OF DRAWDOWN DATA
JACOBS METHOD
PREPARED BY: M.P.COLCHIN
DWN. BY: JC
DATE: 7/31/87
FIGURE: 4.4-13
REV
DATE

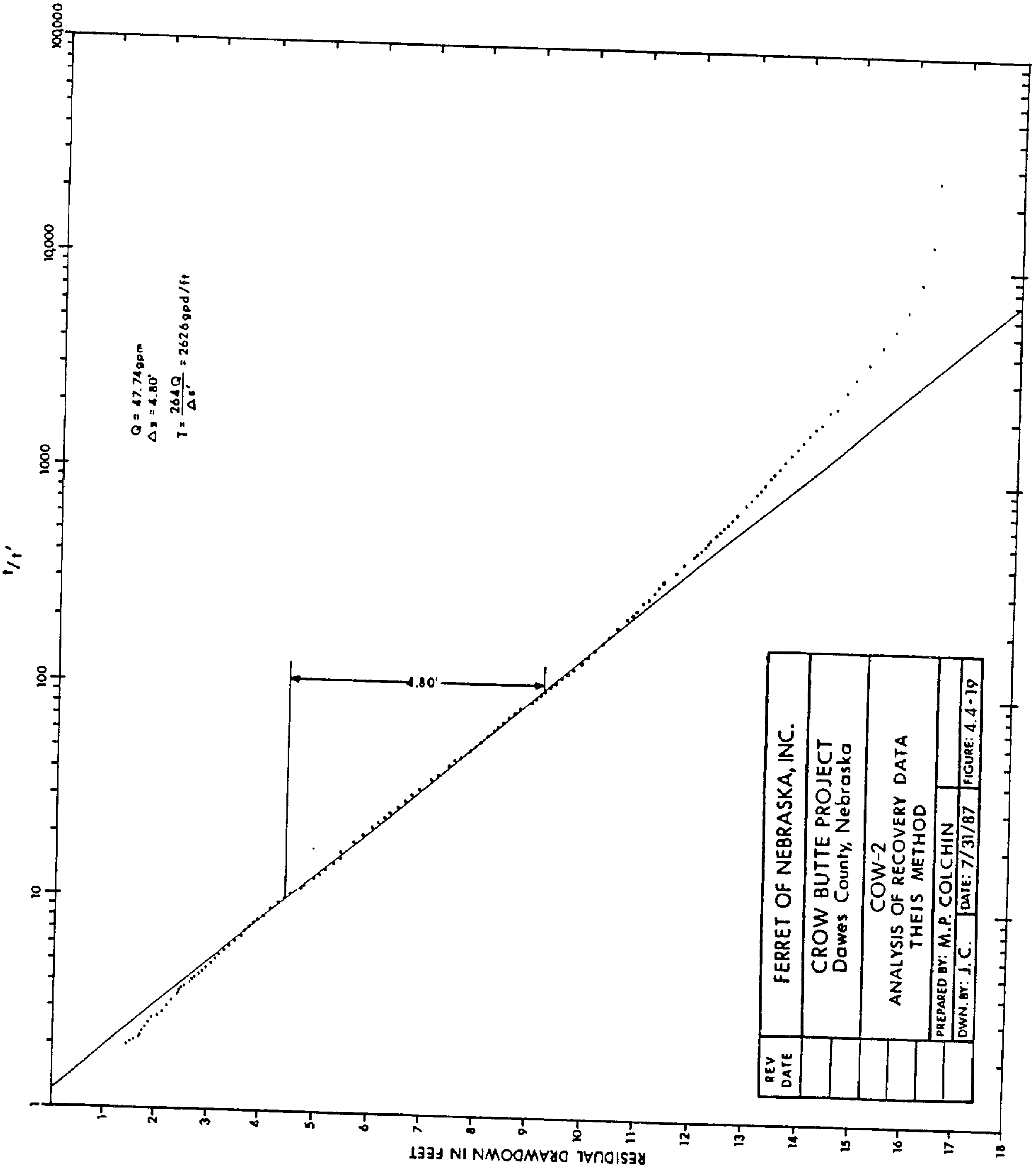

TIME IN MINUTES
10,000
1000
100
10
1
.1
DRAWDOWN IN FEET
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
4.51'
Q = 47.74 gpm
r = 60.93'
t_o = .62 minutes = 4.31 X 10^{-4} days
Δs = 4.51'
T = $\frac{264Q}{\Delta s}$ = 2795 gpd/ft.
S = $\frac{.3Tt_o}{r^2}$ = 9.73 X 10^{-5}
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-3
ANALYSIS OF DRAWDOWN DATA
JACOBS METHOD
PREPARED BY: M.P.COLCHIN
DWN. BY: JC
DATE: 7/31/87
FIGURE: 4.4-14
REV
DATE

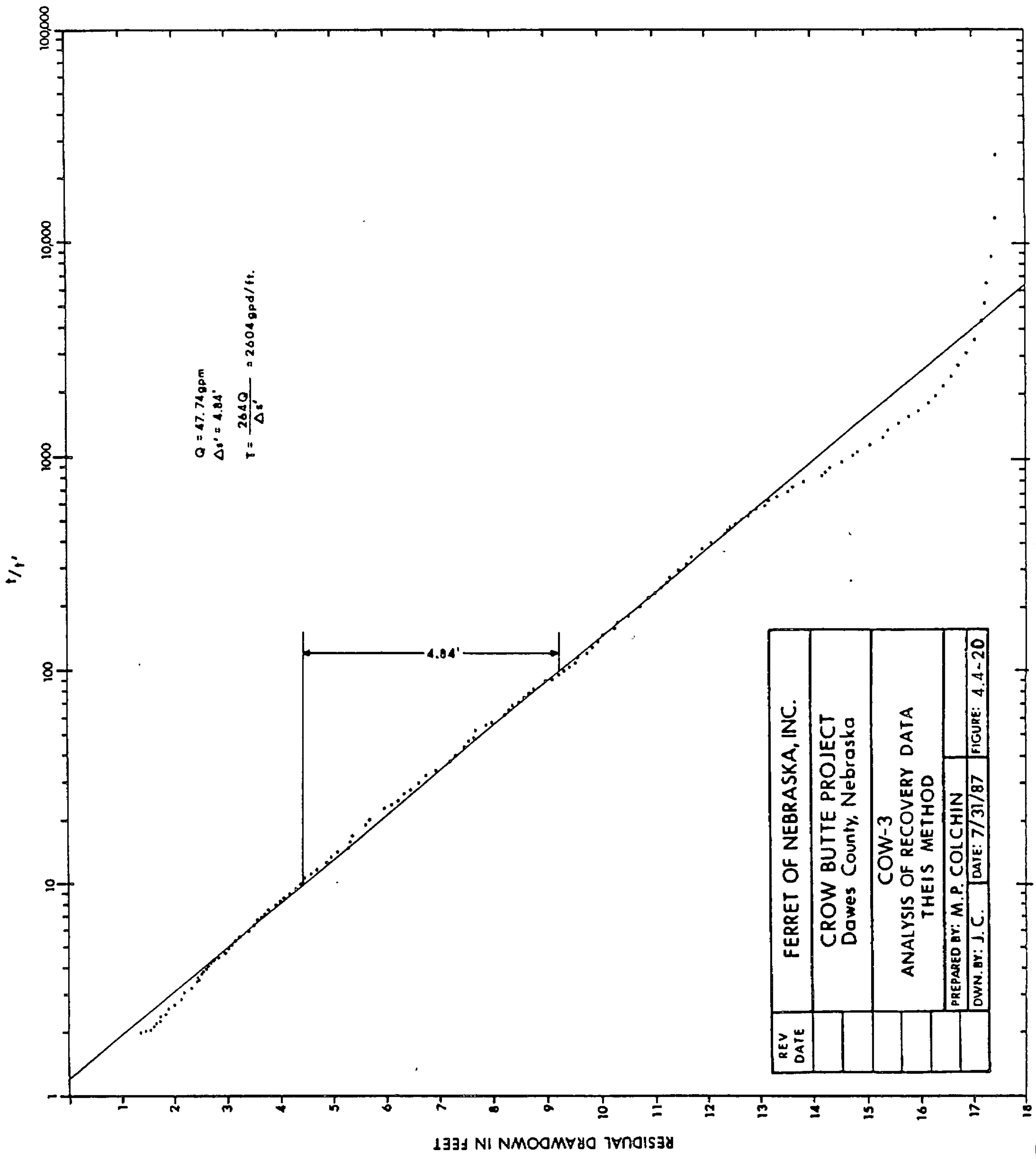

TIME IN MINUTES
.1
1
10
100
1000
10,000
DRAWDOWN IN FEET
100
10
1
.1
MATCH POINT
1/u = 100 u = .01
w(u) = 4.0379
t = 86 minutes = .0597 days
s = 8.09'
Q = 47.74 gpm
r = 101.64'
T = 114.59Q/s W(u) = 2730 gpd/ft
S = uTt/1.87r² = 8.44 X 10⁻⁵
4.4(41) 09/30/87
REV DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-1
ANALYSIS OF DRAWDOWN DATA
THEIS METHOD
PREPARED BY: M. P. COLCHIN
DWN. BY: JC
DATE: 7/31/87
FIGURE: 4.4-15


TIME IN MINUTES
.1
1
10
100
1000
10,000
100
10
1
.1
DRAWDOWN IN FEET
4.4(42) 09/30/87
MATCH POINT
1/u = 100 u = .01
W(u) = 4.0379
t = 67 minutes = .0465 days
s = 8.08'
Q = 47.74gpm
r = 78.10
T = 114.59Q/s W(u) = 2733gpd/ft
S = uTt/1.87r² = 1.11X 10-4
REV DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-2
ANALYSIS OF DRAWDOWN DATA
THEIS METHOD
PREPARED BY: M.P. COLCHIN
DWN BY: JC
DATE: 7/31/87
FIGURE 4.4-16


TIME IN MINUTE
.1
1
10
100
1000
10,000
DRAWDOWN IN FEET
100
10
1
.1
MATCH POINT
1/u = 100 u = .01
W(u) = 4.0379
t = 48 minutes = .0333 days
s = 8.11'
Q = 47.74 gpm
r = 60.93'
T = 114.59Q / s W(u) = 2724 gpd/ft
S = uTt / 1.87r² = 1.31 X 10⁻⁴
4.4(43) 09/30/87
REV DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-3
ANALYSIS OF DRAWDOWN DATA
THEIS METHOD
PREPARED BY: M.P.COLCHIN
DWN. BY: JC
DATE: 7/31/87
FIGURE: 4.4-17


t/t'
.1
1
10
100
1000
10,000
RESIDUAL DRAWDOWN IN FEET
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Q= 47.74 gpm
Δs'= 4.74'
T = 264 Q / Δs' = 2659 gpd/ft
4.74'
REV. DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-1
ANALYSIS OF RECOVERY DATA
THEIS METHOD
PREPARED BY: M.P. COLCHIN
DWN. BY: J. C.
DATE: 7/31/87
FIGURE: 4.4-18


t/t'
1
10
100
1000
10,000
100,000
RESIDUAL DRAWDOWN IN FEET
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Q = 47.74gpm
Δs = 4.80'
T = 264Q/Δs' = 2626gpd/ft
4.80'
REV
DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-2
ANALYSIS OF RECOVERY DATA
THEIS METHOD
PREPARED BY: M.P. COLCHIN
DWN. BY: J. C.
DATE: 7/31/87
FIGURE: 4.4-19


Q = 47.74 gpm
Δs' = 4.84'
T = 264Q/Δs' = 2604 gpd/ft.
4.84'
t/t'
RESIDUAL DRAWDOWN IN FEET
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
COW-3
ANALYSIS OF RECOVERY DATA
THEIS METHOD
PREPARED BY: M. P. COLCHIN
DWN. BY: J. C.
DATE: 7/31/87
FIGURE: 4.4-20
REV DATE

coefficient will vary and is likely to be larger during pumping than during the subsequent recovery (Jacob, 1963). Thus, transmissivity values calculated from pumping data are commonly larger than those calculated from recovery data.

The average thickness of the aquifer at the test site is 40 feet. Therefore, the hydraulic conductivities calculated from the drawdown data ranges from about 67 gpd/ft^2 (8.96 ft/day) to about 70 gpd/ft^2 (9.34 ft/day). The hydraulic conductivities calculated from the recovery data ranged from about 65 gpd/ft^2 (8.7 ft/day) to about 66 gpd/ft^2 (8.89 ft/day) Table 4.4-8 summarizes the results of the analysis of the aquifer test data.

The Hantush Method For Anisotropic aquifers 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) (Figure 4.4-8). The minor axis of transmissivity has an azimuth of about 141° and a magnitude of 2692 gpd/ft 360 ft^2/day.

Overlying and Underlying Confining Layers

The overlying confining layer piezometer (UCP-1) showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test (Figure 4.4-21). However, this piezometer did respond to the rapid changes in barometric pressure that accompanied the passage of a low pressure system and a cold front which confirmed that it was indeed functioning properly. because UCP-1 did not respond to pumping, it was not possible to use the water level data from UCP-1 to calculate the hydraulic properties of the upper confining layer using the Neuman-Witherspoon Method. Therefore, laboratory data from the consolidation tests of core samples from UCP-1 were used to calculate the hydraulic properties of the overlying confining layer.

TABLE 4.4-8

SUMMARY OF AQUIFER-TEST DATA ANALYSIS

Jacob Method (Drawdown)

Well	T (gpd/ft)	T (ft²/day)	S	K (gpd/ft²)	K (ft/day)
COW-1	2682	359	$8.65X10^{-5}$	67	8.98
COW-2	2687	359	$1.14X10^{-4}$	67	8.98
COW-3	2795	374	$9.73X10^{-5}$	70	9.35
Average	2721	364	$9.93x10^{-5}$	68	9.10

Theis Method (Drawdown)

Well	T (gpd/ft)	T (ft²/day)	S	K (gpd/ft²)	K (ft/day)
COW-1	2730	365	$8.44X10^{-5}$	68	9.13
COW-2	2733	365	$1.11X10^{-4}$	68	9.13
COW-3	2724	364	$1.31X10^{-4}$	68	9.10
Average	2729	365	$1.09x10^{-4}$	68	9.12

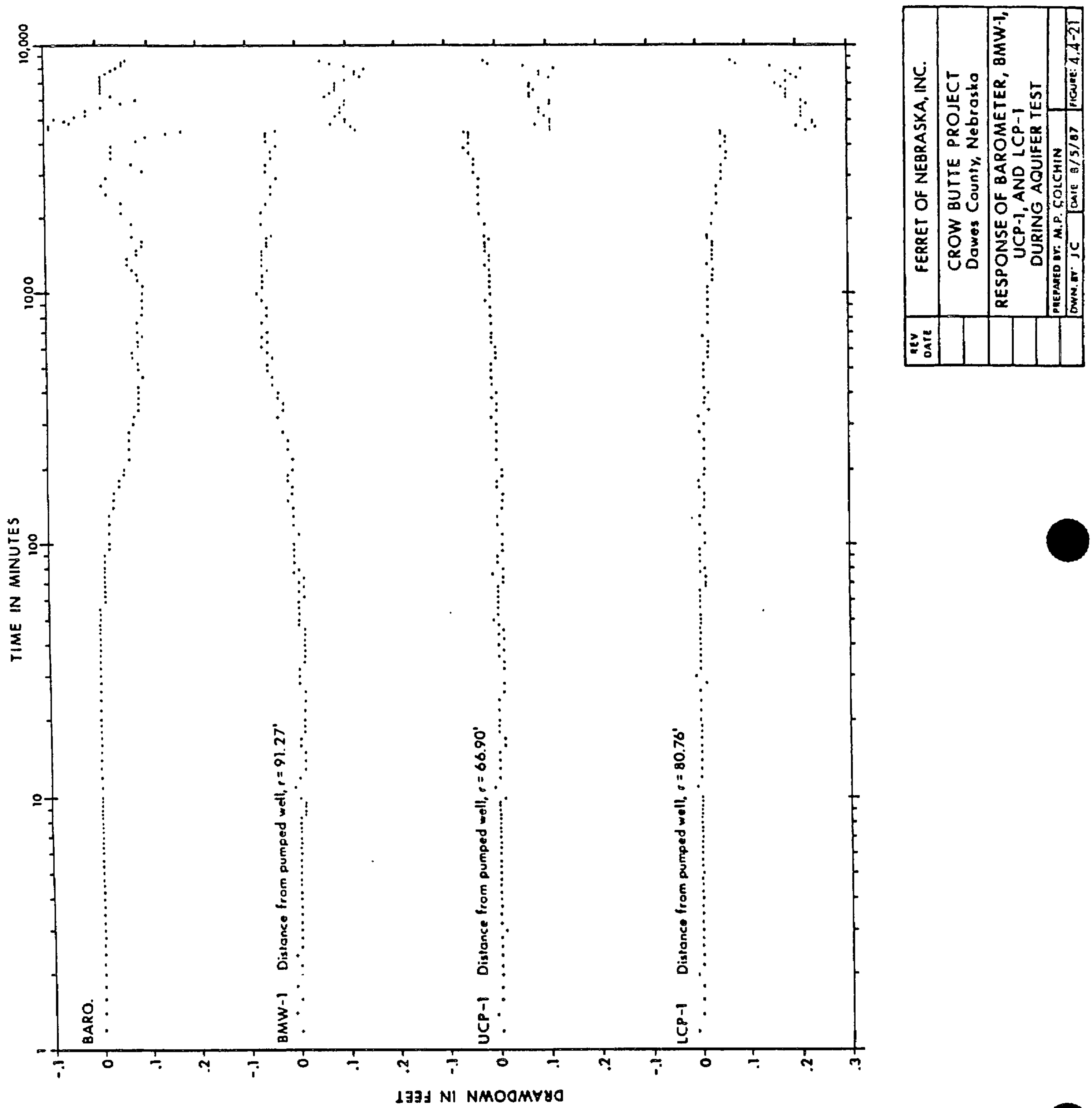
Theis Recovery Method

Well	T (gpd/ft)	T (ft²/day)	K (gpd/ft²)	K (ft/day)
COW-1	2659	355	66	8.88
COW-2	2626	351	66	8.78
COW-3	2604	348	65	8.70
Average	2630	351	66	8.79

Average of Jacob and Theis Methods (Drawdown) *

Well	T (gpd/ft)	T (ft²/day)	S	K (gpd/ft²)	K (ft/day)
COW-1	2706	362	$8.55X10^{-5}$	68	9.05
COW-2	2710	362	$1.13X10^{-4}$	68	9.05
COW-3	2760	364	$1.14X10^{-4}$	69	9.23
Average	2725	364	$1.04x10^{-4}$	68	9.11

* Used in anisotropy calculations.


TIME IN MINUTES
10,000
1000
100
10
1
DRAWDOWN IN FEET
BARO.
BMW-1 Distance from pumped well, r = 91.27'
UCP-1 Distance from pumped well, r = 66.90'
LCP-1 Distance from pumped well, r = 80.76'
-.1
0
.1
.2
.3
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
RESPONSE OF BAROMETER, BMW-1, UCP-1, AND LCP-1 DURING AQUIFER TEST
PREPARED BY: M.P. COLCHIN
DWN. BY: JC
DATE 8/5/87
FIGURE: 4.4-21
REV
DATE

Results of the laboratory consolidation test data from three core samples of UCP-1 are shown earlier in Table 4.4-4. 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. Analysis of drill cuttings and geophysical logs of UCP-1 and exploration holes in the vicinity of the test site show that the lithology of the strata between the Red Clay and the overlying Brule aquifer (Upper Chadron and Lower Brule Formations) is similar to the Red Clay. Therefore, it is reasonable to assume that the hydraulic characteristics of these strata are similar to those of the Red Clay. 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 8,994,000 years for the entire confining layer. The average porosity of the overlying confining layer calculated from the consolidation test data is 31.8%, therefore, the travel time through the red clay portion of the upper confining layer would be about 264,000 years and that of the entire upper confining layer would be about 2,860,000 years under unit gradient. Details of the travel time calculation are found in Appendix 4.4(C). Table 4.4-9 summarizes the confining layer properties determined by laboratory and field methods as part of this investigation.

The underlying confining layer piezometer (LCP-1) responded to the same rapid changes in barometric pressure which were measured in overlying confining layer piezometer (Figure 4.4-21). However, LCP-1 also showed a trend toward a very small amount of drawdown (.06 feet) during the aquifer test. 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^{-11} cm/sec), no drawdown was anticipated in LCP-1 during the test. For this reason, it is suspected that the small amount of drawdown observed in LCP-1 is the result of annular

TABLE 4.4-9

SUMMARY OF CONFINING LAYER PROPERTIES

Parameters	Red Clay (UCP-1)	Pierre Shale (LCP-1)
Coefficient of compressibility, a_v ($cm^2 g/$)	$3.99x10^{-7}$	$5.13x10^{-7}$
Specific storage, S_s', (cm^{-1})	$3.08x10^{-7}$	$2.78x10^{-7}$
Diffusivity, α', (cm^2/sec)	$1.13x10^{-4}$	$5.22x10^{-3}$
Vertical hydraulic conductivity, K_v', (cm/sec)		
Lab Data	$3.49x10^{-11}$	$3.63x10^{-11}$
Field Data	-----	$1.45x10^{-9}$
Hydraulic resistance, c, (years)		
Lab Data	830,200 (1)	31,929,000
Field Data	-----	799,300
Porosity (percent)	31.8	32.5
Travel time (years)		
Lab Data	264,000 (2)	259,700
Field Data	-----	10,377,000

(1) Red Clay Member only - total overlying confining layer = 8,994,000.

(2) Red Clay Member only - total overlying confining layer = 2,860,000.

leakage between the borehole and the packer which was set to hydraulically isolate the piezometer tip from the overlying Basal Chadron Sandstone. If the packer did not completely seal the borehole above the piezometer tip, the piezometer would be affected by the pressure drop in the pumped aquifer which would be transmitted by the annulus leaks. Thus, the response of the piezometer would be the result of borehole-packer annulus leaks. If this were the case, the Neuman-Witherspoon analysis of the piezometer water levels would only serve to quantify the vertical leakage or hydraulic conductivity of the packer and borehole seal, not the vertical hydraulic conductivity of the underlying confining layer. Recognizing that this problem may exist, a Neuman-Witherspoon analysis was made of the water level data from LCP-1.

Results of the laboratory consolidation test data from two core samples from LCP-1 are shown earlier in Table 4.4-4. The calculated average coefficient of compressibility, a_v, of the Pierre Shale is 5.13×10^{-7} cm^2/g and the calculated average vertical permeability is 3.63×10^{-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 2.78×10^{-7} cm^{-1} and the calculated hydraulic diffusivity is 5.22×10^{-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 1.45×10^{-9} cm/sec. Oil test holes have shown that the Pierre Shale is approximately 1200 feet thick in the vicinity of the aquifer test site. Therefore, the calculated hydraulic resistance, c, using field measured vertical hydraulic conductivity, is about 799,300 years. The calculated hydraulic resistance using the vertical hydraulic conductivity calculated from the laboratory consolidation tests is about 31,929,000 years. The average porosity of the Pierre Shale calculated from the consolidation test data is 32.5%. Therefore, the travel time through the Pierre Shale would be about 259,770 years using field determined vertical hydraulic conductivity and about 10,377,000 years using laboratory determined vertical hydraulic conductivity under unit gradient.

Overlying Aquifer

The overlying aquifer monitor well, BMW-1, showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test (Figure 4.4-21). However, this well did respond to barometric changes that occurred during the aquifer test which confirmed that it was functioning properly. 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, no further analysis was made of the test data from BMW-1.

INTERPRETATION OF DATA

Aquifer Response to Pumping

The results of this investigation show that the Basal Chadron Sandstone, which is the ore-bearing aquifer at the Crow Butte site, 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 1.04×10^{-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 piezometric surface of the Basal Chadron Sandstone is approximately 495 feet above the top of the aquifer. 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 fact plus the fact that BMW-1 did not respond to pumping from the Basal Chadron Sandstone, are evidence that the Basal Chadron Sandstone is confined and that it is not hydraulically connected to the overlying aquifer.

Integrity of Confinement

Confined aquifers may receive small amounts of water through vertical recharge from the confining layers. Even confining layers formed of very low permeability may yield small amounts of water if the hydraulic gradient in the aquifer-aquitard system is favorable. The aquitards 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 feet 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 3.49×10^{-11} cm/sec., and that of the underlying confining layer is about 1.45×10^{-9} to 3.63×10^{-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 most graphically by the hydraulic resistance, c. The calculated hydraulic resistance of the entire thickness of the overlying aquiclude is about 8,994,000 years and that of the underlying aquiclude is between 799,300 years and 31,900,000 years. The times needed for a given water molecule to travel through the entire thicknesses of the aquicludes under unit gradient (one foot of head loss per foot of movement in the direction of flow) are about 2,860,000 years for the upper aquiclude and about 260,000 years to 10,377,000 years for the lower. Because the gradients would be much smaller during mining, actual travel times would be much longer than those stated above.

Movement of Groundwater

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 1275 feet. Using a directional hydraulic conductivity of 9.11 ft/day, a gradient 7.84×10^{-4} and a porosity of 29 percent, the average pore velocity across this part of the commercial study area is about 9.00 ft/year. The groundwater flux across the test site was computed to be about .29 ft^3/day per unit width of the aquifer. (Darcy, 1856).

Extent of Investigated Area

Using the Cooper-Jacob Distance-Drawdown Method (Cooper and Jacob, 1946), the radius of influence of the aquifer test in the Basal Chadron Sandstone was calculated to be about 5000 feet. Therefore, the area investigated and characterized by this test is approximately 1803 acres.

4.4-4 Water Quality

Investigations of the groundwater quality and usage for the Commercial Permit 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 4.4-2 of this document.

Water samples were taken from selected representative wells within the commercial permit area and surrounding areas. The sampling schedule is shown

in Table 4.4-10. The baseline water quality indicators to be determined on the pre-mining samples are found in Table 12.4-1 (See section 12.0), ***Monitoring Plan.*** 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 FEN. 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. The locations of these wells are found in Figure 4.4-22. Table 4.4-11 lists the private wells that were sampled to evaluate the local water quality.

Eleven wells originally drilled by WFC and since taken over by FEN expressly for baseline determination were sampled. The locations of these wells are shown in Figure 4.4-22 and the wells are listed in Table 4.4-12. Four are completed in the Brule Formation and seven in the Chadron Sandstone (production zone).

Sample collection and preservation were performed using standard EPA 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. EPA-600/4-82-029) are added to the samples and samples are transported to the lab for analysis. Results of the sampling program are included as Appendix 4.4(A). A summary of these

results on the eleven baseline wells drilled by WFC is given in Table 4.4-13.

4.4-4.1 R&D Area Groundwater Quality

Initial baseline and operational samples have been collected from the R&D wellfield and selected monitor wells. Figure 4.4-23 illustrates the locations of the production zone baseline and overlying aquifer baseline wells, and the monitor wells used during mining. Table 4.4-14 lists the depth and geologic unit for each baseline well.

TABLE 4.4-10

NONRADIOLOGICAL PREOPERATIONAL MONITORING PROGRAM
CROW BUTTE

Type of Sample	Number	Location	Sample Collection: Method	Sample Collection: Frequency	Sample Analysis: Frequency	Sample Analysis: Type of Analysis
WATER						
Ground Water						
	One from each water supply	All wells within 1 km of restricted area boundary	Grab	3 Times	Each Sample	Complete Table 12.4-1 list
	One from each well	Selected Regional wells	Grab	3 Times	Each Sample	Same
	One from each DEC baseline & monitor well	As required by DEC	Grab	Quarterly	Quarterly	Complete Table 12.4-1 list once; common ions only-other quarters
Surface Water						
	One from each pond or impoundment		Grab	Once	Once	Complete Table 12.4-1 list
	Two from Squaw Creek	One up-stream one down-stream of restricted area	Grab	Quarterly	Quarterly	Complete Table 12.4-1 list once; common ions-only other quarters

Background Nonradiological Characteristics (Cont'd)

		Sample Collection			Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	Type of Analysis
	Two from White Clay Creek	Upstream and downstream of Area Permit	Grab	Four times	Quarterly	Complete Table 12.4-1 list once; common ions-only other quarters
	Two from English Creek	Upstream and downstream of Area Permit	Grab	Four times	Quarterly	Complete Table 12.4-1 list once; common ions-only other quarters
	Two from Squaw Creek	One up-stream one down-stream of restricted area	Grab	Quarterly	Quarterly	Suspended sediment
Water Levels	One from each monitor well, baseline well, and selected private wells	Surrounding and within wellfield	Electric line	Monthly	Monthly	Map
Flow	Two from Squaw Creek	One up-stream one down-stream of restricted area	Flow Meter	Monthly through 1982; then quarterly	Monthly through 1982; then quarterly	Tabular

TABLE 4.4-11

PRIVATE WELLS SAMPLED WITHIN AND AROUND THE COMMERCIAL AREA

Well No.	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

TABLE 4.4-12

BASELINE WELLS ORIGINALLY DRILLED BY WFC

Well No.	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

TABLE 4.4-13

AQUIFER WATER QUALITY SUMMARY

Brule Formation*

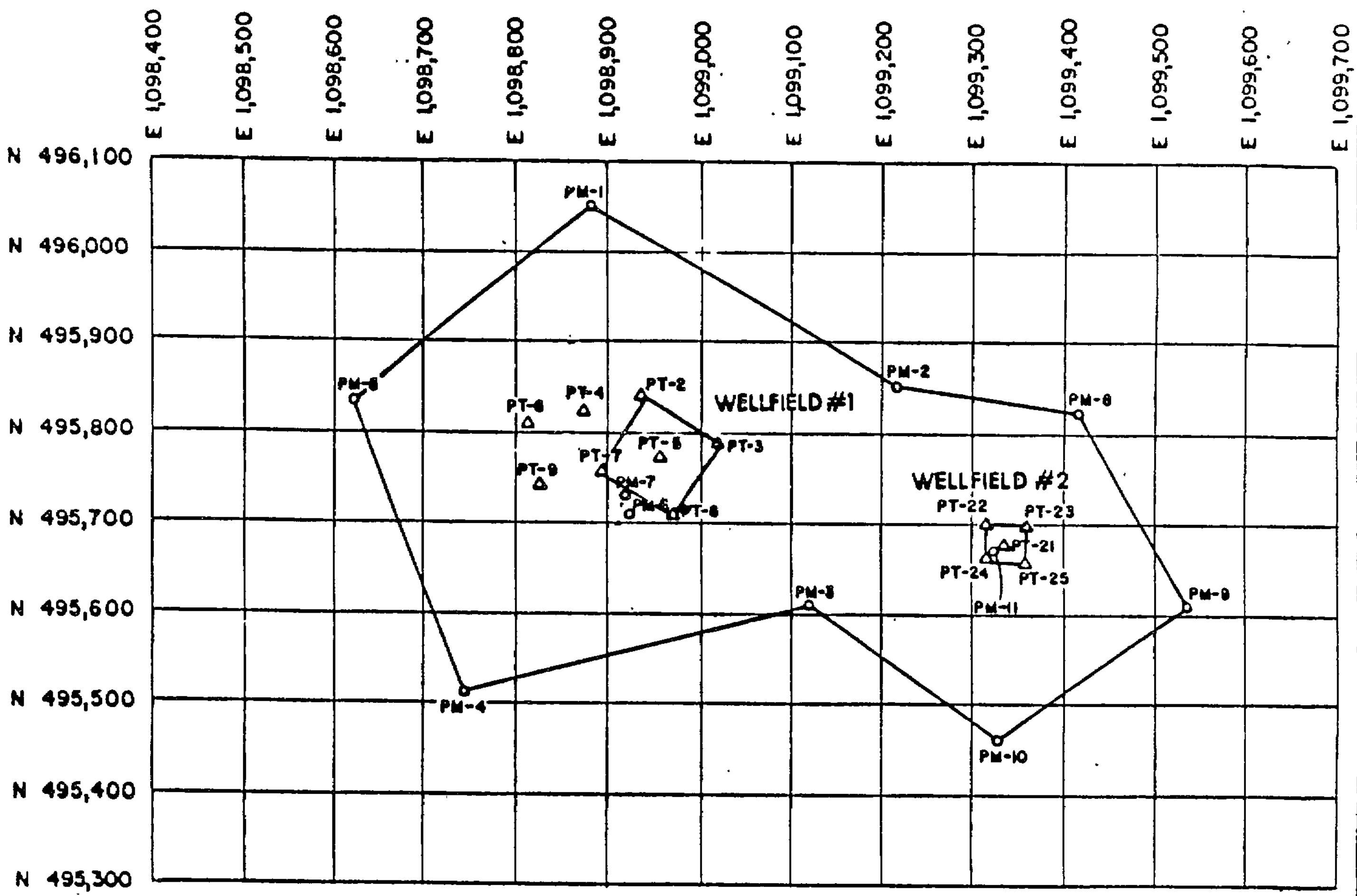
	Range	Mean
Calcium	7.1 - 98	48
Magnesium	0.3 - 16	6.6
Sodium	12 - 340	104
Potassium	4.1 -15.9	9.9
Bicarbonate	137 - 627	364
Sulfate	1 - 23	10
Chloride	1.6 - 192	48
Conductance	246 -1481	714
pH	6.8 - 8.5	7.8
Uranium	0.001 -0.021	0.0064
Radium-226	0.1 - 3.0	0.7

Chadron Formation*

	Range	Mean
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

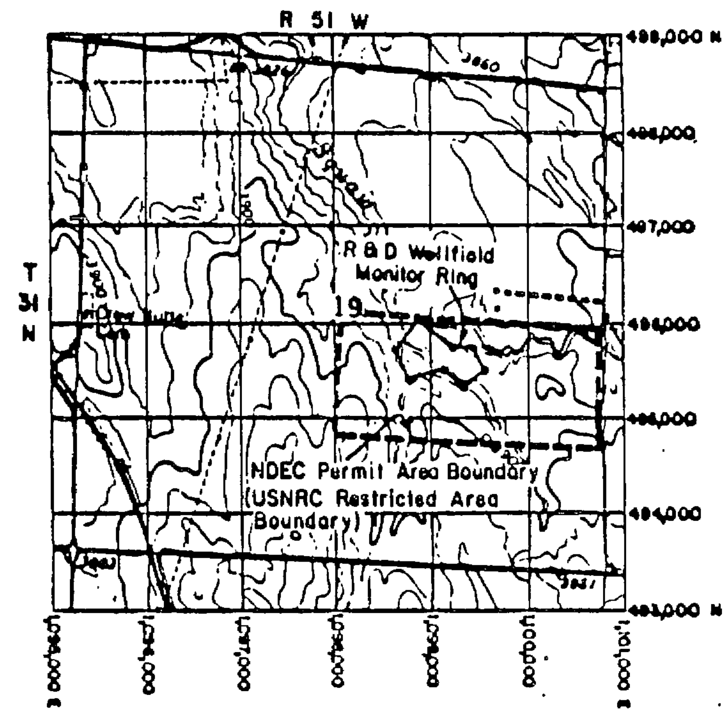
* Summary of average values for baseline wells drilled by WFC listed in Table 4.4-12.

In mg/l, except pH (units), Ra-226 (pCi/l), and Conductance (umhos).



Legend

- △ Pilot Test Wells
- o Pilot Monitor Wells



Scale 1" = 200'

50 25 0 50 Meters

200 100 0 200 Feet

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REV	BY	DATE	FERRET OF NEBRASKA, INC.	
			CROW BUTTE PROJECT Dawes County, Nebraska	
			R & D WELLFIELD WATER QUALITY WELLS	
			PREPARED BY: SADavis	
			DWN BY: SADavis DATE: 5/24/84	Figure 4.4-23

TABLE 4.4-14

WATER QUALITY WELLS USED FOR PREOPERATIONAL AND OPERATIONAL DATA

Well No.	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

Water samples were collected in the same manner as the regional baseline wells. Results of this sampling are presented in Appendix 4.4(A).

4.4-4.2 Groundwater Quality Evaluation

Groundwater from the local Brule sands is commonly used as a domestic and livestock water source. Brule water is used because of its good chemical quality, low total dissolved solids and shallow depth. A majority of the wells are less than 100 feet deep. A review of the Brule water quality does show the presence of small amounts of uranium. The uranium in the Brule Formation probably results from leaching of the uranium associated with the high volcanic ash components of the Brule sediments. The uranium in the Brule waters is high because of the oxidizing nature of groundwater (Spalding, 1982). Connection of the Chadron Formation to the Brule Formation would result in higher chloride, sodium and sulfate levels which are characteristic of Chadron water quality. Since none of these constituents are as high in Brule water as in Chadron water, one can only conclude that the uranium contained in the Brule water results from the Brule Formation and not from the Chadron.

Groundwater can be classified on the basis of its chemical composition. Groundwater from the Brule Formation is termed fresh water, as it has less than 1,000 mg/l TDS. Brule water is also classified as drinking water based on the TDS criteria. Drinking water standards are based on 1), the presence of objectionable tastes, odors or colors, and 2) the presence of substances with adverse physiological effects such as lead, mercury, and radium-226. An evaluation of the data show that Brule water is a calcium/sodium bicarbonate type water. Chadron water is a sodium sulfate/sodium chloride type water. This difference of chemical compositiom indicates that the two aquifers are distinct from each other and are not hydraulically connected.

Water from the Chadron aquifer has objectionable hydrogen sulfide odor, high total dissolved solids concentration, high radionuclides content, and high sodium adsorption ratio (SAR). The SAR is equal to $Na/[0.5(Ca+Mg)]^{0.5}$ with all concentrations expressed as milliequivalents. The radionuclides content exceed the recommended levels for all classifications of water (See Table 4.4-15.). Chadron Formation water is

TABLE 4.4-15

COMPARISON OF GROUNDWATER QUALITY
CRITERIA AND STANDARDS

Parameter	NDEC[a] MCL	Quality Criteria for Water: Drinking	Irrigation	Livestock	USEPA Stds.[d] for Drinking Water
Calcium (mg/l)					
Magnesium (mg/l)					
Sodium (mg/l)					
Potassium (mg/l)					
Carbonate (mg/l)					
Bicarbonate (mg/l)					
Sulfate (mg/l)	250	250[b]			250
Chloride (mg/l)	250	250[b]			250
Ammonia-N (mg/l)		0.5[b]			
Nitrite-N (mg/l)		1.0[b]		10[b]	
Nitrate-N (mg/l)	10.0	10.0[b c]		100.0 (NO_2 +NO_3)[b]	10.0
Fluoride (mg/l)	4.0	1.4-2.4[b] (temp.depen.)	1.0[b]	2.0[b]	1.4-2.4 (temp.depen.)
Silica (mg/l)					
TDS-180°C (mg/l)				3000[b]	500
Conductivity-Field (umhos)					
Conductivity-Lab (umhos)					
Conductivity-Dilute (umhos)					
Alkalinity (mg/l)					
pH-Field					
pH-Lab	6.5-8.5	5.0-9.0[b]			6.5-8.5
Aluminum (mg/l)					
Arsenic (mg/l)	0.05	0.05[c]	0.01[b c]	0.2[b]	0.05
Barium (mg/l)	1.0	1.0[b c]			1.0
Cadmium (mg/l)	0.01	0.01[b c]	0.01[b]	0.05[b]	0.01
Chromium (mg/l)	0.05	0.05[b c]	0.1[b]	0.1[b]	0.05
Cobalt (mg/l)					
Copper (mg/l)	1.0	1.0[b c]	0.2[b]	0.5[b]	1.0
Iron (mg/l)	0.3	0.3[b c]	5.0[b]		0.3
Lead (mg/l)	0.05	0.05[b c]	5.0[b]	0.1[b]	0.05
Manganese (mg/l)	0.05	0.05[b c]	0.2[b]		0.05
Mercury (mg/l)	0.002	0.002[b c]		0.01[b]	0.002
Molybdenum (mg/l)					
Nickel (mg/l)			0.2[b]		
Selenium (mg/l)	0.01	0.01[b c]	0.02[b]	0.05[b]	0.01
Vanadium (mg/l)			0.1[b]	0.1[b]	
Zinc (mg/l)	5.0	5.0[b c]	2.0[b]	25[b]	5.0
Boron (mg/l)			0.75[c]	5.0[b]	
Uranium (mg/l)		5.0[e]			
Radium-226 (pCi/l)	5.0[f]	5.0[f]	5.0[f]	5.0[f]	5.0[f]

TABLE 4.4-15 (Continued)

FOOTNOTES

[a] Maximum contaminant levels as presented in Chapter 4 of Title 118, ***Ground Water Protection Standards***, Nebraska Department of Environmental Control.

[b] Levels based on recommendations from ***Water Quality Criteria***, 1972, EPA-R3-73-003.

[c] Levels based on ***Quality Criteria for Water***, July, 1976, USEPA Stock No. 005-001-01049-4.

[d] Levels based on ***CFR 40, Parts 100-149,*** Revised as of July 1, 1982.

[e] Uranium based on ***Water Quality Criteria*** USEPA 1969 edition.

[f] Radium-226 + Radium-228 = 5 pCi/l.

classed as brackish, as it contains greater than 1,000 and less than 10,000 mg/l TDS. This water is classified as "poor" for general household use and "poor" for irrigation (Davis and DeWiest, 1966). The term "poor" is given because several parameters such as sodium, bicarbonate and sulfate exceed the maximum recommended for "good". Irrigation criteria are also based on tolerance of various plant species to "salt" content of the water and buildup of of minerals in the soils. The chemical quality of the water from the Chadron aquifer and the high cost of completing a well in this formation have prohibited its use as a supply for drinking, irrigation, or livestock water.

4.4-4.3 Water Levels

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

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 Figures 4.4-24 and 4.4-25 and all results listed in Tables 4.4-16 and 4.4-17.

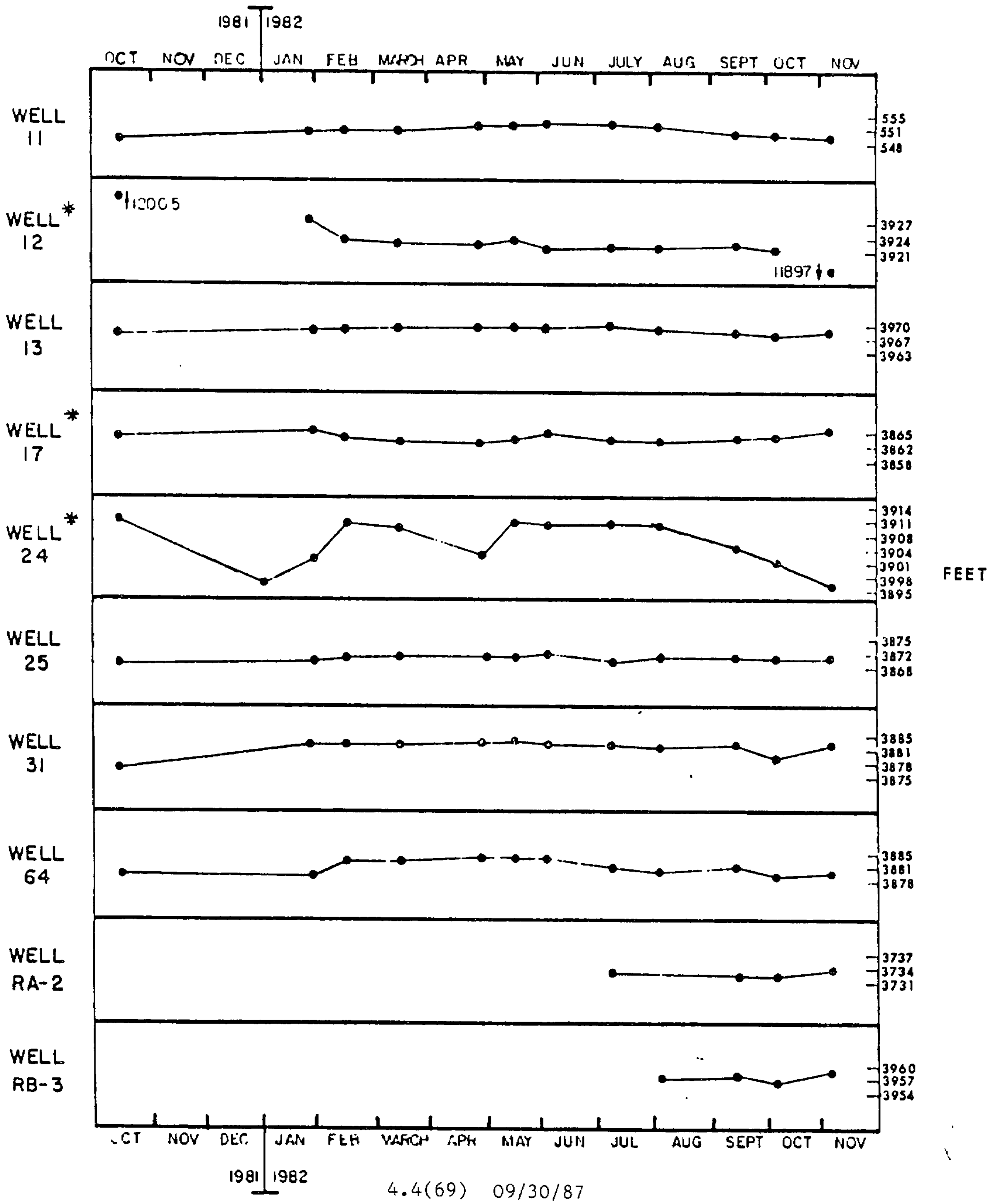
FIGURE 4.4-24

SEASONAL WATER LEVEL FLUCTUATIONS

In Wells Within Area of Review

Crow Butte Project

Brule Formation



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1-12-83

* - Well pumping prior to water level measurement in some cases

FIGURE 4.4-25

SEASONAL WATER LEVEL FLUCTUATIONS

In Wells Within Area of Review

Crow Butte Project

Chadron Formation

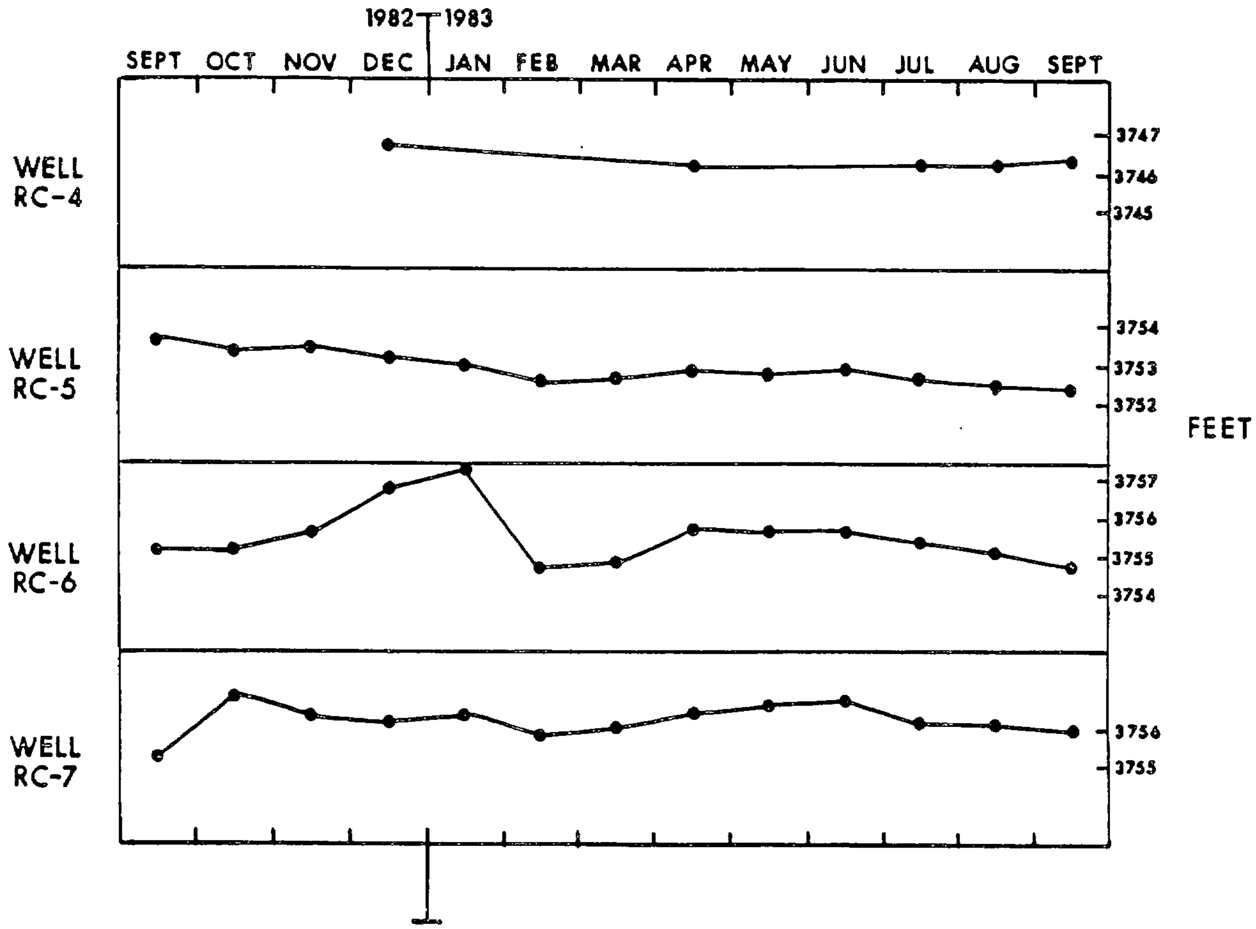


TABLE 4.4-16

BRULE WATER LEVELS
in feet above mean sea level

Well	1982 Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	1983 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

Well	1982 Sept	Oct	Nov	Dec	1983 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

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

TABLE 4.4-17

CHADRON WATER LEVELS
in feet above mean sea level

Well	1982 Sept	Oct	Nov	Dec	1983 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

* Suspect data

4.4-4.4. Surface Water Quality

Samples were collected from Squaw Creek, English Creek, White Clay Creek, White River and all surface bodies of water within the commercial permit area. Table 4.4-10 outlines the sampling schedule and the parameters for analysis. This schedule was begun in 1982 and in some cases has continued into 1987. All data are presented here in Appendix 4.4(A).

Squaw Creek passes through the Crow Butte commercial permit area as it flows towards the White River. Four sampling points located on Squaw Creek are shown on Figure 4.4-22.

English Creek passes through the northern part of the Commercial Permit Area. Two sampling points (E-1/E-2 and E-3) are shown on Figure 4.4-22.

The two sample points on White Clay Creek (WC-2 and WC-2) are located within the Area of Review and are shown on Figure 4.4-22. Saw Log Creek is a tributary of White Clay Creek and was not sampled since White Clay Creek was sampled.

The White River sampling points are not shown on Figure 4.4-22 due to large distances involved. Sample point W-1 is located 3500 feet west of the Town of Crawford; sample point W-2 is located approximately 1.5 miles northeast of Crawford, and W-3 is located approximately 5.5 miles northeast of Crawford. Sample point W-2 is on the White River prior to the confluence of Squaw Creek and the White River. Sample point W-3 is after the confluence.

Water quality results of the sampling are included in Appendix 4.4(A). As can be seen, none of the EPA drinking water standards are exceeded in any surface water sample. Total dissolved solids are generally in the 200 to 300 mg/l range with calcium and bicarbonate being the predominant ions.

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 4.4-18. 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.

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

Eight impoundments are located within the commercial permit area of review; I-1 through I-8. These impoundments are shown on Figure 4.4-22. Samples were collected and handled in the same manner as described above.

4.4-5 Stream Flow

Squaw Creek flows through the Crow Butte commercial permit area from east to northwest. The flowrate of this perennial stream was monitored at two locations according to the schedule given in Table 4.4-10. In addition, discharge rates of the Squaw Creek above the commercial permit area and the White River were monitored. Figure 4.4-22 shows the location of the Squaw Creek monitor stations (S-2 and S-3). The White River monitor station (W-2) is 1.5 miles northeast of Crawford.

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 number 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 4.4-18

SUSPENDED SEDIMENT IN FLOWING WATERS
SQUAW CREEK AND WHITE RIVER

Results given as Total Suspended Solids in mg/1.

	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

Table 4.4-19 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 4.4-26.

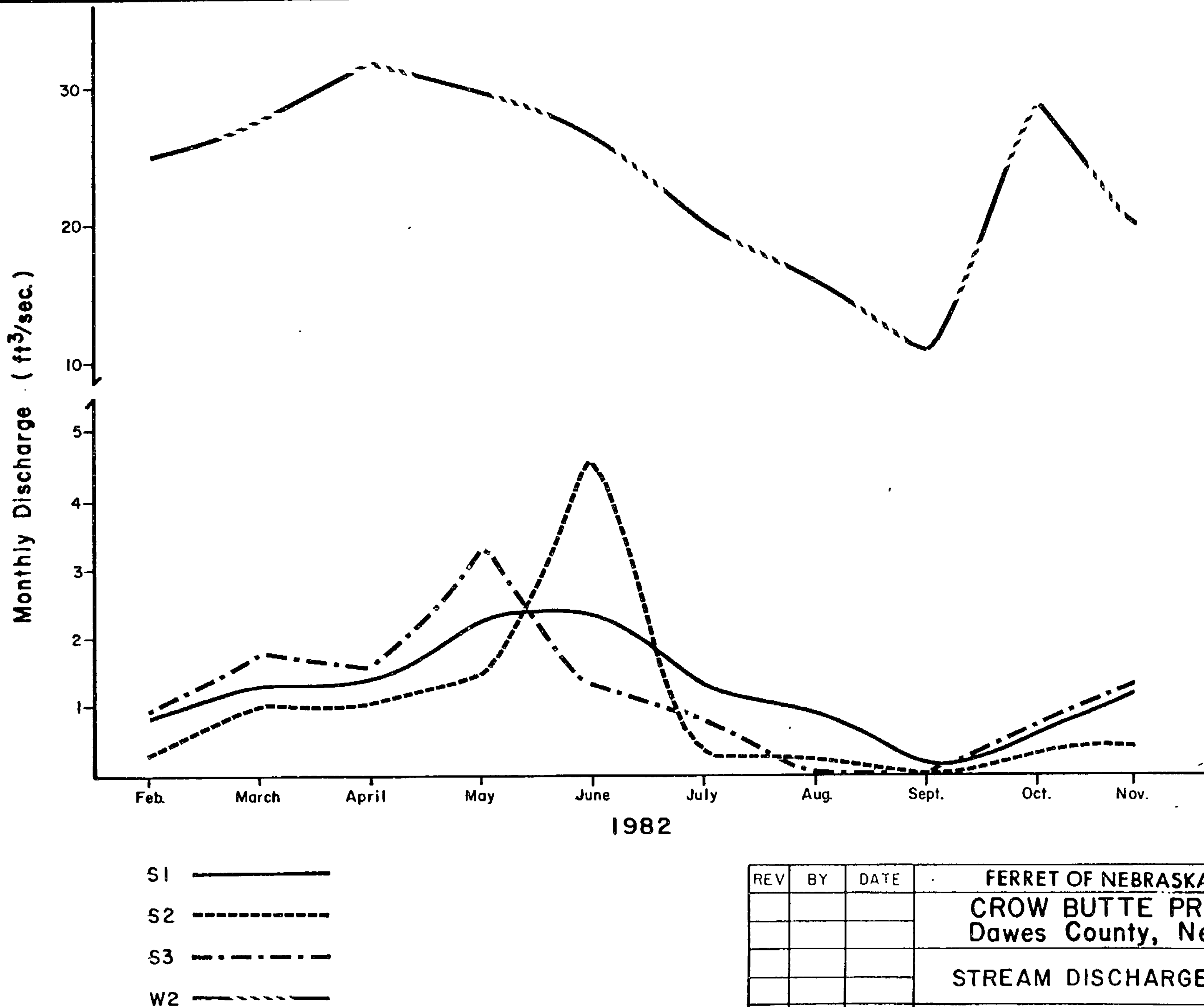
These stream discharge data indicate that during 1982 Squaw Creek was predominately a losing stream in the segment between measurement station S-1 and S-2. The same data show that Squaw Creek was a gaining stream, except during the months of June, August, and September, between measurement stations S-2 and S-3. During 1982, Squaw Creek between station S-1 and station S-3 was approximately in equilibrium or slightly gaining except during the months of June, July, August, and September when the segment is losing.

TABLE 4.4-19

1982 STREAM DISCHARGE RATES
(ft³/sec) CROW BUTTE PROJECT

Station	Feb.	Mar.	Apr.	May	June	July	August	Sept.	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

CBR-014



REV	BY	DATE	FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			STREAM DISCHARGE RATES
			PREPARED BY F.E.N
			DWN BY J.C. · DATE 8/87 · FIG. 4.4-26

4.4(78) 09/30/87

REFERENCES

American Public Health Association, ***Standard Methods for the Examination of Water and Wastewater***, 1976.

American Society for Testing and Materials, ***General Test Methods, Nonmetal; Laboratory Apparatus; Statistical Methods; Space Stimulation; Deterioration of Nonmetallic Materials;*** 1977 Annual Book of ASTM Standards, Part 41; Philadelphia, Pa., Easton, Md., 1977; Designation: E178-75, 195-223pp.

Cooper, H.H. and C.E. Jacob, 1946, ***A generalized graphical method for evaluating formation constants and summarizing well field history:*** Trans. Amer. Geophys. Union, v. 27, pp. 526-534.

Darcy, Henry, ***Les Fontaines Publique de la Ville de Dijon;*** Victor Dalmont, Paris, 1856; p.647.

D'Appolonia Engineers, ***Aquifer/Aquitard Analysis***, Crow Butte ISL Uranium Project; Crawford, Nebraska, 1983.

Davis, Stanley H. and DeWiest, Roger J.M., ***Hydrogeology***, John Wiley & Sons, Inc. New York, 1966.

Environmental Protection Agency, ***Handbook for Sampling and Sample Preservation of Water and Wastewater***, September, 1982.

Ferris, J.G., Knowles, R.H., Brown, R.H., and Stallman, R.W., ***Theory of Aquifer Tests;*** U.S.G.S. Water Supply Paper, 1962; 1536-E., p.171.

Hantush, M.S., ***Modification to the Theory of the Leaky Aquifers***, Jour. of Geophys. Res., 1964; v.65 (1960), 3713-25pp.

Hantush, M.S., ***Analysis of Data From Pumping Tests in Anisotropic Aquifers:*** Jour. of Geophys. Res., 1966; v.71, no.2, 421-426pp.

Hantush, M.S., ***Aquifer Tests on Partially Penetrating Wells:*** Jour. of the Hydraulics Div.; Proc. Amer. Soc. Civil Engr., 1961; HY5, 171-195pp.

Jacob, C.E., ***Recovery Methods for Determining the coefficient of Transmissibility;*** U.S. Geological Survey, 1963; Water Supply Paper 15361.

Kruseman, G.P., and DeRidder, N.A., ***Analysis and Evaluation of Pumping Test Data***; International Institute for Land Reclamation and Improvement Bulletin 11, 1979; 51-69pp.

McKee, Jack Edward and Harold W. Wolf, ***Water Quality Criteria***, California State Water Resource Control Board, 1978.

National Oceanic and Atmospheric Administration, *Annual Climatological Summary for Chadron, Nebraska;* EDS-NNC; Ashville, North Carolina, 1981.

_____, *Climate of Harrison, Nebraska,* Climatography of the United States, 1976; No.20.

_____, *Local Climatological Data,* Annual Summary with Comparative Data, 1980; Scottsbluff, Nebraska.

Neuman, S.P. and P.A. Witherspoon, *Field Determination of the Hydraulic Properties of Leaky Multiple Aquifer Systems:* Water Resour., 1972; v.8, no.5, 1284-1298pp.

Souders, V.L. and [illegible], G.W., *Water-Table Configuration, Fall 1971, Alliance Quadrangle, Nebraska and Eastern Part of Torrington Quadrangle, Wyoming and Nebraska;* University of Nebraska, Institute of Agriculture and Agricultural and Natural Resources, Conservation and Survey Division; Lincoln, Nebraska; U.S. Geological Survey; 1975.

Spalding, Roy, *Baseline Hydrogeochemical Investigation in a Part of Northwest Nebraska.* University of Nebraska, Institute of Agricultural and Natural Resources, Conservation and Survey Division; Lincoln, Nebraska; Nebraska Department of Environmental Control; 1982.

Struempler, A.W., *Trace Metals in Rain and Snow During 1973 at Chadron, Nebraska,* Atmospheric Environment, 1976; v.10, 33-37pp.

Struempler, A.W., *Interrelationships of Selected Physical Properties and Chemical Constituents of Ground Water in Northwest Nebraska,* Trans. Nebr. Acad. Soc.; 1979; v.VII, 41-44pp.

Theis, C.V., *The Relationship between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well using Ground-water Storage;* Eos. Trans. AGU, 1935; v.16, 519-524pp.

Todd, David Keith, *Ground Water Hydrology,* John Wiley & Sons, New York; 1980.

U.S. Department of the Interior, *Water Measurement Manual,* Bureau of Reclamation; Denver, Colorado, 1981.

U.S. Environmental Protection Agency, *Manual of Methods for Chemical Analysis of Water and Wastes,* EPA-62516-74-003a, 1974.

U.S. Environmental Protection Agency, *Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities,* EPA-530/SW-611, August 1977.

U.S. Nuclear Regulatory Commission, Regulatory Guide 3.46, ***Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solutions Mining.***

U.S. Nuclear Regulatory Commission, Regulatory Guide 4.14, ***Radiological Effluent and Environmental Monitoring at Uranium Mills***, April 1980.

U.S. Nuclear Regulatory Commission, Staff Technical Position Paper, ***Ground Water Monitoring at Uranium In-Situ Solution Mines***, WM-8102, December 1981.

U.S. Nuclear Regulatory Commission, Draft Staff Technical Position Paper (WM-8203), ***Hydrogeologic Characterization of Uranium Solutions Mine and Mill Tailings Disposal Sites.***

OIL AND GAS TEST HOLES IN 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 51 West

Roby No. 1, Section 31, Township 31 North, Range 51 West

Soester No. 1, Section 34, Township 32 North, Range 52 West

True State, Section 36, Township 32 North, Range 52 West

SUBSECTION 4.4

APPENDIX 4.4(A)

WATER QUALITY DATA

PRIVATE WELLS

Sampling Periods and Number of Samples used in the Statistical Evaluation of Water Quality Data from Wells in the Crow Butte Commercial Study Area

Private Wells

Well ID#	Formation	Sampling Period	No. of Samples
13	Brule	01/82 - 07/85	8
17	Brule	10/81 - 04/87	23
19	Brule	07/85 - 04/87	4
25	Brule	10/81 - 04/87	25
26	Brule	10/81 - 04/87	25
27	Brule	03/83 - 04/87	18
30	Brule	01/82 - 07/85	8
40	Brule	01/82 - 07/85	8
56	Brule	10/81 - 07/85	9
57	Brule	10/81 - 04/87	18
61	Chadron	10/81 - 07/85	12
62	Chadron	10/81 - 07/85	12
63	Brule	10/81 - 07/85	9
65	Chadron	10/81 - 07/85	11
66	Brule	10/81 - 07/85	14
74	Brule	10/81 - 07/85	11
88	Brule	01/82 - 07/85	8
95	Brule	01/81 - 07/85	8

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WELL •13
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 4019.9 ft. MSL
Well Depth: N/A ft.
Distance from Wellfield: 8500 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	67.4	76.8	72.275	2.715
Magnesium	9.1	10	9.525	.287
Sodium	21	21	21	0
Potassium	4.7	5	4.843	.127
Carbonate	<2	<2	2	0
Bicarbonate	300	318	309.614	5.866
Sulfate	<5	13	9.513	2.59
Chloride	2	5.7	3.629	1.237
Ammonia-N	<0.05	0.18	.086	.057
Nitrite-N	0.001	<0.01	7E-03	4E-03
Nitrate-N	1.1	1.4	1.253	.096
luoride	0.6	0.7	.636	.046
ica(as SiO2)	41	63	57	8.155
DS-180°C	308	370	342.625	21.639
Conductivity (µmhos)	463	520	484.875	18.427
Alkalinity(as CaCO3)	228.2	270	249.529	16
pH (standard units)	7.2	7.6	7.394	.149
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	2	2	0
Barium	300	300	300	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	2	2	2	0
Iron	400	400	400	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	2	2	2	0
ckel	<2	<2	2	0
lenium	<2	<2	2	0
adium	10	10	10	0
Zinc	440	440	440	0
Uranium (as U)	1	12	7.375	3.249
Radium-226(pCi/l)	0.1	0.2	.133	.052

FERRET EXPLORATION CO OF NEBRASKA CBR-014
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL •17
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3910 ft. MSL
Well Depth: 80.1 ft.
Distance from Wellfield: 3000 f

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	57	63.2	59.182	1.622
Magnesium	7.1	9.1	7.948	.477
Sodium	15.8	19	17.259	.764
Potassium	3.6	5	4.427	.403
Carbonate	<1	<2	1.5	.527
Bicarbonate	224	257	240.741	7.672
Sulfate	8.6	13	11.024	1.016
Chloride	2	6	3.74	.926
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	7E-03	4E-03
Nitrate-N	0.74	1.70	1.248	.27
Fluoride	0.6	0.8	.677	.057
Silica(as SiO2)	54	62	58.874	2.446
TDS-180•C	246	330	287	21.711
Conductivity (µmhos)	387	445	408.455	14.651
Alkalinity(as CaCO3)	184	220	200.648	9.594
pH (standard units)	7.22	8.22	7.675	.32
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	6	4.071	1.141
Barium	200	200	200	0
Boron	30	100	63.077	33.263
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt	<1	<50	18.667	27.209
Copper	<10	<10	10	0
Iron	<10	<50	29.231	10.377
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	30	21.167	7.975
Uranium (as U)	<1	11	3.696	3.037
Radium-226(pCi/l)	0.1	0.7	.269	.195

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WELL #19
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3890 ft. MSL
Well Depth: 80 ft.
Distance from Wellfield: 1000 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	75.3	80.5	78	2.14
Magnesium	9.9	11.3	10.55	.597
Sodium	9.3	12.3	11.2	1.332
Potassium	4.1	5.2	4.675	.556
Carbonate				
Bicarbonate	248	258.3	253.35	4.397
Sulfate	7.9	13.3	11.05	2.381
Chloride	6.5	6.5	6.5	0
Ammonia-N	<0.05	0.07	.057	.012
Nitrite-N	0.003	0.012	7E-03	4E-03
Nitrate-N	9.73	10.7	10.233	.415
Fluoride	0.60	0.64	.62	.016
Silica(as SiO_2)	47.2	52.3	49.65	2.575
TDS-180°C	364	364	364	0
Conductivity (µmhos)	527	527	527	0
Alkalinity(as $CaCO_3$)	204	211.7	207.7	3.393
pH (standard units)	7.38	8.14	7.725	.349
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	3	4	3.5	.577
Barium	260	300	275	19.149
Boron	30	30	30	0
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	10	20	15	5.774
Iron	<30	<30	30	0
Lead	<5	8	6	1.414
Manganese	<5	<5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	180	530	347.5	154.137
Uranium (as U)	2	5	3.75	1.258
Radium-226(pCi/l)	0.2	1.7	.875	.624

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WELL •25
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3904.7 ft. MSL
Well Depth: 75.1 ft.
Distance from Wellfield: 3000 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	70	86.8	78.833	4.262
Magnesium	9.6	12.2	10.754	.757
Sodium	11.4	16	13.321	1.076
Potassium	4.0	5.2	4.621	.308
Carbonate	<1	<2	1.5	.527
Bicarbonate	256	301	282.464	11.215
Sulfate	5	<10	7.644	1.507
Chloride	3	12	7.416	2.42
Ammonia-N	0.05	0.05	.05	0
Nitrite-N	0.001	<0.01	6E-03	4E-03
Nitrate-N	2.3	11.3	7.26	2.759
Fluoride	0.6	0.72	.663	.041
Silica(as SiO2)	49.2	55.2	52.757	1.82
TDS-180•C	257	404	344.16	37.877
Conductivity (µmhos)	458	552	517.8	27.347
Alkalinity(as CaCO3)	210	255	232.265	10.465
pH (standard units)	7.03	8.24	7.596	.331
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	8	5.563	1.672
Barium	30	340	259.375	101.158
Boron	<10	140	58.571	40.923
Cadmium	<1	<1	1	0
Chromium	5	5	5	0
Cobalt	<1	<10	5.25	3.686
Copper	10	10	10	0
Iron	<10	<50	27.857	9.75
Lead	<5	<5	5	0
Manganese	5	5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	10	10	10	0
Zinc	26	350	195.067	80.139
Uranium (as U)	<1	10	4.292	2.662
Radium-226(pCi/l)	0.1	0.6	.282	.17

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WELL °26
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3820.1 ft. MSL
Well Depth: 80.1 ft.
Distance from Wellfield: 3700 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	93	156.7	122.464	15.271
Magnesium	10	20	15.116	2.19
Sodium	12	17.5	15.25	1.45
Potassium	5.3	7.6	6.522	.513
Carbonate	<1	<2	1.5	.527
Bicarbonate	289.0	374	339.4	20.051
Sulfate	12	44	28.232	8.757
Chloride	13.2	45	30.605	7.694
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	6E-03	4E-03
Nitrate-N	9.3	35	16.658	6.945
Fluoride	0.4	0.8	.622	.087
Silica(as SiO2)	45.8	55	49.205	2.329
TDS-180°C	372	648	500.44	65.571
Conductivity (µmhos)	630	966	774.48	91.467
Alkalinity(as CaCO3)	256.3	316	282.178	16.795
pH (standard units)	6.8	8.14	7.587	.355
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	7	4.313	1.887
Barium	<100	420	290	101.39
Boron	10	110	60.714	37.716
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt	<1	<50	18.667	27.209
Copper	7	30	14.188	8.28
Iron	10	<50	30.667	10.998
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	20	54	37.267	11.087
Uranium (as U)	<1	12	5.84	3.387
Radium-226(pCi/l)	0.02	1.5	.48	.427

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL °27
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3850 ft. MSL
Well Depth: 80 ft.
Distance from Wellfield: 2500 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	68.9	72.3	70.319	1.117
Magnesium	8.3	10	9.159	.421
Sodium	14.4	19.5	16.582	1.377
Potassium	4.4	5.5	5.088	.33
Carbonate	<1	<1	1	0
Bicarbonate	250	284	269.044	7.909
Sulfate	15.0	18	16.494	1.184
Chloride	2.1	8	4.329	1.715
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	5E-03	4E-03
Nitrate-N	0.8	3.38	2.576	.738
Fluoride	0.6	0.9	.781	.078
Silica(as SiO_2)	47.9	59	54.159	2.635
TDS-180°C	276	364	319.667	20.954
Conductivity (µmhos)	445	502	471	16.62
Alkalinity(as $CaCO_3$)	205	241	223.789	8.848
pH (standard units)	7.28	8.29	7.754	.332
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	6	4.308	1.494
Barium	170	200	182.727	11.909
Boron	40	150	84.615	30.718
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt	<5	<5	5	0
Copper	<10	<10	10	0
Iron	20	60	35.8	11.679
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	10	10	10	0
Zinc	10	60	30.077	15.866
Uranium (as U)	<1	14	4.667	3.929
Radium-226(pCi/l)	0.1	1.9	.52	.555

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL •30
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3770 ft. MSL
Well Depth: 55 ft.
Distance from Wellfield: 13500 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	55.6	62.0	58.229	2.137
Magnesium	4.6	6	5.275	.465
Sodium	37.9	44	40.7	2.159
Potassium	14	16	14.625	.713
Carbonate	<1	<2	1.667	.516
Bicarbonate	243.5	291	261.986	15.507
Sulfate	25	34	29.271	2.901
Chloride	13	17.9	14.971	1.533
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	0.01	8E-03	4E-03
itrate-N	3.4	3.7	3.568	.119
uoride	0.5	0.61	.541	.052
lica(as SiO2)	55	60.5	58.35	2.004
TDS-180•C	336	404	369.429	27.802
Conductivity (µmhos)	486	545	516.333	24.279
Alkalinity(as CaCO3)	199.6	250	219.65	17.949
pH (standard units)	7.3	8.22	7.605	.334
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	2	2	2	0
Barium	300	300	300	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	4	4	4	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
ckel	<2	<2	2	0
enium	4	4	4	0
anadium	5	5	5	0
Zinc	82	82	82	0
Uranium (as U)	11	23	15.625	4.658
Radium-226(pCi/l)	0.2	0.9	.538	.226

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL •40
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3750 ft. MSL
Well Depth: 60 ft.
Distance from Wellfield: 12500 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	61	67.2	63.813	2.016
Magnesium	6.5	9	7.613	.786
Sodium	17	17	17	0
Potassium	6.6	6.8	6.7	.1
Carbonate	<1	<2	1.667	.516
Bicarbonate	250	267	255.1	6.364
Sulfate	5	19	10.663	4.435
Chloride	3	6.7	4.3	1.365
Ammonia-N	<0.05	0.06	.053	5E-03
Nitrite-N	0.001	<0.01	8E-03	4E-03
Nitrate-N	2.1	3.51	2.578	.594
Fluoride	0.4	0.5	.475	.046
Silica(as SiO2)	53	58.6	55.6	2.149
TDS-180°C	272	340	309.375	26.581
Conductivity (µmhos)	424	460	442.143	12.993
Alkalinity(as CaCO3)	200	231	213.1	10.347
pH (standard units)	7.3	8.15	7.67	.319
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	2	2	0
Barium	200	200	200	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	4	4	4	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	9	9	9	0
Zinc	50	50	50	0
Uranium (as U)	<1	7	4.625	2.2
Radium-226(pCi/l)	<0.1	0.8	.363	.233

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL •56
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3730 ft. MSL
Well Depth: 200 ft.
Distance from Wellfield: 22200 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	37	45.5	40.244	2.828
Magnesium	4.1	5.2	4.611	.322
Sodium	210	240	224	10.863
Potassium	14	18	16.189	1.179
Carbonate	<1	<2	1.714	.488
Bicarbonate	249.9	270	259.356	7.379
Sulfate	179	217	196.5	11.006
Chloride	120	150	135.378	8.376
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	8E-03	4E-03
Nitrate-N	5.3	7.0	6.003	.577
Fluoride	0.3	0.4	.353	.047
Silica(as SiO2)	68	81.1	74.111	3.679
TDS-180•C	790	886	838.333	30.274
Conductivity (µmhos)	1218	1340	1280.444	43.356
Alkalinity(as CaCO3)	200	224	213.4	8.823
pH (standard units)	7.5	8.16	7.787	.219
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	8	8	8	0
Barium	<100	<100	100	0
Boron	700	700	700	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	5	5	5	0
Iron	150	150	150	0
Lead	5	5	5	0
Manganese	<100	<100	100	0
Mercury	1.5	1.5	1.5	0
Molybdenum	6	6	6	0
Nickel	<2	<2	2	0
Selenium	71	71	71	0
Vanadium	6	6	6	0
Zinc	560	560	560	0
Uranium (as U)	17	21	19.75	1.389
Radium-226(pCi/l)	0.1	0.4	.225	.116

FERRET EXPLORATION CO OF NEBRASKA

CBR-014

CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL •57
Sample Tvpe: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3800.1 ft. MSL
Well Depth: 24.9 ft.
Distance from Wellfield: 5700 ft

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	61.6	68	64.535	1.86
Magnesium	6.7	9	7.656	.573
Sodium	15.3	20.4	17.611	1.226
Potassium	5.4	6.6	6.087	.305
Carbonate	<1	<2	1.444	.527
Bicarbonate	249	268	257.671	5.547
Sulfate	5	12	9.235	1.928
Chloride	<2	5.6	3.641	1.177
Ammonia-N	0.05	0.05	.05	0
Nitrite-N	<.001	<0.01	6E-03	5E-03
Nitrate-N	1.71	6.09	3.003	1.327
Fluoride	0.5	0.63	.567	.044
Silica(as SiO2)	49.2	62	56.417	2.954
TDS-180•C	280	350	304.824	20.388
Conductivity (µmhos)	404	490	439.5	25.661
Alkalinity(as CaCO3)	204	236	215.36	10.066
pH (standard units)	7.2	8.28	7.646	.366
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<50	190	110	58.31
Arsenic	2	7	4.1	1.449
Barium	200	240	220	11.18
Boron	20	<100	52.222	27.739
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt	<1	<50	18.667	27.209
Copper	<10	<10	10	0
Iron	10	<50	31.2	13.863
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	0.2	0.2	.2	0
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<2	1.2	.422
Vanadium	<10	<10	10	0
Zinc	30	140	68.556	34.479
Uranium (as U)	<1	14	6.5	4.076
Radium-226(pCi/l)	0.1	0.9	.436	.248

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL ·61
Sample Type: PRIVATE WELL
Formation: CHADRON

Surface Elevation: 3710 ft. MSL
Well Depth: 280 ft.
Distance from Wellfield: 20000 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	12.6	16	14.4	1.03
Magnesium	2.7	3.6	3.091	.247
Sodium	380	420	402.167	10.495
Potassium	8.9	9.5	9.25	.193
Carbonate	<1	<2	1.625	.518
Bicarbonate	365	410	388	11.066
Sulfate	340	409	381.083	19.538
Chloride	150	170	160.655	7.231
Ammonia-N	0.14	0.44	.311	.096
Nitrite-N	<0.01	<0.01	.01	0
Nitrate-N	<0.01	<0.1	.051	.041
Fluoride	0.5	0.8	.666	.089
Silica(as SiO2)	7.9	13	10.142	1.264
TDS-180·C	1078	1240	1169.333	45.761
Conductivity (µmhos)	1740	2000	1863.818	84.053
Alkalinity(as CaCO3)	310	349	323.71	12.37
pH (standard units)	7.78	8.42	8.059	.173
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<2	<2	2	0
Barium	<100	<100	100	0
Boron	800	800	800	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	1	1	1	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	13	13	13	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	8	8	8	0
Zinc	8	8	8	0
Uranium (as U)	<1	<2	1.417	.515
Radium-226(pCi/l)	1.9	4.8	3.283	.849

CBR-014

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL #62
Sample Type: PRIVATE WELL
Formation: CHADRON

Surface Elevation: 3780 ft. MSL
Well Depth: 469.8 ft.
Distance from Wellfield: 9700 ft

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	12	18	15.1	1.553
Magnesium	2.5	4.3	3.408	.446
Sodium	380	410	392.417	9.02
Potassium	6.0	14	9.975	1.907
Carbonate	<1	<2	1.667	.5
Bicarbonate	380	445.5	400.017	20.189
Sulfate	328	370	348.727	12.586
Chloride	169.2	186	178.23	5.123
Ammonia-N	0.20	0.44	.314	.117
Nitrite-N	<.001	<0.01	9E-03	4E-03
Nitrate-N	<0.01	<0.1	.049	.036
Fluoride	0.4	0.9	.635	.122
Silica(as SiO2)	10	12	11.082	.564
TDS-180°C	1050	1200	1143.333	51.22
Conductivity (µmhos)	1790	1950	1864.833	48.123
Alkalinity(as CaCO3)	313	365.2	333.73	16.418
pH (standard units)	7.8	8.34	8.085	.173
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	70	70	70	0
Arsenic	<1	<1	1	0
Barium	40	40	40	0
Boron	730	730	730	0
Cadmium	<0.1	<0.1	.1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	1	1	1	0
Iron	30	30	30	0
Lead	<1	<1	1	0
Manganese	13	13	13	0
Mercury	0.3	0.3	.3	0
Molybdenum	<10	<10	10	0
Nickel	<2	<2	2	0
Selenium	<1	<1	1	0
Vanadium	6	6	6	0
Zinc	110	110	110	0
Uranium (as U)	16	36	24.25	6.608
Radium-226(pCi/l)	5.9	18	13.975	3.919

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WELL •63
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3780 ft. MSL
Well Depth: N/A ft.
Distance from Wellfield: 10000 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	60	69	65.1	3.118
Magnesium	6.2	8.7	7.411	.777
Sodium	21.3	24	22.663	.843
Potassium	7.6	8.7	8.4	.384
Carbonate	<1	<2	1.714	.488
Bicarbonate	262.8	281	275.244	6.535
Sulfate	7	15	10.656	2.446
Chloride	3.4	5.5	4.5	.739
Ammonia-N	0.05	0.05	.05	0
Nitrite-N	<.001	<0.01	8E-03	4E-03
Nitrate-N	0.96	3.1	2.022	.551
Fluoride	0.5	0.6	.552	.05
Silica(as SiO_2)	54	60	57.267	2.306
TDS-180°C	295	390	333.667	30.116
Conductivity (µmhos)	439	499	469.667	18.682
Alkalinity(as $CaCO_3$)	210.2	244	227.371	12.889
pH (standard units)	7.2	8.08	7.624	.303
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	3	3	3	0
Barium	200	200	200	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	2	2	2	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	0.1	0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	2	2	2	0
Vanadium	6	6	6	0
Zinc	54	54	54	0
Uranium (as U)	2	22	10.889	5.555
Radium-226(pCi/l)	0.2	0.8	.444	.219

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL #65
Sample Type: PRIVATE WELL
Formation: CHADRON

Surface Elevation: 3710 ft. MSL
Well Depth: 260 ft.
Distance from Wellfield: 19100 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	11.7	14	12.85	.81
Magnesium	1.6	2.2	1.827	.167
Sodium	340	380	360.909	12.413
Potassium	5.4	6.7	6.06	.386
Carbonate	<1	<2	1.556	.527
Bicarbonate	391.3	420	405.673	9.13
Sulfate	255	290	270.091	10.251
Chloride	160	170.4	165.95	4.351
Ammonia-N	0.14	0.63	.412	.159
Nitrite-N	<.001	<0.01	8E-03	4E-03
Nitrate-N	<0.01	<0.1	.049	.042
Fluoride	0.5	0.9	.688	.11
Silica(as SiO_2)	8	10	9.24	.585
TDS-180°C	910	1100	1013.364	48.283
Conductivity (µmhos)	1550	1760	1666.909	72.322
Alkalinity(as $CaCO_3$)	320.8	354	338.333	9.913
pH (standard units)	7.6	8.29	7.937	.18
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	<2	<2	2	0
Barium	<100	<100	100	0
Boron	600	600	600	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	0.4	0.4	.4	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	5	5	5	0
Zinc	10	10	10	0
Uranium (as U)	<1	<2	1.5	.527
Radium-226(pCi/l)	12.0	26.3	19.291	3.68

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WELL •66
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3710 ft. MSL
Well Depth: 60 ft.
Distance from Wellfield: 15400 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	87	169.6	115.271	26.29
Magnesium	10	20	13.536	3.148
Sodium	52	74	59.271	8.131
Potassium	7.6	18	14.107	2.749
Carbonate	<1	<2	1.556	.527
Bicarbonate	410	487	444.077	27.573
Sulfate	26	56	36.429	10.054
Chloride	2	52.4	26	13.553
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	7E-03	4E-03
Nitrate-N	4.1	49.3	16.683	15.382
Fluoride	0.5	0.7	.595	.056
Silica(as SiO2)	47.9	62	57.252	4.168
TDS-180°C	480	720	579.429	77.258
Conductivity (µmhos)	728	1220	881.929	173.228
Alkalinity(as CaCO3)	340	410	369.508	23.307
pH (standard units)	7.10	8.51	7.655	.368
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	5	5	5	0
Barium	<100	<100	100	0
Boron	500	500	500	0
Cadmium	2	2	2	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	6	6	6	0
Iron	<50	<50	50	0
Lead	20	20	20	0
Manganese	<100	<100	100	0
Mercury	0.9	0.9	.9	0
Molybdenum	4	4	4	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	16	16	16	0
Zinc	5200	5200	5200	0
Uranium (as U)	23	33	29.2	3.225
Radium-226(pCi/l)	0.1	0.6	.35	.135

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL •74
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3630 ft. MSL
Well Depth: 60 ft.
Distance from Wellfield: 25000 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	85	128.8	108.073	12.11
Magnesium	10.5	15	12.982	1.258
Sodium	110	130	121.545	5.355
Potassium	19	22	20.7	.781
Carbonate	<1	<2	1.625	.518
Bicarbonate	493	548	519.34	19.401
Sulfate	76	113	91.491	10.944
Chloride	32	110	75.936	21.424
Ammonia-N	<0.05	0.25	.121	.082
Nitrite-N	<.001	<0.01	8E-03	4E-03
Nitrate-N	<0.01	0.14	.069	.055
Fluoride	0.48	0.7	.554	.077
Silica(as SiO2)	51	59.9	55.282	3.118
TDS-180°C	702	820	766.1	35.209
Conductivity (µmhos)	1050	1268	1139	78.961
Alkalinity(as CaCO3)	415	463	434.325	18.521
pH (standard units)	7.00	7.82	7.407	.272
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	18	18	18	0
Barium	600	600	600	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	3	3	3	0
Iron	200	200	200	0
Lead	<5	<5	5	0
Manganese	300	300	300	0
Mercury	0.1	0.1	.1	0
Molybdenum	10	10	10	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	<1	<1	1	0
Zinc	38	38	38	0
Uranium (as U)	7	14	10.333	2.872
Radium-226(pCi/l)	0.2	0.7	.422	.186

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WELL °88
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3610 ft. MSL
Well Depth: 60 ft.
Distance from Wellfield: 28000 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	61	89	74.9	9.659
Magnesium	8.6	12	9.957	1.134
Sodium	75	129	100.15	17.18
Potassium	11	21	16.237	3.116
Carbonate	<1	<2	1.667	.516
Bicarbonate	330	435.7	389.1	32.42
Sulfate	22	190	112.875	47.634
Chloride	13	45.7	32.438	10.969
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	8E-03	4E-03
Nitrate-N	<0.01	3.25	1.964	1.042
Fluoride	0.6	0.8	.693	.058
Silica(as SiO2)	57	61	58.371	1.36
TDS-180°C	490	790	627.25	88.878
Conductivity (µmhos)	647	1101	895.125	147.563
Alkalinity(as CaCO3)	270	357.1	322.3	30.355
pH (standard units)	6.95	8.0	7.531	.395
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	7	7	7	0
Barium	100	100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	5	5	5	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	47	47	47	0
Molybdenum	2	2	2	0
Nickel	<2	<2	2	0
Selenium	5	5	5	0
Vanadium	4	4	4	0
Zinc	490	490	490	0
Uranium (as U)	9	26	17.125	5.915
Radium-226(pCi/l)	0.2	0.9	.463	.262

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WELL •95
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3650 ft. MSL
Well Depth: 100 ft.
Distance from Wellfield: 30000 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	78	110	89.237	11.003
Magnesium	5.5	8.3	6.612	1.092
Sodium	72	80	75.75	2.659
Potassium	22	27	24.313	1.434
Carbonate	<1	<2	1.667	.516
Bicarbonate	290	335	311.438	13.978
Sulfate	79	200	123.325	39.328
Chloride	27.3	39.2	34.825	3.89
Ammonia-N	<0.05	0.06	.054	5E-03
Nitrite-N	<.001	<0.01	8E-03	4E-03
Nitrate-N	2.5	5.9	3.833	1.098
Fluoride	0.3	0.5	.408	.055
Silica(as SiO2)	55	60	57.925	1.469
TDS-180•C	540	680	591.25	53.033
Conductivity (µmhos)	775	933	843.938	51.236
Alkalinity(as CaCO3)	240	287	260.071	14.642
pH (standard units)	7.17	8.10	7.574	.356
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	8	8	8	0
Barium	100	100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	10	10	10	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	35	35	35	0
Molybdenum	7	7	7	0
Nickel	<2	<2	2	0
Selenium	4	4	4	0
Vanadium	7	7	7	0
Zinc	74	74	74	0
Uranium (as U)	18	31	23.125	4.121
Radium-226(pCi/l)	0.2	1.1	.525	.349

BASELINE WELLS
DRILLED BY FEN

Sampling Periods and Number of Samples used in the Statistical Evaluation of Water Quality Data from Wells in the Crow Butte Commercial Study Area

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Baseline Wells Drilled by FEN

Well No.	Formation	Sampling Period	No. of Samples
RA-1	Brule	07/82 - 10/85	12
RA-2	Brule	07/82 - 10/85	13
RB-1	Brule	07/82 - 10/85	13
RB-3	Brule	07/82 - 10/85	11
RC-1	Chadron	07/82 - 10/85	11
RC-2	Chadron	07/82 - 10/85	13
RC-3	Chadron	07/82 - 10/85	15
RC-4	Chadron	07/82 - 10/85	12
RC-5	Chadron	07/82 - 10/85	11
RC-6	Chadron	07/82 - 10/85	7
RC-7	Chadron	07/82 - 10/85	13

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RA-1
Sample Type: REGIONAL BASELINE WELL
Formation: BRULE

Surface Elevation: 3667.3 ft. MSL
Well Depth: 40 ft.
Distance from Wellfield: 21700 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	61.5	98	77.358	12.138
Magnesium	9.1	16	12.267	1.966
Sodium	32.0	45	37.478	3.698
Potassium	8.3	11.4	9.7	.819
Carbonate	<1	<2	1.5	.548
Bicarbonate	314	449	364.091	48.72
Sulfate	9	23	14.9	4.169
Chloride	6	9.6	8.012	1.281
Ammonia-N	<0.05	0.06	.052	4E-03
Nitrite-N	<.001	<0.02	.01	6E-03
itrate-N	<0.01	0.12	.058	.048
uoride	0.8	1.33	1.022	.179
ilica(as SiO_2)	51.4	58	54.922	1.895
TDS-180°C	348	562	415.917	66.003
Conductivity (µmhos)	501	720	598	75.989
Alkalinity(as $CaCO_3$)	259.6	379	309.15	41.705
pH (standard units)	6.8	8.5	7.528	.446
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<25	<100	85.302	30.994
Arsenic	7	16.33	10.859	2.81
Barium	100	400	252.361	95.171
Boron	<1	700	291	248.417
Cadmium	<1	<1	1	0
Chromium	<1	5	3.3	2.003
Cobalt	<1	<1	1	0
Copper	1	<10	6.5	3.722
Iron	20	<50	39.2	11.821
Lead	<5	<5	5	0
Manganese	325	840	510.727	162.372
Mercury	<0.05	<0.3	.155	.076
olybdenum	0.38	<10	5.738	3.914
ckel	<1	10.5	5.95	4.387
lenium	<1	11.3	3.936	4.21
Vanadium	1	<10	5.75	4.559
Zinc	20	160	101.636	42.403
Uranium (as U)	<1	9	4.889	3.18
Radium-226(pCi/l)	0.1	0.5	.244	.159

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RA-2
Sample Type: REGIONAL BASELINE WELL
Formation: BRULE

Surface Elevation: 3744.9 ft. MSL
Well Depth: 40 ft.
Distance from Wellfield: 12200 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	64	75.5	70.415	3.384
Magnesium	6.4	11.5	9.062	1.182
Sodium	34	41	36.814	2.245
Potassium	10.3	11.8	11	.413
Carbonate	<1	14	4.429	5.318
Bicarbonate	278	364	319.883	23.735
Sulfate	11	20	15.992	3.059
Chloride	5	11	6.936	1.845
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	6E-03	5E-03
Nitrate-N	0.01	5.2	2.418	1.324
Fluoride	0.7	1.12	.886	.132
Silica(as SiO2)	49.43	60	55.103	2.703
TDS-180°C	335	394	373.455	17.478
Conductivity (µmhos)	480	614	544.769	33.028
Alkalinity(as CaCO3)	245.0	303	265.7	17.681
pH (standard units)	6.89	8.4	7.643	.414
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	5	<10	7.749	1.854
Barium	<100	300	198.525	84.303
Boron	10	<1000	330	330.234
Cadmium	<1	<1	1	0
Chromium	1	5.5	3.682	1.953
Cobalt	<1	<5	2.333	2.066
Copper	<1	<10	7.475	3.376
Iron	6	80	38	20.919
Lead	<5	<10	6	1.844
Manganese	1	160	41.5	56.539
Mercury	<0.1	0.34	.195	.077
Molybdenum	<2	14	8.5	3.629
Nickel	<1	<10	6.545	4.083
Selenium	<1	3	1.6	.699
Vanadium	10	12	10.444	.882
Zinc	13	197	96.583	70.725
Uranium (as U)	5	21	14.455	4.824
Radium-226(pCi/l)	0.2	0.8	.48	.162

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: RB-1
Sample Type: REGIONAL BASELINE WELL
Formation: BRULE

Surface Elevation: 3663.9 ft. MSL
Well Depth: 133 ft.
Distance from Wellfield: 20800 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	7.1	13	9.254	1.704
Magnesium	0.3	2	.848	.533
Sodium	310	340	325	10.04
Potassium	10.3	15.9	12.262	1.698
Carbonate	<1	<2	1.4	.548
Bicarbonate	586.3	627	608.809	14.396
Sulfate	3	<5	4.35	.891
Chloride	160	192.0	172.6	9.424
Ammonia-N	<0.05	0.26	.179	.077
Nitrite-N	<.001	<0.02	.01	7E-03
Nitrate-N	<0.01	<0.1	.042	.038
Fluoride	0.51	0.68	.606	.05
Silica(as SiO2)	38.3	47	42.692	2.987
TDS-180•C	802	921	870.167	38.551
Conductivity (µmhos)	1318	1481	1440.5	54.093
Alkalinity(as CaCO3)	486.6	527	507.46	13.569
pH (standard units)	7.82	8.5	8.18	.198
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	20.51	<100	84.551	32.587
Arsenic	1	6	2.305	1.831
Barium	<100	400	249.567	126.713
Boron	600	1600	890.833	360.012
Cadmium	<1	<1	1	0
Chromium	1	10	4.409	2.518
Cobalt	0.59	<5	1.949	1.889
Copper	<1	18	8.018	5.068
Iron	20	73.5	42.125	16.215
Lead	<5	<5	5	0
Manganese	<2	<100	36.833	46.684
Mercury	<0.1	<0.3	.17	.067
Molybdenum	<2	<10	6.4	3.893
Nickel	<1	10	5.9	4.332
Selenium	<1	14.3	4.323	4.482
Vanadium	1	<10	7	3.775
Zinc	4	100	30.5	30.691
Uranium (as U)	1	2	1.222	.441
Radium-226(pCi/l)	0.4	3.0	1.59	.872

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RB-3
Sample Type: REGIONAL BASELINE WELL
Formation: BRULE

Surface Elevation: 4040.2 ft. MSL
Well Depth: 142 ft.
Distance from Wellfield: 7500 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	28.55	38	33.923	3.6
Magnesium	3.4	5.5	4.341	.682
Sodium	12.0	24	16.841	4.164
Potassium	4.1	8.6	6.7	1.722
Carbonate	<1	<2	1.5	.548
Bicarbonate	137	180	163.97	12.514
Sulfate	1	7	4.77	2.131
Chloride	1.6	6.2	3.31	1.597
Ammonia-N	0.04	0.06	.05	5E-03
Nitrite-N	<.001	0.48	.093	.191
Nitrate-N	0.4	0.55	.483	.042
Fluoride	0.3	0.42	.357	.049
Silica(as SiO2)	58.6	62	60.786	1.187
TDS-180°C	190	230	211.889	14.979
Conductivity (µmhos)	246	291	273.889	16.244
Alkalinity(as CaCO3)	130	150	139.175	7.45
pH (standard units)	7.6	8.3	7.918	.262
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<25	200	113.716	55.161
Arsenic	<1	<5	2.583	1.331
Barium	<100	230	185.322	47.885
Boron	20	<1000	333	320.036
Cadmium	<1	<1	1	0
Chromium	1	<5	3.278	1.889
Cobalt	<1	<1	1	0
Copper	1	11	7	4.346
Iron	5	70	38.25	19.15
Lead	<5	<5	5	0
Manganese	2	<100	33.9	45.657
Mercury	<0.1	<0.3	.175	.071
Molybdenum	0.04	<10	6.227	4.078
Nickel	<1	<10	6.278	4.309
Selenium	<1	<2	1.429	.535
Vanadium	6	<10	8.833	1.835
Zinc	5	20	11	4.796
Uranium (as U)	<1	11	5	3.162
Radium-226(pCi/l)	0.1	1.1	.533	.383

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Page No. 3 of 3

Sample Number:RC-1
Sample Type: REGIONAL BASELINE WELL
Formation: CHADRON

Surface Elevation: 3646.7 ft. MSL
Well Depth: 374 ft.
Distance from Wellfield: 25200 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	20	22.3	21.5	.718
Magnesium	2.1	3.1	2.669	.307
Sodium	445	540	494.136	24.222
Potassium	15	19.8	16.955	1.681
Carbonate	<1	<2	1.4	.548
Bicarbonate	350	396	374.689	12.354
Sulfate	450	620	574.636	61.282
Chloride	159	183.7	170.92	6.924
Ammonia-N	0.13	0.64	.43	.138
Nitrite-N	<.001	<0.02	.01	6E-03
Nitrate-N	<0.01	<0.1	.042	.039
Fluoride	0.7	1.07	.849	.109
Silica(as SiO2)	9.8	12	10.85	.852
TDS-180°C	1436	1534	1491	26.393
Conductivity (µmhos)	2180	2500	2316.909	99.723
Alkalinity(as CaCO3)	300	336	315.163	11.149
pH (standard units)	7.9	8.5	8.125	.176
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<1	<10	4.404	3.144
Barium	<100	<100	100	0
Boron	930	1300	1111	108.674
Cadmium	<1	<1	1	0
Chromium	1	6.5	3.833	1.936
Cobalt	<1	9.04	4.202	3.756
Copper	<1	<10	7.13	3.583
Iron	15	<50	40.889	12.879
Lead	<5	13	8.2	3.521
Manganese	7	<100	37.3	43.328
Mercury	<0.1	<0.3	.175	.071
Molybdenum	<2	<10	6.429	3.645
Nickel	<2	<10	6.611	3.723
Selenium	<1	47.8	11.176	17.778
Vanadium	1	<10	6.857	4.1
Zinc	<5	32	15.95	9.179
Uranium (as U)	<1	4	2.222	1.302
Radium-226(pCi/l)	0.2	1.3	.65	.366

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RC-2
Sample Type: REGIONAL BASELINE WELL
Formation: CHADRON

Surface Elevation: 3656.9 ft. MSL
Well Depth: 629 ft.
Distance from Wellfield: 26300 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	11	16.8	13.315	1.666
Magnesium	0.83	1.6	1.259	.289
Sodium	473	495	485.091	6.564
Potassium	12	16.4	13.946	1.376
Carbonate	<1	8	3.85	2.991
Bicarbonate	350	385	369.882	11.086
Sulfate	515	610	574.909	30.247
Chloride	134	180	154.869	12.849
Ammonia-N	0.22	0.65	.487	.121
Nitrite-N	<.001	0.03	.01	9E-03
Nitrate-N	<0.01	0.12	.056	.044
Fluoride	1.1	1.54	1.219	.149
Silica(as SiO_2)	10.7	14	12.211	1.104
TDS-180°C	1370	1498	1433.333	43.389
Conductivity (µmhos)	2039	2370	2194.417	98.678
Alkalinity(as $CaCO_3$)	300	337	314.62	10.727
pH (standard units)	8.2	8.7	8.369	.147
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<25	<100	84.138	30.013
Arsenic	<1	3	1.924	.728
Barium	0.71	100	78.374	42.923
Boron	920	1670	1320.6	295.784
Cadmium	<1	<10	2.71	3.386
Chromium	<1	6	3.889	1.965
Cobalt	<1	<1	1	0
Copper	4	<10	7.29	2.913
Iron	10	70	42.1	16.789
Lead	5	5	5	0
Manganese	6	<100	41.55	44.709
Mercury	<0.05	<0.3	.161	.078
Molybdenum	<2	<10	6.429	3.645
Nickel	<1	20	7.833	6.548
Selenium	<1	62.5	13.301	22.87
Vanadium	2	<10	7.571	3.552
Zinc	<10	<10	10	0
Uranium (as U)	<1	5	2.667	1.658
Radium-226(pCi/l)	0.4	1.7	.925	.509

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RC-3
Sample Type: REGIONAL BASELINE WELL
Formation: CHADRON

Surface Elevation: 3708.0 ft. MSL
Well Depth: 293 ft.
Distance from Wellfield: 15600 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	14.5	17.4	15.746	.736
Magnesium	2.3	3	2.528	.242
Sodium	350	390	374.357	11.077
Potassium	7.8	9.9	8.553	.606
Carbonate	<1	2.8	1.686	.701
Bicarbonate	370	408	389.329	10.717
Sulfate	267	340	310.067	23.107
Chloride	160	182.3	171.554	6.41
Ammonia-N	0.23	0.56	.351	.094
Nitrite-N	<.001	<0.02	8E-03	7E-03
Nitrate-N	<0.01	<0.1	.039	.034
Fluoride	0.6	0.72	.634	.039
Silica(as SiO2)	6.8	13.89	10.048	1.735
TDS-180°C	1000	1121	1074.071	41.594
Conductivity (µmhos)	1660	1860	1768.214	68.27
Alkalinity(as CaCO3)	315.2	327	321	3.522
pH (standard units)	7.66	8.5	8.095	.215
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	10.08	<100	82.09	33.523
Arsenic	<1	10	3.002	3.114
Barium	0.80	200	93.808	45.538
Boron	670	1100	905	103.385
Cadmium	<1	<2	1.182	.405
Chromium	1	8.5	3.885	2.417
Cobalt	0.23	<50	12.491	21.316
Copper	<1	<10	6.936	3.745
Iron	10	70	43.836	14.978
Lead	<5	10.5	6.014	1.944
Manganese	2.3	<100	32.607	44.279
Mercury	<0.1	<0.3	.175	.062
Molybdenum	<2	20	8.583	6.445
Nickel	<1	20	8.138	6.469
Selenium	<1	<2	1.364	.505
Vanadium	1	<100	22.417	36.388
Zinc	<2	14	8.167	3.326
Uranium (as U)	<1	6	2.583	1.881
Radium-226(pCi/l)	0.1	2.6	1.208	.776

FERRET EXPLORATION CO OF NEBRASKA
CBR-014

CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RC-4
Sample Type: REGIONAL BASELINE WELL
Formation: CHADRON

Surface Elevation: 3746.2 ft. MSL
Well Depth: 400 ft.
Distance from Wellfield: 12000

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	13.5	18	15.85	1.345
Magnesium	2.4	4.3	3.485	.599
Sodium	368	400	381.909	9.137
Potassium	7.0	11.7	9.542	1.135
Carbonate	<1	14	4.463	5.516
Bicarbonate	386	411	399.156	8.262
Sulfate	270	350	315.833	25.587
Chloride	152	192	169.767	10.544
Ammonia-N	0.09	0.46	.309	.101
Nitrite-N	<.001	0.03	.011	9E-03
Nitrate-N	<0.01	<0.1	.058	.038
Fluoride	0.5	0.92	.679	.135
Silica(as SiO2)	9.3	12	10.344	.977
TDS-180°C	1036	1150	1099.333	35.377
Conductivity (µmhos)	1550	1920	1773.75	105.116
Alkalinity(as CaCO3)	316	332	326.422	5.473
pH (standard units)	7.8	8.52	8.148	.207
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	<10	3.484	3.146
Barium	<100	<100	100	0
Boron	900	1020	953	45.473
Cadmium	<1	12	3.182	3.995
Chromium	1	5	3.5	1.958
Cobalt	<1	2.46	1.406	.639
Copper	<1	<10	7.045	3.798
Iron	17	80	47.364	17.856
Lead	<5	<5	5	0
Manganese	4.5	<100	34.318	42.351
Mercury	<0.1	0.3	.178	.067
Molybdenum	4.09	33	18.209	8.557
Nickel	<2	<10	6.75	4.091
Selenium	<1	34.1	7.814	12.257
Vanadium	5	<10	8.857	2.035
Zinc	<10	110	37	38.938
Uranium (as U)	65	2400	627.8	873.641
Radium-226(pCi/l)	193	619	366.04	119.684

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RC-5
Sample Type: REGIONAL BASELINE WELL
Formation: CHADRON

Surface Elevation: 3903.4 ft. MSL
Well Depth: 646 ft.
Distance from Wellfield: 4000 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	15.8	20.9	18.3	1.446
Magnesium	2.1	3.2	2.845	.406
Sodium	360	393	378.8	10.369
Potassium	10	11	10.456	.448
Carbonate	<1	<2	1.4	.548
Bicarbonate	350	380	366.222	10.923
Sulfate	289	370	340.182	25.187
Chloride	168.6	190	178.77	6.527
Ammonia-N	0.19	0.38	.302	.053
Nitrite-N	<.001	0.03	.013	.011
trate-N	<0.01	<0.1	.047	.042
uoride	0.5	0.72	.62	.068
lica(as SiO2)	9.8	13	11.933	1.507
TDS-180°C	1063	1158	1115.5	27.375
Conductivity (µmhos)	1711	1950	1823.909	67.811
Alkalinity(as CaCO3)	290	321	306.122	8.317
pH (standard units)	7.98	8.4	8.143	.158
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<25	200	111.768	51.143
Arsenic	<1	<10	3.983	3.364
Barium	<100	<100	100	0
Boron	800	<1000	902.222	82.882
Cadmium	<1	<1	1	0
Chromium	1	5	3.667	2
Cobalt	<1	<5	2.06	1.722
Copper	<1	<10	6.65	3.697
Iron	26	80	47.944	17.601
Lead	<5	11	7.65	2.495
Manganese	5	<100	34.45	45.261
Mercury	<0.1	<0.3	.175	.071
olybdenum	0.83	10	7.104	3.443
ckel	<1	20	7.333	6.225
lenium	<1	<2	1.429	.535
Vanadium	1	<10	7.143	4.018
Zinc	10	16	11.556	2.603
Uranium (as U)	<1	3	1.625	.916
Radium-226(pCi/l)	2.8	3.8	3.271	.325

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RC-6
Sample Type: REGIONAL BASELINE WELL
Formation: CHADRON

Surface Elevation: 3945.2 ft. MSL
Well Depth: 738 ft.
Distance from Wellfield: 3500 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	30	41	36.414	3.643
Magnesium	5.1	7.2	6.329	.697
Sodium	380	444	409.143	24.327
Potassium	13	18	15.643	1.978
Carbonate	<1	<2	1.5	.577
Bicarbonate	310	340	326.667	11.361
Sulfate	418	470	442.333	19.325
Chloride	190	250	211.914	22.818
Ammonia-N	0.30	0.58	.387	.105
Nitrite-N	<0.01	<0.01	.01	0
Nitrate-N	0.01	<0.1	.057	.038
Fluoride	0.7	0.71	.703	5E-03
Silica(as SiO2)	16	16	16	0
TDS-180°C	1174	1310	1251.571	58.172
Conductivity (µmhos)	1970	2032	1994.5	27.083
Alkalinity(as CaCO3)	250	285	272.6	13.74
pH (standard units)	7.6	8.4	8.036	.265
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<25	<100	81.453	31.233
Arsenic	5	13.44	8.288	3.577
Barium	<100	<100	100	0
Boron	700	1160	973.333	162.317
Cadmium	1	16.0	5.833	6.178
Chromium	1	6	3.4	2.302
Cobalt	<1	<1	1	0
Copper	2	<10	4.917	3.584
Iron	<50	<50	50	1E-03
Lead	<5	14.5	9.75	4.144
Manganese	8	<100	57.167	47.288
Mercury	<0.1	<0.1	.1	0
Molybdenum	3.08	32	16.616	12.032
Nickel	<2	<2	2	0
Selenium	<2	53	17.613	21.932
Vanadium	2	8	5.333	3.055
Zinc	9	157	55	59.296
Uranium (as U)	<1	6	2.6	2.074
Radium-226(pCi/l)	0.2	0.6	.35	.191

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:RC-7
Sample Type: REGIONAL BASELINE WELL
Formation: CHADRON

Surface Elevation: 4038.8 ft. MSL
Well Depth: 774 ft.
Distance from Wellfield: 7500 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	13	25	18.669	2.845
Magnesium	1.8	4	2.907	.683
Sodium	340	363	350.917	6.037
Potassium	10.1	14	11.485	1.167
Carbonate	<1	9	3.575	3.165
Bicarbonate	308	375	348.967	21.071
Sulfate	254	330	294.231	19.93
Chloride	160	180	170.692	5.774
Ammonia-N	0.03	0.46	.265	.164
Nitrite-N	<.001	<0.02	8E-03	6E-03
Nitrate-N	0.01	0.2	.058	.067
Fluoride	0.66	0.92	.783	.074
Silica(as SiO2)	11.7	16	14.028	1.323
TDS-180°C	958	1136	1042.231	48.999
Conductivity (µmhos)	1500	1800	1655.231	84.698
Alkalinity(as CaCO3)	267	315	295.255	12.725
pH (standard units)	7.77	8.5	8.155	.215
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<1	<10	3.612	3.189
Barium	<100	<100	100	0
Boron	800	1040	948	75.836
Cadmium	<1	<1	1	0
Chromium	1	6	4.045	1.981
Cobalt	<1	<5	2.677	1.8
Copper	<1	<10	7.2	3.594
Iron	<50	60	52.813	4.519
Lead	<5	13	6.958	2.988
Manganese	4.5	<100	30.375	42.022
Mercury	<0.1	0.34	.195	.077
Molybdenum	3.98	22	15.089	6.583
Nickel	<2	20	8.2	5.534
Selenium	<1	<2	1.444	.527
Vanadium	2	<10	7.444	3.321
Zinc	4	10	8.125	2.642
Uranium (as U)	1	6	2.4	1.713
Radium-226(pCi/l)	0.3	2.3	1.1	.786

PREOPERATIONAL AND

OPERATIONAL WELL DATA

Sampling Periods and Number of Samples used in the Statistical Evaluation of Water Quality Data from Wells in the Crow Butte Commercial Study Area

Water Quality Wells Used for Preoperational and Operational Data Collection

Well No.	Formation	Sampling Period	No. of Samples
OB-1(PT-4)	Chadron	11/85 - 12/85	4
OB-2(PT-6)	Chadron	11/85 - 12/85	4
W.F.Domestic	Brule	07/86 - 04/87	7
PT-2	Chadron	12/82 - 12/85	11
3	Chadron	11/85 - 12/85	4
5	Chadron	11/85 - 12/85	4
7	Chadron	12/82 - 12/85	11
8	Chadron	12/82 - 12/85	8
9	Chadron	12/82 - 04/84	7
21	Chadron	11/85 - 12/85	4
22	Chadron	11/85 - 12/85	4
23	Chadron	11/85 - 12/85	4
24	Chadron	11/85 - 12/85	4
25	Chadron	11/85 - 12/85	4
PM-1	Chadron	12/82 - 04/87	12
2	Chadron	11/85 - 04/87	8
3	Chadron	11/85 - 04/87	8
4	Chadron	12/82 - 04/87	12
5	Chadron	11/85 - 04/87	8
6	Brule	12/82 - 04/87	15
7	Brule	01/83 - 04/87	16
8	Chadron	11/85 - 04/87	9
9	Chadron	11/85 - 04/87	9
10	Chadron	11/85 - 04/87	8
11	Brule	11/85 - 04/87	8

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: OB-1
Sample Type: OBSERVATION WELL
Formation: CHADRON

Surface Elevation: 3859.6 ft. MSL
Well Depth: 676 ft.
Distance from Wellfield: 45 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	10.5	14	12.425	1.464
Magnesium	2.9	3.2	3.033	.153
Sodium	392	408	400.75	7.182
Potassium	12	12.7	12.25	.311
Carbonate	8.9	8.9	8.9	0
Bicarbonate	315.2	359.2	337.75	18.005
Sulfate	338	348	342	5.292
Chloride	191	208	199.75	6.946
Ammonia-N	0.15	0.45	.32	.129
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	0.02	0.08	.05	.024
Fluoride	0.65	0.76	.703	.048
Silica(as SiO_2)	10.9	15.4	12.325	2.109
TDS-180°C	1086	1165	1121.25	33.12
Conductivity (µmhos)	1790	1837	1813.75	20.023
Alkalinity(as $CaCO_3$)	273.6	310.0	294.2	15.369
pH (standard units)	8.52	8.52	8.52	0
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	<1	3	1.75	.957
Barium	<100	<100	100	0
Boron	800	980	870	80.829
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	11	11	11	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	10	20	15	5.774
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	<10	10	0
Uranium (as U)	66	101	81	14.855
Radium-226(pCi/l)	17.8	33.1	27.7	6.786

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:OB-2
Sample Type: OBSERVATION WELL
Formation: CHADRON

Surface Elevation: 3863.3 ft. MSL
Well Depth: 677 ft.
Distance from Wellfield: 95 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	14.8	16	15.233	.666
Magnesium	3.0	6	3.998	1.378
Sodium	385	412	396.25	11.442
Potassium	11	11.5	11.25	.208
Carbonate	4.7	4.7	4.7	0
Bicarbonate	364	376.4	371.25	5.788
Sulfate	345	347	346	1
Chloride	185	185	185	0
Ammonia-N	0.17	0.45	.305	.115
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	<0.01	<0.05	.03	.016
Fluoride	0.51	0.72	.643	.092
Silica(as SiO2)	10.0	13.5	12	1.472
TDS-180°C	1148	1182	1162	14.514
Conductivity (µmhos)	1780	1855	1827.25	35.141
Alkalinity(as CaCO3)	307.7	315	310.425	3.269
pH (standard units)	8.22	8.42	8.298	.088
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	<1	<1	1	0
Barium	<100	<100	100	0
Boron	870	980	917.5	48.563
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	50	37.5	9.574
Lead	<5	<5	5	0
Manganese	<5	25	16.5	8.963
Mercury	<0.2	<0.2	.2	0
Molybdenum	10	20	15	5.774
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	10	10	10	0
Uranium (as U)	54	93	69.5	16.823
Radium-226(pCi/l)	53	70.3	64.6	7.97

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WELLFIELD DOMESTIC
Sample Type: PRIVATE WELL
Formation: BRULE

Surface Elevation: 3665 ft. MSL
Well Depth: 60 ft.
Distance from Wellfield: 300 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	54.7	59.4	56.8	2.045
Magnesium	6.4	11	8.329	2.002
Sodium	9.4	14.7	12.286	1.786
Potassium	3.8	4.8	4.3	.396
Carbonate				
Bicarbonate	203	222	214.167	7.885
Sulfate	4.1	12.9	9.243	3.089
Chloride	0.81	14	5.387	5.259
Ammonia-N	<0.05	0.57	.184	.213
Nitrite-N	0.001	<0.01	5E-03	4E-03
Nitrate-N	3.83	4.80	4.383	.409
Fluoride	0.33	0.51	.44	.071
Silica(as SiO2)	54.0	61.3	57.333	2.839
TDS-180°C	231	292	269.5	26.681
Conductivity (µmhos)	381	396	390	5.404
Alkalinity(as CaCO3)	166	185	176.167	7.36
pH (standard units)	7.70	8.18	7.901	.189
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<1	6	3.143	1.574
Barium	<30	210	151.429	73.808
Boron	30	280	136.429	82.296
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	20	<30	27.143	4.88
Lead	<5	<5	5	0
Manganese	<5	<10	6.429	2.44
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	29	134	71.143	46.535
Uranium (as U)	1	11	5.571	3.645
Radium-226(pCi/l)	<0.1	2.3	.943	.757

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-2
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3864.9 ft. MSL
Well Depth: 665 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	7.6	15	10.155	2.305
Magnesium	2	3.6	2.61	.549
Sodium	390	439	411.364	13.002
Potassium	13.1	18	16.21	1.598
Carbonate	<1	14	5.37	4.456
Bicarbonate	337	386	360.2	16.285
Sulfate	329	370	350	11.216
Chloride	188	222	203.918	11.119
Ammonia-N	0.15	0.64	.357	.141
Nitrite-N	<.001	<0.01	8E-03	4E-03
Nitrate-N	<0.01	0.11	.079	.033
Fluoride	0.48	0.7	.596	.065
Silica(as SiO2)	10.1	16	13.441	1.9
TDS-180°C	1100	1220	1172.091	39.351
Conductivity (µmhos)	1675	2050	1857.818	128.236
Alkalinity(as CaCO3)	287	326	308.036	13.694
pH (standard units)	8.06	8.6	8.293	.154
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<1	<10	4.7	2.541
Barium	<100	<100	100	0
Boron	770	1130	927	103.607
Cadmium	<1	<1	1	0
Chromium	<1	<5	4.111	1.764
Cobalt	<1	9	5	2.309
Copper	3	<10	8.556	2.877
Iron	20	<50	35.5	11.045
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	<0.1	<0.3	.2	.067
Molybdenum	<10	24	16.111	5.925
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	10	10	10	0
Zinc	<5	10	9	2
Uranium (as U)	230	933	479.182	206.083
Radium-226(pCi/l)	20.0	68.1	43.85	14.08

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-3
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3864 EST. ft. MSL
Well Depth: 670 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	10.4	14	12.675	1.569
Magnesium	2.70	3.1	2.837	.228
Sodium	361	385	376.25	10.874
Potassium	10.8	11.6	11.225	.386
Carbonate	7.1	10.8	8.6	1.947
Bicarbonate	326.6	334.7	330.6	4.051
Sulfate	284	324	308	16.971
Chloride	189	191	190	1
Ammonia-N	0.14	0.51	.32	.154
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	0.01	<0.05	.025	.019
Fluoride	0.70	0.72	.713	.012
Silica(as SiO2)	12.5	13.87	12.968	.625
TDS-180°C	1062	1110	1086	24.495
Conductivity (µmhos)	1660	1699	1681.5	16.135
Alkalinity(as CaCO3)	284.2	286.1	285.275	.854
pH (standard units)	8.38	8.60	8.475	.093
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	1	<10	5	3.742
Barium	<100	<100	100	0
Boron	820	910	877.5	40.311
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	<10	6.75	2.363
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	30	17.5	9.574
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	<10	10	0
Uranium (as U)	130	173	145.75	19.619
Radium-226(pCi/l)	46	67.2	56.925	9.458

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-5
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3862 EST. ft. MSL
Well Depth: 670 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	5.7	10.8	8.225	2.301
Magnesium	1.4	3	2.345	.68
Sodium	423	499	464.75	36.737
Potassium	14.1	17	15.425	1.261
Carbonate	9.4	24	17.4	7.048
Bicarbonate	268	334.8	305.025	30.203
Sulfate	341	348	344	3.606
Chloride	234	395	316.5	78.505
Ammonia-N	0.22	0.57	.388	.143
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	<0.01	0.07	.04	.026
Fluoride	0.64	0.70	.667	.031
Silica(as SiO_2)	10.1	12.5	11.413	1.077
TDS-180°C	1172	1420	1301.5	121.099
Conductivity (µmhos)	1903	2400	2136	229.122
Alkalinity(as $CaCO_3$)	260	303.0	279.125	20.845
pH (standard units)	8.36	8.72	8.535	.147
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	<1	<1	1	0
Barium	<100	<100	100	0
Boron	720	1020	885	126.095
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	<10	7	2.449
Mercury	<0.2	<0.2	.2	0
Molybdenum	10	10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	20	20	20	0
Uranium (as U)	79	100	87	9.487
Radium-226(pCi/l)	260	612	467.8	166.037

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: PT-7
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3868.3 ft. MSL
Well Depth: 672 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	11.1	20	15.636	2.235
Magnesium	2.6	4.1	3.64	.476
Sodium	390	419	403.4	9.18
Potassium	9.0	15	11.836	1.722
Carbonate	<1	10	4.044	3.494
Bicarbonate	345	390	373	14.553
Sulfate	337	380	354	12.174
Chloride	166	194	182.145	8.822
Ammonia-N	0.08	0.52	.323	.135
Nitrite-N	<0.01	<0.01	.01	0
Nitrate-N	<0.01	<0.1	.068	.041
Fluoride	0.5	0.7	.626	.058
Silica(as SiO2)	12.0	16	14.464	1.236
TDS-180°C	1078	1220	1144	41.96
Conductivity (µmhos)	1510	1960	1783	125.869
Alkalinity(as CaCO3)	291.0	337	315.891	12.936
pH (standard units)	8.1	8.4	8.275	.117
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	<10	4.4	3.406
Barium	<100	<100	100	0
Boron	790	1100	938.889	104.217
Cadmium	0.4	<10	2.74	3.831
Chromium	<1	<10	4.444	2.698
Cobalt	<1	10	4.5	3.332
Copper	3	<10	8	3.041
Iron	10	<50	36	13.565
Lead	<1	<10	5.6	2.633
Manganese	<5	<100	25.9	39.094
Mercury	<0.1	<0.3	.19	.074
Molybdenum	10	<100	33.5	35.419
Nickel	<2	<50	16.4	18.007
Selenium	<1	<10	3	3.712
Vanadium	4	20	10.625	4.984
Zinc	<10	17	11.875	2.8
Uranium (as U)	64	314	150.3	85.781
Radium-226(pCi/l)	66	379	160.355	106.27

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-8
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3870.0 ft. MSL
Well Depth: 674 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	8.4	20	14.8	3.257
Magnesium	1.24	3.6	2.765	.767
Sodium	380	402	392.75	9.301
Potassium	11	13	12.243	.716
Carbonate	<1	15	7.775	6.365
Bicarbonate	332.8	379	358.1	14.167
Sulfate	334	360	347.25	7.978
Chloride	175.9	180	178	1.686
Ammonia-N	0.22	0.55	.399	.114
Nitrite-N	0.01	0.01	.01	0
Nitrate-N	<0.01	0.2	.085	.06
Fluoride	0.5	0.7	.599	.054
Silica(as SiO2)	14.4	19	16.525	1.585
TDS-180°C	1100	1190	1143.25	32.159
Conductivity (µmhos)	1510	1960	1787.25	143.394
Alkalinity(as CaCO3)	287.3	324	310.288	11.806
pH (standard units)	8.14	8.62	8.368	.183
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	<10	4.571	2.878
Barium	<100	<100	100	0
Boron	800	1140	947.143	105.469
Cadmium	<1	<1	1	0
Chromium	<1	<5	3.667	2.066
Cobalt	<5	<5	5	0
Copper	5	<10	8.667	2.16
Iron	10	<50	33	14.629
Lead	<1	<10	5.143	2.61
Manganese	<5	<5	5	0
Mercury	<0.1	<0.3	.186	.069
Molybdenum	<10	30	18.5	7.583
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	13	10.833	1.329
Zinc	5	27	13.143	7.581
Uranium (as U)	113	322	201.875	74.311
Radium-226(pCi/l)	73	151	104.6	27.02

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-9
Sample Type: R&D BASELINE WELL
Formation: CHADRON

Surface Elevation: 3868.6 ft. MSL
Well Depth: 680.2 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	10	17	13	2.449
Magnesium	1.57	2.8	2.126	.405
Sodium	390	420	407.714	11.572
Potassium	12	15	13.429	1.134
Carbonate	<1	24	13.857	9.424
Bicarbonate	341	379	358	12.097
Sulfate	333	367	351.714	13.225
Chloride	180	196	186.6	5.693
Ammonia-N	0.18	0.82	.443	.211
Nitrite-N	<0.01	<0.01	.01	0
Nitrate-N	<0.01	<0.1	.074	.044
Fluoride	0.6	0.7	.656	.052
Silica(as SiO2)	13	21	16.143	2.61
TDS-180°C	1134	1240	1176.286	35.293
Conductivity (µmhos)	1820	1990	1911.667	77.309
Alkalinity(as CaCO3)	310	336	323.857	8.474
pH (standard units)	8.29	8.82	8.604	.198
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	<1	14	7	4.517
Barium	100	100	100	0
Boron	700	1150	943.333	151.349
Cadmium	<1	<1	1	0
Chromium	<1	<5	3.4	2.191
Cobalt	<5	<5	5	0
Copper	4	17	9.333	4.633
Iron	20	90	46.167	24.417
Lead	<5	<5	5	0
Manganese	<5	<10	6.8	2.168
Mercury	<0.1	<0.3	.2	.089
Molybdenum	<10	<100	47.667	35.702
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	30	30	30	0
Zinc	<5	<10	8.25	2.363
Uranium (as U)	229	441	304	82.15
Radium-226(pCi/l)	207	602	420.429	145.263

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-21
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3885 EST. ft. MSL
Well Depth: 685 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	15.6	16.4	16.025	.33
Magnesium	3.49	5	3.993	.694
Sodium	381	403	393	9.201
Potassium	10	13.5	11.2	1.606
Carbonate	2.4	10	5.7	3.897
Bicarbonate	351	369.7	363.325	8.598
Sulfate	343	352	348.333	4.726
Chloride	184	195	188.25	4.992
Ammonia-N	0.19	0.40	.285	.087
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	0.02	<0.05	.03	.014
Fluoride	0.62	0.85	.703	.104
Silica(as SiO2)	12.0	14.0	12.85	.85
TDS-180°C	1148	1178	1164.5	13.304
Conductivity (µmhos)	1767	1786	1777.25	10.178
Alkalinity(as CaCO3)	303.0	306.2	305.1	1.51
pH (standard units)	8.29	8.36	8.323	.033
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	<1	<5	2.25	1.893
Barium	<100	<100	100	0
Boron	900	1100	972.5	87.702
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	7	6	.816
Mercury	<0.2	<0.2	.2	0
Molybdenum	20	20	20	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	<10	10	0
Uranium (as U)	129	134	131.25	2.217
Radium-226(pCi/l)	1315	1541	1436.75	109.217

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-22
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3885 EST. ft. MSL
Well Depth: 681 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	15.6	16	15.833	.208
Magnesium	3.36	3.5	3.423	.071
Sodium	381	396	389.5	6.856
Potassium	10	11.1	10.433	.586
Carbonate	0.9	14	6.067	6.974
Bicarbonate	367.8	374.5	371.767	3.516
Sulfate	304	356	336.5	23.685
Chloride	176	186	181.25	4.272
Ammonia-N	0.20	0.45	.338	.103
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	<0.01	0.06	.033	.026
Fluoride	0.65	0.74	.688	.045
Silica(as SiO2)	10.9	13.7	12.525	1.179
TDS-180°C	1120	1120	1120	0
Conductivity (µmhos)	1710	1786	1750.75	33.079
Alkalinity(as CaCO3)	296	306.9	302.875	4.943
pH (standard units)	8.22	8.40	8.315	.075
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	<1	5	2.5	1.915
Barium	<100	<100	100	0
Boron	900	950	930	26.458
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	13	7.75	3.594
Mercury	<0.2	<0.2	.2	0
Molybdenum	20	20	20	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	20	15	5.774
Uranium (as U)	61	88	72.25	11.442
Radium-226(pCi/l)	674	1124	955.5	204.344

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-23
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3886 EST. ft. MSL
Well Depth: 685 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	14.4	15.7	15.175	.602
Magnesium	3.22	5	3.945	.826
Sodium	383	410	392.75	11.843
Potassium	10	10.8	10.5	.383
Carbonate	0.9	0.9	.9	0
Bicarbonate	371.6	371.6	371.6	0
Sulfate	328	346	339.25	7.89
Chloride	181	187	184.75	2.63
Ammonia-N	0.35	0.38	.363	.015
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	<0.01	0.21	.085	.087
Fluoride	0.57	0.72	.648	.062
Silica(as SiO2)	10.9	14.2	12.65	1.358
TDS-180°C	1106	1144	1122	15.916
Conductivity (µmhos)	1730	1807	1766.25	32.796
Alkalinity(as CaCO3)	304.6	304.6	304.6	0
pH (standard units)	8.21	8.34	8.288	.055
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	1	1	1	0
Barium	<100	<100	100	0
Boron	900	1090	967.5	83.815
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	30	30	30	0
Lead	<5	<5	5	0
Manganese	6	6	6	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	20	20	20	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	10	10	10	0
Uranium (as U)	71	99	82.75	11.899
Radium-226(pCi/l)	23	45.7	35.825	10.113

FERRET EXPLORATION CO OF NEBRASKA
CBR-014

CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-24
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3881 EST. ft. MSL
Well Depth: 670 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	10.4	13.9	12.45	1.484
Magnesium	3.12	5	3.81	.866
Sodium	416	426	421	5
Potassium	11.9	13.4	12.925	.709
Carbonate	3.3	16.7	8.45	6.288
Bicarbonate	342	358.2	349.85	6.904
Sulfate	300	350	327.25	23.343
Chloride	231	245	239	7.211
Ammonia-N	0.17	0.40	.328	.109
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	<0.01	0.13	.06	.05
Fluoride	0.66	0.74	.695	.041
Silica(as SiO2)	11.4	14.2	12.75	1.156
TDS-180°C	1206	1270	1232.5	27.875
Conductivity (µmhos)	1879	1951	1912.75	29.511
Alkalinity(as CaCO3)	294.0	312.4	300.8	8.088
pH (standard units)	8.26	8.42	8.36	.069
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	1	<5	2.25	1.893
Barium	<100	<100	100	0
Boron	890	1070	955	79.373
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	20	20	20	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	10	10	10	0
Uranium (as U)	51	64	56.75	5.909
Radium-226(pCi/l)	1298	1426	1346.5	55.961

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PT-25
Sample Type: INJECTION/RECOVERY WELL
Formation: CHADRON

Surface Elevation: 3886 EST. ft. MS_
Well Depth: 678 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	10.9	14	12.8	1.334
Magnesium	2.45	2.78	2.643	.172
Sodium	389	392	390.333	1.528
Potassium	11	15.4	12.425	2.04
Carbonate	6.6	24	13.175	7.635
Bicarbonate	317	348.6	334.275	14.615
Sulfate	300	350	330.25	22.157
Chloride	191	211	199.5	8.505
Ammonia-N	0.21	0.36	.298	.065
Nitrite-N	<.001	<.001	1E-03	0
Nitrate-N	0.03	0.08	.048	.024
Fluoride	0.68	0.85	.743	.076
Silica(as SiO2)	12.5	14.8	13.375	1.005
TDS-180°C	1124	1164	1142	16.573
Conductivity (µmhos)	1770	1821	1794.75	21.407
Alkalinity(as CaCO3)	289.7	300	295.975	4.413
pH (standard units)	8.38	8.64	8.52	.11
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum				
Arsenic	<1	<5	2.25	1.893
Barium	<100	<100	100	0
Boron	940	940	940	0
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	20	20	20	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	<10	10	0
Uranium (as U)	183	245	208	27.043
Radium-226(pCi/l)	338	380	357.65	18.329

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-1
Sample Type: MONITOR WELL
Formation: CHADRON

Surface Elevation: 3877.1 ft. MSL
Well Depth: 674 ft.
Distance from Wellfield: 220 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	11	17	14.117	2.081
Magnesium	1.9	4.1	2.998	.734
Sodium	387	440	408.25	15.978
Potassium	9.6	18	13.858	3.171
Carbonate	<1	13	7.056	5.105
Bicarbonate	357	387	370.836	9.209
Sulfate	330	380	357.333	14.259
Chloride	173	215.1	192.15	13.722
Ammonia-N	0.10	0.71	.353	.165
Nitrite-N	<.001	<0.01	8E-03	3E-03
Nitrate-N	<0.01	<0.1	.049	.045
Fluoride	0.48	0.8	.611	.093
Silica(as SiO2)	12.1	16.5	14.175	1.284
TDS-180°C	1134	1260	1189.5	36.401
Conductivity (µmhos)	1825	2040	1906.667	69.58
Alkalinity(as CaCO3)	285	342	315.192	19.187
pH (standard units)	8.15	8.7	8.358	.173
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	<5	2.2	1.751
Barium	<100	<100	100	0
Boron	800	1060	947.273	81.128
Cadmium	<1	<1	1	0
Chromium	<1	<5	4.2	1.687
Cobalt	<5	<5	5	0
Copper	5	<10	9.091	2.023
Iron	20	<50	33	9.487
Lead	<1	<10	5.455	2.339
Manganese	4	<10	6.6	1.838
Mercury	<0.1	<0.3	.2	.063
Molybdenum	<10	24	17.4	5.254
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<5	200	66.091	79.386
Uranium (as U)	20	106	54	25.042
Radium-226(pCi/l)	40	163.5	95.15	51.637

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-2
Sample Type: MONITOR WELL
Formation: CHADRON

Surface Elevation: 3883.1 ft. MSL
Well Depth: 685 ft.
Distance from Wellfield: 190 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	17.1	19	17.829	.65
Magnesium	3.6	6	4.529	.736
Sodium	382	408	394.25	7.888
Potassium	9.7	13.4	11.513	1.164
Carbonate	3.7	3.7	3.7	0
Bicarbonate	338	372	361.413	12.213
Sulfate	335	374	352.143	15.378
Chloride	177	212	193.125	11.618
Ammonia-N	0.13	0.42	.325	.101
Nitrite-N	<.001	0.01	4E-03	4E-03
Nitrate-N	0.01	<0.05	.021	.016
Fluoride	0.57	0.72	.673	.051
Silica(as SiO2)	8.9	13.5	11.738	1.434
TDS-180°C	1136	1201	1162.875	21.788
Conductivity (µmhos)	1835	1894	1864.143	21.698
Alkalinity(as CaCO3)	283	305	298.45	8.186
pH (standard units)	8.06	8.37	8.196	.102
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<1	<1	1	0
Barium	<100	<100	100	0
Boron	880	980	910	35.051
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	10	7.75	1.389
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	20	16	5.014
Nickel	<10	<10	10	0
Selenium	1	1	1	0
Vanadium	<10	<10	10	0
Zinc	10	240	111.25	109.21
Uranium (as U)	6	44	27.625	13.783
Radium-226(pCi/l)	3.5	5.3	4.114	.679

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: PM-3
Sample Type: MONITOR WELL
Formation: CHADRON

Surface Elevation: 3863.7 ft. MSL
Well Depth: 664 ft.
Distance from Wellfield: 165 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	8.1	18.0	13.15	3.31
Magnesium	2.6	4.5	3.526	.68
Sodium	387	481	428.125	35.555
Potassium	10.4	17.3	13.85	2.78
Carbonate	4.0	29	13.08	9.829
Bicarbonate	293	359	337.563	21.932
Sulfate	338	359	348.286	8.015
Chloride	180	335	246.125	57.432
Ammonia-N	0.14	0.45	.343	.1
Nitrite-N	<.001	<0.01	4E-03	4E-03
Nitrate-N	<0.01	0.06	.021	.021
Fluoride	0.66	0.74	.692	.03
Silica(as SiO2)	10.9	12.8	11.778	.69
TDS-180°C	1126	1322	1233.125	75.38
Conductivity (µmhos)	1866	2100	1960.75	96.368
Alkalinity(as CaCO3)	285	294	290.438	2.809
pH (standard units)	8.18	8.76	8.4	.202
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<1	4	1.857	1.215
Barium	<100	<100	100	0
Boron	880	960	912.857	24.976
Cadmium	1	1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	20	15.875	4.97
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	70	39.5	25.45
Uranium (as U)	13	58	36.5	13.416
Radium-226(pCi/l)	5.0	23.0	14.913	6.809

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-4
Sample Type: MONITOR WELL
Formation: CHADRON

Surface Elevation: 3862.5 ft. MSL
Well Depth: 674 ft.
Distance from Wellfield: 300 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	12.1	16.6	14.75	1.291
Magnesium	2.85	4.0	3.288	.326
Sodium	390	410	399.917	7.879
Potassium	9.2	14	11.233	1.354
Carbonate	<1	<1	1	0
Bicarbonate	338	399	371.825	16.893
Sulfate	333	370	354.417	11.188
Chloride	170	196	182.35	7.945
Ammonia-N	0.06	0.49	.367	.137
Nitrite-N	<.001	<0.01	8E-03	3E-03
Nitrate-N	<0.01	<0.1	.048	.046
Fluoride	0.5	0.72	.645	.07
Silica(as SiO2)	11.0	18	14.508	2.162
TDS-180°C	1100	1250	1153.5	46.643
Conductivity (µmhos)	1790	1980	1866.909	60.688
Alkalinity(as CaCO3)	284	337	311.533	15.739
pH (standard units)	8.05	8.6	8.227	.164
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	<5	2.2	1.751
Barium	<100	<100	100	0
Boron	870	1050	971	61.364
Cadmium	<1	<1	1	0
Chromium	<1	<5	4.2	1.687
Cobalt	<5	<5	5	0
Copper	4	<10	8.909	2.427
Iron	30	<50	34.909	8.549
Lead	<5	<5	5	0
Manganese	5	14	10	2.494
Mercury	<0.1	<0.3	.209	.07
Molybdenum	<10	23	18	4.546
Nickel	<10	<10	10	0
Selenium	<1	<2	1.222	.441
Vanadium	<10	<10	10	0
Zinc	5	230	88.727	101.436
Uranium (as U)	8	36	19.583	8.207
Radium-226(pCi/l)	35	95.9	61.508	18.436

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-5
Sample Type: MONITOR WELL
Formation: CHADRON

Surface Elevation: 3868.6 ft. MSL
Well Depth: 695 ft.
Distance from Wellfield: 280 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	9.8	17.0	14.288	2.281
Magnesium	3.2	4.1	3.649	.348
Sodium	393	416	402.429	8.658
Potassium	9.5	13	11.425	1.234
Carbonate	2.4	19	8.4	9.207
Bicarbonate	340	374.0	358.286	11.313
Sulfate	348	371	359	7.979
Chloride	175	235	198.375	20.17
Ammonia-N	<0.05	0.64	.388	.204
Nitrite-N	<.001	<0.01	4E-03	4E-03
Nitrate-N	<0.01	0.07	.029	.026
Fluoride	0.62	0.74	.678	.045
Silica(as SiO2)	10.9	12.8	11.774	.804
TDS-180°C	1104	1236	1165.25	49.477
Conductivity (µmhos)	1820	1907	1874.375	26.896
Alkalinity(as CaCO3)	285	306.5	294.2	7.325
pH (standard units)	8.05	8.38	8.226	.122
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<1	<1	1	0
Barium	<100	<100	100	0
Boron	880	1020	936.25	48.088
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	10	6.125	2.1
Manganese	5	6	5.286	.488
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	20	17	4.536
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	190	104.375	81.128
Uranium (as U)	12	53	35.429	14.199
Radium-226(pCi/l)	285	329.7	305.829	16.358

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-6
Sample Type: MONITOR WELL
Formation: BRULE

Surface Elevation: 3869.5 ft. MSL
Well Depth: 217 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	2.3	4.9	3.599	.916
Magnesium	0.13	0.26	.192	.036
Sodium	90.7	100	96.273	3.184
Potassium	6.7	10	8.527	.792
Carbonate	<1	24	9.179	6.811
Bicarbonate	190	210	200.923	4.931
Sulfate	33.9	44	37.64	2.706
Chloride	1.9	12.3	7.24	3.57
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	0.02	.01	6E-03
Nitrate-N	0.46	1.76	1.28	.374
Fluoride	0.39	0.5	.458	.042
Silica(as SiO2)	59	69	64.286	2.698
TDS-180°C	276	363	321.533	19.799
Conductivity (µmhos)	425	480	445.267	16.228
Alkalinity(as CaCO3)	166	195	178.947	8.485
pH (standard units)	8.20	8.9	8.543	.181
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	4	13	8.571	2.344
Barium	<100	<100	100	0
Boron	90	140	114	17.764
Cadmium	<0.1	<10	2.507	3.293
Chromium	2	14	6.231	3.516
Cobalt	<1	<5	3.667	2.066
Copper	4	<10	8.667	2.462
Iron	<10	110	55.714	31.062
Lead	<1	<10	5.5	2.21
Manganese	<1	<100	19.071	34.357
Mercury	<0.02	<0.3	.194	.079
Molybdenum	2	<100	21.429	33.408
Nickel	<2	<50	14.571	15.281
Selenium	1	<10	2.5	3.205
Vanadium	7	<10	9.333	1.231
Zinc	60	290	175	64.031
Uranium (as U)	<1	13	7.133	3.681
Radium-226(pCi/l)	<0.1	1.7	.926	.455

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-7
Sample Type: MONITOR WELL
Formation: BRULE

Surface Elevation: 3868.9 ft. MSL
Well Depth: 129 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	13	33	23.419	6.049
Magnesium	0.13	1	.575	.226
Sodium	61.6	72	66.588	2.487
Potassium	15.0	21	18.806	1.736
Carbonate	<1	18	8.436	5.848
Bicarbonate	166	266	228.744	26.588
Sulfate	5	9.6	7.244	1.497
Chloride	2.1	12	6.7	3.111
Ammonia-N	<0.05	0.07	.053	7E-03
Nitrite-N	0.001	0.03	.011	.01
Nitrate-N	1.6	2.9	2.329	.422
Fluoride	0.2	0.4	.274	.059
Silica(as SiO2)	53.7	59	56.82	1.603
TDS-180°C	248	354	305.375	27.41
Conductivity (µmhos)	365	540	432.125	44.779
Alkalinity(as CaCO3)	177	231	204.306	17.24
pH (standard units)	7.99	8.88	8.423	.232
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	<1	<5	2.083	1.621
Barium	70	210	132.308	44.563
Boron	<10	200	99.667	55.739
Cadmium	<1	<1	1	0
Chromium	<5	11	6.333	2.188
Cobalt	<5	<5	5	0
Copper	<10	<10	10	0
Iron	20	<50	32.727	9.045
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	0.1	<0.3	.192	.049
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<5	270	124.923	113.098
Uranium (as U)	8	40	24.5	10.316
Radium-226(pCi/l)	0.1	1.9	.8	.594

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-8
Sample Type: MONITOR WELL
Formation: CHADRON

Surface Elevation: 3884.9 ft. MSL
Well Depth: 670 ft.
Distance from Wellfield: 175 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	8.7	17.4	14.144	2.732
Magnesium	3.1	7	4.253	1.351
Sodium	393	407	398.625	5.999
Potassium	11.3	13.4	12.45	.725
Carbonate	0.9	19	8.3	7.782
Bicarbonate	317	368	349.733	15.691
Sulfate	302	368	341.556	20.057
Chloride	179	216	198.222	10.378
Ammonia-N	0.16	0.65	.386	.136
Nitrite-N	<.001	<0.01	4E-03	4E-03
Nitrate-N	<0.01	0.05	.026	.02
Fluoride	0.51	0.72	.66	.074
Silica(as SiO2)	9.3	13.3	11.7	1.353
TDS-180°C	1080	1207	1148.778	36.352
Conductivity (µmhos)	1800	1894	1854.875	31.809
Alkalinity(as CaCO3)	283	306	294.556	7.668
pH (standard units)	8.16	8.39	8.27	.093
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	<1	<1	1	0
Barium	<100	<100	100	0
Boron	870	940	905	26.726
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	<10	6.889	1.965
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	20	17.333	4.359
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	160	79.556	63.85
Uranium (as U)	12	55	36.333	13.91
Radium-226(pCi/l)	20	115.3	68.067	25.254

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-9
Sample Type: MONITOR WELL
Formation: CHADRON

Surface Elevation: 3888.1 ft. MSL
Well Depth: 678 ft.
Distance from Wellfield: 220 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	9.3	16	12.478	2.397
Magnesium	2.4	5	3.476	.806
Sodium	385	475	416.667	29.875
Potassium	9.6	17.2	12.956	3.045
Carbonate	4.2	15.5	9.64	4.86
Bicarbonate	321.4	370	347.189	14.531
Sulfate	302	350	331.333	15.199
Chloride	174	307	225.444	45.758
Ammonia-N	0.15	0.65	.386	.137
Nitrite-N	<.001	<0.01	4E-03	4E-03
Nitrate-N	<0.01	0.02	.013	5E-03
Fluoride	0.65	0.76	.718	.037
Silica(as SiO2)	10.9	13.8	12.367	1.057
TDS-180°C	1074	1302	1201.222	79.655
Conductivity (µmhos)	1856	1995	1915.375	48.047
Alkalinity(as CaCO3)	280.7	307	293.533	8.043
pH (standard units)	7.94	8.60	8.299	.205
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	1	1	0
Barium	<100	<100	100	0
Boron	880	960	916.444	28.263
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	9	6.222	1.394
Mercury	<0.2	<0.2	.2	0
Molybdenum	10	20	15.111	5.011
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	150	65.444	64.879
Uranium (as U)	20	95	61.111	23.23
Radium-226(pCi/l)	18.9	72.7	46.078	18.93

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:FM-10
Sample Type: MONITOR WELL
Formation: CHADRON

Surface Elevation: 3882.7 ft. MSL
Well Depth: 671 ft.
Distance from Wellfield: 205 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	15.4	18.2	16.529	.898
Magnesium	3.3	5	3.954	.534
Sodium	381	408	389.375	9.62
Potassium	9.7	12.8	10.988	1.036
Carbonate	4.7	5.4	5.1	.361
Bicarbonate	340	372	360.457	10.799
Sulfate	329	356	339.571	9.199
Chloride	173	200	185.375	8.601
Ammonia-N	0.32	0.51	.413	.056
Nitrite-N	<.001	<0.01	5E-03	4E-03
Nitrate-N	<0.01	0.08	.029	.027
Fluoride	0.66	0.78	.709	.037
Silica(as SiO2)	10.9	12.9	12.195	.803
TDS-180°C	1094	1184	1140.125	27.142
Conductivity (µmhos)	1701	1868	1793.125	65.002
Alkalinity(as CaCO3)	288	308.1	300.2	7.831
pH (standard units)	8.03	8.36	8.254	.123
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	1	1	1	0
Barium	<100	<100	100	0
Boron	890	970	930	28.284
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	9	11	9.75	.886
Mercury	<0.2	<0.2	.2	0
Molybdenum	20	20	20	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<10	240	124.75	93.765
Uranium (as U)	18	47	28.375	11.612
Radium-226(pCi/l)	12.5	37.5	22.375	8.314

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:PM-11
Sample Type: MONITOR WELL
Formation: BRULE

Surface Elevation: 3886.2 ft. MSL
Well Depth: 274 ft.
Distance from Wellfield: 0 ft.

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	4.1	7.2	5.575	1.007
Magnesium	0.16	0.60	.373	.142
Sodium	126	136	130.5	4.276
Potassium	8.8	11.9	10.188	1.087
Carbonate	2.9	24	10.663	8.226
Bicarbonate	210	232	222.688	7.137
Sulfate	50.1	53.0	51.7	1.094
Chloride	30.9	39	35.238	2.948
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	5E-03	4E-03
Nitrate-N	0.76	0.85	.804	.032
Fluoride	0.60	0.66	.631	.025
Silica(as SiO2)	67.6	74.9	70.913	2.771
TDS-180°C	390	448	419.75	25.15
Conductivity (µmhos)	563	636	600.25	25.064
Alkalinity(as CaCO3)	183	212	199.588	12.27
pH (standard units)	8.31	8.86	8.584	.195
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	22	30	26.857	3.579
Barium	<100	<100	100	0
Boron	110	130	122.857	7.559
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	<5	<5	5	0
Mercury	<0.2	<0.2	.2	0
Molybdenum	<10	<10	10	0
Nickel	<10	<10	10	0
Selenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	160	230	186.667	25.82
Uranium (as U)	3	14	9.429	4.117
Radium-226(pCi/l)	0.9	1.2	1.1	.141

SURFACE WATER
DATA

Sampling Periods and Number of Samples used in the Statistical Evaluation of Water Quality Data from Streams and Impoundments in the Crow Butte Commercial Study Area

Well ID#	Description	Sampling Period	No. of Samples
I-1	Impoundment	06/82	1
I-2	Impoundment	06/82	1
I-3	Impoundment	06/82	1
I-4	Impoundment	06/82	1
I-5	Impoundment	06/82	1
I-6	Impoundment	06/82 - 05/83	2
I-7	Impoundment	06/82	1
I-8	Impoundment	06/82	1
E-1/E-2	English Creek	04/82 - 10/85	7
E-3	English Creek	04/82 - 07/84	6
WC-1	White Clay Creek	04/82 - 10/85	7
WC-2	White Clay Creek	04/82 - 10/85	8
S-1	Squaw Creek	02/82 - 10/85	11
S-2	Squaw Creek	02/82 - 04/87	19
S-3	Squaw Creek	02/82 - 04/87	19
S-4	Squaw Creek	04/82 - 07/84	6
W-1	White River	02/82 - 10/85	11
W-2	White River	02/82 - 10/82	4
W-3	White River	03/83 - 10/85	8

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: I-1
Distance from Wellfield: 6300 ft.

Sample Type: IMPOUNDMENT SAMPLE
Water System: SQUAW CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	24	24	24	0
Magnesium	1.9	1.9	1.9	0
Sodium	0.5	0.5	.5	0
Potassium	4.7	4.7	4.7	0
Carbonate	<2	2	2	0
Bicarbonate	86	86	86	0
Sulfate	<5	<5	5	0
Chloride	<2	<2	2	0
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<0.02	<0.02	.02	0
Nitrate-N	<0.02	<0.02	.02	0
Fluoride	0.1	0.1	.1	0
Silica(as SiO2)	9.4	9.4	9.4	0
TDS-180°C	87	87	87	0
Conductivity (µmhos)	147	147	147	0
Alkalinity(as CaCO3)	71	71	71	0
pH (standard units)	7.5	7.5	7.5	0
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	2	2	2	0
Barium	100	100	100	0
Boron	500	500	500	0
Cadmium	<1	<1	1	0
Chromium	1	1	1	0
Cobalt	<1	<1	1	0
Copper	1	1	1	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	1	1	1	0
Zinc	2	2	2	0
Uranium (as U)	4	4	4	0
Radium-226(pCi/l)	0.6	0.6	.6	0

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: I-2
Distance from Wellfield: 13500 ft.

Sample Type: IMPOUNDMENT SAMPLE
Water System: WHITE CLAY CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	57	57	57	0
Magnesium	9.1	9.1	9.1	0
Sodium	26	26	26	0
Potassium	8.5	8.5	8.5	0
Carbonate	<2	<2	2	0
Bicarbonate	260	260	260	0
Sulfate	10	10	10	0
Chloride	5	5	5	0
Ammonia-N	0.07	0.07	.07	0
Nitrite-N	<0.02	<0.02	.02	0
Nitrate-N	0.03	0.03	.03	0
Fluoride	0.7	0.7	.7	0
Silica(as SiO2)	49	49	49	0
TDS-180°C	330	330	330	0
Conductivity (μmhos)	483	483	483	0
Alkalinity(as CaCO3)	220	220	220	0
pH (standard units)	7.9	7.9	7.9	0
Ion Balance				
TDS Balance				
Cond. Balance				
All values in μg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	3	3	3	0
Barium	200	200	200	0
Boron	700	700	700	0
Cadmium	<1	<1	1	0
Chromium	1	1	1	0
Cobalt	<1	<1	1	0
Copper	1	1	1	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	6	6	6	0
Zinc	10	10	10	0
Uranium (as U)	8	8	8	0
Radium-226(pCi/l)	0.3	0.3	.3	0

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: I-3
Distance from Wellfield: 9900 ft.

Sample Type: IMPOUNDMENT SAMPLE
Water System: ENGLISH CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	74	74	74	0
Magnesium	12	12	12	0
Sodium	25	25	25	0
Potassium	7.2	7.2	7.2	0
Carbonate	<2	<2	2	0
Bicarbonate	350	350	350	0
Sulfate	<5	<5	5	0
Chloride	<2	<2	2	0
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<0.02	<0.02	.02	0
Nitrate-N	<0.02	<0.02	.02	0
Fluoride	0.7	0.7	.7	0
Silica(as SiO2)	31	31	31	0
TDS-180°C	350	350	350	0
Conductivity (µmhos)	558	558	558	0
Alkalinity(as CaCO3)	280	280	280	0
pH (standard units)	7.9	7.9	7.9	0
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	3	3	3	0
Barium	400	400	400	0
Boron	500	500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	200	200	200	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	<1	<1	1	0
Zinc	12	12	12	0
Uranium (as U)	3	3	3	0
Radium-226(pCi/l)	0.6	0.6	.6	0

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: I-4
Distance from Wellfield: 11600 ft.

Sample Type: IMPOUNDMENT SAMPLE
Water System: ENGLISH CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	30	30	30	0
Magnesium	11	11	11	0
Sodium	38	38	38	0
Potassium	12	12	12	0
Carbonate	<2	<2	2	0
Bicarbonate	250	250	250	0
Sulfate	<5	<5	5	0
Chloride	<2	<2	2	0
Ammonia-N	0.13	0.13	.13	0
Nitrite-N	<0.02	<0.02	.02	0
Nitrate-N	<0.02	<0.02	.02	0
Fluoride	0.7	0.7	.7	0
Silica(as SiO_2)	9.7	9.7	9.7	0
TDS-180°C	230	230	230	0
Conductivity (µmhos)	432	432	432	0
Alkalinity(as $CaCO_3$)	200	200	200	0
pH (standard units)	7.9	7.9	7.9	0
Ion Balance				
TDS Balance				
Cond. Balance				

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	3	3	3	0
Barium	100	100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	1	1	1	0
Cobalt	<1	<1	1	0
Copper	2	2	2	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	2	2	2	0
Selenium	<2	<2	2	0
Vanadium	2	2	2	0
Zinc	4	4	4	0
Uranium (as U)	8	8	8	0
Radium-226(pCi/l)	0.3	0.3	.3	0

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: I-5
Distance from Wellfield: 13500 ft.

Sample Type: IMPOUNDMENT SAMPLE
Water System: ENGLISH CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	40	40	40	0
Magnesium	9.7	9.7	9.7	0
Sodium	40	40	40	0
Potassium	14	14	14	0
Carbonate	<2	<2	2	0
Bicarbonate	270	270	270	0
Sulfate	5	5	5	0
Chloride	4	4	4	0
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<0.02	<0.02	.02	0
Nitrate-N	0.06	0.06	.06	0
Fluoride	0.7	0.7	.7	0
Silica(as SiO2)	28	28	28	0
TDS-180°C	320	320	320	0
Conductivity (µmhos)	478	478	478	0
Alkalinity(as CaCO3)	220	220	220	0
pH (standard units)	7.9	7.9	7.9	0
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	5	5	5	0
Barium	200	200	200	0
Boron	500	500	500	0
Cadmium	<1	<1	1	0
Chromium	1	1	1	0
Cobalt	<1	<1	1	0
Copper	1	1	1	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	4	4	4	0
Zinc	2	2	2	0
Uranium (as U)	6	6	6	0
Radium-226(pCi/l)	0.5	0.5	.5	0

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: I-6
Distance from Wellfield: 13000 ft.

Sample Type: IMPOUNDMENT SAMPLE
Water System: SQUAW CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	53	53	53	0
Magnesium	7.6	7.6	7.6	0
Sodium	9.8	9.8	9.8	0
Potassium	6.5	6.5	6.5	0
Carbonate	<1	<1	1	0
Bicarbonate	240	240	240	0
Sulfate	<5	<5	5	0
Chloride	<2	<2	2	0
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<0.01	<0.01	.01	0
Nitrate-N	0.02	0.02	.02	0
Fluoride	0.4	0.4	.4	0
Silica(as SiO2)	22	22	22	0
TDS-180°C	240	240	240	0
Conductivity (µmhos)	378	378	378	0
Alkalinity(as CaCO3)	200	200	200	0
pH (standard units)	7.38	7.38	7.38	0
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	2	2	2	0
Barium	300	300	300	0
Boron	600	600	600	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	1	1	1	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	3	3	3	0
Zinc	2	2	2	0
Uranium (as U)	4	8	6	2
Radium-226(pCi/l)	0.4	0.4	[illegible]	0

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: I-7
Distance from Wellfield: 20500 ft.

Sample Type: IMPOUNDMENT SAMPLE
Water System: ENGLISH CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	55	55	55	0
Magnesium	11	11	11	0
Sodium	50	50	50	0
Potassium	18	18	18	0
Carbonate	<2	<2	2	0
Bicarbonate	350	350	350	0
Sulfate	6	6	6	0
Chloride	5	5	5	0
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<0.02	<0.02	.02	0
Nitrate-N	<0.02	<0.02	.02	0
Fluoride	0.7	0.7	.7	0
Silica(as SiO2)	27	27	27	0
TDS-180°C	390	390	390	0
Conductivity (µmhos)	606	606	606	0
Alkalinity(as CaCO3)	280	280	280	0
pH (standard units)	8.0	8.0	8	0
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	5	5	5	0
Barium	300	300	300	0
Boron	700	700	700	0
Cadmium	<1	<1	1	0
Chromium	1	1	1	0
Cobalt	<1	<1	1	0
Copper	1	1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	2	2	2	0
Zinc	18	18	18	0
Uranium (as U)	8	8	8	0
Radium-226(pCi/l)	0.6	0.6	.6	0

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: I-9
Distance from Wellfield: 22000 ft.

Sample Type: IMPOUNDMENT SAMPLE
Water System: WHITE CLAY CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	53	53	53	0
Magnesium	9.1	9.1	9.1	0
Sodium	30	30	30	0
Potassium	9.8	9.8	9.8	0
Carbonate	<2	<2	2	0
Bicarbonate	260	260	260	0
Sulfate	5	5	5	0
Chloride	6	6	6	0
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<0.02	<0.02	.02	0
Nitrate-N	<0.02	<0.02	.02	0
Fluoride	0.7	0.7	.7	0
Silica(as SiO2)	38	38	38	0
TDS-180°C	310	310	310	0
Conductivity (µmhos)	481	481	481	0
Alkalinity(as CaCO3)	210	210	210	0
pH (standard units)	7.8	7.8	7.8	0
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	100	100	100	0
Arsenic	4	4	4	0
Barium	200	200	200	0
Boron	700	700	700	0
Cadmium	<1	<1	1	0
Chromium	1	1	1	0
Cobalt	<1	<1	1	0
Copper	1	1	1	0
Iron	<50	<50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	5	5	5	0
Zinc	14	14	14	0
Uranium (as U)	9	9	9	0
Radium-226(pCi/l)	0.5	0.5	.5	0

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Page No. 3 of 3

Sample Number: E-1 & E-2
Distance from Wellfield: 8400 ft.

Sample Type: STREAM SAMPLE
Water System: ENGLISH CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	65	77	69.043	4.801
Magnesium	6.5	9.9	7.814	1.125
Sodium	17	20.9	18.533	1.562
Potassium	6.3	7.2	6.717	.319
Carbonate	<1	<2	1.6	.548
Bicarbonate	260	290	272.067	10.959
Sulfate	7	31	14.543	10.345
Chloride	3.8	4.9	4.2	.415
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	0.001	0.02	9E-03	7E-03
Nitrate-N	0.66	3.38	1.849	.967
Fluoride	0.5	0.7	.601	.082
Silica(as SiO2)	53	58	55.15	1.953
TDS-180°C	298	402	341.429	33.401
Conductivity (µmhos)	435	500	463.333	25.311
Alkalinity(as CaCO3)	217.6	232	224.883	6.431
pH (standard units)	7.3	8.08	7.6	.309
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	7	4.333	2.517
Barium	100	250	183.333	76.376
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	<30	150	76.667	64.291
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	7	7	7	0
Zinc	2	18	10	8
Uranium (as U)	3	14	9.667	4.926
Radium-226(pCi/l)	0.3	1.2	.8	.383

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:E-3
Distance from Wellfield: 21700 ft.

Sample Type: STREAM SAMPLE
Water System: ENGLISH CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	59	89	72.633	11.409
Magnesium	12	18	14.167	2.317
Sodium	48	67	59.333	7.789
Potassium	14	23	17.883	2.912
Carbonate	<1	<2	1.6	.548
Bicarbonate	375	520	437.75	66.331
Sulfate	<5	30	19.083	10.404
Chloride	9.5	14	11.733	1.615
Ammonia-N	<0.05	0.18	.12	.058
Nitrite-N	0.01	0.05	.023	.018
Nitrate-N	<0.01	0.11	.075	.043
Fluoride	0.8	1.70	1.183	.343
Silica(as SiO2)	41	65	52.533	10.459
TDS-180°C	290	542	444	87.955
Conductivity (µmhos)	620	778	698.833	73.931
Alkalinity(as CaCO3)	320	430	367.233	48.42
pH (standard units)	7.6	8.10	7.85	.188
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	3	3	3	0
Barium	<100	<100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	3	3	3	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	1	1	1	0
Zinc	<2	<2	2	0
Uranium (as U)	<1	14	5.167	5.037
Radium-226(pCi/l)	0.1	0.6	.32	.192

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:WC-1
Distance from Wellfield: 8400 ft.

Sample Type: STREAM SAMPLE
Water System: WHITE CLAY CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	31.9	52	41.371	8.491
Magnesium	8.8	9.9	9.357	.447
Sodium	21	25	22.6	1.479
Potassium	4.2	5.3	4.757	.5
Carbonate	<1	<2	1.6	.548
Bicarbonate	195.0	242	216.286	18.625
Sulfate	<5	14	10.1	2.922
Chloride	2	5.6	3.114	1.398
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	0.01	8E-03	4E-03
Nitrate-N	<0.01	0.20	.091	.068
Fluoride	0.7	0.9	.789	.076
Silica(as SiO_2)	43.3	58	52.143	4.855
TDS-180°C	214	298	261.857	26.823
Conductivity (µmhos)	319	390	354.857	29.14
Alkalinity(as $CaCO_3$)	159.9	217	183.357	22.003
pH (standard units)	7.6	8.56	8.049	.308
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	2	2	0
Barium	100	100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	2	2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	7	7	7	0
Zinc	<2	<2	2	0
Uranium (as U)	2	10	5.857	2.911
Radium-226(pCi/l)	0.1	0.5	.367	.151

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: WC-2
Distance from Wellfield: 22200 ft.

Sample Type: STREAM SAMPLE
Water System: WHITE CLAY CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	62	66.6	64.643	1.726
Magnesium	10	10.4	10.157	.162
Sodium	30.4	41.4	36.263	3.365
Potassium	8.5	12.1	10.7	1.296
Carbonate	<1	<2	1.6	.548
Bicarbonate	288	340	314.013	18.221
Sulfate	14	22	19.514	2.968
Chloride	8.5	10.8	9.633	.931
Ammonia-N	0.05	0.14	.08	.034
Nitrite-N	<.001	0.02	8E-03	7E-03
Nitrate-N	0.3	0.84	.563	.173
Fluoride	0.8	0.9	.863	.045
Silica(as SiO2)	51	57.1	53.286	2.028
TDS-180°C	350	411	385.625	23.201
Conductivity (µmhos)	500	578	538.875	27.915
Alkalinity(as CaCO3)	242.4	283	260.65	15.223
pH (standard units)	7.6	8.11	7.836	.16
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	3	3	3	0
Barium	<100	<100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	100	100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	6	6	6	0
Zinc	<2	<2	2	0
Uranium (as U)	1	13	6.125	4.224
Radium-226(pCi/l)	<0.1	0.4	.271	.125

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: S-1
Distance from Wellfield: 6100 ft.

Sample Type: STREAM SAMPLE
Water System: SQUAW CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	53.7	69	61.818	4.567
Magnesium	8.2	10	9.29	.615
Sodium	10	13	11.927	.932
Potassium	3.1	4.3	3.709	.342
Carbonate	<1	7.5	3.063	2.625
Bicarbonate	206.4	270	254.382	24.074
Sulfate	1	11	6.382	2.583
Chloride	1.0	6	2.755	1.513
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	<0.01	6E-03	5E-03
Nitrate-N	0.10	0.57	.303	.161
Fluoride	0.5	0.7	.575	.06
Silica(as SiO2)	49.6	56	52.189	2.282
TDS-180•C	253	320	282.1	21.074
Conductivity (µmhos)	330	425	395.273	32.419
Alkalinity(as CaCO3)	181	231	212.109	16.974
pH (standard units)	7.6	8.54	8.093	.276
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	2	2	0
Barium	100	100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	5	5	5	0
Zinc	<2	<2	2	0
Uranium (as U)	1	6	2.8	1.932
Radium-226(pCi/l)	0.1	0.4	.211	.127

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:S-2
Distance from Wellfield: 1900 ft.

Sample Type: STREAM SAMPLE
Water System: SQUAW CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	53	66	60.318	4.119
Magnesium	7.9	10	9.195	.546
Sodium	10.5	14	12.256	1.031
Potassium	2.2	5.9	3.926	.814
Carbonate	<1	3.0	1.808	.798
Bicarbonate	215.3	282	249.216	19.975
Sulfate	4.7	11	7.283	1.9
Chloride	1.0	2.6	1.787	.434
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	<.001	0.02	8E-03	5E-03
Nitrate-N	<0.01	1	.302	.291
Fluoride	0.5	0.69	.596	.042
Silica(as SiO_2)	42.5	54.4	48.484	3.626
TDS-180°C	222	312	270.105	26.032
Conductivity (µmhos)	339	450	400.421	31.339
Alkalinity(as $CaCO_3$)	180	243	209.111	16.66
pH (standard units)	7.8	8.50	8.143	.22
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	4	6	4.667	.707
Barium	100	320	216	58.348
Boron	20	600	164	207.803
Cadmium	<1	<1	1	0
Chromium	<1	9	4.6	2.271
Cobalt	<1	<1	1	0
Copper	<1	12	8.4	3.95
Iron	<30	50	34	8.433
Lead	<5	<5	5	0
Manganese	5	<100	29.6	37.869
Mercury	<0.1	<0.2	.18	.042
Molybdenum	<2	<10	7.9	3.479
Nickel	<2	<10	8.4	3.373
Selenium	<1	<2	1.2	.422
Vanadium	<10	<10	10	0
Zinc	<2	<10	8.222	3.528
Uranium (as U)	1	8	3.278	2.164
Radium-226(pCi/l)	0.1	0.4	.236	.108

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: S-3
Distance from Wellfield: 3400 ft.

Sample Type: STREAM SAMPLE
Water System: SQUAW CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	49	73	60.839	6.664
Magnesium	7.6	11.0	9.363	.832
Sodium	10.0	15.7	12.517	1.422
Potassium	2.3	6.7	4.347	.976
Carbonate	<1	3.5	1.909	.877
Bicarbonate	208.6	292	251.4	23.925
Sulfate	5	11.4	7.211	1.756
Chloride	0.6	3.2	2.094	.646
Ammonia-N	<0.05	0.07	.055	8E-03
Nitrite-N	<.001	0.02	8E-03	6E-03
Nitrate-N	<0.01	0.35	.171	.106
Fluoride	0.5	0.69	.605	.049
Silica(as SiO2)	39.7	51.6	47.195	3.07
TDS-180°C	230	322	276.421	22.414
Conductivity (µmhos)	340	470	404.421	36.019
Alkalinity(as CaCO3)	180	249	209.674	19.341
pH (standard units)	7.6	8.55	8.063	.299
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	6	3.909	1.221
Barium	200	250	216.667	20.616
Boron	20	<500	145.455	178.514
Cadmium	<1	<1	1	0
Chromium	<1	9	4.636	2.157
Cobalt	<1	<1	1	0
Copper	<1	<10	8.364	3.641
Iron	30	50	35.3	8.354
Lead	<5	<5	5	0
Manganese	6	<100	35.182	33.406
Mercury	<0.1	<0.2	.182	.04
Molybdenum	2	<10	8.091	3.36
Nickel	<2	<10	8.545	3.236
Selenium	<1	<2	1.182	.405
Vanadium	5	<10	9	2.108
Zinc	<2	20	12.273	6.872
Uranium (as U)	<1	7	2.875	1.962
Radium-226(pCi/l)	0.1	0.9	.322	.258

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:S-4
Distance from Wellfield: 21000 ft.

Sample Type: STREAM SAMPLE
Water System: SQUAW CREEK

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	66.6	78	72.767	4.891
Magnesium	9.1	12	10.517	1.021
Sodium	25	48	35	7.403
Potassium	8.5	16	11.367	2.574
Carbonate	<1	<2	1.6	.548
Bicarbonate	362	392	376.8	13.387
Sulfate	<5	13	7.75	2.962
Chloride	3	10.4	6.01700001	2.878
Ammonia-N	0.05	0.24	.106	.084
Nitrite-N	<0.01	<0.01	.01	0
Nitrate-N	<0.01	0.11	.066	.051
Fluoride	0.6	0.8	.727	.086
Silica(as SiO2)	34	64.3	46.55	11.68
TDS-180°C	364	430	390.667	25.851
Conductivity (µmhos)	555	603	586.8	19.097
Alkalinity(as CaCO3)	300	332	315	11.916
pH (standard units)	7.4	8.20	7.878	.277
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	2	2	0
Barium	200	200	200	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	3	3	3	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	2	2	2	0
Zinc	<2	<2	2	0
Uranium (as U)	<1	8	4.5	2.429
Radium-226(pCi/l)	0.1	0.8	.367	.273

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:W-1
Distance from Wellfield: 24000 ft.

Sample Type: STREAM SAMPLE
Water System: WHITE RIVER

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	46	57	53.045	3.698
Magnesium	6.8	8	7.54	.427
Sodium	12.7	15.9	14.21	.889
Potassium	6.1	7.8	7.13	.542
Carbonate	<1	<2	1.5	.535
Bicarbonate	214.7	235	225.66	6.053
Sulfate	<5	20	10.47	4.397
Chloride	<2	4.7	3.35	.789
Ammonia-N	0.05	0.05	.05	0
Nitrite-N	0.001	0.02	9E-03	7E-03
Nitrate-N	0.24	0.78	.49	.176
Fluoride	0.3	0.6	.499	.096
Silica(as SiO2)	50.6	59	54.218	2.436
TDS-180°C	230	302	266.455	23.183
Conductivity (µmhos)	329	400	365.636	22.028
Alkalinity(as CaCO3)	173.1	201	187.855	9.166
pH (standard units)	7.74	8.05	7.914	.116
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	2	2	0
Barium	100	100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	8	8	8	0
Zinc	<2	<2	2	0
Uranium (as U)	1	6	3.636	2.063
Radium-226(pCi/l)	0.1	0.8	.4	.232

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number: W-2
Distance from Wellfield: 27500 ft.

Sample Type: STREAM SAMPLE
Water System: WHITE RIVER

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	52	57	55	2.16
Magnesium	7.7	8	7.825	.126
Sodium	16	20	17.75	1.708
Potassium	6.5	7.9	7.225	.68
Carbonate	<2	<2	2	0
Bicarbonate	230	230	230	0
Sulfate	<5	16	11.5	4.655
Chloride	4	6	5	1.155
Ammonia-N	<0.05	<0.05	.05	0
Nitrite-N	0.01	0.01	.01	0
Nitrate-N	0.4	0.62	.493	.114
Fluoride	0.4	0.6	.475	.096
Silica(as SiO2)	52	56	54	1.633
TDS-180°C	230	300	270	29.439
Conductivity (µmhos)	377	420	401	19.408
Alkalinity(as CaCO3)	190	200	195	5.773
pH (standard units)	7.5	8.2	7.825	.299
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	2	2	2	0
Barium	<100	<100	100	0
Boron	<500	<500	500	0
Cadmium	<1	<1	1	0
Chromium	<1	<1	1	0
Cobalt	<1	<1	1	0
Copper	<1	<1	1	0
Iron	50	50	50	0
Lead	<5	<5	5	0
Manganese	<100	<100	100	0
Mercury	<0.1	<0.1	.1	0
Molybdenum	<2	<2	2	0
Nickel	<2	<2	2	0
Selenium	<2	<2	2	0
Vanadium	7	7	7	0
Zinc	<2	<2	2	0
Uranium (as U)	1	7	4.75	2.63
Radium-226(pCi/l)	0.3	0.5	.4	.1

FERRET EXPLORATION CO OF NEBRASKA
CROW BUTTE PROJECT
WATER QUALITY REPORT

Sample Number:W-3
Distance from Wellfield: 37800 ft.

Sample Type: STREAM SAMPLE
Water System: WHITE RIVER

SAMPLE SUMMARY

PARAMETER	MINIMUM	MAXIMUM	MEAN	STD.DEVIATION
All values in mg/l unless noted				
Calcium	32.2	63	48.713	10.725
Magnesium	6.7	9.3	8.15	.93
Sodium	24	109	63.888	35.907
Potassium	4	18.0	11.663	4.378
Carbonate	<1	24.0	6.667	9.564
Bicarbonate	257	383.1	308.913	48.19
Sulfate	16	53.2	28.75	12.53
Chloride	5.6	18	12.638	4.837
Ammonia-N	<0.05	0.26	.113	.077
Nitrite-N	<.001	0.01	6E-03	4E-03
trate-N	0.08	0.8	.424	.249
uoride	0.4	0.89	.686	.165
ilica(as SiO2)	45.8	55	51.025	3.552
TDS-180°C	306	460	376.375	59.838
Conductivity (µmhos)	470	709	565.25	96.916
Alkalinity(as CaCO3)	222	314.0	263.375	35.763
pH (standard units)	7.6	8.84	8.133	.363
Ion Balance				
TDS Balance				
Cond. Balance				
All values in µg/l unless noted				
Aluminum	<100	<100	100	0
Arsenic	11	11	11	0
Barium	<100	<100	100	0
Boron	10	10	10	0
Cadmium	<1	<1	1	0
Chromium	<5	<5	5	0
Cobalt				
Copper	<10	<10	10	0
Iron	<30	<30	30	0
Lead	<5	<5	5	0
Manganese	5	5	5	0
Mercury	<0.2	<0.2	.2	0
olybdenum	<10	<10	10	0
kel	<10	<10	10	0
lenium	<1	<1	1	0
Vanadium	<10	<10	10	0
Zinc	<5	<5	5	0
Uranium (as U)	<1	20	11.5	7.764
Radium-226(pCi/l)	<0.1	0.6	.314	.212

SUBSECTION 4.4

APPENDIX 4.4(B)

FIRST AQUIFER TEST - NOVEMBER 1982

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FIRST AQUIFER TEST — PAGE

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FIGURE NUMBER:

First Aquifer Test

The first aquifer test was conducted in the R&D wellfield during November, 1982. The pumping period was 50.75 hours and the recovery was monitored subsequently for 27.6 hours. Water levels in four production zone observation wells and two shallow Brule monitor wells were monitored. The following sections describe the results of that test and the methods of analysis used. Figure 4.4B-1 shows the relative locations of the wells used in the aquifer test.

Aquifer Test Well Pattern. The wells used for the aquifer test were located so that they could be incorporated into the pilot wellfield. Four of the R&D pattern wells were drilled and completed in the lower 15 to 20 feet (4.5 to 6.0 m) of the Basal Chadron Sandstone. They are numbered PT-2, PT-7, PT-8 and PT-9. Two of the production zone monitor wells were also drilled and completed in the same horizon. These two production zone monitor wells are designated PM-1 and PM-4. In addition to the production zone wells, two shallow aquifer monitor wells were installed into saturated upper sands of the outcropping Brule Formation. The deeper of the two is PM-6 and the other is assigned the number PM-7.

The original completion method used for the wells was the integral screen and cement basket completion. Some difficulties with the original 4 inch (10 cm) screen made it necessary to install 2 inch (5 cm) telescoping liners inside the 4 inch (10 cm) to control sand production.

Table 4.4B-1 lists the completion details for the pump test wells along with their distances from the pumping well, PT-7. The Chadron wells are completed only in the lower 15 to 20 feet (4.5 to 6.0 m) of the Basal Sandstone which has a total thickness of 30 to 45 feet (9 to 14 m). The effects of spherical flow as a result of partial penetration of the aquifer by the well screen are most apparent in the vicinity of the pumping well. As a general rule, horizontal flow conditions are assumed to exist at distances from the pumping well greater than 2 times the total aquifer thickness. For this situation, the drawdown data from wells at a distance of more than 60 to 90 feet (18 to 27 m) should be free from the influence

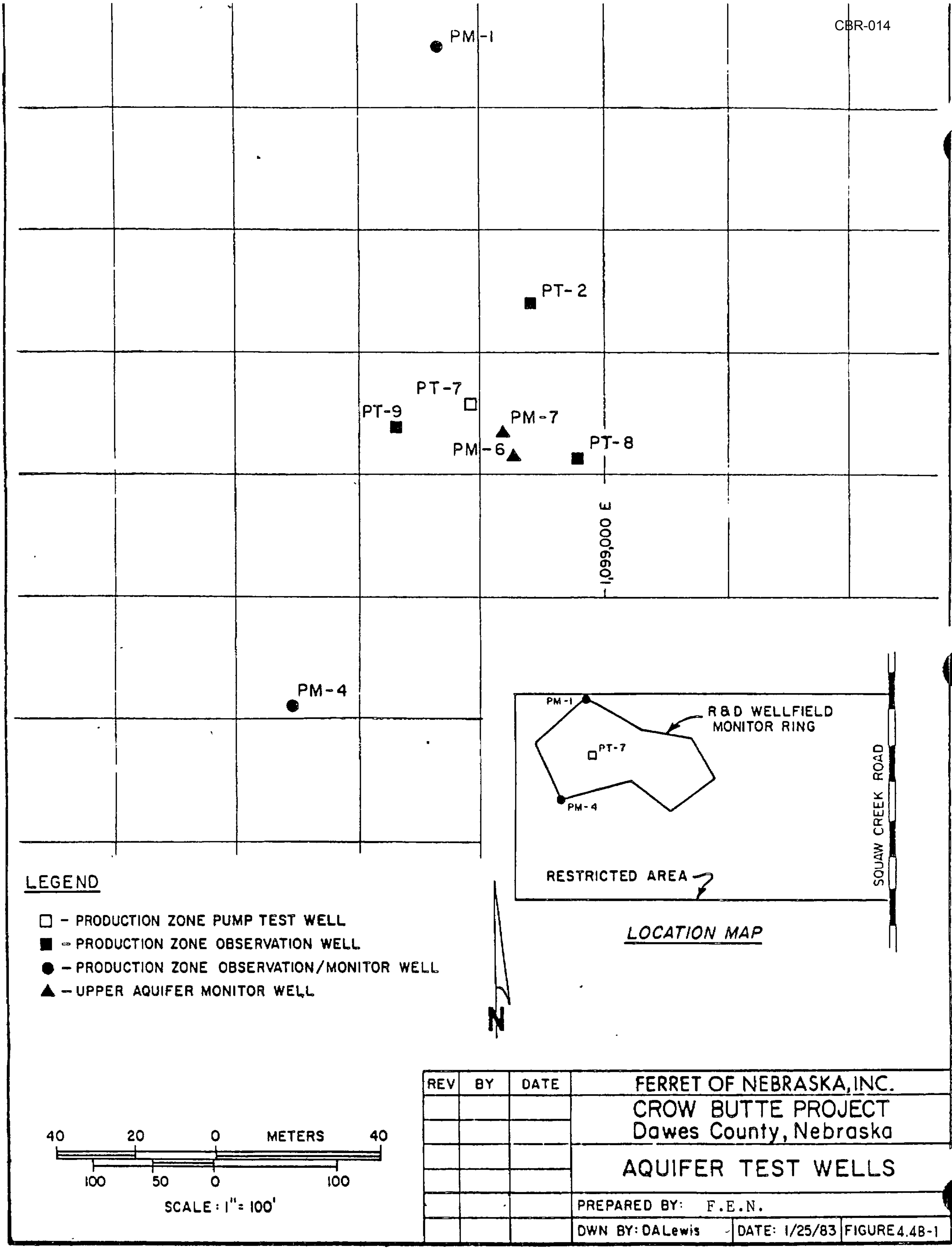
CBR-014
PM-1
PT-2
PT-7
PT-9
PM-7
PM-6
PT-8
1,099,000 E
PM-4
PM-1
R&D WELLFIELD MONITOR RING
PT-7
PM-4
SQUAW CREEK ROAD
RESTRICTED AREA
LOCATION MAP
LEGEND
□ - PRODUCTION ZONE PUMP TEST WELL
■ - PRODUCTION ZONE OBSERVATION WELL
● - PRODUCTION ZONE OBSERVATION/MONITOR WELL
▲ - UPPER AQUIFER MONITOR WELL
N
40 20 0 METERS 40
100 50 0 100
SCALE: 1" = 100'
REV
BY
DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
AQUIFER TEST WELLS
PREPARED BY: F.E.N.
DWN BY: DALewis
DATE: 1/25/83
FIGURE 4.4B-1

TABLE 4.4B-1

PUMP TEST WELL COMPLETION DATA
R & D PROJECT AREA

Well No.	Total Depth (ft)	Centralizer Depths (ft)	Basket Depth (ft)	Screen Interval (ft)	Distance To Pumping Well (ft)
PM-1	674.5	640,540,440,320,240, 160,120,60,Top	645	649.5-669.5	294
PM-4	674.5	10,40,80,115,215 315,415,515,615	637	641.5-646.5 654.5-669.5	289
PM-6	217.5	0, 60, 140, 180	193	196.0-211.0	56
PM-7	129.5	0, 40, 80	85	89.5 - 94.5 99.5 -104.5 109.0-114.0 119.5-124.5	35
PT-2	665.6	10,60,80,119,219, 319,419,519,619	641	641.0-656.0	93
PT-7	672.5	20,80,120,230,330, 430,530,630	648	649.0-664.0	0
PT-8	674.5	630,530,430,330, 230,130,70,30,8	650	653.0-668.0	94
PT-9	680.5	10,50,90,140,240, 340,440,540,640	656	659.0-674.0	66

of partial penetration. Well number PT-9 is the only production zone well closer than 93 feet (28 m) and PT-9 was not monitored during the aquifer test because of screen plugging.

The static water levels for the test area are given in Table 4.4B-2. As can be seen, the piezometric surface is essentially flat across the test pattern.

Pump Test. The center well of the pattern, PT-7, was equipped with a 7-1/2 HP submersible pump which was set at a depth of 620 feet (189 m). The pump discharge line was 1-1/4 inch iron pipe. Power was supplied by a 20 KVA diesel driven generator which ran continuously for the duration of the test. A one inch (2.5 cm) diaphragm valve was used as a flow control valve and two Badger flow totalizers were installed in the discharge line to meter the flow. Only one flow meter was used at any one time, keeping the second in reserve. The discharge line from the flow meters extended 500 feet (152 m) from the well head to insure that leakage down into the shallow aquifers did not occur.

A recording barometer was set up near the test area to monitor fluctuations in atmospheric pressure during the test. Measurements of the water levels in the pilot area wells were also made for a period of 8 days after the aquifer test wells had returned to static conditions. These data were compared with the variations in atmospheric pressure to determine the degree of correlation between atmospheric pressure and hydrostatic head in the aquifer. The barometric efficiency of the aquifer can be estimated by dividing the changes in water level by the concurrent changes in barometric pressure.

TABLE 4.4B-2

STATIC WATER LEVEL IN THE CROW BUTTE R & D PROJECT AREA

Well No.	Aquifer	Water Level Elevation * (feet-msl)
PM-1	Chadron	3754.3
PM-4	Chadron	3754.4
PM-6	Brule	3843.5
PM-7	Brule	3845.9
PT-2	Chadron	3754.6
PT-7	Chadron	3754.2
PT-8	Chadron	3754.4
PT-9	Chadron	3754.6

* Measured January 10, 1983.

Each of the observation wells was equipped with an electric water level indicator and most measurements in each well were made with the same instrument. During the early stages of the test, a person was stationed at each well to take the measurements in rapid succession. Pumping began at 7:15 AM on 11/16/82 and was discontinued at 10:00 AM of 11/18/82; a period of 50.75 hours. A discharge rate of 24 gpm (91 l/min) was chosen for the test. The overall average flow rate was 23.8 gpm (90 l/min) and the fluctuations were generally less than 0.3 gpm (1.1 l/min) or 1.3 percent. Water level measurements were taken at 1, 2 and 5 minutes, then at 5 minute intervals for the first 30 minutes of the test with regularly increasing intervals to 4 hours after 24 hours of elapsed time. Drawdowns were generally smooth and symmetrical and there were no equipment failures or interruptions in the test.

Methods of Data Analysis

Five different approaches have been used to analyze the data from the pump test. The original permit application included analyses based on Theis' Nonequilibrium Method, the Modified Jacob Nonequilibrium Method, and Theis' Recovery method. These analysis techniques, all assuming no leakage, were chosen based on the geology of the site.

Implicit to the application of these types of analyses are a series of assumptions that must be considered of the results. The assumptions underlying the methods used herein are listed below.

- The aquifer has seemingly infinite areal extent,
- The aquifer is homogeneous, isotropic and of uniform thickness over the area influenced by the pumping test,
- Prior to pumping, the piezometric surface is nearly horizontal over the area influenced by the pump test,

- The aquifer is pumped at a constant discharge rate,

- The pumped well penetrated the entire aquifer and thus received water from the entire thickness of the aquifer by horizontal flow,

- The water removed from storage is discharged instantaneously with decline in head,

- The aquifer is fully confined (no leakage or deviation from storage),

- The flow to the well is in unsteady state,

- Storage in the well can be neglected,

- The argument (u) of the well function is less than 0.01 (Modified Jacob and Theis Recovery methods only).

The first three assumptions are seldom entirely satisfied in nature, although small deviations are not prohibitive. The fourth assumption is more easily satisfied by careful control of the pump discharge rate. The next qualification, of full aquifer penetration by the pumping well, is not practical if the wells are to be used in an in situ mining wellfield; but by using observation wells at sufficient distances (greater than twice the aquifer thickness), the effects of spherical flow are eliminated. Emperical evidence from aquifer tests has justified the last assumption (constant storage coefficient).

Based on significant deviation of the pump test data from the Theis type curve in the original analysis, the USNRC questioned the use of a non-leaky analysis method on the data. In response to those concerns, the data were analyzed using a two-stage fit to the Theis type curve. This two-stage analysis was based on changes in aquifer thickness and permeability. In addition, an analysis of leakage was performed based on laboratory testing of core samples.

After further discussions with the USNRC, the data were analyzed again using the Modified Hantush method. This analysis method takes into account fluid derived from storage in the confining bed(s). Since all confining beds exhibit some leakage or loss from storage, however small, and since the Theis equation is a special case of the Modified Hantush equations, use of the Modified Hantush analysis was considered proper for the data available.

The water level in well PT-9 did not respond during the pump test. After the test, the screen was removed from PT-9 and found to be completely plugged with silt and clay sized material. This material is thought to have accumulated due to the use of pumping as the only well development technique. The screen was replaced and the well is now functioning properly.

Water levels in the two shallow monitor wells showed no drawdown during the period of the pump test. Figure 4.4B-2 shows the water level fluctuations in the shallow wells during the period of the test. It is therefore concluded that the confining layers between the production zone and upper water bearing zones do not permit leakage. (Note: Well PM-7 shows a water level change at the beginning of the test. It was determined that a faulty probe was being used during the first two hours of the test. Once this was discovered, the water levels for the remainder of the test were measured with the proper probe).

The fluctuations in water levels in the wellfield were measured after the test from 12/6/82 to 12/13/82. Those data were compared with the barometric pressure changes for the same period. An estimate of the barometric efficiency of the aquifer can be obtained from that comparison. Barometric efficiency is defined as the ratio of the water level changes in a well and the concurrent fluctuations in atmospheric pressure. Both values are usually expressed in meters of water as calculated from the data for the day period of measurement. The barometric efficiency of the Basal Chadron Sandstone was 0.40. A graphical comparison of those data is included as Figure 4.4B-3. The effects of barometric pressure changes are not

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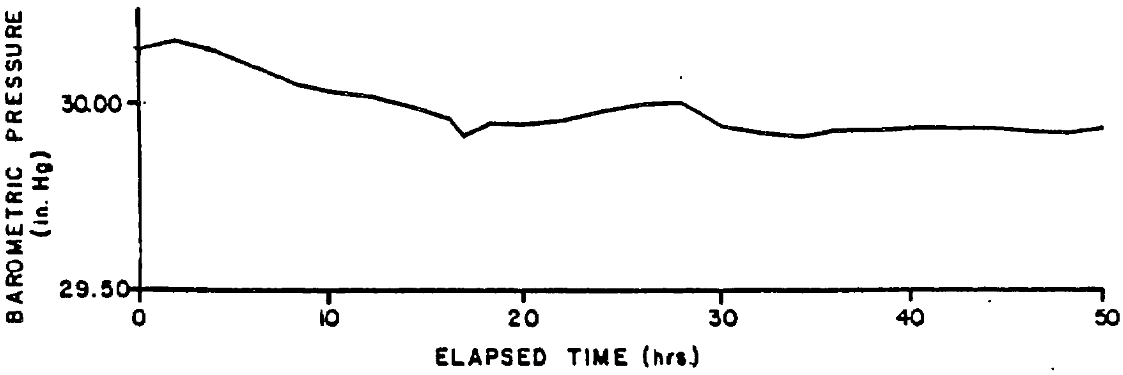
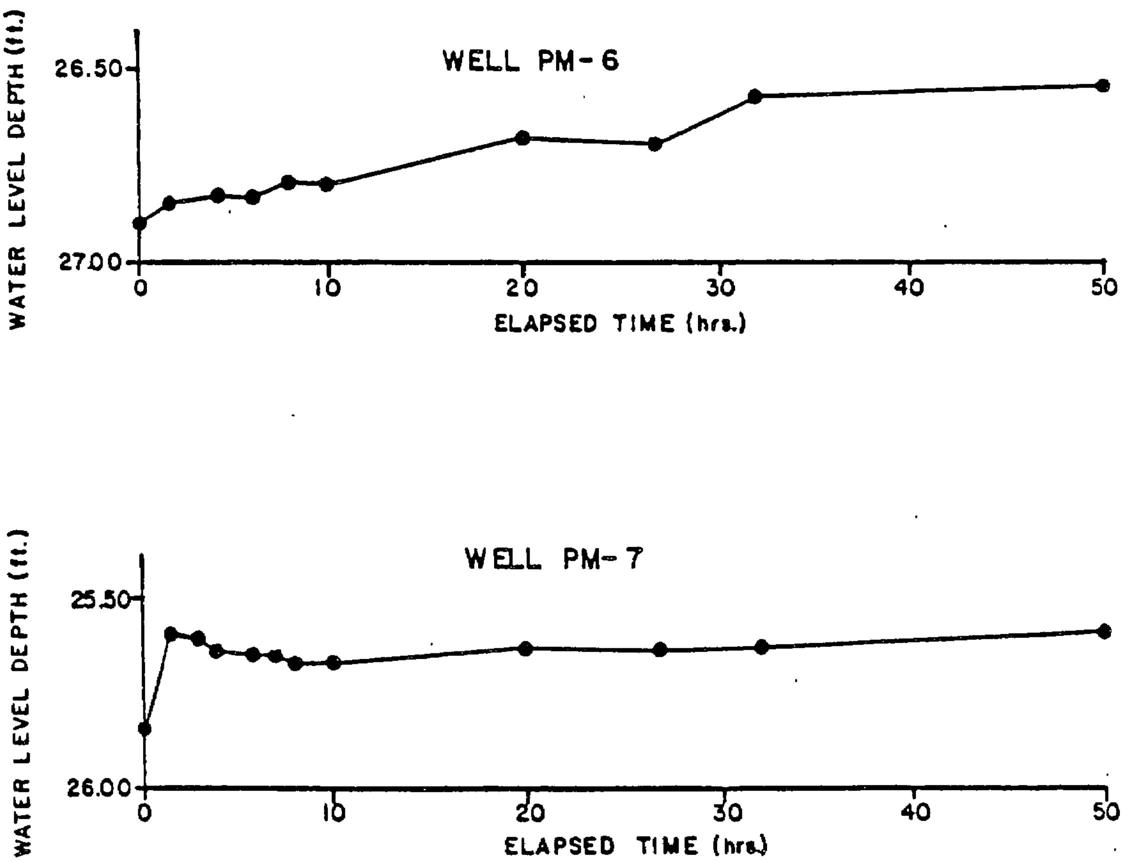
BAROMETRIC PRESSURE vs. ELAPSED TIME OF PUMPING TEST
11/16/82 – 11/18/82



(A)

SHALLOW AQUIFIER WATER LEVELS vs. ELAPSED TIME OF PUMPING TEST



(B)

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FIGURE 4.4B-2
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noticeable during the early part of a pump test but are often responsible for the minor fluctuations in drawdown during the latter portion of the test when the rate of change in drawdown is very small. The following sections summarize the hydrologic analyses performed..

<u>Theis' Nonequilibrium Method</u>. Water levels in the observation wells continued to decline for the duration of the test indicating a continuously expanding cone of depression. Under those circumstances, the unsteady state methods of analysis are generally employed. One of the most common of these methods is the Theis nonequilibrium curve matching technique.

The drawdown data "s" for each well are plotted on log-log coordinate paper versus r^2/t: where r is the distance from pumping well to the observation well and t is the time in minutes since the pumping started. The curves are then compared to a standard non-leaky artesian type curve which is a log-log plot of the "well function" W(u) and its argument u.

The results of the Theis curve matching method produce an average value for transmissivity, T, of 3,724 gal/day-ft ($5.36 \times 10^{-4} m^2/sec$) and an average storage coefficient S, of 9.66×10^{-5}. The variation in the four estimated values of T was less than 4 percent. The results of the Theis analysis are given in Table 4.4B-3.

The results of the analysis of the recovery data are also presented in Table 4.4B-3. The average value of T is 3,936 gal/day-ft ($5.66 \times 10^{-4} m^2/sec$) for this method which is slightly higher than the values from the previous analyses. Here again, conditions appear to be horizontally isotropic. The fact that the recovery curves do not go precisely through s"=0 and intersect the drawdown axis at a value <0 suggests a slight variation in the value of S for the drawdown and S" for the recovery. This can be expected as no aquifer is perfectly elastic and the rate of rebound often shows some hysteresis.

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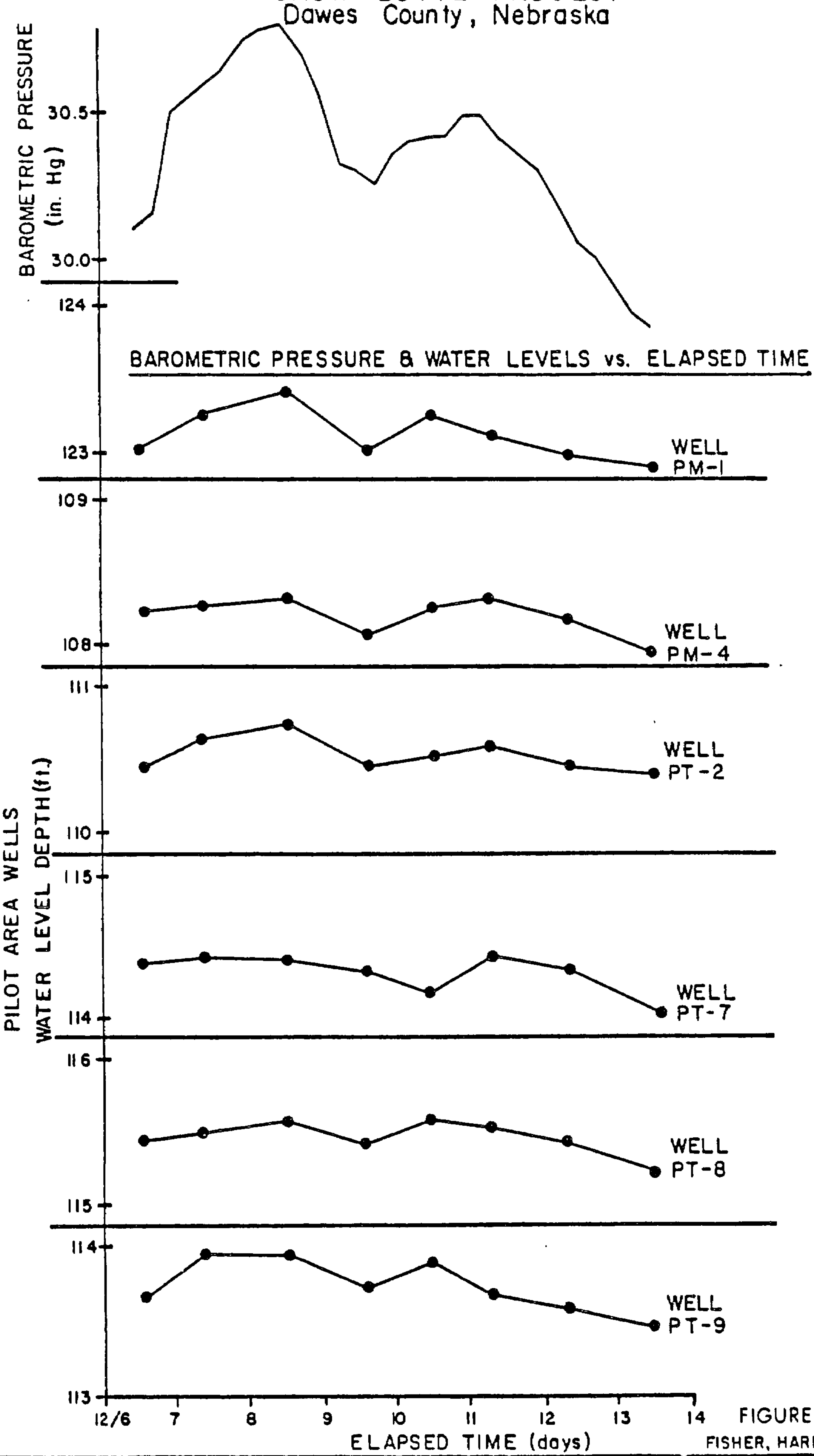

FIGURE 4.4B-3

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TABLE 4.4B-3

ESTIMATED AQUIFER PARAMETERS

Well No.	Theis' Method T (gpd/ft)	Theis' Method T (m^2/sec)	Theis' Method S	Jacob's Method T (gpd/ft)	Jacob's Method T (m^2 sec)	Jacob's Method S	Theis' Recovery Method T (gpd/ft)	Theis' Recovery Method T (m^2/sec)	Theis' Recovery Method S
PT-2	3767	$5.42x10^{-4}$	$1.24x10^{-4}$	3727	$5.36x10^{-4}$	$1.34x10^{-4}$	3662	$5.27x10^{-4}$	-------
PT-8	3793	$5.45x1-^{-4}$	$1.20x10^{-4}$	3840	$5.52x10^{-4}$	$1.23x1-^{-4}$	4010	$5.77x10^{-4}$	-------
PM-1	3595	$5.17x10^{-4}$	$6.51x10^{-5}$	3899	$5.61x10^{-4}$	$5.85x10^{-5}$	3984	$5.73x10^{-4}$	-------
PM-4	3742	$5.38x10^{-4}$	$7.72x10^{-5}$	3984	$5.73x10^{-4}$	$7.28x10^{-5}$	4087	$5.88x10^{-4}$	-------
MEAN	3724	$5.36x10^{-4}$	$9.66x10^{-5}$	3863	$5.56x10^{-4}$	$9.71x10^{-5}$	3936	$5.66x10^{-4}$	-------

Two-Stage Theis Nonequilibrium Analysis. The value of transmissivity T, is the product of hydraulic conductivity k, and the aquifer thickness (b). It was assumed that both of these quantities were virtually constant throughout the area of the aquifer that was affected by the aquifer-test pumping. The thickness of the aquifer at the pumping well PT-7, is 41 feet (12.5 m). At a distance of 93 feet (28.3 m) to the north at well PT-2, the aquifer thickness is 32 feet (9.7 m). Core logs of both holes reveal a marked change in the grain size and sorting of the material comprising the aquifer. Grain size and sorting are controlling factors of formation permeability. Further examination of the geology of the pump test area shows a change in aquifer thickness from 32 to 49 feet (9.7 to 14.9 m) or 53%. If the value of k remains constant, the value of T would then vary 53%. Values for k however, vary widely in braided stream deposits like the Basal Chadron Sand.

This variation in both hydraulic conductivity and aquifer thickness does not strictly follow the assumptions implicit in the methods of data analysis and therefore must be taken into consideration. Variations in aquifer thickness of 30 to 50 percent cannot be ignored. Changes in thickness can be treated by matching the Theis curve to the early and the late data independently, calculating a T value for each segment of the curve. The results of this analysis are given in Table 4.4B-4. The average T for the early part of the curve is 2,450 gal/day-ft and for the later part of the curve is 3,760 gal/day-ft. This represents an increase in transmissivity of approximately 53%, which is comparable to the changes in aquifer thickness.

Modified Hantush Analysis. In this analysis the following techniques were used to determine the aquifer/aquitard characteristics:

- Modified Hantush (1965) method for analyzing pumping test data for aquifers influenced by storage from leaky confining beds.

TABLE 4.4B-4

ESTIMATED AQUIFER PARAMETERS
TWO-STAGE THEIS ANALYSIS

WELL	Early T(gpd/ft)	Early S	Late T(gpd/ft)	Late S
PT-8	2116	3.0×10^{-4}	3667	1.7×10^{-4}
PT-2	2500	2.6×10^{-4}	3618	1.5×10^{-4}
PM-1	2806	7.2×10^{-5}	3767	6.6×10^{-5}
PM-4	2391	1.0×10^{-4}	3986	8.0×10^{-5}
MEAN	**2453**	$\mathbf{1.8\times10^{-4}}$	**3759**	$\mathbf{1.2\times10^{-4}}$

- Hantush (1966) method for defining the major and minor axes of transmissivity in an aquifer.

- Theory of consolidation (Scott, R.F. 1963).

The following analysis is based on ***Aquifer/Aquitard Analysis, Crow Butte ISL Uranium Project*** by D'Appolonia Consulting Engineers, October, 1983.

1. **Transmissivity and Storage Coefficient of the Basal Chadron Aquifer.** The Modified Hantush method was applied to calculate the transmissivities and storage coefficients for the Basal Chadron aquifer. The method is appropriate for the situation when part of the flow from the pumped aquifer comes as a contribution from confining beds. The drawdown versus time curves, Figures 4.4B-4 to 4.4B-7 give the apparent indication of leakage, especially noticeable at the late times. The observation wells completed in the overlying sands of the Brule Formation do not show response to the pumping in the Basal Chadron.

The curve matching technique was used to analyze the data from the observation wells. A log-log plot of drawdown versus elapsed time was laid over the family of type curves which characterize the various possible degrees of leakage from the aquitard to the pumped aquifer. The curve which best fit the data by keeping the axes parallel was determined (Figures 4.4B-4 to 4.4B-7). The designation of the type curve best fitting the drawdown values was recorded and an arbitrary point common to both graphs was selected. The coordinates of the matching point were recorded. The following equations were applied to define the aquifer properties, using match point coordinates:

(Eq. 1)

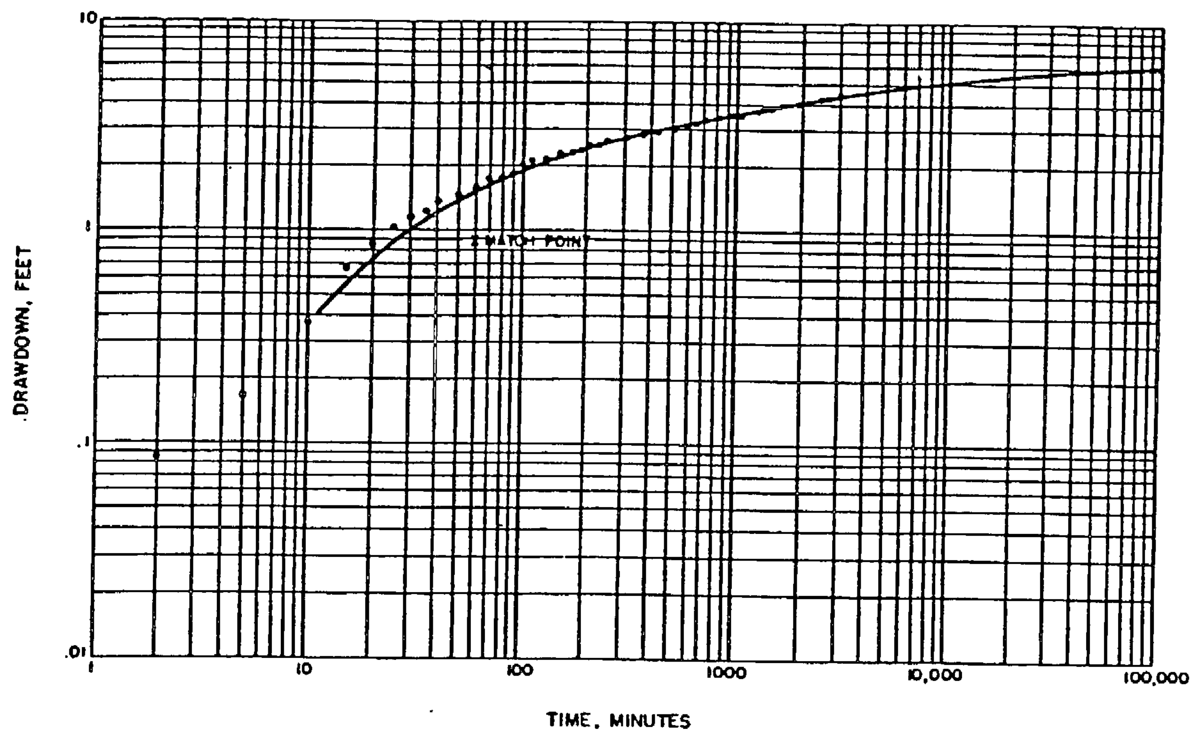
$$T = \frac{Q}{4 \pi s} H(u,\beta)$$

and

(Eq. 2) $S = 4Ttu/r^2$

Where:

T = transmissivity
Q = pumping rate
H (u,ß) = Hantush's leaky aquifer function



$\beta = 0.02$

$H(u,\beta) = 1.0$

$\frac{r}{a} = 10,\ u = 0.1$

$s = .92$ ft

$t = 78$ min

DISTANCE FROM THE PUMPING WELL

$r = 294$ ft

$$T = \frac{Q}{4\pi s} H(u,\beta)$$

$$T = \frac{24}{4\pi(.92)} \times 1.0 \times 1440 = 399\ \mathrm{ft}^2/\mathrm{day}$$

$$S = \frac{4Ttu}{r^2}$$

$$S = \frac{4 \times 399 \times 78 \times 0.1}{(294)^2 \times 1440} = 1.0 \times 10^{4}$$

FIGURE 4.4B-4

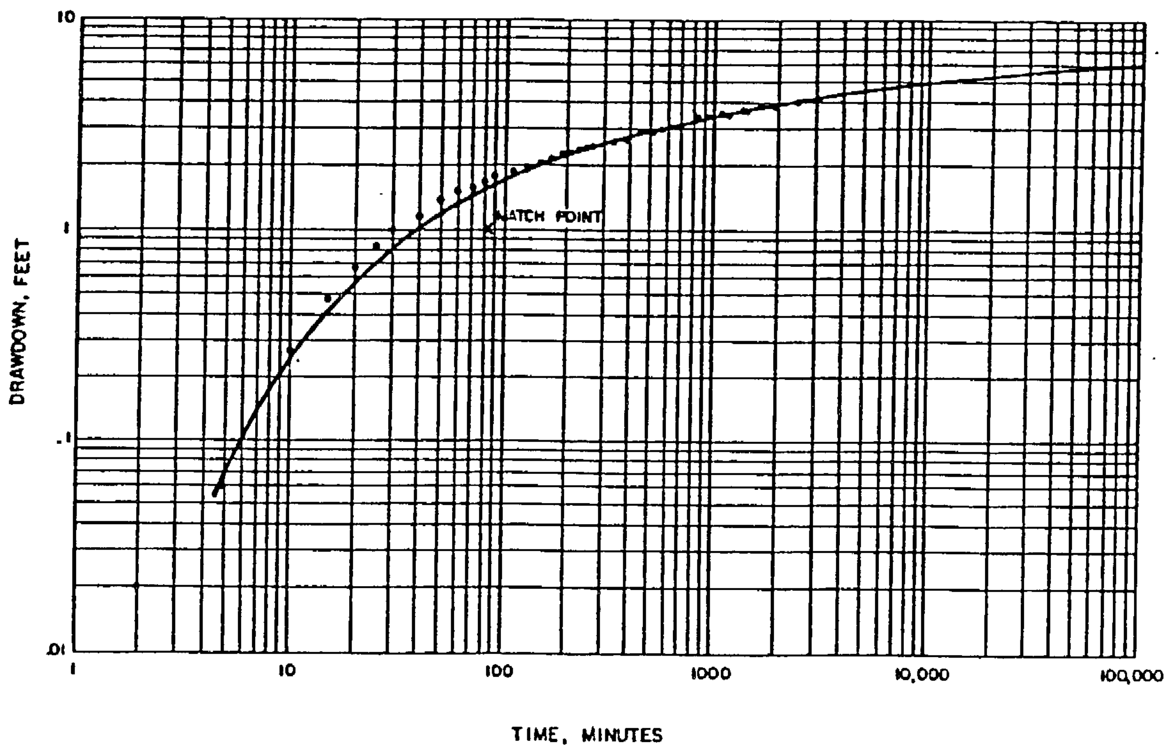
AQUIFER ANALYSIS BY MODIFIED HANTUSH METHOD OBSERVATION WELL PM-1

PREPARED FOR

WYOMING FUEL COMPANY
LAKEWOOD, COLORADO

DAPPOLONIA

DRAWN BY | 10 27 83 | CHECKED BY | RSP | 10/31/83 | DRAWING NUMBER RMB3-1721-B3
APPROVED BY | JTG | 10/31/83



$\beta = 0.05$
$H(u,\beta) = 1.0$
$\frac{1}{u} = 10,\ u = 0.1$
$s = 1.0$ ft
$t = 83$ min

DISTANCE FROM THE PUMPING WELL
$r = 288.75$ ft

$$T = \frac{Q}{4\pi s} H(u,\beta)$$

$$T = \frac{24}{4\pi(1.0)} \times 1.0 \times 1440 = 367\ ft^2/day$$

$$S = \frac{4Ttu}{r^2}$$

$$S = \frac{4 \times 367 \times 83 \times 0.1}{(288.75)^2 \times 1440} = 1.0 \times 10^{-4}$$

AQUIFER ANALYSIS BY
MODIFIED HANTUSH METHOD
OBSERVATION WELL PM-4

PREPARED FOR

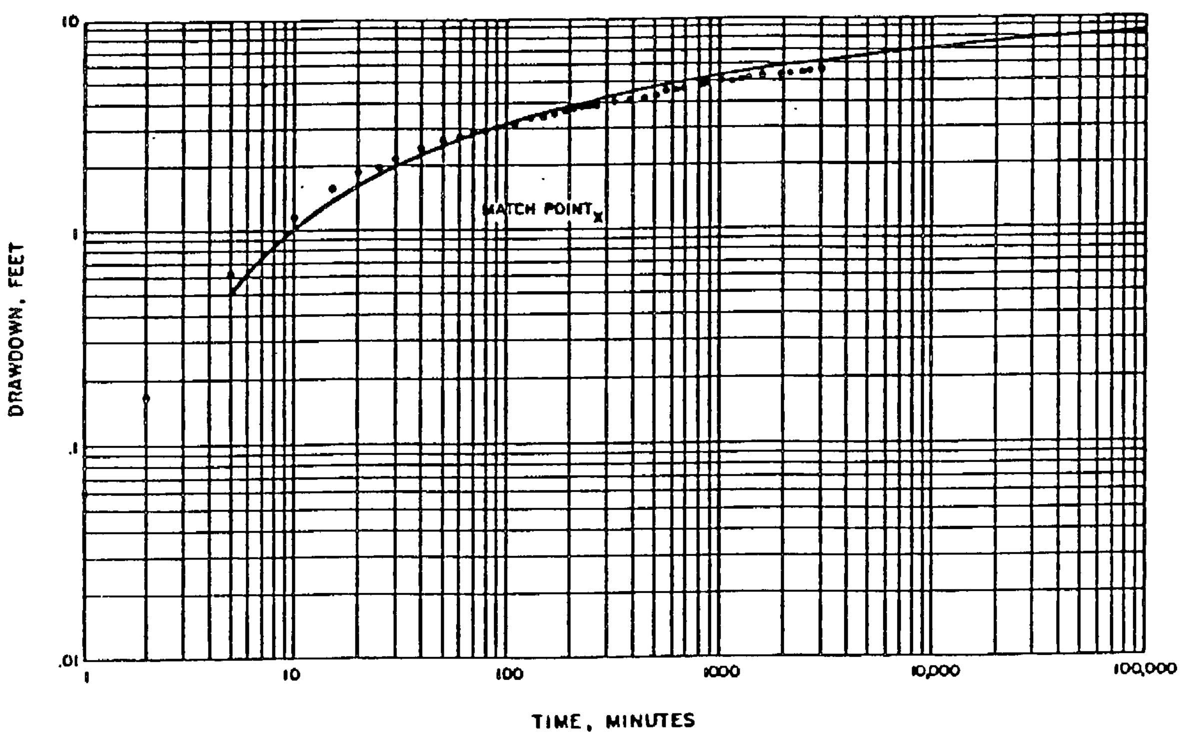
WYOMING FUEL COMPANY
LAKEWOOD, COLORADO

FIGURE 4.4B-5

DAPPOLONIA

DRAWN BY	DJ	12/27/83	CHECKED BY	RPP	12/31/83	DRAWING NUMBER	RM83-1721-B1
			APPROVED BY	JTG	12/31/83		

CBR-014



$\beta = 0.02$

$H(u,\beta) = 1.0$

$\frac{1}{u} = 100, u = .01$

$b = 10$ ft

$t = 200$ min

DISTANCE FROM THE PUMPING WELL

$r = 93.49$ ft

$T = \frac{Q}{4\pi s} H(u,\beta)$

$T = \frac{24}{4\pi(1.0)} \times 1.0 \times 1440 = 367 \text{ ft}^2/\text{day}$

$S = \frac{4Ttu}{r^2}$

$S = \frac{4(367)200(0.01)}{(93.49)^2 \times 1440} = 2.3 \times 10^{-4}$

AQUIFER ANALYSIS BY MODIFIED HANTUSH METHOD OBSERVATION WELL PT 2

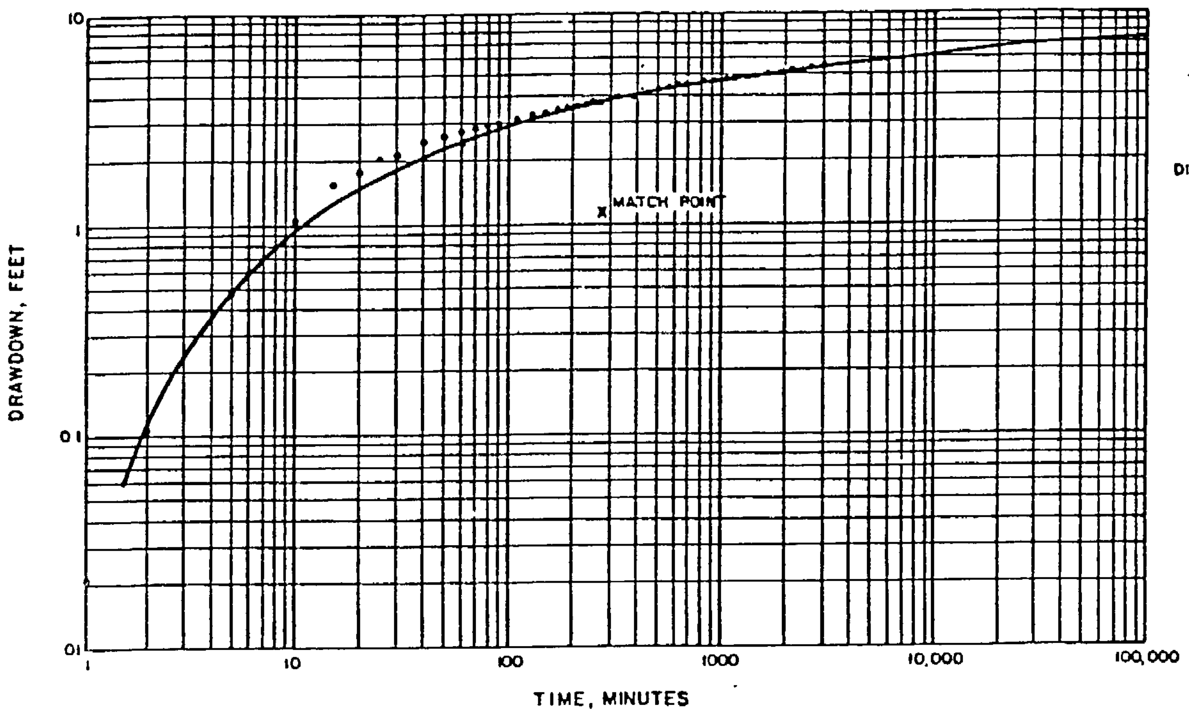
PREPARED FOR

WYOMING FUEL COMPANY
LAKEWOOD, COLORADO

FIGURE 4.4B-6

D'APPOLONIA

DRAWN BY DJ/Rodger 10 27 83 | CHECKED BY RSP 10/31/83 | APPROVED BY JTG 10/31/83 | DRAWING NUMBER RM93-1721-B2



$\beta = 0.05$

$H(u, \beta) = 1.0$

$\frac{1}{u} = 100,\ u = 0.01$

$s = 1.2$ ft

$t = 275$ min

DISTANCE FROM THE PUMPING WELL:

$r = 93.69$ ft

$$T = \frac{Q}{4\pi s} H(u, \beta)$$

$$T = \frac{24}{4\pi(1.2)} \times 1.0 \times 1440 = 306\ ft^2/day$$

$$S = \frac{4Ttu}{r^2}$$

$$S = \frac{4(306)275(0.01)}{(93.69)^2 \times 1440} = 2.7 \times 10^{-4}$$

AQUIFER ANALYSIS BY
MODIFIED HANTUSH METHOD
OBSERVATION WELL PT-8

PREPARED FOR

WYOMING FUEL COMPANY-
LAKEWOOD, COLORADO

D'APPOLONIA

FIGURE 4.4B-7

DRAWN BY	10 27 83			JTG 10/31/83	RM83-1/21-B4

s = drawdown
S = storage coefficient
t = pumping time
u = well function
r = distance from pumping well

The transmissivity measured at four observation wells (PM-1, PT-2, PT-8, and PM-4 ranged from 306 ft^2/day to 399 ft^2/day (2289-2985 gpd/ft) during the pumping period. The storage coefficients ranges from 9.9×10^{-5} to 2.7×10^{-4} (Table 4.4B-5).

The drawdown data as shown in Figures 4.4B-4 to 4.4B-7 do not appear affected by partial penetration of the production well, which is in agreement with the theory (Hantush, 1961) that vertical flow to a partially penetrating well is not significant at the observation well location when the distance between the pumping and observation well exceeds two thicknesses of the aquifer.

2. **Directional Transmissivity of the Basal Chadron Aquifer.** Most aquifers do not exhibit the same transmissivity in all directions in the horizontal plane, but rather show some horizontal anisotropy. Typically, this anisotropy can be described by an ellipse of transmissivity with major and minor axes corresponding to the directions of maximum and minimum transmissivities. Hantush (1966) presented a method for defining these axes. The method requires transmissivity values derived from observation wells located along three different radial lines from the pumping well, and is a trigonometric solution for an ellipse, given three points along its perimeter.

In addition to the orientation and magnitude of the major and minor axes, the method also provides a value for the effective (or geometric mean) transmissivity, and permits the calculation of transmissivity in the direction of flow. If the saturated thickness of the aquifer is generally uniform, the directional hydraulic conductivity of the aquifer will correspond more or less with the directional transmissivity.

The directional transmissivity for the Basal Chadron aquifer was determined from four observation wells. The major axis of transmissivity lies along an azimuth of 2 degrees and has the magnitude of 401 ft^2/day (3000 gpd/ft).

TABLE 4.4B-5

AQUIFER PROPERTIES CALCULATED BY THE HANTUSH METHOD

OBSERVATION WELL	TRANSMISSIVITY (feet²/day)	(gpd/ft)	STORAGE COEFFICIENT S
PM-1	399	2985	$9.9X10^{-5}$
PM-4	367	2746	$1.0x10^{-4}$
PT-2	367	2746	$2.3x10^{-4}$
PT-8	306	2289	$2.7x10^{-4}$
Mean	360	2692	$1.75x10^{-4}$

The minor axis of transmissivity has an azimuth of 92 degrees with a magnitude of 290 ft^2/day (2169 gpd/ft). The geometric mean of transmissivities is 341 ft^2/day (2551 gpd/ft). The major and minor axes of hydraulic conductivity coincide with the transmissivity axes and have magnitude of 10 ft/day and 7.25 ft/day respectively based on a Basal Chadron Sandstone nominal thickness of 40 feet over the area tested (Table 4.4B-7). The geometric mean hydraulic conductivity is 8.52 ft/day.

3. **Properties of the Aquitards.** The results of the laboratory testing performed on core samples from the core hole C6C, the only such samples available, were utilized in the following section of this report. Since no monitoring wells were installed in the Middle Chadron Formation, no aquitard permeability data are available from the pump test.

Information from the laboratory tests used in this report include:

- **for Pierre Shale**
  - vertical hydraulic conductivity - $K_v = 9.6 \times 10^{-8}$ ft/day
  - coefficient of consolidation - $C_v = 6.3 \times 10^{-3}$ cm^2/sec
- **for Red Clay**
  - vertical hydraulic conductivity - $K_v = 7.8 \times 10^{-7}$ ft/day
  - coefficient of consolidation - $C_v = 1.9 \times 10^{-3}$ cm^2/sec
- **for Sandy Claystone**
  - vertical hydraulic conductivity - $K_v = 8.2 \times 10^{-7}$ ft/day
  - coefficient of consolidation - not available

The laboratory test data are summarized in Table 4.4B-6.

4. **Analysis of the Aquifer/Aquitard Interaction.** Examination of the drawdown/time curves plotted for observation wells indicated that some leakage from confining beds occurred during the pumping test. To quantify the aquifer/aquitard interaction which resulted in release of the water from the confining beds when the drawdown in Basal Chadron aquifer occurred, the following analysis of aquifer/aquitard interactions were performed.

TABLE 4.4B-6

SUMMARY OF THE AQUITARD PROPERTIES

	Vertical Hydraulic Conductivity(1),K (feet/day)	(cm-sec)	Coeffecient of Consolidation(2) C_v (cm^2/sec)
Red Clay	7.8×10^{-7}	2.8×10^{-10}	1.9×10^{-3}
Sandy Claystone	8.2×10^{-7}	2.9×10^{-10}	Not Available
Pierre Shale	9.6×10^{-8}	3.4×10^{-11}	6.3×10^{-3}

(1) From laboratory testing on core samples from C6C corehole by Core Laboratories.

(2) From laboratory testing on core samples from C6C corehole by Woodward-Clyde Consultants.

To estimate the drawdown as a function of distance from the pumping wells, a drawdown-distance curve was simulated for the aquifer properties presented in Table 4.4B-5. The drawdown equation used to develop the drawdown-distance curve was based on the modified Hantush theory for a leaky aquifer:

(Eq. 3)

$$s = \frac{Q}{4\pi T} H(u,\beta)$$

(Eq. 4)

$$u = r^2 S/4tT$$

Where:

s = drawdown
Q = pumping rate
T - transmissivity (isotropic)
S = storage coefficient
t = pumping time
r = distance of observation from pump well
H(u,ß) = Hantush leaky well function
u = well function
ß = type curve parameter for leaky aquifer analysis.

The simulated distance-drawdown curve for Basal Chadron Aquifer is presented in Figure 4.4B-8. The observed drawdowns are also shown in this figure; they are in reasonable agreement with the simulated drawdown.

In the process of estimating the magnitude of leakage from the upper confinement both the Red Clay and Sandy Claystone, i.e., two strata immediately overlying the Basal Chadron aquifer, were examined. Initially the permeability of the system comprised of the Red Clay and Sandy Claystone was calculated from the relationship:

(Eq. 5)

$$K_{Av} = \frac{b'}{\frac{b'1}{K'_{z(1)}} + \frac{b'2}{K'_{z(2)}}}$$

Where:

K_{Av} = average vertical hydraulic conductivity of the system
b' = thickness of the system
b'_1, b'_2 = thickness of the different strata comprising the system
$K'_z(1)$, $K'_z(2)$ = vertical hydraulic conductivities of strata comprising the system.

The average hydraulic conductivity of the entire system was found to be almost the same as the hydraulic conductivity of the Red Clay.

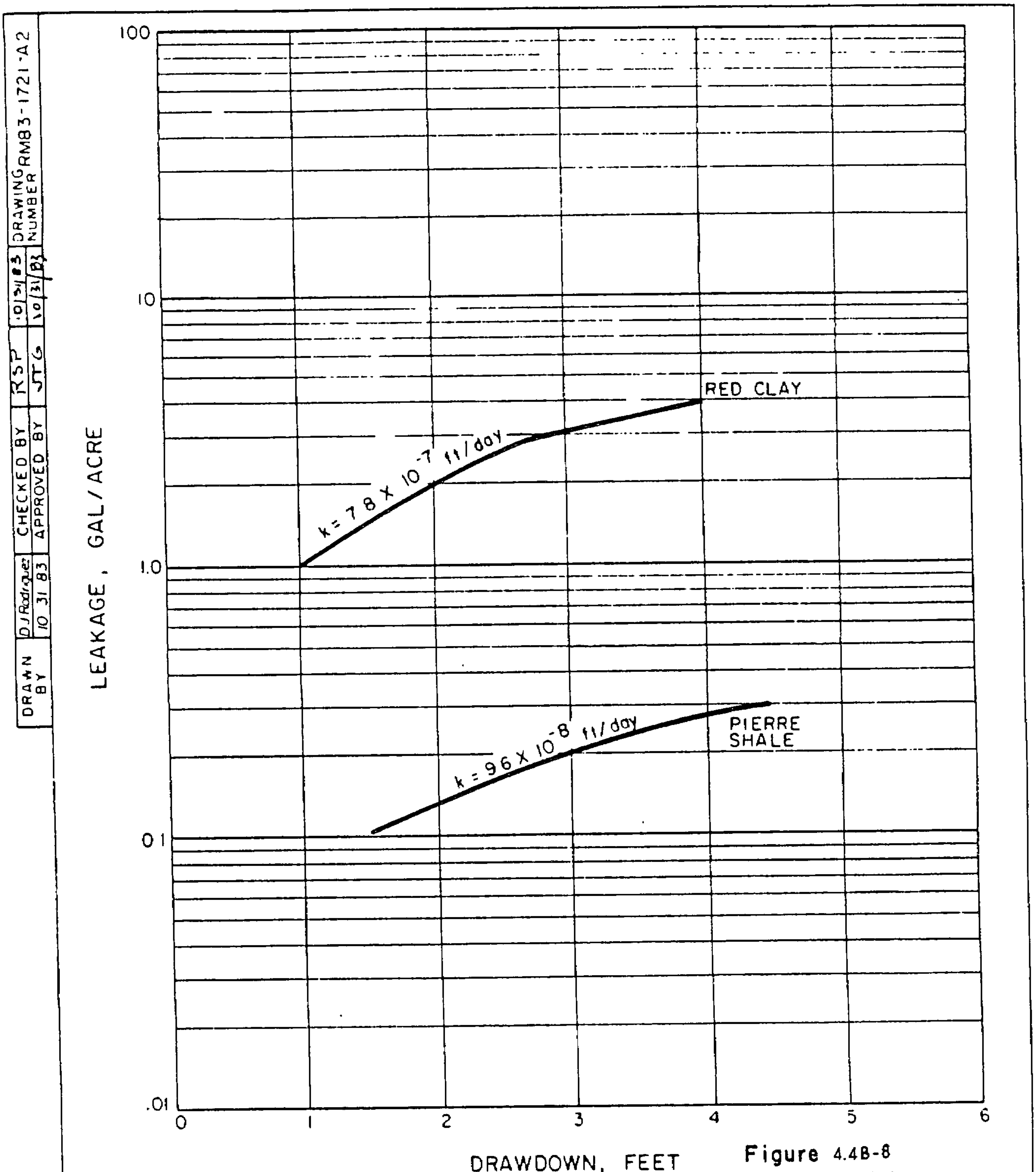


Figure 4.4B-8
LEAKAGE FROM AQUITARD VS DRAWDOWN

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Furthermore, from the analysis of the aquifer/aquitard interaction from the formation consolidation standpoint, it is apparent that during the period of the pumping test, the water released from the upper aquitard is entirely from the Red Clay. Pore pressure changes at the bottom of the Red Clay did not propagate through the clay into the overlying sandy claystone over the pumping test period. Applying the theory of consolidation (Scott, 1963), the volume of water which could be liberated from the Red Clay under induced drawdown was calculated from the relationship:

(Eq. 6)

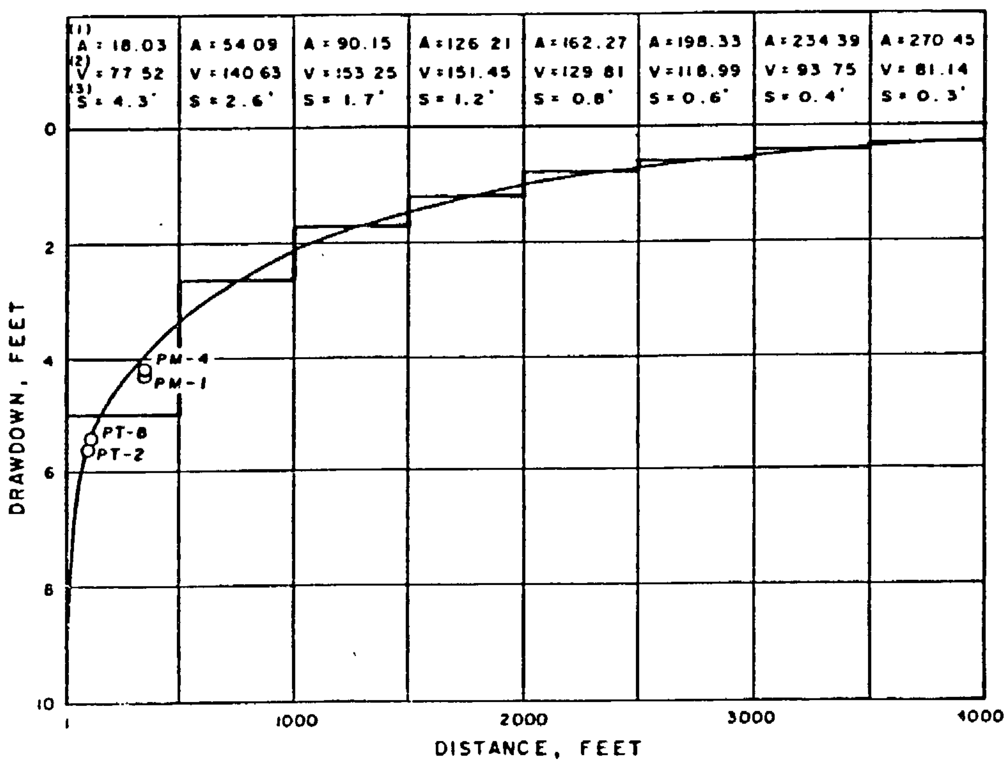
$$Q_T = \frac{2\ K_v U_i}{\gamma\ w \sqrt{\pi}\ C_v} \sqrt{t}$$

Where:

Q_T = volume of water released from the confining bed during the time t
K_v = vertical hydraulic conductivity of the confining bed
w = unit weight of water
U_i = induced change in effective overburden pressure, proportional to drawdown (s = U w)
C_v = coefficient of consolidation
t = time since drawdown occurred
s = drawdown

The analysis showed that Red Clay could release one gallon of water per one foot of drawdown per acre during the 2.09 days (i.e., during the entire pumping test). Using the values of drawdown for a given distance from the pumping well presented in Figure 4.4B-8 and the volumes of water which could be released from confinement, the overall contribution from aquifer upper confinement to the flow produced during the pumping test was calculated. The results of calculations are also illustrated in Figure 4.4B-9. The volume of water released from the Red Clay during the pumping test was thus computed to be about 1,000 gallons. This constitutes approximately 1.4% of the overall flow produced during the pumping test.

The contribution from the Pierre Shale owing to its lower hydraulic conductivity (approximately one order of magnitude less than the upper confinement)(Table 4.4B-6) would be significantly smaller - about 0.06 gallon of water per foot of drawdown per acre - during the entire pumping test. Figure 4.4B-9 illustrates the relationship between volume of inflow from the confining Red Clay and Pierre Shale versus drop in the hydraulic head at the aquifer/aquitard contact.



AREA AFFECTED BY PUMPING

A_t = 1154 ACRES

TOTAL LEAKAGE FROM UPPER CONFINEMENT

V_t = 947 GALLONS

(1) ACRES
(2) GALLONS
(3) FEET

SIMULATED DISTANCE DRAWDOWN CURVE AND INFLOWS FROM UPPER AQUITARD

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FIGURE 4.4B-9

D'APPOLONIA

DRAWN BY	RDB	CHECKED BY	RSP	10/31/83	DRAWING NUMBER	RMB3 1721-B5
10-31-83		APPROVED BY	JTG	11/11/83		

In the above analysis, the transient nature of drawdown versus time was not considered in the analysis. In other words, the maximum drawdowns as observed or simulated for the final phase of the pumping test were assumed to persist for the duration of the pumping test. This is conservative in that it overpredicts the volume of water released.

For time periods extending well beyond the pumping test period, the rate of water released from the aquitard will be less than indicated above, assuming equal drawdown conditions. Quantification of this rate involves an analysis different from that represented in Equation 6.

Two factors which were used to further characterize the degree of confinement are the leakage factor (B) and the hydraulic resistance (c). The leakage factor was defined by Hantush (1964) as:

(Eq. 7) $B = [Kb/(K_{z'}/b')]\ 1/2$

Where:

B = leakage factor
K = hydraulic conductivity of aquifer
b = thickness of aquifer
$K_{z'}$ = vertical hydraulic conductivity of aquitard
b' = thickness of aquitard

The leakage factor has units of length. The greater the value of B, the less the contribution of leakage to the water pumped from the aquifer. For the 15 feet of immediate upper confinement comprised of the Red Clay, B has a value of about 8.1×10^4 feet, which is very large. The hydraulic resistance was defined by Kruseman and DeRidder (1970) as:

(Eq. 8) $c = b'/K_{z'}$

and has units of time. When multiplied by the porosity of the aquitard, the time that a molecule of water would take to pass through the given thickness of the aquitard under a unit gradient could be computed. The hydraulic resistance for the 15 foot thick section of the Red Clay immediately overlying the Basal Chadron sandstone is 53,000 years. To

calculate travel time through the confinement, an effective porosity value of 22 percent was used. This value is based on a measurement of effective porosity performed on a core sample of Red Clay. Only the Red Clay was considered in the analysis, due to its very low permeability and the short time of pumping. Assuming an effective porosity of 22%, the travel time through the 15 foot thick section of the aquitard under unit gradient would be 12,000 years.

5. **Ground Water Movement Within the Investigated Area.** The examination of the average ground water levels in the eight wells in Figure 4.4B-4 completed in the Chadron aquifer shows that the direction of the flow is toward the north and the dip of the potentiometric surface is 0.04 percent.

Using a directional hydraulic conductivity of 10 ft/day and an assumed effective porosity of 29 percent, the average pore velocity across the R&D site was computed to be about 5.0 ft/yr. The ground water flux across the site was computed to be 0.16 ft^3/day per unit width of the aquifer.

APPENDIX 4.4(C)

Travel Time Calculation for Confining Layers

Travel Time Calculation for Confining Layers

Hydraulic resistance, c, is defined as the saturated thickness of the confining layer divided by the vertical hydraulic conductivity of the confining layer:

$$c = \frac{D^1}{k^1}$$ (Kruseman and De Ridder, 1979)

where D^1 = the saturated thickness of the aquiclude
k^1 = the vertical hydraulic conductivity of the aquiclude

Hydraulic resistance characterizes the resistance of the confining layer to leakage. It has the dimension of time.

Travel time, T_t, through the overlaying and underlying confining layers is defined as the hydraulic resistance times the hydraulic gradient, times the porosity of the confining layer:

$$T_t = cin$$

where c= the hydraulic resistance of the confining layer
i= the hydraulic gradient across the confining layer
n= the porosity of the confining layer

For the purpose of this study, unit hydraulic gradient was assumed. Travel time has the dimension of time.

Example Calculations:

Red Clay (overlying confining layer)

Hydraulic resistance, $c = \frac{914 cm}{3.49 \times 10^{-11} cm/sec} = \approx 830,200$ years

Travel time, T_t =830,200 years x 1 ft/ft x .318 = ≈264,000 years

SUBSECTION 4.5

GEOLOGY AND SEISMOLOGY

TABLE OF CONTENTS

4.5 GEOLOGY AND SEISMOLOGY

4.5.1 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 4.5-1). The topography consists of low rolling hills dominated by the Pine Ridge south and west of the project area.

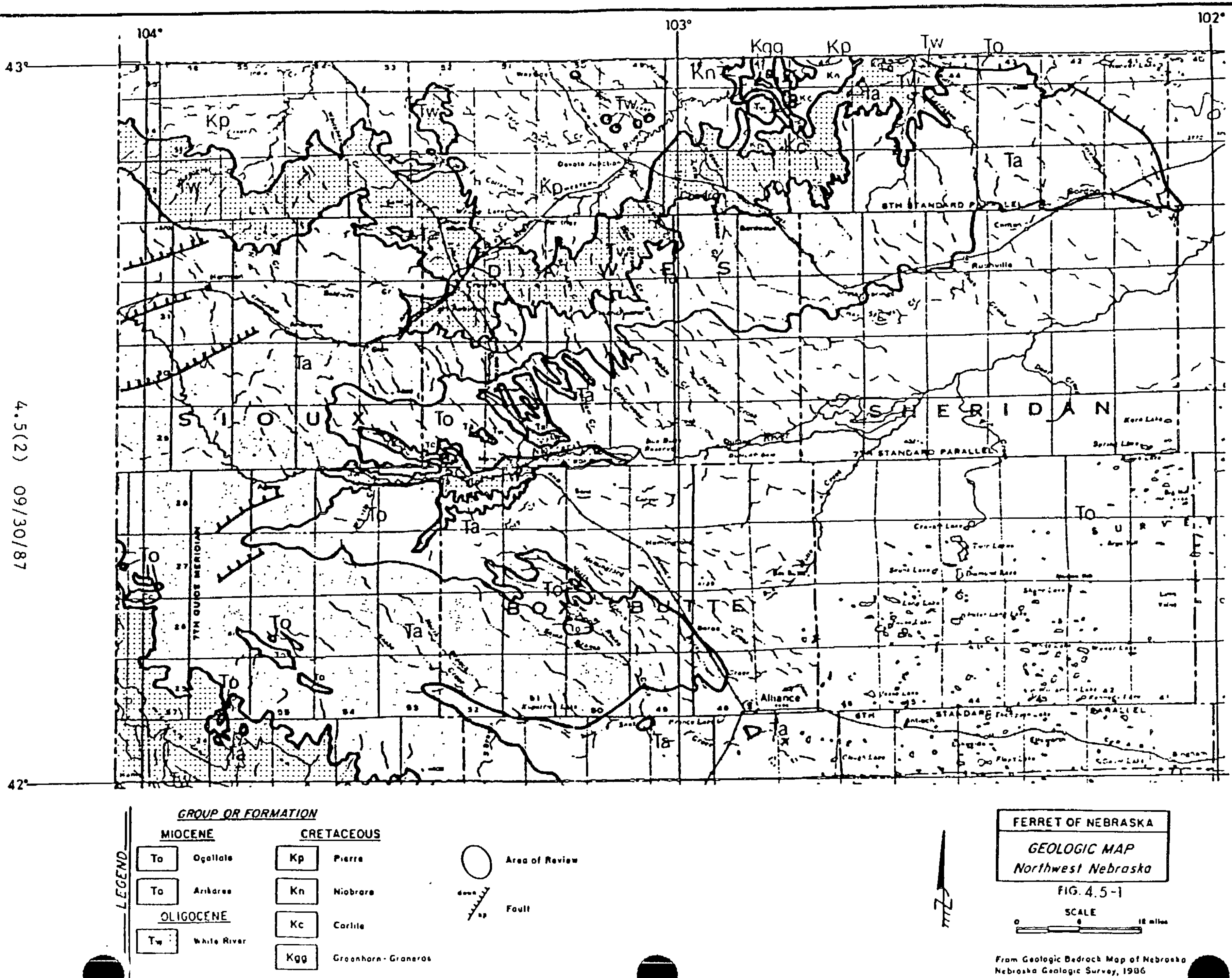
General Stratigraphy

Sedimentary strata ranging from late Cretaceous through Tertiary are exposed throughout northwest Nebraska. Pleistocene alluvial-colluvial material are abundant along the north slope of the Pine Ridge. Table 4.5-1 is a generalized stratigraphic chart for the region.

Pre-Pierre Shale Stratigraphy

Formations older than the Cretaceous Pierre Shale are listed on the general stratigraphic chart (Table 4.5-1). 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, 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 ppm.



FERRET OF NEBRASKA

GEOLOGIC MAP
Northwest Nebraska

FIG. 4.5-1

From Geologic Bedrock Map of Nebraska
Nebraska Geologic Survey, 1986

TABLE 4.5-1

GENERAL STRATIGRAPHIC CHART FOR NORTHWEST NEBRASKA

System	Series	Formation or Group	Rock Types	Thickness
Miocene		Ogallala	SS, Slt	1560*
		Arikaree	SS, Slt	1070*
Oligocene		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
Pennyslvanian	Virgil	Shawnee	Ls	80
	Missouri	Kansas City	Ls, Sh	80
	Des Moines	Marmaton/ Cherokee	Ls, Sh	130
	Atoka	Upper/Lower	Ls, Sh	200
Mississippian	Lower	Lower	Ls, Sh	30
Pre-Cambrian			Granite	

* Maximum thickness based on Swinehart et al, 1985.

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 Quarternary 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 Quarternary 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 Quarternary 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.

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.

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.

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. (Shultz 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 which 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.

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 4.5-1), 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 which 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 4.5-1, 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 FEN 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 FEN informally calls the Inner Crawford Basin located west of the Area of Review (Figure 4.5-1), (Collings and Knode, 1984). The Inner Crawford Basin is characterized by an increase in the thickness of the Chadron Sandstone.

4.5.2 AREA OF REVIEW GEOLOGY

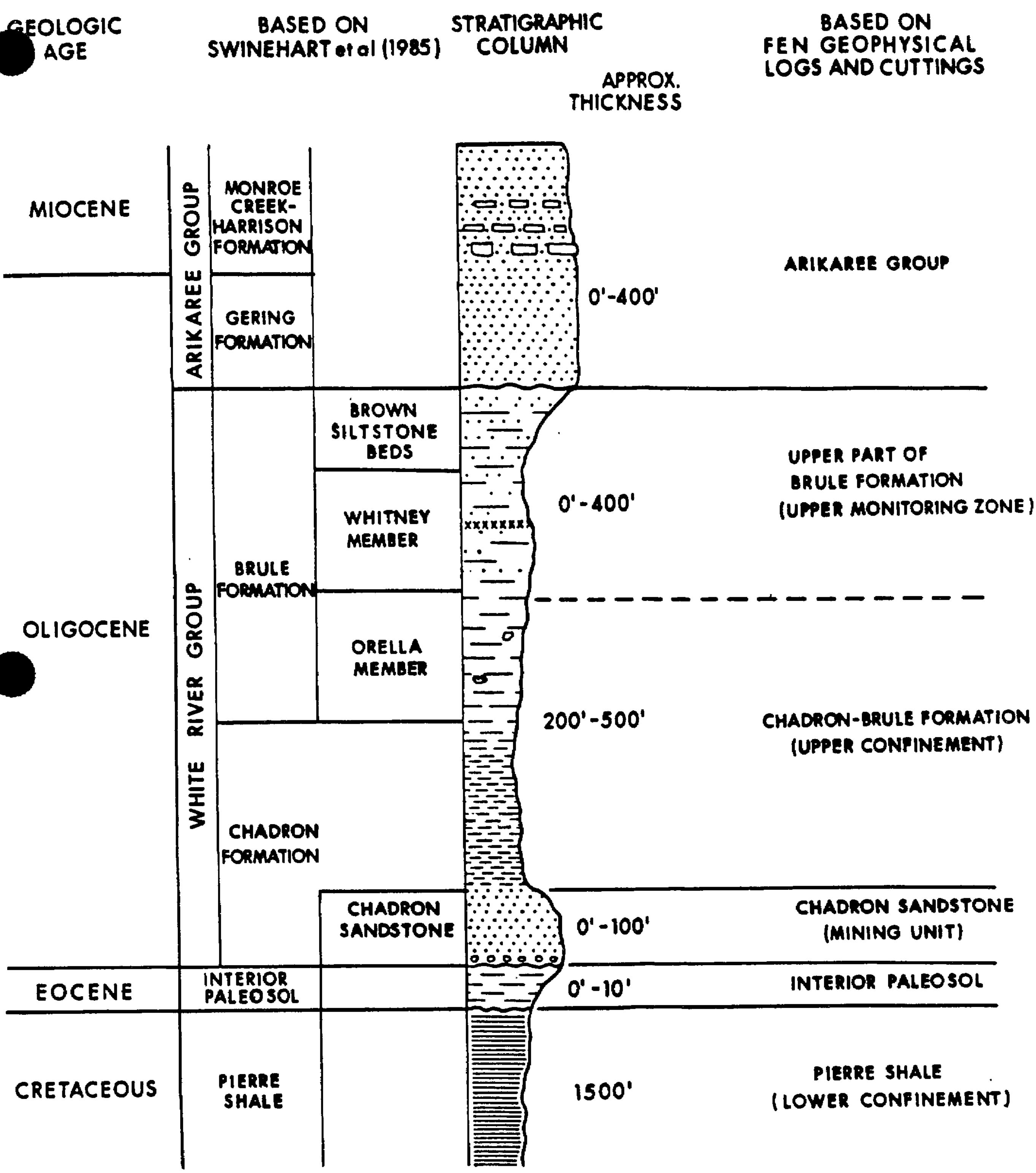
Introduction

An Area of Review stratigraphic column has been prepared and is shown as Figure 4.5-2. The stratigraphic nomenclature of Swinehart et al (1985) and FEN are shown on the column.

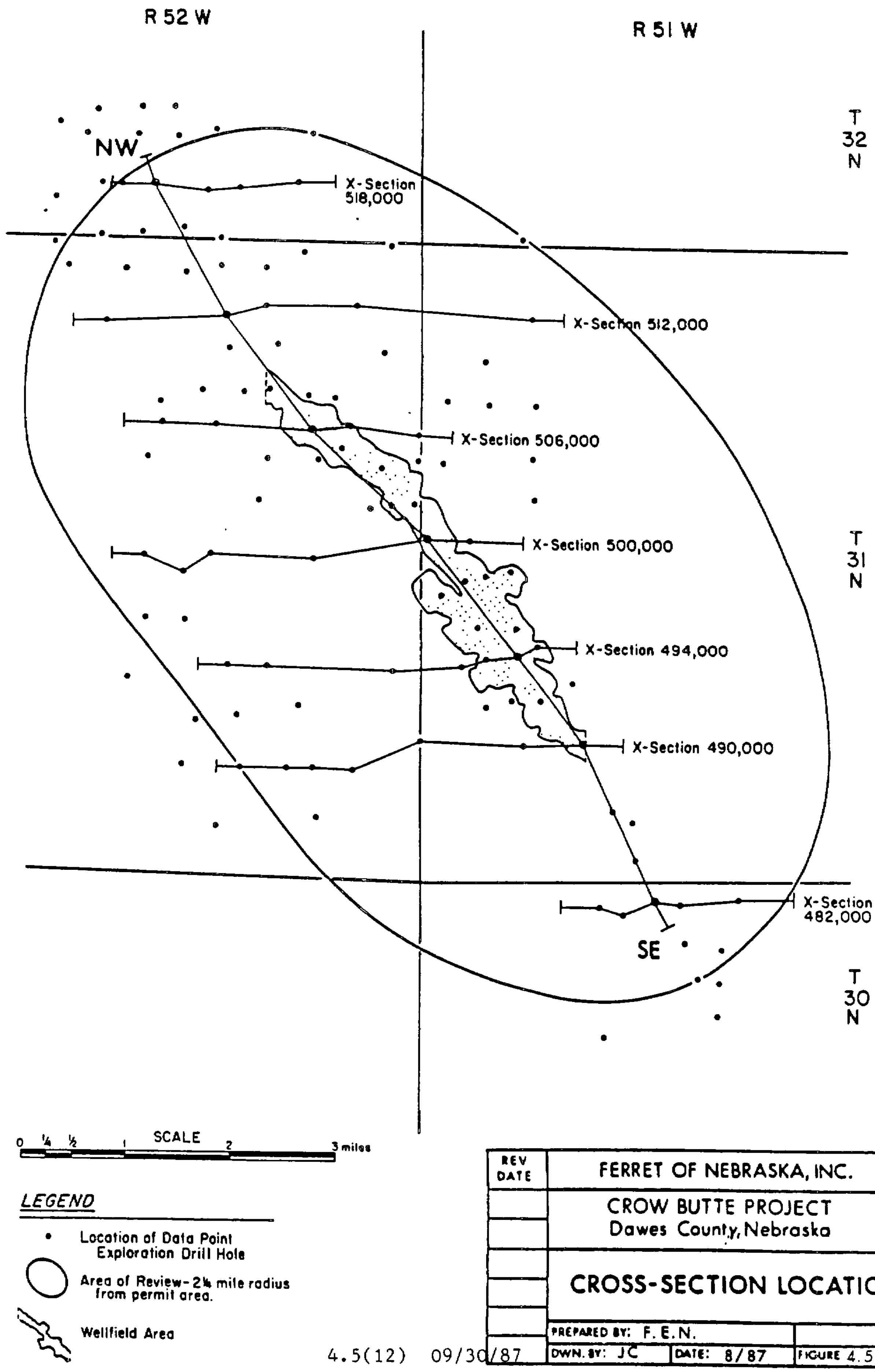
A series of seven east-west cross sections have been constructed through the proposed wellfield area and the Area of Review to demonstrate the geology of the Chadron Sandstone and its relationship to the confining horizons (Figures 4.5-3 to 4.5-10). One northwest-southeast cross section is included to show the continuity of the geology (Figure 4.5-11). Reduced electric geophysical logs from representative FEN 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 the Arikaree Group if present, are subdivided on these cross sections based on log characteristics which are the most important considerations 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 (Figures 4.5-3 to 4.5-11).

Pierre Shale - Lower Confinement

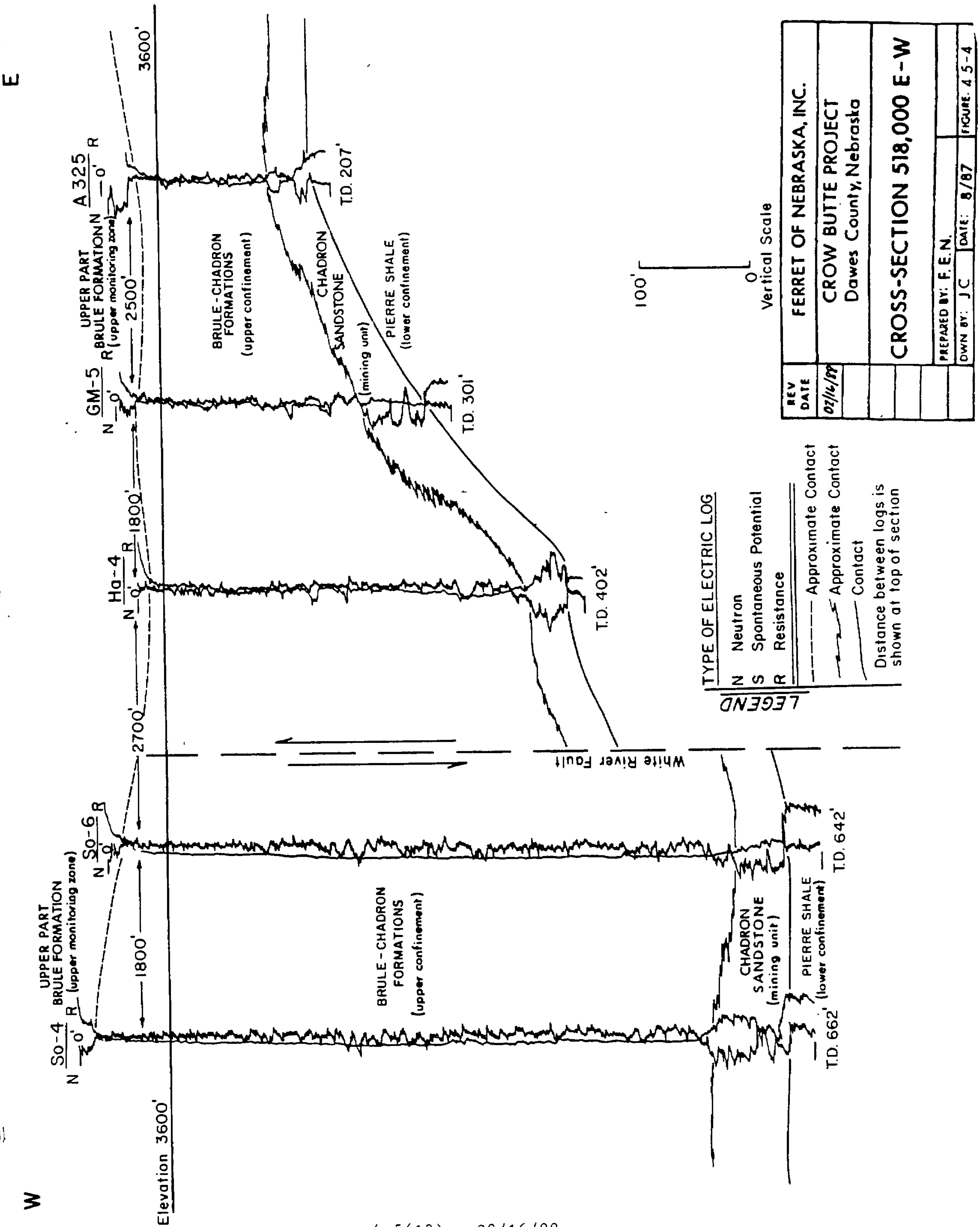
The Pierre Shale is a black marine shale and is the oldest formation encountered in any FEN test holes within the Area of Review (Figures 4.5-3 to 4.5-11). The Pierre Shale is the confining bed below the Chadron

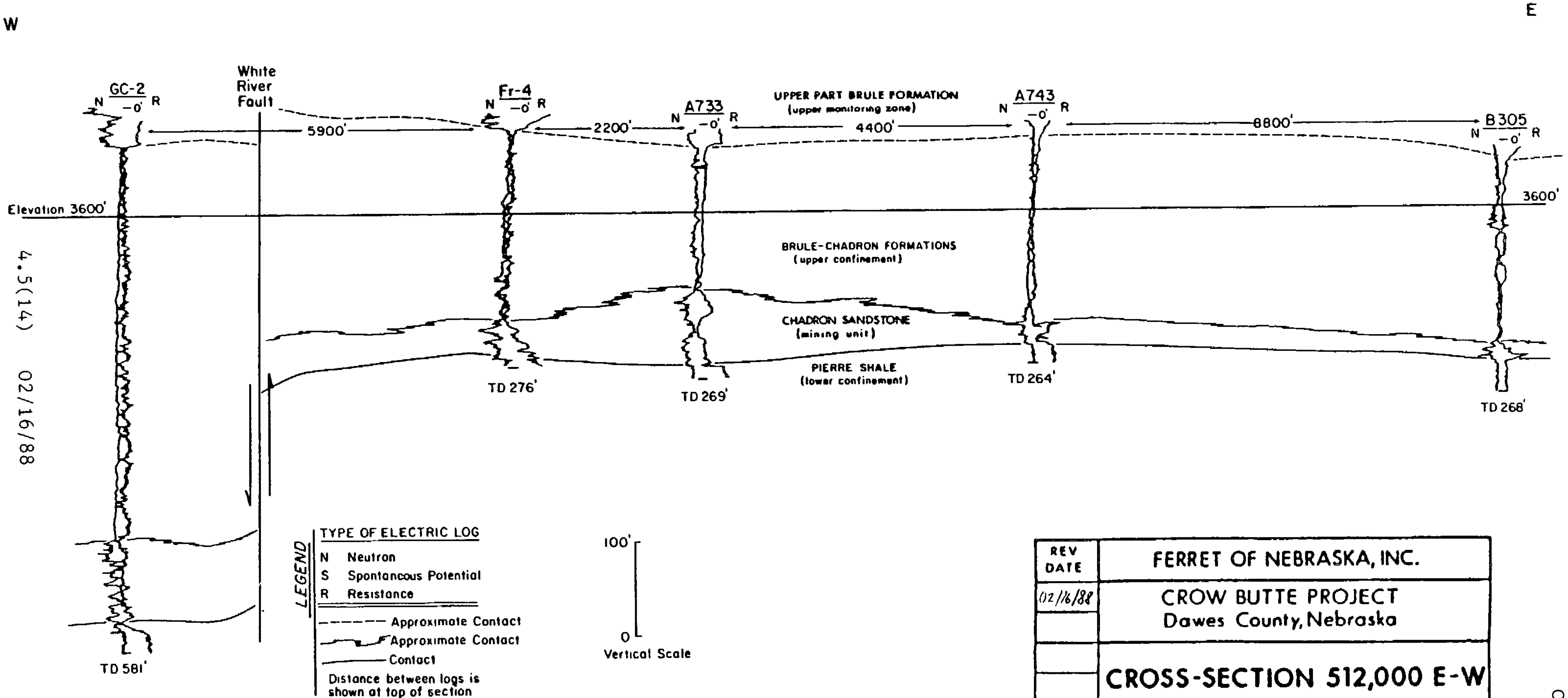


REV. DATE	FERRET OF NEBRASKA, INC.	
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska	
	AREA OF REVIEW STRATIGRAPHIC COLUMN	
	PREPARED BY: F.E.N.	
	DWN. BY: JC	DATE: 2/88	FIGURE: 4.5-2

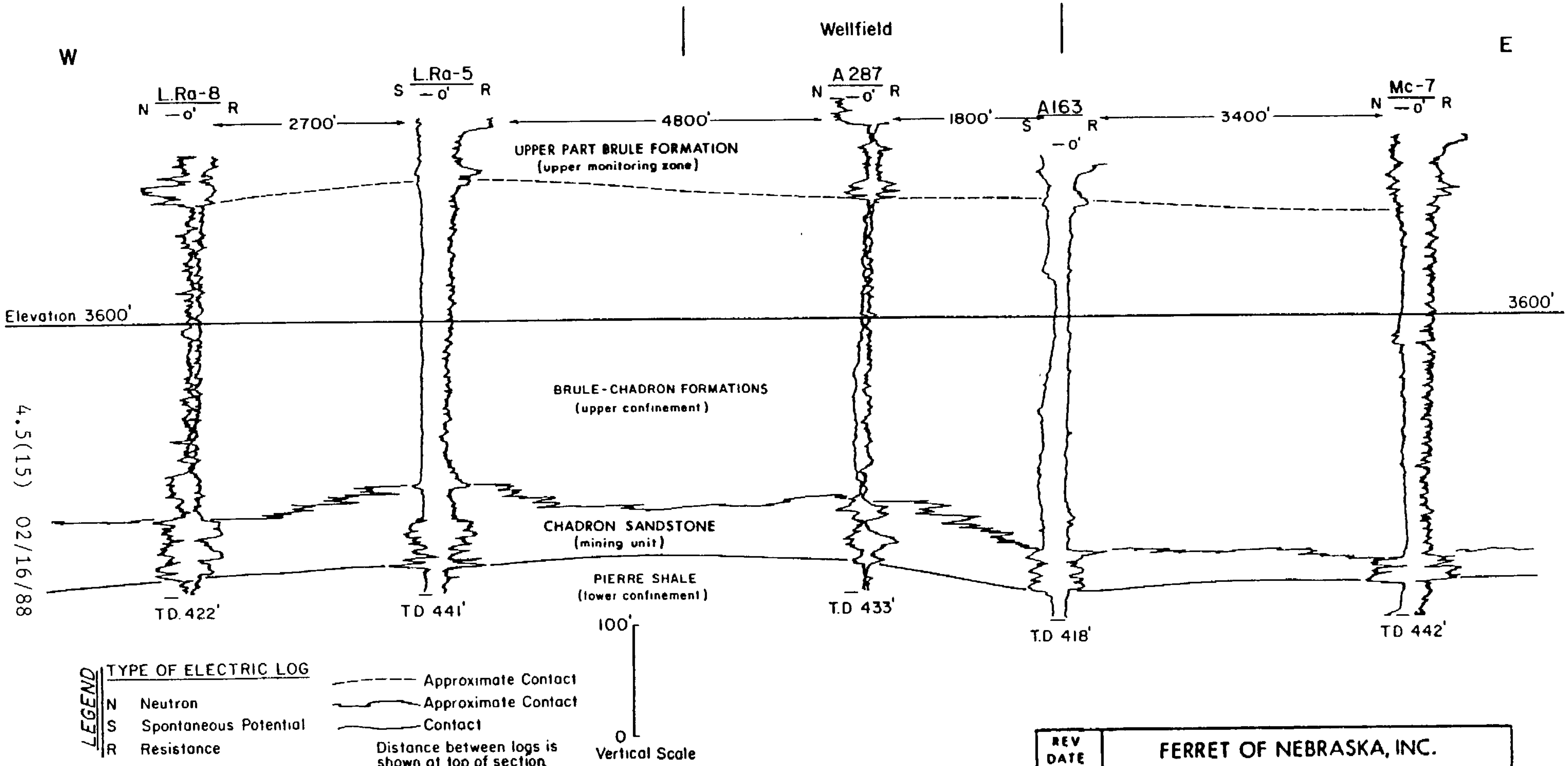


REV DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	CROSS-SECTION LOCATION		
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/87	FIGURE 4.5-3

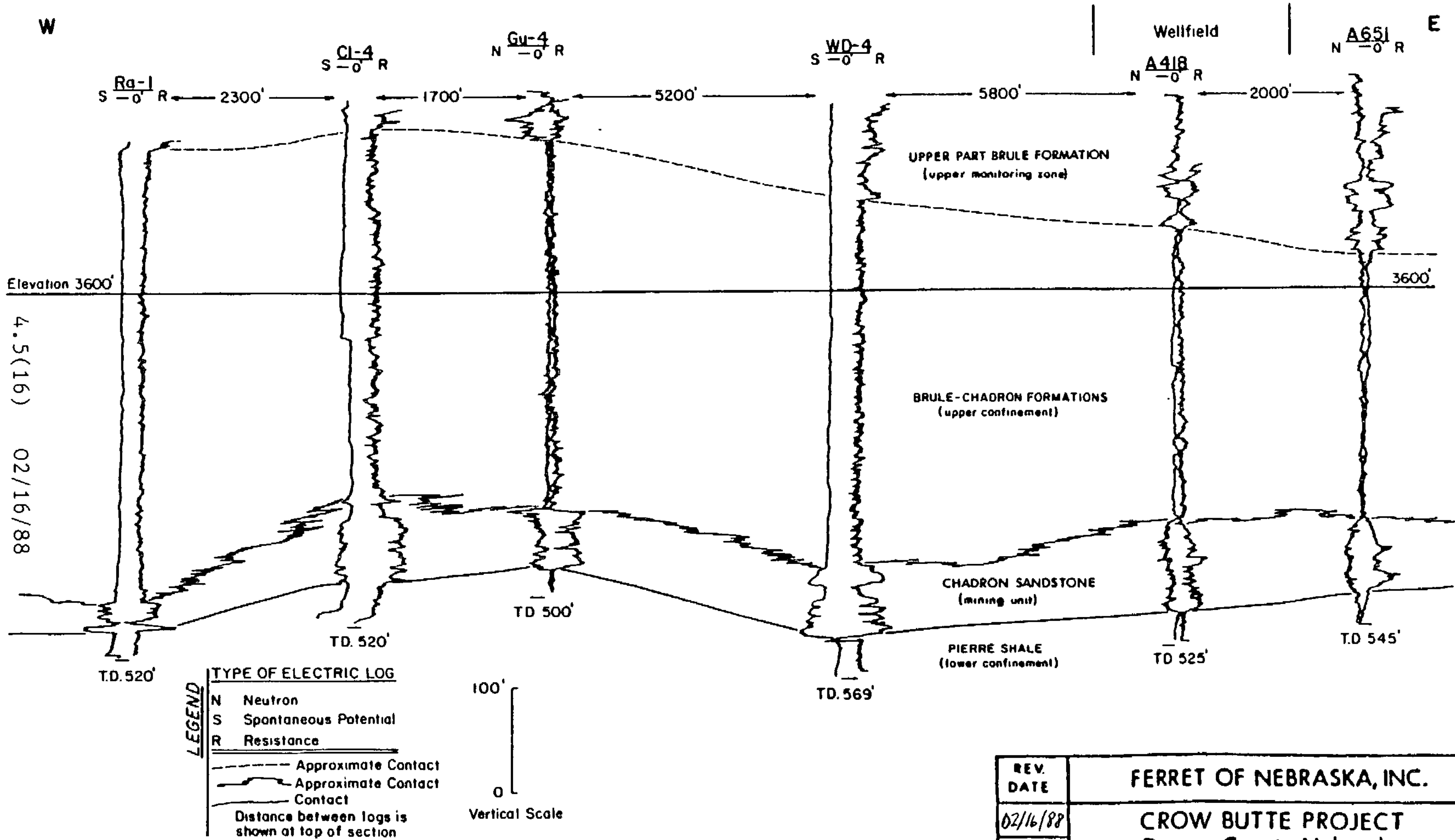

E
W
Elevation 3600'
3600'
A 325
GM-5
Ha-4
So-6
So-4
N
R
0'
2500'
1800'
2700'
1800'
T.D. 207'
T.D. 301'
T.D. 402'
T.D. 642'
T.D. 662'
UPPER PART BRULE FORMATION (upper monitoring zone)
BRULE-CHADRON FORMATIONS (upper confinement)
CHADRON SANDSTONE (mining unit)
PIERRE SHALE (lower confinement)
White River Fault
100'
0
Vertical Scale
LEGEND
TYPE OF ELECTRIC LOG
N Neutron
S Spontaneous Potential
R Resistance
Approximate Contact
Approximate Contact
Contact
Distance between logs is shown at top of section
REV DATE
07/16/87
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
CROSS-SECTION 518,000 E-W
PREPARED BY: F.E.N.
DWN BY: JC
DATE: 8/87
FIGURE 4.5-4



REV DATE	FERRET OF NEBRASKA, INC.
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska
	CROSS-SECTION 512,000 E-W
	PREPARED BY: F.E.N.
	DWN. BY: JC — DATE: 8/87 — FIGURE: 4.5-5

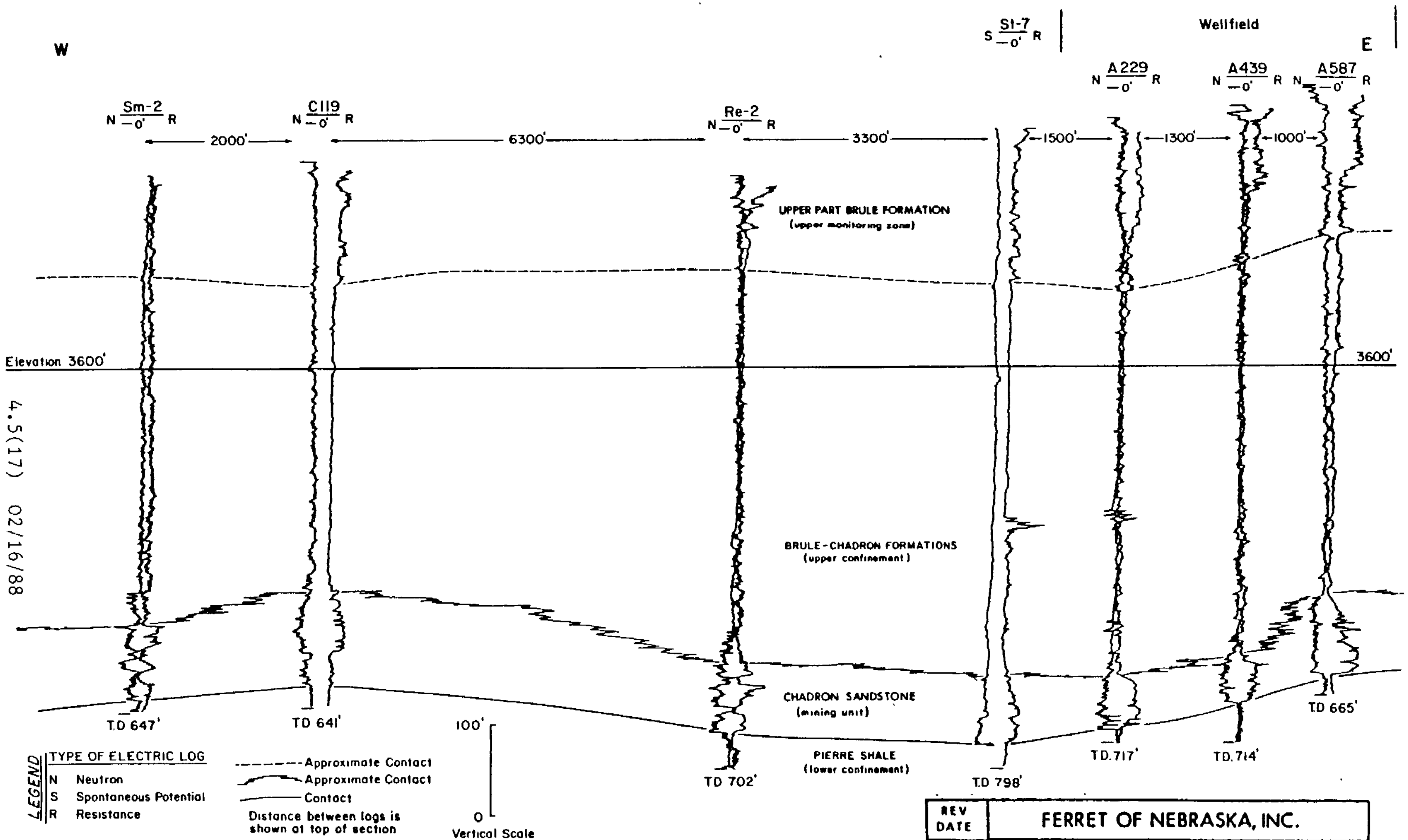


REV DATE	
02/16/88	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	CROSS-SECTION 506,000 E-W
	PREPARED BY: F.E.N.
	DWN BY: JC · DATE: 8/87 · FIGURE 4.5-6



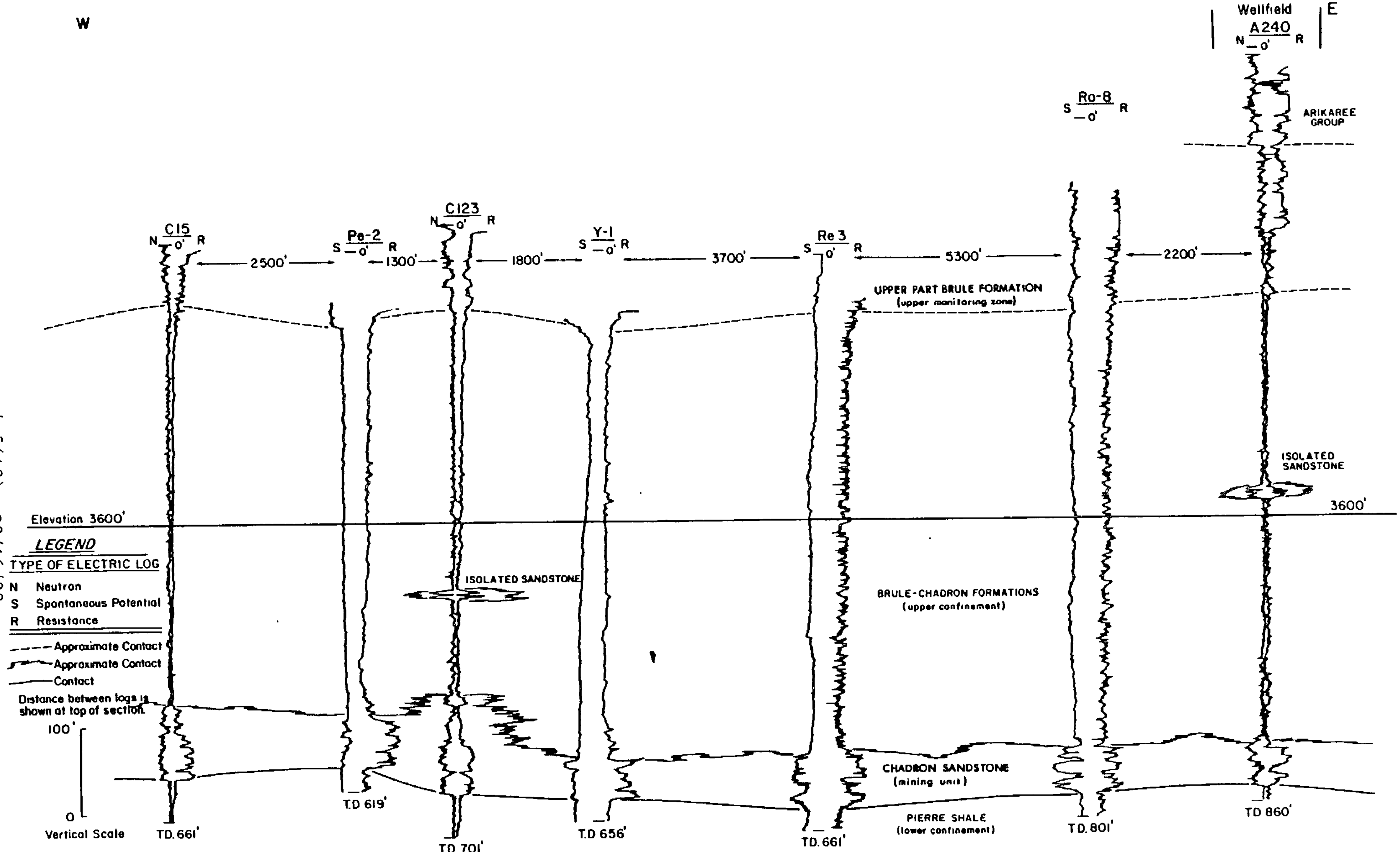
4.5(16) 02/16/88

REV. DATE	FERRET OF NEBRASKA, INC.		
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska		
	CROSS-SECTION 500,000 E-W		
	PREPARED BY: F.E.N.		
	DWN BY: JC	DATE: 8/87	FIGURE 4.5-7

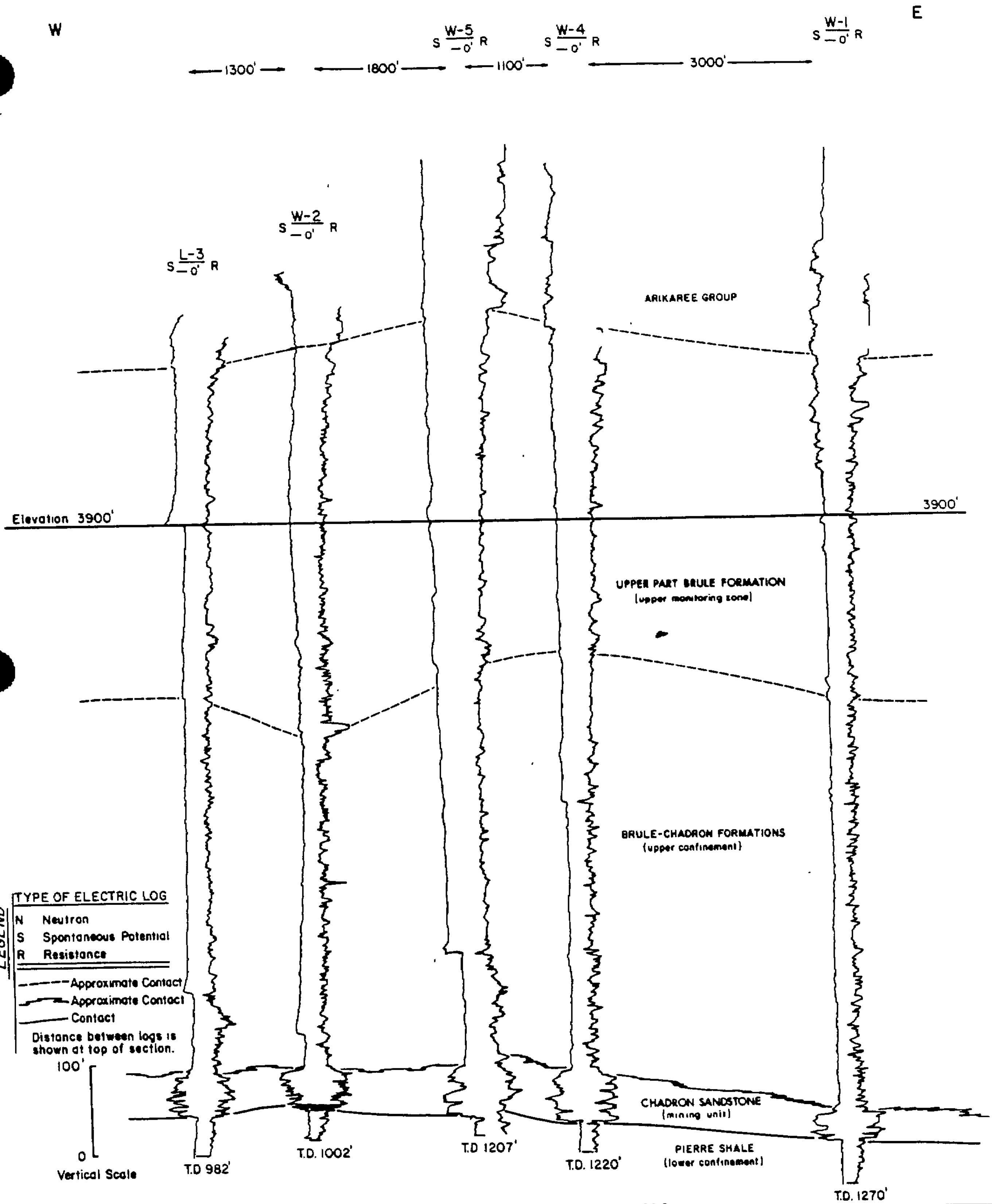


4.5(17) 02/16/88

REV DATE	
02/16/88	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	CROSS-SECTION 494,000 E-W
	PREPARED BY: F.E.N.
	DWN BY: JC — DATE: 8/87 — FIGURE. 4.5-8

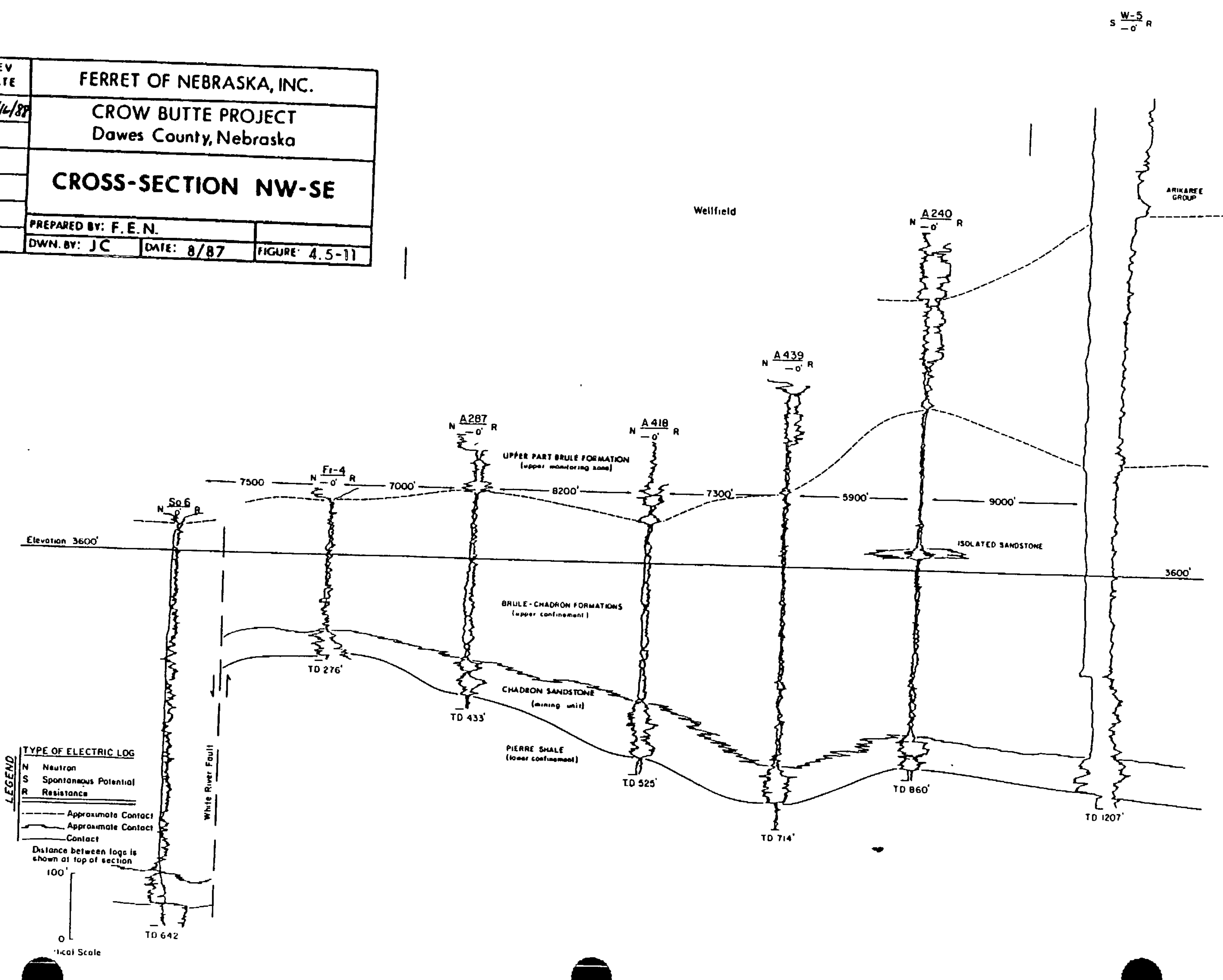


REV. DATE	
	FERRET OF NEBRASKA, INC.
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska
	CROSS-SECTION 490,000 E-W
	PREPARED BY: F.E.N.
	DWN BY: J C DATE: 8/87 FIGURE



REV DATE	FERRET OF NEBRASKA, INC.	
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska	
	CROSS-SECTION 482,000 W-E	
	PREPARED BY: F.E.N.	
	DWN. BY: JC	DATE: 8/87	FIGURE. 4.5-10

REV DATE	FERRET OF NEBRASKA, INC.	
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska	
	CROSS-SECTION NW-SE	
	PREPARED BY: F.E.N.	
	DWN. BY: JC	DATE: 8/87	FIGURE: 4.5-11



Sandstone which is the host for uranium mineralization (Figures 4.5-3 to 4.5-11). 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.

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 4.5-2). 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} 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.

<u>Chadron Sandstone - Mining Unit</u>

The Chadron Sandstone is generally present at the base of the Chadron Formation and is a 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.

TABLE 4.5-2

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

Number in parentheses is number of core samples.

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 4.5-12).

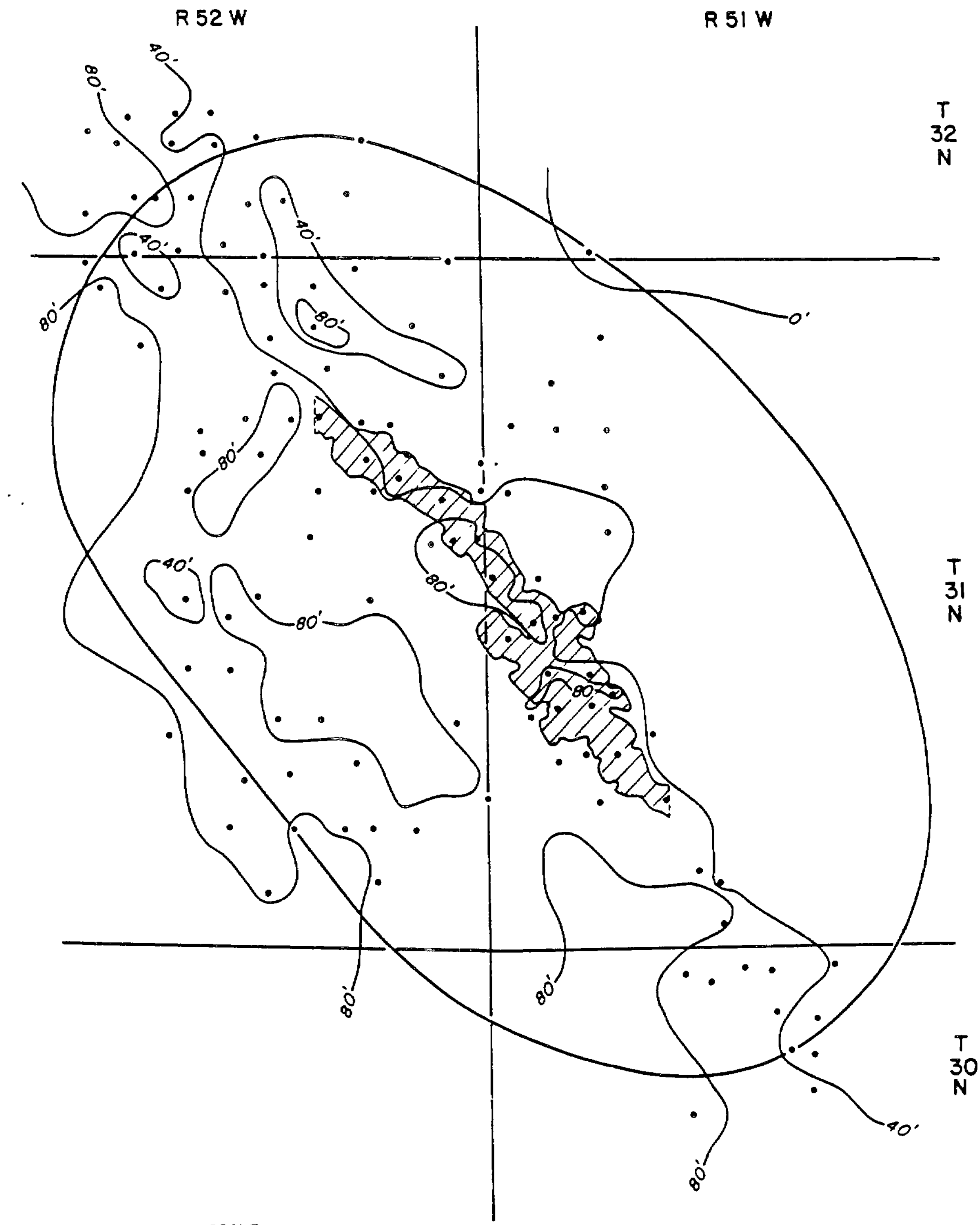
A persistent clay horizon typically brick red in color generally marks the upper limit of the Chadron Sandstone. Occasionally a younger sandstone immediately overlies the red clay and is well enough developed to be included in the Chadron Sandstone unit. This upper sandstone is similar in appearance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

Thin section examination of the Chadron Sandstone reveals its composition to be 50% monocrystalline quartz, 30 to 40% 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% quartz with the remainder K-feldspar and plagioclase (Table 4.5-2).

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 which normally occur during fluvial sedimentation. Within the permit area varying thicknesses of clay beds and lenses commonly separate the Chadron Sandstone into fairly distinct subunits as shown on the electric logs. Drill holes A-287 (Figure 4.5-6), WD-4 (Figure 4.5-7), and Re-2 (Figure 4.5-8) illustrate the subunits.

<u>Chadron-Brule Formations, Upper Confinement</u>

The upper part of the Chadron Formation and the Brule Formation are the upper confinements 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



SCALE 0 ¼ ½ 1 2 3 miles

LEGEND

- • Location of Data Point Exploration Drill Hole
- Area of Review - 2¼ mile radius from permit area.
- Wellfield Area

4.5(24) 09/30/87

REV DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	THICKNESS - BASAL CHADRON		
	PREPARED BY: F.E.N		
	DWN. BY: J C	DATE: 8/87	FIGURE. 4.5-12

a distinct and rapid facies change from the underlying sandstone unit. The upper part of the Chadron Formation is a light green-gray bentonitic clay grading downward to green and frequently red clay. X-ray diffraction analyses of the red clay indicate that it is primarily comprised of montmorillonite and calcite (Table 4.5-2). 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. In the Area of Review the measured vertical hydraulic conductivity of the upper confinement is less than 1.0×10^{-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.

Upper Part of Brule Formation - Upper Monitoring Unit

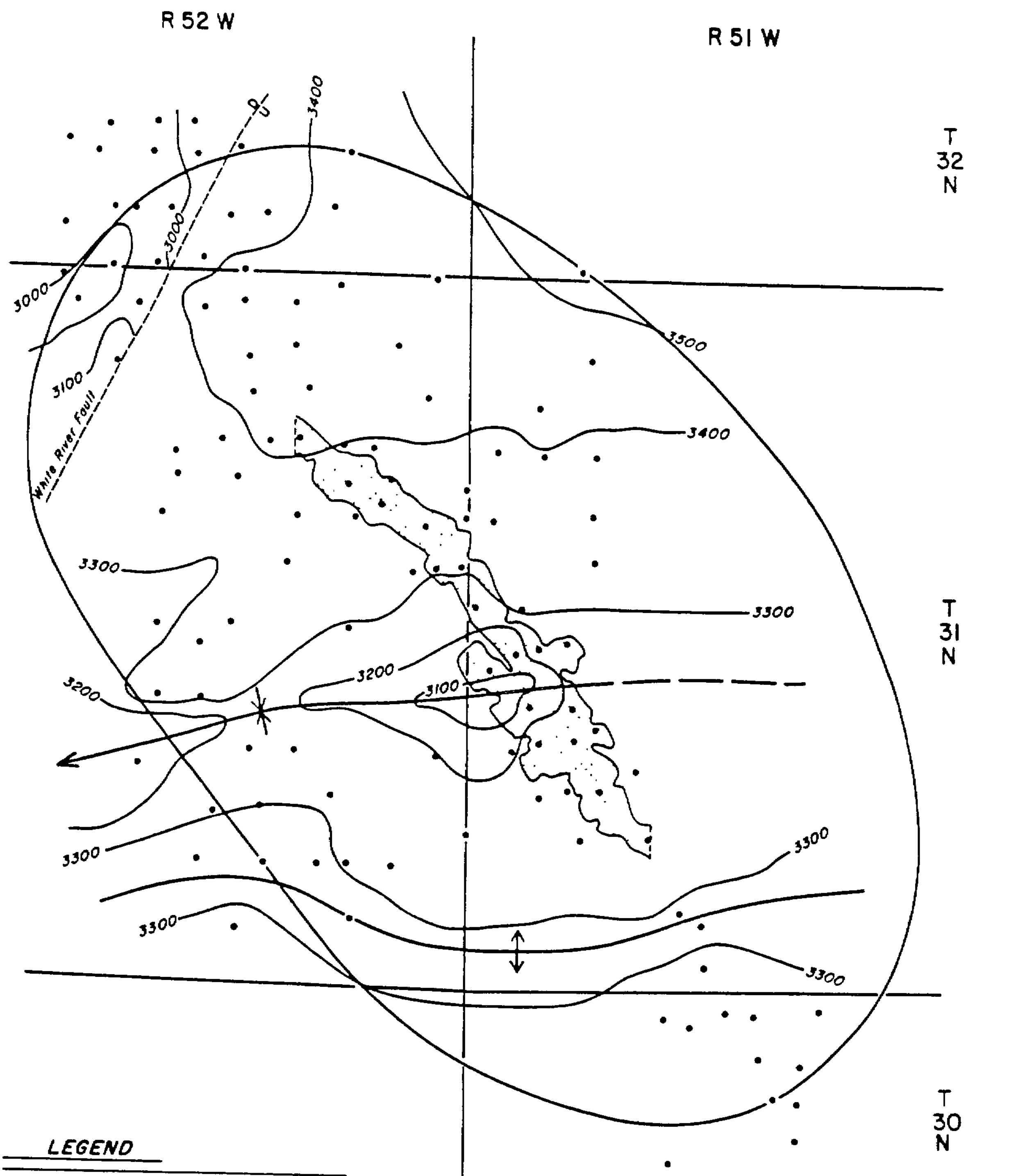
The upper part of the Brule Formation is primarily buff to brown siltstones which have a larger grain size than the lower part of the Brule Formation. Occasional sandstone units are encountered in the upper part of the Brule Formation. The small sand units have limited lateral continuity and, although water bearing, do not always produce usable amounts of water. These sandstones have been included in the upper part of the Brule Formation and are illustrated on the series of cross sections as overlying the upper confinement (Figures 4.5-3 to 4.5-11). 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).

Area of Review Structure

The structure of the Area of Review is illustrated on Figure 4.5-13. Elevation contours on top of the Cretaceous Pierre Shale, base of the Tertiary Chadron Formation, illustrate the structure. The current 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 which occurred after the deposition of the Chadron Formation. Regionally and within the Area of Review, the White River Group, Chadron and Brule Formations dip gently south at about 1/2 to 1 degree. The White River Fault is present along the northwest margin of the Area of Review and is dated as post-Oligocene since it cuts both the Chadron and Brule Formations. The fault has a total vertical displacement of 200 to 400 feet with the upthrown side on the south. The White River Fault is about 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 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 through the Area of Review and plunges west. An associated east-west trending anticlinal feature is present along the southern part of the Area of Review. This anticlinal axis is sub-parallel to the Cochran Arch proposed by DeGraw (1969) and is probably a related feature.



SCALE
0 ¼ ½ 1 2 3 miles

LEGEND

- • Location of Data Point Exploration Drill Hole
- Area of Review - 2¼ mile radius from permit area
- Wellfield Area
- —3300— Structure Contour on Top of Kp
- - - - - Fault
- Anticlinal Axis
- Synclinal Axis with Plunge Indicated

4.5(27) 09/30/87

REV DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	STRUCTURE ELEVATION OF Kp CONTACT TOP OF PIERRE (Base of Chadron Formation)		
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/87	FIGURE 4.5-13

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 a thick, homogenous black shale with very low permeability and is one of the most laterally extensive formations of northwest Nebraska.

The upper confinement is composed of the Chadron Formation above the Chadron Sandstone and that portion of the Brule Formation underlying the intermittent Brule sandstones (Figures 4.5-3 to 4.5-11). This part of the Chadron Formation is an impermeable clay grading upward into several hundred feet of siltstones and claystones of the Brule Formation. These units separate the zone of injection (Chadron Sandstone) from the nearest overlying water bearing unit with several hundred feet of clay and siltstones. The Chadron Formation clays have a large lateral extent and have been observed in all holes within the Area of Review.

From Table 4.5-2 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 which would affect in-situ mining of the uranium mineralization (see Hydrology Section 4.4).

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 4.5-14). Stratigraphically above the wellfield area the upper confinement ranges from 200 feet on the north to 500 feet on the south (Figure 4.5-14). This variation in thickness is primarily due to erosion of the rocks overlaying the Chadron Sandstone during Pleistocene time.

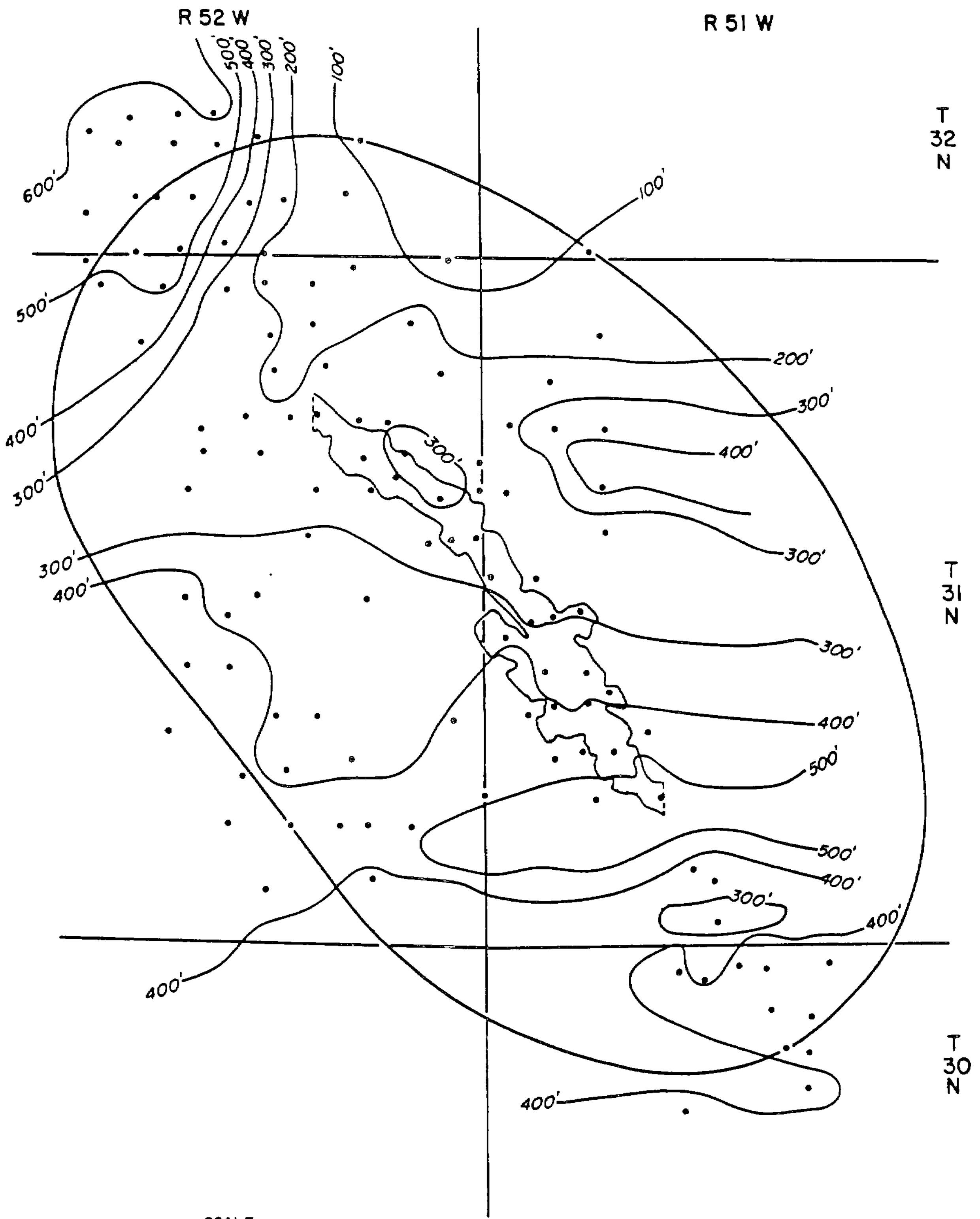
4.5.3 SEISMOLOGY

The Crow Butte Project 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 which 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 project area is within an area of low seismic risk occasional earthquakes have been reported. Over 1100 earthquakes have been catalogued within the Stable Interior of the U.S. since 1699 by Docekal (1970). This study 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 4.5-15 illustrates earthquake epicenters in Nebraska (Burchett, 1979). The location of the Chadron and Cambridge Arches are shown on this map. The earthquakes which have been recorded along these two structural features are tabulated in Table 4.5-3.

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

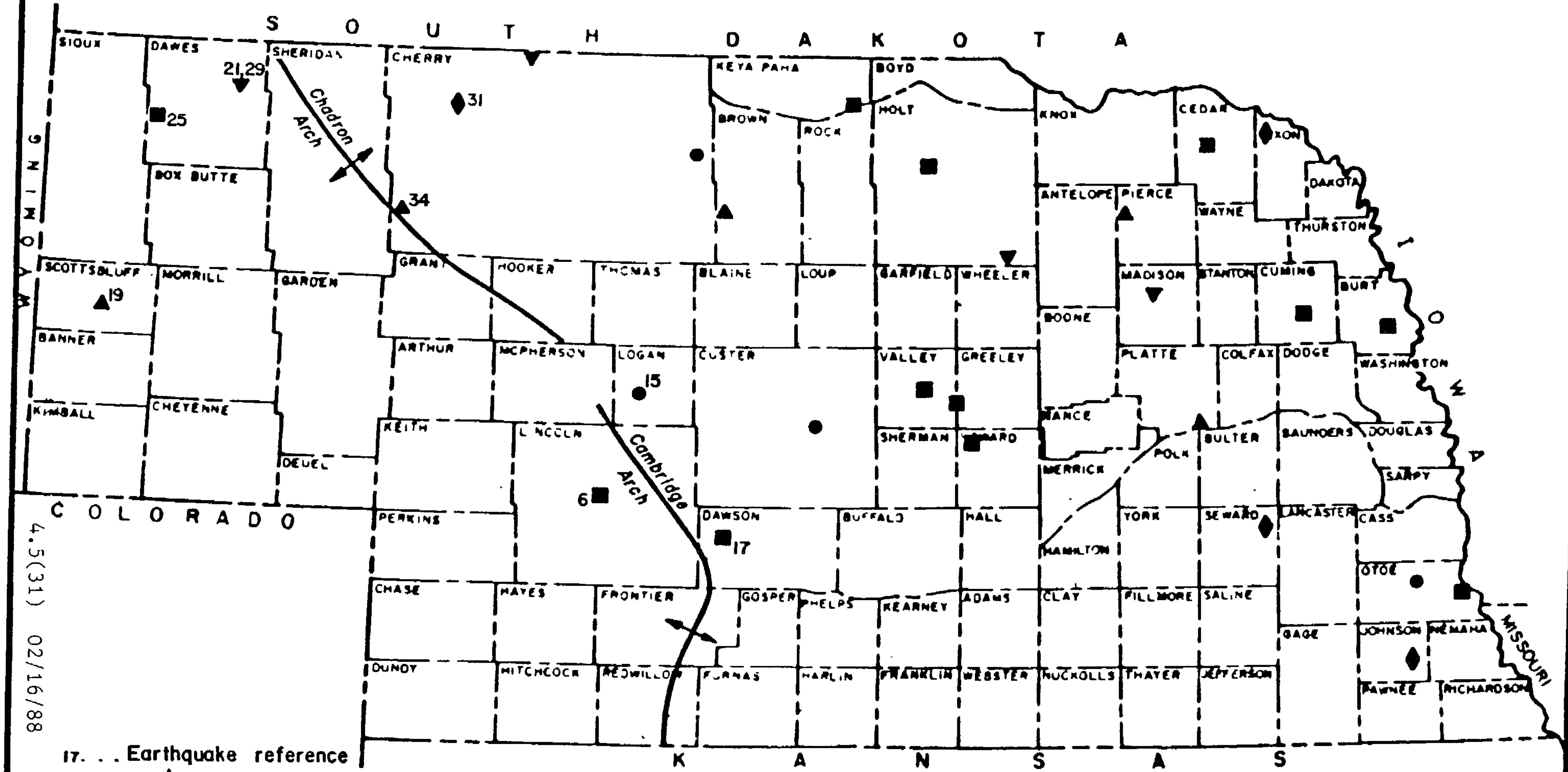


LEGEND

- Location of Data Point Exploration Drill Hole
- Area of Review - 2 1/4 mile radius from permit area.
- Wellfield Area

4.5(30) 09/30/87

REV DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	THICKNESS- UPPER CONFINEMENT	
	PREPARED BY: F. E. N.	
	DWN. BY: JC	DATE: 8/87	FIGURE: 4.5-14



17. . . Earthquake reference number

Epicenter Symbol	Earthquake Intensity (Modified Mercalli)
●	III
■	IV
▲	V
▼	VI
◆	VII

Source: Earthquakes In Nebraska by R.R. Burchett

(Structural features from Carlson, 1970)

REV DATE	FERRET OF NEBRASKA, INC.
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska
	EARTHQUAKE EPICENTERS IN NEBRASKA
	PREPARED BY: F.E.N.
	DWN BY: JC · DATE: 8/87 · FIGURE 4.5-15

TABLE 4.5-3

EARTHQUAKES IN NEBRASKA

Map Ref.	Date	Central Standard Time	Locality	Latitude Degrees North	Longitude Degrees West	Modified Mercalli (MM) Intensity	Source
6	1884 Mar 17	14:00	North Platte	41.133	100.750	IV	A
15	1916 Dec	----	Stapleton	41.550	100.476	II-III	A
17	1924 Sep 24	05:00	Gothenburg	40.950	100.133	IV	A
19	1933 Aug 8	----	Scottsbluff	41.867	103.667	IV-V	A
21	1934 Jul 30	01:20	Chadron	42.850	103.000	VI	A
25	1938 Mar 24	07:11	Fort Robinson	42.683	103.417	IV	A
29	1963 Mar 9	09:25	Chadron	42.860	103.000	II-III	A
31	1964 Mar 28	19:21	Merriman	42.800	101.667	VII	A
34	1978 May 7	10:06	SW Cherry County	42.340	101.930	V	C

Source:

A - Docekal, 1970

C - National Earthquake Information Service

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.

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.

REFERENCES

Algermissen, S.T., 1969, *Seismic Risk Studies in the United States: Proceedings of the Fourth World Conference on Earthquakes, Engineering.* Santiago, Chile, National Oceanic and Atmospheric Administration Reprint, 1:4-27.

Burchett, R.R., 1979, *Earthquakes in Nebraska:* University of Nebraska-Lincoln, Educational Circular No. 4, 20p.

Burchett, R.R., 1986, *Geologic Bedrock Map of Nebraska*: Nebraska Geological Survey.

Chaney, B., *Earthquakes,* Chadron Record, June 24, 1982, p.1.

Collings, S.P. and Knode,R.H., 1984, *Geology and Discovery of the Crow Butte Uranium Deposit, Dawes County, Nebraska: Practical Hydromet '83;* 7th Annual Symposium on Uranium and Precious Metals, American Institute of Metallurgical Engineers, p. 5-14.

DeGraw, H.M., 1969, *Subsurface Relations of the Cretaceous and Tertiary in Western Nebraska:* University of Nebraska, MS Thesis, 137pp.

Docekal, J., 1970, *Earthquakes of the Stable Interior with Emphasis on the Mid-Continent:* University of Nebraska, PhD Thesis.

Hoyt, J.H., 1962, *Pennsylvanian and Lower Permian of North Denver Basin, Colorado, Wyoming and Nebraska*: AAPG Bull., V.46, No.1, pp.46-59.

Momper, J.A., 1963, *Nomenclature, lithofacies and genesis of Permo-Pennsylvanian Rocks - Northern Denver Basin:* Rocky Mountain Association of Geologists, pp.41-67.

Rothe, G.H., 1981, *Earthquakes in Nebraska through 1979*; Earthquake Notes, V.52, No.2, pp. 59-65.

Rothe, G.H., Lui, C.V., and Steeples, D.W., 1981, *Recent Seismicity on the Chadron-Cambridge Arch, South-Central Nebraska*; Earthquake Notes, v. 52 No.1, p.61.

Schultz, C.B. and Stout, T.M., 1938, *Preliminary Remarks on the Oligocene of Nebraska (Abs.)*: Geological Society American Bulletin, V.49, p.1921.

Seeland, D., 1985, *Oligocene Paleogeography of the Northern Great Plains and Adjacent Mountains,* in Flores, R.M. and Kaplan, S.S., eds., Cenozoic Paleogeography of the West-Central United States: Rocky Mountain Section, SEPM, p.187-206.

Singler, C.R. and Pichard, M.D., 1979, *Petrography of the White River Group (Oligocene) in Northwest Nebraska and Adjacent Wyoming*: Contributions to Geology, University of Wyoming, V.18, p.51-67.

Singler, C.R. and Picard, M.D., 1980, ***Stratigraphic Review of Oligocene Beds in Northern Great Plains***: Earth Science Bul., WGA, v.13, No. 1, p. 1-18.

Spalding, Roy, ***Baseline Hydrogeochemical Investigation in a Part of Northwest Nebraska***, prepared for the Nebraska Dept. of Environmental Control by the Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, 1982.

Souders, V.L., ***Geology and Groundwater Supplies of Southern Dawes and Northern Sheridan Counties, Nebraska***, prepared for the Upper Niobrara-White Natural Resource District by the Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, 1981.

Swinehart, J.B., Souders, V.L., DeGraw, H.M. and Diffendal, R.F. Jr., 1985, ***Cenozoic Paleography of Western Nebraska, in Flores, R.M. and Kaplan, S.S.***, eds., ***Cenozoic Paleogeography of the West-Central United States:*** Rocky Mountian Section, SEPM, p. 187-206.

Vondra, C.F., ***The Stratigraphy of the Chadron Formation in Northwestern Nebraska:*** University of Nebraska, MS Thesis, 138p., 1958.

VonHake, C.A., 1977, ***Earthquake History of South Dakota:*** Earthquake Info. Bul., v.9, No.1, pp.35-36.

VonHake, C.A., 1974, ***Earthquake History of Nebraska:*** Earthquake Info. Bul. v.6, No. 5, pp.32-33.

Witzel, F.L., ***Guidebook and Road Logs for the Geology of Dawes and Northern Counties, Nebraska:*** MS Thesis, 97p, 1974.

Wyoming Fuel Company, 1983, ***Crow Butte project, Dawes County, Nebraska, application and supporting environmental report for State of Nebraska***, submitted to Nebraska Dept. of Environmental Control.

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

SUBSECTION 4.6

USES OF ADJACENT LANDS AND WATERS

TABLE OF CONTENTS

4.6 USES OF ADJACENT LANDS AND WATERS

The information in this section provides relevant data concerning the physical, ecological and social characteristics of the proposed commercial study area and surrounding environs for uranium in-situ mining.

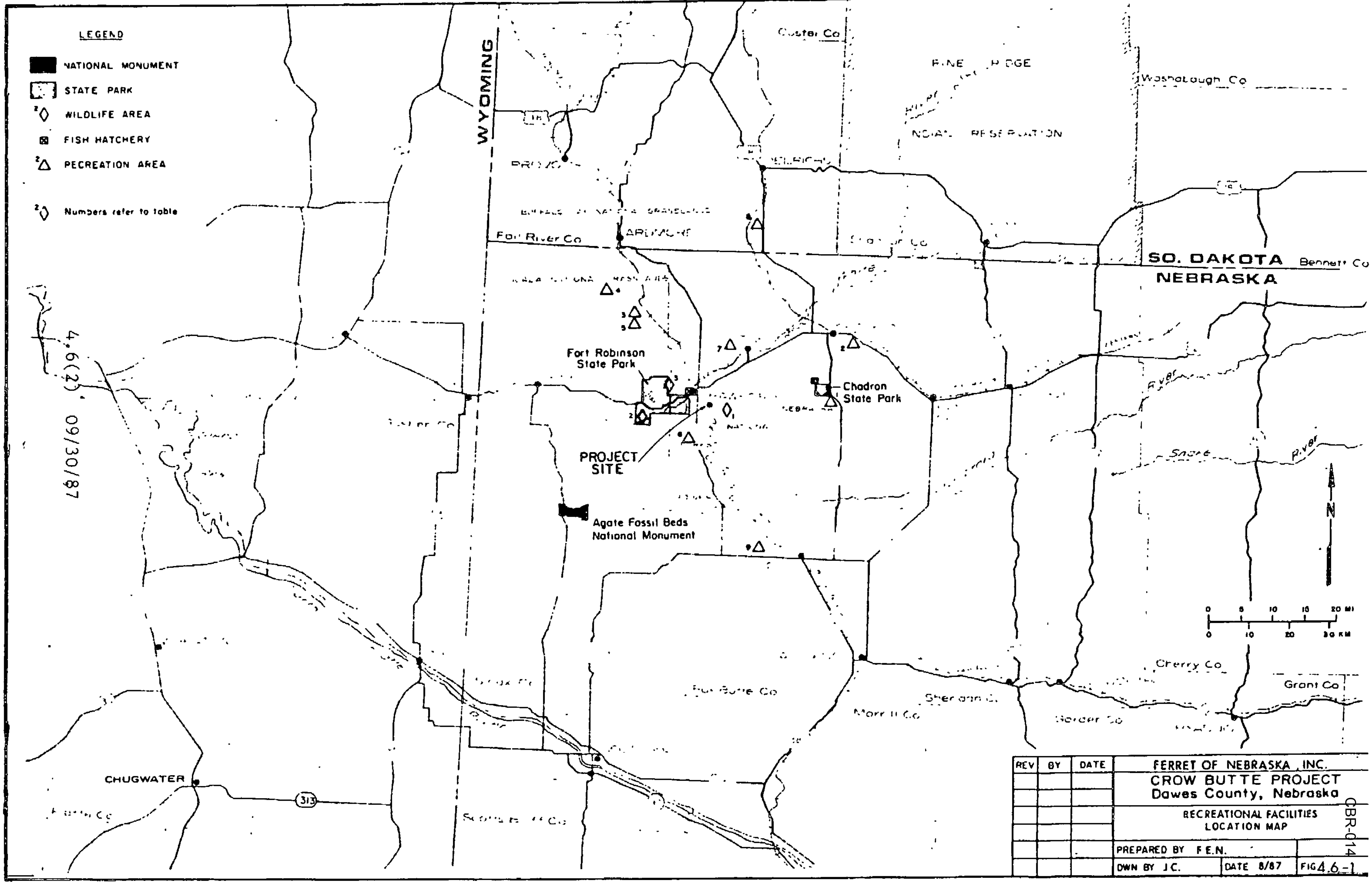
This section indicates the nature and extent of present and projected land and water use and trends in population or industrial patterns. The information in this section was developed over a 9-month period in 1982 as part of the Research and Development (R&D) permit application. Preliminary data were obtained from several sources followed by field studies to collect on-site data to check land uses. Interviews with various state and local officials provided additional useful information. These 1982 data were verified in 1987 through additional data collection and review, personal communications, and a site reconnaissance.

The land and water use information included in this section considers the area within an 8-km (5 mile) radius of the center point of the commercial permit area.

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 4.6-1 shows the general location of the proposed project site. The Crow Butte project site is about 5.25 miles southeast of the City of Crawford via Squaw Creek Road. State Highway 71 provides access to the project area from points north and south of Crawford. U.S. Highway 20 provides access to Crawford and the project area from points east and west.

Approximately 4 percent of the area within an 8-km (5 mile) radius of the project site 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 commercial permit area, is livestock raising. An annual average of 56,833 cattle valued at approximately $21.35 million were reported on Dawes County



REV	BY	DATE	FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			RECREATIONAL FACILITIES LOCATION MAP
			PREPARED BY F.E.N.
			DWN BY J.C. | DATE 8/87 | FIG 4.6-1

CBR-014

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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 (see Figure 4.6-1 and Table 4.6-1). 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).

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 project site.

Land Uses Within the 8-km Project Site Area

For the land use data inventory, the Crow Butte commercial project study area is defined as all lands within an 8-km (5 mile) radius of the proposed

TABLE 4.6-1

RECREATIONAL FACILITIES WITHIN 50 MILES OF THE CROW BUTTE AREA

Number [a]	Name of Recreational Facility	Distance from Site (miles)
1	Red Cloud Picnic Area	19
2	Museum of the Fur Trade	24
3	Toadstool Park	18
4	Warbonnet Battlefield	24
5	Hudson-Meng Bison Kill Site	17
6	Cochran State Wayside Area	5
7	Whitney Lake	10
8	Pioneer Roadside Park	28
9	Box Butte Reservoir	24
1 (Wildlife)	Ponderosa Wildlife Area	2
2 (Wildlife)	Peterson Wildlife Area	11
3 (Wildlife)	Soldier Creek Management Unit	7
	Crawford State Fish Hatchery	6
	Agate Fossil Beds National Monument	27

[a] Refers to numbers and symbols shown on Fig. 4.6-1

Source: Nebraska Dept. of Roads, 1981. South Dakota Division of Tourism, 1981.

project's designated centerpoint. Because the commercial facilities will be an expansion of the existing R&D facilities, the same centerpoint was used as that in the R&D permit application. Figure 4.6-2 shows the land within the project area. Table 4.6-2 presents a detailed breakdown of land use by sector while Table 4.6-3 presents the land uses by percentages and square kilometers. This breakdown is the same as that presented in 1982 since area land use has not changed since (Dawes County, City of Crawford, 1987). Land use categories and definitions are developed from both U.S. Geological Survey and U.S. Office of Surface Mining land use definitions (see Table 4.6-4).

The information presented for the project site area is based on information gathered from recent local and state publications, USGS quadrangle map sheets, a Dawes County U.S. Soil Conservation survey, and telephone interviews with various knowledgeable officials. The information was verified during an on-site field investigation conducted in early May, 1982 and again in 1987.

Agriculture. Several of the soil types found on the Crow Butte project area are classified as prime farmland (Dixon, 1982). However, in Dawes County soils are classified by the U.S. Soil Conservation Service (SCS) as prime only if irrigated. According to 1978, 1979 and 1980 Nebraska State Agricultural Statistics, only 2% of Dawes County land is irrigated, and about 18% of that irrigated acreage is harvested cropland acreage. The remainder of the irrigated land is used for pasture, habitat, or rangeland (Nebraska Crop and Livestock Reporting Service, 1980; 1981). Applying these same percentages to the Crow Butte 8-km (5 mile) area approximately 994 acres of the land is irrigated, of which 179 acres can be classified as harvested cropland. However, a review of Figure 4.6-2 would indicate that the actual irrigated acreage is less than the county average. All of the irrigated lands within the study area occur in the north and northwest sectors where aqueducts flow from the White River to the south and west.

TABLE 4.6-2

LAND USE OF THE CROW BUTTE 8-KM RADIUS, BY SECTOR AND CATEGORY
(in acres)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Subtotal
Cropland																	
0-1.8	70.9	64.8	76.8	110.8	86.5	*	33.4	--	--	30.4	73.3	89.7	64.8	8.2	57.4	27.1	802.1
1.8-3.6	323.7	90.2	17.8	8.3	5.5	--	--	--	74.5	64.8	233.0	276.4	267.8	166.6	292.0	246.9	2067.5
3.6-5.4	308.9	522.5	380.7	87.2	--	--	42.5	5.6	20.8	358.8	240.6	457.2	503.6	523.7	235.1	367.1	4054.3
5.4-7.2	334.0	824.8	636.6	123.9	--	98.2	130.4	151.6	--	164.4	--	384.9	148.0	70.8	495.8	552.9	4116.3
7.2-8.0	297.1	442.9	247.1	238.8	--	172.1	131.1	0	--	0	.2	313.8	43.1	--	156.7	178.3	2224.2
Subtotal	**1334.6**	**1945.2**	**1359.0**	**577.0**	**92.0**	**273.3**	**337.4**	**157.2**	**95.3**	**618.4**	**547.1**	**1522.0**	**1027.3**	**769.3**	**1237.0**	**1372.3**	**13264.4**
Commercial/Services																	
0-1.8												--		--	--	--	--
1.8-3.6												--		--	--	--	--
3.6-5.4												2.8		0.9	13.4	--	17.5
5.4-7.2												--		--	103.1	--	103.1
7.2-8.0												--		--	7.4	5.4	12.8
Subtotal												**2.8**		**0.9**	**124.3**	**5.4**	**133.4**
Forested Land																	
0-1.8	0.9	--	--	2.7	0.9	10.8	5.3	8.6	--	0.9	*	0.9	1.8	3.6	9.4	11.4	57.2
1.8-3.6	--	58.9	230.4	361.4	--	--	104.5	304.5	53.0	10.8	--	--	4.5	--	--	7.2	1135.2
3.6-5.4	--	--	35.7	169.9	53.9	--	512.6	556.7	472.7	31.5	11.1	--	--	--	13.8	3.6	1861.5
5.4-7.2	--	--	15.7	237.7	579.9	717.7	675.5	567.8	804.5	392.2	370.2	27.7	--	--	8.4	30.8	4428.1
7.2-8.0	6.4	--	.9	82.8	411.8	377.4	176.0	360.0	394.3	501.7	284.5	30.4	--	--	33.0	36.9	2696.1
Subtotal	**7.3**	**58.9**	**282.7**	**854.5**	**1046.5**	**1105.9**	**1473.9**	**1797.6**	**1724.5**	**937.1**	**665.8**	**59.0**	**6.3**	**3.6**	**64.6**	**99.9**	**10178.1**

TABLE 4.6-2 (Continued)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Subtotal
Habitat																	
0-1.8				--	25.1	57.8	15.8	--							--		98.7
1.8-3.6				67.9	466.0	471.5	361.6	1.8							--		1368.8
3.6-5.4				241.7	716.6	656.9	102.5	1.9							--		1719.6
5.4-7.2				--	160.1	103.7	--	--							3.7		267.1
7.2-8.0				--	--	--	--	--							1.8		1.8
Subtotal				**309.6**	**1367.8**	**1289.9**	**479.9**	**3.7**							**5.5**		**3456.4**
Industrial																	
0-1.8															--		--
1.8-3.6															--		--
3.6-5.4															--		--
5.4-7.2															13.9		13.9
7.2-8.0															--		--
Subtotal															**13.9**		**13.9**
Mines, Quarries, or Gravel Pits																	
0-1.8										3.6		--	3.6	*	5.7		12.9
1.8-3.6										--		--	--	--	--		--
3.6-5.4										--		0.9	--	--	6.4		7.3
5.4-7.2										--		--	--	--	--		--
7.2-8.0										--		--	--	--	--		--
Subtotal										**3.6**		**0.9**	**3.6**	*	**12.1**		**20.2**
Pastureland																	
0-1.8	85.3	92.4	80.4	35.6	44.6	88.5	102.7	148.5	157.2	122.3	83.8	66.6	87.0	145.4	84.7	118.7	1543.7
1.8-3.6	147.7	320.4	148.6	33.9	--	--	3.6	83.5	344.0	395.9	233.0	195.0	199.3	304.9	176.7	217.4	2803.9
3.6-5.4	477.1	263.6	365.1	287.2	15.5	98.5	93.3	94.2	234.5	395.7	531.4	325.0	282.4	261.4	508.7	129.7	4363.3
5.4-7.2	752.6	273.7	448.1	656.8	145.4	28.5	294.5	221.0	29.2	440.0	717.9	687.7	158.1	122.9	118.8	758.3	5853.5
7.2-8.0	279.5	147.0	347.9	268.8	41.1	5.6	246.6	--	--	--	243.8	246.3	174.1	--	121.6	377.0	2584.3
Subtotal	**1742.2**	**1097.1**	**1390.1**	**1282.3**	**246.6**	**221.1**	**740.7**	**632.2**	**764.9**	**1353.9**	**1809.9**	**1520.6**	**900.9**	**834.6**	**1010.5**	**1601.1**	**17148.7**

TABLE 4.6-2 (Continued)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Subtotal
Rangeland																	
0-1.8		--	--	--	--	--	--	--	--	--	--						--
1.8-3.6		1.8	74.7	--	--	--	1.8	81.6	--	--	--						159.9
3.6-5.4		--	--	--	--	30.7	35.1	127.7	58.0	--	--						251.5
5.4-7.2		--	--	82.0	215.0	152.3	--	160.0	266.6	103.8	6.6						986.3
7.2-8.0		--	--	--	137.5	31.4	36.7	144.6	192.9	84.1	61.9						689.1
Subtotal		**1.8**	**74.7**	**82.0**	**352.5**	**214.4**	**73.6**	**513.9**	**517.5**	**187.9**	**68.5**						**2086.8**
Recreational																	
0-1.8		--				--					--		--	--	--	--	--
1.8-3.6		--				--					--		--	--	--	--	--
3.6-5.4		--				--					--		--	--	--	--	--
5.4-7.2		--				--					6.6		794.2	890.0	127.2		1818.0
7.2-8.0		1.8				0.9					--		382.9	594.5	256.1		1236.2
Subtotal		**1.8**				**0.9**					**6.6**		**1177.1**	**1484.5**	**383.3**		**3054.2**
Urban Residential																	
0-1.8															--		--
1.8-3.6															--		--
3.6-5.4															--		--
5.4-7.2															229.4		229.4
7.2-8.0															9.2		9.2
Subtotal															**238.6**		**238.6**
Water																	
0-1.8	--	--									--			--	--	--	--
1.8-3.6	--	--									5.6			--	2.8	--	8.4
3.6-5.4	--	--									2.8			--	8.3	18.8	29.9
5.4-7.2	13.8	1.8									--			16.8	--	12.7	45.1
7.2-8.0	7.4	-0-									--			--	--	2.3	9.7
Subtotal	**21.2**	**1.8**									**8.4**			**16.8**	**11.1**	**33.8**	**93.1**

TABLE 4.6-2 (Concluded)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
All Land Uses[a]																	
C	1334.6	1945.2	1359.0	577.0	92.0	273.3	337.4	157.2	95.3	618.4	547.1	1522.0	1027.3	769.3	1237.0	1372.3	13264.4
C/S	--	--	--	--	--	--	--	--	--	--	--	2.8	--	0.9	124.3	5.4	133.4
F	7.3	58.9	282.7	854.5	1046.5	1105.9	1473.9	1797.6	1724.5	937.1	665.8	59.0	6.3	3.6	64.6	89.9	10178.1
H	--	--	--	309.6	1367.8	1289.9	479.9	3.7	--	--	--	--	--	--	5.5	--	3456.4
I	--	--	--	--	--												
M	--	--	--	--	--												
P	1742.2	1097.1	1390.1	1282.3	246.6	221.1	740.7	632.2	764.9	1353.9	1809.9	1520.6	900.9	834.6	1010.5	1601.1	17148.7
R	--	1.8	74.7	82.0	352.5	214.4	73.6	513.9	517.5	187.9	68.5	--	--	--	--	--	2086.8
RC	--	1.8	--	--	--	0.9	--	--	--	--	6.6	--	1177.1	1484.5	383.3	--	3054.2
UR	--	--	--	--	--	--	--	--	--	--	--	--	--	--	238.6	--	238.6
W	21.2	1.8	--	--	--	--	--	--	--	--	8.4	--	--	16.8	11.1	33.8	93.1
Total[b]	**3105.3**	**3106.6**	**3106.5**	**3105.4**	**3105.4**	**3105.5**	**3105.5**	**3104.6**	**3102.2**	**3100.9**	**3106.3**	**3105.3**	**3115.2**	**3109.7**	**3100.9**	**3102.5**	**49687.8**

‡ Less than one-tenth of one acre.

[a] See Table 4.6-5 for land-use definitions.

[b] Calculations used in this table for each of the 22-1/2% compass points:

0 - 1.8 km = 157.158 acres
1.8 - 3.6 km = 471.474 acres
3.6 - 5.4 km = 786.038 acres
5.4 - 7.2 km = 1,100.354 acres
7.2 - 8.0 km = 590.407 acres
Total 8 km = 3,105.431 acres

[c] Actual area of the 8-km radius is equal to 49,682.7 acres. However, multiplying the total acreage used for each compass point (3105.43) by 16 equals 49,686.9 acres. Differences between this total as well as other subtotals due to rounding.

TABLE 4.6-3

LAND USE WITHIN THE CROW BUTTE STUDY AREA
(8-km RADIUS)

Category	Acres	km^2	% of Total Area
Cropland (C)	13,264.4	53.7	26.7
Commercial and Services (C/S)	133.4	0.5	0.2
Forested Land (F)	10,178.1	41.1	20.5
Habitat (H)	3,456.4	14.0	7.0
Industrial (I)	13.9	0.1	*
Mines, Quarries, or Gravel Pits (M)	20.2	0.1	*
Pastureland (P)	17,148.7	69.5	34.6
Rangeland (R)	2,086.8	8.4	4.2
Recreational (RC)	3,054.2	12.3	6.1
Urban Residential (UR)	238.6	1.0	0.5
Water (W)	93.1	0.4	0.2
Total	**49,687.8**	**201.1**	**100.0**

* Less than one-tenth of one percent.

TABLE 4.6-4

CROW BUTTE STUDY AREA LAND AND WATER USE DEFINITIONS

Croplands (C): Harvested cropland, including grasslands cut for hay; cultivated summer-fallow and idle cropland.

Commercial and Services (C/S): Those areas 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 are included in this category.

Pastureland (P): Land used primarily for the long-term product 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 one 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.

TABLE 4.6-4 (Continued)

CROW BUTTE PROJECT LAND AND WATER USE DEFINITIONS

Water (W): Areas of land mass that persistently are water covered.

Recreational (RC): Land used for public or private leisure-time use, 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.

Sources: U.S.G.S., 1976; U.S. Department of Interior, 1979.

Tables 4.6-5 through 4.6-8 show agricultural productivity within the 8-km (5 mile) radius as well as Dawes County. Winter wheat and hay are the major crops grown on croplands within the study area. Most of these crops are used for livestock feed while the remaining crops are commercially sold. The livestock inventory found within the study area is similar to the rest of Dawes County, with cattle accounting for over 80% of all livestock.

Habitat. As defined in Table 4.6-4, these lands are dedicated wholly or partially to the production, protection or management of species of fish or wildlife. Significant areas classified as habitat include the Crawford State Fish Hatchery and the Ponderosa State Wildlife area. The hatchery produces mainly Brook, Brown, and Rainbow Trout eggs, which are sent to other fish hatcheries throughout the United States (Litzinger, 1982). Deer and turkey hunting is permitted within the Ponderosa State Wildlife area.

Residential. According to 1980 USGS quad sheets and on-site field investigations, 73 occupied dwelling units are located in the rural area of the Crow Butte 8-km (5 mile) (see Table 4.6-9). Interviews with local citizens were conducted in 1982 within a 10-km (6.2 mile) radius to find actual rural population counts. The average persons per household estimate for the known rural household were then used to estimate the population of the remaining households located in the 10-km (6.2 mile) radius. As a result, an estimated 181 persons reside within the rural portions of the 8-km (5 mile) project radius. An additional 1,315 persons reside in Crawford, approximately 6.5 km (4 miles) from the site centerpoint (U.S.Bureau of the Census, 1982). Two dwelling units are within 1-km (0.62 miles) and another five dwelling units are within 2km (1.24 miles) of the centerpoint of the proposed permit site.

Commercial and Services. Retail and commercial establishments are located in both Crawford and Fort Robinson. The four largest establishments include the Crawford Community Hospital, the Ponderosa Villa Nursing Home, livestock sale barn and railroad.

TABLE 4.6-5

AGRICULTURAL YIELDS (kg/km²) FOR CROPLANDS IN DAWES COUNTY, 1978-1980 AVERAGE

	Planted	Harvested		Production		Yield
	Acres	Acres	km²	Bu/Tons	Kgs	Kgs/km²
Corn						
for grain (bu)		2,333	9.44	229,867	5,838,622	618,498
for silage (tons)		767	3.10	9,650	8,754,287	2,823,964
other		67	.27	843	765,696	2,823,964[c]
Subtotal	3,233[b]	3,167	12.81	240,360	15,358,605	1,198,954.3
Sorghum for Grain (bu)	100	100	0.40	3,750	95,250	238,125
Oats (bu)	7,033	4,367	17.67	162,800	2,360,600	133,593
Barley (bu)	1,500	1,333	5.39	53,300	1,161,940	215,573
Rye (bu)	467	233	0.94	5,367	136,322	145,023
All hay[d] (tons)	69,967	69,967	283.15	100,453	91,128,953	321,840
Wheat (bu)	53,167	47,334	191.56	1,506,000	40,963,200	213,840
Total	135,467	126,501	511.94	----	151,204,870	295,356.6
Irrigated	n/a	3,067	12.41	----	----	----

n/a = not available.
[a] 1 acre = .0040469 km².
[b] Total for grain, silage and forage or pastured.
[c] Used the same kgs/km² as corn for silage.
[d] Includes wild and tame alfalfa.

TABLE 4.6-6

POTENTIAL AGRICULTURAL PRODUCTION FOR CROPLAND IN THE CROW BUTTE 8-km STUDY RADIUS

	Percent of Total Planted[a]	Total Cropland (Acres)	Percent of Planted/ Harvested[a]	Harvested (Acres)	Harvested (km^2)[b]	County Yield (kgs/km^2)	Production 8-km Radius (kgs)
Corn	2.39	317.0	97.96	310.5	1.26	1,198,954	1,510,682
Sorghum	0.07	9.3	100.00	9.3	0.04	238,125	11,906
Oats	5.20	689.7	62.09	428.2	1.73	133,593	231,116
Barley	1.11	147.2	86.67	127.6	0.52	215,573	112,098
Rye	0.35	46.4	49.89	23.1	0.09	145,023	13,052
Hay	51.55	6,837.8	100.00	6,837.8	27.67	321,840	8,905,313
Wheat	39.33	5,216.9	89.03	4,644.6	18.80	213,840	4,041,576
Total	**100.0**	**13,264.4**	**93.34**	**12,381.1**	**50.11**	**(295,864)[c]**	**14,825,743**

a Same as Dawes County.

b 1 acre = .0040469 km^2

c Average yield for all crops harvested in the 8-km project radius.

TABLE 4.6-7

LIVESTOCK INVENTORY, DAWES COUNTY
JANUARY 1, 1978-1980

3-YEAR AVERAGE

	Number	% of Total	Animal Units[a] lbs.	Animal Units[a] % of
All Cattle, except dairy	56,510	82.1	56,510	97.2
Dairy cattle	323	0.5	323	0.5
Hogs	5,100	7.4	1,122	1.9
Sheep	843	1.2	169	0.3
Chickens[b]	6,050	8.8	31	0.1
Total animals	68,826	100.0	58,155	100.0
Milk production (000's lb)	3,400			
Egg production (000's lb)	1,250			

[a] Animal unit conversions:

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

[b] Chickens on farms December 1 of previous year.

Source: Nebraska Crop and Livestock Reporting Service, 1980; 1981.

TABLE 4.6-8

ESTIMATED AVERAGE YIELDS FOR NATIVE GRASSLANDS (RANGELAND) AND IMPROVED PASTURELAND FOR THE CROW BUTTE 8-km PROJECT SITE AREA

	Total Land Use	Total Yield		Potential Animal Units[c]	
		Acres	Tons[a]	Kgs.[b]	Per Month[d]
Rangeland	2,086.8	1,043.4	946,552	1,043	5,215
Pastureland	17,148.7	25,723.1	23,335,482	13,719	68,595
Total	19,235.5	26,766.5	24,282,034	14,762	73,810

[a] Yield for rangeland is .5 tons/acre, yield for improved pasture is 1.5 tons/acre.

[b] 1 ton = 907.18 kg.

[c] 1 animal unit = 1,000 lbs.

[d] 1 acre of rangeland supports .5 animal units in a month (aum); 1 acre of improved pasture supports .8 aum.

[e] Grazing season in Dawes County lasts approximately 5 months.

Source: D. Huls, 1982. Dawes County Agricultural Extension agent.

TABLE 4.6-9

RESIDENCE COUNT AND DISTANCE
(8-km RADIUS OF CROW BUTTE PROJECT CENTERPOINT)

Sector	Structure Count[a]	Nearest Residence (km)	Nearest Vegetable Garden (km)	Nearest Project Boundary (km)
N	2	5.7		2.4
NNE	1	4.0		2.0
NE	3	4.3		2.5
ENE	6	.6	.6	2.1
E	0	--		2.1
ESE	5	.6		1.4
SE	6	3.7		1.6
SSE	1	4.5		2.9
S	3	3.8		4.0
SSW	2	5.0		2.3
SW	3	1.6		1.5
WSW	3	3.1		1.3
W	3	2.5		1.3
WNW	38[b]	4.4		1.3
NW	608[b]	3.1		5.4
NNW	10	1.1	1.1	2.4

[a] Residences.

[b] U.S. Census Bureau reported 621 housing units within the City of Crawford. As with the Sectorial population, housing units for Crawford are allocated as 5% for the WNW sector and 95% for the NW sector.

Sources: USGS, 1980; EH&A, 1982; U.S. Dept. of Commerce, 1981.

Industrial/Mine. Eight gravel pits are found within the 8-km (5 mile) radius of the Crow Butte study area (see Figure 4.6-2). Most of the pits are inactive, although a few are mined periodically for local road construction purposes. Besides FEN, Conoco, Amoco Minerals, Sante Fe Mining, and Union Carbide have also drilled exploratory test holes in the study area.

Other industrial facilities within the 8-km (5 mile) radius include the railroad station and maintenance yard at the City of Crawford.

Recreational. The Ponderosa State Wildlife area, located less than 2 miles from the Crow Butte study area, is open to the public for hunting. Although no park sites in the Nebraska State Forest are found within the 8-km (5 mile) study area, the area is open for hiking and camping. The Cochran State Wayside Area, located 7-km (4.3 miles) southwest of the site, is a primitive camping area with 2 campsites, hiking trails, and scenic views. A small portion of Fort Robinson State Park is within 8-km of the site. Urban recreational facilities in the project area include a golf course and city park in Crawford.

Aesthetics. The Crow Butte project area has varied land form and color variation. Crow Butte provides a backdrop along south and west approaches to the site. Ponderosa pines and mixed evergreens are seen while approaching from north of the project site. As the project area has been used historically for grazing, it is unlikely that any undisturbed area exists within the site boundary. Human influence is evidenced by scattered farmhouses and some fencing, and the existing R&D facility.

Transportation and Utilities. Nebraska Highway 2 and U.S. Highway 20 converge in Crawford. 1980 average daily traffic counts range between 625-825 on Nebraska Highway 2 and between 1,190-1,225 on U.S. Highway 20 within the project area (Nebraska Department of Roads, 1981). Although unpaved, Squaw Creek Road provides access to the Crow Butte site. A Burlington Northern

Railroad runs in a northwesterly direction approximately 1.2-km (0.75 miles) west of the site. Another railroad, the Chicago and Northwestern, travels from the southwest to the northeast through Crawford. Several transmission lines traverse the project area, including one less than 1-km west of the designated centerpoint.

<u>Other</u>. Three cemeteries are within the site area, one within 2km of the site centerpoint. Two radio towers and two schools are also located in the area.

<u>Water Uses Within the 8-km Study Area</u>

The Crow Butte project 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 is used to support agricultural production, wildlife habitat, and both warm and cold-water fish. Within 10-km (6.2 miles) of the project, Dead Man's Creek, upstream from the project, supplies drinking water to the citizens of Crawford. In 1981, average daily usage ranged from a low of 199 gallons per day per person (gpd) in February to a high of 508 gpd 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, are also located within a 10-km (6.2 mile) radius.

Groundwater in the 8km (5 mile) study area is supplied by either the Brule or Chadron Formations (Williams, 1982). A water well survey conducted by Wyoming Fuel Company indicates that most of the groundwater pumped from 123 wells surveyed within 2-1/4 miles (3.62 km) of the proposed commercial

study area is used either to water livestock or for domestic purposes. A spring, located at Fort Robinson State Park, produces an average of 972,000 gpd and this water is piped into ponds at the Crawford State Fish Hatchery. (Storbeck, 1987).

Future water use within an 8-km radius of the project site will likely be a continuation of present use. It is unlikely that any additional irrigation development will occur due to the shortage of existing water. The City of Crawford has upgraded their existing surface water supply system in 1986, and attempts to obtain additional underground water supplies have been abandoned. (Morava, 1987).

REFERENCES

Bump Abstract Company, *Nebraska Ownership Map,* Dawes County, 1979.

Datson, B., *Personal Communication,* Office of Development and Planning, Chadron State College.

Assessors Office, *Personal Communication,* Dawes County, 1987.

Dixon, M., *Personal Communication,* Soils Scientist, U.S. Soil Conservation, 1982.

Fisher, Harden & Fisher, *Water Well Survey of the Crow Butte Study Area,* 1982.

Foster, J., *Personal Communication,* Nebraska Games and Parks Division, 1987.

Huls, D., *Personal Communication,* Agent, Dawes County Agricultural Extension, 1982, 1987.

Lakey, L., *Personal Communication,* Realtor, Crawford State Company, 1982.

Lemmons, L., *Personal Communication,* Ponderosa State Wildlife Area Land, 1982.

Litzinger, J., *Personal Communication,* Crawford National Fish Hatchery, 1982.

Mathis, G., *Personal Communication,* Clerk, Dawes County, 1982.

McGinnis, M., *Personal Communication,* Water Commissioner, City of Crawford, 1982.

Morava, T., *Personal Communication,* Past Mayor, Crawford, Nebraska, 1987.

Nebraska Crop and Livestock Reporting Service, *Nebraska Agricultural Statistics,* Annual Report, 1978-1979; 1981.

Nebraska Department of Roads, *Official State Highway Map, Travel Guide and Campground Directory;* 1981.

_____, *Traffic Flow Map of the State Highways,* 1980.

Nebraska Game and Parks Commission, *Discover Nebraska Travel Guide,* 1982.

_____, *Nebraska Land Magazine,* 1982.

REFERENCES (Concluded)

Roberts, P., *Personal Communication,* Nebraska Oil and Gas Conservation Commission, 1982.

Rotherham, V., *Personal Communication,* Fort Robinson State Park, 1987.

Schmiedt, J., *Personal Communication,* Dean of Students, Chadron State College, 1987.

Soil Conservation Service, *Personal Communication,* Crawford Office, 1987.

South Dakota Department of Tourism, *Official 1981-82 State Highway Map,* 1981.

Storbeck, C., *Personal Communication,* Crawford State Fish Hatchery, 1987.

U.S. Department of Interior, *Permanent Regulatory Program Guidelines,* Office of Surface Mining, 1979.

U.S. Geological Survey, *A Land Use and Land Cover Classification System for Use with Remote Sensor Data,* Geological Survey Professional Paper 964, 1976.

_____, *Quadrangle Maps: Dead Man's Creek, Belmont, Coffee Mill Butte, SW, Chimney Butte, Crow Butte, Crawford, Nebraska.*

_____, *Bedrock Geology, Altitude of Base,* 1981.

_____, *Saturated Thickness of the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas and Wyoming,* 1981.

Bureau of Business Research, *Population Projections of Nebraska, 1970-2000,* University of Nebraska, 1980.

Williams, J., *Personal Communication,* Upper Niobrara-White River Basin Natural Resources District, 1982.

SUBSECTION 4.7

POPULATION DISTRIBUTION

TABLE OF CONTENTS

4.7 POPULATION DISTRIBUTION

Information presented in this section concerns those demographic and social characteristics of the environs that may be affected by the proposed Crow Butte commercial operations. Data were obtained through the 1980 U.S. Census of Population and discussions with state and local agency personnel.

Demography

Regional Population. The 80-km (50 mile) area surrounding the project site includes portions of six counties in northwestern Nebraska, two counties in southwestern South Dakota, and two counties in western Wyoming. Because the 80-km boundary extends only slightly into two very rural counties in Wyoming (with populations less than 2,000 persons) the regional demography in Wyoming is not discussed in detail beyond that summarized in Tables 4.7-1 through 4.7-3.

Historical and current populations trends in the project area counties and communities are contained in Table 4.7-1. Between 1960 and 1980, Box Butte County exhibited the fastest rate of growth with over a 17.0 percent population increase, largely occurring in the latter half of the 1970's. Population growth has been concentrated in the City of Alliance in southeastern Box Butte County, approximately 72-km (45 miles) south of the project site. The City of Alliance recorded a 1980 population of 9,869. Hemingford, also within the project site radius, showed population growth between 1977 and 1980, increasing to 1,023 by 1980. The 1985 population estimate shows continued but slower growth for the county.

With the exception of Scotts Bluff County, the Nebraska counties comprising the project area experienced slight growth or actual population decline between 1960 and 1980. Dawes County had a 1980 population of 9,609, only 0.8 percent above its 1960 level, although Chadron, its largest urban area, increased by nearly 17 percent over the last two decades. Chadron is located approximately 40-km (25 miles) northeast of the project site with a 1980 population of 5,933. The community of Crawford, within 10-km (6.3 miles) of the site, had a 1980 population of 1,315. The population of Dawes County exhibited a slight decrease from 1980 to 1985.

TABLE 4.7-1

HISTORICAL AND CURRENT POPULATION CHANGE FOR COUNTIES AND TOWNS WITHIN 80 K.M. OF THE CROW BUTTE PROJECT SITE, 1960-1980

State / County / City	Population 1960	1970	1977	1980	1985	Annual % Change 1960/1970	1970/1977	1977/1980	1980/1985
Nebraska									
Dawes	9,536	9,761	8,890	9,609	9,400	.23	-1.33	2.63	-0.42
Chadron	5,079	5,921	5,049	5,933		1.55	-2.25	5.53	
Crawford	1,588	1,291	1,254	1,315		-2.05	-0.41	1.60	
Box Butte	11,688	10,094	11,202	13,696	14,400	-1.46	1.50	6.93	1.04
Alliance	7,845	6,862	7,997	9,869		-1.33	2.21	7.26	
Hemingford	904	734	801	1,023		-2.06	1.26	8.50	
Scotts Bluff	33,809	36,432	37,510	38,344	37,900	0.75	0.42	0.74	-0.22
Scottsbluff	13,377	14,507	13,813	14,156		0.81	-0.70	0.82	
Sheridan	9,049	7,285	7,464	7,544	7,600	-2.15	0.35	0.36	0.16
Hay Springs	823	682	627	794		-1.86	-1.19	8.19	
Rushville	1,228	1,137	1,192	1,217		-0.77	0.68	0.69	
Sioux	2,575	2,034	1,925	1,845	1,800	-0.24	-0.78	-1.40	-1.62
Harrison	448	377	384	361		-1.71	0.26	-2.04	
Morrill	7,057	5,813	6,200	6,085	5,100	-1.92	0.93	-0.62	-0.64
South Dakota									
Fall River	10,688	7,505	8,344	8,439	7,800	-3.47	1.53	0.38	-1.52
Hot Springs	4,943	4,434	4,759	4,742		-1.08	1.02	-0.12	
Oelrichs	132	94	145	124		-3.34	6.39	-5.08	
Ardmore	73	14	17	16		-15.22	2.81	-2.00	
Shannon	6,000	8,198	8,494	11,323	11,700	3.17	0.51	10.06	0.60
Wyoming									
Goshen	11,941	10,885	12,139	12,040	12,600	-0.92	1.57	-0.27	0.94
Niobrara	3,750	2,924	2,953	2,924	3,200	-2.46	0.14	-0.33	1.64
Lusk	1,890	1,495	1,710	1,650		-2.32	1.94	-1.18	

Sources: U.S. Bureau of the Census, 1972a, 1972b, 1972c, 1979, 1981, 1986.

TABLE 4.7-2

POPULATION BY AGE AND SEX FOR COUNTIES
WITHIN THE 80-km RADIUS OF THE CROW BUTTE PROJECT AREA, 1980

State/County	Age	Male	Female	Total	Total % Breakdown*
Nebraska					
Dawes	Under 1	79	94	173	1.8
	1-4	280	236	516	5.4
	5-13	552	542	1,094	11.4
	14-17	360	259	619	6.4
	18+	3,453	3,754	7,207	75.0
	Total	4,724	4,885	9,609	100.0
Box Butte	Under 1	164	153	317	4.7
	1-4	526	510	1,036	7.6
	5-13	975	935	1.910	13.9
	14-17	396	409	805	5.9
	18+	4,778	4,850	9,628	70.3
	Total	6,839	6,857	13,696	100.0
Scotts Bluff	Under 1	371	333	704	1.8
	1-4	1,290	1,227	2,517	6.6
	5-13	2,873	2,697	5,570	14.5
	14-17	1,430	1,342	2,772	7.2
	18+	12,633	14,148	26,781	69.8
	Total	18,597	19,747	38,344	99.9

TABLE 4.7-2 (Cont'd)

State/County	Age	Male	Female	Total	Total % Breakdown*
Nebraska (Concluded)					
Sheridan	Under 1	83	67	150	2.0
	1-4	256	225	481	6.4
	5-13	506	503	1,009	13.4
	14-17	281	248	529	7.0
	18+	2,539	2,836	5,375	71.2
	Total	3,665	3,879	7,544	100.0
Sioux	Under 1	11	15	26	1.4
	5-13	109	118	227	12.3
	14-17	66	90	156	8.5
	18+	678	649	1,327	71.9
	Total	925	920	1,845	100.0
Morrill	Under 1	55	58	113	1.9
	1-4	200	194	394	6.5
	5-13	423	414	837	13.7
	14-17	208	205	413	6.8
	18+	2,123	2,205	4,328	71.1
	Total	3,009	3,076	6,085	100.0
South Dakota					
Fall River	Under 1	81	89	170	2.0
	1-4	262	262	524	6.2
	5-13	564	516	1,080	12.8
	14-17	274	274	548	6.5
	18+	3,207	2,910	6,117	72.5
	Total	4,388	4,051	8,439	100.0

TABLE 4.7-2 (Cont'd)

State/County	Age	Male	Female	Total	Total % Breakdown
South Dakota (Concluded)					
Shannon	Under 1	183	208	391	3.5
	1-4	602	565	1,167	10.3
	5-13	1,400	1,261	2,661	23.5
	14-17	585	547	1,132	10.0
	18+	2,915	3,057	5,972	52.7
	Total	5,685	5,638	11,323	100.0
Wyoming					
Goshen	Under 1	95	111	206	1.7
	1-4	391	362	753	6.3
	5-13	851	762	1,613	13.4
	14-17	441	430	871	7.2
	18+	4,110	4,487	8,597	71.7
	Total	5,888	6,152	12,040	100.0
Niobrara	Under 1	28	18	46	1.6
	1-4	87	84	171	5.8
	5-13	190	192	382	13.1
	14-17	80	108	188	6.4
	18+	1,032	1,105	2,137	73.1
	Total	1,417	1,507	2,924	100.0

TABLE 4.7-2 (Concluded)

State/County	Age	Male	Female	Total	Total % Breakdown
Total	Under 1	1,150	1,146	2,296	2.1
	1-4	3,955	3,713	7,668	6.9
	5-13	8,443	7,940	16,383	14.6
	14-17	4,121	3,912	8,033	7.2
	18+	37,468	40,001	77,469	69.3
	Total	55,137	56,712	111,849	100.0

* Percentages may not equal to 100.0% due to rounding errors.
Source: U.S. Bureau of the Census, 1981a, 1981b, 1981c.

TABLE 4.7-3

POPULATION PROJECTIONS FOR COUNTIES WITHIN AN
80-KM RADIUS OF THE CROW BUTTE PROJECT AREA, 1980 - 2020

County	Actual 1980	Projected 1980	Estimated 1985	Projected 1985	1990	1995	2000	2010	2020
Box Butte	13,696	9,465	14,400	9,442	9,529	9,528	9,453	9,327	9,216
Dawes	9,609	10,078	9,400	10,098	10,218	10,390	10,549	10,752	10,905
Scotts Bluff	38,334	39,620	37,900	41,214	42,695	43,854	44,869	46,950	48,657
Sheridan	7,544	6,790	7,600	6,758	6,811	6,789	6,723	6,635	6,581
Sioux	1,845	1,926	1,700	1,933	1,950	1,943	1,926	1,893	1,851
Morrill	6,085	5,635	5,900	5,818	6,077	6,284	6,485	7,019	7,690
Fall River	8,439	9,784	7,800	11,085	12,485	13,900	15,404	-	-
Shannon	11,323	8,397	11,700	8,049	7,724	7,456	7,172	-	-
Goshen	12,040	12,030	12,600	12,900	13,632	-	-	-	-
Niobrara	2,924	2,912	3,200	3,047	3,148	-	-	-	-

Sources: University of South Dakota, Bureau of Business Research, 1981.
University of Nebraska-Lincoln, Bureau of Business Research, 1981.
Wyoming Department of Administration and Fiscal Control, 1981.
U. S. Census Bureau, 1986.

Sheridan, Sioux and Morrill Counties experienced overall population losses between 1960 and 1980, although the small communities of Hay Springs and Rushville increased slightly in the latter half of the 1970's. Between 1980 and 1985, the downward trend continued in Sioux and Morrill Counties with Sheridan County exhibiting a slight turnaround.

Scotts Bluff County experienced gradual population growth over the two decade period with a 1980 population of 38,433, 14,156 of which is found in the City of Scottsbluff, located beyond the 80-km area. Scotts Bluff County showed a slight decrease in population between 1980 and 1985.

The two South Dakota counties in the 80-km study area include Fall River and Shannon. Fall River County declined by nearly 2,000 persons between 1960 and 1980, with a gradual upturn evident by 1975. Shannon County, on the other hand, grew by 5,323 persons since 1960 to over 11,300 by 1980. Most of the increase occurred between 1977 and 1980. Shannon County population continued to increase through 1985 while Fall River County continued its decline. Only the very southern portions of both counties are included within the 80-km project area.

<u>Population Characteristics</u>. 1980 population by age and sex for counties within 80-km of the Crow Butte project area shown in Table 4.7-2 Overall, 69.1 percent of the population in the region are over 18 years of age. Dawes County reported the highest percentage of persons over 18 with 75 percent. About 2.1 percent of the population were less than one year old in 1980. Shannon County reported the youngest population, with 3.5 percent less than one year old and nearly half (47.3 percent) under 18 years of age. Females slightly outnumbered males, 50.7 percent to 49.3 percent.

In 1980 nearly 85 percent of the ten county population were classified as white. Indians and persons with Spanish origin comprised 11.0 percent and 6.3 percent, respectively, of the total population. Over 80 percent of the Indians were Sioux living on the Pine Ridge Reservation in Shannon County, South Dakota.

Population Projections. The projected population for selected years by county within the 80-km radius of the proposed Crow Butte Project is shown in Table 4.7-3. Actual versus projected population for 1980 are either too high or too low for counties in Nebraska and South Dakota. Box Butte, Sheridan and Shannon Counties reported much higher 1980 population count than those projected, while Dawes, Scotts Bluff and Fall River population counts were lower than the projected numbers. There were also significant differences between 1985 projected populations and the 1985 U.S. Census estimate.

Seasonal Population. In 1981, approximately 376,997 people visited Fort Robinson State Park. This number represents a 28.8 percent increase from 1980 and over a 100 percent increase from 1978 total visitors to the park. Fort Robinson officials estimate that total visitors to the park in 1986 should at least equal that of 1981 (Rotherham, 1987; Foster, 1982). Many of of these visitors will be Nebraskan families, staying between 3 to 4 days.

The Trooper National Recreation Trail within the Nebraska National Forest recorded 1,800 visitor days in 1980 (Foster, 1982). Visitor statistics are not recorded for the Ponderosa Wildlife Area. However, some idea of the number visiting these areas can be assessed through the number of hunting permits issued. Most hunters and hikers visit the Ponderosa Wildlife Area and surrounding Nebraska National Forest during the spring and fall turkey season and fall deer season. On the opening day of turkey season, approximately 20 hunters are allowed into the area. This daily number eventually falls to between 5-8 hunters. For opening day of deer season, approximately 40-50 hunters are permitted to hunt the area. This number also drops as the season progresses (Lemmons, 1982 and 1987).

Another source of seasonal population in this region is Chadron State College, located approximately 35-km (21.6 miles) from the site. During the 1982 spring semester, 2,000 students were officially enrolled at the college (Datson, 1982). In Fall 1986, total enrollment was 2,240 with 1,600 at the Chadron campus (Schmiedt, 1987).

Sectorial Population. Existing population for the 80-km radius was estimated for 16 compass sectors, by annual rings of 1,2,3,4,5,10,20,30,40, 50,60,70 and 80-km (a total of 208 sectors). Subtotals by sector and compass points as well as the total population are shown in Table 4.7-4 and in Figure 4.7-1.

Population Within the 10-km Radius

Population in the 10-km radius was estimated in the following manners:

a) 1980 U.S. Census of population estimates of 1,315 for the City of Crawford was used to estimate urban population in the 10-km (6.2 mile radius.

b) The radius was drawn on a 1980 USGS Quad Map (1"=2,000'); the location of houses indicated on the map was then compared with an aerial photograph of the 10-km radius area.

c) A "windshield survey" of the area was conducted to check the rural house for occupancy. Obviously abandoned homes were excluded resulting in a total of 102 occupied rural housing units.

d) To estimate the number of rural residents, local citizens were interviewed. Actual persons per household estimates were used if the persons interviewed agreed on the number of residents in a household.

e) The average persons per household for all known rural households in the 10-km (6.2 mile) radius was then used to estimate the population of the remaining occupied households located in the 10-km radius. 245 persons were identified in this manner.

f) Rural and urban populations were added together resulting in a total estimated population of 1,560 within the 10-km radius.

Population Between the 10-km and the 80-km Radii

Current (1980) population found in-between a 10-km and an 80-km radius of the site was determined as follows:

a) 1980 U.S. Census of population estimates for cities and counties in Nebraska, South Dakota and Wyoming were used to arrive at total urban population.

TABLE 4.7-4

CURRENT POPULATION WITHIN AN 80-KILOMETER
(50-MILE) RADIUS OF THE CROW BUTTE PROJECT SITE

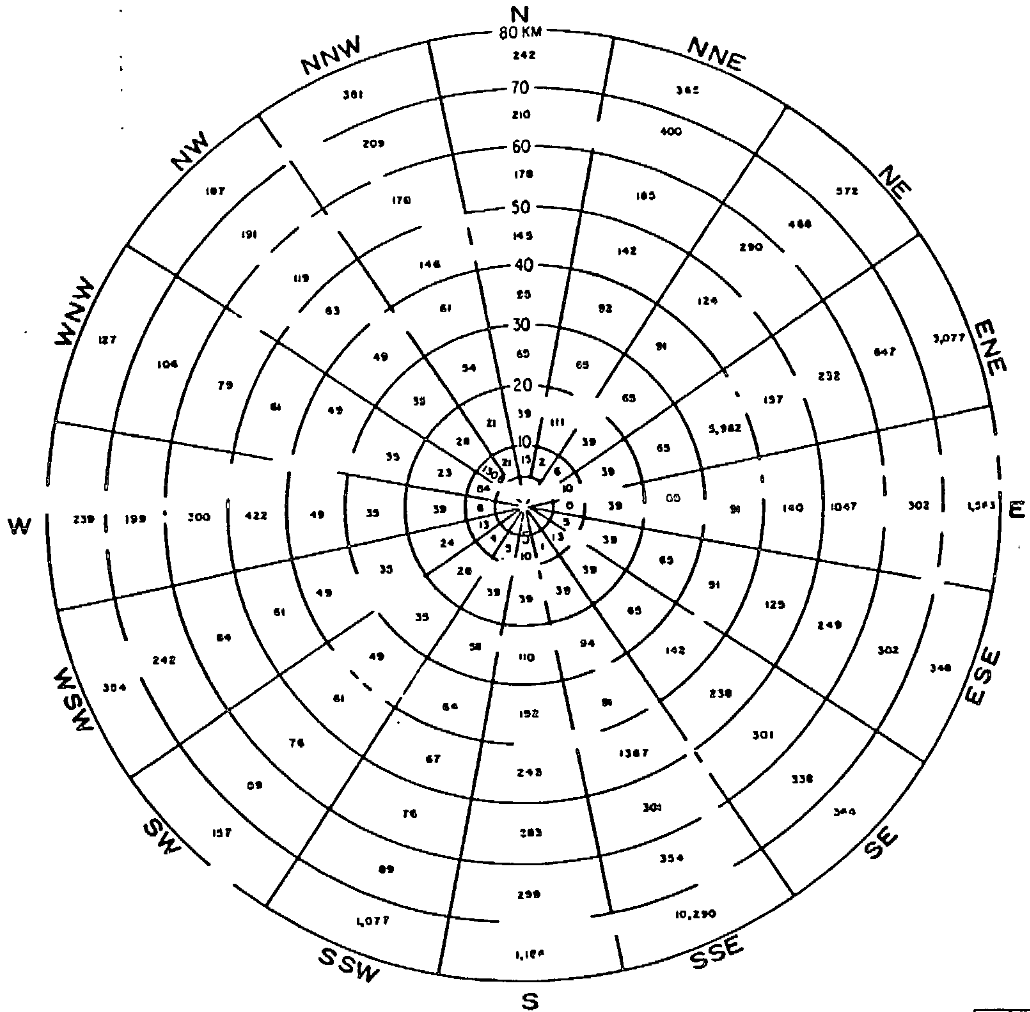
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Total
N	0	0	0	0	0	15	39	65	95	145	178	210	242	989
NNE	0	0	0	0	1	2	111	65	92	142	185	400	365	1,363
NE	0	0	0	0	1	6	39	65	91	124	290	488	572	1,676
ENE	4	0	0	0	0	10	39	65	5,982	157	232	647	3,077	10,213
E	0	0	0	0	0	0	39	65	91	140	1,047	302	1,563	3,247
ESE	2	2*	3	0	0	5	39	65	91	125	249	302	348	1,231
SE	0	0	0	4*	4*	13	39	65	142	238	301	338	364	1,508
SSE	0	0	0	0	6	1*	39	94	91	1,367	301	354	10,290	12,543
S	0	0	0	0	0	10	39	110	192	243	283	299	1,186	2,362
SSW	0	1	0	0	0	5	39	58	64	67	76	89	1,077	1,476
SW	0	2*	4	0	0	4*	28	35	49	61	76	89	157	505
WSW	0	0	0	2*	0	13*	24	35	49	61	84	242	354	864
W	0	0	6*	0	0	6	39	35	49	422	300	199	239	1,295
WNW	0	0	0	0	2	84*[b,c]	23	35	49	61	79	106	127	566
NW	0	2	0	2*	0	1,308[b]	28	35	49	63	119	191	187	1,984
NNW	0	2	2*	0	5	21*	21	54	61	146	178	209	381	1,080
TOTAL	**6**	**9**	**15**	**8**	**19**	**1,503**	**625**	**946**	**7,237**	**3,562**	**3,978**	**4,465**	**20,529**	**42,902**

[a] An actual head count was conducted for the population living within 10-km of the mine site. These figures were supplemented by interviews with local peopla and 1980 census data for Dawes County and the City of Crawford. Current population living between 10-80 km of the mine site were estimated using 1980 census data. See Sec. 4.7.1.5 for a detailed description of EH&A's methodology.

[b] WNW sector includes 5% of the 1980 Crawford population; NW sector includes 95% of the 1980 Crawford population.

[c] Total persons residing at Ft. Robinson State Park.

* The average persons per household number for known rural households in the 10-km radius was used to estimate the population of the remaining households located in the 10-km radius.



REV	BY	DATE	FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			CURRENT POPULATION WITHIN AN 80-KILOMETER RADIUS BY SECTOR
			PREPARED BY: E E N.
			DWN BY JC · DATE 8/87 · FIG 4.7-4

CBR-074

b) City population and areas (sq.mi.) were subtracted from their respective county population and area to determine the population density of the non-urban areas within each county.

c) Non-urban densities were multiplied by the number of square miles of area of each county in each of the 112 sectors to estimate 1980 non-urban population.

d) The population of cities within each sector was added to the rural population of that sector to get total 1980 population for each sector.

Local Socio-Economic Characteristics

Major Economic Sectors. As of February, 1987, the Dawes/Box Butte County area as well as the large Scotts Bluff area to the southwest exhibited higher unemployment rates than 1982, ranging from 4.8 percent in Dawes County to 9.3 percent in Scotts Bluff County. This compared to 5.7 percent for the state. Unemployment rates have increased since submission of the R&D application in 1982 (Nebraska Department of Labor, 1987).

The major economic sectors in the project area have changed little in recent years, although individual sectors have shifted in their relative proportion in the overall economy. The area continues its dependence on trades, government and services with considerable buildup in the transportation and utilities sector as railroad activities increased in the area.

In both Dawes and Box Butte Counties, agriculture accounts for approximately 12 percent of total employment. In Dawes County, government makes up 40 percent of total non-farm employment followed by trade (28%), service (15%), and transportation (10%). In Scotts Bluff County, trade and services compose the greatest part of non-farm employment (30% and 22% respectively) with government (19%) and manufacturing (14%) also important.

Housing. Between 1970 and 1980, total housing units increased by 17 percent in Dawes County and as much as 44 percent in Box Butte County to the south. Chadron, the largest community in Dawes County (1980 population of 5,933) and within 40-km (25 miles) of the project site, experienced a 25

percent increase in housing stock. Alliance, in Box Butte County, approximately 72-km (45 miles) from the project site with a 1980 population of 9,869 exhibited a 54 percent growth in total housing units during the decade (U.S. Department of Commerce, Bureau of the Census, 1981a).

In 1980, Dawes and Box Butte Counties had vacancy rates of 10.9 and 8.4 percent, respectively (U.S. Department of Commerce, 1982). The average value of owner-occupied units for sale ranged from $34,500 in Dawes County (approximately 1600 units) to $45,200 in Box Butte County (approximately 2400 units). The average value of rental units ranged from $142 per month in Dawes County (900 units) to $196 per month in Box Butte County (1250 units) (U.S. Department of Commerce, Bureau of the Census, 1982).

According to a local Crawford realtor, rental property in Crawford is scarce. However, a May 1982 listing of property revealed nine houses, one lot, one rooming house and two parcels of land were up for sale. Housing prices ranged from $11,000 to $28,000 while the parcels of land averaged less than $500/acre (Lakey, 1982).

High interest rates and high tax rates were the major deterrences for potential home buyers in the project area in the past. Currently, it is economic uncertainty and unemployment. Interest rates on most home mortgages run around 10%.

If homes are purchased by FEN employees it would provide the City with ad valorem property taxes. The City of Crawford levys the highest mill rate in the entire State of Nebraska, with taxes on a $50,000 home about $1,500/year (Lakey, 1982).

<u>Preliminary Evaluation of Socio-Economic Impacts</u>

The preliminary evaluation of socio-economic impacts of the commercial facility have been divided into two periods--construction and operation. Since socio-economic impacts will be directly related to the potential work force the following table is an estimate of the work force necessary for each of these periods.

Period	Hired Locally (Crawford)	Hired Sioux-Dawes County	Hired Outside 50-Miles	Total Work Force
Construction	10	15	5	30
Operation	24	8	3	35

The construction period of the commercial facility will require a moderately sized work force that will fluctuate from 12 to 30. This period will last approximately nine to twelve months. During operations the work force will be thirty to thirty-five. Many of the additional operations personnel that are needed (the R&D facility employs 16 locally) will come from the local labor pool and all will reside in the area. Construction will be accomplished by contractors hired to build the plant building, wellfield, and solar evaporation ponds. This labor will be regionally based with local support. The operational time for the commercial facility will be approximately twenty years. Operation of the commercial facility will require fourteen to nineteen additional employees. Based on this work force, the following is a discussion of the possible impacts on the local economy, roads, jobs, housing, schools, transient population and energy costs.

Local Economy. During the construction phase the local economy would be moderately stimulated both by the local purchases of goods, materials and services directly related to the construction activities and by local spending of wages by construction and service workers and their families. This moderate stimulation would result in bringing up to twenty additional workers into the Crawford area for nine to twelve months. Since the construction phase is short, it is doubtful these workers will rent or purchase housing, rather they will either commute or stay in motels in the Crawford or Chadron area.

The operational phase will require a work force of up to nineteen new employees. Approximately ten of these workers will be hired locally and seven will be hired regionally (see previous table). These workers would be considered permanent and would again moderately stimulate the local economy through the purchase of goods and services.

The overall impact on the local economy resulting from these phases of the commercial facility is expected to be positive. New employment will result in more purchases of goods and services. The commercial operations will not result in a boom and bust in the local economy, rather it is expected to provide moderate stimulation as did the R&D facility.

Roads. Truck traffic will be increased slightly through delivery of the necessary equipment and supplies for constructing the commercial facility. This will be a temporary impact and no significant road damage will be associated with this activity.

Once constructed, the plant will receive normal deliveries from vendors and travel to the site by workers.

Jobs. Construction will require twelve to thirty workers and operations up to nineteen additional workers. Additional jobs will result in a positive impact on the Crawford area. As previously discussed, wages earned by workers will moderately stimulate the local economy as well as the regional economy. The additional jobs offered by Ferret-Nebraska should not stress existing facilities or services since only nineteen additional workers are expected to be permanent during the commercial operations. The remaining sixteen will already have resided in the Crawford area.

Housing. Although rental property is scarce, (only two available), a May 1987 listing of property revealed at least twenty-eight houses were up for sale (Peterson, 1987). Housing will be no problem with the limited influx of workers expected to result from the commercial operations. There will be no need for temporary housing (i.e., trailer camps) during the construction or operation of the commercial facility.

Schools. The Crawford High School and grade school are presently under capacity. Total enrollment in these two schools is 122 in the high school and 136 in the elementary school with maximum capacities of 545 and 185 respectively. The grade school currently has a student to teacher ratio of

20 to 1; while the high school has a ratio of 14 to 1. No historical high was given for the grade school; however, it was estimated that the high school historical high was over 200 pupils (present enrollment is 122).

Outside the Crawford district are a number of rural school districts supporting grades one through eight. These are generally one-room school houses. Students living in these rural districts may pay tuition if they elect to go to the Crawford schools for grades one through eight. There is no tuition for high school. In seven rural districts which Crawford high school is drawing from, there is an estimated 100 pupils in these lower grades.

Families moving into the Crawford district as a result of the commercial operations should not stress the current school system, since it is presently under capacity. It was estimated that at least 30 pupils could be handled easily. Using a factor of 2.3 children/family and an estimated 9 new families, the resulting 21 children could be accommodated.

Energy Costs. No increase in energy costs will be associated with construction and operation of the commercial facility because there is an excess of power available in the Tri-State generating system. Any additional costs associated with bringing power to the commercial facility will be borne by FEN.

REFERENCES

Budler, M., *Personal Communication*, Nebraska Department of Labor, 1987.

Datson, B., *Personal Communication*, Office of Development and Planning, Chadron State College, 1982.

Dawes County Clerk's Office, *Personal Communication*, 1987.

Foster, J., *Personal Communication*, Nebraska Game and Parks Division, 1987.

Lemmons, J., *Personal Communication*, Fort Robinson State Park, 1982, 1987.

Mathis, G., *Personal Communication*, Dawes County Clerk, Dawes County, 1982.

Nebraska Department of Economic Development, *Nebraska Community Profile, Crawford*, 1986.

Nebraska Department of Labor, *Annual Planning Report*, Division of Employment, Research and Statistics, 1981a.

_____, *Labor Market Information*, Division of Employment, 1987.

_____, *Labor Trends*, Division of Employment, 1987.

_____, *Nebraska Non-Farm Employment, 1974-1979*, Division of Employment, Research and Statistics, 1981b.

_____, *Nebraska Work Trends*, Division of Employment, Research and Statistics, 1981c.

Nebraska Game and Parks Commission, *Discover Nebraska Travel Guide*, 1982.

_____, *Nebraska Land Magazine*, 1982.

Nebraska Geologic Survey, *Inventory of Mining Operations in Nebraska*, 1974.

_____, *1981 Nebraska Mineral Operations Review*, 1980.

Nebraska Public Power District, *Industrial Facts, - Crawford, Nebraska*, 1986.

Rotherham V., *Personal Communication*, Fort Robinson State Park, 1982, 1987.

Peterson, R., *Personal Communication*, Realtor, Crawford, Nebraska, 1987.

REFERENCES (Concluded)

Schmiedt, J. *Personal Communication,* Dean of Students, Chadron State College, 1987.

U.S. Department of Commerce, *1970 Census of Population, Nebraska,* Bureau of Census, 1971a.

_____, *1970 Census of Population, South Dakota,* Bureau of Census, 1972b.

_____, *1970 Census of Population, Wyoming,* Bureau of Census, 1972c.

_____, *1980 Census of Population and Housing, Advance Report, Nebraska,* Bureau of Census, 1981, 680-V.

_____, *1980 Census,* Census Retrieval and Information Service, 1982, Tape STFIA.

_____, *1986 Provisional Estimates of the Population of Counties,* Bureau of Census, 1985.

_____, *Current Population Reports,* Bureau of Census, 1978a.

_____, *Estimates of the Population of Counties and Metropolitan Areas,* Bureau of Census, 1975, Series P-25, No. 739.

_____, *Estimates of the Population of Counties and Incorporated Places,* Bureau of Census, 1979, Series P-25, Nos. 840,854,863.

U.S. Geological Survey, *Quandrangle Maps: Dead Man's Creek, Belmont, Coffee Mill, Butte SW, Chimney Butte, Crow Butte, and Crawford, Nebraska.*

University of Nebraska, *Population Projections of Nebraska, 1970-2000,* Bureau of Business Research, 1980.

University of South Dakota, *Projections of South Dakota Population, 1980-2000,* Bureau of Business Research, 1980.

Wyoming Department of Administration and Fiscal Control, *Wyoming Population and Employment Forecast Report,* Division of Research and Statistics, 1981.

SUBSECTION 4.8

REGIONAL HISTORIC, ARCHEOLOGICAL, ARCHITECTURAL, SCENIC & NATURAL LANDMARKS

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4.8-1 INTRODUCTION

Identification and assessment of cultural resources within the Crow Butte In-Situ Uranium Mining project have involved two separate field investigations. The initial Research and Development (R&D)-scale study for the project was carried out by the University of Nebraska (UNL) during March and April 1982 under the direction of Robert E. Pepperl. A review of pertinent literature and records and an intensive (100% coverage) pedestrian survey of select project lands (Section 19, T31N, T51W) were completed to identify resources which may be affected by development of the R&D-scale mining operation (Bozell and Pepperl 1982). An equally comprehensive background study and field reconnaissance of the remainder of the Commercial Study Area (CSA) (See Figure 2.1-4 in Section 2.1) was completed by the Nebraska State Historical Society during the period April-June, 1987, under the direction of John R. Bozell. A summary of the results and recommendations of both studies are presented here. All figures, correspondence and field records are organized in a separate volume (Appendices A-B), which is available for professional review at the Nebraska State Historical Society.

PROJECT DESCRIPTION

The Crow Butte project involves in situ solution mining activities within limited portion of the proposed uranium prospect permit area. Pilot-plant mining operations are currently in progress. Immediate project planning concerns application for permits to initiate commercial-scale production.

The Crow Butte CSA encompasses approximately 1350 acres of potential wellfield and 2560 acres of permit area located within a 4.5 mile long strip of land varying in width between 500 ft and .75 mile. The center of the project is located 2.5 miles east and 3.0 miles south of Crawford in extreme northwestern Nebraska (see Appendix B; Figure 1).

The White River flows 2 mi north of the area. Three southern tributaries of this river, including Squaw Creek, English Creek, and White Clay Creek, extend through the project area. The slopes of Crow Butte, a prominent

local landmark visible throughout the project area, are situated 1.5 mi east of the project area. This feature and the Pine Ridge Escarpment are the dominant topographic elements of this area but are, for the most part, situated outside the permit boundary.

STUDY DEFINITION

This study will assist Resource Technologies Group and Ferret Exploration of Nebraska in complying with applicable Federal antiquities legislation and regulations requiring consideration of cultural resources during the planning process, particularly as relevant to permitting and licensing of the proposed mining operations by the U.S. Nuclear Regulatory Commission (NRC). Pertinent authorities include the National Historic Preservation Act of 1966 (P.L. 89-655), the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order 11593 dated May 1971.

The purpose of this work is to recover data necessary to determine the potential effects of the proposed undertaking on resources currently listed or potentially eligible for listing in the National Register of Historic Places. The study will provide recommendations concerning the scope of further study area investigations or site-specific evaluations that may be required to facilitate this determination and, where possible, will suggest stipulations for avoidance of potentially qualified resources pending full assessment and determination of eligibility.

Pursuant to procedures defined for implementation of the above cited authorities (e.g. 36CFR Part 800, as amended October 1, 1986, and 36CFR Part 60), review of the study program and coordination with pertinent Federal agencies will be accomplished through consultation with the State Historic Preservation Officer (SHPO).

STUDY METHODS

Methods utilized in this study were developed in accordance with Federal standards (36CFR1210) for data recovery and reporting requirements published as proposed guidelines (36CFR Part 66) in the Federal Register (42,19.:5374-5383), January 1977). Tasks completed in the work program are identified below.

Literature Review. A thorough review of previous archeological, paleontological, and historical studies relevant to the study area was conducted to identify known resources, particularly those within an 8km (5 mile) adjacent area boundary as defined in the 1983 Wyoming Fuel Company R&D application, and to assess the general cultural and scientific significance of the study region. The status of known resources with respect to National Register eligibilities was determined through consultation of listings published in the Federal Register.

This effort involved examination of select published references as well as other site records and materials on file at the Division of Archeological Research, the University of Nebraska libraries, the Midwest Archeological Center, National Park Service, and the Nebraska State Historical Society.

Archival Research. The reference resources noted above as well as records filed at the National Archives, Washington, and the Dawes County Courthouse, Chadron, were inspected for historic documentation of persons and events associated with project area locations. In addition to published histories and biographies, pertinent records include various land entry files such as the U.S. General Land Office Tract Book, homestead claimant and witness proof documents, and the county Numerical Index, as well as other county records and available historic map sources. This effort involved gathering of general and site specific information concerning the CSA. Beyond interpretive considerations this work provides a basis for assessing the importance of area resources to local, regional or national history.

Field Investigation. On-site efforts consisted of an intensive (100% coverage) pedestrian survey of the R&D study area in 1982 (640 acres) and other CSA lands in 1987 (ca. 700 acres). Limited subsurface testing and other documentation measures were implemented in order to facilitate preliminary resource assessment.

Resource Evaluation and Reporting. Analytic and reporting efforts necessary to the resource management objectives of this study included: 1) processing and descriptive analysis of recorded materials; 2) compilation of site-specific descriptive data and field records; 3) preliminary assessment of identified resources with respect to site integrity and National Register criteria regarding cultural and scientific values; and 4) preparation of a report providing suggested stipulations for clearance of the entire CSA (including the R&D plant unit) for project development. Evaluative considerations and recommendations were accomplished through consultation with appropriate State (SHPO) and Federal (NRC) agencies.

4.8-2 BACKGROUND

ENVIRONMENTAL SETTING

The general project area is located near the northern limits of the High Plains physiographic province and is situated in a region characterized by diverse topography. The climate is semi-arid and vegetation is dominated by western yellow pine and a variety of short grass species.

Physiography and Climate. The most prominent physiographic feature in the general project area is the Pine Ridge Escarpment, which Fenneman (1931:4,18) considers a distinct physiographic sub-unit marking the northern limits of the High Plains section of the Great Plains province. This heavily dissected escarpment occupies the northern half of Sioux and Dawes Counties and rises 300 to 900 ft above a broad area of low relief extending into South Dakota.

A six to eight mile wide band of sloping colluvial lands border the escarpment in most areas. The Crow Butte project area is generally comprised of these gentle slopes with elevations ranging from 3600 to 4400 ft amsl. The topography is generally represented by rolling hills and broad ridges interrupted by a series of permanent and intermittent stream valleys (see Appendix B; Figure 2).

Soils in the area are formed by several kinds of parent material including alluvium, colluvium, loess, and weathered siltstone and sandstone (Ragon et al. 1977). The study area is covered predominantly by loamy sandy soils formed in colluvium and in material weathered from sandstone. Bedrock directly underlying the study area includes the White River and Hemingford-Arikaree formations, both Tertiary in origin.

The climate of the region is semi-arid marked by rather low average annual precipitation (18.2 in) (Ragon et al. 1977:1). The growing season lasts approximately 130 days from mid May to late September. Weather Bureau records from Fort Robinson for the period 1883-1960 indicate mean daily temperatures range from 23.7 degrees in January to 71 degrees in July and August; the wind is generally from the southwest during most of the year and changes to a northwesterly direction during the winter (Meston 1976:9).

<u>Flora and Fauna</u>. Native vegetation of the project area is dominated by a number of short grass species and a variety of sedges (Shelford 1963:344-347; Weaver 1965:155-161). Yucca and cactus are also common. Deciduous timber species characteristic of stream valleys include green ash, American elm, boxelder and hackberry. Ponderosa pine is the dominant coniferous species present in the Pine Ridge Escarpment.

Dominant fauna of the northern temperate grasslands prior to the Historic period include bison, antelope, mule deer and a variety of lesser mammalian influents. Common aviafauna include western meadowlark, longspur and sparrow. The lesser prairie chicken may have been locally dominant at one time (Shelford 1963:344-345).

Scenic and Natural Landmarks. The Pine Ridge region contains a variety of scenic and natural landmarks, several of which are visible or within close proximity to the proposed CSA. The most prominent are the extensive butte and ridge systems surrounding the general vicinity, particularly Crow Butte and Little Crow Butte directly to the east of the project boundary and Red Cloud Buttes ca. 5km to the northwest. Crow Butte, the site of a notorious conflict between the Crow and Brule Sioux Indians in 1848 (Hanson 1969; Hanson and Walters 1976:14-15), also served as a prominent landmark for early explorers, fur traders and settlers. Additional scenic features characterizing this area include the White River valley along the northern edge of the CSA, and the Pine Ridge Division of the Nebraska National Forest near the southern and eastern margins of the project.

CULTURAL SETTING

The general project area is situated in an archeologically intriguing vicinity that has been inhabited intermittently for the past 10,000 years by a variety of Native American populations and more recently by Euroamerican traders, settlers and rural food production communities.

Prehistoric Periods. The project area is situated near the edge of both the Central Plains and Northwestern Plains archeological subareas as defined by Wedel (1961, 1978), Frison (1978) and others.

Recognized cultural units in the general vicinity are: Paleo-Indian (10,000-5,000 B.C.), Archaic (5,000 B.C.-A.D. 1), Plains Woodland (250 B.C.-A.D. 950), and several Plains Village (A.D. 900-1850) taxa including Dismal River, Central Plains and Coalescent prehistoric cultural traditions and variants.

Paleo-Indian remains (projectiles) are commonly reported for this area, but only one site has been systematically investigated. The Hudson-Meng site, located approximately 40km (25 miles) northwest of the project along a tributary of the Cheyenne River in Sioux County, was subjected to testing and excavation by Chadron State College during the late 1960s through the late 1970s (Agenbroad 1978a; 1978b). These investigations have verified

the presence of a Paleo-Indian bison kill and adjacent butchering floor, associated with over three hundred bison, and an abundance of artifactual material. The majority of diagnostic projectile points are assigned to the Alberta culture (Agenbroad 1978a:131). Radiocarbon assays place the occupation between 8900-9400 B.P.

Archaic sites in the region have not been intensively studied but surveys near the project area indicate the period is represented by small temporary camps (Meston 1976:43). It is noteworthy that much of the Archaic materials recorded by Meston and others (site files, NSHS) appear to be associated with the latter portion of the period. Early and Middle Archaic sites are rare in the immediate project vicinity, however notable McKean Complex (Middle Archaic) type sites are located in the Black Hills of northeastern Wyoming and the Scottsbluff area (Forbis et al. n.d., Mulley 1954, Greiser 1985, and Kornfield and Todd 1985). Plains Woodland (2,000-1,000 B.P.) manifestations are equally rare in the Pine Ridge area and are probably a reflection of limited use of the area for hunting or possibly frontier expansion by Central Plains Woodland peoples (Gill and Lewis 1977; Bozell n.d.).

Ceramic and chipped stone diagnostic artifacts indicate several Plains Village Tradition cultural taxa are represented including Dismal River Phase (Gunnerson 1960:226), Central Plains Tradition (Meston 1976:43-44) and Extended Coalescent Variant components (Ludwickson 1982; Ludwickson and Bozell n.d.). A variety of generalized non-ceramic, late prehistoric sites are also recorded in the area (Bozell 1984; Carlson n.d.).

<u>Historic Exploration and Settlement Periods</u>. Historic accounts of Native American presence within the study area, including oral traditions and notes of explorers and military personnel, indicate that during recent times (ca. 1800-1877) this region was contained within various tribal hunting territories as well as territorial boundaries and reservations defined by Federal treaties. However, Native American occupation of relatively permanent or long-term settlements in the immediate area are not

evident. Various nomadic groups such as the Sioux, Cheyenne, Arapahoe and Crow located largely in the Black Hills area to the north utilized the White River region and other areas extending south to the Platte River (see Hartley 1981 and Hanson 1983).

The principal Native American group occupying or utilizing the study area throughout at least much of the nineteenth century was the Teton Sioux tribe (or Lakota). The Teton represent the western division of the Dakota-speaking subgroup (Sioux) of the Siouan linguistic family and include the Brule and Oglala bands (see e.g., Voeglin 1941). The Teton gradually moved westward from their homelands in Minnesota during the eighteenth century (Hyde 1937) and various sources indicate their territory extended to the headwaters of the White River by the early nineteenth century (see e.g., Lewis and Clark 1814:1,714; Thwaites 1905:VI,98-99).

Beginning in 1851, Federal treaties with the various Plains tribes significantly reduced the "Indian Territory" west of the Missouri River but the Sioux retained control of the White River region (Royce 1899: 786-787). By 1868 further land cessations confined the Sioux to a permanent Dakota reservation extending along the southern edge of present South Dakota between the Missouri River and the Black Hills with rights only to hunt within their former territories to the south (Royce 1899: 848-849). The Oglala and Brule, along with other groups were issued supplies at the Red Cloud Agency (1873-1877) and Spotted Tail (Whetstone Agency (1872-1877) located respectively west and east of the present project area but outside the reservation proper. The locations of camps or other occupancy of these groups within the immediate project vicinity are unclear.

Removal of the Indian populations to reservation lands to the north in 1877 opened the area to Euroamerican settlement and large cattle raising operations entered the vicinity as early as 1878 (Grange 1978:225).

The influx of Euroamerican influence within the project area discussed here concerns various episodes of fur trade, military installations and frontier settlement largely involving an 80 year period between the mid nineteenth and early twentieth centuries. Earlier entries into the Central and

Northern Plains by French, English and American explorers were essentially restricted to the Missouri and Platte River drainages. As part of the Missouri Company's efforts to open the upper Missouri River to commerce, James MacKay traveled up the Niobrara River in 1796 but turned south near present Valentine without reaching the general project vicinity (see Nasaatir 1952:93-108; Diller 1955).

The fur trade extended into Dawes County during the 1830s and two trading posts were established south of Chadron in the 1840s (Hanson and Walters 1976:6). These include Chartran's Post (1841-1845) and Bordeaux's Post (1841-1876). The fur trade in western Nebraska ceased following the termination of the Bordeaux Post.

In 1855, a military exploration under the leadership of General W.S. Harney entered the project vicinity by traveling down the White River through South Dakota and into the Nebraska panhandle (Warren 1856). The first permanent military installation in the area was Camp Robinson, established in 1874 near the Red Cloud Agency to control Indian opposition. The installation was renamed Fort Robinson in 1878 and remained an important post for the monitoring of Indians and frontier settlement. The fort was utilized for various military purposes through 1948 (Grange 1978).

Settlement of Dawes County began in 1885 under the provision of the Preemption Act of 1841 and the Homestead Act of 1861 and was intensified with arrival of the railroad in 1886. Most of the land was settled during the 1880s, but adverse environmental and economic conditions, such as the drought of the 1890s, forced three out of five people to leave their claim after several years (Ragon et al. 1977:1). The town of Chadron was formed in 1885 and Dawes County and Crawford were established the following year (Anonymous 1961; Pinny 1985).

SUMMARY AND ASSESSMENT OF PREVIOUS INVESTIGATIONS

The Pine Ridge region including the White River drainage of northwest Nebraska has been the subject of occasional small scale archeological, paleontological and historical studies for a number of years. Interest in the paleontological remains of the area extends to the late nineteenth century. Archeological sites are known but for the most part intensive survey and excavation efforts have not been initiated within the general area until recently in conjunction with the present project and highway archeology efforts (Ludwickson and Bozell n.d.). Attention to historic resources has been directed largely toward the late nineteenth century military and reservation activities associated with sites at the west edge of the study area. In each case, previous work provides a general view of the potential productivity of this region for study but only a limited range of resource types and contexts have been considered. Systematic investigations with the present project unit have not been previously initiated.

Paleontological Studies. Surficial geology and paleontology of northwest Nebraska has been studied by numerous workers beginning with O.C. Marsh in the 1870s (see Schuchert and Levene 1940) and continuing to the present (Schultz and Stout 1955; Martin 1973). Most of these efforts have concentrated on select localities, primarily within the "Little Badlands" area approximately 24km (15 miles) northwest of the Crow Butte project (see Darton 1903; Schultz and Stout 1955; Wood 1969; Singlar and Picard 1980). Limited stratigraphic work and fossil collecting have been carried out in the Pine Ridge Escarpment (see Wellman 1964; Martin 1973) but have not included systematic inspection of exposures located within the Crow Butte project along the eastern and southern margins of the permit area.

Bedrock exposures in the immediate Crawford vicinity are limited to the late Oligocene - early Miocene Arikaree group (Gering, Monroe Creek and Harrison Formations of Lugn, 1939) which have produced important vertebrate fossils in western Nebraska and South Dakota (Macdonald 1970; Martin 1973). This general region is the single source of early Miocene exposures accessible to study east of the Rocky Mountain range.

The uppermost unit of the Arikaree group, the Harrison Formation, is exposed at the top of the buttes within the Pine Ridge Escarpment. The medial unit, the Monroe Creek Formation, comprises the majority of the bluff exposures and is clearly represented within the project. The Gering Formation (known as the Sharps Formation in South Dakota), and possibly a portion of the upper Oligocene Brule Formation, may be accessible at the base of higher sections.

Type sections of these formation in Nebraska are from near Harrison located west of the study area. Exposures of these strata are known to occur in the Crawford area, but with the exception of work in the Fort Robinson vicinity, published stratigraphic sections are not available for the present survey unit.

Fossil taxa expected within strata exposed in the project area include 131 faunas known from rocks of the same age at localities in the surrounding area (see e.g., MacDonald 1970). Fish bearing strata are rare but occasional thin shale lenses representing lake bed deposits can be expected. Few birds are known but numerous lizards and a broad range of mammals are recorded. The only North American early Miocene primate (Ekgmowechashala philotau) is contained within the Gering Formation. Other mammalian faunas of the Arikaree group include marsupials (mini possums); small insectivores and rodents; various carnivores including the last occurrence of archaic canine as well as ancestral dogs and also sabre cats; and finally a variety of ungulates, principally oreodonts but including tapirs, horses, rhinos, a giant hog (Entelodontidae, indet.), camels, and small "deer".

University of Nebraska State Museum (UNSM) collecting localities near the Crow Butte project include four Arikaree sites located largely within escarpment areas beyond the permit boundary.

UNSM DW-108 (Chadron Roadside Locality) is located approximately 27 km (17 mi) northeast of the project and contains fossils of the Gering Formation. This site was discovered by Larry D. Martin and Hal McGrew in 1970 (see Martin 1973).

UNSM SX-22 (unnamed) is situated directly northwest of the project, approximately 20 km (12 miles) beyond the permit boundary, and is also a Gering Formation locality but includes Oligocene units (see Martin 1973).

Cochran Wayside Area Locality is located just southwest of the proposed permit area within the escarpment. Three significant collections have been made from which 10 species of fossil vertebrates have been identified.

Coffin Butte Locality is situated in the Fort Robinson area west of the Crow Butte project. More than 20 scattered fossil finds representing early Miocene mammals have been recorded.

Cultural Resource Investigations. Early archeological reconnaissance in the region was largely an unprogrammed effort associated with paleontological research carried out by the University of Nebraska State Museum. Barbour identified weathered-out features (hearths) as early as 1891 in the general vicinity (Barbour and Schultz 1936:444). Various Paleo-Indian projectiles, particularly Yuma and Folsom types, were collected during preliminary paleontological and geological reconnaissance of the area (Barbour and Schultz, 1936:432, 444).The Nebraska State Historical Society also conducted limited pre-World War II reconnaissance the area including excavation of a Plains Village Pattern earthlodge south of Chadron.

More recent reconnaissance of the region has been conducted by the Nebraska State Historical Society from the late 1950's through the present. The bulk of this work has been limited to site inspections and testing largely associated with highway salvage efforts, but resulting in identification of numerous archeological localities in both Sioux and Dawes Counties (see Grange 1964, 1978; Bozell 1984; Carlson n.d.). In 1984, one Coalescent hunting camp was excavated and several other prehistoric components tested in response to reconstruction of U.S. Highway 20 between Ft. Robinson and Crawford (Ludwickson and Bozell n.d.).

Portions of the White River and Hat Creek drainage systems within the Oglala National Grassland Preserve north of the Crow Butte project were systematically surveyed in 1972 by the University of Nebraska, Department

of Anthropology. Intensive surface inspection along segments of the creek terraces was limited to the upper reaches of Whitehead Creek and entire lengths of Big Cottonwood and Sand Creeks, all in northern Sioux and Dawes counties (Meston 1976). These survey units extended to within 8-16km (5-15mi) north of the Crow Butte project permit boundary. More than 30 Native American sites were identified (Meston 19776:2). Diagnostic cultural materials indicate occupation of the region during the Paleo-Indian, Archaic, Woodland, Plains Village and Historic periods (Meston 1976:42).

Additional surveys were initiated in the Hat Creek and Whitehead Creek drainage during the early 1970's by Chadron State College under contract to the U.S. Forest Service. These surveys encompassed lands within the Oglala National Grasslands 20-30 miles northwest of the CSA and resulted in identification of well over 100 sites ranging in age from Paleo-Indian to Historic Sioux (Agenbroad 1979; Cassells and Agenbroad 1981). Chadron State College excavated a major portion of the Hudson-Meng site, a PaleoIndian bison kill in the Hat Creek drainage (Agenbroad 1978).

In sum, reconnaissance survey and limited testing have been conducted in the immediate vicinity for over 50 years. These efforts were largely oriented toward documentation of select cultural manifestations. The manner in which these recorded resources are representative of the range of cultural variability within the region cannot presently be defined. Sustained, systematic investigations necessary to this evaluation have not been initiated. However, through previous efforts, it is evident that the northwestern Nebraska region has supported human occupation throughout the range of recognized prehistoric and historic periods.

Prior to 1987, 65 archeological sites and seven architectural sites had been recorded within the 8km (5mi) radius of the Crow Butte project. Seven were discovered as a result of the 1982 Crow Butte Project. All are summarized in Table 4.8-1 and indicated in relationship to the Pilot Plant (Section 19, T31N, R51W).

Table 4.8-1. **Summary of previously recorded cultural resources within an 8km (5 mi) radius of the R&D plant(1) location; Crow Butte Project, Dawes County, Nebraska.**

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
ARCHEOLOGICAL			
25DW17 (Slaughter-house Creek)	lithic, ceramic, bone, features; Native American: Coalescent	1982 survey (NSHS); 1984 excavation (NSHS): Ludwickson and Bozell (n.d.)	4.5 mi NW
25DW18	lithic; Native American: unassigned	1982 survey (NSHS)	4.5 mi NW
25DW19	lithic and bone; Native American: unassigned	1982 survey and surface collection (NSHS); 1984 testing (NSHS): Ludwickson and Bozell (n.d.)	4.5 mi NW
25DW20	lithic and bone; Native American: unassigned	1982 and 1984 survey and surface collection (NSHS): Ludwickson and Bozell (n.d.)	5.5 mi NW
25DW21	lithic and bone; Native American: Late Archaic or Woodland (NSHS):	1982 survey (NSHS); 1984 testing Ludwickson and Bozell (n.d.)	6.0 mi NW
25DW51/55 (Ft. Robinson)	US military post guardhouse, ca. 1874	1966 excavation (NSHS): Grange (1978)	6.5 mi W
25DW54 (Red Cloud Agency)	Oglala Sioux reservation agency post, ca 1873-1878	1958 survey, excavation (NSHS)	6.5 mi NW

(1) Commercial Scale Plant will be located approximately 500 feet west of the R&D plant.

Table 4.8-1 (Continued)

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
25DW59	lithic; Native American: Archaic or Woodland	1956, 1982 survey (NSHS); 1984 testing: Ludwickson and Bozell (n.d.)	5.5 mi NW
25DW60	lithic and ceramic; Native American:Plains Village possible Historic Nomad	1956, 1982 survey (NSHS); 1985 and testing: Ludwickson and Bozell (n.d.)	4.5 mi NW
25DW73	bone; Native American: unassigned	1959 survey and testing (NSHS)	4.0 mi N
25DW74 (Franey)	lithic debris, tools (end scrapers),hearth; Native American: pre-ceramic	1956 survey and surface collection (NSHS): Grange (1964)	5.0 mi NW
25DW77	lithic; Native American: unassigned	1961 survey (NSHS)	9.0 mi N
25DW78	lithic; Native American: unassigned	1961 survey (NSHS)	9.0 mi N
25DW80	lithic; Native American: unassigned	1961 survey (NSHS)	8.0 mi N
25DW81	lithic, bone, glass, burned earth; Native American: unassigned	1961 survey (NSHS)	8.5 mi N
25DW84	lithic; Native American: unassigned	1962 survey (NSHS)	10.0 mi N

Table 4.8-1 (Continued)

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
25DW87	lithic and bone; Native American: unassigned	1964 survey (NSHS)	8.5 mi N
25DW88	Historic Dakota burial	1969 survey (NSHS)	4.5 mi N
25DW89	Euroamerican homestead(?)	1972 recorded (NSHS)	1.5 mi NW
25DW90 (Mayfield)	Euroamerican homestead (?)	1972 recorded (NSHS)	6.0 mi N
25DW105 (OK Ranch)	lithic, ceramic, bone; Native American: Upper Republican/ Dismal River (Agenbroad 1976); Extended Coalescent (Ludwickson 1982)	1976 survey (CSC); 1982 survey (NSHS)	6.5 mi N
25DW111 (Harvey Homestead ?)	glass, ceramic, metal, bone debris; Euroamerican; late 19th century (?)	1982 survey (UNL); Bozell and Pepperl (1982)	within pilot plant study area
25DW112/00-17 (Wulf/Daniels Place)	abandoned farmstead (house, depression, 11 outbuildings); Euro-american: late 19th century(?)	1982 survey (UNL); Bozell and Pepperl (1982)	within pilot plant study area
25DW113 (Fiandt Homestead)	glass, ceramic, metal, wood, leather, debris; 4 depressions; Euroamerican; late 19th century	1982 survey (UNL); Bozell and Pepperl(1982)	within pilot plant study area

Table 4.8-1 (Continued)

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
25DW114	lithic, bone; Native American: Middle and Late Archaic and possible other pre-Plains Village period components	1982 survey (UNL); Bozell and Pepperl(1982)	within pilot plant study area
25DW115 (School No. 25)	glass, brick debris; former location of First Presbyterian Church and public school; Euro-american: late 19th century	1982 survey (UNL); Bozell and Pepperl (1982)	within pilot plant study area
25DW116	lithic; Native American: unassigned	1982 survey (UNL); Bozell and Pepperl (1982)	within pilot plant study area
25DW117 (Fleming Homestead ?)	windmill, cistern, stock tank complex; Euroamerican (possible association with Fleming Homestead): late 19th century	1982 survey (UNL); Bozell and Pepperl (1982)	within pilot plant study area
25DW128	historic trash dump (Ft. Robinson period)	1982 survey (NSHS); Carlson (n.d.)	6.5 mi W
25DW129	historic trash dump (Ft. Robinson period)	1982 survey (NSHS); Carlson (n.d.)	6.5 mi W
25DW130	historic trash dump (Ft. Robinson period)	1982 survey (NSHS); Carlson (n.d.)	6.5 mi W
25DW131	historic trash dump (Ft. Robinson period)	1982 survey (NSHS); Carlson (n.d.)	6.5 mi W

Table 4.8-1 (Continued)

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
25DW132	lithic, ceramic, bone, glass, metal; Native American: prehistoric (Coalescent?) and early historic	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25DW133	lithic, bone, glass bead; Native American: unknown prehistoric and/or early historic	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25DW134	lithic, bone, metal; Native American: unknown prehistoric	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25DW135	lithic, bone, metal; Native American: historic (possibly one of Red Cloud's camps) and possible unknown prehistoric	1982 survey (NSHS); Carlson (n.d.)	4.5 mi NW
25DW136	lithic, bone, glass; Native American Plains Archaic and possible early historic	1982 survey (NSHS); Carlson (n.d.)	4.5 mi NW
25DW137	lithic, bone, metal; Native American: unknown prehistoric and/or early historic	1982 survey (NSHS); Carlson (n.d.)	6.5 mi W
25DW140	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	6.0 mi W
25DW141	lithic, ceramic: Native American: late prehistoric	1982 survey (NSHS); Carlson (n.d.)	6.5 mi W

Table 4.8-1 (Continued)

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
25DW142	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	10.0 mi N
25DW143	Sidney-Blackhills stage station (Little Cottonwood) and Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	6.0 mi SE
25DW144	lithic; Native American: Paleo-Indian(?) and/or unknown prehistoric	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25DW145	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	3.0 mi SW
25DW146/00-18	ceramics, glass, metal, bone, stone Euroamerican: possible station associated with Red unknown prehistoric	1982 survey (NSHS); Carlson (n.d.)	
25DW147	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25DW148	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25DW149	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW

Table 4.8-1 (Continued)

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
25DW150	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25DW151	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25DW152	Sidney-Black Hills stage station (White Clay Creek)	1982 survey (NSHS); Carlson (n.d.)	4.0 mi S
25DW153	lithic, bone; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	6.5 mi W
25DW154	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	2.5 mi W
25DW501	flour mill; Euroamerican: 19th century	1982 survey (NSHS); Carlson (n.d.)	5.0 mi NW
25SX126 (Raum)	lithic, ceramic, refuse deposit and possible house depression; Native American: late prehistoric	1982 survey (NSHS); Carlson (n.d.)	10.0 mi NW
25SX164	historic trash dump; Euroamerican: Ft. Robinson period	1982 survey (NSHS); Carlson (n.d.)	7.0 mi W
25SX165	lithic, bone; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	7.0 mi W
25SX168	lithic, bone; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	8.5 mi W

Table 4.8-1 (Continued)

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
25SX173	metal, glass, lithic; Euro-american small military outpost related to Ft. Robinson	1982 survey (NSHS); Carlson (n.d.)	8.5 mi NW
25SX174	lithic, ceramic, metal; Native American: early historic and possible unknown prehistoric	1982 survey (NSHS); Carlson (n.d.)	8.5 mi NW
25SX178	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	7.0 mi NW
25SX179	lithic; Native American: unassigned	1982 survey (NSHS); Carlson (n.d.)	7.0 mi NW
25SX451	lithic, bone; Native American: unassigned	1984 survey (NSHS); Bozell (1984)	8.0 mi NW
25SX452	lithic, ceramic; Native American: probable Plains Village	1984 survey (NSHS); Bozell (1984)	8.5 mi NW
25SX457	windmill, stock tank; Euroamerican: 20th century	1984 survey (NSHS); Bozell (1984)	9.0 mi NW
ARCHITECTURAL			
25DW004(1-43)	Crawford, Nebraska; Euroamerican: 1886 to present	? survey (NSHS)	5.0 mi NW
25DW00-5	Belmont RR tunnel; Euroamerican: 19??	? survey (NSHS)	6.5 mi S

Table 4.8-1 (Concluded)

Site Number (Name)	Site Description and Cultural Affiliation	Extent of Investigations and Published References[1]	Distance from Pilot Plant
25DW00-17 (25DW112)	farmstead; Euroamerican: 19th - 20th century	1982 survey (UNL); Bozell and Pepperl (1982)	within pilot plant study area
25DW00-18 (25DW146)	log building; Euroamerican: probable association with Red Agency	1982 survey (NSHS)	3.0 mi SW
25DW00-19	log house; Euroamerican: late 19th century	? survey (NSHS)	10.0 mi NW
25DW00-20	covered log house; Euroamerican: late 19th century	? survey (NSHS)	9.0 mi NW
25SX00-27	1-1/2 story log house; Euroamerican: late 19th century	? survey (NSHS)	10.0 mi NW

[1] NSHS = Nebraska State Historical Society; CSC = Chadron State College; UNL = University of Nebraska-Lincoln

National Register Properties. A consultation of the most recent full listing of properties on the National Register of Historic Places (Federal Register 44<26>, Part II, 1979) and all subsequent annual updates indicate seven sites in Dawes and Sioux Counties are on the Register, but none are located within proposed project boundaries. Three registered sites are within the adjacent area, including Fort Robinson and the Red Cloud Agency which have been designated as National Historic Landmarks and the Co-operative Block Building in Crawford (see Table 4.8-1).

The final listing of the National Registry of Natural Landmarks was also consulted (Federal Register 1977, 37<20>:1496-1499). A single Nebraska resource, Fontanelle Forest in Sarpy County at the eastern margin of Nebraska, is listed.

REGIONAL NATURAL AND HISTORICAL SIGNIFICANCE

Extant information, as discussed above, offers ample evidence that the Nebraska panhandle segment of the High Plains physiographic unit contains a variety of natural and historical resources characteristically limited to this region that could potentially provide unique research opportunities from several perspectives. The Pine Ridge region and the adjacent White River drainage system include a number of widely recognized paleontological localities as well as prominent natural landmarks. In addition, the region contains key historic resources associated with military and Native American reservation periods (i.e., Fort Robinson and the Red Cloud and Spotted Tail Agencies). Recent archeological investigations in the High Plains suggest the prehistory of the region is characterized by a high degree of cultural homogeneity within a broad temporal sequence (Frison 1978:2-3). This portion of the High Plains also provides a number of lithic source localities including the Chadron formation outcroppings, Little Badlands and the Spanish Diggings quarries (Wyoming) that could influence the range of Native American site types present within the study area.

Although general categories of potentially significant natural and scientific values have been identified, a systematic record of the full range of resource variability has not been compiled. This situation is particularly

true of paleontological and prehistoric cultural resources. Implementation of a regional-scale systematic sampling program would be required to fully address issues relevant to prehistoric, historic and natural significance and to develop an appropriate regional preservation plan.

4.8-3 ARCHIVAL RESEARCH

A preliminary search of historical documents was completed prior to initiation of the 1982 and 1987 field investigations to generate expectations concerning the potential presence of historic sites within the study area and to develop a basis for evaluating identified resources. Work involving local sources was carried out during the field visits. Following the on-site inspection, additional records were researched for particular locations within the study unit to obtain data concerning individuals, construction dates, periods of occupation and other information relevant to identification of recorded resources (see Bozell and Pepperl 1982:20).

RURAL DOMESTIC SETTLEMENT

The survey unit encompasses 16 full or partial one-quarter sections. Encouraged by construction of the Chicago, Burlington and Quincy Railroad through the area in 1886, most of these were initially settled as entire 160 acre tracts, although four were segmented into smaller units (Table 4.8-2). The majority of individuals claimed under the Homestead (1862) or Pre-emption (1841) Acts. Two Timber Culture Act (1873) claims and one railroad claim are also recorded.

The earliest homestead in the area appears to be settled by James English, a native of Ireland who moved to the area in 1879 from a freighting career in the Rocky Mountains. English purchased a "squatters claim" for $100.00 in portions of the SE 1/4 of Section 13 (T31N R52W) and the SW 1/4 of Section 18 (T31N R51W) in 1880 (Anonymous 1961:120; Pinny 1984: 120). This claim is depicted as triangular shaped and includes a residence, outside the CSA, in Section 13 on the 1881 General Land Office plat map. English formally filed a Pre-emption claim for only the Section 13 tract in 1886. Remaining initial claims were filed between 1885 and 1893, but the majority

Table 4.8-2. **Summary of initial Euroamerican settlement within the CSA; Crow Butte Project, Dawes County, Nebraska**

Claimant	Claim Year	Patent Year	Legal Description	Claim Type	Acres	Euroamerican Sites within Tract
Luther Keenan	1887	1888	SE 1/4 S11 T31N R52W	homestead	160	25DW199
Malinda A. Cooper	1889	1891	NE 1/4 S11 T31N R52W	homestead	160	
Charles L. Cutler	1885	1889	SW 1/4 S12 T31N R52W	timber	160	
Daniel Clark	1887	--	S 1/2 SE 1/4 S12 T31N R52W	pre-emption	80	
Josephine Bohers	1887	1894	NE 1/4 SE 1/4 S12 T31N R52W	homestead	40	
David Clark	1887	--	N 1/2 NE 1/4 S 13 T31N R52W	pre-emption	80	
James English	1886	1890	S 1/2 NE 1/4 + N 1/2 SE 1/4 S13 T31N R52W	pre-emption	160	
Sanford West	1891	1892	W 1/2 NW 1/4 + W 1/2 SW 1/4 S13 T31N R52W	homestead	160	
Preston C. Woods	1885	1894	E 1/2 NW 1/4 + E 1/2 SW 1/4 S13 T31N R52W	timber	160	
William Hamlin	1888	1891 ?	NW 1/4 + SW 1/4 + SE 1/4 of SW 1/4 S20 T31N R51W	homestead	120	25DW00-26
Eugene Stetson	1887	1890 ?	SW 1/4 S18 T31N R51W	pre-emption	160	25DW00-25, 25DW193
Winfield A. Campbell	1887	--	NW 1/4 S18 T31N R51W	pre-emption	160	

Table 4.8-2 (Continued)

Claimant	Claim Year	Patent Year	Legal Description	Claim Type	Acres	Euroamerican Sites within Tract
Frank Fleming	1886	1890	NW 1/4 S19 T31N R51W	pre-emption	160	25DW117 (?)
Hans Wulf	1889	1891	NE 1/4 S19 T31N R51W	pre-emption	160	25DW112/00-17
Cyrenius Fiandt	1886	1891	SE 1/4 S19 T31N R51W	pre-emption	160	25DW113
J.J. Harvey	1888	1891	SW 1/4 S19 T31N R51W	pre-emption	160	25DW111
John Dougherty	1893	1899	W 1/2 NW 1/4 S29 T31N R51W	homestead ?	80	25DW191
William Hamlin (?)	1886	1886	SW 1/4 S29 T31N R51W	homestead	160	
Elisha Stetson	1893	1896	NE 1/4 S30 T31N R51W	homestead ?	160	25DW192
Bennet B. Warford	1888	--	NW 1/4 S 30 T31N R51W	railroad	160	

were maintained by original settlers for less than ten years. Within 20 years all of Section 18 and a major portion of Section 19 were owned by two individuals, Eugene Stetson and Henry Daniels. Other long-term holdings in the study area involve the English, Gibbons and McDowell families. Much of the remainder of the CSA tracts were the subject of numerous short-term transactions, often involving nonresident interests.

The field investigation resulted in identification of eight sites potentially associated with early settlement episodes of the project area. Further details concerning initial claimants and select subsequent landowners as well as possible buildings constructed on the claims are provided in the "Site Descriptions" section of this report (see also Bozell and Pepperl 1982:21-23). Relevant site locations are: 25DW111, 25DW112, 25DW113, 25DW117, 25DW191, 25DW192, 25DW00-25 and 25DW00-26.

There existed an overall discrepancy between historic map data and archival or field study data. Many of the archivally predicted or identified homestead sites do not appear on historic map sources, suggesting many claims were abandoned and structures removed prior to 1913 when the first reliable map depicting residence locations was issued. A series of dry years beginning in 1887 forced many people to leave large areas of the county abandoned. This trend continued up to the turn of the century. By 1910 the county population had decreased from its mid-1880s position (Burn et al. 1917:11). Previous rural settlement on project lands was likely of greater density than indicated by historic map information. During the 1982 field investigation, 34 historic resource locations were noted within the CSA and adjoining lands. Only 24 of these are represented on available maps.

RURAL INSTITUTIONS AND COMMERCIAL CONCERNS

Evidence of rural community facilities previously located within the study area consists of two public schools, an icehouse, a cemetery, a possible sawmill and a blacksmith shop.

Superintendent of Schools records on file at the county courthouse in Chadron indicate that Section 19 was once within former School District No. 25 and lands directly north (Section 18) were at one time within District No. 9.

District No. 25 was formed 15 February 1886 and a schoolhouse was apparently established in the extreme northeast corner of Section 19 (see 25DW115). District No. 9 was formed 3 October 1885. A former schoolhouse location is in the extreme southwest corner of Section 18, 1 mi due west of School No. 25 (25DW193). The two districts were consolidated in 1903 and dissolved in 1976. The consolidated district occupied the Section 18 tract.

The presumed original site (25DW115) of the District No. 25 schoolhouse was also the location of the First Presbyterian Church of Crow Butte which was constructed ca. 1896 on an acre of land purchased for $25.00 from A.E. Hobson (Numerical Index). According to Mr. Harold Gibbons, who presently farms this tract, the church building was later moved several times eventually arriving at its present location at the Wulf/Daniels farmstead (see 25DW112).

The relationships between the school and church usage of this site, or the date when the building ceased functioning for either purpose is unclear. The Standard Atlas of Dawes County (1913), the earliest map source for this area showing structural locations, labels both of the two sites in Section 18 (25DW193) and Section 19 (25DW115) as schools. These two structure locations are also plotted on the U.S.D.A. 1917 series soil survey map (Burn et al. 1917), and both appear to be represented by church symbols. However, only the site in Section 18 is shown on the 1939 Department of Roads highway map suggesting that the church (or former school building) located in Section 19 (25DW115) was moved sometime between 1915 and 1937.

The Stetson family apparently managed commercial sawmill and threshing operations in the vicinity (Anonymous 1961:71). Precise locations for these activities were not identified. A current landowner in the area, Frank Ehlers, believes Eugene Stetson had a blacksmith shop at site 25DW191, although this could not be verified. Frank Fleming also notes

operating a blacksmith shop on his claim (see site 25DW117). Finally a commercial icehouse was established in the early 20th century (25DW199) which serviced both Crawford and the local rural community (Mrs. Lorentz Raben:personal communication).

In summary, the study area apparently contained a sufficient population to sustain a church and school during the late nineteenth century and maintained a school until 1976. An icehouse and possible other commercial operations were established in the area during the late 19th - early 20th century. Archival records concerning the Crow Butte Cemetery (1888-1971) located at the western edge of the survey unit were not investigated. The cemetery contains at least 16 tombstones which date from 1888-1971.

4.8-4 FIELD INVESTIGATIONS

An in-field inspection of the R&D study area (Section 19, T31N, R51W) was conducted during the period 29 March - 2 April 1982, by an experienced four-member UNL field crew. Additional procedures carried out during this effort included verification of architectural structures visible from roadways throughout the CSA, coordination with Wyoming Fuel Company (WFC) field personnel and landowners, and historic archival research for Section 19 conducted at the Dawes County Courthouse.

The remaining CSA land in portions of Sections 18, 20, 29 and 30 (T31N R51W) and Sections 11, 12 and 13 (T31N R52W) was surveyed by a 3 member NSHS crew during the period 27-30 April 1987. Additional archival research was completed at this time.

SURVEY PROCEDURES

All lands within the project area were subjected to intensive (100%) pedestrian surface survey. The investigation procedure consisted of walking in a zigzag reconnaissance pattern at closely spaced intervals, normally 20-30m. Intervals were modified as necessary to meet varying terrain and

vegetational conditions. Inspection of all exposed areas, such as animal burrows, exploratory drill pads and eroded surfaces was completed. An intensive effort was made to examine all cutbanks exposed along creeks and adjacent intermittent tributaries for buried cultural deposits.

All cultural sites identified during the surveys were plotted on U.S.G.S. 7.5 minute topographic maps (Crow Butte and Crawford quadrangles). A detailed examination of the immediate area of each located cultural resource was performed to identify horizontal limits and composition of surface materials. A preliminary field inventory of observed materials and sketch map of the immediate site vicinity were also made at this time. In addition, photographic documentation of all site locations was completed. More extensive field documentation, such as: instrument mapping (transit), test unit excavation, collection of select surface specimens, and cutbank profiling, was carried out during further investigations of potentially significant sites.

Surface visibility varied within the study area. Much of the tract surface was covered with short bunch grass offering fair visibility. Roughly 300 acres was cultivated (winter wheat) providing good to excellent visibility. About 100 acres in the extreme southeastern corner of the survey area are sparsely covered with evergreen forest where visibility was fair. The surface of the wooded creek bottomland was generally obscured, however creek bank exposures facilitated subsurface observations throughout this area (see Appendix B; Figure 3).

SURVEY RESULTS

Approximately 1350 acres including segments of the Squaw, English and White Clay Creek channels and associated terraces were inspected resulting in identification of 21 previously unrecorded cultural resources. Eighteen of these are assigned systematic site numbers while the remaining three locations are designated only by their field numbers for reasons discussed below. Descriptive characteristics are summarized in Table 4.8-3. A map of recorded resource locations is provided in Appendix B of this report (Figure 4).

Table 4.8-3. **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; Euroamerican; 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); Euroamerican 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 (25-40cm 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 Pre-historic 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 pub-lic school; Euroamerican; late 19th century	small rise on upper slope	900	survey, sketch map

Table 4.8-3 (Continued)

Site Number	Description and Temporal Assignment	Topographical Location	Area (m^2)	Field Investigation
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; Euroamerican (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, controlled bank profile/collection, sketch map, photographs
FN-3	Crow Butte Cemetery; Euroamerican; 1880-1971	level ridge top	2,700	survey, sketch plan, photographs
1987				
25DW191 (Dougherty/ Smith)	surface/buried; outbuilding; 2 depressions;, farm machinery; Euroamerican; late 19th century	foot of Pine Ridge colluvial slope	50,000	survey, sketch map, photographs
25DW192 (Stetson/ Roby)	surface/buried; glass and metal debris; 2 depressions, 2 foundations; Euroamerican; late 19th century	top and slope of small knoll overlooking Squaw Creek tributary	1,000	survey, sketch map, uncontrolled surface collection, photographs

Table 4.8-3 (Continued)

Site Number	Description and Temporal Assignment	Topographical Location	Area (m^2)	Field Investigation
25DW193 (School Dist. 9/25)	surface/buried; ceramic, glass, 2 foundations, extant outhouse; Euroamerican (1904-1976)	upland valley	2,500	survey, sketch map, uncontrolled surface collection, photographs
25DW194	surface/buried; chipped stone flaking debris. bone; unassigned and possible historic Native American components	saddle in ridge above Squaw Creek	1,600	survey, transit map, uncontrolled surface collection, controlled tests (2), photographs
25DW195	surface; chipped stone tool, flaking debris, bone; unassigned Native American	broad terrace; English Creek	1,000	survey, uncontrolled surface collection, sketch map, photographs
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 tests (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; 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 tests (3), photographs

Table 4.8-3 (Concluded)

Site Number	Description and Temporal Assignment	Topographical Location	Area (m^2)	Field Investigation
25DW199 (Crawford Ice House)	surface/buried; foundation, pond; Euroamerican; 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 out-buildings, 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 out-buildings, corral); Euro-american; early 20th century to present	broad terrace, Squaw Creek	25,000	survey, sketch plan, photographs

Native American Resources. Two Native American sites, an isolated fragment of chipped stone flaking debris (FN-1) and a subsurface deposit of bone (cf. bison) and charcoal (FN-2) exposed along the Squaw Creek cutbank were identified within the pilot plant unit. Origin of the bone deposit is unclear. Site 25DW114 consists of an extensive scatter of chipped stone tools, flaking debris, bone and trade goods. Remains at site 25DW116 are limited to three specimens of chipped stone flaking debris. All of these sites are located within 100 meters of Squaw Creek in the northeastern portion of the section.

Five additional Native American lithic or lithic and bone scatters were identified during survey of the remainder of the CSA (25DW194-25DW198). All of these resources are located northwest of the R&D unit on either upland divides or level terraces of English or Squaw Creeks.

Euroamerican Resources. Five Euroamerican sites and the Crow Butte Cemetery (FN-3) were recorded during the 1982 R&D survey. These resources include an abandoned farmstead (25DW112), three historic debris scatters marking the former locations of two possible homestead sites (25DW111 and 25DW113) and a removed church (25DW115), as well as an isolated windmill complex (25DW117).

Six Euroamerican sites were discovered during the 1987 CSA study. Two are occupied farmsteads (25DW00-25, 25DW00-26), one is a series of outbuildings and two depressions (25DW191) and three are represented by foundation remains. One of these is a school (25DW193), one is an icehouse (25DW199) and the final resource appears to be a pre-1900 homestead site.

4.8-5 SITE DESCRIPTIONS

Brief narrative descriptions summarizing locational information and the results of site-specific investigations are presented in sequence by site number. Select photographs and site maps appear in Appendix B. Figure 4.8-1 shows the locations of the sites described in this section. Detailed field records for each of the resource locations are contained in Appendix B.

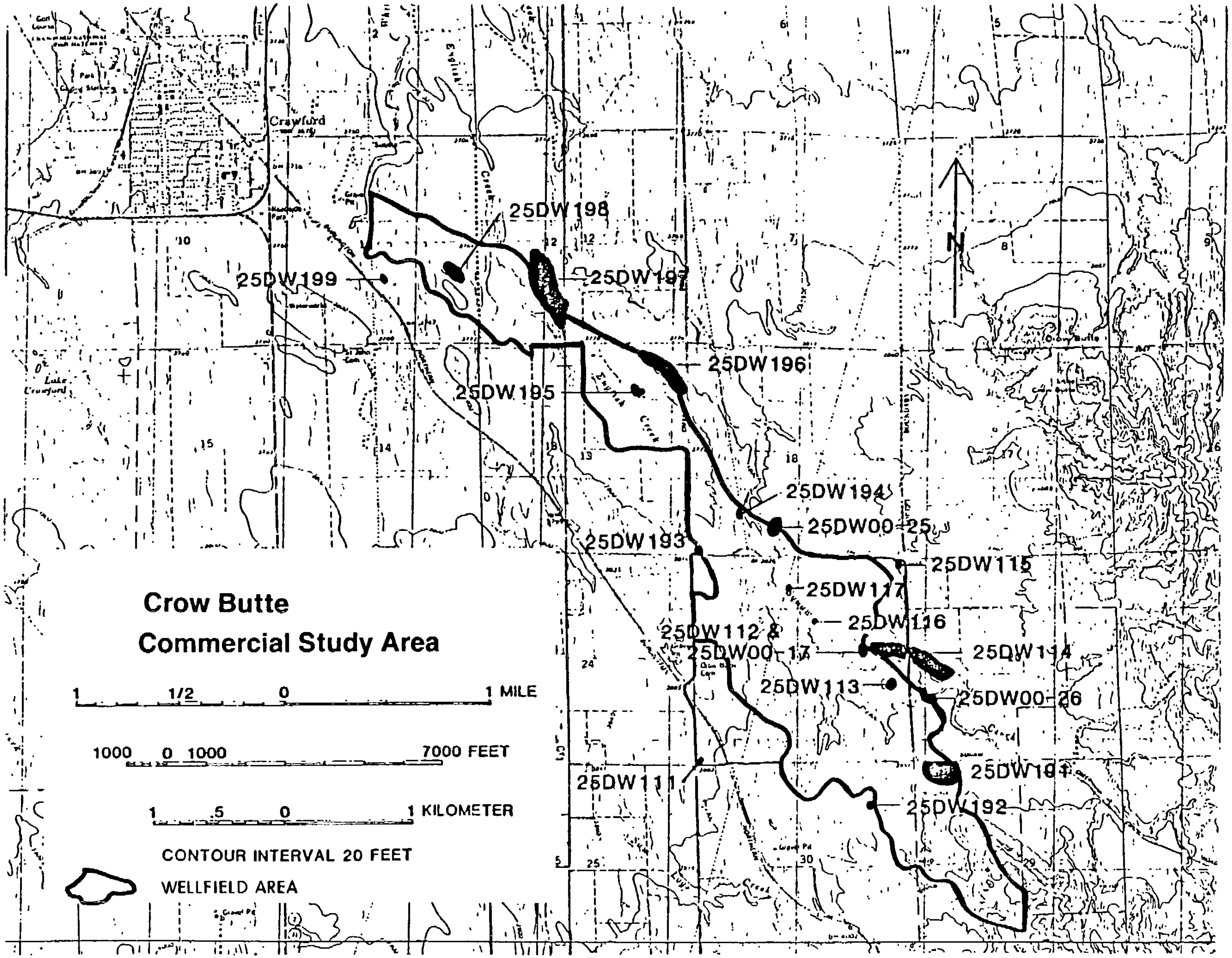

Figure 4.8-1 Location of cultural resources identified during 1982 and 1987 investigations within the Crow Butte Project; Dawes County, Nebraska.

Field observations lacking spatial integrity (e.g., isolated specimen locations) or identifiable cultural association, as well as sites (e.g., cemeteries) not eligible for National Register consideration are designated by field numbers (FN-1 through FN-3).

25DW111 (HARVEY HOMESTEAD?)

This site consists of historic debris thinly scattered on the top and slopes of a small knoll at 3885 ft. elevation. Approximately 25-30 specimens including window glass, milk glass, china, white (thin) ironstone, metal, and bone were observed within an area of ca. 32 x 32 m, and left in place. A sketch map of the site was prepared (see site form in Appendix B) and standardized archival research was initiated.

The site is situated on a land tract for which the initial claim (preemption) was filed by Jefferson J. Harvey in 1888, and finalized in 1891 (U.S. General Land Office tract book). The land was purchased by Eugene Stetson in 1907, and remains in the family. Federal census records for 1900 (Crawford Precinct) indicate Harvey was born in Missouri in 1852, married Lillie Phelps in 1876, and together they had six children. Harvey and his family moved to Dawes County in April of 1886 and filed a preemption claim for the southwest quarter of Section 19. Harvey initially constructed a dugout on the land, where he and his family lived for several years, while Harvey farmed and worked for the Chicago and Northwestern Railway. The family eventually moved to Crawford where Harvey was appointed City Marshall from 1901-1908 (Anonymous 1909:315).

Claimant's testimony filed by Harvey (17 October 1888) summarizes improvements he made on the claim (National Archives, Washington). The house (16 x 32 ft) was a two-story frame structure with shingle roof, board floors, three doors, and six windows. Additional structures included: a log stable (14 x 16 ft), cellar (10 x 12 ft), hen house/cow shed, and a well (53 ft deep). Harvey's cost estimate for these improvements was $598.00. At the time of his testimony, Harvey had 30 acres of tilled land on which he raised corn, oats, millet and vegetables.

Although this site may represent the former location of the farmstead constructed by the Harvey family in homesteading this land tract, no definite evidence of this possibility was obtained. However, other potential homestead remains were not identified within Harvey's initial claim (southwest quarter).

25DW112 (WULF/DANIELS PLACE)

This site is an abandoned farmstead consisting of an intact house and twelve outbuildings as well as various structural remains and debris situated at 3880 ft elevation on a broad south and west-facing terrace directly above the east bank of Squaw Creek. An access drive connects the farm to a county road approximately 0.3-km (0.2 miles) to the east.

Field procedures included production of photographs and a detailed sketch plan of the site including exterior measurement of all architectural features. Standardized archival research and local resident interviews were carried out.

The site consists of 18 features encompassing an area of 6000 square meters. Each are identified in Table 4.8-4. The present condition of each of the nine intact buildings ranges from poor to good, but in general all appear to remain structurally sound. A map of the site and photographs of various structures is provided in Appendix B (Figures 5, 6 and 7).

Feature 1, the dwelling, is comprised of four major structural components which may represent as many construction episodes. A veranda or open porch extends along the eastern facade, or formal front, of the house and connects the gabled upright at the southeastern corner, the central wing, and a smaller gabled unit at the northern end of the building. In addition to the present door in the wing extension, a former doorway, later converted to a window, is located in the east facade or gable end of the upright unit.

Table 4.8-4. **Summary of structures and surface features recorded at the Wulf/Daniels Place (25DW112) during the 1982 investigation Crow Butte Project, Dawes County, Nebraska**

Feature Number	Description and Structural Details	Exterior Dimensions(m)
1	house; single story balloon (?) frame; hipped and gable roofs, stone and concrete foundation; wire and cut nails (see Appendix B; Figure 6)	13.8 x 13.0
2	chicken coop; balloon frame, gable roof, concrete foundation; wire nails	2.5 x 3.75
3	chicken coop; balloon frame, hipped roof, concrete foundation; eight sided; wire nails (see Appendix B; Figure 7A)	5.0 x 10.9
4	4 shed; log, stone foundation; wire nails	3.3 x 3.0
5	depression; large, rectilinear; possibly barn location	13.0 x 19.5
6	latrine; frame, gable roof; wire nails	1.4 x 1.4
7	shed (poultry ?); balloon frame, shed roof, stone and concrete foundation; wire nails	3.7 x 2.6
8	former church; balloon frame, gable roof, stone and concrete foundation; wire nails (see Appendix B; Figure 7B)	11.2 x 7.4
9	storage shed; balloon frame, gable roof, stone foundation; wire and cut nails	7.5 x 5.0
10	grain storage/barn; balloon frame, gable roof, stone and concrete foundation; wire nails	9.5 x 6.2
11	garage/work shop; balloon frame, gable roof, concrete foundation; wire nails	8.8 x 6.1
12	windmill/stock tank; metal, concrete block foundation	-
13	stone foundation	3.6 x 1.8
14	stone foundation	-
15	lumber debris (structure location ?)	-

Table 4.8-4 (Concluded)

Feature Number	Description and Structural Details	Exterior Dimensions(m)
16	cistern; metal cover	2.0 x 1.3
17	propane tank	-
18	lumber debris (structure location ?)	-

NOTE: The location of each feature is shown on the site map (see Appendix B; Figure 5).

On the basis of Wulf's proof testimony (see below) the gabled upright at the southeastern corner of the building likely represents the core component or initial dwelling unit. The exterior of this structure is sheathed with vertical planking (1 x 12 in) over which horizontal clapboard (1/4 x 4 in) has been added suggesting the possible use of timber frame construction.

The site is situated on the land tract initially claimed (pre-emption) in 1889 and patented in 1891 by Hans Wulf who held the property for four years until 1893. Wulf's homestead testimony (8 April 1889) summarizes improvements he made on the claim. The house (14x16 ft) is a frame structure with a single roof, board floor, one door, and two windows. Additional structures include a frame barn (16 x 24 ft), cave (8 x 12 ft),corral and fence (40 acres). Wulf's cost estimate for these improvements was $310.00. At the time of his testimony, Wulf was farming 10 acres (corn and vegetables).

The dimensions (4.4 x 5.0 m or 14.4 x 16.4 ft) of the gabled upright at the southeastern corner of the present dwelling are consistent with the house dimensions (14 x 16 ft) recorded by Wulf. The barn dimensions provided by Wulf (16 x 24 ft) are similar to those recorded for Feature 9 (16.4 x 24.6 ft). The vertical siding of this feature could indicate a relationship to construction utilized in Wulf's house and that a later nineteenth century episode is reasonable. Similar construction was recorded for Features 10 and 11, possibly indicating that these buildings were part of the original Wulf farmstead constructed prior to 1893 and suggesting that the original farmyard likely occupied the southeastern third of the site. The location of the cave or cellar constructed by Wulf is presently unclear.

The site appears to have been occupied since 1888, however particular details concerning occupational history remain unclear; these can likely be established through interviews with local residents. The house at the site is of potential architectural interest.

25DW113 (FIANDT HOMESTEAD?)

This site consists of one large and three small depressions (see Table 4.8-5) located on a broad terrace surface. A sparse scatter of historic debris (10-15 specimens) is situated on the eroded terrace slope adjacent to the depressions. The site is located at 3890-3900 ft elevation approximately 60-100 meters south of the west bank of Squaw Creek.

The surface contains bottle and window glass fragments, thick brown ironstone, and metal. Subsurface materials identified in probe tests of one depression (Feature 3) include burned wood, glass, metal, and . leather. A contour map of the site is presented in Appendix B (Figure 8).

The site is situated on a land tract for which the initial claim was filed by Cyrenius Fiandt in 1888 and finalized in 1891 (U.S. General Land Office tract book). Claimant's proof testimony filed by Fiandt (10 December 1888) summarizes the improvements he made on the claim (National Archives, Washington). The house (12 x 15 ft) was a frame structure with board and tar paper roof, board floor, three doors and five windows. An 8 x 12 ft addition was also added. Additional structures include a frame barn (12 x 28 ft), board barn (12 x 16 ft), cave (8 x 12 ft), log chicken coop (8 x 12 ft), fence (105 x 36 ft), hog yard, and a well (41 ft deep). Fiandt's cost estimate for the improvements was $400.00. At the time of his testimony, Fiandt was farming 10 acres planted in corn, wheat, potatoes and millet.

Fiandt moved to the claim in 1886 (National Archives, Washington) from Merrick County, Nebraska, although he did not file until two years later. In addition to farming, Fiandt provided carpentry services to his neighbors and the military at Ft. Robinson. He moved to Crawford prior to 1900 and operated a blacksmith shop and livery stable (LaVerne Stetson:personal communication).

Site 25DW113 is likely the former location of the Fiandt homestead. No alternative locations were identified within Fiandt's initial claim. LaVerne Stetson recalls abandoned standing structures on the site. Additional

Table 4.8-5. **Summary of surface features identified at site 25DW113 during the 1982 field investigation; Crow Butte Project, Dawes County, Nebraska**

Feature Number	Description	Dimensions(m) Length x Width	Depth (m)	Comments
1	depression with remains of stone foundation (7 rocks) at perimeter	7.5 x 7.0	ca. 0.85	probe test; sterile
2	depression	7.2 x 6.2	ca. 0.35	shovel test (0-40cm S.D.): burned wood, glass, metal, leather noted at 25-40cm S.D.
3	depression with remains of stone foundation (ca. 25 rocks) on east edge	9.4 x 7.5	ca. 0.50	shovel test (0-25cm S.D.): rocks noted at 10-15cm S.D.
4	depression	27.0 x 23.0	ca. 1.00	shovel test (0-25cm S.D.): sterile

NOTE: The location of each feature is shown on the site map (see Appendix B; Figure 8).

interviews with local residents could serve to clarify the chronology and use of this site.

25DW114

This site consists of an extensive scatter (150,000 square m) of chipped stone tools, flaking debris, bone fragments and trade goods exposed on the surface of a cultivated field (winter wheat). The site is situated at 3880 ft elevation on the broad south-facing terrace above the east bank of Squaw Creek and extends across the entire cultivated area limited by a drive on the north, by the terrace edge on the south, and by an abandoned farmstead (25DW112) on the west.

During the 1982 survey a total of 37 specimens was recorded at 28 surface locations; all on the west side of a county road dividing Sections 19 and 20. Included are chipped stone tools (n=10), flaking debris (n=18), and un-modified bone (n=9) as described in Table 4.8-6. A contour map showing the distribution of these materials is presented in Appendix B (Figure 9). Only eight stone tools and a single identifiable bone fragment were collected. These specimens are discussed in Bozell and Pepperl (1982:4347) and illustrated in Appendix B (Figure 10).

The site was not revisited during the 1987 survey, however, Mrs. Frank Ehlers owns a large collection of artifacts recovered from the site including bifaces, scrapers, flakes, bone fragments, glass trade beads and over fifty projectile points (Appendix B, Figure 11).

The presence of an Archaic period component on the western edge of the site is indicated by a nearly completed projectile (Appendix B; Figure 10-C) recovered during 1982. The specimen compares with a Duncan type specimen originally illustrated by Wheeler (1954:Figure 1-a, c). This point type has been recovered from sites in Montana, Wyoming and central South Dakota, as well as western Nebraska and is affiliated with prehistoric occupations during a time span ranging from 2550-850 B.C. In general, the type is attributed to mid-to-late (ca. 1500 B.C.) Archaic period origins (see e.g., Wedel 1961:250-251; Frison 1978:40-56).

Table 4.8-6. Inventory of cultural material recovered at site 25DW114 during the 1982 investigation; Crow Butte Project, Dawes County, Nebraska

Cat. No.	Specimen Category and (Frequency)	Description
1	lithic tool (1)	triangular biface (?), edge fragment; quartz
2	lithic tool (1)	endscraper, distal fragment; quartz
3	lithic tool (1)	straight/ovate biface, solid quartzite
4	lithic tool (1)	triangular biface, proximal fragment; chert
5	lithic tool (1)	endscraper, distal fragment; chert
6	lithic tool (1)	double-notched biface; chert
7	lithic tool (1)	double-notched biface; chert
8	lithic tool (1)	retouched flake; solid quartzite
9	lithic tool (1)	Bovidae; right proximal radius
10	lithic tool (1)	retouched flake; solid quartzite
11	unmodified bone (1)	unidentifiable fragment
12	unmodified Bone (1)	unidentifiable fragment
13	lithic debris (1)	chipped stone flake; quartzite
14	lithic debris (1)	chipped stone flake; chert
15	lithic debris (1)	chipped stone flake; chert
16	lithic debris (1)	chipped stone flake; quartzite
17	lithic debris (1)	chipped stone flake; clear chalcedony
18	unmodified bone (1)	unidentifiable fragment
19	unmodified bone (1)	unidentifiable fragment
20	lithic debris (2)	chipped stone flake; chert chipped stone; solid quartzite
21	unmodified bone (1)	unidentifiable fragment
22	unmodified bone (1)	unidentifiable fragment
23	lithic debris (1)	chipped stone flake; chert
24	lithic debris (1)	chipped stone flake; solid quartzite
25	unmodified bone (1)	unidentifiable fragment
26	unmodified bone (1)	unidentifiable fragment
27	lithic tool (1)	retouched flake; chert
	lithic debris (1)	chipped stone flake; chert
28	lithic debris (6)	chipped stone flake; chert
	lithic debris (1)	chipped stone flake; solid quartzite
	lithic debris (2)	chipped stone flake; chalcedony

NOTE: The provenience of all specimens is indicated per catalog number on site map (see Appendix C; Figure 9). Catalog numbers 1-9 were collected; all other materials were left in place.

The eastern two-thirds of the site (Section 20) appears to possess a higher density of cultural material based on comments made by Mrs. Ehlers who has surface collected the site for over twenty years. Projectiles in the Ehlers collection represent the late Paleo-Indian, Early Archaic, Middle Archaic, Late Archaic-Woodland, Late Prehistoric and Historic periods. Nearly one-half of the projectiles are affiliated with the Middle Archaic period.

25DW115 (SCHOOL NO. 25)

This site is the former location of a rural schoolhouse and the First Presbyterian Church of Crow Butte, which has been moved to another location (see site 25DW112, Feature 8). The site presently consists of a limited scatter of brick fragments and window glass located on a small rise in the extreme northeastern corner of Section 19 at 3900 ft elevation. The surface of the area is currently under cultivation (winter wheat).

The initial claim for this land tract (NE 1/4, Section 19) was filed by Hans Wulf in 1889 and finalized in 1891 (U.S. General Land Office tract book). A.E. Hobson acquired the property in 1893. The First Presbyterian Church of Crow Butte purchased one acre of land from Hobson in the northeast corner of the quarter section for $25.00 in 1896 (Dawes County Numerical Index). Construction of the church began in the same year. It is unclear when the structure was moved to the Daniels farmstead, however, the Standard Atlas of Dawes County (1913) and the 1918 soil survey map show the structure (as a school) at its original location. The 1937 Department of Roads map and current topographic map (1980 Crow Butte Quadrangle) have no structures plotted for this location, indicating the building was probably moved sometime between 1917 and 1937. Harold Gibbons, who currently farms this tract, indicated that the structure had been used as both a church and school at its original location, and for hay storage at the present location at site 25DW112.

The site appears to have been originally developed as a school (ca. 1886) and later as a church (ca. 1896; see Archival Research). The building was moved several times prior to arriving at its present location. The precise

date of the original movement is uncertain but probably occurred between 1915 and 1937. Interviews with local residents could clarify the function and use periods of this site.

25DW116

A single chipped stone tool and flaking debris (n=2) were observed along the west-facing terrace slope above and ca. 30 meters east of Squaw Creek. The site is situated at 3850 ft elevation. A retouched flake (silicified wood) and two specimens of chipped stone flaking debris (chert and red/ white chalcedony) were recorded within a 1 x 2 meter surface area. These specimens were left in place. and a sketch map of the general area was prepared.

The observed lithic specimens are not temporarily diagnostic and the site has not been assigned to a particular cultural period. Verification of subsurface deposits and possible relationship to an isolated find (FN-1) located approximately 200 meters northwest would require limited subsurface testing of the west-facing Squaw Creek terrace slope within and between these two locations.

25DW117 (FLEMING HOMESTEAD?)

The site consists of a wooden framed windmill, concrete cistern and metal stock tank situated within a barbed wire fence near the edge of the southwest-facing terrace approximately 40 meters northeast of Squaw Creek at 3840 ft elevation. The windmill, manufactured by the Aeromotor Company, is in good and operable condition, but presently is not utilized.

The site is located in the northwest quarter of Section 19. The initial claim for this land was filed by Frank Fleming in 1886 and finalized in 1890 (U.S. General Land Office tract book). The 1900 series Federal census records for Dawes County indicate Frank Fleming was born in Ohio in December of 1852 and homesteaded in Dawes County during the 1880s. By 1900, Fleming was a blacksmith residing in Crawford. Fleming's homestead proof testimony (26 October 1886) summarizes improvements he made on the

claim (National Archives, Washington). The house (18 x 24 ft) was a log structure with three doors and five windows. Outbuildings included a frame blacksmith shop (14 x 22 ft), frame stable (12 x 14 ft), corn crib/ wagon shed (16 x 16 ft), and a well. Fleming's cost estimate for these improvements was $525.00. At the time of his testimony, Fleming was farming 12 acres as well as operating the blacksmith shop.

This site may be the former location of the Fleming homestead but positive evidence for this possibility was not obtained. No other potential location for this farmstead was identified within Fleming's initial claim.

25DW191 (DOUGHERTY/SMITH HOMESTEAD ?)

This site is comprised of two small depressions, non-residential buildings and scattered farm machinery situated near the base of a broad Pine Ridge colluvial slope. The site is located at 3940-3980 ft elevation about one-half mile southwest of Squaw Creek.

Following an intensive survey of the site area, a sketch map was prepared and general view photographs taken from a north facing slope above the site. Standardized archival research was initiated for this location and an interview conducted with the present landowners.

The scattered farm machinery and thirteen outbuildings (including shops, shed, chicken coops, a windmill and stables) occupy the southern two-thirds of the site. Immediately northwest of the building cluster are two depressions and an east-west vehicle trail. One depression is circular and about 3 m in diameter. The other is oval or rectangular and measures 5 x 3 m. The entire site occupies approximately 50,000 square meters.

The site is situated on an 80 acre land tract (W 1/2, NW 1/4) originally claimed by John Dougherty in 1893. The transaction was finalized in 1899 (U.S. General Land Office Tract Book). Dougherty sold the land to W.P. Smith in 1910. A number of short-term transactions occurred until 1960 when the tract was purchased by Frank Ehlers and his wife, the current owners (Dawes County Numerical Index). All of the buildings on the site

have been constructed or moved in by the Ehlers since 1960. Frank Ehlers stated in an interview that he believed the site was never used as a residence and the depressions mark the location of Eugene Stetson's blacksmith shop. The Dawes County Numerical Index does not, however, record Stetson as an owner of this tract. A structure is plotted at the site location on the 1917 County Atlas, and LaVerne Stetson recalls extant abandoned buildings on the site prior to the Ehlers' ownership (L. Stetson:personal communication.

Dougherty's homestead testimony (August 28, 1899) summarizes improvements he made on his claim (National Archives, Washington). At the time Dougherty was 48 years old and residing with his wife and eleven children. The home was a frame structure measuring 20 x 30 ft, probably constructed in 1893 or before. Other structures include a frame barn (12 x 30 ft), a frame granary (10 x 12 ft), a well and a windmill. Dougherty's cost estimate for these improvements was $500.00. Twenty-five acres were under cultivation on the claim at the time of testimony.

The site is likely the location of a blacksmith shop or early homestead associated with John Dougherty or W.P. Smith.

25DW192 (STETSON/ROBY HOMESTEAD ?)

Site 25DW192 consists of a small cluster of foundation remains and depressions situated on the top and slope of a small knoll overlooking a Squaw Creek tributary at 3960-3970 ft elevation. The site was covered with short bunch grass at the time of survey.

The site was discovered during the initial survey of the area. A return investigation consisted of making measured drawings of all surface features, taking photographs of features and the general site area and collecting select surface artifacts. Standardized archival research was initiated for this tract and interviews conducted with local residents.

The site is comprised of five features (Table 4.8-7), encompassing an area of over 3000 square meters (see Appendix B; Figure 12). Feature 1 is an oval mound surrounded by an intermittent rectangular stone foundation measuring 8.7 m x 6.2 m. Foundation remains consist of well-sodded-in natural cobbles (see Appendix B; Figure 13). Feature 2 is a deep circular depression, 9 m in diameter. A raised ring of earth surrounds this depression. Feature 3 is an oval to rectangular depression measuring 10 x 6 m. A natural stone foundation corner is present at the northeast edge of the depression. Feature 4 is a circular concentration of coal and stone approximately 1 m in diameter. Feature 5 is a 4.5 m north-south running stone line with corner remnants evident.

Three artifacts were collected from the surface of the site, including a chain link or large post staple, a fragment of pink bottle glass and a portion of a bottle base. The last specimen was recovered from Feature 4 and displays raised letters typical of a bitters or compound bottle (Table 4.8-8).

The site is situated on a 160 acre tract of land originally claimed by Elisha Stetson in 1893. The transaction was finalized in 1896 (U.S. General Land Office Tract Book). In 1901 Stetson deeded the land to Godfrey Roby. The tract remained largely in Roby family ownership until the 1950s, although several short-term transactions took place during this period (Dawes County Numerical Index). In 1898 Stetson sold 1 acre of the tract, at an unknown location, to Public School District 25. The school sold the acre back to Roby in 1906. No structures are plotted in this quarter section on any historic map sources consulted. Interviews were conducted with members of the Ehlers and Stetson families. No one recalls standing structures at the site. The late Orville Stetson's wife Anna believes her husband's Uncle Elisha moved back to Wisconsin shortly after 1900. The 1900 Dawes County census lists Elisha as a civilian carpenter working for the U.S. Army and residing at Ft. Robinson.

Elisha Stetson's homestead testimony (June 16, 1896) lists improvements made on his claim (National Archives, Washington). Stetson was 27 years old and single at the time of his testimony. Stetson constructed a house

Table 4.8-7. **Summary of features recorded at site 25DW192 during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska**

Feature Number	Description and Structural Details	Exterior Dimensions(m)
1	stone building foundation surrounding oval mound	8.7 x 6.2
2	circular depression	9.0 x 9.0
3	rectangular depression with stone foundation	10.0 x 7(?)
4	coal and stone concentration	1.0 x 1.0
5	west edge of stone building foundation	4.5 x ?

NOTE: The location of each feature is shown on the site map (see Appendix B; Figure 12).

Table 4.8-8. **Inventory of material recovered at site 25DW192 during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska.**

Cat. No.	Provenience	Description
1	general surface	chain link or heavy fence post staple; 55.8mm long, 30.3mm wide, 8.5mm thick
2	general surface	pink bottle glass; 4.5mm thick
3	surface; Feature 4	green bottle glass base; 7.0mm thick; with raised letters: - LMER'S - MP -

on the claim in 1890 (no dimensions given) but built a second structure in 1892. The second structure included a frame main component (14 x 20 ft) with a 10 x 12 ft frame addition. Other structures include a stable (10 x 14 ft), a shed (14 x 14 ft) a hen house (6 x 12 ft), a cave or cellar (10 x 12 ft) and a well 100 ft deep. Stetson's cost estimate for the improvements was $600.00. Forty acres were under cultivation at the time of the testimony.

The dimensions of either Feature 1 (6.2 x 8.7 m or 20.3 x 28.5 ft) or possibly Feature 3 (7 x 10 m or 22.9 x 32.8 ft) are generally consistent with the house (and addition) dimensions (20 x 26 ft) given by Stetson. Feature 5 (4.5 x ? m or 14.76 x ? ft) may also represent a building similar in size to Stetson's shed (14 x 14 ft).

It is likely this site is the location of Elisha Stetson's homestead (1890-1901). The site may have also been occupied by Godfrey Roby after 1900, however at some point prior to 1913 the site was abandoned and all structures removed.

25DW193 (SCHOOL NO. 9/25)

This site is the location of a rural schoolhouse and presently consists of foundation remains, one extant outhouse and scattered historic artifacts. The site is located in a nearly level upland valley about one-half mile west of Squaw Creek at 3810 ft elevation.

The field effort consisted of preparing measured drawings of foundation features and an uncontrolled surface collection. Photographs of individual features and the general site area were taken. Standardized archival research was initiated for the location and interviews conducted with local residents.

The site includes four features (Table 4.8-9) within an area of 2500 square meters (see Appendix B; Figure 14). Feature 1 is the schoolhouse foundation which is constructed of concrete and measures 11.1 m (N/S) by 6.6 m (E/W). The average thickness of the foundation is 20 cm. The entrance to the

Table 4.8-9. **Summary of features recorded at School No. 9/25 (25DW193) during the 1987 investigation; Crow Butte Project Dawes County, Nebraska**

Feature Number	Description and Structural Features	Exterior Dimensions (m)
1	schoolhouse foundation; rectangular cement foundation with porch at front center and fireplace on side near rear of building; foundation thickness is about 20cm	11.1 x 6.6
2	extant outhouse; concrete block with gable roof	1.6 x 1.6
3	outhouse foundation; concrete block	2.0 x 1.6
4	small circular cement slab with metal cap, probably well or electric lamp post base	0.6 x 0.6

NOTE: The location of each feature is shown on the site map (see Appendix B; Figure 14)

school is on the south and features a small porch 2.45 x 1.0 m. Near the back of the east wall a 1 x 1 m extension was observed, which includes a light scatter of burned material and brick suggesting a stove or fireplace location. According to LaVerne Stetson, the school was heavy timber frame construction with horizontal wood siding. Features 2 and 3 are outhouses. Feature 2 is extant with concrete block construction and a gable roof. Feature 3 is represented only by foundation remains. Feature 4 is a small oval cement slab with a square metal cap. This appears to be the location of either a well, electric lamp post or flag pole.

A small collection of artifacts was recovered from within the schoolhouse foundation, including window glass (n=1), bottle glass (n=2) and a white ware sherd (n=1). See Table 4.8-10 for a description of the collection.

The initial claim for this land (SW 1/4, Section 18) was filed by Eugene Stetson in 1887 and finalized in 1890 (U.S. General Land Office Tract Book). In March of 1904 Stetson granted a warranty deed for 1 acre to Public School District No. 25.

Two School Districts, 9 and 25, are relevant to site 25DW193 (see Archival Research Section and Bozell and Pepperl 1982:23-25). District 25 was formed in 1886 in Section 19 and District 9 in 1885 in Section 18. The districts were consolidated in 1903, one year before Eugene Stetson sold 1 acre in the extreme SW 1/4 of Section 18 for use as a school. Anna Stetson recalls her late husband Orville, who was born in 1898 (1900 Federal Census, Dawes County), began his schooling at the location of 25DW193, suggesting the consolidated district was in fact established in Section 18 by 1903 or 1904. Evidently the school remained in place at the site until dissolution of the district in 1976. Shortly thereafter the building was moved to Crawford. A school is plotted on the 1913 County Atlas, 1917 Soil Survey and 1939 Department of Roads map.

Site 25DW193 represents the location of consolidated Public School District No. 9/25, which operated a school on the site from 1903 or 1904 until 1976. It is likely the present foundation remains represent the original 1903-04 construction (L. Stetson:personal communication).

Table 4.8-10. Inventory of material recovered at School No. 9/25 (25DW193) during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska

Cat. No.	Provenience	Description
1	general surface	burned bottle glass 8.5mm thick
2	general surface	window glass; 2.1mm thick
3	general surface	undecorated whiteware; plate or saucer edge; 4.3mm thick
4	general surface	clear curved bottle glass; 3.2mm thick

25DW194

Site 25DW194 consists of a very sparse scatter of chipped stone debris and bone fragments exposed on the surface of a cultivated field (winter wheat). The site is at 3820-3840 ft elevation on a small knoll within an upland saddle overlooking Squaw Creek, which flows 50-100 m to the east. Surface materials were observed within a 1600 square meter area. (See Appendix B; Figure 15). An historic Native American burial was exposed and removed on a high ridge immediately north of the site in the 1950s during gravelling operations (L. Stetson:personal communication).

A general surface collection was made of all observed surface specimens during the initial survey. A return investigation was carried out consisting of preparation of a measured sketch map of the site area and excavation of two controlled test units. Test 1 measured 1 x .5 m and Test 2 was .7 x .4 m. Both were excavated in three 20 cm levels to 60 cm and all soil was passed through 1/4 in screen.

Test 1 was placed at the wheat field edge on the crest of the knoll at a position that did not appear to have been as severely eroded and deflated as the main portion of the site. A weakly developed artifact producing soil horizon occurs below loose topsoil in the test from approximately 30-40 cm. This unit overlays sterile yellow brown loamy soil. Test 2 was excavated approximately 50 m south-southeast of Test 1 on the crest of the east-facing slope leading to Squaw Creek. The Test 2 soil profile was similar to that observed in Test 1 although no cultural material was recovered.

Material recovered (Table 4.8-11) includes three flakes (one retouched), two large mammal leg bone fragments and one large mammal tooth enamel fragment collected from the surface; and three flakes, one burned bone fragment and three sandstone pebbles recovered from Test 1 (20-40 cm). Lithic raw material types include chalcedony cobble (n=1), Hartville Uplift chert (n=4) and purple and white chalcedony (n=1). All three types are available within a 100 mi radius of the project area (Carlson and Peacock 1975).

Table 4.8-11. Inventory of cultural material recovered at site 25DW194 during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska

Cat. No.	Provenience	Description
1	general surface	flake: Hartville Uplift
2	general surface	retouched/utilized flake: Hartville Uplift
3	general surface	shatter: chalcedony cobble
4	general surface	long bone fragment: Bovidae
5	general surface	long bone fragment: Bovidae
6	general surface	tooth enamel: Bovidae
7	Test 1 (20-40cm)	flakes (3); Hartville Uplift, (2), purple and white chalcedony (1)
8	Test 1 (20-40cm)	sandstone (3)
9	Test 1 (20-40cm)	burned bone: mammal

No temporally diagnostic materials were recovered and the site is not assigned to a particular cultural period. Much of the site has been plowed resulting in cultural materials being restricted to the eroded plow zone. A narrow north-south strip (30-40 m) of the site near the fence line possesses some intact subsurface deposits relating to an undefined and probably limited prehistoric use of the area. Although no evidence of burials was obtained during the current study, the presence of additional historic Native American graves in the site area should remain a consideration.

25DW195

This site consists of a small, thin scatter of aboriginal debris observed near the edge of a terraced wheat field on a broad terrace above English Creek. The site is at 3780 ft elevation and covers an area of 1000 square meters (see sketch map in Appendix C).

A general collection of all observed stone artifacts was made and a sketch map prepared during the survey. No further work was required at the site.

Materials recovered from the surface are inventoried in Table 4.8-12. Several small bone fragments and pieces of burned rock were also noted on the surface but not collected. The recovered sample includes one hammerstone, one bifacial tool and three flakes. The hammerstone (Figure 16:1) is an oval quartz cobble weighing 306 gm with a maximum diameter of 73.5 mm. Battering marks are evident intermittently around the widest diameter margin of the specimen. The chipped stone tool is a crude, or unfinished, ovate biface with one U-shaped corner notch (Figure 16:2). The specimen is 46.1 mm long, 27.2 mm wide and 10.7 mm thick, and manufactured from an unidentified white chert or chalk-like rock. No edge damage is evident suggesting the specimen represents an unfinished knife or projectile.

None of the recovered artifacts are temporally diagnostic and the site is not assigned to a particular cultural period. The presence of burned rock fragments may indicate the site possessed a hearth feature although terracing has compromised the resource's subsurface integrity and productive data recovery is not expected.

Table 4.8-12. **Inventory of cultural material recovered at site 25DW195 during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska**

Cat. No.	Provenience	Description
1	general surface	biface; unidentified white chert
2	general surface	flake; purple and white chalcedony
3	general surface	flake; unidentified white chert
3	general surface	flake; clear brown chalcedony
4	general surface	hammerstone; quartz

25DW196

Site 25DW196 consists of an extensive scatter of lithic and bone debris exposed on the crest of a long narrow ridge dividing the English Creek and Squaw Creek drainages. The site is at 3780-3820 ft elevation and covers nearly 80,000 square meters (see Appendix B; Figure 17). Short winter wheat covered the surface at the time of survey.

A general collection of observed surface specimens was made during the initial survey. A return investigation featured a more intensive surface examination with additional collections, excavation of four controlled test units and instrument mapping. Test 1-3 were .5 x .5 m and Test 4, .3 x .3 m. Tests 1 and 4 were excavated in three 10 cm levels to 30 cm, and Tests 2 and 3 excavated in one 10 cm level and three 20 cm levels to 50 cm. All soil was passed through 1/4 inch mesh. The soil profile was similar in all four units consisting of loose plow zone (0-15 cm); brown silt loam (20-40 cm); and yellow clayey subsoil (4050cm). Cultural materials were recovered from only one unit and occurred within the plow zone.

The recovered sample was collected primarily from the site surface (n=27) although two flakes were present in Test 3 (Table 4.8-13). The collection includes: one biface, one side scraper, four retouched flakes, fourteen pieces of flaking debris; three tooth enamel fragments, three mussel shell fragments; two pieces of coal and a hammerstone. The coal, and probably the mussel shell, are associated with agricultural use of the site area. A variety of lithic raw materials are present in the sample including Hartville Uplift chert (n=6); silicified wood (n=3); plate chalcedony (n=3); purple and white chalcedony (n=2); solid quartzite (n=1); unidentified white chert (n=3) and unidentified beige chert (n=2).

The hammerstone is granite and exhibits battering on one surface (see Appendix B; Figure 16:3). The specimen is 69.1 mm long, 46.3 mm wide and weighs 205 grams. The biface is a distal segment of an ovate form, manufactured from Hartville Uplift chert (Appendix B; Figure 16:4). The specimen is 45.0 mm long, 27.3 mm wide and 7.9 mm thick. Edge damage and resharpening scars are evident around the entire margin of the tool. The side

Table 4.8-13. Inventory of cultural material recovered at site 25DW196 during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska

Cat. No.	Provenience	Description
1	general surface	ovate biface; distal fragment; Hartville Uplift
2	general surface	side scraper; proximal fragment; silicified wood
3	general surface	retouched flake; Hartville Uplift
4	general surface	retouched flake; plate chalcedony
5	general surface	retouched flake; unidentified white chert
6	general surface	retouched flake; Hartville Uplift
7	general surface	flake; unidentified white chert
8	general surface	flake; silicified wood
9	general surface	flake; unidentified white chert
10	general surface	flake; purple and white chalcedony
11	general surface	flake; Hartville Uplift
12	general surface	flake; unidentified beige chert
13	general surface	flake; Hartville Uplift
14	general surface	flake; purple and white chalcedony
14	general surface	flake; silicified wood
14	general surface	flake; plate chalcedony
14	general surface	flake; plate chalcedony
14	general surface	flake; unidentified beige chert
15	general surface	hammerstone; granite
16	general surface	tooth enamel fragments (3);

Table 4.8-13 (Concluded)

Cat. No.	Provenience	Description
17	general surface	shell (3)
18	general surface	coal (2)
19	Test 3 (10-30cm)	flake; solid quartzite
20	Test 3 (10-30cm)	flake; Hartville Uplift

scraper is the proximal end of a pointed specimen made of grey translucent silicified wood (Figure 16:5). Both converging margins display steeply retouched edges (55 and 50 degrees) with use wear. Specimen dimensions are: length 27.0 mm; width 23.3mm; and thickness 6.6 mm. Three of the retouched flakes have one straight or slightly concave unifacially flaked margin (Appendix B; Figure 16:6). These specimens are made from Hartville Uplift chert, an unidentified white chert and plate chalcedony. The remaining specimen is an angular piece of Hartville Uplift chert shatter with two concave unifacially retouched margins (Appendix B; Figure 16:7).

None of the recovered cultural materials are temporally diagnostic and the site is not assigned to a particular cultural period. As a result of long tern cultivation, it is unlikely intact subsurface deposits remain at this location.

25DW197

This site is defined on the basis of four spatially discrete artifact scatters exposed on the surface of a terraced wheat field (see sketch map in Appendix C). Each scatter is referred to by its field number (FN87-10 through FN87-13). The site covers an area of 150,000 square meters and is situated on a wide upland ridge dividing Squaw and English Creeks at 3740-3760 ft elevation.

All observed surface materials exposed in the four areas were collected separately. A sketch map was prepared and photographs of the general site area taken at the time of survey. The site is largely outside of the project area eliminating the need for subsurface testing at the present time. Surface artifacts recovered are summarized below and inventoried in Table 4.8-14.

The FN87-10 collection consists of an endscraper, four flakes (1 plate chalcedony, 3 Hartville Uplift) and one proximal ulna fragment of either cow or bison. The endscraper is a complete Hartville Uplift specimen,

Table 4.8-14. Inventory of cultural material recovered at site 25DW197 during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska

Cat. No.	Provenience	Description
1	general surface; FN87-10	endscraper; Hartville Uplift
2	general surface; FN87-10	flake; plate chalcedony
3	general surface; FN87-10	flake; Hartville Uplift
3	general surface; FN87-10	flake; Hartville Uplift
3	general surface; FN87-10	flake; Hartville Uplift
4	general surface; FN87-10	bone; Bovidae-proximal ulna
5	general surface; FN87-11	endscraper; Hartville Uplift
6	general surface; FN87-11	flake; unidentified beige chert
7	general surface; FN87-11	tooth enamel; Bovidae ?
8	general surface; FN87-13	sidescraper; Hartville Uplift
9	general surface; FN87-13	bone fragment; large mammal
9	general surface; FN87-13	bone fragment; large mammal
9	general surface; FN87-13	bone fragment; large mammal
10	general surface; FN87-12	flake; solid quartzite
11	general surface; FN87-12	flake; solid quartzite
11	general surface; FN87-12	flake; solid quartzite
11	general surface; FN87-12	flake; solid quartzite
11	general surface; FN87-12	flake; plate chalcedony

plano-convex in cross-section and measuring 49.9 mm x 21.4 mm (Appendix B; Figure 16:8). This artifact has a maximum thickness of 8.7 mm and the angle of the working margin is 75 to 80 degrees.

One endscraper, a flake (beige chert) and a large mammal tooth enamel fragment make up the FN87-11 sample. The endscraper is made of Hartville Uplift chert, is plano-convex in cross-section, measures 33.2 mm x 33.0 mm, and is 8.9 mm thick. The working margin is at a 75-90 degree angle (Appendix B; Figure 16:9). Some bifacial retouch is present along the distal lateral margins of the specimen.

The FN87-12 sample consists of five flakes. Four are white or grey solid quartzite and the fifth is probably plate chalcedony.

One side-scraper and three large mammal long bone splinters constitute the FN87-13 collection. The side-scraper is manufactured from a long plano-convex Hartville Uplift flake measuring 53.6 mm x 27.6 mm (Figure 16:10). The specimen is 8.8 mm thick with uniform retouch on both lateral margins.

The present sample from site 25DW197 does not contain temporally diagnostic remains and this location is not assigned to a particular cultural period. Although not tested, locations FN87-10, -11 and -13 have probably been impacted to a large degree by plowing and terracing. FN87-12 and the northern one-quarter of the site do not appear to have been farmed and may still possess subsurface integrity.

25DW198

This site consists of a scatter of chipped stone tools and flaking debris exposed along the crest of a prominent linear knoll on a wide upland divide between English and White Clay Creeks. The site is at 3800-3810 ft elevation and encompasses an area of 30,000 square meters (see Appendix B; Figure 18).The initial survey consisted of a general collection of observed surface specimens. During a return investigation, photographs were taken,

three controlled tests excavated and data collected for preparation of a contour map. Test 1 was placed near the center of the scatter. Tests 2 and 3 were excavated on a knoll and a saddle adjacent to the site. All three tests were approximately 0.5 sq m in diameter.

Test 1 was excavated in four 15 cm levels to 60 cm and Tests 2 and 3 excavated in two 15 cm levels to 30 cm. All soil was passed through 1/4 inch mesh. A measured profile of Test 1 was completed, revealing three soil units (see excavation form in Appendix C). From the ground surface to 10 cm lies a dark gray soil zone. Below this a thick horizon of light brown clayey silt-loam occurs from 10-40 cm. The basal unit is a very light to almost white bed of sandy silt loam. Artifacts were recovered from the surface to 40 cm.

The recovered artifact sample is inventoried in Table 4.8-15, and summarized below. The collection is comprised of one biface edge segment, two retouched flakes and 39 pieces of flaking debris. Lithic raw material is diverse, but dominated by solid quartzite (28.6%) and Hartville Uplift chert (33.3%). The chert and probably the quartzite were obtained at the Spanish Diggings Quarries in eastern Wyoming about 100 mi from the project area. Quartzites are also available in the Blackhills, the Laramie Range and the Bighorn Range (Craig 1982). Other lithic types represented include locally available purple and white chalcedony and silicified wood, as well as a variety of unidentified cherts and chalcedonies (see Table 4.8-16).

The biface edge segment was recovered from Test 1, Level 2, and is manufactured from Hartville Uplift chert (Figure 16:11). The specimen is 21.2 mm long and 4.4 mm thick. Both retouched flakes were collected from the surface. One specimen is made of silicified wood, is 23.9 mm long and 2.9 mm thick, and is bifacially retouched along one slightly convex margin (Figure 16:12). The other example is made of Hartville Uplift chert with a convex unifacially retouched margin. This specimen is 15.9 mm long and 2.9 mm thick.

Table 4.8-15. Inventory of cultural material recovered at site 25DW198 during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska

Cat. No.	Provenience	Description
1	general surface	retouched flake; silicified wood (?)
2	general surface	retouched flake; Hartville Uplift
3	general surface	flake; solid quartzite
4	general surface	flake; unidentified brown chert
5	general surface	flake; purple and white chalcedony
6	general surface	flake; unidentified banded maroon chert
7	general surface	flake; solid quartzite
8	general surface	flake; solid quartzite
9	general surface	flake; solid quartzite
10	general surface	flake; solid quartzite
11	general surface	flake; unidentified brown chalcedony
12	general surface	flakes (16); Hartville Uplift (5), purple and white chalcedony (3), solid quartzite (3); unidentified dark brown-purple chert (3), unidentified brown chalcedony (2)
13	general surface	shatter or cobble; quartz
14	Test 1 (0-15cm)	flake; purple and white chalcedony cortex
15	Test 1 (0-15cm)	flake; banded Hartville Uplift/ solid quartzite
16	Test 1 (0-15cm)	flakes (5); Hartville Uplift
17	Test 1 (15-30cm)	flakes (3); Hartville Uplift (1), solid quartzite (2)

Table 4.8-15 Concluded))

Cat. No.	Provenience	Description
18	Test 1 (15-30cm)	biface edge; Hartville Uplift (?)
19	Test 1 (30-45cm)	flake; Hartville Uplift
19	Test 1 (30-45cm)	flake; unidentified grey speckled chert
20	Test 2 (0-15cm)	flake; solid quartzite

Table 4.8-16. **Summary of lithic raw material types represented at site 25DW198; Crow Butte Project, Dawes County, Nebraska**

Material Type	Frequency	% of Total
Hartville Uplift chert	14	33.3
solid quartzite	12	28.6
purple and white chalcedony	5	11.9
unidentified brown chalcedony	3	7.1
unidentified brown-purple chert	3	7.1
silicified wood	1	4.8
quartz	1	4.8
unidentified brown chert	1	4.8
unidentified brown maroon chert	1	4.8
unidentified grey chert	1	4.8
Total	**42**	**100.0**

The recovered sample does not contain temporally diagnostic material and the site has not been assigned to a specific cultural period. The site does not appear to be particularly rich although based on the excavation of Test 1, intact subsurface deposits likely remain.

25DW199 (CRAWFORD ICE HOUSE)

Site 25DW199 is represented by a single foundation located near the edge of a narrow White Clay Creek terrace at 3740 ft elevation. The foundation is situated about 50 m from the creek (see sketch map in Appendix C).

During the initial survey an intensive surface inspection of the general area was made, a measured sketch plan of the foundation was completed and photographs taken. The site is outside of the project area and a return return investigation was not scheduled.

The foundation is made of grouted-aggregate concrete containing pebble to cobble-sized rocks and measuring 24.8 m (E/W)by 12.5 m (N/S). Much of the foundation is at or near ground level, however, segments of the north wall are over 80 cm high. No artifactual material was noted in the general vicinity of the structure although ground cover was quite dense at the time of survey. Approximately 250-300 m north/northwest of the foundation on the edge of White Clay Creek is a circular pond about 10 m in diameter. This feature may be stone or brick-lined.

The site is situated on a 160 acre land tract originally claimed by Luther Keenan in 1887. The transaction was finalized in 1911 (U.S. General Land Office Tract Book). A series of short-term transactions took place between 1898 and 1943, at which point the land was purchased by Lorentz Raben, the present owner. No structures are plotted on any historic map sources consulted; however, a lake is depicted near the site on the 1913 County Atlas, 1917 Soil Survey and 1939 Department of Roads map.

A telephone interview was conducted with Mrs. Lorentz Raben following the field investigation. Mrs. Raben indicated the site is the remains of a commercial ice house which serviced the city of Crawford and the local

rural community from approximately 1910-1915 through World War II. Apparently the small lake depicted on historic maps and the extant circular pond were contributing properties to the operation. The Dawes County Numerical Index for this tract does not list entries specifying a commercial ice concern; however, possible commercial transactions relevant to this site include Russell Thorp (1891), "Sutter Bros." (1892), "Thorp Co." (1915) and several others. Additional interviews and archival research could help clarify ownership and history of the business.

25DW00-25 (STETSON PLACE)

Site 25DW00-25 is the occupied farmstead of Anna and the late Orville Stetson. The site covers an area of nearly 20,000 square meters and is located on a broad terrace on the east side of Squaw Creek at 3800-3820 ft elevation.

Field investigation of the site consisted of preparing measured exterior drawings of all buildings, drafting interior floor plan sketches of the residence and barn, and photographing select structures and the general area. Standardized archival research was initiated for the tract and interviews conducted with Anna Stetson and her son LaVerne.

The Stetson property presently consists of a house, a barn with corral, and seven additional outbuildings (see Table 4.8-17 and Figure 19 in Appendix B). The architectural elements of the farmyard are organized in a compact, almost formal, pattern, similar to site plans advocated in turn-of-the-century farm publications. The buildings uniformly face south, with the exception of two (Features 7 and 8) which face east and enclose the entry yard at the rear of the house. The farmstead is set back roughly 200 m from the road, with the angled drive providing visual separation between the residence and barn for visitors as they advance toward the house without needing to pass the livestock areas (cf. e.g., Saunders Publishing Co. 1905:12).

All buildings are in good to excellent condition and appear to be structurally sound. Importantly, key structures appear to have been constructed

Table 4.8-17. **Summary of structures recorded at the Stetson Place (25DW00-25) during the 1987 investigation, Crow Butte Project, Dawes County, Nebraska**

Feature Number	Description and Structural Details	Exterior Dimension (m)
1	shed; heavy frame; shed roof; wood foundation; wire nails	8.7 x 4.5
2	chicken coop; hollow clay tile construction; shed roof; concrete foundation	9.3 x 5.7
3	chicken coop; hollow clay tile construction; shed roof; concrete foundation	9.3 x 3.7
4	barn; heavy frame; gable roof; grouted aggregate concrete foundation; wire and cut nails	18.2 x 12.4
5	shed; balloon frame; shed roof; concrete foundation; wire nails	4.4 x 3.8
6	garage; quonset roof; concrete foundation; wire nails	18.4 x 10.0
7	garage; balloon frame; gable roof; brick foundation; wire nails	8.7 x 5.7
8	shed; balloon frame; gable roof; concrete foundation; wire nails	7.3 x 3.7
9	house; two story; concrete block construction; stucco siding; gable roof; concrete and concrete block foundation; wire nails	14.6 x 10.3

NOTE: The location of each feature is shown on the site map (see Appendix B; Figure 19).

at about the same time and the general plan of the farmstead during that period does not seem to have been subsequently altered. These buildings are characterized by extensive use of masonry and concrete. Most were probably built about the same time as the house which was constructed around 1910 to replace the original homestead dwelling (L. Stetson, personal communication).

The two-story house (Feature 9) is of concrete block construction with stucco surfacing and a gable roof (Figure 20 in Appendix B). An enclosed porch covers the front (formal) entry which is centered in the south gable end and faces the road. A small rear-entry porch faces the farmyard and provides access to the kitchen and basement. The nearly square plan of the house is quartered, with the living and dining areas each side of the central, second-floor staircase placed at the front and the kitchen and a bedroom at the rear. A bath was added after 1950 and the kitchen was shortened to provide a hallway to the bath (L. Stetson: personal communication). Although this alteration had little effect on the functional zoning of the original plan, it greatly improved traffic flow by providing access to all ground-floor rooms from the center of the house. Fenestration is symmetrical with the exception of off-set windows in the remodeled northwest corner. Small gable windows light and ventilate the attic at both ends.

The principal livestock area is defined around a single multi-purpose structure. This buildings (Feature 4) is a two-level, side-entry bank barn of seven bays in length (Figure 20b in Appendix B). The upper (ground) level is a loft with two bays for hay storage on each side of the central (transverse) drive floor. The lower (basement) level is the livestock area. With the exception of a grain storage at the northeast corner, the basement is subdivided by fencework for feeding, holding and milking activities arranged along three aisles running the length of the building. The central and southern aisles have access to the corral at both their eastern and western ends. The heavy framing of the upper part of the barn is constructed of dimension lumber with solid uprights which are tied and braced at plate level, and again at purlin level but only along the central runway and at the end walls. Collar beams tie the rafters near the peak but a ridge beam is not used. The main tie beam (plate level) is made up of

paired segments of lumber which are spliced (nailed) at the posts (a central bent and plans for both levels are sketched in Appendix C). The basement walls are concrete (grouted-aggregate) and, along with a system of two central posts, supports the upper frame component of the barn. The embankment is along the northern (front) wall. Windows are restricted to the south-facing basement wall. The only large entry is at the embanked access to the loft. The barn has a small cupola and a painted ranch brand decorates the small (rear) drive-floor door.

Although a portion of the tract had previously been occupied by James English, the land (160 acres) was formally claimed by Eugene Stetson in 1887 and the transaction was finalized in 1890 (U.S. General Land Office Tract Book). By 1913 Stetson had purchased all of Section 18 and 3/4 of Section 19. The holdings are presently owned by Eugene's daughter-in-law, Anna, who resides on the tract. The NE1/4 of Section 19 has been owned by the Daniels family since 1901 (see site 25DW112 - the Wulf-Daniels farmstead in Bozell and Pepperl 1982).

Eugene Stetson's father Isaiah moved to Dawes County in 1886 from Manitowoc County, Wisconsin (Anonymous 1909:888). His eldest son Isaiah followed him in 1887, and his wife, Aurelia, a native of Norway, joined them in Nebraska in 1889. Aurelia was accompanied by her sons Eugene, Elisha and Benjamin (Anonymous 1961:71). Isaiah Sr., and his son, Eugene, operated a steam threshing machine and sawmill as well as being involved in ranching and farming. In 1892, at the age of 25, Eugene married his wife Annie. By 1900 they had three children; Elmer, Orville and Ernest. A farmhand, John Combs, was also residing with the family at this time (1900 Federal Census). The 1910 census lists five children.

Stetson established residence at site 25DW00-25 in the late 1800s and the present farmhouse was constructed about 1910 (L. Stetson: personal communication). Prior to that time Eugene lived in a dugout about one half mile east of the current farmyard. Anna Stetson noted this location is marked by a depression although the site is well outside the survey area and was not formally recorded.

A residence is plotted at the site on all map sources consulted (1913 - present). A structure is also depicted on the 1917 Soil Survey near the point where Anna Stetson believes Eugene's dugout to be.

Homestead testimonies for Section 18 claims were provided by Stetson in 1887 and 1894. Both summarize improvements made on the claim (National Archives, Washington). In 1894 Stetson lists his house as a one-story 12 x 16 ft frame structure with a 10 x 16 ft addition. Other structures include a frame stable (12 x 32 ft), a hen house (12 x 16 ft), a cellar (12 x 16 ft) and a granary (16 x 24 ft). Stetson estimated the cost of his claim improvements at $600.00. Several 25DW00-25 outbuildings correspond rather closely to some testimony dimensions, however, based on their present dimensions the existing home and barn do not appear to be listed in the testimony inventory. The one-story frame house listed by Stetson was probably situated on the same spot where the extant 1910 stucco structure now exists (L. Stetson:personal communication).

The Stetson Place is situated on land homesteaded and occupied continuously by members of the Stetson family since 1887. Throughout this 100 year period, the family has maintained a prominent position in the community and can be viewed as contributing importantly to local. history. The existing farmstead is also notable for lengthy continuity, both in plan-form and buildings (ca. 1910-present), and warrants assessment of potential National Register eligibility (see Discussion section).

25DW00-26 (GIBBONS/EHLERS PLACE)

This site is the occupied farmstead of Mr. and Mrs. Frank Ehlers. The farm covers an area of 25,000 square meters and is located on a broad terrace on the west side of Squaw Creek at 2900 feet elevation. The field effort consisted of preparing measured exterior drawings of all buildings,

drafting an interior floor plan sketch of the primary residence, and photographing select structures and the general area. Standardized archival research was initiated for the tract and an interview conducted with the Ehlers.

The Ehlers property is comprised of a frame house, a trailer house, a small livestock barn, a machine shed, ten other scattered outbuildings and several corrals (see Table 4.8-18 and site map in Appendix C). This site represents a dispersed type of farmstead which is characterized by a large number of small, special-function structures (cf., e.g., Pepperl et al. 1983: 56-58). Some of the buildings were apparantely moved intact to the site from other locations and probably had different prior functions. Their former uses and locations could not be established, however. Although building dates are also not available for structures erected on-site, a variety of construction episodes appear to be represented by existing buildings, and perhaps involve the full range of principal occupations at the site (ca. 1913 - present).

The recently vacated one-story, frame house is comprised of two gableroofed buildings butted end-to-side in a T-plan. The smaller, eastern component (possibly the initial part of this structure) has shed additions on each side and a central chimney near the east gable end. This part of the existing house (probably erected on-site) may have been constructed at the same time as the adjacent storm/root cellar, perhaps during the Gibbons' occupation (Hamlin, who homesteaded this tract, does not mention a cellar in his testimony). The larger, western component may have been moved from another location. This two-room part of the composite structure appears to contain the front (formal) entry to the residence which is located in the center of its west side and faces the road. A window is placed on each side of this door. Both components have a single window centered in one gable end.

The land tract (120 acres) including site 25DW00-26 was originally claimed by William A. Hamlin in 1888. Hamlin held the land until 1900, although it is unlikely he ever received a patent for the property (U.S. General Land Office Tract Book). After several short-term transactions, the land was

Table 4.8-18. **Summary of structures recorded at the Gibbons/Ehlers Place (25DW00-26) during the 1987 investigation; Crow Butte Project, Dawes County, Nebraska**

Feature Number	Description and Structural Details	Exterior Dimension (m)
1	house; one-story; balloon frame; gable roof; concrete foundation; wire nails	8.5 x 7.7
2	cellar; earth and concrete construction; wooden door	3.0 x 1.0
3	shed; 1 1/2 stories; balloon frame; gable roof; wood foundation; wire nails	3.9 x 3.1
4	tack shop; balloon frame; gable roof; concrete foundation; wire nails	12.8 x 3.8
5	shop; balloon frame; gable roof; wood foundation; wire nails	4.9 x 3.1
6	barn; balloon frame; gable roof; concrete foundation; wire nails	13.5 x 7.8
7	stable; heavy frame; gable roof; concrete foundation; wire nails and wood pegs	11.0 x 7.0
8	shed; heavy frame; gable roof; wood foundation; wire nails	2.5 x 2.0
9	garage; balloon frame; gable roof; wood foundation; wire nails	5.0 x 3.0
10	chicken coop; balloon frame; shed roof; wood foundation; wire nails	6.0 x 2.0
11	single stall stable; balloon frame; gable roof; wood foundation; wire nails	5.0 x 2.5
12	single stall stable; balloon frame; gable roof; wood foundation; wire nails	4.0 x 2.0

NOTE: The location of each feature is shown on the site map (see Appendix B; Figure 21.

purchased by William H. Gibbons in 1913. The tract remained in Gibbons' family ownership until the late 1950s. Shortly following the Gibbons' sale of the land, the property was purchased by Mr. and Mrs. Frank Ehlers who are the present owners and reside at site 25DW00-26.

No one in the Hamlin or Gibbons families appears in the 1885, 1900 or 1910 Federal Census. An occupied residence is depicted on the 1913 County Atlas and the 1939 Department of Roads map, but not on the 1917 Soil Survey.

William Hamlin's homestead testimony, supplied in June of 1886, inventories improvements made to the claim (National Archives, Washington). These include an 18 x 24 ft log house, with an 8 x 24 ft lean addition; a log stable 12 x 16 ft, a chicken house and a shed. The dimensions of the latter two structures are not provided. Hamlin estimated the cost of his improvements at $440.00. At the time of his testimony, Hamlin had 30 acres under cultivation.

Although the farmstead may have been established by William Hamlin or another immediate post-19th century owner, it seems more likely initial construction of the house and associated buildings are related to the Gibbons family after 1913. Many of the later structures were either constructed or moved in by Frank Ehlers. Mr. Ehlers may be able to furnish further, more detailed information regarding the origins of various farmstead structures. It would appear, however, that specific periods of development for the general farmstead plan will be difficult to clearly define, and that many of the buildings lack integrity of location required for National Register consideration.

FIELD NUMBER-1

This locality consists of an isolated fragment of chipped stone flaking debris located on a west-facing terrace slope approximately 20 meters east of Squaw Creek at 3840 ft elevation. The observed specimen is a small brown chert percussion flake. No additional cultural materials were located, however, a small lithic scatter (25DW116) was identified approximately 200 meters southeast of FN-1.

The surface specimen is not temporally diagnostic and the locality is not assignable to a particular cultural period. Verification of potential subsurface materials and possible relationship to site 25DW116 would require limited subsurface testing of the west-facing Squaw Creek terrace slope within and between these site areas.

FIELD NUMBER-2

This locality consists of a buried horizon of bone (Bovidae) and charcoal exposed in an approximately 50 meter extent of the west bank of Squaw Creek at 3830 ft elevation. The majority of these materials occur in two soil levels of light brown/grey mottled silty sand. Surface depth of these levels ranges from ca. 1.00-1.50 meters. A very limited quantity of bone and charcoal was observed in an upper level of medium grey/brown mottled fine silty sand (0.20-0.40 meters s.d.).

A controlled profile of the bank was excavated and matrix was dry screened through 1/4 in hardware cloth. Materials recovered through these procedures included approximately 20 large mammal bones (see Table 4.8-19). No cultural materials were observed in the creek bank or recovered through the screening process.

All recovered vertebrate materials appear to be Bovidae (cow/bison). Two elements (fibular tarsal and metacarpal) compare well with bison materials. Most of the remaining elements also appear to be bison but positive identification could not be made due to the incomplete and eroded condition of the specimens.

No information gathered during investigation of FN-2 suggests this deposit of bone and charcoal is the result of human activity. However, given the limited nature of the testing during the spring 1982 investigation as well as the association of bison bone and charcoal, future cutbank profiling and subsurface testing on the overlying creek bottom surface may be warranted to clarify the origin of these materials.

Table 4.8-19. Summary of vertebrate remains recovered during 1982 from controlled bank profile #1 at site FN-2, Crow Butte Project, Dawes County, Nebraska

Cat. No.	Depth No. (S.D.)	Taxa	Element	Side/Portion	Comment
1	0.25 m	Bovidae	unidentified long bone	unsided diaphysis fragment	
2	1.35 m	Bison bison	fibular tarsal	right complete	
3	1.40 m	Bison bison	metacarpal	left proximal	rodent gnawing
4	1.30 m	Bovidae	1st phalange	left complete	carnivore gnawing
5	bank slump	Bovidae	mandible	right posterior (m/2)	
5	bank slump	Bovidae	patella	right complete	carnivore gnawing
6	bank slump	Bovidae	rib fragments (7)	unsided	
7	1.05 m	Bovidae	cranial fragments (6)	unidentified	
8	0.80 m	Bovidae	rib fragment	unsided	rodent gnawing

NOTE: See Appendix C for drawing of bank profile.

FIELD NUMBER-3 (CROW BUTTE CEMETERY)

This locality is the site of the Crow Butte Cemetery which is situated on a nearly level bluff top on the western margin of Section 19 at 3910 ft elevation. The cemetery contains at least 16 headstones with dates of death ranging from 1888-1971. Dimensions of the site area are ca. 90x30 meters and it is surrounded by a barbed wire fence with wooden posts. A gate is located in the fence line along the western margin.

In that cemeteries are ordinarily not considered eligible for National Register (36CFR60.6), this location was not further documented or evaluated.

4.8-6 DISCUSSION

PRELIMINARY NATIONAL REGISTER EVALUATION

Intensive subsurface testing or other National Register documentation tasks were not formally programmed into the Crow Butte study efforts. Therefore, as future development operations are defined, additional field investigations may be required to assess impact levels, data potential and integrity of some resources. Preliminary National Register evaluations for each of the twenty-one recorded resource locations are summarized below and in Table 4.8-20.

Evaluation of any properties' National Register eligibility is based on consideration of four significance criteria set forth in 36CFR60.6 (redesignated CFR1202). In addition to addressing significance values, a site's physical integrity must be established prior to further consideration of eligibility. In general the most relevant significance criterion is whether a site "has yielded, or may be likely to yield, information important in history or prehistory" (36CFR60.6(d)). Assessment of what information categories are "important" involves association of site characteristics with previously formulated research questions. Normally those questions are a component of state cultural resource management plans

Table 4.8-20. **Preliminary resource evaluation and recommendations for sites identified during the 1982 and 1987 field investigations; Crow Butte Project, Dawes County, Nebraska**

Site Number (Name)	Site Type and Period of Use	Preliminary Evaluation and National Register Potential	Relationship to 1987 CSA Boundary	Recommendation
25DW111 (Harvey ?)	surface debris (former homestead?); ca. 1888-?	limited historical (local) value; limited data recovery potential (archeological); not eligible	600 m outside limits of CSA	no further work
25DW112 (Wulf/ Daniels Place)	abandoned farm building ca. 1889-1960s	moderate historic (local) value; probably architectural (regional) interest; productive data recovery potential (architectural); potentially eligible	within limits of CSA	avoid physical effects
25DW113 (Fiandt ?)	surface debris; depressions, (former homestead?) ca. 1888-?	moderate historic value (local); limited data recovery potential (archeological), not eligible	within limits of CSA	no further work
25DW114	surface; lithic, bone trade goods; Paleo-Indian through historic periods (principal components Middle Archaic and Late Prehistoric)	probable scientific value; productive data recovery potential (archeological); potentially eligible	western margin within limits of CSA	avoid physical effects; test or monitor if to be impacted
5DW115 (School No. 25)	surface debris (former school and/or church); ca. 1886-1930s(?)	moderate historic (local) value; limited data recovery potential (archeological); not eligible	150 m outside limits of CSA	no further work

Table 4.8-20 (Continued)

Site Number (Name)	Site Type and Period of Use	Preliminary Evaluation and National Register Potential	Relationship to 1987 CSA Boundary	Recommendation
25DW116	surface; lithic; unassigned Native American	limited scientific value; limited data recovery potential; not eligible	within limits of CSA	no further work
25DW117 (Fleming ?)	unused livestock watering facilities; contemporary	limited historic value; limited data recovery potential; not eligible	within limits of CSA	no further work
25DW191 (Dougherty/ Smith ?)	surface debris; depressions, non-residential structure (former homestead?) ca. 1880s-?	moderate historic value (local); limited data recovery potential; not eligible	within limits of CSA	no further work
25DW192 (Stetson/ Roby ?)	surface debris; depressions, foundations (former homestead); ca. 1883 1915	moderate historic value (local); productive data recovery potential; potentially eligible	ca. 50 m outside limits of CSA	no further work
25DW193 (School No. 9/25)	surface debris, foundations (former school) ca. 1903-1976	moderate historic value (local); limited data data recovery potential; not eligible	on limits of CSA	no further work
25DW194	surface/buried; lithic, bone, burials (reported); unassigned Native American and possible historic Native American components	moderate scientific value; moderate data recovery potential; potentially eligible	within limits of CSA	avoid physical effects; test or monitor if to be impacted

Table 4.8-20 (Continued)

Site Number (Name)	Site Type and Period of Use	Preliminary Evaluation and National Register Potential	Relationship to 1987 CSA Boundary	Recommendation
25DW195	surface; lithic, bone; unassigned Native American	limited scientific value; limited data recovery potential; not eligible	within limits of CSA	no further work
25DW196	surface; lithic, bone; unassigned Native American	limited scientific value; limited data recovery potential; not eligible	on limits of CSA	no further work
25DW197	surface, lithic, bone; unassigned Native American	unknown scientific value; unknown data recovery potential; not eligible	on limits of CSA	no further work
25DW198	surface/buried; lithic; unassigned Native American	moderate scientific value; moderate data recovery potential; potentially eligible	within limits of CSA	avoid physical effects; test or monitor if to be impacted
25DW199 (Crawford Ice House)	foundation, pond (former commercial ice house); ca. 1910-1940s	limited historic value (local); limited data recovery potential; not eligible	150m outside limits of CSA	no further work
25DW00-25 (Stetson Place)	occupied farmstead; ca. 1880-present	moderate historic value (local); probable archi- tectural interest (regional); productive data recovery potential: potentially eligible	within limits of CSA; exempt from develop ment	avoid physical effect

Table 4.8-20 (Concluded)

Site Number (Name)	Site Type and Period of Use	Preliminary Evaluation and National Register Potential	Relationship to 1987 CSA Boundary	Recommendation
25DW00-26 (Gibbons/ Ehlers Place)	occupied farmstead; ca. 1900-present	moderate historic value (local); limited archi- tectural interest; not eligible	within limits of CSA; exempt from develop ment	no further work
FN-1	isolated; lithic; unassigned Native American	limited scientific value; limited data recovery potential; not eligible	within limits of CSA	no further work
FN-2	buried; bone, charcoal; unknown cultural association	unknown scientific value	within limits of CSA	no further work
FN-3 (cemetery)	Crow Butte Cemetery	not eligible for National Register consideration	200m outside limits of CSA	no further work

or other regional research efforts. Such a plan is presently in preparation for Nebraska, but at this juncture is not available for practical use. As a result we must turn to more general regional research questions and priorities developed under a variety of circumstances.

Native American Resources. The eight locations containing evidence of Native American remains are all located along terraces or ridges adjacent to Squaw, English or White Clay Creeks within 300 m of the stream channels. A ninth location consisting of buried bone (cf. bison) and charcoal exposed in a Squaw Creek cutbank, is of uncertain cultural association.

Two of these sites, 25DW116 and FN-1, are represented by very limited surface materials (four chipped stone specimens). Sites 25DW195 and 25DW196 are adjacent to one another on an upland ridge/slope system and possess more extensive surface scatters. Subsurface testing and visual inspection in this vicinity however, indicates the ridge has been extensively plowed and terraced. Regular plowing and erosion over the years appears to have deflated this surface resulting in artifacts being laterally and vertically displaced throughout the present plow zone. We do not anticipate intact cultural material or features remain at these locations. A major portion of a fifth site, 25DW197, has also been compromised by agriculture. A small segment of this site may contain intact deposits but is outside the CSA limits and was not tested. Based on present evidence, these five sites are not felt to possess productive data recovery potentials and are not considered appropriate for further National Register evaluation.

Three sites, 25DW114, 25DW194 and 25DW198, are more clearly of potential research interest in that they may contain materials relevant to taxonomic, functional or subsistence considerations, along with a greater likelihood for intact subsurface remains.

Site 25DW114 is the product of multiple Native American use episodes carried out intermittently for as long as 8,000-10,000 years. Based on projectiles recovered during the 1982 survey and examined in the Ehlers collection, the primary component(s) at the site is attributed to the

McKean Complex. McKean is a Middle Archaic period archeological unit unit principally associated with the Northwestern and Northern Plains (see e.g. Mulloy 1954; Wedel 1961:250-251; Frison 1978:40-56; and Kornfeld and Todd 1985). The most common Middle Archaic forms from 25DW114 include McKean, Oxbow, Duncan and Hanna (Wheeler 195485:7). At least six sites in the Nebraska panhandle are attributed to the McKean Complex and dated within a 5000-3500 B.P. time frame (Carlson and Steinacher 1978: 5-6).

Projectiles associated with the Pelican Lake complex are also common in the Ehlers collection. Pelican Lake is a Northwestern and Northern Plains manifestation attributed to the Late Archaic Period -3,0001,500 B.P. (Wettlaufer 1958; Reeves 1983:76-91). Reeves attributes five sites in the Nebraska panhandle to the "Glendo Subphase" (Reeves 1983:316-317).

Previous systematic investigation of Middle and Late Archaic components have not been initiated within the Pine Ridge District of Nebraska. Much of the research regarding these units has been carried out in Wyoming, Montana and the Dakotas (see e.g. Mulloy 1954; Gant and Hurt 1965; Reeves 1983; Tratebas 1984; Greiser 1985), but these complexes in general are not well understood.

The final well represented period at the site is based on the presence of a number of small triangular side-notched projectiles. The forms are attributed to the Late Prehistoric period (A.D.O. - 1750) and are common throughout the Central and Eastern Plains at a variety of Plains Village Tradition communities (e.g. Wedel 1961:95, 198), as well as hunting camps and kill sites in the Western Plains (Frison 1970:34-39; Reher and Frison 1980:25-28; Speth 1983:37; Ludwickson and Bozell n.d.). It is unclear whether kills and camps are the remains of village populations on seasonal hunts, or are affiliated with semi-nomadic Western Plains residents.

Other periods represented only by several Ehlers collection specimens include late Paleo-Indian (10,000-8,000 B.P.), Early Archaic (8,0005,000 B.P.) and Historic (1750-1890).

In summary, site 25DW114 appears to possess remains significant for addressing a broad spectrum of research questions relating to most major cultural periods identified for the region. On a local level the site may represent an important locality for evaluating the nature of White River tributary use by Native Americans. While the site is considered to be "potentially eligible" for the National Register, a formal determination must be preceeded by subsurface test excavations and surface collection to establish horizontal limits and determine if the location has any remaining integrity.

Sites 25DW194 and 25DW198 were both the subject of subsurface testing which indicated these resources do possess intact, although sparse, subsurface remains below the sod/plow zone.

Only a narrow strip of 25DW194 appears to be intact. The remaining portions of the site have probably suffered major agricultural damage. An Historic Native American burial was exposed over 30 years ago in a ridge directly adjacent to the site. This ridge and one immediately south of the site may contain undetected burials or other archeological features.

Plains equestrian nomad archeology has largely been ignored because 1) these sites generally have low archeological visibility, and 2) the historical record for this period, particularly regarding the military frontier, is quite rich. In addition, the wealth of information available on Western Plains tribes has generally showcased spectacular events and noteworthy individuals. The archeological value of historic Indian sites in the Western Plains has yet to be determined. For example, we know very little about historic Native use of the area prior to the late 19th century, however nomadic historic tribes entered the region in the early 19th century (Hanson 1983:17). Also semi-sedentary tribes such as the Pawnee and Arikara probably used the area prior to the 1800s. The potential for burials or other undisturbed features in the vicinity of 25DW194 relating to historic (or prehistoric) groups argue in favor of the site's inclusion on the inventory of potentially eligible sites.

No diagnostic remains were recovered from site 25DW198, however, the location does possess intact deposits of chipped stone tools and debris. The site has suffered little, if any, agricultural impact and it is felt the entire known limits of the resource can be assigned a high integrity value. Due to the site's lack of a temporal association, linking it to previously formulated research questions is difficult. However, it is one of only several White River tributary artifact scatters which have documented subsurface remains and it provides an opportunity to evaluate small scale limited activity sites important to understanding the full range of local prehistoric site variability. As a result, the site, is considered potentially eligible for the National Register.

Euroamerican Archeological Resources. Nine Euroamerican sites with few, if any, extant structures were recorded. These include two former school-houses, three probable 19th century homestead sites, one commercial operation, one cemetery and two locations of unknown association. All but one, 25DW192 (Stetson/Roby Homestead), are considered ineligible for listing in the National Register for reasons discussed below.

The school sites consist of a light artifact scatter (25DW115) and foundation remains (25DW193). While the latter may possess archeological integrity, neither are likely to yield information regarding rural settlement and education in the area which cannot be more effiiently obtained through historical and archival research.

Two of the three homestead sites (25DW113 and 25DW191) are represented by only depressions and have been subject to cultivation or other disturbance following abandonment. They no longer retain elements which convey feelings and association with their period of historic significance (1880s - 1920s) and further archeological investigations are not likely to provide significant information with which to interpret early settlement in northwest Nebraska.

The Crawford Ice House (25DW199) is a somewhat unique resource (Rapp and Beranek 1984:124-125) and likely possesses intact remains, but is considered of limited interpretive value in adding to the historic and archival record. The site may deserve fresh evaluation when industrial archeology significance values are developed in the state cultural resource management plan.

Sites 25DW111 and 25DW117 are a light surface artifact scatter and contemporary windmill complex respectively. Periods of use and relevant personalities could not be firmly established. Neither property is presently eligible for National Register listing.

The final ineligible Euroamerican archeological site is FN-1, the Crow Butte Cemetery, which dates to the period 1888-1971. Unless under unusual circumstances, marked cemeteries are not eligible for National Register consideration (36CFR60.6).

The Stetson/Roby Homestead (25DW192) is considered potentially eligible for the National Register. The land was originally claimed by Elisha Stetson in 1893, who held title until 1901, at which point the tract was sold to Godfrey Roby. The land remained largely under Roby ownership until the 1950s. Homestead files summarizing Stetson's proof testimony indicate he constructed two houses, a stable, a hen house, a shed and a cellar during the period 1890-1896. It is unclear if Roby made additional improvements.

The site does not appear on any historic map source and Anna Stetson, who has resided in the area most of her life, does not recall standing structures at the property, indicating buildings were removed prior to circa 1913-1915. The site was apparently constructed and occupied for less than eight years by Elisha Stetson. Godfrey Roby may have also resided on the property for a short while, however he had purchased an adjacent tract in 1892 which likely contains the remains of his residence, if he in fact lived on his holdings.

Unlike other project area homestead sites (25DW113, 25DW191), Stetson/ Roby likely appears much the way it did shortly following abandonment and re-removal of structures. The site and its surrounding environs do not appear to have been cultivated or otherwise modified and this property is the only project homestead site with intact foundation remains present. Surface artifacts are not abundant at the site, however, it is likely sealed deposits are present in association with features. Two similar properties have been identified in the Pine Ridge area and are considered potentially eligible (see Cassells and Agenbroad 1981:175-176; Moore and Rosenburg 1985:64-65). In general, the site is of local and state significance in that it offers a high integrity, restricted use period, example of an early northwestern Nebraska homestead. The property is likely to contain intact archeological deposits of scientific value.

Euroamerican Architectural Resources. Three sites contain architectural features. One, the Ehlers/Gibbons Place (25DW00-26), is not considered eligible in that the property lacks chronological and locational integrity with respect to the origin of buidings and construction dates.

The Wulf/Daniels Place (25DW112-0017) is an abandoned farmstead of potential architectural significance. In particular, the dwelling (Feature 1) at this site may provide an example of architectural developments that are represented by a limited number of houses in Nebraska and are not normally associated with the period during which the structure was likely constructed.

The original component of this house apparently consisted of a single upright unit at the south end of the building. The upright and wing which extends to the north at the front central portion of the house may represent the initial stage of modification in developing the present structural form. Alone, the small, nearly square (4.4 x 5 meter) upright component represents a minimal housing unit (Glassie 1975:118) such as that utilized for early colonial dwellings as derived from the English "Hall" or one-bay cottage house generally of about 16 ft (ca. 5 meters) in length (Foley 1980:14). The vertical planking beneath the horizontal clapboard siding of this unit may also indicate an English traditional influence and suggests

the possibility that this portion of the structure may be constructed of timber framing rather than balloon framing more commonly used during the late nineteenth century.

In considering the upright and northern wing as a composite house unit, this component is referable to Greek Revival forms which are typified by a door in the gable end with one or two wings extending from the sides of the house (Glassie 1968:129). This formal architectural style was largely associated with the period 1820-1860 (Whiffen 1969:37-47) but apparently continued in folk construction beyond the mid-nineteenth century (Glassie 1968:133).

Although the building would be of interest in either case noted above, further consideration of these possibilities will require inspection of the house interior to develop floor plans, structural details, and clarification of the sequence of construction of the various components.

The Stetson Farmstead (25DW00-25) is presently occupied by Anna Stetson, the daughter-in-law of Eugene Stetson who claimed the tract in 1887, and constructed the home circa 1910. The Stetson family immigrated to Dawes County during the period 1886-1889 from Wisconsin. The family shortly became locally prominent through land holdings and involvement in community development.

Historic architectural interest in the Stetson Place centers on the full farmstead unit and may extend to certain individual structures as well. In contrast to many cases where farmsteads are built up or modified over a period of years, often involving accumulated structures of uncertain origins, the Stetson Place appears to represent a unified construction episode, perhaps during a relatively brief period. Key structures are substantial constructions, characterized by extensive use of masonry and concrete in both foundations and walls. These buildings were probably added as replacements for the initial homestead features around the turn of the century, a period of general economic prosperity and expansion in the state. Importantly, this construction appears to reflect the heightened attention to formal site planning and organization of farmsteads being

advocated at that time (see e.g. Saunders Publishing Co. 1905:1114). Indeed, materials and methods utilized in many of the structures, as well as building arrangement, seem consistent with such published efforts to update and modernize the turn-of-the-century farmstead. The multi-purpose barn, however, can be more specifically referred to traditional and ethnic architectural influences, although materials and typical bent of the framing could be viewed as "modern". The side-entry form and tripartite functional zoning of the framed upper component (loft) are similar to that of the traditional "English barn," as commonly represented in the New England states (cf. e.g., Glassie 1968:133-140; Glassie 1974; Arther and Witney 1972:58-83). The full, two-level banked structure, however, may be more closely related to building traditions of Upper Bavaria. In the United States these traditions are characterized by barns built by Swiss and German immigrants in Pennsylvania, a type often referred to as the "Pennsylvania barn" (cf. e.g., Glassie 1968:55-62, 140-141; Arthur and Witney 1972:84-113). While the Stetson barn lacks the projecting laube or forebay of the Upper Bavarian model, its form and and interior zoning are generally consistent with traditions represented by the Pennsylvania barn type. Glassie (1968:141) suggests such loose interpretations of earlier Pennsylvania traditions may have been prompted prompted by plans in agricultural publications of the post-Civil War period. The possible mixing of traditional influences with turn-of-thecentury "modern" ideas for farm planning and construction at the Stetson Place, given its apparent physical and temporal integrity, makes the full farmstead unit significant for historic architectural research. This site could contribute important information toward developing an appropriate historic context and evalua-evaluating related High Plains agricultural resources of northwestern Nebraska.

Based on both architectural interest and association with locally prominent individuals, the Stetson Place is considered potentially eligible for inclusion on the National Register.

POTENTIAL PROJECT IMPACTS

Criteria of effect are as defined in 36CFR800.3 and involve direct or indirect changes resulting from project development that alter the integrity of location, setting, materials, or other characteristics relevant to potential National Register qualifications of the subject resources. Direct environmental alterations considered here are short range, immediate effects including surface modifications and constructed features associated with the R&D building site, access roads, R&D production locations and commercial scale mining locations that could potentially result in: 1) physical disturbance of resources locations; or 2) introduction of visual elements that are out of character and disrupt or alter the setting of applicable resources. Other than the R&D facility, location of commercial uranium extraction sites are not presently defined. Therefore impact to cultural resources can only be identified on a general level (e.g. relationship to CSA limits).

Considerations relevant to the R&D and commercial scale operations are as follows:

1. No properties previously listed in the National Register of Historic Places or registered as natural or historic landmarks occur within the CSA survey unit and no pending plans in this regard were identified.

2. Twenty-one identified resource locations were recorded as a result of the survey, but data recovery sufficient to fully assess National Register eligibilities was not programmed as part of this work.

3. On the basis of present information, six of the twenty-one newly recorded resource locations are potentially eligible for the National Register but may warrant further field investigation and assessment with respect to significance and integrity criteria. These locations are of potential site-specific importance on the basis of scientific data recovery opportunities (25DW114, 25DW192, 25DW194 and 25DW198) and architectural merit (25DW112 and 25DW00-25).

4. Four potentially eligible sites are situated within the CSA boundary (25DW112, 25DW00-25, 25DW194 and 25DW198). One, 25DW00-25, is exempt from on-site development but may be the subject of temporary visual intrusion. Site 25DW114 is largely outside of the CSA boundary, however the documented western margin of the site is contained within the project area. It is also likely the site extends into the 25DW112 farmyard although ground cover prohibited surface visibility. If commercial mining is scheduled in this area, access road facilities outside CSA limits may result in impact to a larger area of the site. Site 25DW192 lies approximately 50m outside CSA limits, but could also potentially be impacted by ancillary activities.

5. The R&D facility layout involves a plant building (ca. 70 x 100 ft) of approximately two stories in height, two evaporation ponds, and a well field. These and other minor features are contained within an area of approximately 8 ha (20 ac). This location occupies a resource-free area directly south of Squaw Creek. The existing building is west (ca. 350 meters or 1150 ft) of site 25DW113 and is southwest (ca. 330 meters or 1100 ft) across Squaw creek from the southern margin of sites 25DW112 and 25DW114.

6. The R&D facility does not physically disturb any of the identified resources. The unimposing size and orientation of the R&D structures do not significantly disturb the rural character of this area, which is germane to the potential significance of site 25DW112,

RECOMMENDATIONS

Cultural remains recorded at fifteen of the twenty-one newly identified resources located within the survey unit appear to represent limited site-specific historical values and data recovery potentials and in themselves do not presently warrant National Register consideration. Further field work at these sites is not recommended on the basis of extant information. Although it is unlikely that these fifteen sites will be important in consideration of resource significance at a projectwide level, it remains possible that further professional evaluation could be required should subsurface remains be encountered as a result of project development.

The six resources (25DW112, 25DW114, 25DW192, 25DW194, 25DW198 and 25DW00-25) which do warrant further consideration of potential National Register eligibilities have not been directly affected by development of the R&D site but continued assessment of these resources may become necessary prior to commercial scale production.

In sum, general and site-specific recommendations regarding the survey unit area as follows:

1. No further reconnaissance level survey is required for the CSA as presently defined. Clearance is recommended for all resource free areas as well as all locations containing ineligible properties.

2. Continued coordination between the Nebraska State Historical Society and project staff will be required during development in the immediate vicinity of the six potentially eligible sites. Detailed locational maps of these properties have been provided to project development staff and are available for professional review at the Nebraska State Historical Society

3. Avoidance of long-term visual impact at sites 25DW112 and 25DW00-25; and direct effect for all six sites is the recommended course of action.

4. If avoidance in any area(s) is judged to be unreasonable due to adverse design modification or anticipated reduction in the commercial success of the undertaking, then arrangements will need to be made for either in-field earth moving monitoring or intensive National Register documentation to facilitate formal eligibility determinations and recommendation for mitigative action.

5. If opted for, National Register level evaluation for the two architectural sites should involve the following procedures for the house at site 25DW112 and the full farmyard at site 25DW00-25: develop floor plans and record interior details to complete stylistic and temporal assessments, and inspect accessible wall and roof exposures to identify structural systems and determine construction sequence. Additional archival research may also be required to clarify certain historic attributes of these properties.

6. If opted for, National Register level evaluation for the four archeological sites should involve initiation of systematic subsurface testing programs of a sufficient magnitude to determine horizontal limits and subsurface integrity values. Further archival research may also be required if evaluation of site 25DW192 becomes necessary.

7. In the event subsurface cultural deposits are encountered during commercial scale operations throughout the project area, professional evaluation should be permitted to determine the need for data recovery.

4.8-7 SUMMARY AND CONCLUSIONS

The Research and Development stage of cultural resources investigations within the proposed Crow Butte Uranium Project near Crawford, Dawes County, Nebraska, was carried out during March and April 1982 under a contractual agreement between Wyoming Fuel Company and the University of Nebraska. Further investigations were completed for the remaining Commercial Study Area land during April and May, 1987, by the Nebraska State Historical Society under contract to Resource Technologies Group. Preliminary background and archival research were initiated in conjunction with intensive field surveys to obtain data required for preparation of both Research and Development and Commercial Scale Applications. This work established a basis for addressing potential effects of the proposed undertaking on identified cultural resources. Pertinent results and conclusions are outlined below.

1. Preliminary literature and records research indicated that systematic investigations had not been previously conducted within the study area and that no National Register eligible properties had been recorded within or immediately adjacent to the survey unit.

2. 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 on project lands. Registered National Historic

Landmarks representing military and Native American reservation period use of the study area are located near the proposed Crow Butte project.

3. Intensive (100% coverage) pedestrian inspection of the R&D area and the full CSA-scale survey unit (1350 ac) resulted in identification of twenty-one newly recorded resource locations. Included are eight sites representing Native American components, twelve Euroamerican locations, and a buried bone deposit of undetermined cultural association.

4. 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 on the basis of the archival research. These sites do not warrant further National Register consideration.

5. The remaining six sites are of potential archeological data recovery importance (25DW114, 25DW192, 25DW194 and 25DW198) and possible architectural interest (25DW112 and 25DW00-25). Further information would be required to more completely determine potential National Register eligibilities.

6. The R&D facility has not directly affected any of the resources identified within the survey unit and clearance of this area for R&D operations was previously recommended.

7. Although no further investigations are needed at this point, project planning should allow for professional evaluation if needed during major earth-moving operations and should provide for avoidance, monitoring or assessment of the six potentially eligible sites during future phases of the Crow Butte Project.

REFERENCES

Agenbroad, L.D.

1978a *The Hudson-Meng Site: An Alberta Bison Kill in the Nebraska High Plains.* University Press of America, Washington, D.C.

1978b *The Hudson-Meng Site: An Alberta Bison Kill in the Nebraska High Plains.* In *Bison Procurement and Utilization: A Symposium*, edited by Leslie B. Davis and Michael Wilson, pp. 128-131. *Plains Anthropologist*, Memoir 14, Vol. 23, No. 82.

1979 Cultural Resource Survey: Whitehead Creek Drainage, Oglala National Grasslands. MS on file U.S. Forest Service, Chadron

Anonymous

1909 *Compendium of History Reminiscence and Biography of Western Nebraska Containing a History of the State of Nebraska; also a Compendium of Reminiscence of Western Nebraska.* Alden Publishing Co., Chicago.

1961 *Crawford, Nebraska 1886-1961.* The Jubilee Committee, Crawford, Nebraska.

Arthur, E. and D. Witney

1972 *The Barn: A Vanishing Landmark in North America.* New York Graphic Society Ltd. Greenwich, Connecticut.

Barbour, E.H. and C.B. Schultz

1936 Paleontologic and Geologic Considerations of Early Man in Nebraska. *University of Nebraska State Museum Bulletin*, 1(45).

Bozell, J.R.

1984 *A Cultural Resources Survey of the Nebraska Forest Highway, Route 7.* Report prepared for the U.S. Department of Transportation by the Nebraska State Historical Society, Lincoln.

n.d. The Middle Woodland Complexes of Nebraska. MS on file at the Nebraska State Historical Society.

Bozell, J.R. and R.E. Pepperl

1982 Preliminary Cultural Resources Investigations within the Proposed Crow Butte Permit Area, Dawes County, Nebraska. Stage 1: The Pilot Plant study. Department of Anthropology, *Technical Report* No. 82-02, University of Nebraska, Lincoln.

Burn, R.R.(in charge), L.V. Davis and J.M. Snyder of the U.S. Department of Agriculture and F.A. Hays and T. Kokjer of the Nebraska Soil Survey

1917 *Soil Survey of Dawes County, Nebraska.* U.S. Department of Agriculture, Government Printing Office, Washington, D.C.

Carlson, G.F.

n.d. Results of the 1982 Cultural Resource Survey in Northwestern Nebraska. MS on file, Nebraska State Historical Society, Lincoln.

Carlson, G.F. and C.A. Peacock

1975 Lithic Distribution in Nebraska. In *Lithic Source Notebook*, Ronald A. Thomas, editor. Division of Historical and Cultural Affairs, State of Delaware

Carlson, G.F. and T.L. Steinacher

1978 A Preliminary Culture-Historical Sequence for the Plains Archaic Period in Nebraska. MS on file, Nebraska State Historical Society, Lincoln.

Cassells, E.G. and L.D. Agenbroad

1981 *Cultural Resource Overview of the Nebraska National Forest*. Report prepared by Plano Archeological Consultants for the U.S. Forest Service, Chadron

Craig, C.

1982 Lithic Source Analysis and Interpretation: Some Problems and Applications in Eastern Wyoming. In *Wyoming Contributions to Anthropology* No. 3. University of Wyoming, Laramie.

Darton, N.H.

1903 Preliminary report on the Geology and Water Resources of Nebraska West of the 103rd Meridian. *Professional Paper, U.S. Geological Survey* 17:1-69.

Diller, A.

1955 James MacKay's Journal in Nebraska 1796. *Nebraska History* 36(2):123-128.

Fenneman, N.W.

1931 *Physiography of the Western United States*. McGraw-Hill, New York.

Foley, M.M.

1980 *The American House*. Harper and Row, New York.

Forbis, R.G., W.D. Strong and M.E. Kirby

n.d. Signal Butte and MacHaffie: Two Stratified Sites on the Northern Great Plains. MS on file at the Department of Archeology, University of Calgary.

Frison, G.C.

1970 The Glenrock Buffalo Jump, 48CO304, *Plains Anthropologist*, Memoir 7.

1978 *Prehistoric Hunters of the High Plains*. Academic Press, New New York.

Gant, R.D. and W.R. Hurt

1965 The Sturgis Archeological Project: An Archeological Survey in the Northern Black Hills. *Museum News* 26, Nos. 7-8, University of South Dakota, Vermillion.

Gill, G.W. and R.D. Lewis

1977 A Plains Woodland Burial from the Badlands of Western Nebraska. *Plains Anthropologist* 22(75):67-73.

Glassie, H.

1968 *Pattern in the Material Folk Culture of the Eastern United States*. University of Pennsylvania Press, Philadelphia.

1974 Barn Building in Otsego County, New York. *Geoscience and Man* 5:177-235.

1975 *Folk Housing in Middle Virginia*. University of Tennessee Press, Knoxville.

Grange, R.T.

1964 A Cache of Scrapers Near Crow Butte, Nebraska. *Plains Anthropologist* 9(25):197-201.

1978 Fort Robinson outpost on the Plains. Nebraska State Historical Society. Reprinted from *Nebraska History* 1958, 39(3):191-241.

Greiser, S.T.

1985 Predictive Models of Hunter-Gatherer Subsistence and Settlement Strategies on the Central High Plains. *Plains Anthropologist* Memoir No. 20.

Gunnerson, J.H.

1960 An Introduction to Plains Apache Archeology-The Dismal River Aspect. *Bureau of American Ethnology Bulletin* 173:131-269.

Hanson, J.A.

1983 *Northwest Nebraska's Indian People*. Chadron Centennial Committee, Chadron, Nebraska.

Hanson, C.E., Jr.

1969 The Battle of Crow Butte. *The Museum of the Fur Trade Quarterly*, Vol. 5:(3):3-7.

Hanson, C.E., Jr., and V.S. Walters

1976 The Early Fur Trade in Northwestern Nebraska. *Nebraska History* 47(4):1-21.

Hartley, R.J.

1980 Ethnohistorical Background: The Calamus and Davis Creek Projects, Nebraska. In Cultural and Paleontological Resource Investigations within the Calamus and Davis Creek Reservoir Areas, Carl R. Falk and Robert E. Pepperl. Department of Anthropology, *Technical Report* 80-04, University of Nebraska, Lincoln.

Hyde, G.

1937 *Red Cloud's Folk*. University of Oklahoma Press, Norman.

Kornfeld, M. and L.C. Todd

1985 McKean/Middle Plains Archaic: Current Research. *Occasional Papers on Wyoming Archeology*, No. 4. Laramie.

Lewis, M. and W. Clark

1814 *History of the Expeditions Under the Command of Captain Lewis and Clark...*, edited by Nicholas Biddle, 2 vols. Philadelphia.

Ludwickson, J.

1982 Evidence for a Coalescent Tradition (Extended variant) presence on the White River, northwest Nebraska. Paper presented at the 1982 Nebraska Academy of Science Meeting, Lincoln.

Ludwickson, J. and J.R. Bozell

n.d. The Nebraska Highway Archeology Program: 1976-1985. Report in preparation for the Nebraska Department of Roads.

Lugn, A.L.

1939 Classification of Tertiary Systems in Nebraska, *Bulletin of the Geological Society of America* 50:1243-1276.

Macdonald, J.F.

1970 Miocene Wounded Knee Faunas of Southwestern South Dakota. *Science Bulletin of the Los Angeles County Museum* No. 8:1-82.

Martin, L.D.

1973 The Mammalian Fauna of the Lower Miocene-Gering Formation of Western Nebraska and the Early Evolution of the North American Cricetidae. Unpublished Ph.D. dissertation, University of of Kansas.

Meston, L.K.

1976 Archeological Investigations in the White River Region, Northwest Nebraska. Department of Anthropology, ***Technical Report*** 76-12, University of Nebraska, Lincoln.

Moore, G.L. and R. Rosenburg

1985 A Cultural Resources Inventory of Portions of the Pine Ridge Ranger District, Nebraska National Forest, Dawes County, Nebraska. Overland Associates, Inc., ***Research Paper*** No. 12. Boulder, Colorado.

Mulloy, W.T.

1954 The McKean Site in Northeastern Wyoming. ***Southwestern Journal of Anthropology*** 10(4):432-460.

Nasatir, A.P.

1952 ***Before Lewis and Clark*** (2 vols.) Historical Documents Foundation, St. Louis.

Pepperl, R.E., J. Pepperl, D. Henning and S. Donovan

1983 Historic Architecture and Rural Settlement of the Central Niobrara River Valley (1881-1981): The Norden Study, North Central Nebraska. University of Nebraska ***Technical Report*** 82-08 submitted to the U.S. Bureau of Reclamation, Lower Missouri Region, Denver, Colorado.

Pinney, P.M.

1985 ***Dawes County: The First 100 Years.*** Curtis Media Corporation, Dallas.

Ragon, L.G., L.D. Worth, M.A. Sherwood and M.L.Fausch

1977 ***Soil Survey of Dawes County, Nebraska.*** United States Department of Agriculture, Soil Conservation Service in Cooperation with the University of Nebraska, Conservation and Survey Division.

Rapp, W.R. and S.K. Beranek

1984 ***The Industrial Archeology of Nebraska.*** J-B Publishing, Crete, Nebraska.

Reeves, B.O.K.

1983 Culture Change in the Northern Plains 1000 B.C. - A.D. 1000. Archeological Survey of Alberta. ***Occasional Papers*** No. 20.

Reher, C. and G.C. Frison

1980 The Vore Site, 48OK302, A Stratified Buffalo Jump in the Wyoming Black Hills. ***Plains Anthropologist*** Memoir 16.

Royce, C.C.

1899 Indian Land Cessions in the United States. *18th Annual Report of the Bureau of American Ethnology*, Part 2.

Saunders Publishing Company

1905 *Farm Buildings.* Chicago.

Schuchert, C. and C.M. LeVene

1940 *O.C.Marsh: Pioneer in Paleontology.* Yale University Press, New Haven.

Schultz, C.B. and T.M. Stout

1955 Classification of Oligocene Sediments in Nebraska. *Bulletin of the University of Nebraska State Museum* 14:17-52.

Shelford, V.

1963 *The Ecology of North America.* University of Illinois Press, Urbana.

Singler, C.R. and M.D. Picard

1980 Stratigraphic Review of Oligocene Beds in the Northern Great Plains. *Earth Science Bulletin*, Wyoming Geological Association, 13:1-18.

Speth, J.D.

1983 *Bison Kills and Bone Counts.* University of Chicago Press, Chicago.

Standard Atlas of Dawes County, Nebraska

1913 Compiled and published by the George A. Ogle Company, Chicago.

Thwaites, R.G.

1905 *Original Journals of the Lewis and Clark Expedition*, 1804-1806 (8 vols.), Dodd and Mead, New York.

Tratebas, A.M.

1981 Current Status of Research on the McKean Complex in South Dakota. In The Future of South Dakota's Past, L.J. Zimmerman and L.C. Stewart, editors. *Special Publication of the South Dakota Archeological Society*, Number 2.

1984 *Functional Variability and Settlement Locations in the Black Hills.* Unpublished Ph.D. dissertation, Department of Anthropology, Indiana University, Bloomington. Voeglin, C.F. 1941 Internal Relationships of Siouan Languages. American Anthropologists 43(2):246-249.

Warren, G.K.

1856 Explorations in the Dakota Country in the Year 1855. 34th Congress, 1st Sess., Sen. Doc. No. 76, Ser. 822.

Weaver, J.E.

1965 *Native Vegetation of Nebraska*. University of Nebraska Press, Lincoln.

Wedel, W.R.

1961 *Prehistoric Man on the Great Plains*. University of Oklahoma Press, Norman.

1978 The Prehistoric Plains. In *Ancient Native Americans*, J.D. Jennings, editor. W.H. Freeman and Company, San Francisco.

Wellman, S.S.

1964 Stratigraphy of the Lower Miocene Gering Formation, Pine Ridge Area, Northwestern Nebraska. Unpublished M.S. Thesis, University of Nebraska, Lincoln.

Wettlaufer, B.N.

1955 The Mortlach Site in the Besant Valley of Central Saskatchewan Department of Natural Resources, *Anthropological Series* No. 1. Regina.

Wheeler, R.P.

1954 Two New Projectile Point Types: Duncan and Hanna Points. *Plains Anthropologist* 1:7-14).

1985 The Middle Prehistoric Period in the Central and Northern Plains. In *Occasional Papers on Wyoming Archeology* No. 4, edited by M. Kornfeld and L.C. Todd. Laramie. Whiffen, M. 1969 American Architecture Since 1780: A Guide to the Styles. M.I.T. Press, Cambridge, Mass.

Whiffen, M.

1969 *American Architecture Since 1780: A Guide to the Styles.*__ M.I.T. Press, Cambridge, Massachusetts.

Wood, A.E.

1969 Rodents and lagomorphs from the "Chadronia Pocket", early Oligocene of Nebraska. *American Museum of Natural History, Novitates*, 2418:1-18.

SUBSECTION 4.9

ECOLOGY

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SUMMARY

Beginning in March, 1981, plans were initiated to undertake ecological studies for Ferret Nebraska's Crow Butte Uranium Project near Crawford, Nebraska. At that time, all appropriate state and federal regulations pertaining to uranium solution mining were reviewed, and studies were designed which were deemed appropriate to comply with legislative precedents in the region.

Information deemed necessary for completion of a suitable permit application was outlined in a detailed task analysis, which identified the following objectives:

1. Describe the flora and the fauna in the vicinity of the site, their habitats and distributions.
2. Identify "Important Species" - species which are:
   a. commercially or recreationally valuable
   b. threatened or endangered
   c. likely to affect the well-being of species in the above categories
   d. critical to the structure and function of the ecological system
   e. biological indicators of radionuclides or chemical pollutants in the environment.
3. Identify and provide information on the relative abundance of the majority of terrestrial and aquatic organisms.
4. Provide count data on domestic animals and important game animals.
5. Provide a map of the principal plant communities.
6. Discuss species-environmental relationships, diversity measurements, and predator-prey relationships of "important" species.
7. For "important" species, discuss:
   a. life histories
   b. seasonal populations fluctuations
   c. habitat requirements
   d. food chains and interspecies relationships.
8. Identify any pre-existing environmental stresses.
9. Describe the status of ecological succession within each plant community type.

10. Discuss histories of any infestations, epidemics or catastrophes.
11. Present the information in two separate subsections, "Terrestrial Ecology" and "Aquatic Ecology".
12. Identify sources of information and list pertinent published information dealing with the ecology of the region.
13. Reference and describe all ecological and biological studies of the site or its environs currently in process of planned.
14. Update and verify baseline data for expansion to a commercial facility.

Methods of investigation were chosen which would address the above objectives. A review of literature was completed, and discussions were held with local representatives of the state and federal agencies, and with faculty of Chadron State College.

A detailed work plan was developed that would provide sufficient data to satisfy local, state, and federal requirements for a uranium in situ leach Research and Development (R&D) and, with updating, satisfy requirements for expansion to a Commercial facility. Baseline studies were undertaken in January 1982 and continued through December 1982 in order to provide a full year's data. These studies have been updated in 1987 through literature searches, recontacting critical personnel, and field verification.

Stated in its simplest terms, the ecological study entailed, 1) the identification and documentation of plant communities and wildlife habitat types, 2) the systematic documentation of wildlife species within each type, and 3) updating the baseline data and assessing impacts to the ecology of the area caused by development and operation of the R & D facility as well as the upgrading to the commercial scale.

In the attached report, emphasis is placed on the relationships of plants and animals to particular habitat types. This "habitat affinity" approach allows one to address potential impacts in a systematic matter. If a particular habitat type is disturbed, it can be anticipated that the representative plant and animal species will be affected in direct proportion to the

level of disturbance. Conversely, undisturbed habitat types, and their representative species, should not be adversely affected. On the site in question, for example, if only mixed grass habitat is disturbed, one should not expect such species as fox, squirrels and white-tailed deer, which reside in streambank forest, to be adversely affected.

The baseline information presented in the attached report is intended not only as a basis for assessing anticipated impacts, but as a basis for reference against which to measure impacts as they occur. It should be understood that such studies are considered important not only in terms of the public welfare, but also to protect the interests of the company. If, for example, years hence a "decline" in the fishery of Squaw Creek were to be suggested and attributed to mining activities, it would be appropriate to note from the baseline study that there was no significant fishery at the outset of mining activities.

Intensive investigations were conducted throughout the 13 section "Commercial Study Area (CSA). The commercial Permit Area is contained within the CSA. Equivalent studies were conducted within a 5 mile (8-km) "Adjacent Area" (AA). Finally, extensive studies were conducted within a 50 mile (80-km) "Outer Area" (OA). Hence it is possible to compare conditions within the proposed area of development to conditions in the general vicinity and to a much larger area. It is subsequently possible to make statements concerning the relative importance of the permit area on a local and regional basis.

In the course of the study, no phenomena were discovered which would preclude issuance of permits for development of the property in the current legal and socioeconomic environment. Although the Pine Ridge area contains a wealth of plant and animal species and is regarded as an important hunting and fishing unit, environmental conditions within the CSA proper are relatively degraded due to widespread deleterious land practices.

Of threatened, endangered and rare species, bald eagles and peregrine falcons are winter residents and migrants of the region. The CSA is within the range of the swift fox, but no sightings have been recorded in the CSA.

From a purely ecological point of view, perhaps the most significant aspect of the study was the diversity of raptors (birds-of-prey) with 21 species documented within the study area from January through July, 1982. No adverse impacts, however, are anticipated since no reduction in the prey base is expected to result from project activities. Quite to the contrary, there is considerable opportunity to enhance conditions for raptors, if attention is given to improving habitat conditions in the reclamation phase.

4.9-1 TERRESTRIAL ECOLOGY

Introduction

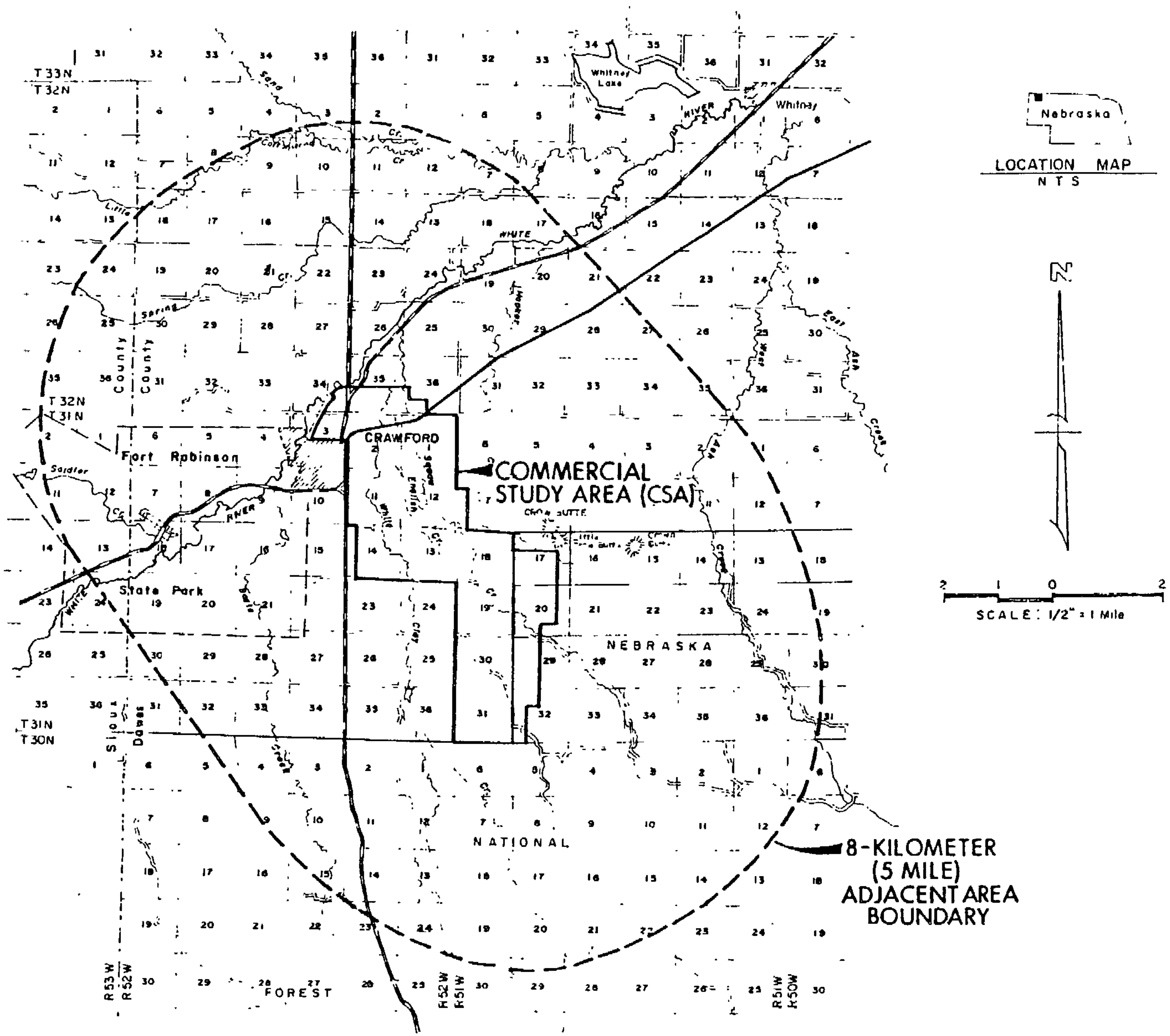
A one-year ecological baseline study was initiated in January, 1982, in conjunction with the Crow Butte Uranium Project, Dawes County, Nebraska.

The principal study area is shown in Figure 4.9-1. Intensive studies were conducted on the proposed CSA. Comparable investigations were conducted within an 8-km (5 mi) AA, in order to assess the ecological importance of the CSA in relation to the immediate environs. Extensive investigations were conducted within an 80-km (50 mi) OA centered on Section 19, drawing primarily upon published sources of information.

The information presented in this section includes findings of the baseline studies conducted in 1982 and updated in 1987. The data base will prove sufficient to comply with federal and state requirements for commercial license applications and sufficient to assess the probable impacts of the the project.

Description of the Study Area. The project area lies within Dawes County in northwestern Nebraska. The 8-km AA includes portions of Sioux County on the west. The 80-km OA includes portions of South Dakota on the north and Wyoming to the west.

The climate is dry continental. The normal annual amount of precipitation is about 19 in (48 cm). Seventy percent of that amount falls during the growing season.



4.9(5) 09/30/87

REV DATE	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	ECOLOGICAL STUDY AREA
	PREPARED BY: F E N.
	DWN BY: JC DATE: 8/87 FIGURE 4.9-1

CBR-014

The winters are cold, with January having a low mean temperature of about -5°C. Warmest temperatures occur during late July, when mean highs range from 35-38°C. The growing season averages about 130 days. The latest killing frost occurs during mid-May, and the earliest in fall occurs during late September (Visher 1954; Urbatsch and Eddy 1969). Violent thunderstorms accompanied by high winds, torrential rains, and hail, can be expected to occur each spring and summer.

The study area lies in two physiographic provinces. The Pine Ridge Escarpment, the region's most prominent geological feature, marks the northern boundary of the Northern High Plains and the southern boundary of the unglaciated Missouri Plateau. The Pine Ridge, which lies along the southern boundary of the CSA, is characterized by buttes, ridges, vertical slopes and deep canyons. The Missouri Plateau, which represents the northern portion of the study area is distinguished from the High Plains by deep erosion and has badlands developed at some sites (Fenneman 1931). The White and Niobrara Rivers are the two major streams which drain the region, the former traversing the study area (Figure 4.9-1).

The soils of the study area have a tremendous range, from clays in the north, to sands in the south, with an intermittence of badlands and relatively fertile soils. The clays (Pierre series) developed from shales in the northern part of Dawes County, where badland outcrops of Tertiary sandstone, and alkaline flats occur. Soils of the CSA are predominantly of a of siltstone and sandstone origin.

Elevations within the primary study area (CSA and AA) range from 3,400 ft (1,100m) to 4,600 ft (1,480m). The CSA lies primarily in a foothill and valley bottom situation, surrounded by buttes and escarpments to the east, south and west, and expansive plains to the north.

Methods

Methods of investigation were chosen, taking into account the principal floral and faunal species of the area, and following discussions with agency biologists (J. Peterson, H. Suetsuga, Nebraska Game and Parks

Commission). Whenever possible, methods were employed which would provide continuity and compatibility with ongoing investigations in the state and the region.

Plant Collections were conducted throughout the growing season in order to prepare a comprehensive voucher of plant species within the study area.

Vegetation Mapping was completed at a scale of 1:12,000 for the CSA, and at a scale of 1:24,000 for the AA. Vegetation/Habitat types were chosen in compliance with 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 utilized to generate a species list for the study area and to obtain information on faunal distribution. In addition to routine sightings, observation time was programmed specifically for 1) raptor nest surveys, 2) 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) carnivore dens, and 11) reptile and amphibian surveys.

Indirect Evidence of wildlife was recorded to supplement visual documentation. Such evidence included tracks, scat, hair or quills, feathers, vocalization, and evidence of forage utilization. Fresh snowfall afforded special documentation opportunities, e.g., radius of action and behavioral phenomena.

Aerial Observation was the primary means of documenting big game use within the study area. Nesting activity of raptors was monitored by aircraft, and an aerial search was made for grouse leks. Flight lines for big game were oriented north-south and spaced at 1/2 mile intervals within the CSA and AA.

Transects were used to determine relative utilization of the major habitat types by wildlife and to document seasonal songbird activity. One 1,000m transect was placed in each major habitat type. Transects were sampled at 2-week intervals from sunrise to no later than 3 hours after sunrise. Perpendicular distance of each observation was used to compute density by species (Emlen 1977).

Time-area Counts were incorporated to provide consistency in sampling wildlife use within special habitat types, e.g., ponds and impoundments.

Rodent Trapping was conducted over a 3-day period in spring, to provide an index of abundance by habitat type. Fifty traps were placed parallel to each flush transect (above) for 3 consecutive days and nights (150 trap-nights per habitat type).

Spotlight Routes were employed to document the status of carnivores, and to provide herd structure data for ungulates. Four routes, each about 80-km long, were run monthly.

Data Reduction and Analysis. All field data were recorded on prepared forms or on cassette recorder. Raw data were reduced onto Fortran coding forms for permanent storage and analysis. Locations of the major wildlife species were recorded to within 50m, and for certain phenomena, e.g., raptor nests to within 10m with reference to the Universal Transverse Mercator (UTM) system and encoded on mylar overlays at a scale of 1:24,000.

Further details of methodologies are discussed in association with specific taxa.

Vegetation

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

1. Plains and Prairie Flora. This vegetation region is comprised of two subregions - the True Prairie Flora and the Great Plains Grassland Flora. The transition from True Prairie in the eastern part of the state to Great Plains Grassland westward is primarily a factor of reduced effective precipitation. Many species are common to both subregions. There is a general conformity in the composition of the plant cover. A dominance of grasses, absence of trees, rolling topography, and a characteristic xerophytic flora are the main features. Species occurring on the study area which tend to represent the True Prairie (Tall Grass) subregion are Andropogon gerardi, Andropogon scoparius, Elymus canadensis, Poa pratensis, Amorpha canescens, Artemisia ludoviciana, Astragalus crassicarpus, Echinacea angustifolia, Onosmodium molle, Psoralea esculenta, Solidago missouriensis and related species. Species typical of the Great Plains Grassland (Short-Grass, Mid-grass) include Bouteloua gracilis, Agropyron smithii, Buchloe dactyloides, Koeleria pyramidata, Allium textile, Artemisia frigida, Carex filifolia, C. eleocharis, Oxytropis lambertii, Penstemon albidus and Rosa arkansana.

2. 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 Berberis repens, Juniperus scopulorum, Pinus ponderosa, and Calochortus nuttallii.

In addition to the above vegetation regions, there are several other plant communities which are noteworthy. Wooded Bottomlands display certain characteristics of the Eastern Deciduous Flora. Representative species include Populus deltoides, Fraxinus pennsylvanica, Acer negundo, Salix amygdaloides, Salix exigua, Toxicodendron rydbergii, Ulmus americana, and Vitis riparia.

Lakes, Ponds and Prairie Potholes display a characteristic vegetation, including Cicuta maculata, Equisetum hyemale, Scirpus validus, S. americanus, S. maritimus, Eleocharis erythropoda, Typha latifolia, Carex nebraskensis, Polygonum coccinium and Potamogeton pectinatis.

The Great Basin Flora is sparsely represented in the northern portion of the study area, where saline conditions exist. Typical species include Sarcobatus vermiculatus, Artemisia cana, and several species of halophytic forbs.

The Circumpolar and Circumboreal Alpine Groups, well represented in the Black Hills, are poorly represented in the Pine Ridge Area, due to the lower elevations and warmer summer temperatures, but species which occur include Arnica rydbergii, Juniperus communis, and Epilobium angustifolium.

A large number of Exotic Species occurs, representative of Europe, Asia and elsewhere in North America. Indeed, as a result of cultivation and range rehabilitation, perhaps 30 percent of species and more than 50 percent of plant cover is comprised of exotics. Species which are conspicuously successful include Bromus inermis, B. japonicus, B. tectorum, Melilotus officianalis, M. alba, and a large number of Brassicaceae, including the genera Sisymbrium, Descrurainia, Thlaspi, Brassica, and Capsella. Cultivated species include wheat, oats, rye, corn, milo and alfalfa.

VanBruggen (1977) points out that the Black Hills/Pine Ridge region is not an area where endemics occur. If one assumes a less than conservative taxomic interpretation of the species present, it is doubtful that any endemics are present in the Pine Ridge area.

Study Area Vegetation/Habitat Types. A vegetation classification system (Table 4.9-1) was derived from the study area, sufficient to include the flora within the 80-km OA, taking into account regional precedents - terrestrial flora (Coenenberg et al. 1977), and wetlands (Stewart and Kantrud 1971), with particular reference to generating a system useful in identifying faunal habitat affinities. Table 4.9-2 summarizes the habitat types and amounts of each that comprise the CSA. Individual habitat types are described briefly below:

Wetlands (000-009). These types correspond directly to those of Steward and Kantrud (1971), with the addition of 008 (Dugouts) and 009 (Excavated Wetlands, usually abandoned gravel pits). All wetland types are represented

TABLE 4.9-1

HABITAT CLASSIFICATION SYSTEM

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)

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

TABLE 4.9-1 (Continued)

HABITAT CLASSIFICATION SYSTEM

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

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

TABLE 4.9-2

COMMERCIAL STUDY 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	**8673.70**	**3510.25**	**100.00**

within the 80-km OA, but are poorly represented on the study area (CSA and AA). A few prairie potholes exist in the northern portion of the study area. Those are Temporary and Seasonal wetlands (Class II and III, resp.) representing wet meadow and shallow marsh vegetation types.

Special Features (010-014). Cliffs, rock outcrops and escarpments are common in the south, west and east portions of the study area. Badlands, typical of outcroppings of the Pierre and Brule Formations are encountered within the northeast portion of the study area. By definition, these are areas almost devoid of vegetation, except for a few representatives of the Mixed Grass element.

Riverine Habitats (050-059). These types directly correspond, floristically, to wetland types, and are discussed further in the Aquatic Ecology Section.

Woodlands (100-160). The Deciduous Streambank Forest occupies streamside sites adjacent to all perennial streams and rivers of the study area, except where it has been destroyed by cultivation and/or grazing. Populus deltoides dominates throughout. Other species present include Fraxinus pennsylvanica, Acer negundo, Ulmus americana, Salix amygdaloides, S. Exigua, S. lucida, Prunus americana, and P. virginiana. Understory vegetation varies greatly, depending primarily upon the amount of grazing which occurs. Where reasonable protection is afforded, such species as Clematis ligusticifolia, Parthenocissus vitacea, Vitis riparia, and Bromus inermis tend to predominate. Where heavy grazing has been conducted, the understory is characterized by Urtica dioica, Toxicodendrom rydbergii, Apocynum cannabinum, Euphorbia podperae, Croton texendis, Chorispora tenella, Bromus tectorum, Conium maculatum, and other poisonous plants and noxious weeds.

Floristic characteristics of the Deciduous Basin Forest are identical to the above, but with floral zones representing moisture gradients and periods of shoreline inundation. This type is not represented within the study area proper, owing to the absence of sizeable wetland/lake basins.

The Deciduous Wooded Draw is similar to the Deciduous Streambank type, but occupying as it does intermittent upland drainages, is characterized by species with a greater tolerance to aridity. Acer negundo, for example, may predominate over Populus deltoides, and mesophytic shrubland species (below), such as Shepherdia argentea, are closely associated.

Tree plantings are common on the study area, including the CSA. Species most commonly selected for shelterbelts and farmyards are Ulmus pumila, U. americana, Populus deltoides, Juniperus virginiana, and to a much lesser extent, Cornus stolonifera, Pinus ponderosa, and Salix spp. Many shelter-shelterbelts are comprised exclusively of Ulmus spp., and are rapidly disappearing as a result of widespread disease.

The Ponderosa Pine (Pinus ponderosa) Complex dominates the highlands of the study area, but is not well represented at the lower elevations which characterize the CSA. Ponderosa-Juniper (P. ponderosa-Juniperus scopulorum) is found on the more dissected terrain, growing on calcareous lithosols. Very few understory species are present. The type is not represented on the CSA. Ponderosa Pine-Deciduous Woodland Type is the most complex on the study area, where the Deciduous Streambank flora penetrates the Ponderosa Pine Woodland flora at the middle to upper elevations. The Ponderosa Pine Grassland occupies foothills and the plateaus at the higher elevations, above the level of the escarpments. Typical Mixed Grass meadows (below) are interspersed with the stands of pine. Understory species found in association with Ponderosa Pine throughout include Thermopsis rhombifolia, Anemone patens, Galium boreale, Potentilla spp., Penstemon glaber, and related species common to the Rocky Mountain element. Ponderosa Pine-Shrubland occurs sporadically on ridge-tops and southern exposures. Associated shrubs are few-predominantly Rhus aromatica var. trilobata, and Ribes odorata. The absence of well developed shrublands within the Ponder

Ponderosa Type is not understood, but the role of fire in the past is probably responsible in large measure.

The Juniper Type (Juniperus scopulorum) is not represented on the primary study area, but pure stands, usually with few associated understory species, are found on lithosols to the north and west.

The Aspen Type (Populus tremuloides) is the rarest community on the study area, and is not found on the CSA. A typical stand, consisting of about 20 trees, exists on a steep, shaded, northern exposure in West Ash Creek, about 4-km east of the CSA. No regeneration is evident. The species probably constitutes a Pleistocene relic in the area, is at the extremity of its range, and will probably disappear over the next few decades.

Xerophytic Shrublands (200-240) are poorly represented on the CSA, but are common in the northern portion of the OA. Big Sagebrush (Artemisia tridentata) and Big Sagebrush-Grassland form expansive communities about 30-km northwest of the CSA.

Sand Sagebrush (Artemisia filifolia) and associated psammophytic flora are found on sandy soils throughout the study area, but expansive stands are absent from the CSA. Rarely are stands of this species more than 1 ha in extent. Most often, the species is found along roadways in sandy areas.

Mesophytic Shrublands (300-330). The Upland Drainage Seep Type is comprised primarily of Prunus americana, P. virginiana, and Shepherdia argentea. These copses are found along intermittent water courses and upland plains sites with temporarily high water tables. The type is represented on the CSA, but with stands usually less than 0.5 ha in extent. The Chionophilous Copse Type is comprised almost exclusively of Symphoricarpos occidentalis. The species typically occupies snow-accumulation sites on the downwind side of hills and escarpments, and reaches it's greatest expansion on the plateaus at the higher elevations. It is poorly represented on the CSA.

Grasslands (400-420). Characteristics of the grassland types were described earlier. Within the study area, the differentiation between the Shortgrass Type and Mixed Grass Type could be made only on a subjective basis. The Shortgrass Type tends to be dominated by Bouteloua gracilis and Buchloe dactyloides, whereas the Mixed Grass Type exhibits a more diverse grass component. In practice, differentiation was based on the presence or absence of Tall Grass species, e.g., Andropogon scoparius. Classification

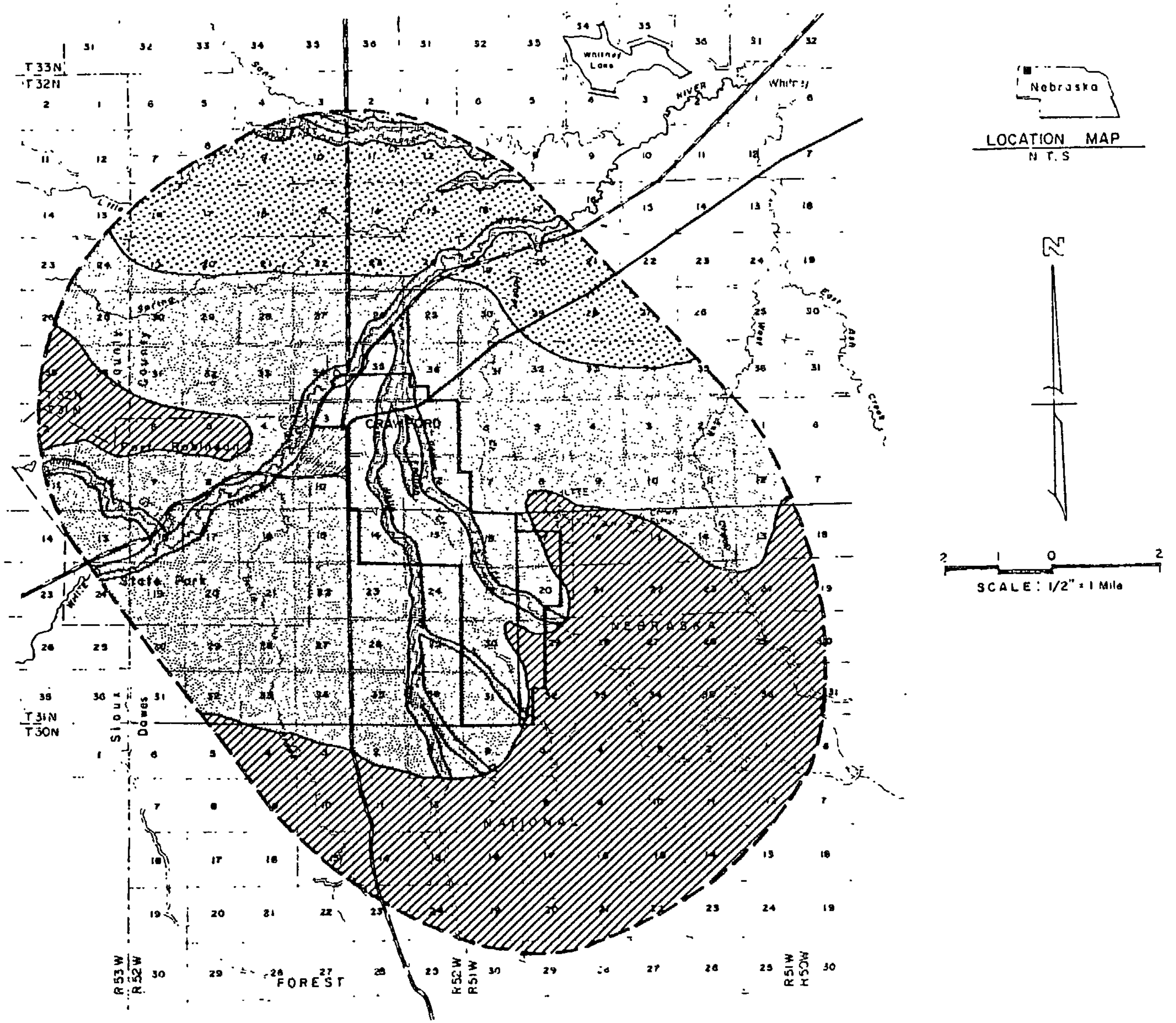
is complicated by the over-grazed nature of the range, whereby much of the Mixed Grass Type has been degraded and now takes on a Shortgrass aspect. Figures 4.9-2 and 4.9-3 represent our estimation of potential grassland vegetation.

Range rehabilitation areas are increasing in size, as lands within the CSA are subjected to increasingly intensive management. Species most commonly selected for seeding are **Bromus inermis**, **Poa pratensis**, **Agropyron cristatum**, **A. pectiniforme**, **A. smithii**, **A. intermedium**, **A. elongatum**, and **Elymus** spp. The quality and composition of the type varies greatly, depending upon the interval between seeding and grazing, and the intensity of the grazing. The aspect varies from pure to sparse grass stands, to annual weed complex or bare ground.

Cultivated (500-552). This type comprises about one-third of the CSA. Winter wheat cultivation is the most common practice, typically with a 50 percent rotation (summer-fallow) pattern. Other crops include oats, barley, milo, rye, corn, alfalfa, and small vegetable gardens.

Structure Biotopes (600-650). Man-made features other than cultivation include gravel pits, buildings and farmyards, parks, cemeteries, roads, highways and roadside rights-of-way. These comprise about 5 percent of the CSA.

Commercial Facility Location. The permanent structures that will be constructed for the development of the commercial facility will comprise a maximum of 80 acres located in Section 19. The northeast 1/4 of Section 19 is under wheat cultivation. The Burlington Northern Railroad traverses the southwest 1/4. The area southwest of the railroad is under alfalfa cultivation. An abandoned farmstead is located in the eastcentral portion of the section. The Old Crow Butte cemetery lies along the western boundary of the section. The remainder is in a natural, albeit degraded state of Deciduous Streambank Forest and Mixed Grass Prairie types (Figure 4.9-3). About 30 cattle graze the area from 1 May to 1 November.



LEGEND

- SHORTGRASS PRAIRIE
- MIXED GRASS PRAIRIE (SHORT / MID-GRASS)
- DECIDUOUS WOODLAND
- CONIFEROUS WOODLAND

REV	BY	DATE	FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			MAJOR VEGETATION TYPES-BIOMES (Potential Vegetation)
			PREPARED BY F Harrington & Assoc.
			DWN BY D&D Graphics · DATE 8-1-82 · FIG. 4.9-2

CBR-014

Squaw Creek, which passes through Section 19, is characterized by steep, eroded banks, due to livestock trampling. The riparian forest is comprised of Populus deltoides, with a few specimens of Fraxinus pennsylvanica and Acer negundo. Copses of Prunus virginiana and P. americana occur along the watercourse as well. The bottomland vegetation is comprised principally of indicators of over-grazing - noxious weeds and poisonous plants - Croton texensis, Euphorbia podperae, Urtica dioica, Galium aparine, Toxicodendron rydbergii, and several members of the Brasicaceae.

The Mixed Grass community, which comprises about 65 percent of the section is in poor condition, but with a moderate to high plant cover. The most evident indicator of over-grazing is Yucca glauca, which is the aspect dominant over much of the site. Other indicators of disclimax conditions include high percentages of Bromus tectorum, B. japonicus, Festuca octoflora, Opuntia fragilis, Carex filifolia, C. rossii, Oxytropis lambertii, and various cushion plants - Arenaria hookeri, Paronychia jamesii, and Phlox andicola.

A preliminary estimate of grazing capacity of the range, in its present condition, based on experience elsewhere in the region, would suggest a proper stocking rate from 5-15 acres per animal-unit-month. 1982 stocking rates were about 1.7 acres per animal-unit-month, or about 3-8 times in excess of proper stocking rates, not uncommon for the area. Since 1982, domestic livestock numbers in the area have declined by 12-20% (Raymer 1987), reducing but not eliminating, overuse of the range.

Plant Species List. 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. The Chadron State College herbarium (Urbatsch and Eddy 1969) contains 468 species from Dawes County.

In the course of the baseline study, between March and Mid-July, 1982, more than 400 species of plants were collected within the study are (CSA, AA). Of that number, 163 species were recorded within Section 19 (Table 4.9-3).

TABLE 4.9-3

PLANT SPECIES LIST - SECTION 19

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

TABLE 4.9-3 (Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
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

TABLE 4.9-3 (Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
SALICACEAE	
Populus deltoides	Plains Cottonwood
Salix exigua	Coyote Willow
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 Rocky 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

TABLE 4.9-3 (Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
FABACEAE	
Astragalus gracilis	Slender Milkvetch
Astragalus missouriensis	Missouri Milkvetch
Lupinus argenteus	Silvery Lupine
Medicago falcata	Yellow Lucerne
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	Texas Croton
Euphorbia podperae	Leafy Spurge
VITACEAE	
Parthenocissus vitacea	Woodbine
ACERACEAE	
Acer negundo	Box Elder

TABLE 4.9-3 (Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
ANACARDIACEAE	
Rhus aromatica	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

TABLE 4.9-3 (Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
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

TABLE 4.9-3 (Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
CAPRIFOLIACEAE	
Symphoricarpos occidentalis	Western Snowberry
ASTERACEAE	
Achillea millefolium	Yarrow
Agoseris glauca	False Dandelion
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
Erchinacea 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
Rudbeckia 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

TABLE 4.9-3 (Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
CYPERACEAE	
Carex filifolia	Thread-leaved Sedge
Carex hystericina	Bottlebrush Sedge
Carex lanuginosa	Wooly-headed Sedge
Carex nebraskensis	Nebraska Sedge
Carex rossii	Ross' Sedge
POACEAE	
Agropyron cristatum	Crested Wheatgrass
Agropyron intermedium	Intermediate Wheatgrass
Agropyron pectiniforme Wheatgrass	Smooth Crested Wheatgrass
Agropyron smithii	Western Wheatgrass
Andropogon 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
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

TABLE 4.9-3 (Continued)

PLANT SPECIES LIST - SECTION 19

Scientific Name	Common Name
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

No species of state or federal concern has been found on the study area. The species considered "most rare" was Townsendia exscapa (Easter-Daisy). About 20 specimens were observed on the site. The species, traditionally collected by pioneers during the Easter season, enjoys a wide distribution in the region, but is evidently nowhere abundant. The species does not merit consideration as endangered or threatened. Hayden penstemon (Penstemon haydenii) is a state endangered species that is found in the region near the study area. However, no individuals have been found on the CSA nor are any expected, as the species is restricted to blow-outs and no blow-outs exist within the CSA (Weedon 1987). All other species are generally considered common to abundant in the region.

Mammals

Domestic ungulates on the CSA include cattle, horses, and swine (Table 4.9-4). 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. Livestock numbers have declined since 1982 by 12-20%.

Wild Mammals. Thirty six species of mammals have been documented on the study area, and another 28 species, mostly bats, insectivores and small rodents, are deemed likely to occur (Table 4.9-5, 5A).

Big Game Mammals

Mule Deer* are distributed primarily along the foothills and escarpments, ranging outward into cultivated land, and are occasionally found along watercourses at the lower elevations (Figure 4.9-4). During the period 1 January - 15 July, 1982, 853 observations of the species were recorded within the study area (Table 4.9-6).

* Scientific names are included in the fauna species list.

TABLE 4.9-4

DOMESTIC LIVESTOCK NUMBERS, COMMERCIAL STUDY AREA*
(1982)

Landowner	Cattle	Horses	Swine
Moore	160 (Year-round)	10 (Year-round)	
Taggert	34 (1May-1Nov)		
Franey	59 (1May-1Nov) 80 (1Nov-1May)		
McDowell	69 (1May-1Nov) 180 (1Nov-1May)		
Brott	70 (Year-round)		
Stetson	106 (1May-1Nov)		
Dodd	190 (1Nov-1May)		
Roby	30 (1May-1Sep) 100 (Year-round)		
Lux	130 (1Feb-1May)		
Gibbons(1)	100 (Year-round)		
Ehlers(2)		30 (Year-round)	80 (Year-round)
Totals	**~910 (Winter)** **~598 (Summer)**	**40 (Year-round)**	**80 (Year-round)**

* Since 1982, domestic livestock numbers have declined by 12-20%.

(1) As of 1987 this landowner had approximately 35 swine.

(2) As of 1987 this landowner had zero swine.

TABLE 4.9-5

MAMMAL SPECIES LIST

Common Name	Scientific Name	Status
INSECTIVORA		
Masked Shrew	*Sorex cinereus*	E-CA-U
Dwarf Shrew	*Sorex nanus*	E-CA-U
Merriam Shrew	*Sorex merriami*	E-AA-U
Least Shrew	*Cryptotis parva*	E-CA-U
Eastern Mole	*Scalopus aquaticus*	D-CA-U
CHIROPTERA		
Keen Myotis	*Myotis keeni*	E-CA-U
Little Brown Myotis	*Myotis lucifugus*	E-CA-C
Fringed Myotis	*Myotis thysanodes*	E-CA-U
Long-eared Myotis	*Myotis evotis*	E-CA-U
Long-legged Myotis	*Myotis volans*	E-CA-U
Small-footed Myotis	*Myotis subulatus*	E-CA-U
Silver-haired Bat	*Lasionycteris noctivagans*	E-CA-U
Red Bat	*Lasiurus borealis*	E-AA-U
Big Brown Bat	*Eptesicus fuscus*	E-CA-C
Hoary Bat	*Lasiurus cinereus*	E-CA-U
Western Big-eared Bat	*Plecotus townsendi*	E-AA-U
CARNIVORA		
Raccoon	*Procyon lotor*	D-CA-C
Long-tailed Weasel	*Mustela frenata*	D-CA-U
Mink	*Mustela vison*	D-AA-U
Black-footed Ferret	*Mustela nigripes*	?E-OA-F?
Badger	*Taxidea taxus*	D-AA-U
Spotted Skunk	*Spilogale putorius*	E-AA-U
Striped Skunk	*Mephitis mephitis*	D-CA-C
Coyote	*Canis latrans*	D-CA-U
Swift Fox	*Vulpes velox*	R-AA-S
Red Fox	*Vulpes fulva*	D-CA-U
Bobcat	*Lynx rufus*	D-AA-U
Mountain Lion	*Felis concolor*	R-OA-U
RODENTIA		
Black-tailed Prairie Dog	*Cynomys ludovicianus*	D-CA-U
Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*	D-CA-C
Spotted Ground Squirrel	*Citellus spilosoma*	D-OA-U
Least Chipmunk	*Eutamias minimus*	D-AA-U

TABLE 4.9-5 (Continued)
MAMMAL SPECIES LIST

Common Name	Scientific Name	Status
RODENTIA		
Eastern Fox Squirrel	*Sciurus niger*	D-CA-C
Northern Pocket Gopher	*Thomomys talpoides*	D-CA-C
Plains Pocket Gopher	*Geomys bursarius*	E-CA-U
Wyoming Pocket Mouse	*Perognathus fasciatus*	E-CA-U
Plains Pocket Mouse	*Perognathus flavescens*	E-CA-U
Silky Pocket Mouse	*Perognathus flavus*	E-CA-U
Hispid Pocket Mouse	*Perognathus hispidus*	E-CA-U
Ord Kangaroo Rat	*Dipodomys ordii*	D-CA-C
Beaver	*Castor canadensis*	D-AA-U
Plains Harvest Mouse	*Reithrodontomys montanus*	E-CA-U
Western Harvest Mouse	*Reithrodontomys megalotis*	E-CA-U
White-footed Mouse	*Peromyscus leucopus*	D-CA-C
Deer Mouse	*Peromyscus maniculatus*	D-CA-A
Northern Grasshopper Mouse	*Onychomys leucogaster*	E-CA-U
Eastern Woodrat	*Neotoma floridana*	E-AA-U
Bushy-tailed Woodrat	*Neotoma cinerea*	E-AA-U
Brown Rat	*Rattus norvegicus*	E-CA-U
House Mouse	*Mus musculus*	D-CA-C
Meadow Vole	*Microtus pennsylvanicus*	D-CA-C
Prairie Vole	*Microtus ochrogaster*	D-CA-U
Muskrat	*Ondatra zibethicus*	D-CA-C
Meadow Jumping Mouse	*Zapus hudsonicus*	D-CA-U
Porcupine	*Erethizon dorsatum*	D-CA-C
LAGOMORPHA		
White-tailed Jackrabbit	*Lepus townsendi*	D-CA-C
Black-tailed Jackrabbit	*Lepus californicus*	D-CA-U
Eastern Cottontail	*Sylvilagus floridanus*	D-CA-C
Desert Cottontail	*Sylvilagus audubonii*	?D-AA-U?
ARTIODACTYLA		
Mule Deer	*Odocoileus hemionus*	D-CA-C
White-tailed Deer	*Odocoileus virginianus*	D-CA-C
Pronghorn	*Antilocapra americana*	D-AA-C
Wapiti (Elk)	*Cervus elaphus*	D-AA-U
Bighorn Sheep	*Ovis canadensis*	D-AA-U
Bison	*Bison bison*	D-AA-C
Moose	*Alces alces*	R-OA-U
Mule Deer/White-tailed Deer Hybrid	*O. hemionus x virginianus*	D-AA-U

(See Table 2.9-5A for Status Codes)

TABLE 4.9-5A

FAUNAL SPECIES LIST - STATUS CODES

Column 1 **Documentation**

D - Documented in the course of the present study
R - Reported by knowledgeable individual(s)
E - Expected to occur - historical or recent evidence

Column 2,3 **Distribution**

CA - Within the Commerical Study Area Boundary
AA - Within the 8-km Adjacent Area Boundary
OA - Within the 80-km Outer Area Boundary

Column 4 **Abundance**

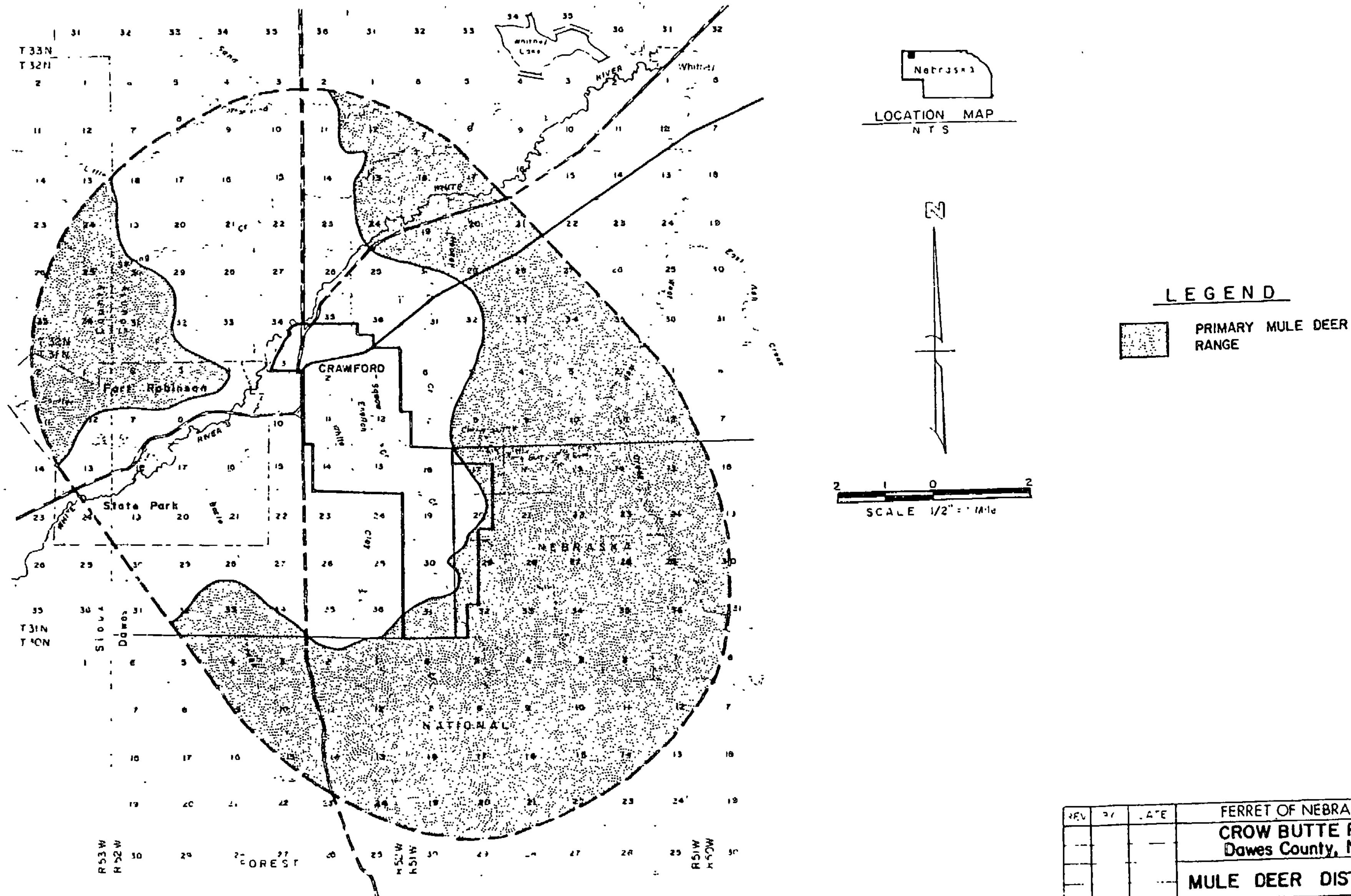
A - Abundant
C - Common
U - Uncommon
O - Occasional, Accidental, or Rare in the study area
F - Federally-listed Rare, Threatened, or Endangered
S - State-listed Rare, Threatened, or Endangered

Column 5,6 **Migratory Status (Birds Only)**

pr - permanent resident
sr - summer resident
sv - summer visitor
wv - winter visitor
m - migrant

Column 7,8 **Breeding Status (Birds Only)**

* - confirmed breeder
** - suspected breeder



REV	BY	DATE	FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			MULE DEER DISTRIBUTION
			PREPARED BY F. Harrington & Assoc.
			DRAWN BY DBD Graphics · DATE 8-1-82 · FIG. 4.9-4

CBR-014

TABLE 4.9-6

BIG GAME MAMMAL HABITAT AFFINITIES

Species	Deciduous Woodlands Obs	(%)	Coniferous Woodlands Obs	(%)	Mesophytic Shrublands Obs	(%)	Shortgrass Prairie Obs	(%)	Mixed Grass Prairie Obs	(%)	Range Rehab. Obs	(%)	Cultivated Obs	(%)	Structure Biotopes Obs	(%)	Totals Obs	(%)
Mule Deer																		
CSA*	18	(75.0)							2	(8.3)			4	(16.7)			24	(100)
Total Area	132	(15.4)	53	(6.2)					106	(12.4)	57	(6.7)	492	(57.7)	13	(1.5)	853	(100)
White-tailed Deer																		
CSA	39	(37.9)							4	(3.8)	6	(5.8)	54	(52.4)			103	(100)
Total Area	480	(55.8)	23	(2.6)	14	(1.6)			160	(18.6)	31	(3.6)	141	(16.3)	10	(1.1)	860	(100)
Pronghorn																		
CSA	(NOT PRESENT ON COMMERCIAL STUDY AREA)																	
Total Area							109	(22.1)	242	(49.1)	126	(25.6)	13	(2.6)	3	(0.4)	493	(100)

*CSA (Commercial Study Area)

The preferred habitat type during the observation period was Cultivation, with about 58 percent of deer recorded in the type. This reflects a high proportion of mule deer occurring in winter wheat fields during the period January-April. Indeed, it was determined that mule deer on the study area rely very heavily, and in some cases exclusively, on winter wheat during the late winter period. This is doubtlessly due to the relative absence of well developed shrub communities - typical winter range for the species elsewhere in the region.

Utilization of winter wheat, and the tendency to utilize haystacks in some areas, has been noted by area farmers and ranchers, who commonly voice complaints about deer damage - complaints which are reported in the local press, e.g., *"Plague of hay-eating deer herds costs area ranchers plenty"* (Page 1, The Crawford Tribune, 17 February 1982).

Group size during the period ranged from 1-39, with largest aggregations observed in March, in winter wheat fields. In May there was a general dispersal of deer into the upper elevations and away from cultivated types. Smallest group size (x=1.7) was observed in June. First fawns were seen in early July.

Distribution of mule deer within the CSA was slight, with only 3 percent of observations recorded there. In contrast to the study area proper, most mule deer on the CSA (75%) were documented in Deciduous Streambank habitat-primarily along Squaw Creek in the southeast portion of the CSA and adjacent to the Ponderosa Wildlife Area.

White-tailed deer were distributed more widely than mule deer (Figure 4.9-5) and were recorded in a greater range of habitat types (Table 4.9-6). Most commonly utilized habitats, however, were the Deciduous Woodland Types.

Herd size ranged from 1-42, with largest aggregations seen in February. During the late winter months, the deer displayed a "yarding" tendency, typical for the species, with concentrations occurring in wooded bottom-

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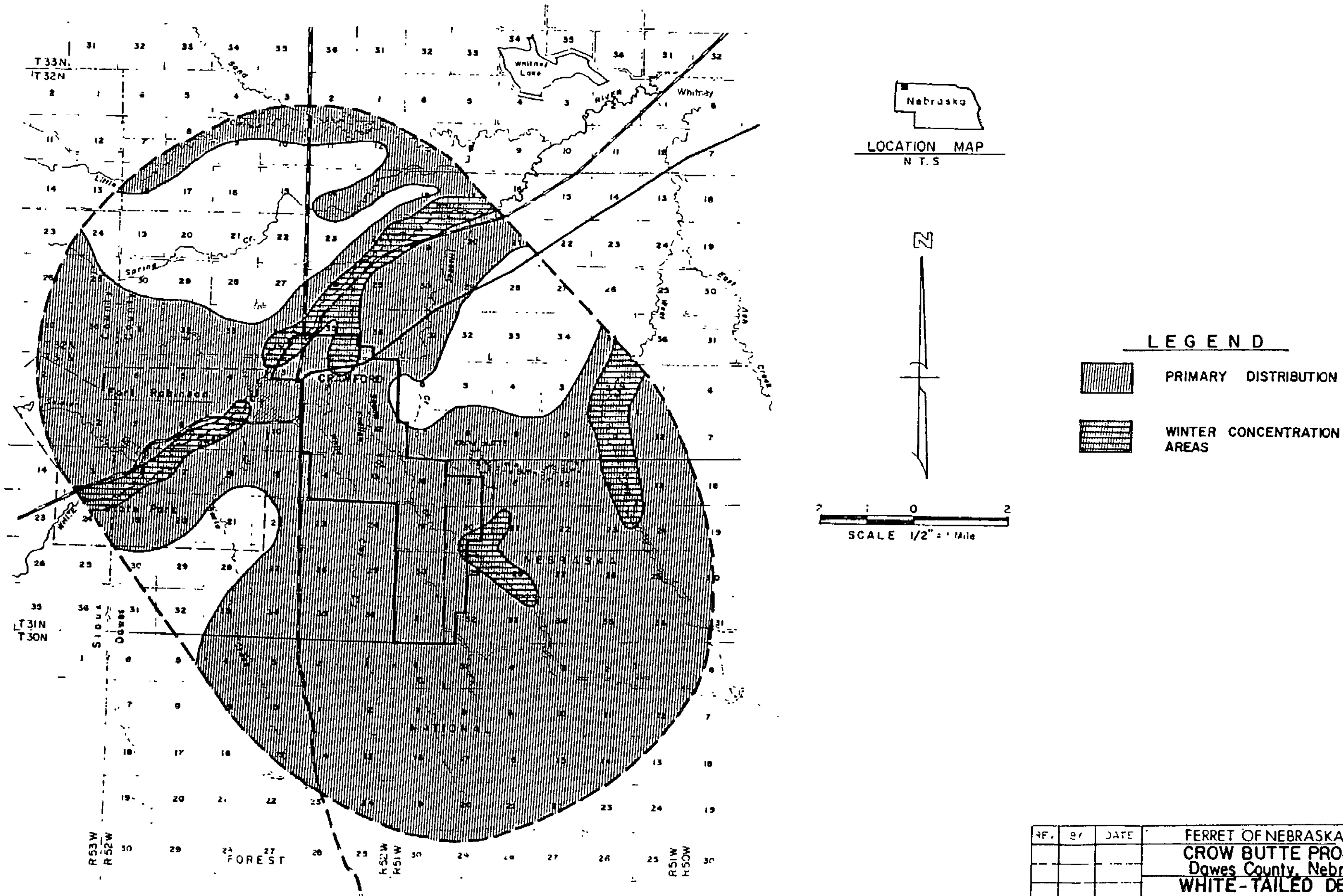

REV.	BY	DATE	FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			WHITE-TAILED DEER DISTRIBUTION
			PREPARED BY F. Harrington & Assoc.
			DRAWN BY D&D Graphics — DATE 8-1-82 — FIG. 4.9-5

lands. Like mule deer, whitetails made considerable use of winter wheat fields, but about equal use was made of winter annual forbs within the Deciduous Streambank Forest type and adjoining meadows.

In May a general dispersal was observed, with deer moving into upland drainages, although a large percentage remained along the lower watercourses. First fawns were seen in late June.

Compared to mule deer, whitetails were more commonly observed on the CSA, with 12 percent of observations recorded there. Greatest us of the CSA was observed in Woodland and Cultivated types along the lower portion of English, Squaw and White Clay Creeks, in the northern portion of the CSA.

Pronghorn in the region are divided into three separate populations (Figure 4.9-6). During the study period, the "Fort Robinson" population, consisting of 12 animals, ranged in and out of the park, northward to the outskirts of the town of Crawford. This population was restricted primarily to the Mixed grass Type (Table 4.9-6).

The "eastern" population ranged along the plains and foothills south of the White River, in Mixed Grass and Shortgrass habitat, eastward to perhaps the city of Chadron. A maximum number of 7 was recorded on the AA during the study period.

A large population of pronghorn ("northern" population), ranges over the Shortgrass prairie from the edge of the AA northward to the foothills of the Black Hills. Sagebrush communities would appear to be the preferred winter habitat of pronghorn. Since none of this habitat type is found on the CSA, no pronghorn were recorded there. During the winter months herds of up to 70 pronghorn were found in the sagebrush communities north of the study area. Most of them moved north towards the Black Hills in spring with only about 10 individuals remaining in the vicinity.

Elk or wapiti. Since the baseline studies were conducted in 1982, elk have been expanding their range (Figure 4.9-7)to include Pine Ridge south of the project area and have been moving westward in the Nebraska National Forest

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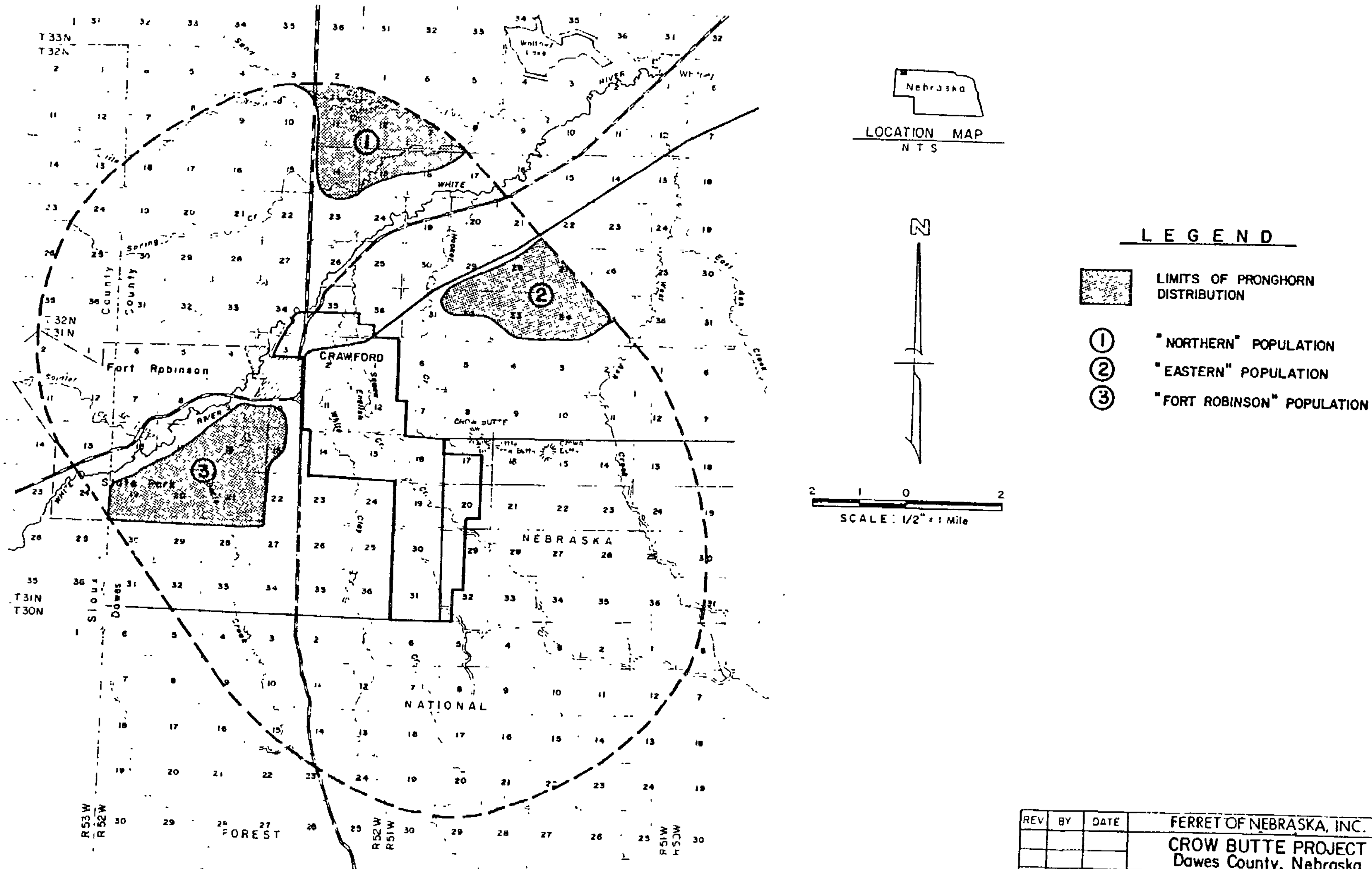
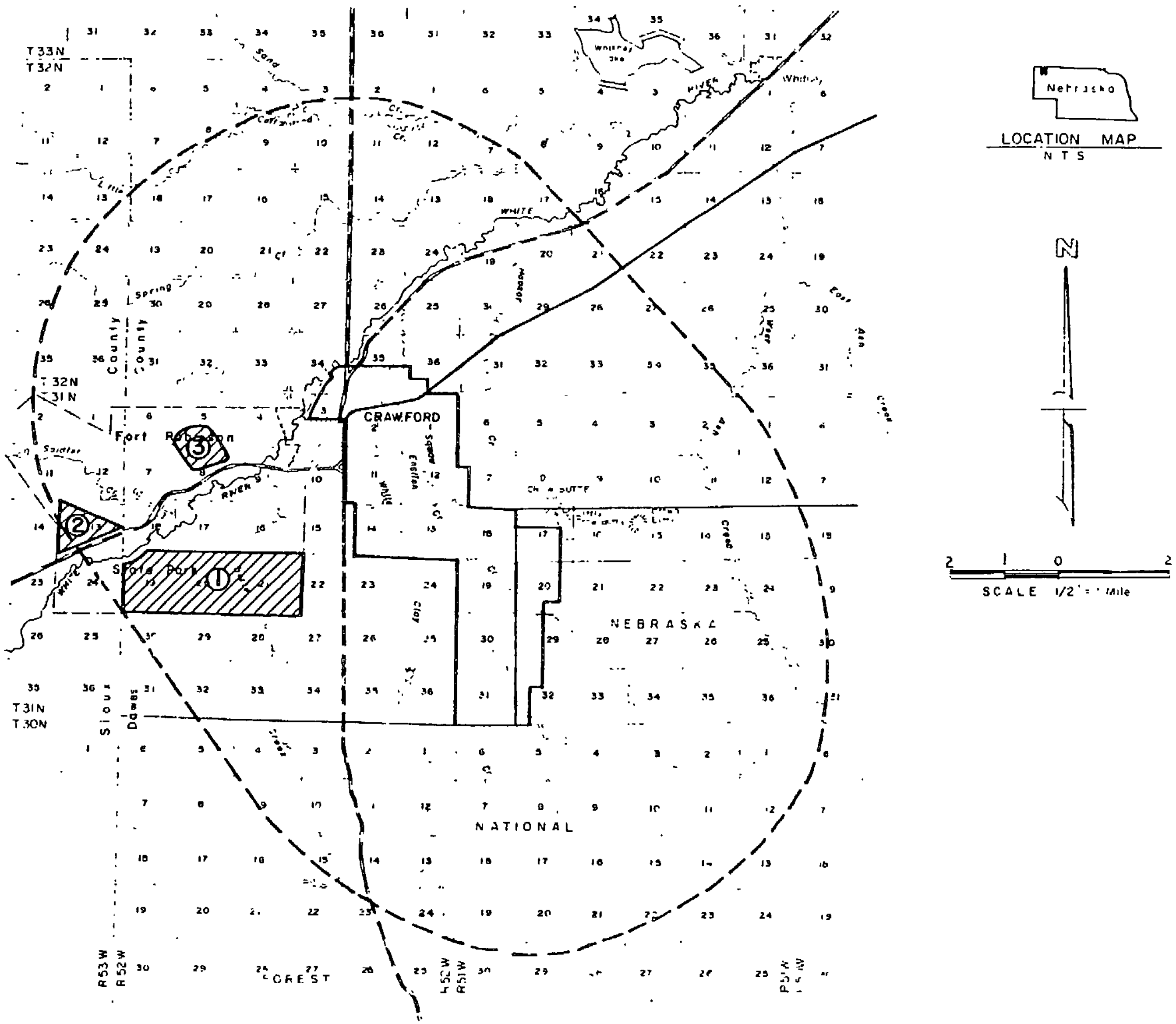


REV	BY	DATE	FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			PRONGHORN DISTRIBUTION
			PREPARED BY F. Harrington & Assoc.
			DWN BY D&D Graphics · DATE 8-1-82 · FIG. 4.9-6



LEGEND

① BISON WINTER COMPOUND

② BISON SUMMER COMPOUND

③ BIGHORN SHEEP, WAPITI COMPOUND

FERRET OF NEBRASKA, INC.

CROW BUTTE PROJECT
Dawes County, Nebraska

CAPTIVE UNGULATES
Bison, Bighorn Sheep, Wapiti
(Fort Robinson)

F. Harrington & Assoc

DBD Graphics 8-1-82 FIG. 4.9-7

CBR-014

toward the project area (Suetsuga, Lemmons, 1987). The project area could be used sporadically by elk for feeding, but it would not be classified as home territory (Prochazka 1987). Elk have also been seen more frequently north of the project area between Crawford and Harrison.

According to USFS and Nebraska Game and Parks, Ferret Nebraska's expansion to a commercial facility should have no adverse impacts on elk.

Captive Ungulates. About 200 bison are _impounded at Fort Robinson _State Park in two seasonal compounds encompassing Mixed Grass habitat (Figure 4.9-7). The animals are maintained as a tourist attraction, but are also cropped and offered as fare in the Park dining room and evening "buffalo cookouts".

Elk (8) and bighorn sheep (22) are maintained in a separate compound (Figure 4.9-7), consisting of Cliff, Ponderosa-Grassland, and Mixed Grass habitat types. One bighorn ram was reported west of the compound, and another found dead (shot) two years previously (J. Murphy, pers.comm.). There are no elk and few bighorn sheep at Fort Robinson.

One cow moose, evidently a migrant from Wyoming, was observed for a number of years west of Fort Robinson, but the species does not occur regularly in the Pine Ridge area.

Neither bison, bighorn sheep, nor moose occur on the CSA, nor are they expected to occur there.

Carnivores. Populations of carnivores on the study area are conspicuously low, compared to studies using similar methods elsewhere in the region. A number of factors is believed to contribute to the relatively low numbers: 1) a federal predator control agent has been operating in the area, 2) trapping by area residents is conducted intensively throughout the area, and 3) landowners routinely kill all carnivores encountered. Don Fryda, Animal Control Officer for the project and surrounding area, stated recently (1987) that the R&D project has had no effect on the number of calls he has received for predator control.

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The most commonly observed carnivore on the study area was the feral house cat, occurring widely and in a ratio of 5 cats per wild carnivore observed (estimated ratio, records for this species were not kept until well into the study).

Coyotes range widely throughout the study area in low numbers, with most observations in the western portion of the study area. Preferred habitats were grasslands (Table 4.9-7). An individual, believed to be a young male, was observed regularly in the central portion of the CSA. The species can be expected to range over the site in search of suitable prey such as jack-rabbits and rodents.

Red Foxes were observed primarily in cultivated habitat (Table 4.9-7). Tracks of the species, however, suggested that they ranged to some degree throughout the study area. Two dens were located north of the CSA, with 5 and 3 pups, respectively. The former den, and presumably its occupants, were destroyed by the landowner. Red fox tracks suggest that the species regularly ranges over the study area, primarily in association with stands of Yucca, which afford plentiful denning opportunities for rodents.

Tracks of bobcats were observed at widely spaced locations in Deciduous and Coniferous Woodland types within the AA. An individual was documented dead on the highway in the southern portion of the AA. The species is relatively uncommon in the area.

Striped skunks were seen primarily in roadside situations, but judging from tracks the species occurs throughout the study area in low numbers.

Long-tailed weasels are widely distributed in a variety of habitats, judging from tracks presumably of this species. An individual was found dead on the highway in the southern portion of the AA. The species can be expected to occur there in proportion to the seasonal populations of small mammals.

Evidence of badgers was recorded on the edge of the study area, north of Little Cottonwood Creek. The species can be reasonably expected to occur on the study area in low numbers.

TABLE 4.9-7

CARNIVORE HABITAT AFFINITIES

Species	Aquatic Habitats		Deciduous Woodlands		Coniferous Shrublands		Shortgrass Prairie		Mixed Grass Prairie		Range Rehab.		Cultivated		Structure Biotopes		Totals	
	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)
Coyote			2	(8.0)	4	(16.0)	2	(8.0)	17	(68.0)							25	(100)
Red Fox	1	(6.2)							1	(6.2)	1	(6.2)	12	(75.2)	1	(6.2)	16	(100)
Striped Skunk									2	(28.6)					5	(71.4)	7	(100)
Long-tailed Weasel															1*	(100)	1	(100)
Bobcat															1*	(100)	1	(100)
Raccoon	3	(13.6)	9	(40.9)	1	(4.5)					1	(4.5)	3	(13.6)	5	(22.9)	22	(100)

* Dead on Road

Tracks of a single **mink** were observed along the White River within Fort Robinson State Park. The species is relatively rare in the area and probably restricted to the larger streams.

Threatened and Endangered Carnivores which may occur in the region include **swift fox** (state designated) and **black-footed ferret** (federal designated). Approximately forty (40) sightings of swift fox (confirmed and probable) have been documented in northwest Nebraska by Nebraska Game and Parks since the late 1970's (Appendix 4.9-A). Most of these sightings have occurred west of Fort Robinson State Park. However, two confirmed and 1 probable sighting of swift fox have occurred within the 5 mile radius of the AA. These sightings were in the shortgrass prairie west of the CSA in habitat typical of the species. The closest sighting occurred just west of the CSA near Highway 2 in 1986. No sightings have occurred on the CSA and although the swift fox could use the CSA as a hunting area, the amount of cultivated land and poor condition of the range would most likely preclude the swift fox from inhabiting the CSA. Swift foxes, however, might be expected to occur in low numbers anywhere within the grassland habitat within the region. Protection of the species would appear to be problematic in the local area, however, given the intensity of trapping and poisoning.

The black-footed ferret was last observed in the state north of the study area in 1959 (USFS 1978). Its principal prey, prairie dogs, are uncommon on the study area. The two colonies, and a single observation on the CSA (Figure 4.9-8) are probably insufficient to sustain a viable ferret population. Protection of the species would appear difficult given the policy of county and state agencies to poison prairie dogs.

Other Mammals. Small mammal live-trapping was conducted during the spring season (Table 4.9-8). The most ubiquitous species, and the most abundant, was the deer mouse, occurring at every sampling site. Other species captured included white-footed mouse, 13 lined ground squirrel, and meadow mole. Greatest densities (0.16 per trap-night) were recorded in the Lower Wooded Riparian transect, and lowest (0.01 per trap-night) in the Non-Wooded Riparian. Greatest diversity (1.04, Shannon and Weaver 1949) was detected in the Shortgrass type, and lowest diversity (0.00) in the Non-Wooded Riparian and Lower Wooded Riparian types.

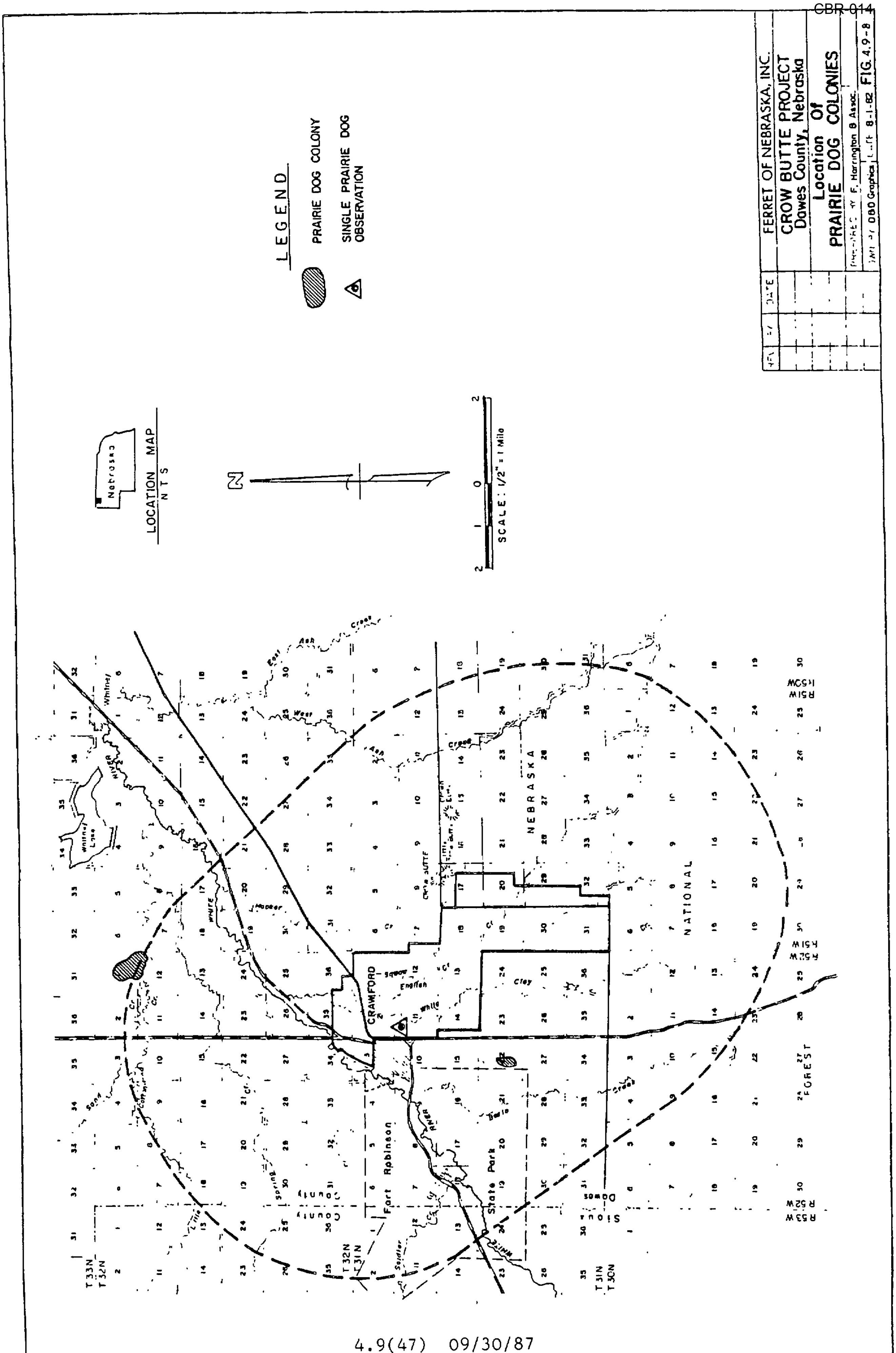

FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
Location Of
PRAIRIE DOG COLONIES
F. Harrington & Assoc.
DBD Graphics
8-1-82
FIG. 4.9-8
LEGEND
PRAIRIE DOG COLONY
SINGLE PRAIRIE DOG OBSERVATION
LOCATION MAP
NTS
Nebraska
SCALE: 1/2" = 1 Mile
CRAWFORD
Fort Robinson State Park
NEBRASKA NATIONAL FOREST
Whitney Lake
WHITE RIVER
Sioux County
Dawes County
T33N
T32N
T31N
T30N
R53W
R52W
R51W

TABLE 4.9-8

SMALL MAMMAL TRAPPING RESULTS - SPRING 1982

Species	Night	Ad	Ad	Juv	Juv	Total	Recapture	Juv: Ad	Male:Female	#/Trap-Night	Composition (%)
SHORTGRASS (150 Trap-Nights)											
Deer Mouse	1	2				2	-	-	-	.04	
	2			1		1	0	-	-	.02	
	3			1		1	1	-	-	.02	
	T	2		2		4	1	1:0: 1	-	.03	21%
Thirteen-lined Ground Squirrel	1	2	2			4	-	-	1.0: 1	.08	
	2	1	3			4	2	-	0.3: 1	.08	
	3		2			2	2	-	-	.04	
	T	3	7			10	4	-	0.4: 1	.06	53%
White-footed Mouse	1					0	-	-	-	.00	
	2	3		2		5	-	0.7: 1	-	.10	
	3					0	0	-	-	.00	
	T	3		2		5	0	0.7: 1	-	.03	26%
Totals						**19**	**6**			**.13**	**100%**

Diversity Index = 1.014

TABLE 4.9-8 (Continued)

SMALL MAMMAL TRAPPING RESULTS - SPRING 1982

Species	Night	Ad	Ad	Juv	Juv	Total	Recapture	Juv: Ad	Male:Female	#/Trap-Night	Composition (%)
PONDEROSA PINE (150 Trap-Nights)											
White-footed Mouse	1	1				1	-	-	-	.02	
	2	1				1	0	-	-	.02	
	3			1		1	0	-	-	.02	
	T	2		1		3	0	0.5: 1	-	.02	33%
Deer Mouse	1					0	-	-	-	.00	
	2					0	-	-	-	.00	
	3	3		1	1	5	-	0.7: 1	4.0: 1	.10	
	T	3		1	1	5	-	0.7: 1	4.0: 1	.03	55%
Meadow Vole	1					0	-	-	-	.00	
	2					0	-	-	-	.00	
	3	1				1	-	-	-	.02	
	T	1				1	-	-	-	.01	12%
Totals						**9**	**0**			**.06**	**100%**

Diversity Index = 0.949

TABLE 4.9-8 (Continued)

SMALL MAMMAL TRAPPING RESULTS - SPRING 1982

Species	Night	Ad	Ad	Juv	Juv	Total	Recapture	Juv: Ad	Male:Female	#/Trap-Night	Composition (%)
MIXED GRASS (150 Trap-Nights)											
Deer Mouse	1	1				1	-	-	-	.02	
	2	2				2	1	-	-	.04	
	3	1				1	1	-	-	.02	
	T	4				4	2	-	-	.03	40%
Thirteen-lined Ground Squirrel	1	1	2			3	-	-	0.5: 1	.06	
	2	1	2			3	2	-	0.5: 1	.06	
	3					0	0	-	-	.00	
	T	2	4			6	2	-	0.5: 1	.04	60%
Totals						**10**	**4**			**.06**	**100%**
Diversity Index = 0.673											
LOWER WOODED RIPARIAN (100 Trap-Nights)											
Deer Mouse	1	5	1	2		8	-	0.3: 1	7.0: 1	.16	
	2	6		1	1	8	5	0.3: 1	7.0: 1	.16	
	3					(Flood - Traps Inundated)				-	
	T	11	1	3	1	16	5	0.3: 1	7.0: 1	.16	100%
Totals						**16**	**5**			**.16**	**100%**
Diversity Index = 0.000											

TABLE 4.9-8 (Continued)

SMALL MAMMAL TRAPPING RESULTS - SPRING 1982

Species	Night	Ad	Ad	Juv	Juv	Total	Recapture	Juv: Ad	Male:Female	#/Trap-Night	Composition (%)
UPPER WOODED RIPARIAN (150 Trap-Nights)											
Deer Mouse	1	1				1	-	-	-	.02	
	2	1	1			2	1	-	1.0: 1	.04	
	3	1				1	1	-	-	.02	
	T	3	1			4	2	-	3.0: 1	.03	67%
White-footed Mouse	1	1				1	-	-	-	.02	
	2	1				1	1	-	-	.02	
	3					0	0	-	-	.00	
	T	2				2	1	-	-	.01	33%
Totals						**6**	**3**			**.04**	**100%**
Diversity Index = 0.634											
NON-WOODED RIPARIAN (150 Trap-Nights)											
Deer Mouse	1					0	-	-	-	.00	
	2				1	1	-	-	-	.02	
	3					0	-	-	-	.00	
	T				1	1	0	-	-	.01	100%
Totals						**1**	**0**			**.01**	**100%**
Diversity Index = 0.000											

TABLE 4.9-8 (Continued)

SMALL MAMMAL TRAPPING RESULTS - SPRING 1982

Species	Night	Ad	Ad	Juv	Juv	Total	Recapture	Juv: Ad	Male:Female	#/Trap-Night	Composition (%)
CULTIVATED (150 Trap-Nights)											
Deer Mouse	1			1		1	-	-	-	.02	
	2	1				1	0	-	-	.02	
	3	1				1	1	-	-	.02	
	T	2		1		3	1	0.5: 1	-	.02	60%
Thirteen-lined Ground Squirrel	1		1			1	-	-	-	.02	
	2		1			1	1	-	-	.02	
	3					0	0	-	-	.00	
	T		2			2	1	-	-	.01	40%
Totals						**5**	**2**			**.03**	**100%**

Diversity Index = 0.673

Other small mammals observed or captured during extensive trapping exercises included eastern mole (uncommon along streambanks and in Mixed Grass habitats), spotted ground squirrel (uncommon in Shortgrass habitat), northern pocket gopher (common throughout), house mouse (common in structure biotopes) and meadow jumping mouse (uncommon along streambanks).

Muskrats were recorded commonly along watercourses and occur in all permanent impoundments. Beaver are located in the White River Basin and have been introduced into Squaw Creek since 1982. It is not yet known if they have established themselves into a viable colony. Porcupines are common, ranging throughout the woodland area. Fox squirrels are abundant in woodlands, farmyards and towns.

Two species of jackrabbits range over the study area. White-tailed jackrabbits are common in grassland and cultivated areas, and black-tailed jackrabbits are relatively scarce in the same habitats. This would appear to be a reflection of the relatively cold winter climate. Eastern cottontails are common on the study area in upland as well as woodland and cultivated types. Cottontails observed in the northern portion of the AA, in Shortgrass and Sand-Sagebrush habitats, are believed to be desert cottontails, judging from the smaller size and pale coloration.

Birds

According to published sources (Johnsgard 1979, USFS 1981), 302 species of birds have been reported within 80-km of the study area. In the course of the present study, 201 species have been documented within the study area (Table 4.9-9).

Upland Game Birds. The Turkey is the most popular game bird in the region. The species is not native to the Pine Ridge area. After the introduction of 28 Merriam's Turkeys in 1959 about 29-km northwest of the CSA, the population increased to an estimated 1500-2000 birds in three breeding seasons (USFS 1978).

TABLE 4.9-9

BIRD SPECIES LIST

Common Name	Scientific Name	Status
GAVIIFORMES		
Common Loon	*Gavia immer*	R-OA-O-m
Arctic Loon	*Gavia arctica*	R-OA-O-m
PODICIPEDIFORMES		
Red-necked	*Podiceps grisegena*	R-OA-O-m
Horned Grebe	*Podiceps auritus*	D-AA-U-m
Eared Grebe	*Podiceps caspicus*	D-CA-U-sv
Western Grebe	*Aechmophorus occidentalis*	D-CA-U-sv
Pied-billed Grebe	*Podilymbus podiceps*	
PELECANIFORMES		
White Pelican	*Pelecanus erythrorhynchos*	D-AA-U-sr**
Double-crested Cormorant	*Phalacrocorax auritus*	D-CA-U-sr**
CICONIIFORMES		
Great Blue Heron	*Ardea herodias*	D-CA-U-sr
Green Heron	*Butorides virescens*	R-OA-O-m
Cattle Egret	*Bubulcus ibis*	R-OA-O-m
Great Egret	*Casmerodius albus*	R-OA-O-m
Snowy Egret	*Leucophoyx thula*	R-OA-O-m
Black-crowned Night Heron	*Nycticorax nycticorax*	D-CA-U-sr**
Yellow-crowned Night Heron	*Nyctanassa violacea*	R-OA-O-m
American Bittern	*Botaurus lentiginosus*	D-AA-U-sr**
White-faced Ibis	*Plegadia chihi*	R-OA-O-m
ANSERIFORMES		
Whistling Swan	*Olor columbianus*	R-OA-O-m
Trumpeter Swan	*Olor buccinator*	D-AA-O-m
Canada Goose	*Branta canadensis*	D-CA-U-pr
Brant	*Branta bernicla*	R-OA-U-m
White-fronted Goose	*Anser albifrons*	D-AA-U-m
Snow Goose	*Chen hyperborea*	D-CA-U-m
Mallard	*Anas plantyrhynchos*	D-CA-C-pr*
Black Duck	*Anas rubripes*	R-OA-O-m
Gadwall	*Anas strepera*	D-CA-C-sr**
Pintail	*Anas acuta*	D-CA-C-sr**
Green-winged Teal	*Anas Carolinensis*	D-CA-U-sr**
Blue-winged Teal	*Anas discors*	D-CA-C-sr**

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
ANSERIFORMES		
Cinnamon Teal	*Anas cyanoptera*	D-CA-U-sr**
American Wigeon	*Mareca americana*	D-CA-U-sr**
Northern Shoveler	*Spatula clypeata*	D-CA-C-sr**
Wood Duck	*Aix sponsa*	D-CA-U-sv**
Redhead	*Aythya americana*	D-CA-U-sv
Ring-necked Duck	*Aythya collaris*	D-AA-U-m
Canvasback	*Aythya valisineria*	D-AA-U-m
Lesser Scaup	*Aythya affinis*	D-CA-C-m
Common Goldeneye	*Bucephala clangula*	D-CA-U-m
Barrow's Goldeneye	*Bucephala islandica*	R-OA-O-wv
Bufflehead	*Bucephala albeola*	D-CA-C-m
Oldsquaw	*Clangula hyemalis*	R-OA-U-m
White-winged Scoter	*Melanitta deglandi*	R-OA-U-m
Surf Scoter	*Melanitta perspicillata*	R-OA-U-m
Black Scoter	*Oidemia nigra*	R-OA-U-m
Ruddy Duck	*Oxyura jamaicensis*	D-CA-C-sr**
Hooded Merganser	*Lophodytes cucullatus*	D-CA-U-m
Common Merganser	*Mergus merganser*	D-CA-U-m
Red-breasted Merganser	*Mergus serrator*	R-OA-O-m
FALCONIFORMES		
Turkey Vulture	*Cathartes aura*	D-CA-U-sr**
Goshawk	*Accipiter gentilis*	D-CA-U-wv
Sharped-shinned Hawk	*Accipiter striatis*	D-AA-U-pr**
Cooper's Hawk	*Accipiter cooperi*	D-AA-U-pr*
Red-tailed Hawk	*Buteo jamaicensis*	
(Light Phase)	"	D-CA-C-sr*
(Dark Phase)	"	D-AA-U-m
Red-shouldered Hawk	*Buteo lineatus*	R-OA-O-m
Broad-winged Hawk	*Buteo platypterus*	R-OA-O-m
Swainson's Hawk	*Buteo swainsoni*	R-OA-U-sr**
Rough-legged Hawk	*Buteo lagopus*	D-CA-C-wv
Ferruginous Hawk	*Buteo regalis*	D-AA-U-sr*
Golden Eagle	*Aquila chrysaetos*	D-CA-C-pr*
Bald Eagle	*Haliaeetus leucocephalus*	D-CA-F-wv
Northern Harrier	*Circus cyaneus*	D-CA-C-pr**
Osprey	*Pandion haliaetus*	R-AA-O-sv
Gyrfalcon	*Falco rusticolus*	D-AA-U-m
Prairie Falcon	*Falco mexicanus*	D-CA-C-pr**
Peregrine Falcon	*Falco peregrinus*	R-OA-F-m
Merlin	*Falco columbarius*	D-AA-U-pr**
American Kestrel	*Falco sparverius*	D-CA-A-pr*

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
GALLIFORMES		
Sharp-tailed Grouse	*Pedioecetes phasianellus*	D-CA-C-pr*
Bobwhite	*Colinus virginianus*	R-OA-O-pr
Ring-necked Pheasant	*Phasianus colchicus*	D-CA-C-pr*
Turkey	*Meleagris gallopavo*	D-AA-C-pr*
Gray Partridge	*Perdix perdix*	D-AA-O-pr**
GRUIFORMES		
Sandhill Crane	*Grus canadensis*	D-OA-U-m
Virginia Rail	*Rallus limicola*	D-AA-U-sr**
Sora Rail	*Porzana carolina*	D-CA-U-sr**
American Coot	*Fulica americana*	D-CA-C-sr**
CHARADRIIFORMES		
Semipalmated Plover	*Charadrius semipalmatus*	R-OA-U-m
Piping Plover	*Charadrius melodus*	R-OA-U-m
Snowy Plover	*Charadrius alexandrinus*	R-OA-O-m
Killdeer	*Charadrius vociferus*	D-CA-C-sr*
American Golden Plover	*Pluvialis dominica*	R-OA-U-m
Black-bellied Plover	*Squatarola squatarola*	D-AA-U-m
Marbled Godwit	*Lemosa fedoa*	D-AA-U-m
Whimbrel	*Numenius phaeopus*	R-OA-O-m
Long-billed Curlew	*Numenius americanus*	D-AA-U-sr**
Upland Sandpiper	*Bartramia longicauda*	D-AA-U-sr**
Greater Yellowlegs	*Totanus melanoleucus*	D-CA-C-m
Lesser Yellowlegs	*Totanus flavipes*	D-CA-C-m
Solitary Sandpiper	*Tringa solitaria*	D-CA-U-m
Willet	*Catoptrophorus semipalmatus*	D-CA-U-sr**
Spotted Sandpiper	*Actitis macularia*	D-CA-C-sr**
Common Snipe	*Capella gallinago*	D-CA-C-pr*
Short-billed Dowitcher	*Limnodromus griseus*	R-OA-U-m
Long-billed Dowitcher	*Limnodromus scolopaceus*	D-AA-C-m
Red Knot	*Calidris canutus*	R-OA-O-m
Sanderling	*Calidris alba*	D-AA-U-m
Semipalmated Sandpiper	*Ereunetes pusillus*	D-AA-U-m
Western Sandpiper	*Ereunetes mauri*	R-OA-U-m
Least Sandpiper	*Eriola minutilla*	D-CA-U-m
White-rumped Sandpiper	*Eriola fuscicollis*	R-OA-U-m
Baird's Sandpiper	*Eriola bairdii*	D-AA-C-m
Pectoral Sandpiper	*Eriola melanotos*	R-OA-U-m
Stilt Sandpiper	*Micropalama himantopus*	D-AA-C-m

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
CHARADRIIFORMES		
Buff-breasted Sandpiper	*Tryngites subrufficollis*	R-OA-U-m
American Avocet	*Recurvirostra americana*	D-AA-C-sr**
Wilson's Phalarope	*Steganopus tricolor*	D-CA-C-sr**
Northern Phalarope	*Lobipes lobatus*	D-AA-U-m
Parasitic Jaeger	*Stercorarius parasiticus*	R-OA-O-m
Herring Gull	*Larus argentatus*	R-OA-U-m
California Gull	*Larus californicus*	R-OA-U-m
Ring-billed Gull	*Larus delawarensis*	D-CA-C-sv
Black-headed Gull	*Larus ridibundus*	R-OA-O-m
Franklin's Gull	*Larus pipixcan*	D-AA-C-sv
Bonaparte's Gull	*Larus philadelphia*	R-OA-U-m
Forster's Tern	*Sterna forsteri*	D-AA-U-sv
Common Tern	*Sterna hirundo*	R-OA-O-m
Little (Least Interior) Tern	*Sterna albifrons*	R-OA-S-m
Black Tern	*Chlidonias niger*	D-AA-U-sr**
COLUMBIFORMES		
Mourning Dove	*Zenaidura macroura*	D-CA-A-sr*
Rock Dove	*Columba livia*	D-CA-C-pr*
CUCULIFORMES		
Yellow-billed Cuckoo	*Coccyzus americanus*	D-CA-U-sr**
Black-billed Cuckoo	*Coccyzus erythropthalmus*	D-CA-U-sr**
STRIGIFORMES		
Barn Owl	*Tyto alba*	D-AA-U-pr**
Screech Owl	*Otus asio*	D-AA-U-pr**
Great Horned Owl	*Bubo virginianus*	D-CA-C-pr*
Snowy Owl	*Nyctea scandiaca*	R-OA-U-wv
Burrowing Owl	*Speotyto cunicularia*	D-AA-U-sr*
Barred Owl	*Strix varia*	R-OA-O-pr
Long-eared Owl	*Asio otus*	R-OA-U-pr
Short-eared Owl	*Asio flammeus*	D-CA-U-pr**
Saw-whet Owl	*Aegolius Acadicus*	D-AA-U-pr**

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
CAPRIMULGIFORMES		
Common Poor-will	*Phalaenoptilus nuttallii*	D-AA-U-sr**
Common Nighthawk	*Chordeiles minor*	D-CA-C-sr**
APODIFORMES		
Chimney Swift	*Chaetura pelagica*	D-AA-U-sr**
White-throated Swift	*Aeronautes saxatalis*	D-AA-U-sr**
Broad-tailed Hummingbird	*Selasphorus platycercus*	R-OA-O-m
Rufous Hummingbird	*Selasphorus rufus*	R-OA-O-m
CORACIIFORMES		
Belted Kingfisher	*Megaceryle alcyon*	D-CA-U-sr**
PICIFORMES		
Common Flicker	*Colaptes auratus*	D-CA-C-pr*
Red-bellied Woodpecker	*Centurus carolinus*	R-OA-O-sr
Red-headed Woodpecker	*Melanerpes erythrocephalus*	D-CA-C-sr*
Lewis' Woodpecker	*Asyndesmus lewis*	D-AA-U-sr**
Yellow-bellied Sapsucker	*Sphyrapicus varius*	R-OA-U-m
Hairy Woodpecker	*Dendrocopos villosus*	D-CA-C-pr**
Downy Woodpecker	*Dendrocopos pubescens*	D-CA-C-pr**
PASSERIFORMES		
Tyannidae		
Eastern Kingbird	*Tyrannus tyrannus*	D-CA-C-sr*
Western Kingbird	*Tyrannus verticalis*	D-CA-C-sr*
Cassin's Kingbird	*Tyrannus vociferans*	R-OA-U-sv
Scissor-tailed Flycatcher	*Muscivora forfic*	R-OA-O-m
Great Crested Flycatcher	*Myiarchus crinitus*	D-CA-U-sr**
Eastern Phoebe	*Sayornis phoebe*	D-AA-U-sr**
Say's Phoebe	*Sayornis saya*	D-CA-U-sr**
Black Phoebe	*Sayornis nigricans*	D-AA-O-m
Willow Flycatcher	*Empidonax traillii*	D-AA-U-sr**
Least Flycatcher	*Empidonax minimus*	D-AA-U-m
Hammond's Flycatcher	*Empidonax hammondii*	R-OA-O-m
Western Flycatcher	*Empidonax difficilis*	R-OA-O-m
Eastern Pewee	*Contopus virens*	D-AA-U-sr**
Western Pewee	*Contopus sordidulus*	D-CA-C-sr*
Olive-sided Flycatcher	*Nuttalornis borealis*	R-OA-U-m

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
Alaudidae		
Horned Lark	*Eremophila alpestris*	D-CA-C-pr*
Hirundinidae		
Violet-green Swallow	*Tachycineta thallassina*	D-CA-U-sr**
Tree Swallow	*Iridoprocne bicolor*	D-CA-U-sr**
Bank Swallow	*Riparia riparia*	D-CA-C-sr*
Rough-winged Swallow	*Stelgidopteryx ruficollis*	D-CA-U-sr**
Barn Swallow	*Hirundo rustica*	D-CA-C-sr*
Cliff Swallow	*Petrochelidon pyrrhonota*	D-CA-C-sr*
Purple Martin	*Progne subis*	R-OA-O-m
Corvidae		
Gray Jay	*Perisoreus canadensis*	R-OA-O-wv
Blue Jay	*Cyanocitta cristata*	R-CA-C-pr**
Steller's Jay	*Cyanocitta stelleri*	R-OA-O-wv
Black-billed Magpie	*Pica pica*	D-CA-C-pr*
American Crow	*Corvus brachyrhynchos*	D-CA-C-pr*
Pinyon Jay	*Gymnorhinus cyanocephalus*	D-CA-C-pr**
Clark's Nutcracker	*Nucifraga columbiana*	R-OA-O-wv
Paridae		
Black-capped Chickadee	*Parus atricapillus*	D-CA-C-pr**
Tufted Titmouse	*Parus bicolor*	R-OA-O-m
Sittidae		
White-breasted Nuthatch	*Sitta carolinensis*	D-CA-C-pr**
Red-breasted Nuthatch	*Sitta canadensis*	D-CA-C-pr**
Pygmy Nuthatch	*Sitta pygmaea*	D-AA-C-pr**
Certhiidae		
Brown Creeper	*Certha familiaris*	D-AA-U-pr**
Cinclidae		
Dipper	*Cinclus mexicanus*	R-OA-U-wv

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
Troglodytidae		
Northern House Wren	*Troglodytes aedon*	D-CA-C-sr**
Winter Wren	*Troglodytes troglodytes*	R-OA-U-wv
Bewick's Wren	*Thryomanes bewickii*	R-OA-O-m
Carolina Wren	*Thryothorus ludovicianus*	R-OA-O-m
Marsh Wren	*Telmatodytes palustris*	D-AA-U-sr**
Canyon Wren	*Catherpes mexicanus*	R-OA-O-wv
Rock Wren	*Salpinctes obsoletus*	D-AA-U-sr**
Mimidae		
Mockingbird	*Mimus polyglottos*	R-OA-U-sv
Gray Catbird	*Dumetella carolinensis*	D-CA-C-sr**
Brown Thrasher	*Toxostoma rufum*	D-CA-C-sr**
Sage Thrasher	*Orescoptes montanus*	R-OA-U-sv
Turdidae		
American Robin	*Turdus migratorius*	D-CA-C-sr*
Wood Thrush	*Hylocichla mustelina*	D-AA-U-m
Hermit Thrush	*Hylocichla guttata*	D-AA-U-m
Swainson's Thrush	*Hylocichla ustulata*	D-CA-C-m
Gray-cheeked Thrush	*Hylocichla ustulata*	D-CA-C-m
Veery	*Hylocichla fuscenscens*	D-CA-U-m
Eastern Bluebird	*Sialia sialis*	R-OA-U-sv
Mountain Bluebird	*Sialia currucoides*	D-CA-C-sr**
Townsend's Solitaire	*Myadestes townsendi*	D-AA-U-pr**
Sylviidae		
Blue-gray Gnatcatcher	*Polioptila caerulea*	R-OA-O-m
Golden-crowned Kinglet	*Regulus satrapa*	R-OA-U-m
Ruby-crowned Kinglet	*Regulus calendula*	D-AA-U-m
Motacillidae		
Water Pipit	*Anthus spinoletta*	D-AA-C-m
Bombycillidae		
Bohemian Waxwing	*Bombycilla garrulus*	D-CA-C-wv
Cedar Waxwing	*Bombycilla cedrorum*	D-PA-C-sr**

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
Laniidae		
Northern Shrike	*Lanius excubitor*	D-CA-U-wv
Loggerhead Shrike	*Lanius ludovicianus*	D-CA-U-sr**
Sturnidae		
European Starling	*Sturnus vulgaris*	D-CA-C-pr*
Vireonidae		
White-eyed Vireo	*Vireo griseus*	R-OA-O-m
Bell's Vireo	*Vireo bellii*	D-AA-U-sr**
Yellow-throated Vireo	*Vireo flavifrons*	R-OA-O-m
Solitary Vireo	*Vireo solitarius*	R-OA-U-sv
Red-eyed Vireo	*Vireo olivaceus*	D-CA-C-sr**
Philadelphia Vireo	*Vireo philadelphicus*	R-OA-O-m
Warbling Vireo	*Vireo gilvus*	D-CA-C-sr**
Parulidae		
Black and White Warbler	*Mniotilta varia*	D-AA-U-m
Prothonotary Warbler	*Protonotaria citrea*	R-OA-O-m
Tennessee Warbler	*Vermivora peregrina*	D-AA-U-m
Orange-crowned Warbler	*Vermivora celata*	D-CA-U-m
Nashville Warbler	*Vermivora ruficapilla*	D-AA-U-m
Northern Parula	*Parula Americana*	R-OA-U-m
Yellow Warbler	*Dendroica petechia*	D-CA-C-sr**
Magnolia Warbler	*Dendroica magnolia*	R-OA-U-m
Cape May Warbler	*Dendroica tigrina*	R-OA-U-m
Yellow-rumped Warbler	*Dendroica coronata*	
(Audubon Race)	"	D-CA-C-sr**
(Myrtle Race)	"	D-CA-U-m
Townsend's Warbler	*Dendroica townsendi*	R-OA-U-m
Black-throated Green Warbler	*Dendroica virens*	R-OA-U-m
Cerulean Warbler	*Dendroica cerulea*	R-OA-O-m
Blackburnian Warbler	*Dendroica fusca*	R-OA-O-m
Chestnut-sided Warbler	*Dendroica pensylvanica*	R-OA-U-m
Blackpoll Warbler	*Dendroica striata*	D-AA-U-m
Palm Warbler	*Dendroica palmarum*	R-OA-U-m
Ovenbird	*Seiurus aurocapillus*	D-AA-U-sr**
Northern Waterthrush	*Seiurus noveboracensis*	D-CA-U-m

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
PARULIDAE		
Mourning Warbler	*Oporornis philadelphia*	R-OA-O-m
MacGillivray's Warbler	*Oporornis tolmiei*	R-OA-U-m
Common Yellowthroat	*Geothlypis trichas*	D-CA-C-sr**
Yellow-breasted Chat	*Icteria virens*	D-CA-C-sr**
Hooded Warbler	*Wilsonia citrina*	R-OA-O-m
Wilson's Warbler	*Wilsonia pusilla*	D-AA-C-m
American Redstart	*Setophaga ruticilla*	D-RA-C-sr**
Ploceidae		
House Sparrow	*Passer domesticus*	D-CA-C-pr*
Icteridae		
Bobolink	*Dolichonyx oryzivorus*	D-CA-U-sr**
Eastern Meadowlark	*Sturnella magna*	D-AA-U-sr**
Western Meadowlark	*Sturnella neglecta*	D-CA-C-sr*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	D-CA-U-sr**
Red-winged Blackbird	*Agelaius phoeniceus*	D-CA-C-sr*
Orchard Oriole	*Icterus spurius*	D-CA-C-sr**
Northern (Bullock) Oriole	*Icterus galbula*	D-CA-U-sr**
Rusty Blackbird	*Euphagus carolinus*	R-OA-U-m
Brewer's Blackbird	*Euphagus cyanocephalus*	D-CA-U-sr**
Common Grackle	*Quiscalus quiscula*	D-CA-C-sr**
Brown-headed Cowbird	*Molothrus ater*	D-CA-C-sr**
Thraupidae		
Western Tanager	*Piranga ludoviciana*	D-CA-U-sr**
Scarlet Tanager	*Piranga olivacea*	R-OA-O-m
Fringillidae		
Cardinal	*Richmondena cardinalis*	R-OA-O-pr
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	R-OA-U-m
Blue Grosbeak	*Guiraca caerulea*	D-CA-U-sr**
Indigo Bunting	*Passerina cyanea*	D-CA-U-sr**
Lazuli Bunting	*Passerina amoena*	D-CA-C-sr**
Indigo x Lazuli Hybrid	*P. cyanea x amoena*	D-CA-U-sr**

TABLE 4.9-9 (Continued)

BIRD SPECIES LIST

Common Name	Scientific Name	Status
FRINGILLIDAE		
Dickcissel	*Spiza americana*	R-OA-U-sv
Evening Grosbeak	*Herperiphona vespertina*	D-AA-C-wv
Purple Finch	*Carpodacus purpureus*	R-OA-U-m
Cassin's Finch	*Carpodacus cassinii*	R-OA-U-m
House Finch	*Carpodacus mexicanus*	D-CA-U-m
Pine Grosbeak	*Pinicola enucleator*	R-OA-O-wv
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*	R-OA-U-wv
Common Redpoll	*Acanthis flammea*	R-OA-U-wv
Pine Siskin	*Spinus pinus*	D-CA-C-pr**
American Goldfinch	*Spinus tristis*	D-CA-C-pr**
Red Crossbill	*Loxia curvirostra*	D-AA-A-pr**
White-winged Crossbill	*Loxia leucoptera*	R-OA-O-wv
Green-tailed Towhee	*Chlorura chlorura*	R-OA-O-m
Rufous-sided Towhee	*Pipilo erythrophthalmus*	D-CA-C-sr**
Lark Bunting	*Calamospiza melanocoryx*	D-CA-C-sr**
Savannah Sparrow	*Passerculus sandwichensis*	D-CA-C-m
Grasshopper Sparrow	*Ammodramus savannarum*	D-AA-U-m
Vesper Sparrow	*Pooecetes gramineus*	D-CA-U-sr**
Lark Sparrow	*Chondestes grammacus*	D-CA-C-sr*
Black-throated Sparrow	*Amphispiza bilineata*	R-OA-O-m
Dark-eyed Junco	*Junco hyemalis*	
(White-winged Race)	"	D-CA-C-pr**
(Slate-colored Race)	"	D-CA-C-wv
(Oregon Race)	"	D-CA-C-wv
(Gray-headed Race)	"	D-AA-U-m
Tree Sparrow	*Spizella arborea*	D-CA-C-wv
Chipping Sparrow	*Spizella passerina*	D-CA-C-sr**
Clay-colored Sparrow	*Spizella pallida*	D-CA-C-sr**
Brewer's Sparrow	*Spizella breweri*	D-AA-U-sr**
Field Sparrow	*Spizella pusilla*	R-OA-U-m
Harris' Sparrow	*Zonotrichia querula*	R-OA-U-m
White-crowned Sparrow	*Zonotrichia leucophrys*	D-CA-C-m
White-throated Sparrow	*Zonotrichia albicollis*	R-OA-U-m
Fox Sparrow	*Passerella iliaca*	R-OA-O-m
Lincoln's Sparrow	*Melospiza lincolnii*	D-AA-U-m
Swamp Sparrow	*Melospiza georgiana*	R-OA-O-m
Song Sparrow	*Melospiza melodia*	D-CA-C-wv
McCown's Longspur	*Rhynchophanes mccownii*	D-AA-U-sr**
Lapland Longspur	*Calcarius lapponicus*	D-AA-C-m
Chestnut-collared Longspur	*Calcarius ornatus*	D-AA-U-sr**
Snow Bunting	*Plectrophenax nivalis*	D-AA-C-wv

SEE TABLE 2.9-5A FOR STATUS CODES

The turkey is widely distributed on the study area, primarily along the foothills and plateaus, within the Ponderosa habitat, and along drainages in the northern portion of the study area. Of 701 observations of the species from January to mid-July, most (38%) were observed in structure biotopes, mainly farmyards, with 24 percent in Deciduous Woodlands, 21 percent in Coniferous Woodlands, and the remainder in Cultivated, Mixed Grass, and Range Rehabilitation types (Table 4.9-10).

In winter, nearly all observations of the species were in four concentration areas, inside the study area and outside, where the birds were being fed or were feeding among livestock in farmyard situations: 1) Lux Ranch (AA) - 55, 2) Ponderosa Wildlife Area (AA) - 20, 3) Ostermeyer Ranch (10-km northwest of the AA) - 200, and 4) Johnson Ranch (2-km southwest of the AA) - 150. The total winter population was estimated at 450 birds, including 350 outside the study area. Additional concentrations in the OA were recorded between Whitney and Chadron, along the White River in farmyard situations (about 500). Only about 75 birds in the study area proper, and none within the CSA.

In spring, there was a broad dispersal of birds away from the winter concentration areas. Courtship was first observed 30 March, and shortly thereafter males with harems were observed primarily in woodland habitats at widely separated locations.

In May, tracks of a single turkey were documented along Squaw Creek within Section 19 - the only record of the species on the CSA. The first brood (5 young) was observed east of the CSA on 27 June.

In summary, the turkey constitutes a semi-domesticated bird in this area. There are no historical records of turkeys in the region probably because there is inadequate winter habitat, and an absence of mast-produced trees. Birds, therefore, are required to rely on supplemental feeding in winter. Although the species does not regularly occur on the CSA, it may be expected to occur in proportion to the amount of supplemental winter feeding offered by local landowners.

TABLE 4.9-10

GAME BIRD HABITAT AFFINITIES

Species	Riverine Habitats Obs	(%)	Deciduous Woodlands Obs	(%)	Coniferous Woodlands Obs	(%)	Mixed Grass Prairie Obs	(%)	Range Rehab. Obs	(%)	Cultivated Obs	(%)	Structure Biotopes Obs	(%)	Totals Obs	(%)
Sharp-tailed Grouse																
CSA*			10	(58.8)			5	(29.4)	2	(11.8)					17	(100)
Total Area			10	(8.1)	2	(1.6)	80	(65.0)	4	(3.2)	10	(8.1)	17	(14.0)	123**	(100)
Pheasant																
CSA	2	(2.3)	9	(10.7)			2	(2.3)	16	(19.0)	4	(4.8)	51	(60.9)	84	(100)
Total Area	5	(2.9)	24	(13.9)			10	(5.8)	18	(10.4)	12	(6.9)	104	(60.1)	173	(100)
Turkey																
CSA					(NOT OBSERVED ON COMMERCIAL STUDY AREA)											
Total Area			167	(23.8)	148	(21.1)	12	(1.7)	29	(4.1)	80	(11.4)	265	(37.9)	701	(100)
Gray Partridge																
CSA					(NOT OBSERVED ON COMMERCIAL STUDY AREA)											
Total Area													2	(100)	2	(100)

* CSA (Commercial Study Area) ** Excludes 568 Observations on Leks

Pheasants are common on the study area, with about half the observations recorded on the CSA. Preferred habitats (Table 4.9-10) were structure biotopes and cultivated types, with most pheasants observed in roadside situations.

Pheasant crowing counts were conducted along a route lying largely within the CSA (Table 4.9-11; Figure 4.9-9). Number of calls for the route (20 listening stations, 2 minutes each) ranged from 15 in April to 106 in late May, with courtship activity declining sharply thereafter. Based on the above counts and taking into consideration the sex ratio observed during the same period (0.68 females/male), the total CSA population was estimated at 180 birds in spring. Most of those were distributed from the central portion of the CSA northward. The first pheasant brood was observed 27 June (5 young).

Sharp-tailed grouse are common on the study area, distributed primarily in foothills areas and plains. During the study period the preferred habitat was Mixed Grass Prairie (Table 4.9-10).

In spring, an intensive search revealed the presence of 6 sharptail leks within the study area, and 2 additional leks on the perimeter (Table 4.912; Figure 4.9-9). Peak mate attendance ranged from 4 to 33 (x=15.6). Activity on the leks was evident from mid-April into late May, with the peak of attendance from late April into early May.

No lek was found on the CSA, and only about 10% of birds were recorded there. The absence of leks may be due to 1) the higher level of disturbance which exists on the CSA (roads, railroads, farming activities), 2) unfavorable climatic conditions, much of the CSA lies within a wind-lane in the eastern part of the valley. Sharptails typically display reduced activity on windy days, 3) the high level of raptor activity and abundance of raptor perching sites on the CSA, telephone and power transmission poles, including two high voltage electric transmission lines.

One pair of Gray Partridge was observed on 26 June in the AA, in a roadside situation adjacent to a Range Rehabilitation area about 4-km northeast of the CSA. This is the first record of the species in the area.

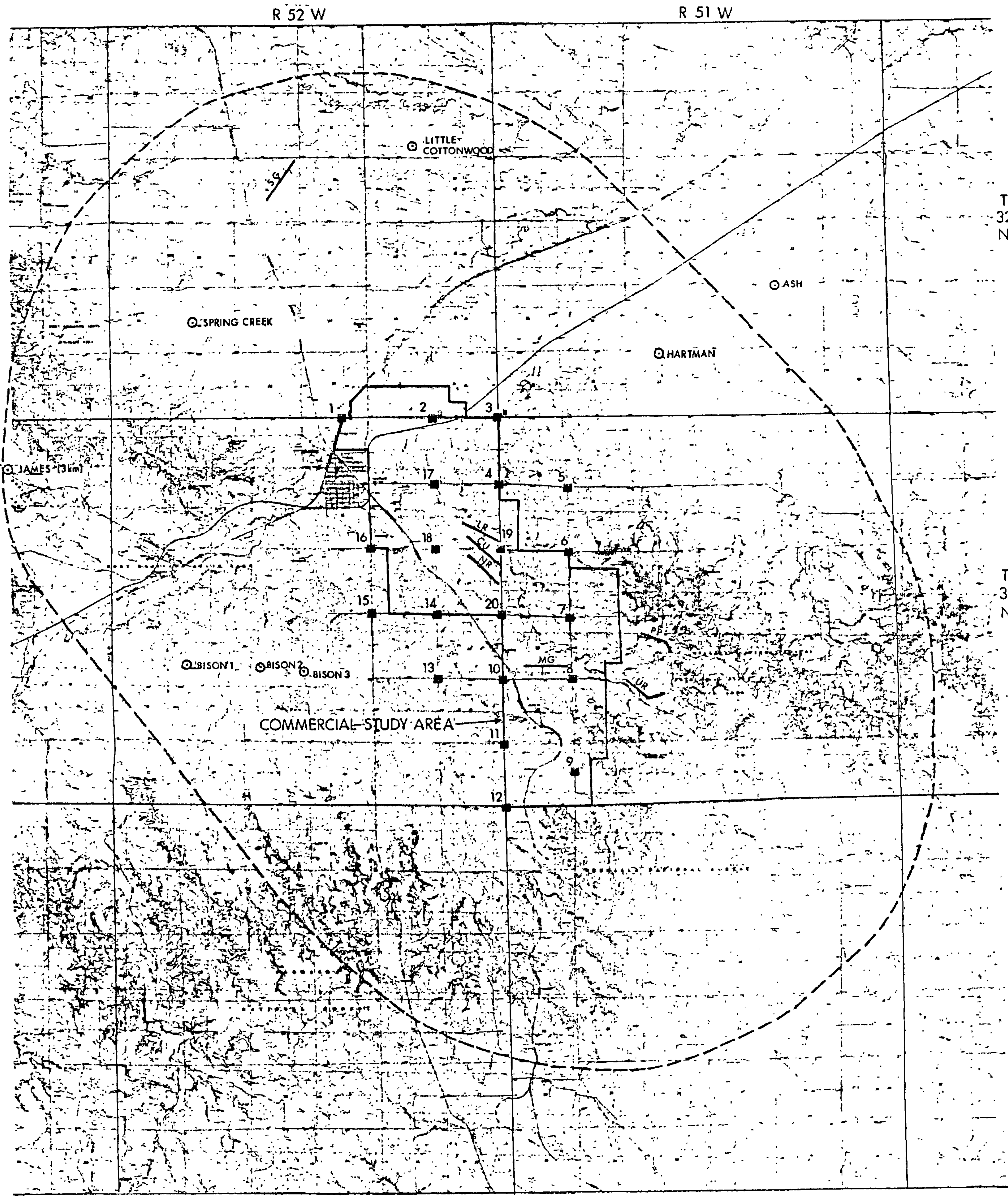
TABLE 4.9-11

PHEASANT AND DOVE CALLING COUNTS*

Station	Pheasant 22 April 82	Pheasant 17 May 82	Pheasant 25 May 82	Dove 25 May 82
1	0	2	2	41
2	2	4	2	46
3	0	0	0	2
4	3	0	2	54
5	0	1	1	30
6	0	0	0	0
7	0	0	0	15
8	0	2	0	5
9	0	1	0	0
10	0	5	5	28
11	1	3	6	30
12	1	2	5	41
13	0	0	1	7
14	2	1	12	37
15	0	1	5	11
16	1	1	5	31
17	2	3	5	25
18	1	1	6	13
19	2	2	9	6
20	0	2	4	21
Total Calls	15	31	106	443
Males Observed	0	2	2	-
Females Observed	0	0	0	-
Total Birds Observed	0	2	2	87

* Calls per Two-Minute Interval

CBR-014

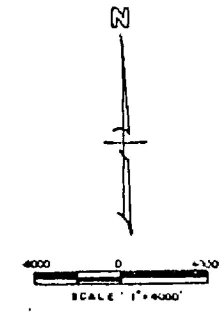


L E G E N D

- ⊙ SHARP-TAILED GROUSE LEK
- ■ LISTENING STATION (Pheasant and Dove Counts)

BIRD AND SMALL MAMMAL SAMPLING LOCATIONS

SG	SHORTGRASS
MG	MIXED GRASS
CU	CULTIVATED
LR	LOWER WOODED RIPARIAN
UR	UPPER WOODED RIPARIAN
NR	NON-WOODED RIPARIAN
PP	PONDEROSA PINE



REV DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	UPLAND GAME BIRD PHENOMENA AND SAMPLING LOCATIONS		
	PREPARED BY: FEN		
	DWN BY: JC	DATE: 8/5/87	FIGURE 4.9-9

4.9(68) 09/30/87

TABLE 4.9-12

SHARP-TAILED GROUSE LEK COUNTS

Lek Name	Date Located	No. Counts	Peak Male Attendance	Highest Count (M&F)
Bison 1	11 March	11	18 (14 April)	18 (14 April)
Bison 2	22 April	6	11 (24 April)	11 (24 April)
Bison 3	24 April	5	16 (17 May)	18 (28 April)
James	18 April	6	19 (18 April)	19 (18 April)
Spring Creek	22 April	6	33 (22 April)	34 (22 April)
Little Cottonwood	22 April	5	4	5 (22 April)
Hartman	21 April	5	13 (17 May)	13 (17 May)
Ash	23 April	4	11 (24 April)	11 (24 April)
Totals, 1982			125	128
$\bar{x}$, 1982			15.6	16.0

Mourning Doves are abundant throughout the study area during the summer residence period. Count data (Table 4.9-11) compare favorably with other areas in the region. The species is common on the CSA.

Bobwhite Quail were reported by local residents as common in the past, but were evidently extirpated. The species was not recorded on the study area. If present, the distinctive calls of the species would most certainly have been heard. The demise of the species in the local area would appear to reflect the on-going degradation of riparian areas due to over-grazing and deleterious land practices, patterns which have doubtlessly led to the decline of other species as well.

Raptors. A large number of raptor species was documented on the study area, a reflection of the diversity in habitat types and the existence of a large number of suitable nesting sites such as trees and cliff sites.

Golden Eagles are permanent residents of the area, ranging over most of the study area in a variety of habitats. Most eagles (55%) were observed perched on cliffs and escarpments (Table 4.9-13). Indeed, eagles, perched on escarpments, could be observed at any time within the study area, if one chose to scan the area with a spotting scope. The presence of 5 active golden eagle nesting territories on the study area (Table 4.9-14; Figure 4.9-10) would suggest that the species is at saturation density in the area. The presence of another territory along Sand Creek in the northern AA was deemed possible, but only red-tailed hawks (below) were found there. All golden eagle nests were located on northeast cliff exposures, perhaps a reflection of temperatures during the late nesting period, and all appeared to have been used for several years, if not decades.

The eagle distribution pattern suggested that the CSA falls chiefly within the territory of the pair occupying GE-1, about 200m south of the CSA boundary. The nest was reported by the landowner (Lux) as active for the past several years. Nesting was unsuccessful in 1982. Incubation was first observed on 28 March. The female assumed a brooding position on 25 April, but abandoned the nest on 7 May. She attended an alternate nest (GE-1A1) for several days and then departed. We are not certain to what

TABLE 4.9-13

RAPTOR HABITAT AFFINITIES*

Species	Cliff Sites Obs	Cliff Sites (%)	Riverine Habitats Obs	Riverine Habitats (%)	Deciduous Woodlands Obs	Deciduous Woodlands (%)	Coniferous Woodlands Obs	Coniferous Woodlands (%)	Shortgrass Prairie Obs	Shortgrass Prairie (%)	Mixed Grass Prairie Obs	Mixed Grass Prairie (%)	Range Rehab. Obs	Range Rehab. (%)	Cultivated Obs	Cultivated (%)	Structure Biotopes Obs	Structure Biotopes (%)	Totals Obs	Totals (%)
Golden Eagle**	44	(55.0)	.		9	(11.3)	5	(6.3)			8	(10.0)	4	(5.0)	6	(7.6)	3	(3.8)	80	(100)
Bald Eagle**					3	(60.0)	2	(40.0)											5	(100)
Red-tailed Hawk																				
Light Phase**	3	(1.7)			97	(57.4)	4	(2.4)	7	(4.1)	27	(16.0)	5	(3.0)	20	(11.6)	6	(3.6)	169	(100)
Dark Phase					4	(80.0)									1	(20.0)			5	(100)
Rough-legged Hawk**			1	(3.6)	5	(17.9)					7	(25.0)	6	(21.4)	9	(32.1)			28	(100)
Ferruginous Hawk									1	(16.7)	3	(50.0)			2	(33.3)			6	(100)
Prairie Falcon**	14	(56.0)			1	(4.0)			1	(4.0)	5	(20.0)	1	(4.0)	2	(8.0)	1	(4.0)	25	(100)
Gryfalcon, Dark Phase											1	(100)							1	(100)
Merlin											2	(40.0)			1	(20.0)	2	(40.0)	5	(100)
Kestrel**	*		*		*		*		*		*		*		*		*		ABUNDANT	
Goshawk**					3	(75.0)	1	(25.0)											4	(100)
Cooper's Hawk**					2	(50.0)	1	(25.0)									1	(25.0)	4	(100)
Sharp-shinned Hawk					4	(80.0)			1	(20.0)									5	(100)
Northern Harrier**					14	(20.9)			2	(3.0)	18	(16.9)	17	(25.4)	25	(37.3)	1	(1.6)	67	(100)
Turkey Vulture	4	(20.0)			11	(55.0)	3	(15.0)	1	(5.0)	1	(5.0)							20	(100)
Great Horned Own**					74	(80.0)	3	(3.3)			4	(4.3)			1	(1.1)	10	(10.9)	92	(100)
Screech Owl					1	(50.0)					1	(50.0)							2	(100)
Barn Owl																	1	(100)	1	(100)
Short-earred Owl**											2	(100)							2	(100)
Saw-whet Owl					1	(100)													1	(100)
Burrowing Owl											4	(100)							4	(100)

* Commercial Study Area and Adjacent Area Data Combined

** Observed on Commercial Study Area

TABLE 4.9-14

RAPTOR NESTING DATA

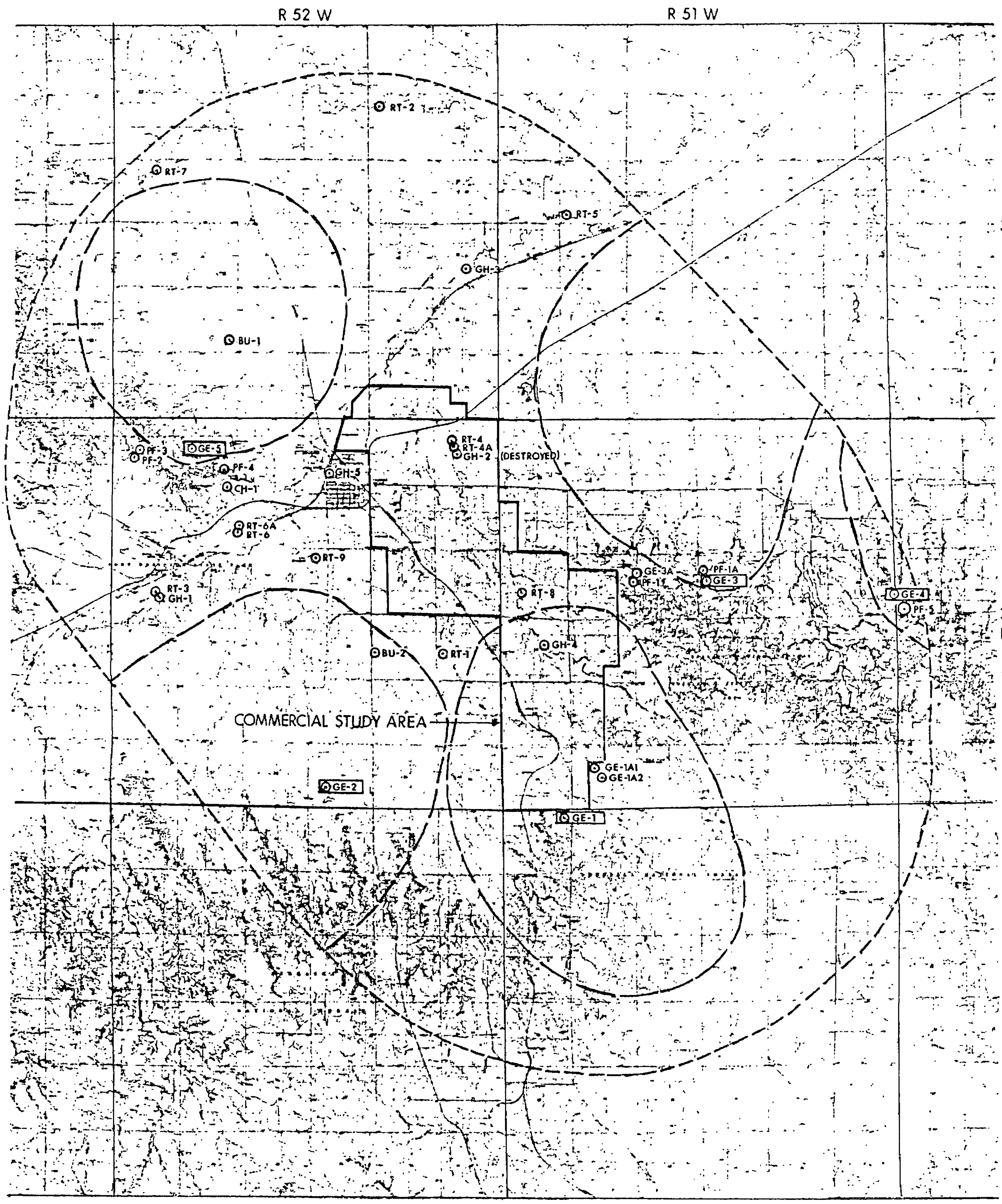
Species Nest Number	UTM Location	Nest Site	Nesting Status, 1982
Golden Eagle			
GE-1	471862,063577	Cliff	Incubating 28 Mar, Abandoned 7 May
GE-1A1*	471970,063666	Cliff	Unoccupied
GE-1A2	471962,063667	Cliff	Unoccupied
GE-2	471908,062995	Cliff	2 Young Fledged - 1 July
GE-3	472439,063911	Cliff	1 Young Fledged - 5 July
GE-3A	472433,063760	Cliff	Unoccupied
GE-4	472838,064378	Cliff	1 Young Fledged - 1 July
GE-5	472745,062645	Cliff	2 Young Fledged - 1 July
Red-tailed Hawk			
RT-1	472248,063278	Cottonwood	Incubation 30 Mar, Abandoned 7 May
RT-2	473600,063090	Cottonwood	1 Young Fledged - 1 July
RT-3	472386,062561	Cottonwood	2 Young Fledged - 10 July
RT-4	472780,063276	Cottonwood	Incubating 12 May, Abandoned 10 July
RT-4A	472780,063276	Cottonwood	Unoccupied
RT-5	473340,063560	Cottonwood	2 Young Fledged - 1 July
RT-6	472548,062765	Cottonwood	1 Young Fledged - 30 June
RT-6A	472552,062768	Cottonwood	Unoccupied
RT-7	473429,052544	Cottonwood	2 Young Fledged - 1 July
RT-8	472401,063466	Willow	2 Young Fledged - 30 June
RT-9	472475,062952	Cottonwood	2 Young Fledged - 5 July
Cooper's Hawk			
CH-1	472651,062735	Ponderosa	Nest Occupied 1 July, Incubation

TABLE 4.9-14 (Concluded)

RAPTOR NESTING DATA

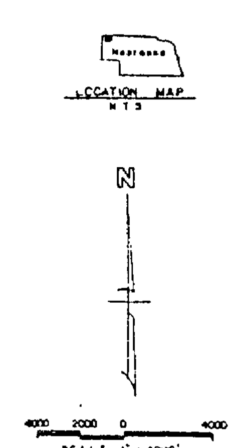
Species Nest Number	UTM Location	Nest Site	Nesting Status, 1982
Prairie Falcon			
PF-1	472450,063745	Cliff Cavity	Courtship May, Unoccupied 1 July
PF-1A	472456,063908	Cliff Cavity	Courtship May, Unoccupied 1 July
PF-2	472720,062503	Cliff Cavity	Occupied 1 July, 1+ Young
PF-3	472728,062518	Cliff Cavity	Occupied 1 July, 1+ Young
PF-4	472692,062710	Cliff Cavity	Occupied 1 July, 1+ Young
PF-5	(Barrel Butte)	Cliff?	Nest Not Located 1 July, Pair in Vicinity
Great Horned Owl			
GH-1 (RT-3A?)	472378,062567	Cottonwood	2 Young Fledged - 25 May
GH-2 (RT-4A?)	472769,062379	Cottonwood	1 Young Present 20 April Nest Destroyed 4 May
GH-3 (RT-10?)	473205,063303	Cottonwood	1+ Young Fledged - 25 May
GH-4 (RT-8A)	472271,063512	Cottonwood	2 Young Fledged - 5 June
GH-5	472691,062982	Cottonwood	2 Young Fledged - 28 May
Burrowing Owl			
BU-1	472023,062744	Burrow	Occupied 1 July, Status Uncertain
BU-2	472250,063105	Burrow	Occupied 1 July, Status Uncertain

CBR-014



LEGEND

GE (boxed)	GOLDEN EAGLE (PRIMARY)
GE	GOLDEN EAGLE (ALTERNATE)
RT	RED - TAILED HAWK
CH	COOPER'S HAWK
GH	GREAT HORNED OWL
BU	BURROWING OWL
PF	PRAIRIE FALCON
(dashed line)	ESTIMATED LIMITS OF GOLDEN EAGLE TERRITORY



REV. DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	RAPTOR NEST LOCATIONS	
	PREPARED BY: FEN	
	DWN. BY: JC	DATE: 8/5/87 FIGURE: 4.9-10

4.9(74) 09/30/87

the abandonment may be attributed, infertility, young mortality, or nest predation. It is probable that nesting attempts will take place every year, however. The remaining nests were successful, producing 1, 1, 2 and 2 fledglings respectively. Conversation with residents and state and federal agency representatives in 1987 confirmed that the status of golden eagles in the area has remained unchanged since 1982.

Bald Eagles (protected under federal act) were observed at several locations on the study area in winter and early spring. An individual was observed perched in the center of the CSA in March 1982. Evidently the species is an uncommon winter resident and migrant, with its primary winter distribution lying along rivers 100-km+ to the east (Lock 1974). The species does not nest on the area, and neither critical habitat nor regular roosting sites are present on the CSA.

Two races of red-tailed hawks occur on the study area. The dark phase (Harlan's) was recorded in spring migration in the AA (Table 4.9-13). The pale phase (paler than Harlan's but darker than birds of the Rocky Mountain region to the west) is a regular summer resident and breeder. The first spring arrivals appeared on territories 1 March 1982.

Nine nesting territories were located on the study area and believed to represent the entire summer population. Seven of the 9 nests were successful, producing a total of 12 fledglings (x=1.3/nesting territory). The female which was unsuccessful at RT-1 was believed to have renested at RT-4 and was unsuccessful there also. The eggs were probably infertile on both attempts. No male was present during the second attempt.

Rough-legged hawks are common winter residents, occurring on the study area until early April. They occur in a variety of habitats but typically perch in tall cottonwoods and feed over grassland habitat. The species was observed regularly on the CSA in winter.

Ferruginous hawks are migrants, moving through the study area in small numbers in mid to late March. Nesting of the species in the Shortgrass Prairie about 30-km north of the CSA was confirmed during an aerial reconnaissance of the northern plains area in April. The species would appear to be plentiful within its preferred range.

Swainson's hawks are reported as "common summer residents" in the Crawford area (USFS 1981). But we observed none in the course of the 6 month study period. Either the species is more common to the east, outside the realm of the red-tailed hawk, or errors in identification were made by the responsible agency officials. It is possible, as is often the case, the species was confused with juvenile red-tailed hawks.

The prairie falcon is a common permanent resident and breeder, perching on cliffs and ranging over a variety of habitats (Table 4.9-13). Four active nests of the species were located on the study area, all in cliff cavities. A fifth nest was believed to exist in the extreme eastern portion of the AA (Barrel Butte), but was not located.

A single GRYFALCON, probably in migration, was observed in the northeast portion of the AA.

Merlins are uncommon, with 5 observations recorded on the AA. The species is probably a resident and may nest in the Pine Ridge area, but no nest was found.

Kestrels are abundant summer residents, recorded in all habitat types. The species may number in the hundreds on the study area in migration, and breeding territories were deemed too numerous to address within the terms of reference of the current study.

Goshawks are uncommon winter residents, evidently ranging over large areas. Four were observed at widely separated locations, including one in the northern portion of the CSA in March.

Cooper's hawks formerly reported as winter residents in the area, were determined in the course of the study to be permanent residents and breeders. One nest was found in the AA, on Fort Robinson State Park. The species was not observed on the CSA, but probably forages over the entire area from time to time.

Sharp-shinned hawks were seen on several occasions on the study area. A pair was observed in courtship on Fort Robinson, but no nest was found.

Northern harriers are permanent residents on the study area, ranging primarily over grassland habitats, and more common in summer. The species was frequently observed on the CSA and may nest there, but no nest was found. Courtship was seen on Fort Robinson, and it is likely that the species (a ground-nester) more regularly nests in the taller grasses found there.

Turkey vultures are common migrants and uncommon summer residents, occasionally seen soaring above cliffs. The species was recorded on the CSA only during migration.

Great horned owls are common permanent residents. A large population was documented, primarily within Deciduous Streambank Forest habitat. During February, when courtship was evident and the owls were vocalizing a great deal, it was estimated that a pair of owls existed every 4-km along the White River. Five nests were found, two of which were located on the CSA. One nest, located in the northern portion of the CSA, along Squaw Creek, was destroyed, evidently by area residents. Another nest, located in the center of Section 19 in a cottonwood on Squaw Creek produced 2 young. Of raptor species, great horned owls are most apt to be tolerant of disturbance. Nest GH-5, for example, was located at the corner of 1st and Elm Streets in the city of Crawford, and 2 young were successfully fledged 28 May.

The burrowing owl is a summer resident. Two dens were found in the AA. The species is relatively uncommon on the study area and probably does not nest on the CSA.

One barn owl was found dead on the highway on the northeast perimeter of the AA. The species is evidently uncommon in the area, and was not found in a search of abandoned buildings and barns on the CSA.

Two short-eared owls were observed in May, probably in migration, in Mixed Grass habitat in the center of the CSA.

Two screech owls were documented, one on Fort Robinson and another on the Ponderosa Wildlife Area east of the CSA. The species is probably more common than observations would suggest.

One saw-whet owl was recorded in the West Ash Creek drainage of the eastern AA. The status of the species is unclear, but is probably relatively common though infrequently observed.

Waterfowl. Ground surveys for waterfowl were initiated in March 1982 and were conducted weekly until the end of June. Procedures established by Duzbin (1969) for assessing breeding populations of ducks were utilized. Data collected during surveys included the following: date, time, weather conditions, habitat type, species, numbers, sex and location.

A total of 24 species was observed in 9 habitat types (Table 4.9-15). The mallard (see species list for scientific names) was the most commonly observed species of waterfowl while the snow goose and hooded merganser were the least commonly observed. Impoundments were important to the largest number of species and the greatest numbers of waterfowl. Class II, III and V Wetlands were also important habitats for dabblers. These wetlands were concentrated in an area 1-2-km north and northwest of impoundment M-1 (see Figure 4.9-11 in the Aquatics Section) in the 8-km AA.

Habitat utilization shifted from riverine in early March when these were the only open water areas, to impoundments and natural wetlands after mid-March, when these areas became ice-free. The Class II, III, and V wetlands became increasingly important in May as spring rains filled them.

TABLE 4.9-15

WATERFOWL HABITAT AFFINITIES

Species	Class II Wetland Obs	(%)	Class III Wetland Obs	(%)	Class V Wetland Obs	(%)	Riverine Obs	(%)	Impoundment Obs	(%)	Range Rehab. Obs	(%)	Cultivated Obs	(%)	Roadside Obs	(%)	Total Obs	(%)
Trumpeter Swan									4	(100)							4	(100)
Canada Goose			7	(47)							8	(53)					15	(100)
White-fronted Goose			1	(100)													1	(100)
Snow Goose	1	(20)							4	(80)							5	(100)
Mallard	74	(6)	249	(19)	16	(1.1)	59	(4.3)	907	(69)			4	(.3)	4	(.3)	1313	(100)
Pintail	28	(3.6)	603	(77)	8	(1)	1	(.1)	137	(17.6)			3	(.4)	2	(.3)	782	(100)
Cadwall	7	(2)	58	(12)	115	(25)			286	(61)							466	(100)
American Wigeon	24	(6)	97	(23)	148	(34)			161	(37)							430	(100)
Northern Shoveler	34	(6)	67	(11.9)	10	(1.8)	2	(.3)	455	(80)							568	(100)
Blue-winged Teal	34	(14)	51	(21)	16	(7)	4	(2)	133	(56)							238	(100)
Green-winged Teal	23	(5.1)	105	(24)	13	(3)	6	(1.3)	295	(66)					3	(.6)	445	(100)
Cinnamon Teal					1	(12)			7	(88)							8	(100)
Wood Duck	2	(67)			1	(33)											3	(100)
Redhead	8	(5)	12	(8)					128	(67)							148	(100)
Canvasback									40	(100)							40	(100)
Ring-necked Duck					13	(3)			434	(97)							477	(100)
Wooded Merganser									1	(100)							1	(100)
Common Merganser									46	(100)							46	(100)
Lesser Scaup			2	(.4)	10	(20)			549	(97.6)							561	(100)
Common Goldeneye									14	(100)							14	(100)
Bufflehead									65	(100)							65	(100)
Ruddy Duck									64	(100)							64	(100)
American Coot			7	(25)					21	(75)							28	(100)
Double-crested Cormorant									45	(100)							45	(100)

Two areas of waterfowl concentration were identified, one on the CSA and one on the AA. The area of waterfowl concentration on the CSA included impoundment M-1 and the Class II, III and V wetlands north and northwest of this impoundment.

Nineteen species were observed on the CSA, with 18 of the 19 species reported for I-6 (Table 4.9-16). I-1 was the only impoundment where no species of waterfowl were observed. This is a small stockwater pond which had little water in March and April. Heavy livestock use, lack of aquatic vegetation and a low water level during early spring probably precluded use of this impoundment by waterfowl.

Estimates of breeding pairs of waterfowl on the CSA and AA are presented in Table 4.9-17. The mallard was the most common of nesting waterfowl on both the CSA and AA. Although several thousand ducks stopped on the study area during migration, very few remained to nest. The greatest number of ducks thought to be nesting on the study area utilized the Class III and V wetlands and impoundment M-1 on the AA. Heavy grazing by livestock and cultivation limit the quantity and quality of upland nesting cover for dabblers, and the limited amount of emergent vegetation in the impoundments provides few nesting areas for species which nest over water.

Two broods of mallards were the only waterfowl broods observed during May and June 1982. The first hen with three young was on I-6 in the CSA and the second hen with eight young was on the White River in the AA. A few observations of broods is due in part to poor visibility caused by the presence of tall vegetation on the Class III and V wetlands and the tall perimeter vegetation on many of the impoundments.

Eared grebes, pied-billed grebes and western grebes were observed on the CSA. The pied-billed grebe is the only species of the grebe thought to nest on the CSA. Horned grebes were observed during migration on the AA.

During early April a migrating flock of 45 lesser sandhill cranes was observed flying over the AA. No sandhill cranes were observed to stop on the study area.

TABLE 4.9-16

WATERFOWL OCCURRENCE ON COMMERCIAL STUDY AREA IMPOUNDMENTS

	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8
Snow Goose					x	x		
Mallard		x	x	x	x	x	x	x
Pintail					x	x		x
Gadwall		x		x	x	x		x
American Wigeon		x	x	x	x	x		x
Northern Shoveler			x	x	x	x		
Blue-winged Teal		x	x	x	x	x	x	
Green-winged Teal			x	x	x	x	x	x
Cinnamon Teal							x	
Redhead				x	x	x		x
Canvasback						x		x
Ring-necked Duck			x	x	x	x	x	x
Hooded Merganser						x		
Common Merganser				x	x	x		
Lesser Scaup				x	x	x	x	x
Bufflehead				x	x	x	x	
Ruddy Duck						x	x	
Double-crested Cormorant				x	x	x	x	x
Coot						x		x

TABLE 4.9-17

WATERFOWL BREEDING PAIR ESTIMATES
(1982)

	Assigned Breeding Pairs	
	Commercial Study Area	Adjacent Area
Mallard	14	21
Pintail	1	7
Gadwall		10
American Wigeon		1
Northern Shoveler	1	3
Blue-winged Teal	3	8
Green-winged Teal		3
Wood Duck	1	
Redhead		
Lesser Scaup		1
Ruddy Duck	2	
Coot	1	4

Whooping cranes were not observed on the study area. The nearest confirmed report for the period 1950 to 1980 was about 100-km southeast of the study area (USFWS 1981). Whooping cranes would not be expected on the study area, since the western boundary of the regular migration corridor is over 200-km east of the study area (USFWS 1981).

The interior least tern (little tern) a state-listed threatened species, which nests on islands of the Platte River, was not observed on the study area.

No mountain plovers (state-listed threatened species) were observed on the study area. This species is relatively common on the shortgrass prairie 250-km south of the study area.

White pelicans were seen during April on Lake Whitney and a lake near Toadstool Park, located northeast and north of the AA, respectively. They evidently do not breed in the vicinity of the study area.

Twenty species of shorebirds were seen during spring, with the killdeer being the most common. Due to the dry weather in April and early May, during the period of peak shorebird migration, there was little suitable habitat available. The largest number of species and individuals were seen on the Class III and V wetlands and the impoundment M-1 on the AA.

<u>Other Bird Species</u>. Seven 1-km flush transects were located within the AA and CSA in order to sample bird populations (Figure 4.9-10). Transect sites were selected in a fashion judged representative of the diversity of bird habitats and feeding niches within the study area, Lower Wooded Riparian (Deciduous Streambank Forest within grassland and cultivation), (Ponderosa Pine, Grassland, Shrubland), Upper Wooded Riparian (Deciduous Streambank Forest-Ponderosa Pine Interspersion), Non-wooded Riparian (Deep Marsh, Shallow Marsh, Wet Meadow Riparian Complex), Cultivated (primarily alfalfa), Mixed Grass Prairie, and Shortgrass Prairie.

Greatest bird densities in spring (Table 4.9-18) were observed in the Upper Wooded Riparian area (18.50 birds/ha), and lowest in the Cultivated Area (0.43 birds/ha). The most abundant bird was the red crossbill, with densities of 12.50/ha in the Upper Wooded Type and 5.90/ha in Ponderosa Pine. This reflects the high ponderosa pine seed production in 1982. Numbers of red crossbills fluctuate widely in the region, and in years of poor seed production the species is expected to be scarce or absent entirely.

Other common birds, with densities of more than 1/ha in suitable habitat in spring were the redwing blackbird, blackcapped chickadee, mourning dove, rufous-sided towhee, yellow warbler, house wren, violet-green swallow and pine siskin.

Greatest diversities (Shannon and Weaver 1949) were observed in the Lower Wooded Riparian and Upper Wooded Riparian Types (2.924 and 2.080, resp; 31 and 26 species, resp). Lowest diversity was recorded in the Cultivated Type (0.325, 2 species).

The data may underestimate the overall importance of the Mixed Grass Prairie type. The site is relatively impoverished due to abusive land practices, and therefore does not properly represent the full capability of the Mixed Grass type. Only 2 species were observed during 5 transect exercises in spring, yielding a computed density of 0.64 birds/ha, and a diversity index of 0.468.

In 1987, Nebraska Game and Parks, Fort Robinson State Park, Ponderosa State Wildlife Area, USFWS, US Forest Service, Upper Niobrara-White River Conservation District personnel and local residents were contacted to verify the status of birds in the study area. All people contacted claimed that no change in the status of birds in the area has occurred since 1982.

Reptiles and Amphibians

Of 25 species of reptiles and amphibians recorded for the region (Table 4.9-19), 13 were documented on the study area during the period of investigation.

TABLE 4.9-18

SPRING 1982 BIRD DENSITIES - TRANSECT DATA

Species	No. Obs.	Mean Dist. (m)	Density Birds/ha	Percent
		SHORTGRASS		
Horned Lark	8	18.1	0.44	34.8
Western Meadowlark	14	40.6	0.34	60.9
Upland Sandpiper	1	6.0	0.17	4.3
Totals	23	32.0	0.72	100.0
Diversity Index = 0.797				
		MIXED GRASS		
Western Meadowlark	13	35.2	0.36	81.2
Bank Swallow	3	5.0	0.60	18.8
Totals	16	29.6	0.64	100.0
Diversity Index = 0.468				
		NON-WOODED RIPARIAN		
Common Snipe	12	12.4	0.96	3.8
Western Meadowlark	29	46.4	0.62	9.3
Redwing Blackbird	222	47.0	4.72	70.7
Killdeer	23	32.7	0.70	7.4
Common Flicker	2	47.5	0.04	0.6
Starling	5	50.0	0.10	1.6
Bobolink	2	15.0	0.13	0.6
Common Grackle	8	80.0	0.10	2.5
Mourning Dove	1	60.0	0.02	0.3
Blue-winged Teal	5	33.0	0.15	1.6
Mallard	3	31.0	0.10	1.0
Lark Bunting	2	41.0	0.05	0.6
Totals	314	44.9	6.99	100.0
Diversity Index = 1.200				
		CULTIVATED		
Western Meadowlark	19	42.9	0.44	90.5
Robin	2	100.0	0.02	9.5
Totals	21	48.3	0.43	100.0
Diversity Index = 0.325				

TABLE 4.9-18 (Continued)

SPRING 1982 BIRD DENSITIES - TRANSECT DATA

Species	No. Obs.	Mean Dist. (m)	Density Birds/ha	Percent
LOWER WOODED RIPARIAN				
Black-capped Chickadee	18	15.3	1.18	7.6
Great Horned Owl	5	23.0	0.21	2.0
Common Crow	7	30.0	0.23	2.9
Pine Siskin	25	32.0	0.78	10.6
Starling	24	27.8	0.86	9.9
American Robin	28	15.1	1.85	11.7
Common Flicker	4	21.0	0.19	1.6
Redwing Blackbird	4	20.0	0.10	0.8
Mourning Dove	33	18.4	1.79	13.6
Yellow-rumped Warbler	12	21.5	0.55	4.9
Common Grackle	6	25.8	0.23	2.6
Pheasant	5	80.0	0.06	2.0
Hairy Woodpecker	1	40.0	0.02	0.4
Tree Sparrow	3	15.0	0.20	1.2
Slate-colored Junco	4	18.7	0.21	1.7
Western Meadowlark	4	15.0	0.27	1.7
Brown Thrasher	3	6.7	0.45	1.2
Chipping Sparrow	2	20.0	0.10	0.8
Clay-colored Sparrow	2	20.0	0.10	0.8
Orange-crowned Warbler	1	20.0	0.05	0.4
Lark Sparrow	5	15.0	0.33	2.0
Yellow Warbler	11	7.7	1.42	4.5
Eastern Kingbird	2	5.5	0.36	0.8
Rufous-sided Towhee	8	7.5	1.06	3.3
House Wren	14	9.6	1.45	5.8
Downy Woodpecker	5	8.0	0.62	2.0
Violet-Green Swallow	1	1.0	1.00	0.4
American Redstart	2	9.0	0.22	0.8
Northern Waterthrush	1	10.0	0.10	0.4
American Goldfinch	2	15.0	0.13	0.8
Mallard	2	5.0	0.40	0.8
Totals	242	5.0	11.90	100.0

Diversity Index = 2.924

TABLE 4.9-18 (Continued)

SPRING 1982 BIRD DENSITIES - TRANSECT DATA

Species	No. Obs.	Mean Dist. (m)	Density Birds/ha	Percent
UPPER WOODED RIPARIAN				
Common Flicker	1	10.0	0.10	0.2
Red Crossbill	172	13.8	12.50	46.6
B.-c. Chickadee	30	24.3	1.23	8.2
Black-billed Magpie	2	30.0	0.06	0.5
Starling	19	37.9	0.50	5.2
Downy Woodpecker	8	39.6	0.20	2.3
Blue Jay	1	20.0	0.05	0.2
Evening Grosbeak	49	9.6	5.10	13.3
Slate-colored Junco	6	26.7	0.22	1.6
Hairy Woodpecker	1	20.0	0.05	0.2
American Robin	8	11.6	0.68	2.2
Pinyon Jay	10	40.0	0.25	4.9
Pygmy Nuthatch	2	1.0	2.00	0.5
Red-breasted Nuthatch	12	13.8	0.87	3.3
Oregon Junco	4	40.0	0.10	1.1
Great Horned Own	1	20.0	0.05	0.2
Kestrel	4	43.7	0.09	1.1
House Wren	18	32.7	0.55	4.9
Mourning Dove	5	37.0	0.13	1.3
Rufous-sided Towhee	5	40.0	0.12	1.3
Black-headed Grosbeak	3	18.3	0.16	0.8
Blackpoll Warbler	1	20.0	0.05	0.2
Hermit Thrush	1	60.0	0.02	0.2
Brewer's Blackbird	4	52.5	0.01	1.1
Ruby-crowned Kinglet	1	100.0	0.01	0.2
Chipping Sparrow	2	40.0	0.05	0.5
Totals	**370**	**19.9**	**18.50**	**100.0**

Diversity Index = 2.080

TABLE 4.9-18 (Continued)

SPRING 1982 BIRD DENSITIES - TRANSECT DATA

Species	No. Obs.	Mean Dist. (m)	Density Birds/ha	Percent
		PONDEROSA PINE		
Red Crossbill	227	38.5	5.90	86.5
Red-br. Nuthatch	14	28.2	0.50	5.5
Downy Woodpecker	2	32.5	0.06	0.7
Pine Siskin	1	1.0	1.00	0.3
B.-c. Chickadee	3	50.0	0.06	1.1
Slate-colored Junco	2	30.0	0.06	0.7
Ruby-crowned Kinglet	3	41.7	0.07	1.1
Mourning Dove	6	25.0	0.24	2.3
Rufous-sided Towhee	4	47.5	0.08	1.5
House Wren	1	10.0	0.10	0.3
Totals	263	42.4	6.20	100.0

Diversity Index = 0.551

TABLE 4.9-19

REPTILE AND AMPHIBIAN SPECIES LIST

Common Name	Scientific Name	Status
Tiger Salamander	*Ambystoma tigrinum*	E-CA-C
Plains Spadefoot	*Scaphiopus bombifrons*	D-AA-C
Woodhouse's Toad	*Bufo woodhousei*	D-CA-C
Great Plains Toad	*Bufo cognatus*	D-CA-C
Boreal Chorus Frog	*Pseudacris triseriata*	D-CA-C
Leopard Frog	*Rana pipiens*	D-CA-C
Bullfrog	*Rana catesbeiana*	D-CA-C
Snapping Turtle	*Chelydra serpentina*	D-CA-C
Western Box Turtle	*Terrepene ornata*	E-CA-U
Painted Turtle	*Chrysemys picta*	D-CA-U
Spiny Softshell	*Trionyx spiniferus*	E-AA-U
Lesser Earless Lizard	*Holbrookia maculata*	E-AA-U
Eastern Fence Lizard	*Sceloporus undulatus*	E-AA-U
Short-horned Lizard	*Phrynosoma douglassi*	E-CA-U
Great Plains Skink	*Eumeces obsoletus*	E-CA-U
Many-lined Skink	*Eumeces multivirgatus*	E-CA-U
Six-lined Racerunner	*Cnemidophorus sexlineatus*	E-CA-U
Western Hognose Snake	*Heterodon nasicus*	E-CA-U
Racer	*Coluber constrictor*	D-AA-U
Bullsnake	*Pituophis melanoleucas*	D-CA-C
Milk Snake	*Lampropeltis triangulum*	E-CA-U
Common Water Snake	*Natrix spipedon*	E-OA-U
Common Garter Snake	*Thamnophis sirtalis*	D-CA-U
Plains Garter Snake	*Thamnophis radix*	D-CA-C
Prairie Rattlesnake	*Crotalus viridis*	R-CA-U

Toads which were observed, and distribution determined primarily by their calls, were Woodhouse's toad (not numerous, but occurring on all the large impoundments and watercourses), Great Plains toad (not numerous, but widely distributed in a variety of habitats), and plains spadefoot (abundant at selected locations, permanent and seasonal wetlands within the prairie areas).

Documented frogs included the boreal chorus frog (common and widely distributed in a variety of habitats), leopard frog (common in areas of perennial water), and bullfrogs (abundant in impoundments where they have been stocked, in the central and northern portions of the CSA and uncommon elsewhere).

The two species of turtles observed were the snapping turtle (common in all streams and permanent impoundments) and painted turtle (common at selected locations, larger impoundments and rivers).

No lizard was recorded during the study period.

Bullsnakes and the plains garter snake were commonly seen. The common garter snake and racer were each observed on only one occasion each. Surprisingly, in view of reports, no rattlesnake was observed, and none found dead on roads.

4.9-2 AQUATIC ECOLOGY

Introduction

Aquatic habitats on the CSA consist of three streams and eight impoundments. Within the CSA, English Creek, Squaw Creek and White Clay Creek are first-order streams (smallest perennial streams marked on a 1:24,000 scale map) that form the drainage basin for the CSA (Figure 4.9-11). English Creek is entirely within the confinement of the CSA originating from springs on the eastern edge of Section 13 and flowing northerly for about 5.6-km (3.5 mi) where it empties into Squaw Creek in Section 35. Squaw Creek originates in the Nebraska National Forest and the Ponderosa State Wildlife Area to the southeast and flows through the CSA to its confluence with White Clay Creek. White Clay Creek drains from the national forest to the south and flows northerly through the CSA and empties into the White River. Seven of the eight impoundments are on-stream with four 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.

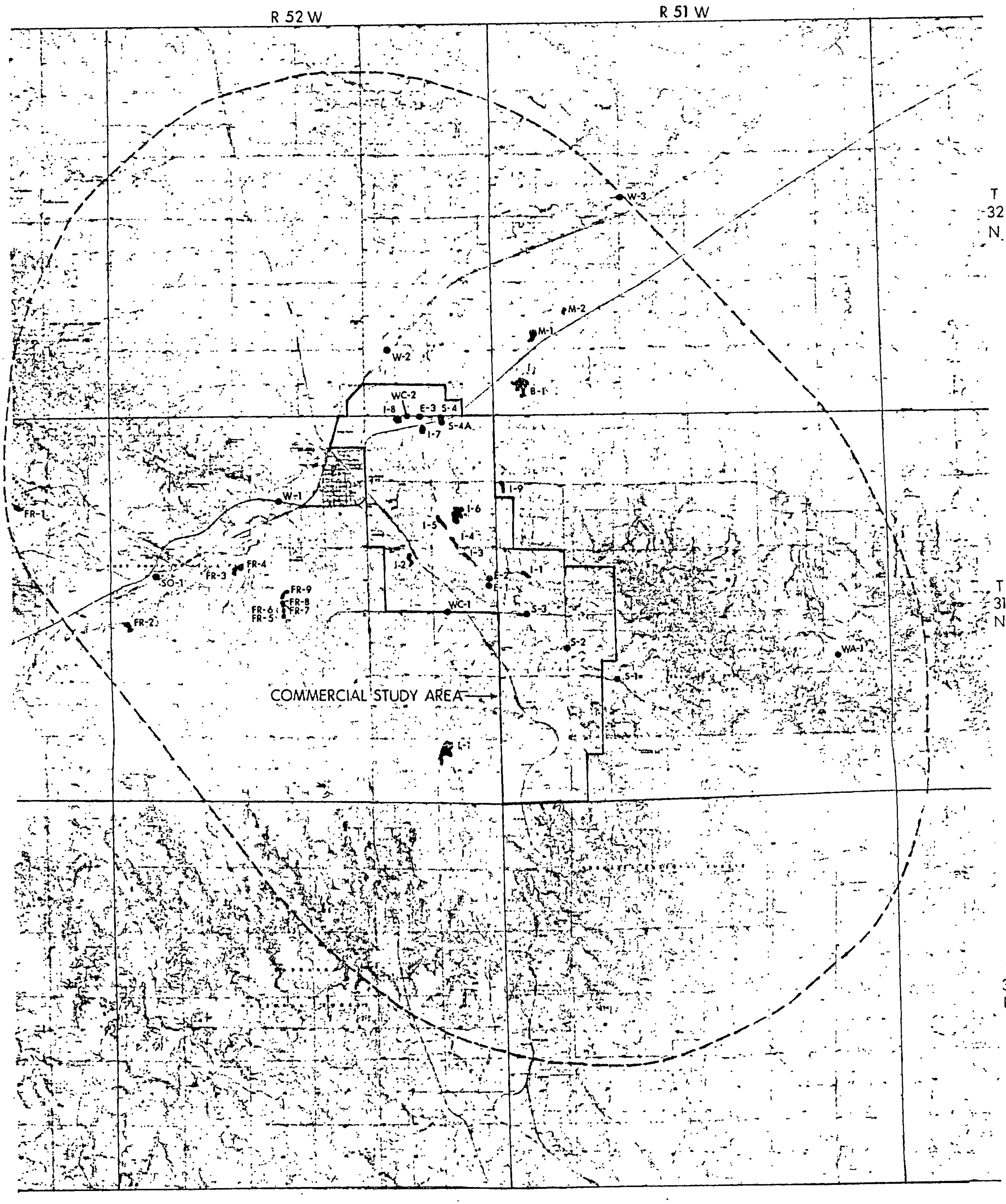
In addition, a spring fed impoundment just off the CSA in Section 7 and the White River north of the CSA were included for sampling.

The objectives of this study were designed to provide the information necessary to assess the aquatic resources of streams and impoundments on the CSA. Specifically, the objectives of the study were as follows:

1. To determine water quality parameters.
2. To inventory and compile species lists of aquatic vertebrates, invertebrates and plants (macrophytes, algae and diatoms).
3. To determine the relative abundance and habitat utilization of aquatic vertebrates, invertebrates and plants.

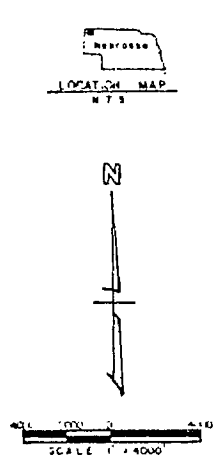
Methods

Surface water quality for biological studies. Streams and impoundments were selected for physical and biological sampling based on the following rules:



SAMPLING SITE KEY

B	BRITTON
E	ENGLISH CREEK
FR	FORT ROBINSON
I	IMPOUNDMENT
L	LUX
M	MANSFIELD
S	SQUAW CREEK
SO	SOLDIER CREEK
W	WHITE RIVER
WA	WEST ASH CREEK
WC	WHITE CLAY CREEK



REV. DATE	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	AQUATIC SAMPLING SITE LOCATIONS
	PREPARED BY: FEN
	DWN. BY: JC · DATE: 8/5/87 · FIGURE: 4.9-11

4.9(92) 09/30/87

1. All streams and impoundments within the CSA were chosen for collection of biological and water quality data (Figure 4.9-12). Small diversion structures which are used primarily for irrigation were not considered as impoundments. Sample site S-4A as shown in Figure 4.9-12 was not sampled, rather it was an alternate site for flood conditions if they occurred.

2. Within the 8-km AA impoundments with permanent water, which could possibly support fish populations, and selected streams were chosen for collection of water quality data.

Information concerning water quality parameters in the section is not intended to replace that collected for studies for surface water hydrology, but to provide on-site information for biological studies.

Samples of surface water were taken from streams, springs and impoundments during February and April 1982. The sampling time was made as uniform as possible with all field samples and physico-chemical determinations being made between 0800 and 1600 hours.

Nine physico-chemical determinations: air temperature, water temperature, dissolved oxygen, total alkalinity, carbon dioxide, pH, conductivity, turbidity and hydrogen sulfide, were made on each stream, spring or impoundment within or on the boundary of the CSA. Impoundments within the AA had six parameters: air temperature, water temperature, dissolved oxygen, pH, conductivity, and hydrogen sulfide, checked during the February sampling season, and all parameters were checked during April.

Fish. A variety of sampling gear and methods was employed to collect fish from the study area streams and impoundments. Choice of equipment was indicated by the type of habitat being sampled, the effectiveness of the equipment, and by prior knowledge of the presence of important species. Methods used to collect fish included electrofishing, gill-netting, hoop-netting, minnow-trapping and angling with rod and reel.

The sampling effort expended in collecting fish in 1982 was not standardized due to differences in the 1) amount of suitable habitat present, 2) types of habitats sampled, 3) sampling equipment used, and 4) abundance of fish present at each location. As such, fish were collected at each location to document their occurrence and to determine their relative abundance but no attempt was made to determine absolute densities. However, in 1983, data were collected from two stations on the White River from which population estimates for selected fish species were calculated.

At each sampling location all fish collected were identified, counted, measured for total length, and whenever possible, returned unharmed to the water.

Benthic Macroinvertebrates. Quantitative samples of Benthic Macroinvertebrates were collected from soft substances in streams and impoundments with a Ponar Dredge ($0.22m^2$) and from gravel riffle substrates with a Surber Sampler ($0.0093m^2$). All dredge and surber samples were collected in triplicate at each location. Samples were preserved in 70% ethanol.

Invertebrates were hand-picked from substrate material and identified to the lowest practical level with the aid of stereoscopic and standard taxonomic references (Ward and Whipple 1959; Pennak 1953). Data from Ponar and Surber samples were reported as number of individuals per square meter of bottom by multiplying by 45.93 and 10.76, respectively. Qualitative samples collected by sweep netting were used to augment the species list. Shannon-Weaver (1949) diversity indices were calculated from all Ponar and Surber samples.

Periphyton (Algae and Diatoms). 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 and were preserved in 5% formalin. Preserved samples were identified under a compound microscope using appropriate taxonomic references (Ward and Whipple 1959; Prescott 1962; Weber 1966). Diatom proportional counts were performed at the generic level after counting a minimum of 250 valves. Green and blue-green algae were identified and their occurrence noted for each sampling location.

RESULTS AND DISCUSSION

Water Quality. The sampling sites were grouped into two categories: streams which include two springs (E-1 and E-2) at the upper end of English Creek, and impoundments (Figure 4.9-12). The streams had flows ranging from .75 cms on the White River to less than 0.1 cms on lower Squaw Creek during the two sampling periods. Impoundments ranged in size from 0.2 ha to 7.7 ha for FR-3 and I-6 respectively.

Comparison of constituents at stream and spring sample sites for February and April 1982 are presented in Table 4.9-20. Dissolved oxygen was above 10 mg/l at all stream stations, with the exception of S-4 during February. The reduced dissolved oxygen at S-4 was probably due to ice coverage extending several hundred meters upstream from the sampling site. The spring, E-1, had dissolved oxygen levels below 10 mg/l during both sampling periods, while E-2 was below 10 mg/l only during February. Lower dissolved oxygen levels would be expected from springs, as groundwater generally has lower levels of dissolved oxygen than surface water.

TABLE 4.9-20

SURFACE WATER QUALITY FOR CROW BUTTE, 1982
SAMPLED STREAMS AND SPRINGS

Constituent	Stream Station											
	S-1		S-2		S-3		S-4		WA-1		SO-1	
	02/25	04/19	02/25	04/19	02/25	04/19	02/25	04/19	02/22	04/21	02/22	04/21
Air Temperature (Degrees C)	-3	4	-3	6	-3	7	1	8	16	13	21	13
Water Temperature (Degrees C)	1	5	1	7	1	8	1	10	5	12	8	10
Dissolved Oxygen (mg/l)	12.0	11.9	12.1	12.4	12.1	11.2	7.8	12.3	11.2	10.2	10.2	11.1
Total Alkalinity (mg/l $CaCO_3$)	206	195	213	195	215	198	286	257	165	193	160	180
Carbon Dioxide (mg/l)	12.0	4.0	11.0	5.0	11.0	5.5	15.0	9.0	11.5	9.0	10.5	9.0
pH	7.71	7.30	7.78	7.73	7.83	7.80	7.58	7.91	7.70	7.23	7.60	7.20
Conductivity (mhos/cm)	420	380	430	390	430	390	560	530	380	380	310	350
Turbidity (FTU)	3	6	3	4	8	8	10	9	3	4	7	4
Hydrogen Sulfide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

TABLE 4.9-20 (Continued)

SURFACE WATER QUALITY FOR CROW BUTTE, 1982
SAMPLED STREAMS AND SPRINGS

Constituent	Stream Station													
	W-1		W-2		E-1*		E-2*		E-3		WC-1		WC-2	
	02/24	04/21	02/24	04/21	02/22	04/22	02/22	04/22	02/24	04/20	02/24	04/22	02/24	04/22
Air Temperature (Degrees C)	0	8	-1	9	8	15	18	15	3	3	3	16	4	19
Water Temperature (Degrees C)	3	4	3	6	11	9.5	10	12	4	4	3	8	2	9
Dissolved Oxygen (mg/l)	11.2	12.3	12.1	13.9	9.8	8.2	5.1	11.2	10.8	11.9	11.4	12.9	11.0	10.6
Total Alkalinity (mg/l $CaCO_3$)	187	178	191	186	230	213	226	205	209	375	192	182	244	233
Carbon Dioxide (mg/l)	15.0	10.0	17.0	11.0	13.5	15.0	20.0	10.0	17.5	8.0	8.0	9.0	18.0	11.0
pH	7.74	7.05	7.50	7.72	7.37	6.60	7.50	6.90	7.38	7.70	8.05	7.63	7.52	7.75
Conductivity (mhos/cm)	350	340	390	350	460	450	400	440	420	770	380	380	520	520
Turbidity (FTU)	28	12	31	3	7	7	12	5	12	6	9	10	12	15
Hydrogen Sulfide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Sample stations E-1 and E-2 are springs at the top of English Creek.

Total alkalinity fluctuated little between February and April 1982 for the stream and spring sample sites, with the exception of E-3 (Table 4.9-20). Flow at E-3 in April was about 30% of that in February. The decreased flow would maintain the concentration of constituents picked up from the alluvial aquifer, and the four impoundments on English Creek were ice-free in April. Thus, evaporation and the concentration of ions was greater in April than February. Total alkalinity increased between stations on a stream as distance increased between stations and the number of impoundments on a stream became greater.

The greatest concentrations of carbon dioxide (20 mg/l) was recorded at E-3. E-3 is a spring and groundwater often exceeds surface water concentrations of carbon dioxide. Lower concentrations of carbon dioxide were found in April than in February within stream stations. This may have been due to increased algae and the initiation of aquatic plant growth.

Hydrogen-ion concentration expressed as pH varied from 6.60 for stream station E-1 to 8.05 for stream station WC-1.

Conductivity, like alkalinity, increased with greater distance between stations on a stream and with a greater number of impoundments between the upstream and downstream stations. The highest conductivity reading (770 umhos/cm) was recorded at E-3 in April. As was mentioned in the section on total alkalinity the flow at this station in April was very low and there are four impoundments upstream from it, thus limiting flow and increasing concentrations of salts from greater evaporation.

Turbidity values were low for all streams and springs. The highest value recorded was 28 FTU (formazin turbidity units) at W-1 in February. The streams in the project area have a sand and gravel substrate with little clay, silt or fine organic matter which are the major causes of higher turbidity values.

The high oxygen levels in the streams and springs precluded detectable levels of hydrogen sulfide (H_2S). These levels of oxygen would oxidize sulfides to sulfates.

Impoundments, with the exceptions of I-1, FR-8 and FR-9, had high levels of dissolved oxygen during February (Table 4.9-21). All impoundments were ice covered at this time. The average thickness was 25 cm and ranged from 10 to 50 cm.

Impoundment I-1 is a small stock pond with little aquatic vegetation to produce oxygen, while FR-8 had a large amount of dead emergent vegetation at its upper end. This large amount of oxidizable material in FR-8 probably caused the low concentration of dissolved oxygen (1.9 mg/l). The water from FR-8 drains directly into FR-9 and combined with the dead emergent vegetation in FR-9 probably causes this impoundment to have a dissolved oxygen concentration of 2.6 mg/l. Impoundment L-1, however, had a supersaturation of 20 mg/l. This was probably due to the clearness of the ice and the amount of green plants beneath the ice.

Total alkalinity content of the impoundments within or on the boundary of the CSA generally had the highest levels in April. This was probably due to low precipitation during early spring. More precipitation would have diluted ion concentrations in the impoundments. The lowest recorded total alkalinity was during February 1982 in I-1 (50 mg/l $CaCO_3$) during April. Total alkalinity values for the streams and impoundments fell within the range which are considered to have little direct affect on fish. However, fish may be indirectly affected by total alkalinity, as waters with values below 40 mg/l are biologically less productive than those with higher values (Lagler, 1956).

The pH values for all impoundments, with the exception of I-1 which had a supersaturation of oxygen in February, were lowest in winter. Dissolved oxygen and carbon dioxide, both of which affect pH values, are readily influenced by the processes of plants and animals. No extremely low or high pH values were recorded, as the lowest and highest values were 6.05 and 8.7 respectively.

The conductivity of the impoundments ranged from 110 to 960 umhos/cm. As with alkalinity there was generally a trend of higher conductivity readings for the downstream impoundments on the stream system.

TABLE 4.9-21

SURFACE WATER QUALITY RESULTS FOR CROW BUTTE, 1982
SAMPLED IMPOUNDMENTS

	I-1		I-2		I-3		I-4		I-5		I-6		I-7		I-8	
Constituent	**02/17**	**04/21**	**02/17**	**04/22**	**02/17**	**04/20**	**02/17**	**04/20**	**02/17**	**04/20**	**02/16**	**04/19**	**02/16**	**04/20**	**02/16**	**04/21**
Air Temperature (Degrees C)	9	12	11	17	14	3	13	3	11	2	12	8	12	3	14	11
Water Temperature (Degrees C)	1	8.5	4	7	1	3	1	5	17	6	1	9	1	8	1	8
Dissolved Oxygen (mg/l)	4.8	11.8	10.1	11.8	7.8	11.0	9.9	10.7	7.8	10.8	10.4	10.6	6.2	9.2	9.8	11.6
Total Alkalinity (mg/l $CaCO_3$)	50	68	201	211	182	228	149	230	213	248	141	190	298	237	184	217
Carbon Dioxide (mg/l)	8.0	7.0	9.0	10.0	10.0	11.0	10.0	11.0	9.0	10.0	9.0	11.0	14.0	12.0	8.0	9.0
pH	6.07	7.70	7.40	7.64	7.20	8.13	7.26	7.81	7.10	7.83	7.14	7.88	6.78	7.52	7.56	7.81
Conductivity (mhos/cm)	110	190	410	450	380	490	310	480	430	530	280	400	580	570	330	490
Turbidity (FTU)	47	26	28	16	8	28	11	20	6	48	58	115	34	10	55	26
Hydrogen Sulfide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

TABLE 4.9-21 (Continued)

SURFACE WATER QUALITY RESULTS FOR CROW BUTTE, 1982
SAMPLED IMPOUNDMENTS

	I-9		FR-1		FR-2		FR-3		FR-4		FR-5		FR-6	
Constituent	**02/16**	**04/21**	**02/14**	**04/18**	**02/14**	**04/18**	**02/14**	**04/18**	**02/14**	**04/18**	**02/14**	**04/17**	**02/14**	**04/17**
Air Temperature (Degrees C)	12	12	18	4	16	4	12	5	10	5	9	17	10	17
Water Temperature (Degrees C)	3	7	1	9	1	11	1	9	1	11	4	10	1	10.5
Dissolved Oxygen (mg/l)	13.2	12.5	7.8	10.4	11.8	10.4	8.8	14.8	10.2	14.0	14.2	12.1	11.0	11.8
Total Alkalinity (mg/l $CaCO_3$)	65	152		142		185		166		113		147		136
Carbon Dioxide (mg/l)	5.0	12.0		10.5		10.0		10.0		4.5		10.0		9.0
pH	7.40	7.85	6.82	7.90	7.79	7.82	6.91	7.52	6.42	8.48	7.20	7.55	7.15	7.89
Conductivity (mhos/cm)	150	340	310	250	380	390	120	280	120	240	420	350	400	310
Turbidity (FTU)	24	9		2		1		1		4		2		3
Hydrogen Sulfide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

TABLE 4.9-21 (Continued)

SURFACE WATER QUALITY RESULTS FOR CROW BUTTE, 1982
SAMPLED IMPOUNDMENTS

	Impoundment													
	FR-7		FR-8		FR-9		B-1		M-1		M-2		L-1	
Constituent	02/14	04/17	02/14	04/17	02/14	04/17	02/15	04/18	02/15	04/18	02/15	04/18	02/15	04/18
Air Temperature (Degrees C)	10	17	7	17	5	17	12	17	10	17	9	17	4	14
Water Temperature (Degrees C)	1	11	1	12	1	13	1	9	1	11	1	11	1	12
Dissolved Oxygen (mg/l)	11.2	11.3	1.9	8.8	2.6	10.7	12.5	10.0	12.1	11.6	12.6	13.1	20.0	11.2
Total Alkalinity (mg/l $CaCO_3$)		121		136		166		334		220		161		162
Carbon Dioxide (mg/l)	5.0	9.0		11.0		12.5		5.0		3.5		3.0		7.0
pH	7.40	8.00	7.06	7.45	6.95	7.67	8.02	8.71	7.04	8.39	7.55	8.70	8.50	7.92
Conductivity (mhos/cm)	450	290	480	320	520	350	960	920	340	550	500	380	380	350
Turbidity (FTU)		4		4		4		155	42	42		22		10
Hydrogen Sulfide (mg/l)	<0.01	<0.01	2.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

The highest turbidity value for impoundments was greater than the highest for streams, 155 FTU and 28 FTU respectively. The greater amount of silt and especially fine organic matter provided by aquatic plants in the impoundments would cause this difference.

The only impoundment with a detectable level of hydrogen sulfide during February 1982 was FR-8 (2.0 mg/l). The large amount of dead emergent vegetation at the upper end of this impoundment, the ice covering and the low level of dissolved oxygen were responsible for this condition.

Habitat Characteristics. In general, all 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 has affected many of the impoundments. Livestock grazing and watering add to impoundment problems. The end result of these environmental stresses is reflected in a fishery mostly consisting of non-game, tolerant species. Periodic stocking by the Nebraska Game and Parks Commission has created some put-and-take sport fisheries in the area but these are not self-sustaining due to environmental factors.

English Creek. English Creek flows through rangeland on the CSA. The riparian zone consists mostly of grasses and aquatic plants including cattails (Typha ssp.), bulrushes (Scirpus spp.), and sedges (Carex spp.). Low flow and a vegetation choked stream channel do not provide for much in the way of habitat for fish. On-stream impoundments and pools created by washouts below culverts provide about the only suitable fish habitat.

Squaw Creek. Squaw Creek changes dramatically from the upstream areas to the lower reaches. At the upper sampling station (S-1) the pine and grass-covered slopes, and the thick, undisturbed riparian zone provide for a relatively stable watershed. The substrates in this area consist of hardpan, gravel riffle areas, and some silted-in pools. The streambanks

are relatively stable with overhanging trees and vegetation with some undercutting. The creek is generally less than 2 m wide. Log jams, undercut tree roots and banks and pools 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. Although cottonwoods continue to provide the overstory as in the upper reaches, the understory in this lower section has virtually been eliminated by livestock grazing. The stream banks are degraded and unstable and the substrate is mostly sand. The stream is generally less than 2 m wide. Few gravel riffle areas are present and most of the pools are heavily silted. Pools to 1.5 m deep, undercut tree roots and log jams provide cover for fish. Aquatic vegetation is rather 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 highwater debris, is subjected to periodic severe flooding. During the evening of 19 May 1982, about 2 inches of rain fell in one hour on the middle and lower Squaw Creek watershed. Considerable damage to roads and riparian areas on and below the CSA was caused by this event. Squaw Creek flowed over the road one-half mile above I-6 causing gullies across the road. English Creek went over the road northwest of I-6, over U.S. Highway 20 and washed out the culvert at E-3. Squaw Creek was diverted into English Creek at I-6 which was the cause of the overflow on Highway 20 and the washing out of culvert E-3. Bridges have been built on Squaw Creek to accommodate floods, whereas only culverts exist on English Creek which were designed to carry the flow of a much smaller watershed.

Sand and silt deposits up to 24 inches and log jams up to 4 ft above the channel were observed the following day on Squaw Creek above I-6. The damage to riparian areas on the CSA was aggravated by a flood of similar or greater proportion during the previous summer and the heavy use of these areas by livestock. Very little ground cover existed in riparian areas prior to the event, which could have reduced water velocity and the resultant damage.

Measurements of maximum depth and extent of flooding were taken the day following the event in an effort to estimate water volumes. These measurements were used to provide streamflow estimates for Squaw Creek stations S-1 and S-5 using a HP 67 Trapezoidal Channel Program. The estimated streamflow at S-1 was .18 cms while at S-2 it was 3.09 cms. The very high increase from S-1 to S-3, a distance of two miles, was probably due in part to less precipitation on the upper watershed, but mainly to differences of vegetation cover. Much of the upper watershed is forested and the area immediately above S-1 is the Ponderosa Wildlife Area where livestock grazing and cultivation is prohibited, whereas, the middle and lower watershed is comprised of heavily grazed rangeland, cultivated small grains or summer fallow.

Estimates of streamflow below S-3 are much less accurate as water overflowed the stream channel making it impossible to use the Trapezoidal Channel method. Based on highwater marks and other evidence, it would appear that flow in English Creek at E-3 was close to 5 cms.

The problem of flooding on English Creek could be greatly reduced or eliminated if more water could be released from I-6 or an emergency spillway constructed to prevent the water from Squaw Creek from flowing into English Creek. But most importantly, watershed management of Squaw Creek could be improved by reducing grazing pressure on rangelands, reducing or eliminating grazing in riparian zones and improving soil conservation practices for cultivated lands.

White Clay Creek. White Clay Creek flows through a riparian grass area at Station WC-1. The stream channel is generally less than a meter wide with relatively stable stream banks provided by grasses. The substrate in this section is mud and sand. Depths range from 25 to 74 cm with no well defined pools or riffles. At station WC-2 the creek flows through pastureland. In this section the substrate consists of sand, gravel and rubble with some silting in pools. Riffle areas are present as well as pools to 75 cm deep. Although this area is grazed by livestock, the stream banks appear to be relatively stable.

White River. The White River has a shifting sand and silt substrate and appears turbid most of the time due to suspended materials. Very few riffle areas exist and pools are not well defined. Some shallow sand bars are present along the edges but for the most part depths range from 0.5 to probably 2 m. Eroding stream banks are present along most sections. Stream width varies from about 3 to 5 m. Cover for fish is provided by deep water, log jams and undercut tree roots. Some good riparian areas exist along the river especially around Fort Robinson State Park. Other riparian areas are heavily grazed and lack understory vegetation. The White River is subject to fluctuating water levels and flooding.

Impoundments. Impoundments range in size from 0.4 ha (I-1) to 7.7 ha (I-6). I-1 is a small stockwater pond created by an earthen dam on a small drainage basin. Heavy livestock use and lack of water during some periods have prevented the growth of aquatic vegetation. Other impoundments on the CSA have extensive aquatic vegetation growth including: cattails, bulrushes, horned pondweed (**Zanichellia** sp), aquatic buttercup (**Ranaunculus** sp), smartweed (**Polygonum** spp), hornwort (**Ceratophyllum** sp and stonewort (**Chara** sp). 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 also serves for stock watering.

Fish. The status and distribution of fish species for the study area are presented in Table 4.9-22. Fourteen species of fish were collected from the CSA streams and impoundments (Table 4.9-23). Game fish collected included: black bullheads, rainbow trout, brown trout, and brook trout. Black bullheads were collected from White Clay Creek but were not present in sufficient number or of sufficient size to contribute to a sport fishery.

Brook trout were collected from Squaw Creek, which is not currently stocked, at several locations. Six brook trout were captured at station S-1 in approximately 500 m of stream. In over 1-km of stream sampled between station S-2 and I-6, two brook trout were collected. Trout ranged in size from 184 to 245 mm (7&1/4 to 9&1/2 in). Periodic stocking by the Nebraska

TABLE 4.9-22

FISH SPECIES LIST

Family/Common Name	Scientific Name	Status
Hiodontidae		
Goldeye	*Hiodon alosoides*	R-OA
Salmonidae		
Brook trout	*Salvelinus fontinalis*	D-PP-O
Brown trout	*Salmo trutta*	D-AA-C
Rainbow trout	*Salmo gairdneri*	D-AA-C
Esocidae		
Northern pike	*Esox lucius*	R-OA
Cyprinidae		
Fathead minnow	*Pimephales promelas*	D-PP-C
Creek chub	*Semotilus atromaculatus*	D-PA-C
Longnose dace	*Phinichthys cataractae*	D-PP-C
Golden shiner	*Notemigonus crysoleucas*	D-PA-C
Sand shiner	*Notropis stramineus*	D-PA-U
Common shiner	*Notropis cornutus*	R-OA
Red shiner	*Notropis lutrensis*	R-OA
Flathead chub	*Hybopsis gracilis*	R-OA
Plains minnow	*Hybognathus placitus*	D-PA-O
Carp	*Cyprinus carpio*	D-OA-C
Catostomidae		
White sucker	*Catostomus commersoni*	D-PA-C
Longnose sucker	*Catostomus catostomus*	R-OA
River carpsucker	*Carpiodes carpio*	R-OA
Ictoluridae		
Black bullhead	*Ictalurus melas*	D-PA-U
Channel catfish	*Ictalurus punctatus*	D-OA-U
Stonecat	*Noturus flavus*	D-AA-O
Cyprinodontidae		
Plains topminnow	*Fundulus sciadicus*	D-PA-O
Percichthyidae		
White bass	*Morone chrysops*	D-OA-C

TABLE 4.9-22 Continued)

FISH SPECIES LIST

Family/Common Name	Scientific Name	Status
Centrarchidae		
Smallmouth bass	*Micropterus dolomieui*	R-OA
Largemouth bass	*Micropterus salmoides*	D-OA-C
Green sunfish	*Lepomis cyanellus*	D-PA-C
Bluegill	*Lepouis macrochirus*	D-OA-C
Black crappie	*Pomoxis nigromaculatus*	D-OA-C
Peridae		
Walleye	*Stizostedion vitreum*	D-OA-C

TABLE 4.9-23

OCCURRENCE OF FISH SPECIES BY HABITAT

Fish Species	English Cr.	Squaw Cr.	White Clay Cr.	White River	Impoundments 1	2	3	4	5	6	7	8	9
SALMONIDAE													
Brook Trout		X											X
Brown Trout				X									
Rainbow Trout				X									
CYPRINIDAE													
Creek Club	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		4			3	2			1
Sampling Method													
Electrofishing	o	o	o	o		o			o				o
Gill Netting													
Pond Netting													
Minnow Trapping	o	o	o	o		o			o				o
Rod & Reel Angling													o

Game and Parks Commission provides a limited put-and-take fishery of local importance in the Ponderosa State Wildlife Area. This area is a self-reproducing brook trout fishery created by stocking by the Game and Parks Commission. The last major stocking took place in 1981 when 9600 two-inch fish were stocked in April and 500 five-inch fish were stocked in September.

Periodic severe flooding is probably the most important factor limiting the effectiveness of stocking and reducing the trout population in Squaw Creek. This occurred in 1987 and the Nebraska Game and Parks Commission stocked 600 five and one-half brook trout into the segments of Squaw Creek on the Ponderosa State Wildlife Area in August, 1987.

Brown trout and rainbow trout were collected in the White River at station W-1 and brown trout were collected at W-2. Eight brown trout were captured in approximately 350 m of stream and ranged in size from 184 to 390 mm (7-1/4 to 15-1/2 in). Only one rainbow trout was caught and it measured 217 mm (8-1/2 in). Population estimates for selected species were calculated based on additional sampling at station W-1 conducted during November, 1983. Rainbow trout were not encountered and approximately six brown trout per 100 meters of stream were observed.

A regionally important put-and-take fishery exists in the White River around the Fort Robinson State Park area. Currently, the White River is on a stocking schedule of 2000 - 3500 catchable trout/year in the upper end, while the lower end receives 4000 catchable trout/year.

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.

Longnose dace were the most abundant fish species captured at the White River stations and they appear to be an important forage fish for trout (Tables 4.9-24A and 4.9-24B). Several brown trout stomachs were examined and were found to contain from one to three longnose dace. Good benthic macroinvertebrate production areas in the White River are generally lacking and as a result aquatic insects are probably not as important in the diet as longnose dace.

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 which includes fathead minnows and golden shiners. The presence of golden shiners in White Clay Creek and English Creek undoubtedly results from these operations.

TABLE 4.9-24A

RELATIVE ABUNDANCE (PERCENT OCCURENCE) OF FISH COLLECTED AT EACH SAMPLING LOCATION, 1982

	Streams								Impoundments								
Fish Species	**E-3**	**S-1**	**S-2 S-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				
Catostonimidae																	
White sucker					2.2	1.1	18.5	20.4									
Ictaluridae																	
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

TABLE 4.9-24B

POPULATION ESTIMATES DERIVED FROM ONE-PASS ELECTROFISHING, JUNE 1982

Number of Fish/100 m of Stream
Sampling Location

Fish Species	S-1	S-2 S-3	S-4	WC-1	WC-2	E-3	W-0*	W-1	W-2	W-3
Rainbow trout								0.6		
Brown trout								2.8	2.6	
Brook trout	1.3	0.3								
Creek chub				58.6	4.4	2.2				20
Longnose dace	19.6	7.2		7.1	86.6		31.1	8.9	61.8	6
Sand shiner							0.9			4
Plains minnow					2.2					
Fathead minnow	2.7	14.3	40	5.0	486.7	82.1				10
Golden shiner					4.4	15.5				
White sucker				2.9	8.9		2.0	2.8	16.5	4
Stone cat										0.5
Plains topminnow					2.2					
Green sunfish				6.4	148.7	22.2				0.5
TOTAL FISH/100 m	23.6	21.8	40	80.0	744.1	122.0	34	15.1	80.9	45
NUMBER OF SPECIES	3	3	1	5	8	4	3	4	3	7
METERS SAMPLED	450	800	45**	140	45**	45**	450	180	115	200

* Upstream from FR-2 footbridge
** Total extent of stream channel a) suitable for electrofishing at the site, or b) total extent between sites (S-2 to S-3)

Additional information on fish populations at Stations W-1 and W-3 obtained from three-pass electrofishing in November 1983 is presented in Appendix 4.9(B).

Benthic Macroinvertebrates. Aquatic insects accounted for 33 of the taxa identified and noninsect invertebrates made up the 18 remaining taxa (Table 4.9-25). Distribution of taxa within the insect orders were as follows: Diptera (true flies) 13; Coleopetra (beetles) 7; Ephemeroptera (mayflies) 4; Trichoptera (caddis flies) 4; Odonata (Dragon flies and Damsel flies) 3; Plecoptera (stone-flies) 1; and Hemiptera (true bugs) 1.

Non-insect invertebrates included snails (Gastropoda), leeches (Hirudinea), aquatic worms (Oligochaeta), Crustacea (Crayfish, scuds, seed shrimp), clams (Pelecypoda), planaria (Turbellaria), and round worms (Nematoda).

Of approximately 6,500 macroinvertebrates counted and identified 33.6% were midges (Tendipedidae=Chironomidae), 20% black flies (Simulidae), 19.1% aquatic worms (Oligochaeta), 14.5% biting midges (Ceratopogonidae), 7% mayflies, and 1.4% caddis flies. Together these six taxa accounted for over 95% of the total number of invertebrates collected. Percent contribution of these taxa to the total number of benthic macroinvertebrates collected at each station is presented in Table 4.9-26. In general, midges or aquatic worms were numerically dominant at most sampling stations. Exceptions occurred at sampling stations E-1 and E-2 where biting midges were most abundant; station S-2 where caddis flies and mayflies dominated; and at station S-3 where black flies were dominant. Aquatic worms occur widely in all types of habitats, but the greatest abundance is usually associated with organically rich substrates and such is the case in most of the impoundments.

Table 4.9-26 presents data on other benthic macroinvertebrates community values, Although densities were high at most sampling stations, diversity values were low. The use of diversity indices is based on the generally observed phenomenon that relatively undisturbed environments support communities having large numbers of species with no individual species present in overwhelming abundance. Healthy streams usually have diversity

TABLE 4.9-25

OCCURRENCE OF BENTHIC MACROINVERTEBRATES IN STUDY AREA
STREAMS AND IMPOUNDMENTS FOR SAMPLES
COLLECTED IN APRIL 1982

Taxon	English Cr.	Squaw Cr.	White Clay Cr.	White River	Impoundments 1	2	3	4	5	6	7	8	9
Class: Insecta (Insects)													
Order: Coleoptera (Beetles)													
Family: Dryopidae													
Helichus		X											
Family: Dytischidae													
Agabinus		X											
Hydrovatus		X											
Family: Elmiade													
Dubiraphia		X											
Neoelmis		X											
Optioservus		X											
Family: Hydrophilidae													
Berosus									X				
Order: Diptera (True Flies)													
Family: Anthomyiidae													
Limnophora	X	X											
Family: Ceratopogonidae													
Palpomyia	X	X	X	X	X		X						X
Family: Dolichopodidae	X												
Family: Ptychopteridae													
Bittacomorpha	X												
Family: Simulidae		X											
Family: Stratiomyiidae	X												
Euparyphus	X												
Odontomyia	X												
Family: Tendipedidae	X	X	X	X	X	X	X	X	X		X	X	X
Family: Tipulidae													
Hexatoma		X											
Limnophila		X											
Limonia		X											
Tipula		X											

TABLE 4.9-25 (Continued)

OCCURRENCE OF BENTHIC MACROINVERTEBRATES IN STUDY AREA
STREAMS AND IMPOUNDMENTS FOR SAMPLES
COLLECTED IN APRIL 1982

Taxon	English Cr.	Squaw Cr.	White Clay Cr.	White River	Impoundments								
					1	2	3	4	5	6	7	8	9
Order: Ephemeroptera (Mayflies)													
Family: Baetidae													
Baetia		X		X									
Caenis								X			X		X
Callibaetis								X					
Tricorythodes		X		X									
Order: Hemiptera (True Bugs)													
Family: Gerridae													
Gerris		X											
Order: Odonata													
Suborder: Anisoptera (Dragon Flies)													
Family: Libellulidae													
Libellula							X						X
Suborder: Zygoptera (Damsel Flies)													
Family: Agrionidae													
Amphiagrion							X						
Family: Coenagrionidae													
Argia													X
Order: Plecoptera (Stoneflies)													
Family: Perlodidae													
Isoperla		X											
Order: Trichoptera (Caddisflies)													
Family: Hydropsychidae													
Cheumatopsyche		X											
Hydropsyche		X		X									

TABLE 4.9-25 (Continued)

OCCURRENCE OF BENTHIC MACROINVERTEBRATES IN STUDY AREA
STREAMS AND IMPOUNDMENTS FOR SAMPLES
COLLECTED IN APRIL 1982

Taxon	English Cr.	Squaw Cr.	White Clay Cr.	White River	Impoundments 1	2	3	4	5	6	7	8	9
Family: Limnephilidae													
Hesperophylax		X											
Limnephilus	X												
OTHER INVERTEBRATES													
Class: Crustacea													
Subclass: Malacostraca													
Order: Amphipoda (Scuds)													
Family: Gammaridae													
Gammarus	X												
Family: Talitridae													
Hyallela axteca	X		X					X	X				X
Subclass: Malacostraca													
Order: Decopoda (Crayfish)													
Family: Astacidae													
Orconectes immunis	X	X	X	X									
Subclass: Ostracoda (Seed Shrimp)		X						X					
Class: Gastropoda (Snails)													
Order: Pulmonata													
Family: Ancylidae													
Ferrissia													X
Family: Lymnaeidae													
Lymnaea	X						X						
Family: Physidae													
Physa	X	X							X		X		X
Family: Planorbidae													
Gyraulus									X				

TABLE 4.9-25 (Continued)

OCCURRENCE OF BENTHIC MACROINVERTEBRATES IN STUDY AREA
STREAMS AND IMPOUNDMENTS FOR SAMPLES
COLLECTED IN APRIL 1982

Taxon	English Cr.	Squaw Cr.	White Clay Cr.	White River	Impoundments 1	2	3	4	5	6	7	8	9
Class: Hirudinea (Leeches)													
Order: Arhynchobdellida													
Family: Erpobdellidae	X	X	X		X		X				X		X
Order: Rhynchobdellida													
Family: Glossiphonidae													
Glossiphonia somplanata	X	X											
Helobdella stagnalis	X						X						X
Placobdella rugosa					X								
Phylum: Nematoda (Round Worms)	X	X						X			X		
Class: Obligochaeta (Worms)													
Order: Opisthopora		X	X	X	X	X		X			X		
Order: Plesiopora	X	X	X	X	X	X	X	X	X	X	X		X
Order: Prosopora													X
Class: Pelecypoda (Clams)													
Order: Heterodonta													
Family: Sphaeridae													
Musculium					X								
Psidium	X	X	X		X								
Class: Turbellaria													
Order: Tricladia													
(Planaria)	X												X
Number of Taxa	18	33	8	7	8	3	8	9	6	1	7	1	13

TABLE 4.9-26

BENTHIC MACROINVERTEVRATE COMMUNITY VALUES FOR STUDY AREA STREAMS AND IMPOUNDMENTS DERIVED FROM SAMPLES TAKEN IN APRIL, 1982

SAMPLING LOCATIONS

	Streams												Impoundments								
Parameter/sample	R-1	R-2	R-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
$\bar{x}$	13090	1745	3399	706	5729	897	5896	3062	5435	428	352	5818	15	7237	8972	4792	4731	138	980	276	10242
Diversity ($\bar{d}$)																					
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
$\bar{x}$	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																					
Tendipedidae	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	89.3	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 = Dredge Sample; S = Surber Sample

values between 3.0 and 4.0, but many forms of stress tend to reduce diversity by making the environment unsuitable for some species or by giving other species a competitive advantage. Squaw Creek at S-1 was the only stream sampling station that had diversity values within this range indicating a higher quality and a more stable habitat.

The density and diversity of benthic macroinvertebrates in the impoundments also reflects the quality of habitat. Impoundment E-1 is a mud bottom stockpond with little aquatic vegetation that supports an impoverished benthic community. Impoundment I-9 on the other hand, is spring fed, cool, productive, has a rich organic substrate and supports a diverse and abundant benthic community.

Periphyton. The Periphyton community of the aquatic habitats on the study area was composed of diatoms (21 genera) with a few green algae (8 genera) and one blue-green algae (Table 4.9-27). In general, only minor differences were found between communities in the streams and those in impoundments.

A good diversity of diatoms was present at each sampling location with the number of genera ranging from 8 to 15 and averaging 11. **Cymbella**, **Nauicula**, **Nitzschia**, **Surirella**, and **Synedra** were the most common genera and were found in every sample. In addition, **Synedra** was numerically dominant in 7 of 18 samples, **Nitzschia** 4/18, **Nauicula** 2/18, and **Cymbella** 1/18. Although **Surirella** was found in all samples, its present occurrence was low and in only one sample did it occur in excess of 10%.

Green algae were found in all sampling locations, with the greatest development occurring in the impoundments. Clodophora was the most common and abundant green algae found in the streams and at some locations formed thick mats with tassels approaching a meter in length.

TABLE 4.9-27

DIATOM PROPORTIONAL COUNTS (PERCENT OCCURRENCE) AND OCCURRENCE OF OTHER ALGAE BY SAMPLING LOCATION. DATA ARE FROM SAMPLES COLLECTED IN APRIL, 1982

	Streams											Impoundments							
Diatoms	R-1	R-2	R-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
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	11.3	3.9	1.4	8.5	13.7
Diatoma		0.6						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			
Cladphora			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																			
na																x			

4.9-3 POTENTIAL IMPACTS

In the assessment of potential impacts of the proposed development, particular attention was paid to "important species" (USNRC 1980). These include 1) commercially or recreationally valuable species, 2) threatened or endangered species, 3) species affecting the well-being of species within criteria 1) or 2), and 4) species which are critical to the structure and function of the ecological system or biological indicators of chemical pollutants or radionuclides in the environment. Anticipated impacts of the proposed project are outlined below.

Short-term Impacts

Economic Considerations. Although the Pine Ridge area is among the most popular hunting and fishing areas in the state of Nebraska, most activities take place on public lands adjacent to the CSA: Fort Robinson State Park, Fort Robinson Wildlife Area, Ponderosa Wildlife Area, the Nebraska National Forest, and the Oglala National Grassland. The proposed project is not expected to diminish in any way the hunting and fishing opportunities on those areas.

The entire CSA is privately owned, and hunting and fishing opportunities are the prerogative of individual landowners. Harvestable wildlife populations are relatively low, and a sport fishery is practically non-existent. Estimates of total annual harvest on the CSA based on observed phenomena and discussions with landowners are: mule deer (fewer than 5); white-tailed deer (fewer than 5); other big game species (0); turkeys (fewer than 5); pheasants (fewer than 20); sharp-tailed grouse (fewer than 10); quail and partridges (0); doves and pigeons (fewer than 10); ducks and geese (fewer than 30); rabbits, all species (fewer than 10); squirrels (fewer than 10); game fish (0).

Flora. No threatened or endangered plant species was documented on the CSA.

Mammals, General. No threatened or endangered species was documented on the CSA.

Big Game Mammals. The big game mammals that are known to or could inhabit the CSA (white-tailed and mule deer, elk and pronghorn antelope) will not be affected by the proposed project. The elk and deer tend to use the wooded watercourses for shelter moving into the cultivated and grassland areas for feeding. The areas of disturbance for wells and access roads will impact less than 100 acres of the Commercial Permit Area at any one time. The remainder will be in native or cultivated habitat.

Impacts caused by the proposed project to big game hunting will be minimal. The yearly harvest from the CSA has averaged only 10 total deer (white-tailed and mule) and no elk or pronghorn antelope. These deer were generally harvested from private property and FEN's proposed project will not affect or preclude the landowners from allowing big game hunters from hunting on their property.

Carnivores. Red foxes, coyotes, raccoons, long-tailed weasels and striped skunks are expected to occur regularly but in low numbers on the CSA. Impacts are expected to be in direct proportion to the reduction in suitable prey species, including small mammals, birds and insects. If reasonable attention is given to protection of vegetation during the operational phase, there is no reason to anticipate a significant reduction in the prey base.

Birds, General. Bald eagles, protected under federal act, were recorded on the AA, including one on the CSA. The species is an uncommon winter resident and migrant. Critical habitat does not exist for the species within or near the study area.

Game Birds. No significant impacts to the game bird populations or hunting opportunities are anticipated. Only a single turkey has been recorded on the CSA, and pheasant, which are relatively common on the CSA, are found mainly in structure biotopes and cultivated areas with most in roadside

situations. The proposed project will have minimal impact on these types of areas. Sharp-tailed grouse are common on the study area, but only a small population and no leks were recorded on the CSA. The low population figures for the CSA would limit hunting opportunities for sharp-tailed grouse.

Raptors. The CSA, with an abundance of raptor habitat, has a large number of raptors, including golden eagles, red-tailed hawks, rough-legged hawks, northern harriers, prairie falcons, kestrels and great horned owls both nesting on the area and using it as a hunting ground. In addition, one bald eagle was observed on the CSA and is discussed in a previous section. Impacts are expected to be in direct proportion to any reduction in suitable prey, including small mammals, birds, reptiles and insects. In view of the degraded range conditions on the site, it is probable that habitat conditions for rodents, lagomorphs, and other suitable prey species can be enhanced during the operational and reclamation stages of development, if attention is paid to vegetation protection and rehabilitation.

Reptiles, Amphibians and Fish. No threatened or endangered species were recorded, and none is expected to occur on the CSA. Owing to the unstable nature of Squaw Creek on the CSA, it is likely that aquatic conditions can be enhanced during the operational phase, if attention is paid to vegetation protection and rehabilitation.

Disturbances, General. Impacts caused by expansion to and operation of FEN's proposed commercial facility will be minimal. The processing facility, active wells, and wells being reclaimed will total less than 100 acres of disturbance at any one time.

Long-term Impacts. No long-term impacts from the project are anticipated, and no impairment of ecological stability, or diminishment of biological diversity should be realized.

4.9-4 REFERENCES

American Public Health Association, 1971. ***Standard Methods for the Examination of Water and Wastewater,*** 13th ed. American Public Health Association, Inc., New York 1196 p.

Bailey, R.M. and M.O. Allum, 1962. ***Fishes of South Dakota,*** Misc. Publ. Mus. Zool., Univ. Michigan. 119:1-131.

Baxter, G.T. and J.R. Simon, 1970. ***Wyoming Fishes,*** Bull. No.4, Wyoming Game and Fish Department, Cheyenne, 168 p.

Baxter, G.T. and M.D. Stone. 1980. ***Amphibians and Reptiles of Wyoming,*** Bull. No.16, Wyoming Game and Fish Department, Cheyenne, 137 p.

Bellrose, F.C. 1976. ***Ducks, Geese and Swans of North America,*** Stackpole Books, Harrisburg, PA. 543 p.

Bennett, J.W. 1969, ***Northern Plainsmen Adaptive Strategy and Agrarian Life,*** AHM Publ., Arlington Heights, Va. p.352.

Bliss, Q.P. and S. Schainost. 1973. ***White River - Hat Creek Basin Stream Inventory Report,*** Nebraska Game and Parks Commission, Lincoln. 28 p.

Bohn, C., C. Galen, C. Moser and J. Thomas. 1980. ***Homesteads - Man-Made Avian Habitats in the Rangelands of Southeastern Oregon,*** Wildl. Soc. Bull. 8(4):332-341.

Brown, C. 1987. USDA Animal Control Officer, ***Personal communication.***

Buechler, D. 1987. USFWS Enhancement Division, ***Personal communication.***

Burgess, H., H. Prince and D. Trauger, 1965. ***Blue-winged Teal Nesting Success as Related to Land Use.*** J. Wildl. Manage. 29(1):89-95.

Call, M.W. 1978, ***Nesting Habitats and Surveying Techniques for Common Western Raptors,*** U.S. BLM Tech. Note 316, 115 p.

Coenenberg, J.D., E.J. DePuit, and W.H. Willmuth. 1977. ***Wildlife Habitat Classification System and Habitat Types - Southeast Montana,*** Montana Agr. Exper. Sta., Miles City. 41 p.

Collins, J.T. 1974, ***Amphibians and Reptiles in Kansas,*** Univ. Kansas Mus. Nat. History Publ. Ed. Ser. 1:1-283.

Conner, R.N. and J.G. Dickson. 1980, ***Strip Transect Sampling and Analysis for Avian Habitat Studies,*** Wildl. Soc. Bull. 8(1):4-10.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979, *Classification of Wetland and Deepwater Habitats of the United States,* U.S. Fish and Wildl. Serv. FWS/OBS-79/31. 103 p.

Cross, F.B. 1967, *Handbook of Fishes of Kansas,* Univ. of Kansas Mus. of Natl. Hist. Misc. Publ. 45.357 p.

Daniel, C. and R. Lamaire. 1974, *Evaluating Effects of Water Resource Developments on Wildlife Habitat,* Wildl. Soc. Bull. 2(3):114-118.

Dinan, J. 1987, Bird Biologist, Nebraska Game and Parks, *Personal communication.*

Dorn, R.D. 1977, *Manual of the Vascular Plants of Wyoming,* (2 Vol.) Garland Publ., Ithaca, NY. 1498 p.

Dzubin, A. 1969, *Assessing Breeding Populations of Ducks by Ground Counts,* pp. 178-230 In Saskatoon Wetlands Seminar. Canad. Wildl. Serv. Report Ser. 6. 262 p.

Eddy, S. 1957, *How to Know the Freshwater Fishes,* W.C. Brown. 253 p.

Elder, J.A. 1969, *Soils of Nebraska,* Resource Rept. No. 2. Univ. Nebraska Cons. and Surv. Div., Lincoln, 60 p.

Emlen, J.T. 1977, *Estimating Breeding Bird Densities from Transect Counts,* Auk 94:455-468.

Environmental Protection Agency. 1973, *Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents,* NERC, Cincinnati.

Evans, K.E. 1968, *Characteristics and Habitat Requirements of the Greater Prairie Chicken and Sharptailed Grouse - A Review of Literature,* U.S. Forest Service, Cons. Res. Rept. No. 12.

Fannes, C.A. and W. Norling. 1981, *Nesting of the Great-Tailed Grackle in Nebraska,* American Birds. 35(2):148-149.

Fannes, C.A. and D. Bystrak. 1981, *The Role of Observer Bias in the North American Breeding Bird Survey,* Studies in Avian Biology. 6:353-359.

Fenneman, N.M. 1931, *Physiography of the Western United States,* McGraw-Hill *k* Co., NY. 534 p.

Fortenberry, D.K. 1972, *Characteristics of the Black-Footed Ferret,* USDI, Fish and Wildlife Service. Resource Publ. No. 109. 8 p.

Fryda, D. 1987, USDA Animal Damage Control, *Personal communication.*

Gibson, J. 1987, Professor of Biology, Chadron State Collegs, ***Personal communication.***

Great Plain Flora Association. 1977, ***Atlas of the Flora of the Great Plains,*** T.M. Barkley, Ed. Iowa State Univ. Press, Ames. 600 p.

Hitchcock, A.S. 1971, ***Manual of the Grasses of the United States*** (2 Vol.), 2nd Ed., A. Chase Ed. Dover Publ., NY 1051 p.

Johnsgard, P.A. 1973, ***Grouse and Quails of North America,*** Univ. of Nebraska Press, Lincoln, 553 p.

_____. 1979, ***Birds of the Great Plains: Breeding Species and Their Distribution.*** University of Nebraska Press, Lincoln. 539 p.

Kennedy, L. 1980, ***Raptor Baseline Studies in Energy Development,*** Wildl. Soc. Bull. 8(2):129-135.

Kirsch, L. 1969, ***Waterfowl Production in Relation to Grazing,*** J. Wildl. Manage. 33(4):821-828.

Krull, J. 1970, ***Aquatic Plant-Macroinvertebrate Associations and Waterfowl,*** J. Wildl. Manage. 34(4):707-719.

Lagler, K.F. 1956, ***Freshwater Fishery Biology,*** 2nd Ed. W.C. Brown and Co., Dubuque, IA. 421 p.

Lemmons, L. 1987, Ponderosa State Wildlife Area, ***Personal communication***

Lingle, G.R. 1981, ***Status of American Woodcock in Nebraska with Notes on a Recent Breeding Record,*** The Prairie Naturalist. 13(2):47-51.

Lock, R. 1972, ***Population Trends of Non-Game Species,*** Nebraska Game and Parks Comm., Lincoln, 7 p.

_____. 1974, ***Population Surveys of Non-Game Species,*** Nebraska Game and Parks Comm., Lincoln, 10 p.

_____. 1977, ***Nebraska's Endangered and Threatened Wildlife,*** Nebraska Game and Parks Comm., Lincoln. 35 p.

Mathisen, J.E., and A. Mathisen. 1968. ***Species and Abundance of Diurnal Raptors in the Panhandle of Nebraska,*** Wilson Bull. 80:479-486.

Matthews, J. 1987, USFWS, ***Personal communication.***

McGahn, J. 1968, ***Ecology of the Golden Eagle,*** Auk 85:1-12.

McCarraher, D.B. 1977, ***Nebraska's Sandhill Lakes,*** Nebraska Game and Parks Comm., Lincoln.

Mills, L. 1987, USFWS, *Personal communication.*

Moyle, J.B. 1946, *Some Indices of Lake Productivity,* Tans. Amer. Fish. Soc. 76:322-334.

Muenscher, W.C. 1944, *Aquatic Plants of the United States,* Comstock Publ., Ithica, NY. 374 p.

Nebraska Game and Parks Commission, 1977, *Fish and Wildlife Plan,* Vols. 1 and 2. Nebraska Game and Parks Comm., Lincoln.

Nebraska Game and Parks Commission. 1980, *State Comprehensive Outdoor Re-Creation Plan,* Nebraska Game and Park Commission, Lincoln.

Nixon, F.S. 1967, *A Vegetational Study of the Pine Ridge of Northwestern Nebraska,* Southwest Naturalist. 12:134-145.

Ogden, V.T. and M.G. Hornocker. 1977, *Nesting Density and Success of Prairie Falcons in Southwestern Idaho,* J. Wildl. Manage. 41:1-11.

Over, W.H. 1932, *Flora of South Dakota,* Univ. South Dakota, Vermillion.

Pennak, R.W., 1953, *Freshwater Invertebrates of the United States,* Ronald Press Co., NY.

Peterson, C.R. 1974, *A Preliminary Report on the Amphibians and Reptiles of the Black Hills of South Dakota and Wyoming,* M.S. Thesis, Univ. Illinois. 112 p.

Peterson, J. 1987, Fish Biologist, Nebraska Game and Parks, *Personal communication.*

Peterson, J. 1988, Fish Biologist, Nebraska Game and Parks, *Personal communication.*

Prescott, G.W. 1962, *How to Know the Freshwater Algae,* W.C. Brown, Dubuque, IA.

Prochazka, J. 1987, USFS Nebraska National Forest, *Personal communication.*

Reid, G.K. 1961, *Ecology of Inland Waters and Estuaries,* Reinhold Pub.,NY.

Roback, S.S. 1974, *Insects (Arthropoda:Insects)* Chapter 10 In Hart, C.W. and S.L.H. Fuller (eds), Pollution Ecology of Freshwater Invertebrates, Academic Press, NY 63 p.

Rotherham, V. 1987, Supervisor, Fort Robinson State Park, *Personal communication.*

Ruttner, F. 1963, *Fundamentals of Limnology,* 3rd ed. Univ. Toronto Press, 295 p.

Rydberg, P.A. 1932, *Flora of the Prairies and Plains of Central North America,* New York Botanical Garden, NY.

Schranck, B. 1972, *Waterfowl Nest Cover and Some Predation Relationships,* J. Wildl. Manage. 36(1):182-186.

Sharma, R.K., J.D. Buffington, and J.T. McFadden. 1975, *Proceeding of the Nuclear Regularoty Commission Workshop on the Biological Significance of Environmental Impacts,* USNRC, Washington, D.C. 327 p.

Shickley, G.M. 1961, *Wintering Bald Eagles in Nebraska,* 1959-1960. Nebraska Bird Review. 29:26-31.

Sisson, L. 1976, *The Sharp-tailed Grouse in Nebraska, a Research Study,* Nebraska Game and Parks Comm., Lincoln. 88 p.

Smith, H.M. 1956, *Handbook of Amphibians and Reptiles of Kansas,* 2nd ed. Misc. Publ. Univ. Kansas Mus. Nat. Hist. 9:1-356.

Spalding, R. 1987, University of Nebraska Conservation and Survey Division, *Personal communication.*

Stewart, R.E. and H.A. Kantrud. 1971, *Classification of Natural Ponds and Lakes in the Glaciated Prairie Region,* USDI, Fish and Wildlife Service Res. Publ. No. 92 57 p.

Struempler, A.W. 1979, *Inter-relationships of Selected Physical Properties and Chemical Constituents of Ground Water in Northwestern Nebraska,* Trans. Nebraska Acad. Sci. 8:41-45.

Struempler, A. 1987, Professor of Chemistry, Chadron State College. *Personal communication.*

Suetsuga, H. 1987, Big Game Biologist, Nebraska Game and Parks, *Personal communication.*

Taylor, M.W., C.W. Wolfe, and W.L. Baxter. 1978, *Landuse Change and Ring-necked Pheasants in Nebraska,* Wildl. Soc. Bull. 6(4):226-230.

Tolstead, W.L. 1947, *Woodlands in Northwestern Nebraska,* Ecology. 28(2):180-188.

Urbatsch, L.E. and R. Eddy. 1969, *A Floristic Study of Dawes County, Nebraska,* Trans. Nebraska Acad. Sci. 2:190-203.

U.S. Fish and Wildlife Service. 1972, *Memorandum on Animal Damage Control on the Nebraska National Forest,* (IAW Div. Wildl. Service Policy Handbook 69-S-1 6,000). USDI/USFWS, Div. Wildl. Services, Denver.

____. 1981, *The Platte River Ecology Study,* USDI/USFWS Spec. Res. Rept. 187 p.

U.S. Forest Service. 1969, *Timber Management Plan 1974-84,* (Unapproved). USDA/USFS, Nebraska National Forest, Chadron.

____. 1978, *Comprehensive Plan for Fish and Wildlife on Nebraska National Forest System Lands,* USDA/USFS, Nebraska National Forest/Nebraska Game and Parks Comm. 26 p.

____. 1980, *Nebraska National Forest, Planning Action 2 Documents,* USDA/ USFS, Nebraska National Forest, Chadron.

U.S. Forest Service, 1980, *Revision of 1980 RPA Values,* USDA/USFS, Office of Management and Progressive Planning. Region 2.

____. 1981, *Birds of the Nebraska Pine Ridge Area - Field Checklist,* USDA/ USFS, Nebraska Forest, Chadron. 10 p.

____. 1981, *Forest Plan, Nebraska National Forest,* USDA/USFS, Nebraska National Forest, Chadron.

____. 1981, *Nebraska National Forest - Analysis of the Management Situation for the Forest Plan,* USDA/USFS, Nebraska National Forest 455 p.

U.S. Soil Conservation Service, 1977, *Rangeland Resource of Nebraska,* USDA/ SCS, Lincoln.

____. 1977, *Soil Survey of Dawes County, Nebraska,* USDA/SCS 132 pp.

VanBruggen, T. 1976, *The Vascular Plants of South Dakota,* Iowa State Univ. Press, Ames. 538 p.

Van Tersch, L. 1982, *Plague of Hay-eating Deer Herds Costs Area Ranchers Plenty,* The Chadron Record/Crawford Tribune. (17 Feb 82, Page 1).

Van Nelson, R.C., 1974, *Trout Management in Western Nebraska,* Nebraska Chapter Wildlife Society, Chadron.

____. 1978, *The McConaughy Rainbow - Life History and a Management Plan for the North Platte River Valley,* Nebraska Game and Parks Comm. Tech. Ser. No. 2, 82 p.

Visher, S.S. 1954, *Climatic Atlas of the United States,* Harvard Univ. Press, Cambridge 403 p.

Ward, H.B. and G.C. Whipple. 1958, *Freshwater Biology,* John Wiley and Sons. NY.

Weber, C.I. 1966, ***A Guide to the Common Diatoms at Water Pollution Surveillance System Stations,*** USDI/FWPCA, Cincinnati, OH.

Weedon, R. 1987, Professor of Biology, Chadron State College, ***Personal communication.***

Williams, A.B. 1936, ***The Composition and Dynamics of a Beechmaple Climax Community,*** Ecological Monogr. 6:317-408.

Williams, J. 1987, Director, Upper Niobrara-White River Conservation District, ***Personal communication.***

Wright, H.E. 1970, ***Vegetational History of the Central Plains,*** pp. 157-172 In W. Dorf and J.D. Jones, eds. Pleistocene and recent environments of the central Great Plains.

APPENDIX 4.9(A)

Endangered Species Statement

Nebraska Game and Parks Commission
2200 North 33rd Street / P.O. Box 30370 / Lincoln, Nebraska 68503

September 9, 1983

David M. Stout
Environmental Coordinator
Wyoming Fuel Co.
445 Union Blvd., Suite 310
Lakewood, CO 80228

Dear Mr. Stout:

We were advised by Fred Harrington that The Nuclear Regulatory Commission needs a statement on the occurrence of threatened or endangered species in the area of the Crow Butte uranium project.

The black-footed ferret (State and Federally endangered) and swift fox (endangered in Nebraska) are two endangered species that could be impacted by the project. We have no sighting records of black-footed ferrets in the project area; however, extensive efforts have not been conducted by our agency to locate ferrets in that area. Because black-footed ferrets are usually found in association with prairie dogs, we feel ferrets could exist anywhere in western Nebraska where prairie dogs are found.

We have no records of swift fox within the 80 acre Restricted Area Boundary; however, we do have two probable sightings of swift fox within the 8 kilometer Adjacent Area Boundary. The dates and locations of those sightings are listed below:

Date	Location
April-June 1983	NE¼ S26, T32N, R52W
October 1, 1981	S36, T32N, R52W

The "probable" classification simply means that the reports appeared accurate but were not confirmed through observation by Game and Parks Commission personnel.

Please let me know if we can be of any further assistance.

Sincerely,

Ross A. Lock/rw

Ross A. Lock
Nongame Specialist

RAL/FA/rw
cc: Fred A. Harrington, Jr.

APPENDIX 4.9(B)

Fish Population Data

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M E M O R A N D U M

To: Dave Stout
WYOMING FUEL COMPANY

20 November 1983

From: Fred Harrington

Subject: Three-pass electro-fishing results at W-1 and W-3, Crow Butte Study Area, 2 November 1983.

Introduction

On 2 November 1983, stream sampling stations W-1 and W-3, upstream and downstream, respectively, from the Crow Butte Uranium Prospect, were sampled for fish populations. Dave Stout, Fred Harrington, Daryl Howell, and Rhonda Grantham were present. Weather was favorable, with an air temperature of 12-18°C and water temperature 4-6°C. Station W-1 was slightly to moderately turbid, as always, and station W-3 was clear. Flow was relatively low - typical for the season.

Methods

A 100-m section of stream was sampled at each site. Each end of the sampled section was blocked with ¼" seine segments attached to steel fence posts driven into the stream bed. Three passes were made with a back-pack electro-fishing unit on 150 volts DC. Captured fish were tallied by species, and representative specimens of the larger species were measured. Subsequently, all live fish were released below the sampled section.

Calculations were based on regression methods suggested by DeLury (1947), Kono (1953), Zippin (1956), Kemp-Turnbull (1960), and Wada (1962), and are presented in the appendix.

Findings and Discussion

Fewer species were caught at both stations than during previous exercises (Tables 1,2). At W-1, brown trout, white suckers, and longnose dace were captured. Rainbow trout, found previously, were not caught. At W-3, six speices were captured - creek chub, fathead minnow, stone cat, green sunfish, longnose dace, and white sucker. Sand shiners, present in the spring of 1982, were not found.

Findings were comparable with previous sampling efforts, revealing a very limited sport fishery and low to moderate numbers of rough fish. The higher relative abundance of fathead minnows is attributable to recruitment in the current growing season.

Table 4.9(B)-1

Three-pass electro-fishing results, Crow Butte Study Area, 2 November 1983.

Species	1st Pass	2nd Pass	3rd Pass	Total
	W-1			
Brown trout	5	0	1	6
White sucker	1	0	0	1
Longnose dace	0	0	3	3
Rainbow trout*	0	0	0	0
	W-3			
Creek chub	32	10	8	50
Fathead minnow	153	82	35	270
Stone cat	2	0	0	2
Green sunfish	1	4	0	5
Longnose dace	35	28	11	74
White sucker	1	0	0	1
Sand shiner*	0	0	0	0

* know to have occurred previously

Table 4.9(B)-2

Population estimates for selected species, Crow Butte Study Area, 2 November 1983 - calculations in accordance with Kono (1953).

Species	Population Estimate*	Standard Error	Confidence Interval**
	W-1		
Brown trout	6.19	0.01	±0.02
	W-3		
Fathead minnow	306.82	11.07	± 22.14
Green sunfish	8.33	91.85	±183.70
Longnose dace	94.67	27.60	± 55.20
Creek chub	55.56	1.29	± 2.58

* fish/100 m stream
** $p < 0.05$

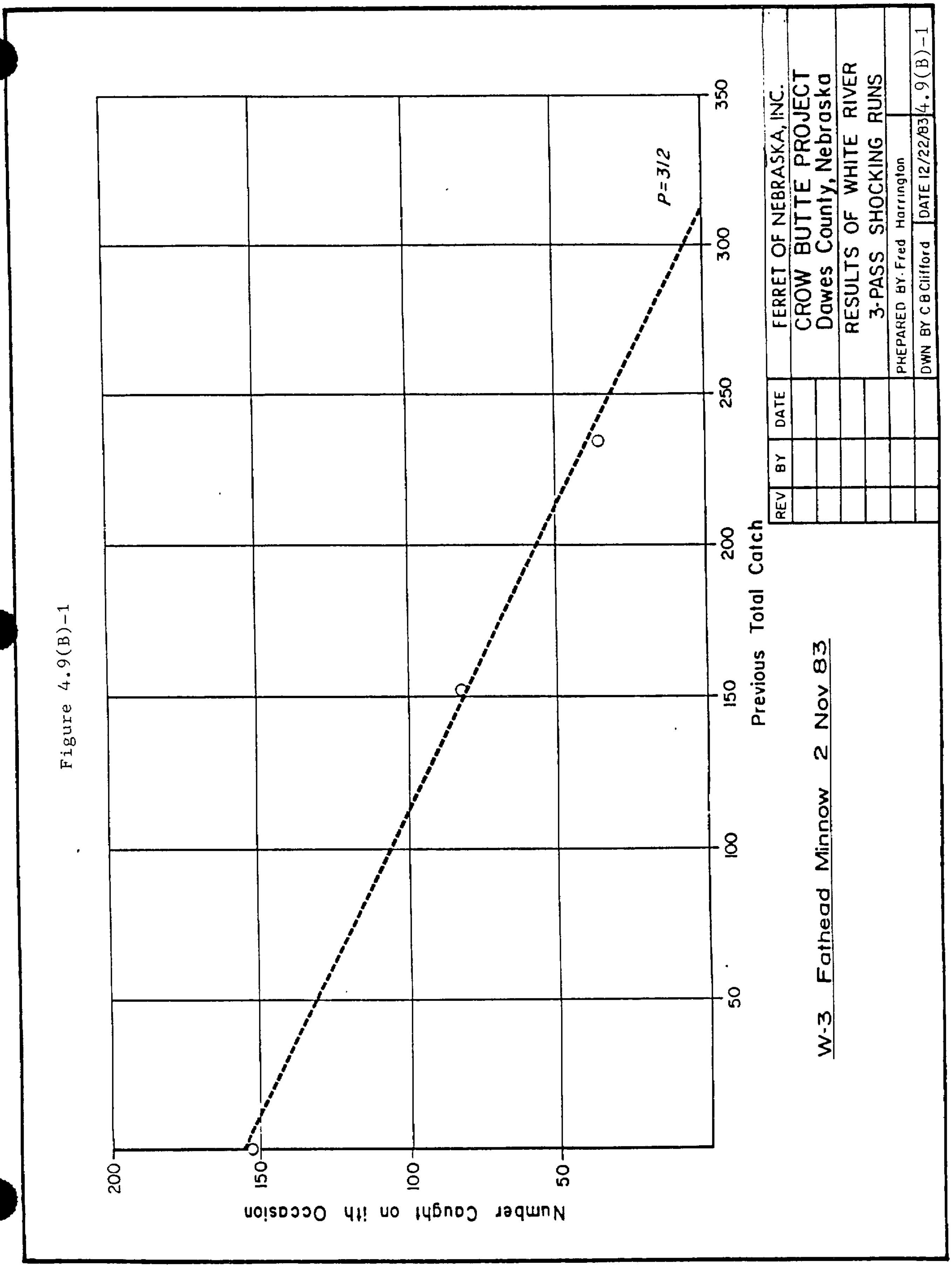
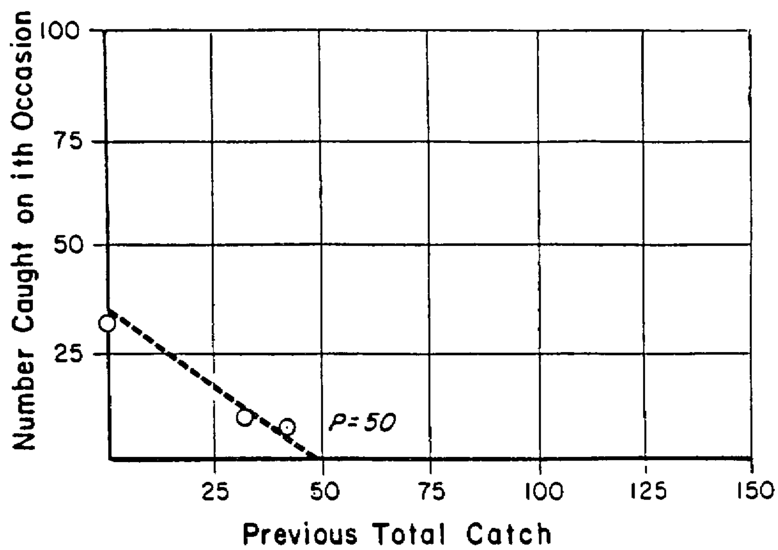
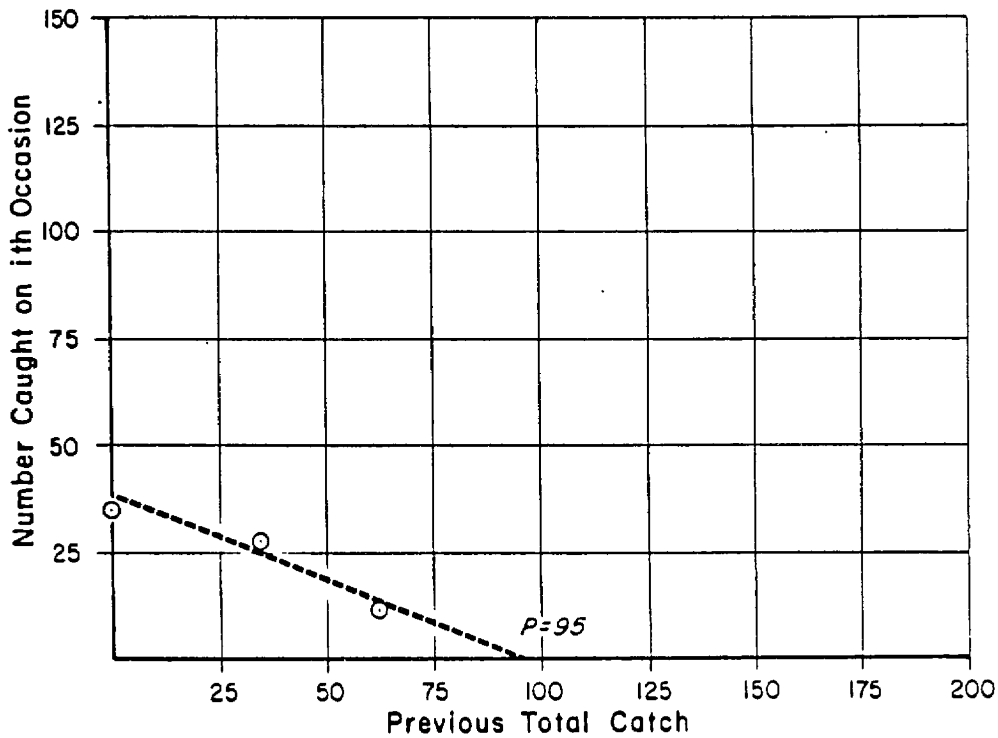

P=312
Number Caught on ith Occasion
200
150
100
50
Previous Total Catch
50
100
150
200
250
300
350
W-3 Fathead Minnow 2 Nov 83
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
RESULTS OF WHITE RIVER
3-PASS SHOCKING RUNS
PREPARED BY: Fred Harrington
DWN BY C B Clifford
DATE 12/22/83
4.9(B)-1
REV
BY
DATE

Figure 4.9(B)-1

Figure 4.9(B)-2



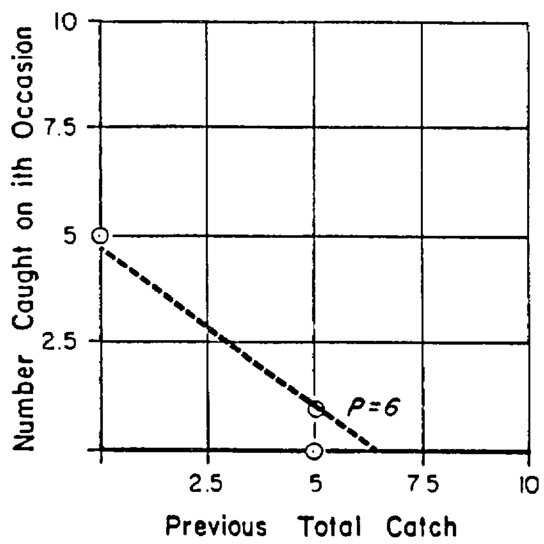
W-3 Creek Chub 2 Nov 83



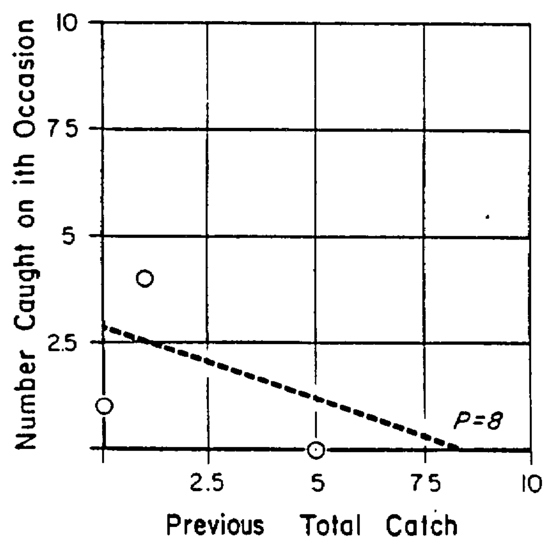
W-3 Longnose Dace 2 Nov 83

REV	BY	DATE	FERRET OF NEBRASKA, INC.	
			CROW BUTTE PROJECT Dawes County, Nebraska	
			RESULTS OF WHITE RIVER 3-PASS SHOCKING RUNS	
			PREPARED BY Fred Harrington	
			DWN BY S.A.Davis	DATE 12/22/83 4.9(B)-2

Figure 4.9(B)-3



W-1 Brown Trout 2 Nov 83



W-3 Green Sunfish 2 Nov 83

REV	BY	DATE	FERRET OF NEBRASKA, INC.	
			CROW BUTTE PROJECT Dawes County, Nebraska	
			RESULTS OF WHITE RIVER 3-PASS SHOCKING RUNS	
			PREPARED BY: Fred Harrington	
			DWN BY: C B. Clifford DATE: 12/22/83	4.9(B)-3

FISH COLLECTIONS

Project 101-5 Location Crow Butte W-1 Date/Time 2 NOV 83

Water Characteristics Slightly - Moderately Turbid 4°C

Sampling Effort Electrofishing 100 m Closed Above + Below

Gear/Personnel D. Stout, F. Harrington, D. Howell, R. Grantham

Species	No.	L mm	W	Species	No.	L	W
PASS 1							
Brown Trout	1	425					
	1	282					
	1	390					
	1	340					
	1	268					
White Sucker	1	420					
PASS 2							
Nothing Captured	0	–	–				
PASS 3							
Brown Trout	1	280					
Longnose Dace	3	–					

Summary/Remarks

Totals

Brown Trout 6

White Sucker 1

Longnose Dace 3

FISH COLLECTIONS

Project 101-5 Location Crow Butte - W-3 Date/Time 2-26-88

Water Characteristics Clear 4°C

Sampling Effort Electro-fishing 100m Closed Above + Below

Gear/Personnel D. Stout, F. Harrington, D. Howell, R. Grantham

Species	No.	L mm	W	Species	No.	L	W
PASS 1							
Creek Chub	1	140					
"	1	162					
"	1	158					
"	1	182					
"	1	130					
"	1	182					
"	1	117					
"	1	125					
"	1	135					
"	1	130					
"	22	–					
Fathead Minnow	153	–					
~~Madtom~~ Stonecat	1	151					
~~Madtom~~ Stonecat	1	153					
Green Sunfish	1	74					
Longnose Dace	35	–					
White Sucker	1	245					
PASS 2							
Creek Chub	10	–					
Green Sunfish	1	89					
"	1	103					
"	1	78					
"	1	86					
"							
Fathead Minnow	82	–					
Longnose Dace	28	–					
PASS 3							
Creek Chub	8	–					
Fathead Minnow	35	–					
Longnose Dace	11	–					

Summary/Remarks

Totals

Creek Chub 50
Fathead Minnow 270
Madtom 2
Green Sunfish 5
Longnose Dace 74
White Sucker 1

FATHEAD MINNOW W-3

T = 153 + 82 + 35 = 270

$\sum_{i=1}^{k}$ (1-1)153 + (2-1)82 + (3-1)35 = 152

R = 153/270 = 0.57

P = 270 divided by 0.88 = 307

307 (307-270) 270 = 3,066,930
270^2 - 307(307-270) [(3x0.50)^2/(1-.50)] 276,935
72900 - 11359 [2.25/0.5]
61541 [4.5] S.E. of P = 11.07

95% confidence limits of the estimate are: 307+/- 2 x 11.07 = 307 +/- 22

GREEN SUNFISH W-3

T = 1 + 4 + 0 = 5

$\sum_{i=1}^{k}$ (1-1)1 + (2-1)4 + (3-1)0 = 4

R = 4/5 = 0.80

P = 5 divided by 0.60 = 8.33

S.E. of P = 8.33 (8.33 - 5)5 = 138.69
5^2 - 8.33(8.33-5) [(3x0.22)^2/(1-0.22)] -1.51
25 - 27.7 [.44/0.78]
-2.7 [0.56] 91.85

95% confidence limits of the estimate are: 8.33 +/- 2 x 91.85 = 8.33 +/- 183.7

LONGNOSE DACE W-3

T = 32 + 28 + 11 = 71

$\sum_{i=1}^{k}$ (1-1)32 + (2-1)28 + (3-1)11 = 50

R = 50/71 = .70

P = 71 divided by .75 = 95

95 (95-71) 71
71^2 - 95(95-71) [(3x0.38)2/(1-0.38)]
5041 - 2280 [1.30/.62]
1761 [2.10]

= 160176 / 5798.1

S.E. of P = 27.6

95% confidence limits of the estimate are: 95 +/- 2 x 27.6 = 95 +/- 55

CREEK CHUB W-3

T = 32 + 10 + 8 = 50

$\sum_{i=1}^{k}$ (1-1)32 + (2-1)10 + (3-1)8 = 26

R = 26/50 = 0.52

P = 50 divided by 0.90 = 56

56 (56-50) 50
50^2 - 56(56-50) [(3x0.55)2/(1-0.55)]
2500 - 336 [2.72/0.45]
2164 [6.04]

= 16800 / 13071

S.E. of P = 1.29

95% confidence limits of the estimate are: 56 +/- 2 x 1.29 = 56 +/- 2.58

BROWN TROUT W-1

T = 5 + 0 + 1 = 6

$\sum_{i=1}^{k}$ (1-1)5 + (2-1)0 + (3-1)1 = 2

R = 2/6 = 0.33

P = 6 divided by 0.97 = 6.19

6.19 (6.19-6) 6
6^2 - 6.19 (6.29-6) [(3x0.70)2/(1-0.70)]
36 - 1.18 [4.41/.30]
34.82 [14.7]

= 7.06 / 511.85

S.E. of P = 0.01

95% confidence limits of population estimates are: 6.19 +/- 2 x 0.01 = 6.19 +/- 0.02

SECTION 5.0

PROPOSED OPERATING DATA

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5.0 PROPOSED OPERATING DATA

5.1 Proposed Activity

The proposed activity is a commercial scale uranium in-situ leach facility. The proposed facility is designed to process an average of 2500 gallons per minute (gpm) of leach solution. The 2500 gpm will not include restoration flow.

5.1-1 Wellfield Operation

The proposed mine schedule for the Crow Butte Project is shown in Table 5.1-1. This mine schedule covers the first ten years of the project. Mine schedules for later years will be submitted one year prior to the proposed mining. A map showing the proposed mine plan is found as Figure 5.1-1. A typical wellfield layout is shown in Figure 5.1-2. The wellfield is a repeated 5 spot design or a repeated 7 spot hexagon design or a combination. The spacing between injection wells will range from 40 to 100 ft.

Piping from the plant building to the wellfield building and from the wellfield building to the individual wells will be buried below the frost line. Either high density polyethylene or PVC pipe will be used for the underground service. Individual wells will be fitted with pitless adaptors or insulated wellhead covers to protect against freezing. All underground piping will be leak tested prior to use.

Monitor wells will be placed in the Chadron sand. In addition to the Chadron sand, monitor wells will also be placed in the first significant water bearing Brule sand above the Chadron sand. All monitor wells will be completed and developed prior to leach solution injection.

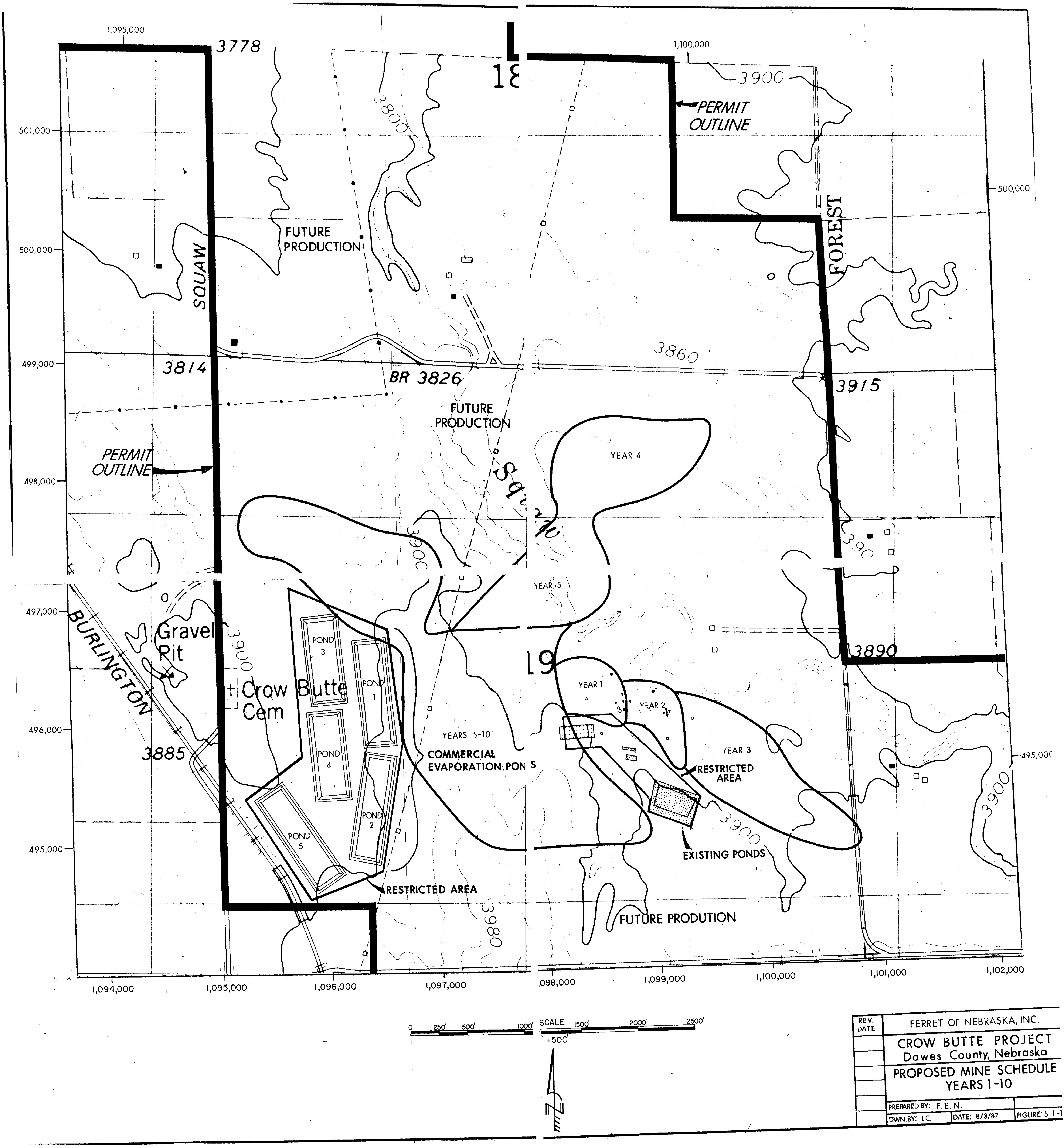
Computations have indicated the minimum pressure that could initiate hydraulic fracture will be 0.63 psi/ft of well depth. The injection pressure will be limited to less than 0.63 psi/ft of well depth to prevent fracturing the formation. The 0.63 psi/ft. of well depth limit provides a

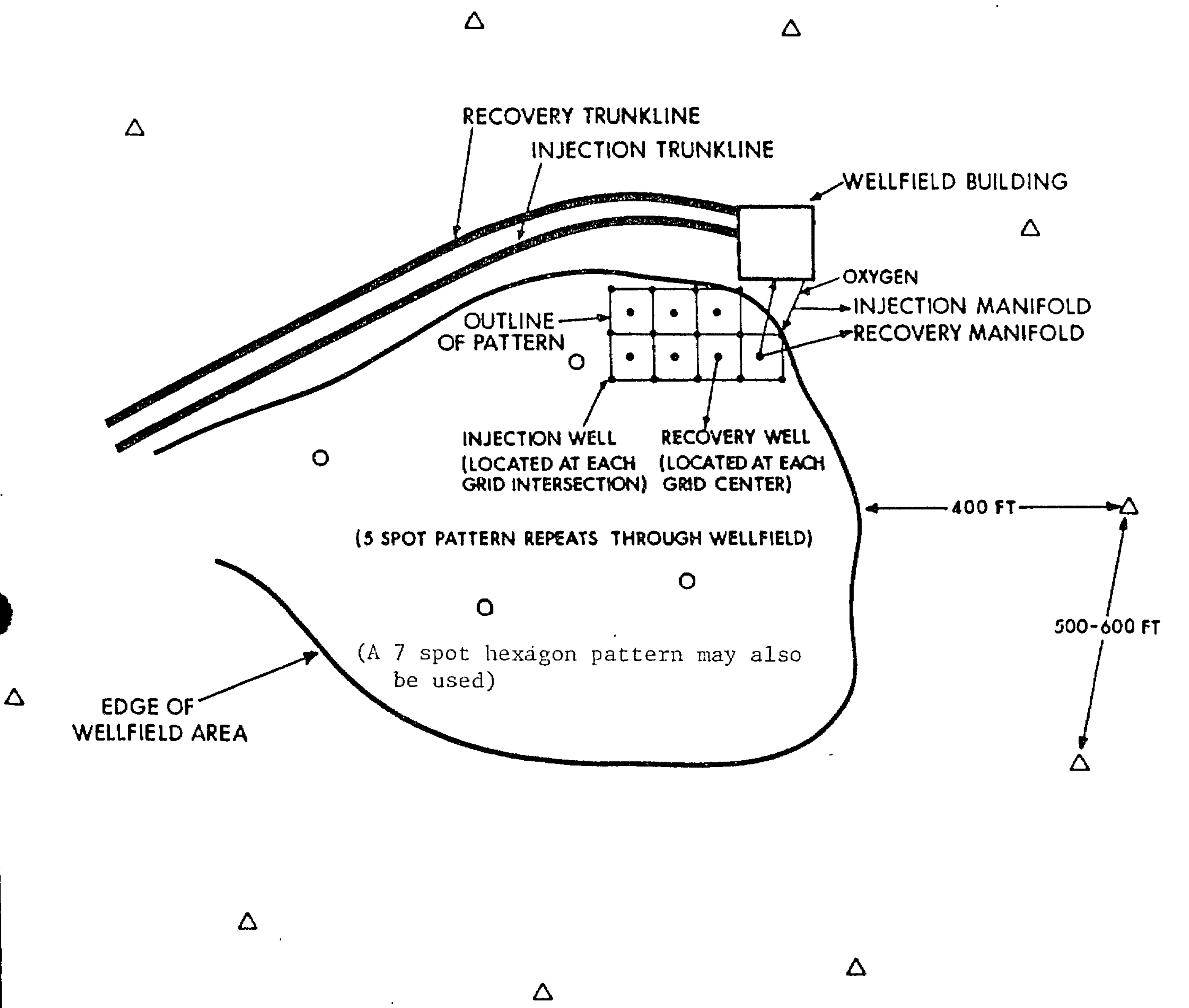
TABLE 5.1-1

CROW BUTTE PROJECT

MINE SCHEDULE

Years No.	Mining Flow (GPM)	Restoration Flow (GPM)	Average Area Being Mined (Acres)	Average Area Being Restored (Acres)	Average Area Being Reclaimed (Acres)
1	1250	0	11.25	0	0
2	1250	0	11.25	0	0
3	2500	0	22.5	0	0
4	2500	400	22.5	22.5	0
5	2500	400	22.5	22.5	22.5
6	2500	400	22.5	22.5	22.5
7	2500	400	22.5	22.5	22.5
8	2500	400	22.5	22.5	22.5
9	2500	400	22.5	22.5	22.5
10	2500	400	22.5	22.5	22.5
11-20+	2500	400	22.5	22.5	22.5
+1 yr.	0	400	0	22.5	22.5
+2 yrs.	0	400	0	22.5	22.5
+3 yrs.	0	0	0	0	22.5 Site Decom- missioning


1,095,000
1,100,000
3778
18
3900
3800
PERMIT OUTLINE
501,000
500,000
FOREST
FUTURE PRODUCTION
SQUAW
499,000
3814
3860
BR 3826
3915
FUTURE PRODUCTION
YEAR 4
PERMIT OUTLINE
498,000
Squaw
3900
YEAR 5
497,000
BURLINGTON
Gravel Pit
Crow Butte Cem
POND 3
POND 1
POND 4
POND 2
POND 5
19
3890
YEAR 1
YEAR 2
YEARS 5-10
COMMERCIAL EVAPORATION PONDS
YEAR 3
RESTRICTED AREA
496,000
3885
495,000
3900
EXISTING PONDS
RESTRICTED AREA
3980
FUTURE PRODUTION
1,094,000
1,095,000
1,096,000
1,097,000
1,098,000
1,099,000
1,100,000
1,101,000
1,102,000
0
250'
500'
1000'
SCALE
1500'
2000'
2500'
1" =500'
N
REV. DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
PROPOSED MINE SCHEDULE
YEARS 1-10
PREPARED BY: F.E.N.
DWN.BY: J.C.
DATE: 8/3/87
FIGURE 5.1-1



• INJECTION / RECOVERY WELLS

△ ORE ZONE MONITOR WELLS

○ SHALLOW ZONE MONITOR WELLS (ONE PER 5 ACRES)

REV. DATE	
	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	TYPICAL WELLFIELD PATTERN
	PREPARED BY: F.E.N.
	DWN. BY: J.C. DATE: 8/27/87 FIGURE: 5.1-2

factor of safety to avoid fracturing the formation at the depths and piezometric surfaces encountered in the vicinity of the wellfield. Injection pressures will not exceed the pressure at which the well was integrity tested, less safety factor.

5.1-2 Uranium Recovery Process

Sodium and carbonate species along with an oxidizer (oxygen or hydrogen peroxide) will be added to the formation water for dissolution of uranium. In this report sodium bicarbonate ($NaHCO_3$) will be used as a generic term to describe sodium combined with any form of carbon dioxide. These forms include carbonate ion (CO_3), bicarbonate ion (HCO_3), and dissolved carbon dioxide (CO_2 aqueous). The distribution of these forms of carbon dioxide is determined by the pH.

Uranium dissolution is a process involving an oxidation step and a dissolution step. The reactions representing these steps at a neutral pH are:

Oxidation: $UO_2 + H_2O_2 \text{ ---> } UO_3 + H_2O$

$$\underset{\text{(solid)}}{UO_2} + \underset{\text{(in solution)}}{1/2\text{-}O_2} \text{ ---> } \underset{\text{(at solid surface)}}{UO_3}$$

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

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

The principal uranyl carbonate complex ions formed as illustrated above, are uranyl dicarbonate, $(UO_2)(CO_3)_2^{-2}$ (UDC), and uranyl tricarbonate $(UO_2)(CO_3)_3^{-4}$, (UTC). The relative abundance of each is a function of pH and total carbonate strength. In addition to the complexing agent, sodium bicarbonate, an oxidant is added to the injection solution to carry out the oxidation reaction shown above. Although several oxidants could be used, the common choices are hydrogen peroxide (H_2O_2) or gaseous oxygen (O_2). Both of these oxidants revert to naturally occurring substances.

Uranium bearing solution resulting from the leaching of uranium underground will be recovered and the uranium will be extracted in the processing plant. The plant process will utilize the following steps:

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

b. Reconstitution of the leach solution by addition of sodium bicarbonate, pH adjustment with CO_2, and addition of oxygen;

c. Elution of uranium complexes from the resin using a sodium chloride/sodium bicarbonate eluant;

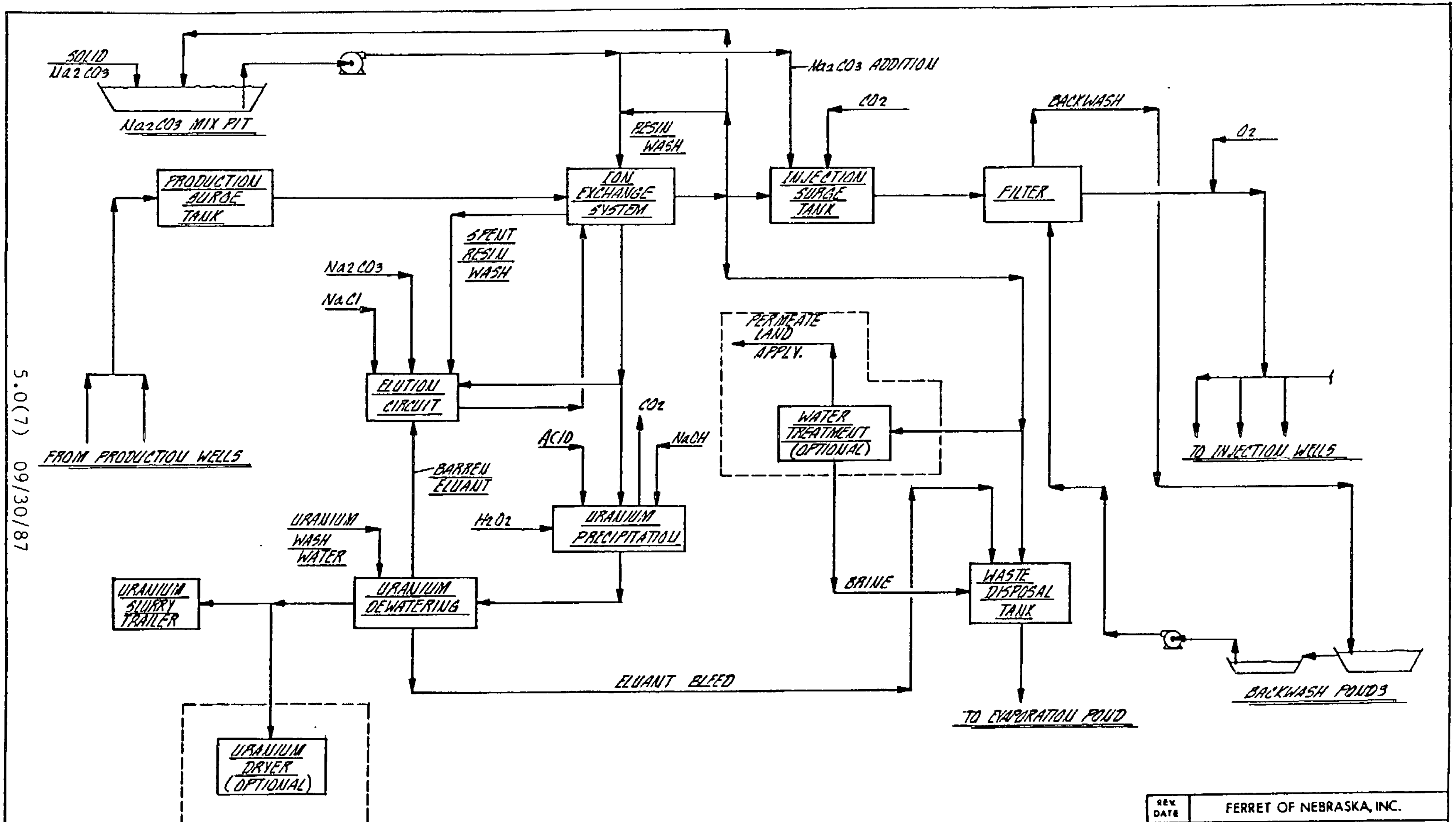
d. Precipitation of uranium using H_2O_2 and necessary pH adjustment.

The process flow sheet for the above steps is shown in Figure 5.1-3. The anticipated process plant layout is shown in Figure 5.1-4. The plant will be designed to operate at an average capacity of 2500 gallons per minute. Because of operational considerations at times, the flow will be in excess of 2500 gpm and at times below 2500 gpm but the nominal annual average is 2500 gpm. FEN does not anticipate a flow in excess of 3500 gpm during operations. The process flow sheet and plant layout as shown are based upon preliminary engineering data. If during detail design and equipment selection more suitable equipment is identified and purchased, the details of the layout may change; however, the general process will remain the same. The effluents will remain approximately the same and the space requirements will be approximately as shown.

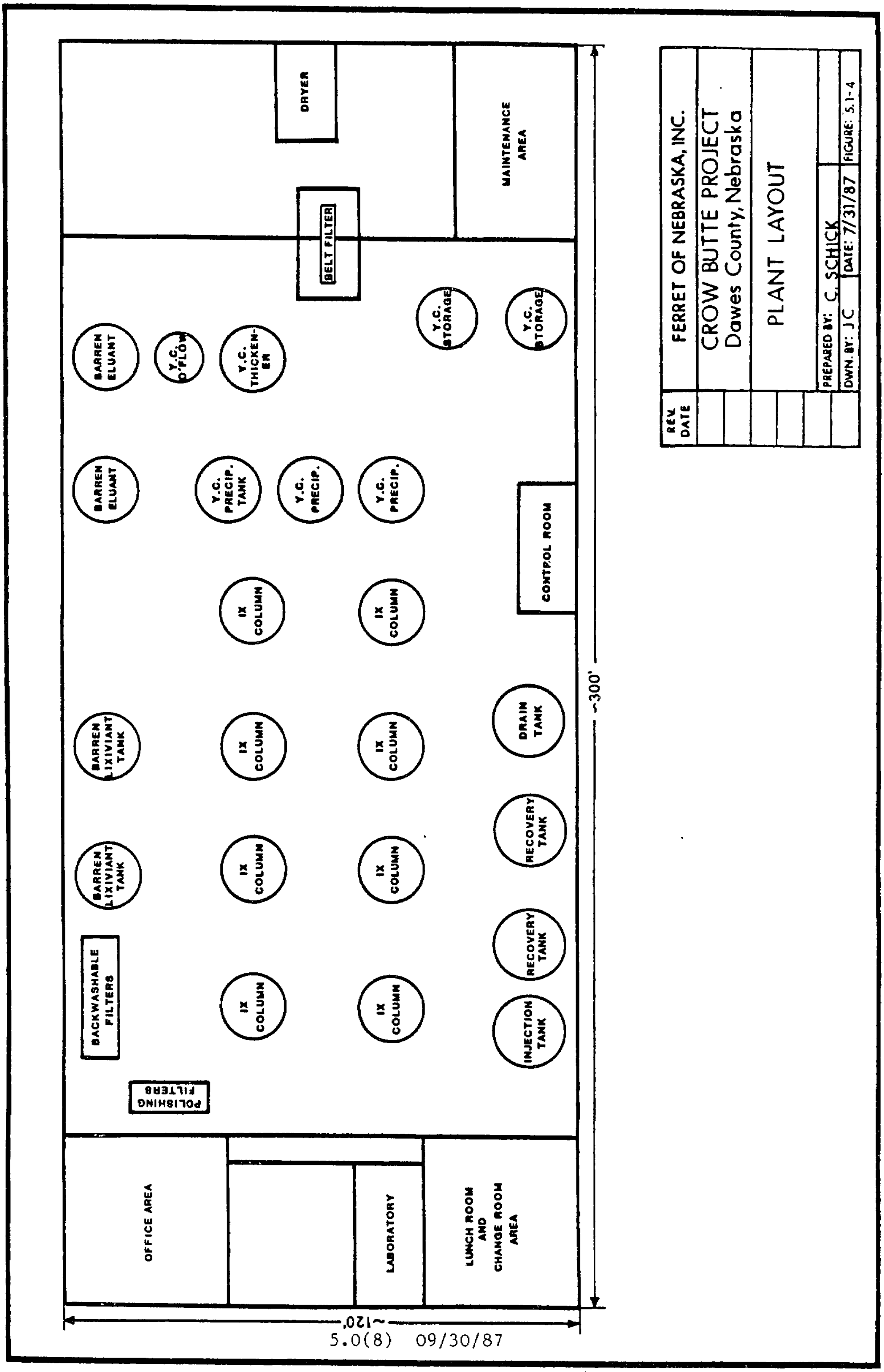
Recovery of uranium will take place in the ion exchange columns. The uranium bearing leach solution will enter the column and as it passes through, the uranium complexes in solution will be loaded onto the IX resin in the column. The loading process is represented by the following chemical reaction.

$$2\ R\ HCO_3 + UO_2(CO_3)_2^{-2} \text{ ---> } R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$
$$2\ RCl + UO_2(CO_3)_2^{-2} \text{ ---> } R_2UO_2(CO_3)_2 + 2Cl^-$$
$$R_2SO_4 + UO_2(CO_3)_2^{-2} \text{ ---> } R_2UO_2(CO_3)_2 + SO_4^{-2}$$

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



REV. DATE	
	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	PROCESS FLOWSHEET
	PREPARED BY F.E.N.
	DWN BY R S. — DATE 7/31/87 — FIGURE 5.1-3


DRYER
MAINTENANCE AREA
BELT FILTER
Y.C. STORAGE
Y.C. STORAGE
BARREN ELUANT
Y.C. O'FLOW
Y.C. THICKEN-ER
BARREN ELUANT
Y.C. PRECIP. TANK
Y.C. PRECIP.
Y.C. PRECIP.
CONTROL ROOM
IX COLUMN
IX COLUMN
BARREN LIXIVIANT TANK
IX COLUMN
IX COLUMN
DRAIN TANK
BARREN LIXIVIANT TANK
IX COLUMN
IX COLUMN
RECOVERY TANK
RECOVERY TANK
BACKWASHABLE FILTERS
IX COLUMN
IX COLUMN
INJECTION TANK
POLISHING FILTERS
OFFICE AREA
LABORATORY
LUNCH ROOM AND CHANGE ROOM AREA
~300'
~120'
5.0(8) 09/30/87
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
PLANT LAYOUT
PREPARED BY: C. SCHICK
DWN. BY: J C
DATE: 7/31/87
FIGURE: 5.1-4
REV. DATE

The now-barren leach solution passes to a barren lixiviant surge tank. At this point the solution is refortified with sodium and carbonate chemicals as required and pumped to the wellfield for reinjection into the formation. The expected lixiviant concentration and composition is shown in Table 5.1-2.

Once the majority of ion exchange sites on the resin in an IX column are filled with uranium, that column is taken off stream. The loaded resin is then stripped of uranium in place through an elution process based on the following chemical reaction:

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

During the elution process, the first half of the pregnant eluate will be transferred to the precipitation tank. The second half of the eluant volume, which is lower in uranium content, will be stored in the intermediate eluant storage tank to be used on the first half of the next elution cycle.

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

When a sufficient volume of pregnant eluant is held in storage it is acidified to destroy the uranyl carbonate complex ion. The solution is agitated to assist in removal of the resulting CO_2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \text{--->} UO_2^{++} + 3\,CO_2 + 3H_2O$$

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

TABLE 5.1-2

TYPICAL LIXIVIANT CONCENTRATION AND COMPOSITION

SPECIES	RANGE LOW	RANGE HIGH
Na	≤ 400	6000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2500
HCO_3	≤ 400	5000
Cl	≤ 200	5000
SO_4	≤ 400	5000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12000
pH	6.5	10.5
Alkalinity	≤ 328	4100

* All values in mg/l except pH.

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

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

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

5.1-3 Process Wastes

The operation of the process plant results in two primary sources of liquid waste. They are (1) eluant bleed, and (2) production bleed.

All these waste streams are routed to water treatment or the evaporation ponds. The anticipated composition and flowrates of the liquid waste streams are shown in Table 5.1-3. A water and material balance diagram for the process plant including the waste streams are shown in Figure 5.1-5.

5.1-4 Recovery Plant Equipment

The proposed plant facilities and process equipment will be housed in a building approximately 300 feet long by 120 feet wide. This will include office and laboratory space. The proposed facility layout is shown in Figure 5.1-4.

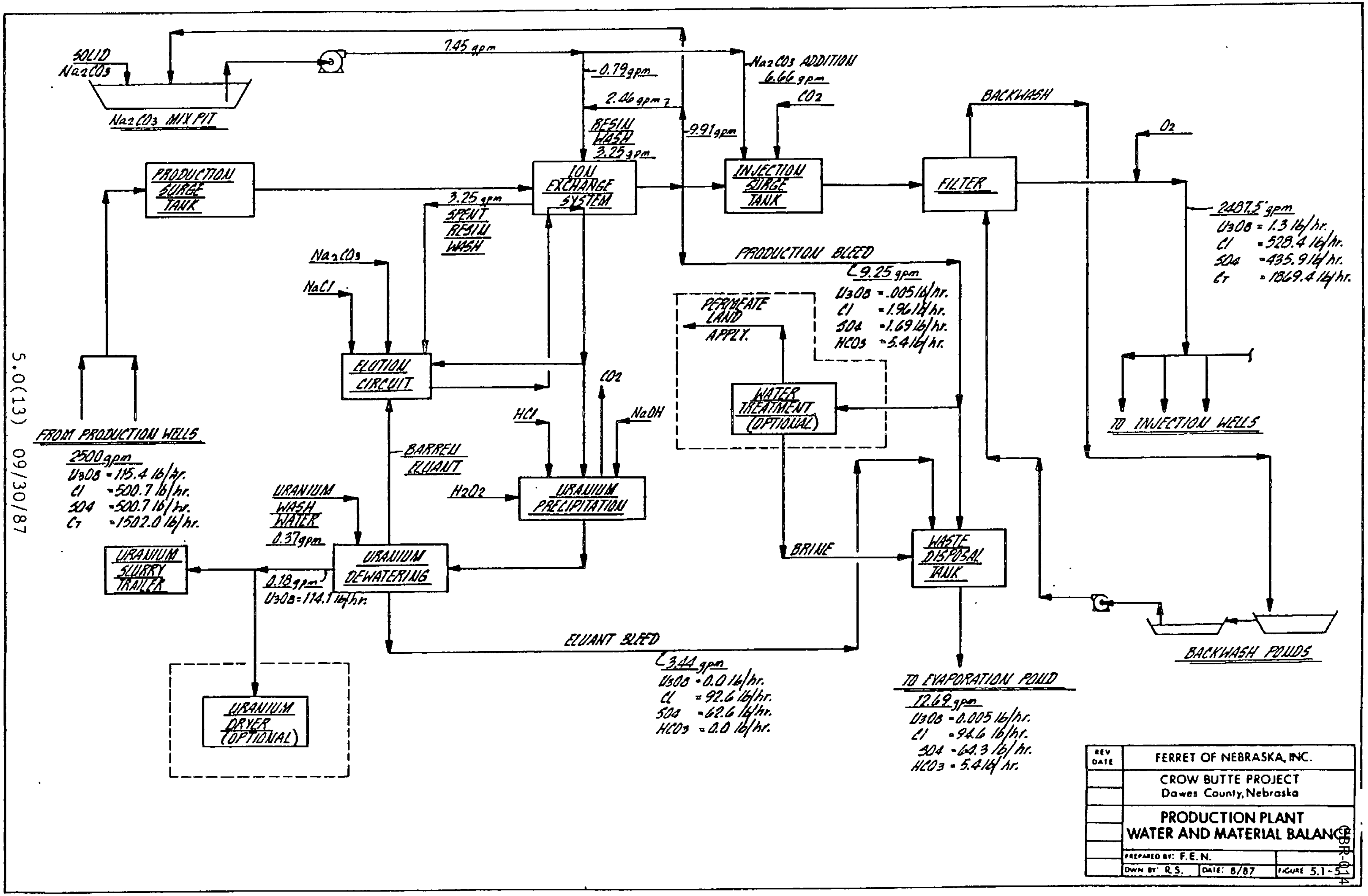
The recovery plant equipment can be placed in one of the following unit operations: lixiviant recovery, ion exchange, filtration, lixiviant injection, elution/precipitation and dewatering/drying. All these unit operations are tied together to comprise the recovery plant.

The lixiviant recovery system consists of recovery surge tanks and ion exchange feed pumps. The surge tanks are fiberglass reinforced plastic (FRP) construction and the pumps are centrifugal type.

TABLE 5.1-3

ESTIMATED WASTE VOLUMES AND COMPOSITIONS
(Mg/l except as noted)

Parameter	Production Bleed	Eluant Bleed
Flowrate (GPM)	9.25	3.44
U_3O_8	0.2 to 50	0.2 to 100
Cl^-	200 to 3000	20,000 to 75,000
$SO_4^=$	500 to 5000	1,000 to 40,000
$CO_{3(T)}$	350 to 5000	10 to 1,000
Na	50 to 6000	20,000 to 75,000
Ca	20 to 1000	10 to 500


SOLID Na2CO3
Na2CO3 MIX PIT
7.45 gpm
0.79 gpm
2.46 gpm
Na2CO3 ADDITION 6.66 gpm
CO2
BACKWASH
O2
RESIN WASH 3.25 gpm
9.91 gpm
PRODUCTION SURGE TANK
ION EXCHANGE SYSTEM
INJECTION SURGE TANK
FILTER
2487.5 gpm
U3O8 = 1.3 lb/hr.
Cl = 528.4 lb/hr.
SO4 = 435.9 lb/hr.
CT = 1869.4 lb/hr.
3.25 gpm SPENT RESIN WASH
PRODUCTION BLEED
9.25 gpm
U3O8 = .005 lb/hr.
Cl = 1.96 lb/hr.
SO4 = 1.69 lb/hr.
HCO3 = 5.4 lb/hr.
Na2CO3
NaCl
PERMEATE LAND APPLY.
ELUTION CIRCUIT
CO2
TO INJECTION WELLS
HCl
NaOH
WATER TREATMENT (OPTIONAL)
FROM PRODUCTION WELLS
2500 gpm
U3O8 = 115.4 lb/hr.
Cl = 500.7 lb/hr.
SO4 = 500.7 lb/hr.
CT = 1502.0 lb/hr.
BARREN ELUANT
H2O2
URANIUM PRECIPITATION
URANIUM WASH WATER 0.37 gpm
URANIUM SLURRY TRAILER
URANIUM DEWATERING
0.18 gpm
U3O8 = 114.1 lb/hr.
BRINE
WASTE DISPOSAL TANK
ELUANT BLEED
3.44 gpm
U3O8 = 0.0 lb/hr.
Cl = 92.6 lb/hr.
SO4 = 62.6 lb/hr.
HCO3 = 0.0 lb/hr.
BACKWASH PONDS
TO EVAPORATION POND
12.69 gpm
U3O8 = 0.005 lb/hr.
Cl = 94.6 lb/hr.
SO4 = 64.3 lb/hr.
HCO3 = 5.4 lb/hr.
URANIUM DRYER (OPTIONAL)
REV DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
PRODUCTION PLANT
WATER AND MATERIAL BALANCE
PREPARED BY: F.E.N.
DWN BY: R.S.
DATE: 8/87
FIGURE 5.1-5

CBR-014

The ion exchange system consists of two sets of four (4) columns. These four columns are operated in a carousel configuration. The columns are constructed out of FRP and operate in an upflow, fluidized bed manner. The resin will be eluted and rinsed in place. The uranium loading process is continuous but the elution process is operated on a batch basis.

The injection filtration system will consist of backwashable filters with the option of installing polishing filters downstream of the backwashable filters. The backwash system will be operated on a closed loop circuit meaning the backwash water would be collected and reused for backwashing.

The lixiviant injection system will consist of the injection surge tanks and the injection pumps. The tanks will be fabricated out of FRP and the injection pumps will be centrifugal type.

The elution/precipitation circuit will consist of the barren eluant tanks and the acidizer/precipitator tanks. The barren eluant tanks and the precipitator tanks are fabricated out of FRP. The eluant is pumped from the barren eluant tanks to the ion exchange column which is in the elution mode. After the resin is eluted the pregnant eluant is transferred to the acidizer/precipitator where the uranium is precipitated.

The precipitated uranium (yellowcake) is dewatered and washed using a vacuum belt filter or equivalent. The yellowcake can then be either shipped as a slurry for drying or converting at a licensed facility, or it will be dried on site by a vacuum dryer. A vacuum dryer vent is sealed by passing the resultant water vapors and particulates through a liquid filled chamber and the environmental impacts are minimized.

The production solution surge tank is a possible source of radon and CO_2 gases and vents to the atmosphere by a turbine ventilator or fan. Other process tanks are similarly vented for radon and CO_2 removal. Building ventilation in the process equipment area is accomplished by the use of an exhaust system. This exhaust system draws fresh air in from ventilators and help to sweep radon, which accumulates near the floor of the building, out to the atmosphere.

5.1-5 Instrumentation

Wellfield instrumentation is provided to measure total production and injection flow. In addition, instrumentation is provided to indicate the maximum pressure which is being applied to the injection wells. Instrumentation is calibrated on a schedule that is consistent with good operating practice.

In the plant, instrumentation is provided to monitor the total flow into the plant, the total injection flow leaving the plant and the total waste flow leaving the plant. Instrumentation is provided on the injection manifold to record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The injection pumps are sized or equipped so that they are incapable of producing pressures high enough to exceed the design pressure of the injection lines or the maximum pressure to be applied to the injection wells.

Other instrumentation such as pressure gauges, pH indicators, and flow indicators are provided at various places in the process where required.

SECTION 6.0

ZONE OF ENDANGERING INFLUENCE

6.0 ZONE OF ENDANGERING INFLUENCE

Since a net withdrawal of fluid from the mining zone is being proposed, the calculation called for in Code of Federal Regulations 40 CFR 146.6(a) and Title 122, Chapter 10, Section 001.01 does not give meaningful results when calculating a zone of endangering influence; i.e., it produces a negative number. As a result, FEN is using a fixed radius of one-fourth (1/4) mile as provided for in the regulations.

SECTION 7.0

FORMATION TESTING PROGRAM

7.0 FORMATION TESTING PROGRAM

A narrative description of the formation testing program determining the characteristics of the receiving formation can be found in Subsection 4.4 ***Hydrology and Water Quality.*** Water Quality data for groundwater are in Subsection 4.4, Appendix 4.4(A). Hydrologic test data can be found in Subsection 4.4 and Appendix 4.4 (B).

A coring program has been carried out in the vicinity of the wellfield area and the cores collected have been examined in detail to characterize the lithology of the ore zone. Samples from the cores have been in metallurgical testing to evaluate the leachability of the uranium using the proposed leach chemistry. Test results indicate that the leach solution to be used is generally compatible with the ore and no unexpected reactions occur. Porosity and permeability determinations on samples taken from these core very widely, but in general support the results observed in the hydrologic testing.

A R & D facility was operated at Crow Butte from July of 1986 to present. Results from the R & D operation indicate that the leach solutions are compatible with the formation and the uranium is leachable using the leach chemistry proposed in this commercial scale application.

From February 1987 to August 1987 FEN conducted a restoration program at the R & D site. Results of the Restoration Program are found in Section 11.0 of this application. The Restoration Test program showed that FEN could restore the water quality of the affected zone to the quality level specified by NDEC which is a quality of use consistent with the "uses for which the resource was suitable" prior to the activity.

SECTION 8.0

STIMULATION PROGRAM

8.0 STIMULATION PROGRAM

After completion of a well, the well will be air lifted until the fluid coming from the well is clear to the naked eye and the fluid pH and conductivity are typical of the formation fluid. The air lifting may be carried out at various depths and may be used in conjunction with bailing, jetting or surging techniques. Pumping may also be used as a final stimulation technique. During air lifting and/or pumping the natural sand pack shown on Figures 10.2-1 and 10.2-2 is developed. Although its use is not anticipated, acidizing may be employed to treat wells which do not respond to physical stimulation techniques.

It is the goal of FEN to operate the Crow Butte Commercial Scale Plant in such a way that subsequent well stimulation is not needed. However, based on the pilot plant experience at Crow Butte, well stimulation may be required occasionally. The anticipated frequency of stimulation is difficult to determine at this point without operational background. The frequency of stimulation will vary with the formation characteristics and operations. Therefore, some wells may require stimulation every month to two months while others may go several years without stimulation.

SECTION 9.0

INJECTION PROCEDURE

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9.0 INJECTION PROCEDURE

The commercial operation at Crow Butte will operate at an average flow of 2500 gpm with an annual production goal of 1,000,000 lbs. U_3O_8. At least fifty recovery wells and 60 injection wells along with the required monitoring wells will be in operation at any time. The spacing between injection wells will range from 40 to 100 feet depending upon the ore grade in the area being mined. A typical commercial wellfield is shown in Figure 9.0-1. The well field will be constructed to allow wells to be operated as either injection wells or production wells.

Prior to the injection of leaching chemicals FEN will recirculate the natural ground water for a time that may range from one day to one week. FEN will achieve the following during the ground water recirculation phase:

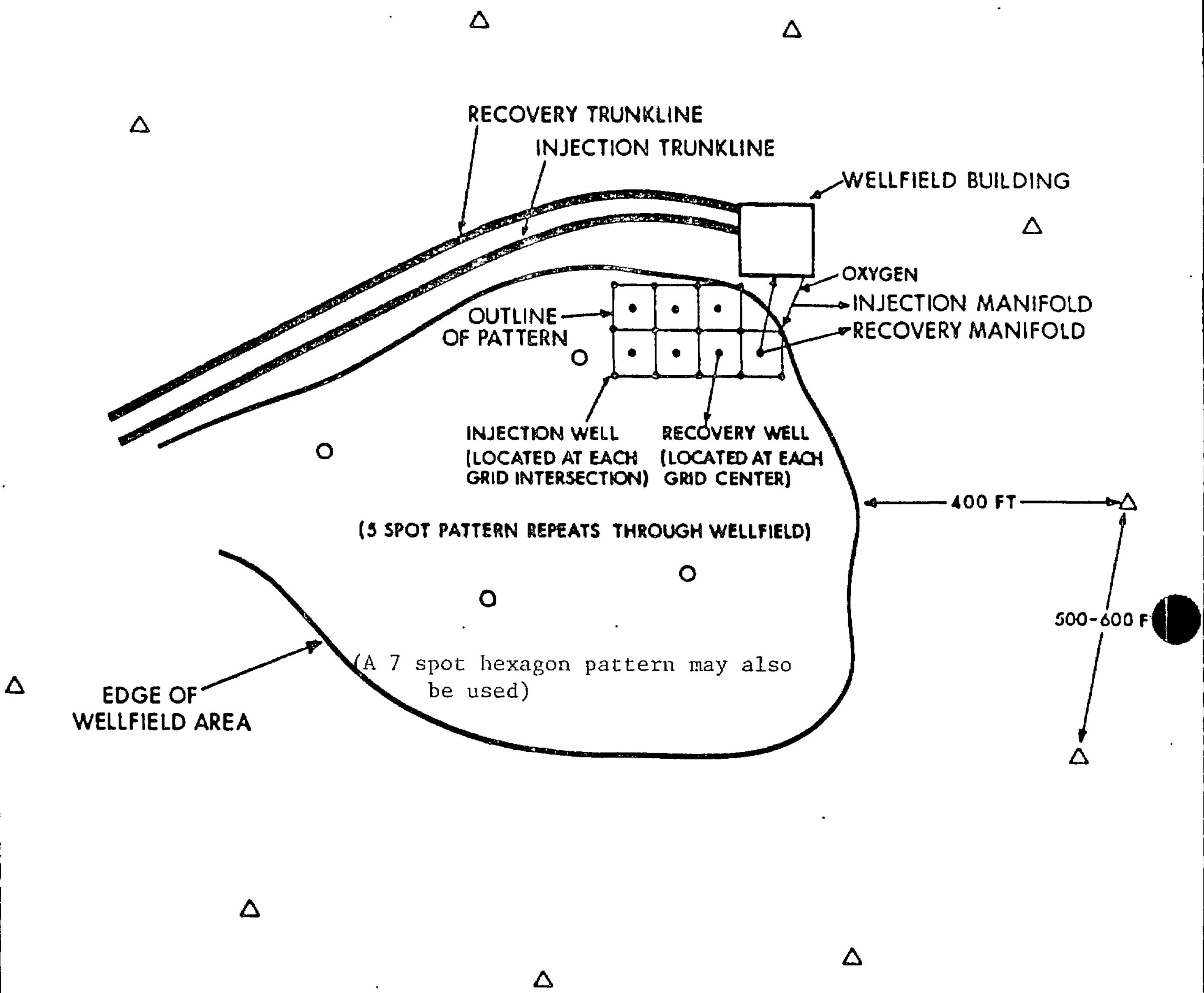
- Calibration of the injection/recovery operational systems, including surface equipment and final selection of injection pressures.

- Establishment of the circulation pathways between the injection and recovery wells.

- Development of the hydraulic gradients toward the production cell(s) to prevent outward movement of the lixiviant from the very beginning of the production phase.

- Observation of the Basal Chadron aquifer response to the injection/pumping operations and final adjustment of the rate of over-pumping.

After the initial recirculation injection of lixiviant will be initiated in the injection wells and solution production will be initiated in the recovery wells. The recovered solutions will then be transferred to the recovery plant. Due to the wellfield bleed and the operation of the recovery plant, average production will always exceed average injection by a slight amount. The net effect of this practice will be to create a



- • INJECTION / RECOVERY WELLS
- △ ORE ZONE MONITOR WELLS
- O SHALLOW ZONE MONITOR WELLS (ONE PER 5 ACRES)

REV. DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	TYPICAL WELLFIELD PATTERN		
	PREPARED BY: F.E.N.		
	DWN. BY: J.C.	DATE: 8/27/87	FIGURE: 9.0-1

piezometric low in the wellfield. This dip in the piezometric surface will tend to draw formation fluid into the pattern and prevent injected fluids from traveling away from the pattern. Water level measurements will be made in the monitoring wells during operations to assure the proper piezometric surface.

The overproduction rate at the commercial operation will range from less than 0.5 to 1% of the total injection rate. The final rate of overproduction will depend on the aquifer response noted in the observation wells during the "calibration" and initial production periods.

Fluid will be injected through the wells into the ore zone. Initially little, if any, pressurization of the casing will be required to achieve the desired injection flow rates. As injection continues, it is anticipated that more pressure will be required to maintain injection flow. When this casing pressure nears the maximum allowable, the well may be taken off line and treated to restore injectivity. Air lifting, jetting, surging, bailing, acidizing and swabbing are among the methods which may be used to restore injectivity.

All injection wells will be operated from a common trunk line. The injection pressure will be measured on the trunkline and continuously recorded in the process plant. The injection trunkline will go into the wellfield building where injection manifolds will be located. The lines to the individual wells will split off from this manifold. Flow totalizers for each well will be located in the wellfield building. The injection pressure will be limited to 0.63 psi/ft. of well depth or the maximum operating pressure of the injection piping. The 0.63 psi/ft. of well depth limit provides a factor of safety to avoid fracturing the formation at the depths and piezometric surfaces encountered in the vicinity of the wellfield. The injection pressure monitoring system will have a high pressure alarm and if the pressure exceeds the set point, corrective action will be taken. This corrective action may include shutting down the injection pump.

Flow to the injection wells will be measured in the main process building leading to the wellfield. Flow will be measured once per 8 hour shift and recorded by the operator. Totalizers will be used to measure volume on individual wells.

Solutions will be pumped from the production wells into the wellfield building. The flow from the individual wells will be collected in a manifold and then transferred to the recovery trunkline to be sent to the process facility. Recovery flow will be measured by totalizers on each line from the production wells and on the recovery trunkline. The flow indicating totalizer on the recovery trunkline will be located in the main process building.

SECTION 10.0

CONSTRUCTION PLAN

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10.0 CONSTRUCTION PLAN

10.1 Surface and Subsurface Injection System Details

The wellfield area, to produce 2500 gpm and 1 million lbs of U_3O_8 per year, will require an average of approximately 22.5 acres to be developed and mined on an annual basis. Each wellfield area will be connected via underground pipelines to the production plant. These underground pipelines will be buried below the frost line. The individual wellheads will be fitted with pitless adaptors or insulated wellhead covers to protect against freezing. The underground piping will be either high-density polyethylene or PVC pipe. All underground piping will be leak tested prior to use. Figure 10.1-1 shows details of the piping connections between the wellheads and the main manifolds.

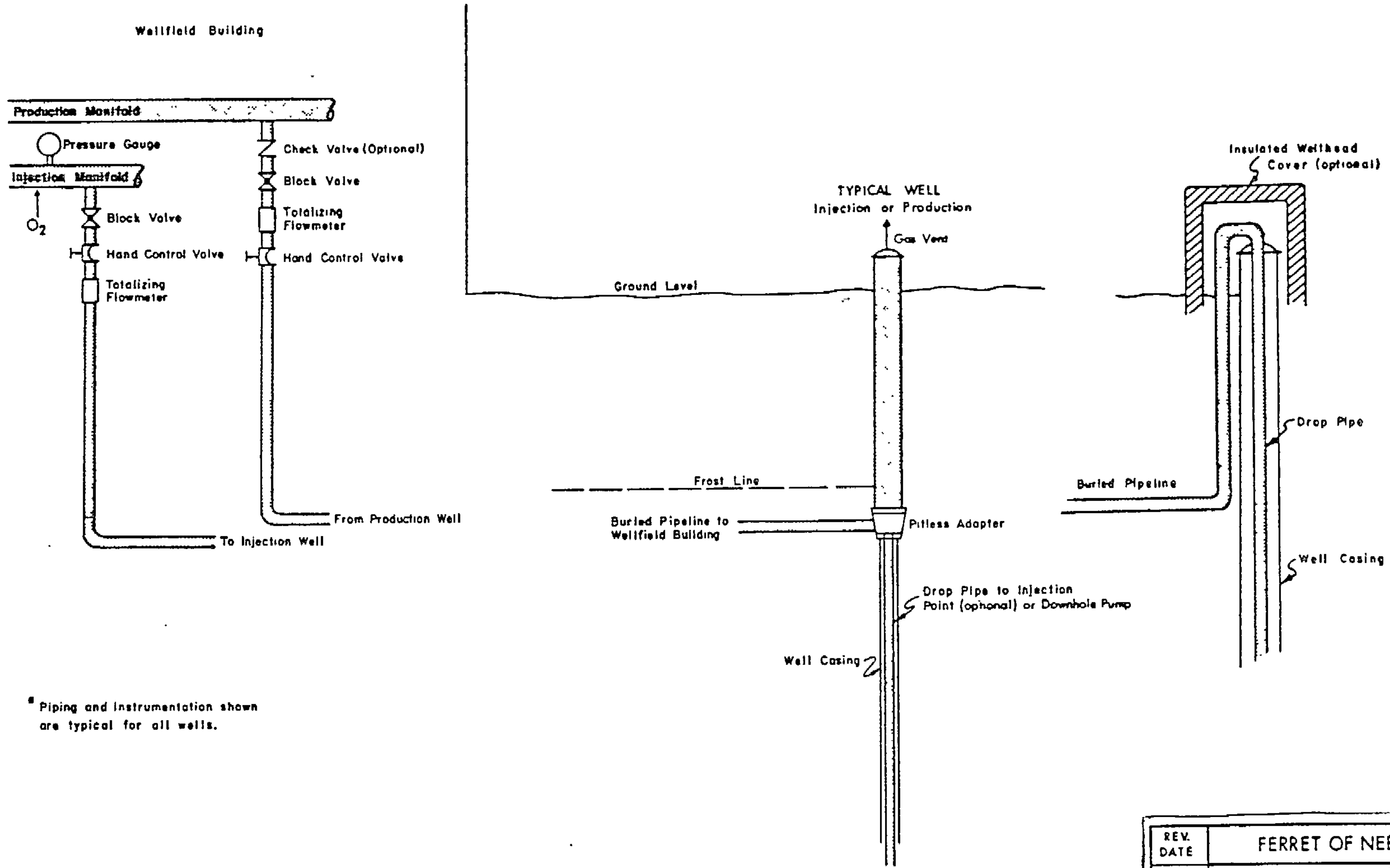
10.2 Well Construction Procedure

10.2.1 Well Construction and Integrity Testing

All wells will be drilled using a conventional hydraulic rotary drill rig and a bentonite or polymer drilling fluid. A hole will be drilled down to and through the ore sand and the hole will be electrically logged. This logging operation will consist of a gamma log, resistance log, neutron log, and a drift/deviation survey. Following examination of the logs, it will be decided whether the hole will be completed or whether it will be plugged and abandoned.

Two well construction methods and appropriate casing materials will be used for the well construction and installation of production and injection wells. The well construction methods are not necessarily described in the order of their preferred use. Either of these methods could also be used for monitor wells.

Method No. 1, Figure 10.2-1, involves the setting of an integral casing/ screen string. The method consists of drilling a hole, geophysically logging the hole to define the desired screen interval, and reaming the

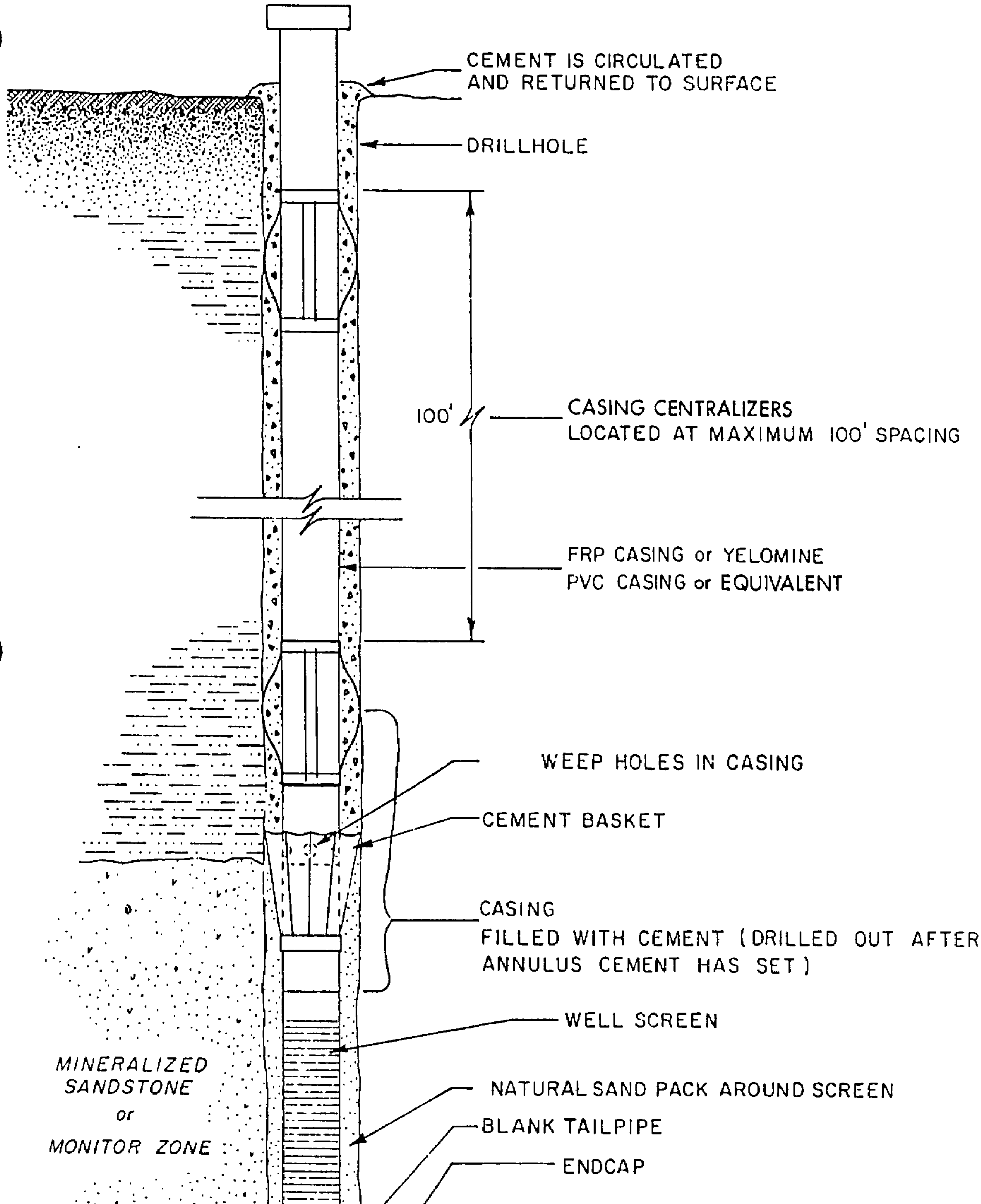


* Piping and instrumentation shown are typical for all wells.

REV. DATE	
10/88	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	SURFACE AND SUBSURFACE SYSTEM DETAILS
	PREPARED BY: F.E.N.
	DWN. BY: J.C. — DATE: 7/31/87 — FIGURE: 10.1-1

CBR-014

WELL COMPLETION METHOD No. I



REV	BY	DATE	FERRET OF NEBRASKA, INC.	
1	DL	2/2/82	CROW BUTTE PROJECT Dawes County, Nebraska	
2	DL	1/25/83		
3	BC	2/16/88	Typical Cement Basket Completion for Monitor or Injection/Production Wells	
			PREPARED BY: F.E.N.	
			DWN BY: JC DATE: 8/87	FIG. 10.2-1

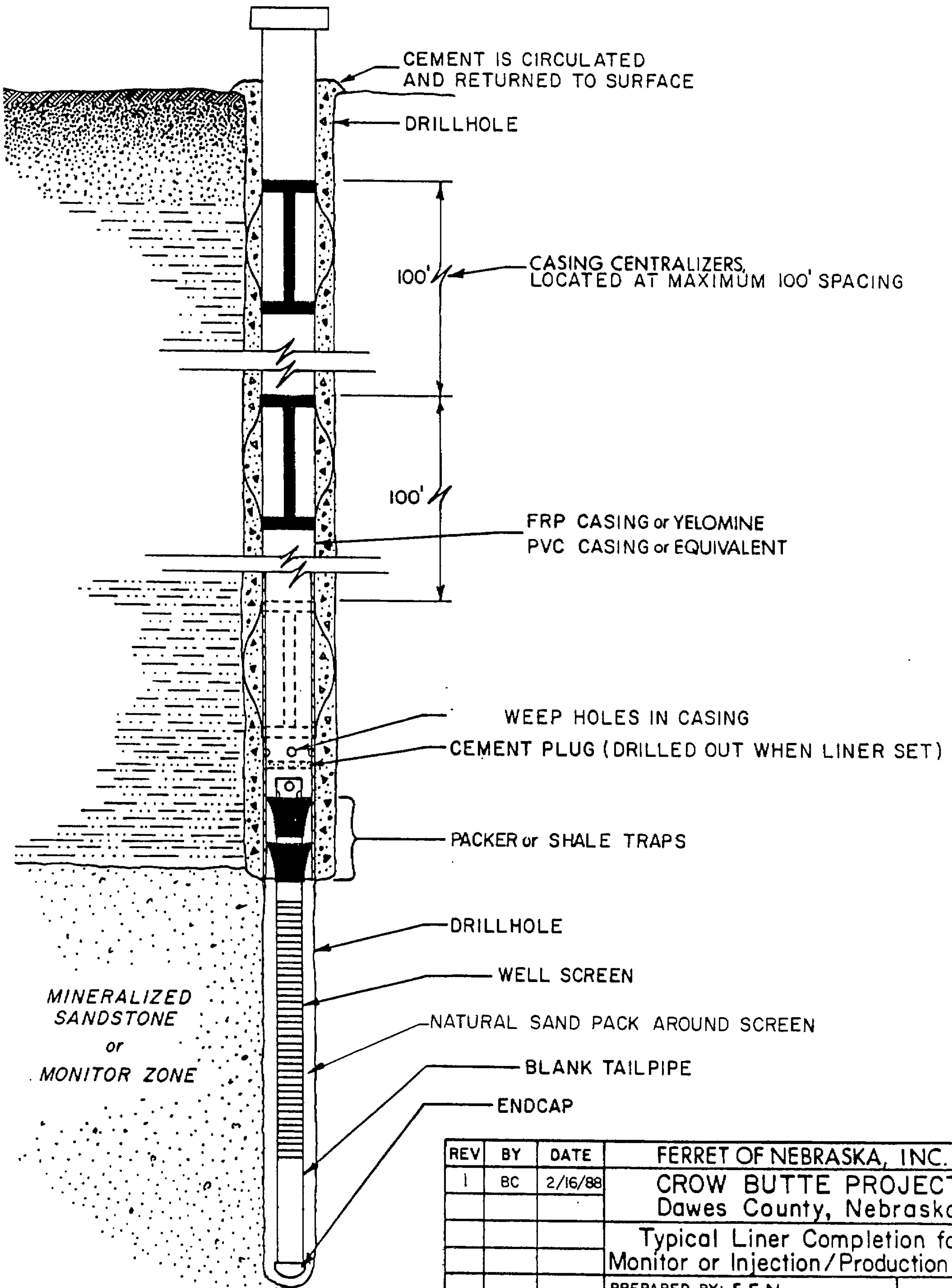
hole to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is placed in the hole. A cement basket is attached to the blank casing just above the screen to prevent blinding of the screen interval during cementing. The cement is then pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weep holes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement has cured sufficiently, the residual cement and plug are drilled out, and the well is developed by air lifting or pumping.

Method No. 2, shown in Figure 10.2-2, uses a screen telescoped down inside the cemented casing. As in the first method, a hole is drilled and geophysically logged to locate the desired screen interval. The hole is then reamed, if necessary, only to the top of the desired screen interval. Next a string of casing with a plug at the lower end and weep holes just above the plug is set in the hole. Cement is then pumped down the casing and out the weep holes, and the cement goes back to the surface through the annulus. After the cement has cured, the residual cement in the casing and the plug are drilled out and the drilling continues through the desired zone. The screen with a packer or shale traps is then telescoped through the casing and set in the desired interval. The packer or shale traps serve to hold the screen in the desired position while acting as a fluid seal. Well development is again accomplished by air lifting or pumping. Minor variations from these procedures may be used as conditions require.

A well completion report will be filled out for each well. The completion report form as provided by NDEC is shown in Figure 10.2-3. These data will be kept available on site for review.

Prior to leach solution injection, field testing of injection and recovery wells will be performed to demonstrate the mechanical integrity of the well casing. This testing will be performed using pressure-packer tests. The mechanical integrity tests will use the following procedure:

WELL COMPLETION METHOD No. 2



REV	BY	DATE	
1	BC	2/16/88	FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			Typical Liner Completion for Monitor or Injection/Production Wells
			PREPARED BY: F.E.N.
			DWN BY: J.C. DATE: 8/87 FIG. 10.2-2

FIG. 10.2-3

NEBRASKA DEPARTMENT OF ENVIRONMENTAL CONTROL

WELL COMPLETION REPORT

FOR AGENCY USE — APPLICATION NUMBER: CBR-014

Company: ____________________ Project: ____________________

Type of Well: Production/Injection _____ Monitor _____ Well No.: ____________

Ground Elevation: ____________________ Well Head Elevation: ____________

Drilling Contractor: ____________________

Driller: ____________________

Mud Products: ____________________

Amount: ____________________

Bit Size: ____________________ Date Drilling Began: ____________

Date Drilling Completed: ____________ Depth Drilled: ____________

Completed Formation: ____________________

Casing Diameter: ____________ Casing Type: ____________

Casing Depth: ____________ Basket Depth: ____________

Packer Type: ____________ Packer Depth: ____________

Centralizer Depth(s): ____________________

Screen Size: ____________ Gravel Size: ____________

Screened Interval(s): ____________________

Upper boundary of Completed Formation: ____________

Lower boundary of Completed Formation: ____________

Cement Contractor: ____________ Operator: ____________

Estimated Cement Volume: ____________ Cement Volume, used: ____________

Cement Weight: ____________ Water Amount: ____________

Cement Type or Class: ____________ Additives: ____________

Cement Circulated to Surface: Yes _____ No _____ Density of Fluid: ____________

Logging Contractor: ____________________

Operator: ____________________

Unit No.: ____________ Probe No.: ____________

Log Type: ____________________

Well Deviation: ____________________

White-Yellow: DEC Pink: Your records

1. The well will be tested after the cement plug at the bottom of the of the casing has been drilled out. The test consists of placement of one or two packers within the casing. The bottom packer will be set just above the well screen and the upper packer, if used, will be set at the wellhead. Alternatively, a well cap can be used at the wellhead. The bottom packer will be inflated and the casing will be pressurized to a value which simulates the maximum anticipated operating pressure plus an engineering safety factor.

2. The well will then be "closed in" and the pressure observed for a minimum of 20 minutes.

3. If more than 10% of the pressure is lost during this period, the well will be deemed unacceptable for use as an injection well.

When possible, the well will be repaired and the integrity tests will be repeated. If the well casing leakage cannot be repaired or corrected, the well will be plugged and reclaimed as described in Section 11.0 ***Contingency Plans*** of this application.

An alternate method of integrity testing an operational well may be used. The alternate method would involve installing a well cap and pressurizing the well with air to force the water column down the casing to a level where air pressure will be equal to the maximum operating pressure plus an engineering safety factor. After the well is pressurized, the well will be sealed and the pressure monitored for 20 minutes. If more than 10% of the pressure is lost during this period, the well will be deemed unacceptable for use as an injection well.

FEN will have available on site the results of all mechanical integrity tests for regulatory review. An example form is included as Figure 10.2-4. FEN will test all injection and recovery wells for mechancial integrity.

CASING INTEGRITY TEST REPORT FORM

WELL NO ________ DATE ____________

WELLFIELD ________________________

CASING TYPE ______________________ DIAMETER ________________

TOTAL DEPTH __________________ TOP OF SCREEN ______________

TEST PACKER(S) DEPTH ________________ TEST DURATION __________

COMMENTS ____

____

____

____

____

TIME	ELAPSED TIME (MIN)	PRESSURE (psig)			TIME	ELAPSED TIME (MIN)	PRESSURE (psig)	

TEST PERFORMED BY: ______________

10.0(8) 09/30/87 DATE: ____________

FIGURE 10.2-4

SECTION 11.0

CONTINGENCY PLAN

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11.0 CONTINGENCY PLAN

11.1 AQUIFER RESTORATION PROGRAM

Prior to discussing restoration methodologies and results of the R & D restoration, discussion of the ore body genesis and the chemical and physical interactions between the ore body and the lixiviant is provided.

11.1.1 Ore Body Genesis

The Crow Butte uranium deposit is roll front deposit in a fluvial sandstone. The deposit is very similar to those in the Wyoming basins such as Gas Hills, Shirley Basin and the Powder River Basin. The origin of the uranium in the deposit could be from within the host rock itself either from the feldspar or volcanic ash content of the Basal Chadron Sandstone. (The source of the uranium could also be the volcanic ash of the Middle Chadron Formation which directly overlies the Basal Chadron Sandstone). Regardless of the origin of the uranium, the uranium has been precipitated in several long sinuous roll fronts. The individual roll fronts are developed within subunits of the Basal Chadron Sandstone. The Basal Chadron Sandstone is divided into local subunits by thin clay beds that confined the uranium bearing waters to several distinct hydrologic subunits of the sandstone. These clay beds are laterally continuous for hundreds of feet but control the deposition of the uranium over greater distances as other clay beds exert vertical control when the locally controlling beds pinch out. Precipitation of the uranium resulted when the oxidizing water containing the uranium entered reducing conditions. These reducing conditions probably resulted from H_2S and to a lesser degree organic material and pyrite.

Solution mining of the deposit is accomplished by reversing the natural processes that deposited the uranium. Oxidizing solution would be injected into the mineralized portion of the Basal Chadron Sandstone to oxidize the reduced uranium and to complex it with bicarbonates. The uranium bearing solution is then drawn through the mineralized portion of the sandstone between the clay beds toward a recovery well by pumping. The presence of reducing agents will increase oxidant requirements over that necessary to only oxidize the uranium.

Since the deposition of the uranium was controlled between clay beds within the Basal Chadron Sandstone, the mining solutions will be largely confined to this portion of the sandstone by selectively screening these intervals. This will limit the contamination and thus the required restoration of unmineralized portions of the sandstone.

11.1.2 Chemical and Physical Interactions of Lixiviant with Ore Body

The following discussion is based on a range of lixiviant conditions from 0.5 to 3.0 grams per liter total carbonate and a pH of from 6.5 to 9.0. This represents the most likely range of operating conditions for the Crow Butte Commercial Plant.

11.1.3 Ion Exchange

The main ion exchange reaction will be the exchange of sodium from the lixiviant onto exchangeable sites on ore minerals with the release into solution of calcium, magnesium and potassium. This reaction can be shown as follows:

$$Ca_{clay} + 2\ Na^{+}_{soln} = 2\ Na_{clay} + Ca^{++}_{soln}$$

Similar reactions can be written for magnesium and potassium. Due to higher solubility of their sulfate and carbonate compounds and their low concentrations in Basal Chadron groundwater and the ore, magnesium and potassium in solution should have no impact. The limited solubility of calcium carbonate, and to a lesser degree, calcium sulfate, may lead to the potential for calcium precipitation.

Laboratory tests have indicated that the maximum calcium ion exchange capacity of the ore in a sodium lixiviant with 3 g/l total carbonate strength is 1.21 milliequivalents of calcium per 100 grams of ore. This equates to roughly 1/2 pound of calcium or about 1.2 pounds of calcium carbonate per ton of ore which could potentially be precipitated. Not all of this calcium, however, will be realized since the laboratory testing is

run in such a way as to indicate the maximum amount of calcium which can be exchanged. Somewhat less than this will be released and only a portion of that precipitated. There are no ways to directly control the buildup of calcium in the lixiviant circuit. In practice, one controls the lixiviant carbonate concentration and the lixiviant pH. The formation characteristics dictate an equilibrium calcium concentration in the lixiviant system and ion exchange and/or precipitation will occur until this equilibrium is satisfied. The overproduction bleed represents a departure from this equilibrium and as such has some effect on the amount of calcium exchanged. If the bleed is kept generally small, on the order of a few percent, the effect of the bleed on the ion exchange will be small.

11.1.4 Precipitation

In the presence of carbonate ions and bicarbonate ions in the lixiviant system, calcium ions will precipitate provided the limit of saturation has been reached. Calcium precipitation is a function of total carbonate, pH, and temperature. For example, at 15°C, a pH of 8.5, and 3 grams/liter total carbonate in a lixiviant solution the solubility of calcium will be approximately 1 to 5 ppm. Under the same conditions at pH 7.5, the equilibrium solubility will be in the range of 15 to 30 ppm, while at the same conditions in a pH 6.5 lixiviant the equilibrium solubility will be from 200 to 500 ppm. At 15°C, a pH of 7.5 and 1 gram/liter carbonate in lixiviant, the equilibrium solubility of calcium will be approximately 40 to 100 ppm. Some uncertainty is seen in these numbers due to the effect of ionic strength and supersaturation considerations. However, these figures do illustrate the effect of carbonate concentration and pH on the equilibrium solubility of calcium.

The amount of calcium produced depends on the ion exchange which is taking place, while the precipitation of calcium is a function of the lixiviant chemistry, and the degree of supersaturation which is observed in the system. As a first approximation, the proportion of calcium precipitation

occurring above ground and underground will occur in the ratio of the residence times. In other words, if the residence time is much longer underground than it is above ground, as is the case in most every in-situ leach operation, then more of the calcium will precipitate underground than above ground. The calcium precipitation is a function of turbulence in the solution, changes in CO_2 partial pressure or pH, and the presence of surface area. The most likely places for calcium to precipitate are underground where the ore provides abundant surface area for precipitation, at or near the injection or production wellbore where changes in pressure, turbulence and CO_2 partial pressure are all observed, and on the surface in the filters, in pipes, and in tanks. If all the calcium were to precipitate underground (based on 1.2 lb $CaCO_3$ per ton of ore) the precipitate would occupy about 0.15% of the void space in that ton of ore.

Calcium may be removed from the system in the following ways: filters will be routinely backwashed to the ponds and periodically will be acid cleaned if necessary to remove precipitated calcium carbonate from the filter housing or the filter media; the solution bleed taken to compensate for over production will also serve to eliminate some calcium from the system. Should precipitation in pipes and tanks become excessive, the precipitate will be pumped to the waste ponds. Should precipitation of calcium carbonate at or near the well bore of the wellfield wells become a problem, these wells will be air lifted, surged, water jetted, or acidified as necessary to remove the precipitated calcium. Any water recovered from these wells containing dissolved calcium carbonate or particulate calcium carbonate will be collected and placed into the evaporation ponds. A layer of water will be maintained on any calcium carbonate in the ponds to prevent dispersion during operations . Upon decommissioning, calcium carbonate from the plant equipment and pond residues will be disposed of in either a licensed tailings pond, if available, a regional compact disposal site, if available, or a commercial disposal site.

The other possible precipitating species which has been identified is iron which would probably precipitate as either the hydroxide or the carbonate and could cause some fouling. Such fouling is usually evidenced by a

reduction in the ion- exchange capacity of the resin in the extraction circuit. Should this fouling become a serious problem, the resin can be washed and the wash solution disposed of in the evaporation ponds. Due to the small amount of iron present in the Basal Chadron Sandstone, however, ion precipitation is not anticipated to be a problem.

11.1.5 Hydrolysis

Hydrolysis reactions, those which involve ore minerals and hydrogen or hydroxide ions, are not expected to play an important role in the ore/lixiviant interaction. In the pH range of 6.5 to 9.0, the concentration of hydrogen and hydroxide ions is so small that these types of reactions do not occur to any great degree. The only potential impact would be a small increase in the dissolved silica content of the lixiviant system, a possible small increase in the cations associated with the silicious minerals. The hydrolysis reactions are not expected to have a significant effect on operations.

11.1.6 Oxidation

The oxidant consumers in the Basal Chadron Sandstone are hydrogen sulfide in the groundwater, uranium, vanadium, iron pyrite, and other trace and heavy metals. The impacts of these oxidant consumers on the operation of the pilot plant will be to generally increase the oxidant consumption over that which would be required for uranium alone. The second effect will be the release of iron and sulfate into solution from oxidation of pyrite. A third effect will be to increase the levels of some trace metals such as arsenic, vanadium and selenium in solution. As mentioned previously, the iron solubilized will most likely be precipitated as the hydroxide or carbonate, depending on its oxidation state. Any vanadium which is oxidized along with the uranium will be solubilized by the lixiviant, recovered with the uranium and could potentially contaminate the precipitated yellowcake product. The Crow Butte Pilot Plant used hydrogen peroxide precipitation of uranium in an effort to reduce the amount of vanadium precipitated in the product. Oxidation will also solubilize arsenic and selenium. The restoration program will return these substances

to acceptable levels. A final potential oxidation reaction is the partial oxidation of sulfur species resulting in compounds such as polythionates which can foul the ion exchange resins. In in-situ operations using chemistries similar to the proposed at Crow Butte, these sulfur species are completely oxidized to sulfate and Crow Butte is not expected to be different.

11.1.7 Organics

Organic materials are generally not present in the Crow Butte ore body at levels greater than 0.1 to 0.2%. Where present their effect will be to increase the oxidant consumption and make uranium leaching a bit more difficult. On longer flow paths, organic material could potentially reprecipitate uranium, should all of the oxidant be consumed and conditions become reducing. Another potential impact of organics could be the coloring and fouling of leach solutions should the organics be mobilized. FEN plans to operate at pH's in the range of 6.5 to 9.0, which should be low enough to avoid mobilization of organics and coloring of the leach solutions.

11.2 Restoration Goals

The FEN restoration program is designed to return the water quality of the affected zone to the quality level specified by the NDEC which is a quality of use consistent with the "uses for which the resource was suitable" prior to the activity.

Restoration criteria will be established by the NDEC prior to the initiation of mining activity in an area.

FEN proposes that the restoration criteria be established on a mine unit average basis. An average mine unit will be approximately 22.5 acres and FEN proposes that one well per acre be designated as a representative well for purposes of establishing restoration criteria. The representative wells (23 in an average mine unit) will be sampled three times at two week intervals (a total of 69 individual analysis) and analyzed for the list

shown in Table 12.4-1 (Section 12). The average of all analyses will be determined and the standard deviation. Outliers will be evaluated utilizing the "Recommended Criteria for Single Samples", taken from the 1977 Annual Book of ASTM Standards. This method involves comparing a test-statistic (TS) to a critical value (CV). If the value of the calculated TS is greater than the CV for a specific number of observations at a specified alpha level, the outlier is rejected. Thus the test statistic:

$$TS = \frac{x_n - \bar{x}}{s}$$

Where:

$\bar{x}$ = arithmetic average of all n values
x_n = doubtful value
s = estimate of the population standard deviation based on the sample data.

FEN utilized an alpha level of 0.05, one-sided test in calculation of CV. The actual CV varies depending on **n** or a total number of obsevations in the data set. Values of CV for various **n** values are tabulated in the reference cited above.

The confidence interval or the range of X values that encompass some percentage of the total population of the restoration criteria can be expressed by the following:

$$u - z\sigma < X < u + z\sigma$$

Where:

u = mean
σ = sample standard deviation
z = number of standard deviations to encompass some given probability

For a 95% confidence interval with 69 observations the "t" distribution can be used to determine z. The "t" distribution is appropriate when small numbers of samples (usually less than 100) are available. As can be seen from the "t" factor table for m = 60 is as close to 69-1 as can be determined (Guttman, Wilks, and Hunter, 1971). The 95% confidence interval then becomes:

$$u - 2.00\sigma < X < u + 2.00\sigma$$

As can also be seen from the table the "t" value for an infinite number of samples is 1.96. This means that the confidence interval obtained with 69 samples is almost the same as a confidence interval with an infinite number of samples. Thus FEN has concluded that 69 data points are appropriate to establish the restoration criteria. Actually there is little difference in the confidence interval above 20 data points.

The use of one well per acre to establish restoration criteria is being used or proposed at the two newest mines in the Powder River Basin of Wyoming. The Highland Uranium Project establishes restoration criteria using one well per acre and the Christensen Ranch Project has proposed one well per acre.

The NRC has indicated that approximately one well per acre can be utilized for baselining and that the data from these wells can be combined, resulting in average baseline water quality conditions for the entire production unit (Konwinski, G., 1988).

Restoration criteria for a mine unit will be established as the average plus two standard deviations for any parameter that exceeds the applicable drinking water standard. If a drinking water standard exists for a parameter, and baseline is below that standard, the drinking water standard will be used to establish the restoration criteria. If there is no drinking water standard for an element, for example vanadium, the restoration criteria will be based on best practicable technology. The restoration criteria for the major cations (Ca, Mg, K) should allow for the concentation of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criteria should allow for the total carbonate to be less than 50% of the TDS.

At the conclusion of restoration and during stabilization, the representative wells will be sampled and if the average meets the restoration criteria, the mine unit will be considered restored.

11.3 R & D Groundwater Quality Restoration

FEN operated a R & D facility at Crow Butte from July 1986 to present. Two wellfields (WF-1 and WF-2) were operated during the R & D phase. Leaching activities were terminated in WF #2 in January of 1987 and restoration was initiated on February 9, 1987. Restoration was conducted following the Restoration Plan submitted to the USNRC on October 9, 1986.

The goal of the Restoration Plan was to return all groundwater affected by the R & D mining to restoration values as defined by Nebraska Department of Environmental Control (NDEC) based on baseline groundwater sampling. FEN accomplished aquifer restoration by utilizing a series of stages carefully designed in a specified sequence. The stages utilized in the program were:

1. Halo Recovery Stage
2. Permeate Injection/Reductant Stage
3. Aquifer Recirculation

Prior to the initiation of restoration, samples were taken from wells PT-21, PT-22, PT-23, PT-24 and PT-25 to establish the post mining water quality. The data from these samples are found in Table 11.3-1 through 11.3-5.

11.3.1 Halo Recovery Stage

The first step in the restoration process was to draw contaminated water in toward the wellfield until the majority of the plume of contamination was drawn inside the perimeter injection wells. The solution was recalled by operating the recovery well in the wellfield with no injection. This stage was continued until it was clear that the major portion of the contamination had been recalled from the area surrounding the wellfield. Samples from the injection wells and comparative volume calculations were used to help make that determination. This stage required 15 days, and a total of 707,800 gallons of water was removed.

TABLE 11.3-1

WELL #PT-21

Parameter	Restoration Value	Post-Mining (2-9-87)	Restoration Sample (6-15-87)	Restoration Sample (8-26-87)
As	.05	0.023	0.009	.004
B	1.112	1.16	1.00	.95
Ba	1	1.16	<0.10	<0.1
Ca	160	47	19	9.3
Cd	.01	<0.001	0.001	<0.001
Cl	250	292	234	168
Cr	.05	<0.005	0.007	<0.005
Cu	1	0.06	0.02	<0.01
F	2.4	0.90	0.62	.6
Fe	1	<0.005	<0.005	<0.03
Hg	.002	<0.0002	<0.0002	<0.0002
K	112	19	12.8	9.0
Mg	40	11.3	4.4	2.4
Mn	.2	0.024	0.011	.005
Mo	1	0.09	0.01	<0.01
Na	500	676	479	321
NH_4 as N	.5	0.24	0.46	.23
Ni	.2	<0.01	<0.01	<0.01
NO_2 as N	1	0.066	0.028	.018
NO_3 as N	10	0.39	0.09	.02
Pb	.05	<0.005	0.011	<0.005
pH	6.5-8.5 s.u.	7.84	7.89	7.91
Ra-226	1611 pCi/l	2198	1020	359.3
Se	.01	0.020	<0.001	<0.001
SO_4	600	508	408	282
TDS	1186	2130	1518	948
TOT. CARB.	<593	895	454	278
U	5.0	40.1	14.8	3.793
V	.01	1.08	0.13	.03
Zn	5	0.03	<0.01	<0.01

*All units are mg/l unless otherwise noted.

TABLE 11.3-2

WELL #PT-22

Parameter	Restoration Value	Post-Mining (2-9-87)	Restoration Sample (6-16-87)	Restoration Sample (8-26-87)
As	.05	0.022	0.005	<0.001
B	1.184	1.14	1.02	.95
Ba	1	<0.1	<0.10	<0.10
Ca	151	46	19.5	9.2
Cd	.01	<0.001	<0.001	<0.001
Cl	250	323	231	167
Cr	.05	<0.005	<0.005	<0.005
Cu	1	0.02	<0.01	<0.01
F	2.4	0.9	.6	.64
Fe	1	0.03	<0.03	<0.03
Hg	.002	<0.0002	<0.0002	<0.0002
K	116	24	12.9	9.2
Mg	38	9.7	4.2	2.2
Mn	.2	0.024	.012	.006
Mo	1	0.09	.01	<0.01
Na	500	768	479	332
NH_4 as N	.5	0.14	.32	.24
Ni	.2	<0.01	<0.01	<0.01
NO_2 as N	1	0.043	.021	.033
NO_3 as N	10	0.79	.05	.07
Pb	.05	<0.005	<0.005	.005
pH	6.5-8.5 s.u.	7.69	7.94	7.98
Ra-226	1281 pCi/l	2365	1028	97
Se	.01	0.02	0.001	<0.001
SO_4	600	497	414	288
TDS	1157	2270	1508	982
TOT. CARB.	<579	1039	465	274
U	5.0	7.428	1.59	.258
V	.01	0.82	.02	<0.01
Zn	5	0.11	<0.01	<0.01

*All units are mg/l unless otherwise noted.

TABLE 11.3-3

WELL #PT-23

Parameter	Restoration Value	Post-Mining (2-9-87)	Restoration Sample (6-16-87)	Restoration Sample (8-26-87)
As	.05	0.029	0.003	<0.001
B	1.101	1.15	.99	.96
Ba	1	<0.1	<0.1	<0.1
Ca	152	45	18.8	9.1
Cd	.01	<0.001	<0.001	<0.001
Cl	250	291	234	164
Cr	.05	<0.005	<0.005	<0.005
Cu	1	0.01	<0.01	<0.01
F	2.4	0.9	.6	.6
Fe	1	0.05	<0.03	<0.03
Hg	.002	<0.0002	<0.0002	<0.0002
K	105	11	13.3	9.0
Mg	39	11	4.4	2.2
Mn	.2	0.024	.012	.006
Mo	1	0.10	<0.01	<0.01
Na	500	735	482	322
NH_4 as N	.5	0.17	.52	.25
Ni	.2	<0.01	<0.01	<0.01
NO_2 as N	1	0.046	.027	.009
NO_3 as N	10	0.51	.08	.02
Pb	.05	<0.005	<0.005	.013
pH	6.5-8.5 s.u.	7.73	7.87	7.93
Ra-226	52 pCi/l	2741	975	96.5
Se	.01	0.018	<0.001	<0.001
SO_4	600	508	408	288
TDS	1147	2106	1508	946
TOT. CARB.	<574	898	455.8	274
U	5.0	6.256	.143	.0558
V	.01	0.84	0.01	<0.01
Zn	5	0.03	<0.01	.01

*All units are mg/l unless otherwise noted.

TABLE 11.3-4

WELL #PT-24

Parameter	Restoration Value	Post-Mining (2-9-87)	Restoration Sample (6-17-87)	Restoration Sample (8-26-87)
As	.05	0.025	0.006	.001
B	1.081	1.15	.98	.95
Ba	1	<0.10	<0.1	<0.1
Ca	125	48	18.8	9.0
Cd	.01	<0.001	<0.001	<0.001
Cl	305	289	233	169
Cr	.05	<0.005	<0.005	<0.005
Cu	1	0.01	<0.01	<0.01
F	2.4	0.90	.62	.6
Fe	1	<0.03	<0.03	<0.03
Hg	.002	<0.0002	<0.0002	<0.0002
K	129	12	12.9	9.0
Mg	38	9.8	4.1	2.2
Mn	.2	0.021	.011	.005
Mo	1	0.10	.02	<0.01
Na	500	700	476	327
NH_4 as N	.5	0.10	.42	.27
Ni	.2	<0.01	<0.01	<0.01
NO_2 as N	1	0.018	.021	.008
NO_3 as N	10	0.59	.08	<0.01
Pb	.05	<0.005	<0.005	.011
pH	6.5-8.5 s.u.	7.64	7.98	7.84
Ra-226	1436 pCi/l	2605	928	96.4
Se	.01	0.019	<0.001	<0.001
SO_4	600	508	408	282
TDS	1277	2092	1498	942
TOT. CARB.	<639	901	460	278
U	5.0	7.904	3.689	.0708
V	.01	0.86	.02	<0.01
Zn	5	0.04	.01	<0.01

*All units are mg/l unless otherwise noted.

TABLE 11.3-5

WELL #PT-25

Parameter	Restoration Value	Post-Mining (2-9-87)	Restoration Sample (6-17-87)	Restoration Sample (8-26-87)
As	.05	0.032	0.02	<0.001
B	1.229	1.13	1	.95
Ba	1	<0.10	<0.1	<0.1
Ca	128	44	18.5	9.0
Cd	.01	<0.001	<0.001	<0.001
Cl	250	301	231	163
Cr	.05	<0.005	<0.005	<0.005
Cu	1	0.01	<0.01	<0.01
F	2.4	0.90	.6	.6
Fe	1	<0.03	<0.03	<0.03
Hg	.002	<0.0002	<0.0002	<0.0002
K	124	21	13	9.0
Mg	30	9.7	4.2	2.2
Mn	.2	0.021	.012	.005
Mo	1	.09	<0.01	<0.01
Na	500	735	484	322
NH_4 as N	.5	0.12	0.52	.26
Ni	.2	0.01	<0.01	<0.01
NO_2 as N	1	0.011	.024	.013
NO_3 as N	10	0.94	.07	.02
Pb	.05	<0.005	<0.005	.007
pH	6.5-8.7 s.u.	7.78	7.92	7.92
Ra-226	387 pCi/l	2330	944	85.4
Se	.01	0.018	<0.001	<0.001
SO_4	600	507	408	294
TDS	1168	2130	1500	960
TOT. CARB.	<584	925	468	274
U	5.0	6.47	.712	.0418
V	.01	0.82	0.02	<0.01
Zn	5	.08	<0.01	.01

*All units are mg/l unless otherwise noted.

All water removed during this stage was pumped from the center well in WF-2, which was PT-21. During this stage, it became apparent that the uranium concentration was higher in wells PT-22 and PT-24 and that it would be beneficial to pump from these wells. A pump was installed in PT-22 and PT-24 and the solution was pumped into the PT-21 casing and then pumped into the plant for processing. Table 11.3-6 shows the uranium, sulfate, sodium and pH values obtained on samples from the individual wells during the halo recovery stage. As can be seen from the data, the concentration of the sodium and sulfate showed a general decreasing trend while the uranium concentration was variable. The variation in the uranium concentration was most likely due to the transfer of solutions from PT-22 and PT-24 into PT-21 for transfer to the plant.

The water recovered during the halo recovery was processed by a reverse osmosis (R.O.) unit in order to minimize waste volumes in the evaporation ponds. The clean water (permeate) produced by the R.O. was sent to the east pond and the brine was sent to the west pond. The clean water was further treated by R.O. to reduce contaminant levels to standards specified by the NDEC for land application of water. The clean water was then land applied.

11.3.2 Permeate Injection/Reductant Phase

After Halo Recovery had been completed, the Permeate Injection/Reductant stage was initiated. In the Permeate Injection/Reductant stage, the water recovered from the wellfield was processed in a water treatment system using a reverse osmosis unit and the permeate (clean water) was injected into the wellfield.

Reductant was added to the permeate injection stream a number of times during this phase. Table 11.3-7 shows a chronology of the activities that occurred during this phase. The Table also shows a water balance during this phase.

TABLE 11.3-6

HALO RECOVERY ANALYSIS DATA WF-2

	2-9-87	2-12-87	2-15-87	2-17-87	2-25-87	2-28-87	3-4-87
PT-21							
U_3O_8	43	60	52	49	83	21	75
Na		647			600		552
SO_4		453			446		411
pH		7.5			7.5		7.5
PT-22							
U_3O_8	5	76	115	127	149	128	119
Na		724			680		597
SO_4		516			470		426
pH		7.5			7.3		7.3
PT-23							
U_3O_8	8	5	7	6	6	7	4
Na		641			680		707
SO_4		453			458		455
pH		7.8			7.6		7.5
PT-24							
U_3O_8	9	41	38	37	45	46	41
Na		453			426		430
SO_4		373			364		358
pH		7.8			7.6		7.6
PT-25							
U_3O_8	7	8	3	2	4	5	4
Na		624			495		497
SO_4		433			385		376
pH		7.6			7.9		7.7

*All units are mg/l except pH which is in Standard Units (S.U.)

NOTE: Recovery was stopped from 2-17-87 to 2-25-87 to obtain approval from NDEC to allow recovery from PT-22 and PT-24

TABLE 11.3-7

PERMEATE/REDUCTANT INJECTION CHRONOLOGY

Date Start	Date End	Description	Gallons Produced	Gallons Injected
2-9-87	3-3-87	Halo Recovery	707,800	0
3-4-87	3-10-87	Permeate Injection, Recirculation	263,933	266,815
3-11-87	3-25-87	Recirculation	710,970	710,784
3-26-87	4-7-87	Reductant Injection, 400# Na_2S	543,310	541,957
4-8-87	4-12-87	Recirculation	222,467	214,805
4-13-87	4-20-87	Reductant Injection, 350# Na_2S	408,034	405,054
4-21-87	4-29-87	Recirculation	360,290	361,364
4-30-87	5-6-87	Reductant Injection, 400# Na_2S	368,448	368,277
5-7-87	5-17-87	Recirculation	442,520	444,200
5-18-87	5-25-87	Shut-in to Monitor Response	0	0
5-26-87	5-28-87	Recirculation	137,267	136,482
5-29-87	5-31-87	Permeate Injection, TDS Reduction	154,208	147,328
6-1-87	6-9-87	Reductant Injection, 200# Na_2S	429,924	428,314
6-10-87	6-21-87	Shut-in, Sampled All Wells	12,417	10,775
6-22-87	6-23-87	Recirculation	105,586	105,462
6-24-87	X	Reductant Injection, PT-21, 60# Na_2S	0	11,268
6-25-87	7-8-87	Shut-in	0	0
7-9-87	7-12-87	Recirculation with Radium Sel. Comp.	147,234	144,040
7-15-87	X	PT-22 Pump and Sample	1,458	1,261
7-16-87	7-20-87	PT-25 Recirculation with R.S.C.	115,836	116,789
7-21-87	7-30-87	PT-25 Permeate Injection 130# Na_2S	387,784	347,786
7-31-87	8-2-87	PT-21 Recirculation w/o Processing	107,288	99,033
8-03-87	8-07-87	Permeate Inj, Reduct Inj, 60# Na_2S	178,839	160,865
8-08-87	8-13-87	Recirculation with Radium Sel. Comp. plus 20# Na_2S	233,054	235,640
8-14-87	8-15-87	Permeate Inj, Reduct Inj, 30# Na_2S	82,816	83,882
8-16-87	8-19-87	Recirculate with R.S.C.	147,288	147,105
8-20-87	8-22-87	Permeate Inj, Reduct Inj, 30# Na_2S	130,800	125,128
8-23-87	8-26-87	Recirculate with R.S.C + 20# Na_2S	114,353	112,926
8-26-87		Split Samples with NDEC/EPA, Shut-in Wells	0	0
		TOTAL	6,513,722	5,727,340
		OVER PRODUCTION	786,382	

An evaluation of Table 11.3-7 shows that the wellfield was recirculated a number of times during this phase. Recirculation was conducted to allow the reductant (Na_2S) to contact as much of the host rock as possible and to make the aquifer more reducing.

11.3.2.1 Wellfield Configuration

During Halo Recovery, the primary pattern used consisted of pumping from the center well in the WF-2 five spot (PT-21). Figure 11.3-1 shows the general layout. FEN modified the pumping pattern periodically to reduce specific contaminants in Wells PT-22 and PT-24. Pumps were placed in these wells and the solutions transferred to PT-21 for transfer to the plant.

During the Permeate Injection/Reductant Phase, the pattern used was normally similar to the mining pattern which used the center well (PT-21) for recovery and the perimeter wells (PT-22, PT-23, PT-24, PT-25) for injection. This pattern was modified periodically to allow the injection of reductant into specific wells in an effort to reduce uranium.

11.3.2.2 Plant Operations

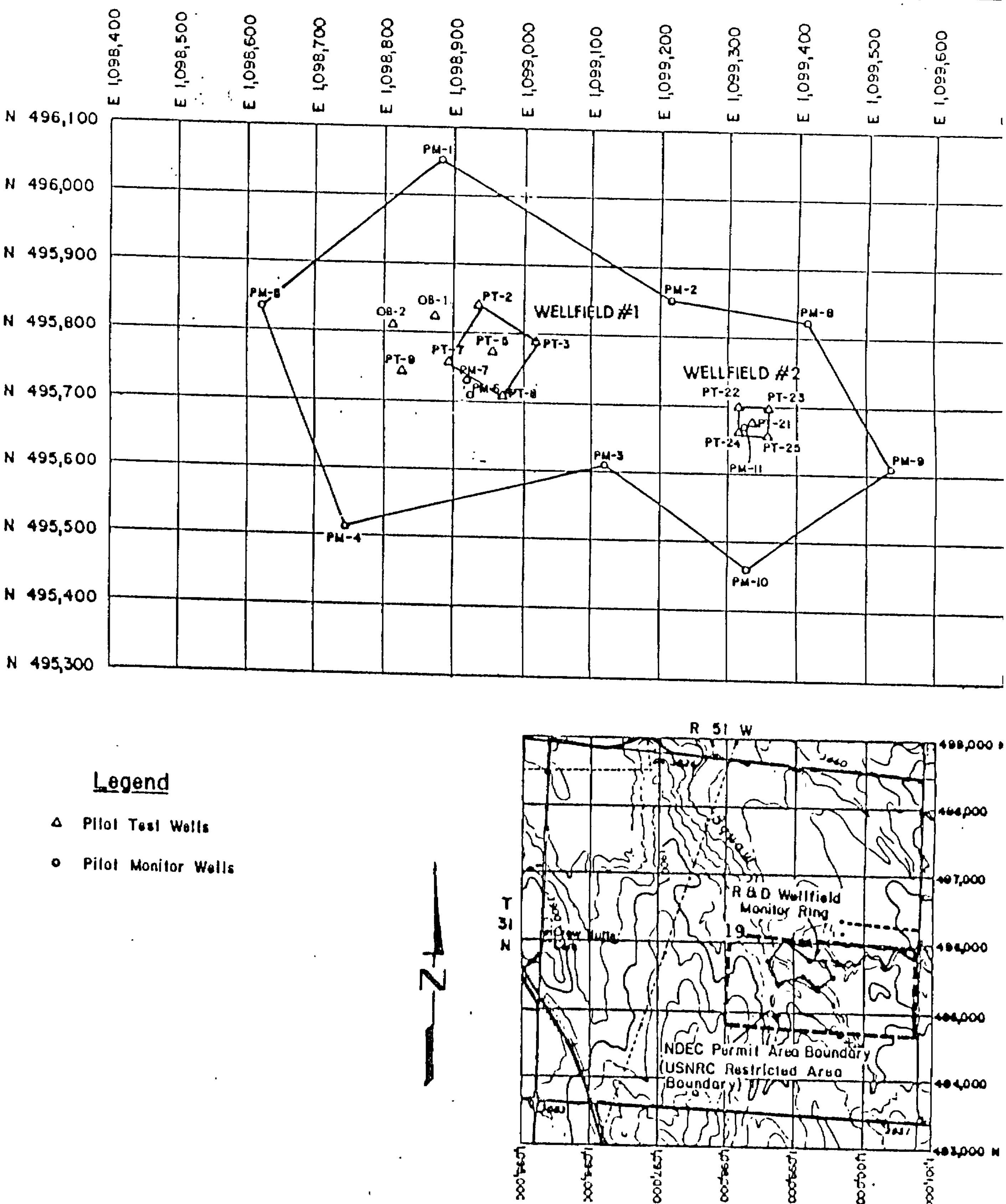
The water recovery during the Halo Recovery phase or restoration was treated using Reverse Osmosis (R.O.) until the water was suitable for land application as authorized by the NDEC and USNRC. The R.O. system used for treatment of the Halo Recovery water was similar to the system used for the Permeate Injection Phase.

A Process Schematic of the R.O. System is shown in Figure 11.3-2 and a description of the system follows:

(a) Uranium Removal

The recovered solution was filtered and then passed through the IX Column to remove uranium.

CBR-014



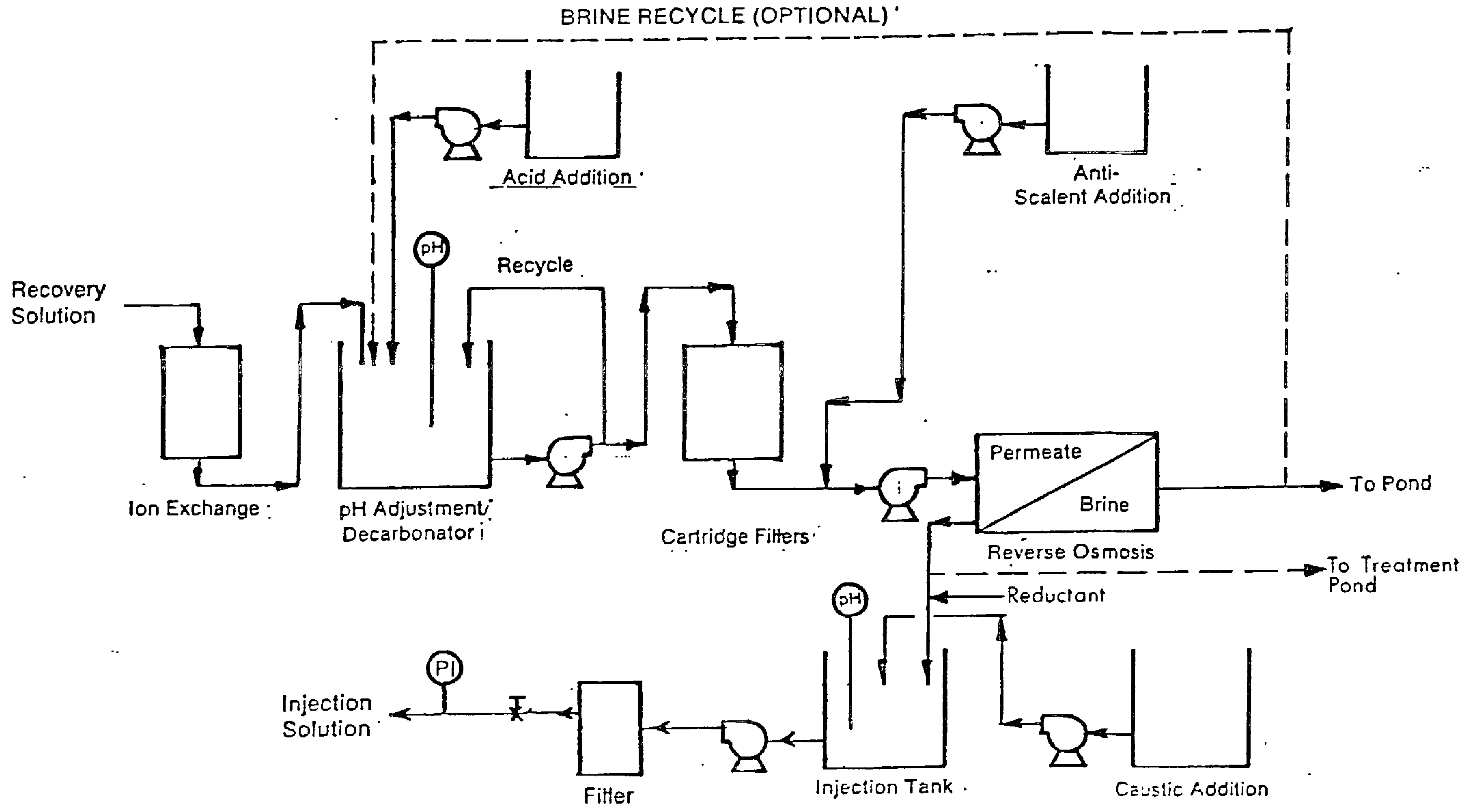
Scale 1" = 200'

50 25 0 50 Meters

200 100 0 200 Feet

11.0(18) 09/30/87

REV DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	R & D WELLFIELD WATER QUALITY WELLS		
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/87	FIGURE 11.3-1



PERMEATE INJECTION/REDUCTANT

PROCESS SCHEMATIC

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(b) pH Adjustment

After uranium removal, the pH was adjusted with acid to a pH of 3.5 to 7.0. This pH range is the desired range for the R.O. membranes that were used.

(c) Filtration

After pH adjust, the solution was filtered to remove all suspended solids prior to R.O. treatment.

(d) Anti-Scalent Addition

An anti-scalent was added to suppress the precipitation of sparingly soluble compounds in the R.O. and thus prevent fouling of the membranes.

(e) Reverse Osmosis Treatment

After adequate pretreatment, the recovered solution was introduced into the R.O. where the soluble species were concentrated in a brine stream that was 10 to 20% of the feed volume. About 80 to 90% of the feed volume was in the clean water stream (permeate) which was sent to a pH adjustment system prior to injection in the wellfield.

(f) Permeate pH Adjustment

The permeate pH was adjusted to the desired pH by the addition of caustic or reductant prior to injection into the wellfield.

11.3.2.3 Results-Permeate Injection/Reductant Phase

Samples were taken daily from PT-21 and analyzed for U_3O_8, V, $CO_{3(T)}$, pH, Ca, Na, Cl, SO_4 and conductivity. An aliquot of each daily sample was taken and a monthly composite sample prepared and analyzed. The results of the monthly samples from PT-21 (the recovery well during mining) are shown in Table 11.3-8. As can be seen from Table 11.3-8, all Restoration values except vanadium have been met on the August 1987 samples. The Restoration values, the post mining water quality analyses and the results of the post Restoration samples are found on Tables 11.3-1 through 11.3-5. A review of the data show that the Restoration values have generally been achieved.

FEN is now at Phase II of Restoration as defined in the NDEC Permit. During Phase II, the representative well (PT-21), and any monitor well which was placed on excursion status (none) during mining must be sampled monthly for the Restoration parameters found in Part IV of the NDEC/UIC permit. Phase II will be completed when the representative well (as defined earlier) samples have reached the Restoration values found in Part IV of the NDEC/UIC permit. The values for PT-21 are found in Table 11.3-8. Prior to stabilization, samples were taken from Wells PT-21, PT-22, PT-23, PT-24 and PT-25 and analyzed for the Restoration Values. These samples were taken on August 26, 1987 and results are shown in Table 11.3-1 through 11.3-5 and Table 11.3-8.

Phase III will be initiated at the completion of Phase II. Phase III is the stabilization stage and during Phase III, samples shall be taken for a period of six months from representative wells (as defined earlier) and analyzed for the Restoration Parameters as specified on the Restoration Table. This data will be submitted to the USNRC and the NDEC when available.

11.3.2.4 Discussion of Restoration Results

A review of the restoration results found in Tables 11.3-1 through 11.3-5 and Table 11.3-8 indicate that all restoration values were met on all wells with the following exceptions:

TABLE 11.3-8

WELL #PT-21

Parameter	Restoration Value	JAN 1987	FEB 1987	MAR 1987	APR 1987	MAY 1987	JUNE 1987	JULY 1987	AUG 1987
As	.05	.016	.015	.008	.013	.002	.01	.006	.004
B	1.112	1.22	1.12	1.02	1.02	.96	.96	.96	.95
Ba	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ca	160	59	33.4	25.7	29.4	25.3	14.4	17.8	9.3
Cd	.01	.002	<0.001	<0.001	.004	<0.01	<0.001	<0.001	<0.001
Cl	250	347	226	277	284	318	234	209	168
Cr	.05	<0.005	<0.005	<0.005	<0.005	<0.05	<0.005	<0.005	<0.005
Cu	1	.09	.07	.02	.04	.03	.04	.06	<0.01
F	2.4		.9	.56			.62		0.6
Fe	1	.11	.09	.04	.06	.04	.04	.05	<0.03
Hg	.002	.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
K	112	18	19.9	14.5	17.7	13.1	12.2	11.6	8.5
Mg	40	13.8	9.6	6.2	6.8	6.3	4.9	4.53	2.4
Mn	.2	.003	.055	.012	.012	.012	.01	.013	0.005
Mo	1	1	.08	.05	.02	.03	.07	<0.01	<0.01
Na	500	852	650	479	562	532	486	428	321
NH_4 as N	.5		.24	.29			.46		.23
Ni	.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NO_2 as N	1		.066	.101			.028		.018
NO_3 as N	10		.39	.19			.09		.02
Pb	.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
pH	6.5-8.5s.u.	7.61	7.44	8.15	7.66	8.02	7.89	8.13	7.91
Ra-226	1611 pCi/l	3127	1654	860	1040	1156	723	666	359
Se	.01	.027	.015	.009	.002	<0.001	.002	<0.001	<0.001
SO_4	600	477	411	388	436	371	408	345	282
TDS	1186		2130	1436	1600	1800	1518	900	948
TOT. CARB.	<593	1183	702	577	582	558	447	493	278
U	5.0	66.3	43.9	22.8	21.3	21.0	8.434	8.889	3.793
V	.01	1.84	1.2	.68	.36	.16	.13	.05	.03
Zn	5	.35	<0.01	<0.01	<0.01	.02	.19	.13	<0.01

* All units are mg/l unless otherwise noted.

Note: 8-26-87 sample split with EPA.

o Radium-226 on Well Number PT-23.

The baseline radium-226 concentration in Well PT-23 was 52 pCi/l. The average radium-226 baseline for PT-21 through PT-25 was 953 pCi/l with a standard deviation of 690 pCi/l. The range obtained on the radium-226 baseline data (52 pCi/l to 1611 pCi/l) indicates that the aquifer is not homogeneous with respect to radium-226 concentration. The baseline radium-226 concentration in a sample from a well appears to be a function of the amount of radium-226 in the host rock in the vicinity of the well bore. During mining, the radium-226 in the groundwater increases and tends to become more homogeneous. Since radium-226 is removed from water by precipitation as the sulfate and by ion exchange with the clays it would also be expected that the radium in the host rock will also become more homogeneous.

During restoration the radium-226 concentration in the groundwater is lowered by treatment above ground. The treated water is injected into the aquifer and the radium-226 concentration in the water will equilibrate at a level dependent on the radium-226 concentration in the host rock. The mining process does not significantly change the amount of radium-226 in the host rock but it does change the distribution of radium-226 in the host rock. With this distribution change, the radium-226 concentration in the various wells will approach the average concentration that existed prior to mining, but the concentration in any single well may be above baseline. This is the situation that exists with Well PT-23. Although the radium-226 concentration in this well exceeds baseline for this well, radium-226 concentration after restoration does not exceed the baseline average for wells PT-21 through PT-25. The radium-226 level in PT-23 is 96.5 pCi/l (as of 8-26-87) which is far below the average baseline value of 953 $\pm$ 690 pCi/l for Wells PT-21 through PT-25.

The average radium-226 concentration after restoration (as of 8-26-87) in wells PT-21 through PT-25 is 147 $\pm$ 119 pCi/l which is also well below the average baseline concentration of 953 $\pm$ 690 pCi/l for the same wells. During the stabilization period, the present average radium-226 levels in wells PT-21 through PT-25 may increase to an equilibrium level approaching

the average baseline concentration for the same wells. Based on the above evaluation, FEN believes that the restoration criteria for radium-226 and most other elements should be based on the average concentration in the field and not on the concentration found in a single well.

- The vanadium concentration in the restoration samples exceeds the restoration value of 0.01 mg/l in Well PT-21.

The restoration value for vanadium for Well PT-21 is 0.01 mg/l and the measured value on the 8-26-87 sample is 0.03 mg/l. All other wells sampled showed vanadium levels of less than 0.01 mg/l.

As can be seen from the data, the measured values are very close to the restoration value. The restoration value for vanadium was set at baseline (0.01 mg/l) because there are no criteria for vanadium in any EPA drinking water standards. FEN has lowered the vanadium concentration to a level approaching the restoration values using the best available technology. The vanadium concentration in the restored water does not exceed any standards and has no environmental impact. Thus, the vanadium levels achieved by FEN should be considered acceptable for restoration.

- **Water Balance**

Table 11.3-7 shows the volume of water produced, injected and overproduced during the restoration program. As can be seen from the data in Table 11.3-7, the majority of the overproduction occurs during the Halo Recovery Phase. The 707,800 gallons produced in this Phase are equivalent to approximately 2.36 pore volumes. The pore volume estimate for Wellfield #2 is based on the results of computer modeling using the Bureau of Mines model ISL-50. This model defined a maximum pore volume as approximately 300,000 gallons.

Further review of Table 11.3-7 indicates that very little water was overproduced during the permeate injection/reductant stage of restoration.

Approximately 1,276,000 gallons of water were treated by reverse osmosis during the permeate injection/reductant stage and approximately 90% of this volume was reinjected and 10% was sent to the evaporation ponds as brine.

The remainder of the water produced and injected, as shown in Table 11.3-7 was recirculated in an effort to lower the uranium and radium concentrations below the restoration values. Reductant was periodically added during recirculation in an effort to suppress the solubility of uranium and the solutions were periodically passed through a radium selective complexer to remove radium. Approximately 4,456,000 gallons of water (14.9 pore volumes) were recirculated during the restoration program. During recirculation, there is no overproduction.

The recirculation volume used for the R & D restoration program is larger than that expected for the commercial restoration. As was noted earlier, the primary purpose of the recirculation was to reduce the uranium levels and the secondary purpose was to reduce the radium levels. The uranium levels during restoration at the commercial facility will be lower than the levels encountered during R & D restoration. R & D restoration was initiated with a significant amount of uranium remaining in the cell and in the areas immediately adjacent to the cell. This causes the uranium to be mobilized during the restoration program. During restoration at a commercial facility, the uranium is mined more completely and mobilization is minimized during restoration and thus less reductant will be required to reduce uranium concentration to the restoration value.

The radium levels observed during the R & D restoration program were discussed earlier. FEN will propose that restoration values for radium at the commercial facility be determined from the average concentration in a wellfield and this will also reduce the recirculation requirement and may lower the water consumption requirement also.

In summary, the water balance during the R & D program follows:

	Gallons Produced	Over Production
Halo Recovery	707,800	707,800
Permeate Injection/Reductant	1,198,177	78,582
Recirculation	4,607,745	0
	6,513,722	786,382

The total number of pore volumes produced was approximately 19 and approximately 16.4 pore volumes were reinjected with approximately 2.6 pore volumes of overproduced water. FEN has demonstrated, the use of best available technology during the R & D restoration program and has demonstrated achievement of virtually all restoration values with minimal consumptive use of water.

11.4 Hole Plugging and Abandonment

All monitor, injection and production wells will be plugged and abandoned prior to final closure of the site and after NRC and NDEC have accepted groundwater restoration.

The plugging method to be used is as follows: Approved abandonment mud (a mud-polymer mix) will be mixed in a cement unit and pumped down a hose, which is lowered to the bottom of the well casing using a reel. When the hose is removed, the casing is topped off and a cement plug placed on top. A hole is then dug around the well, and, at a minimum, the top 3 feet of casing removed. The hole is backfilled and the surface revegetated.

11.5 Shut-Ins or Well Failures

Reasons for shutting in and abandoning a well fall into basically two categories; first, well damage or second, inability to restore well performance. Fracturing of a well casing and casing damage due to maintenance operations are two possible examples of situations requiring well replacement. The second category of failures might be typified by a

well which, due to formation damage or other reasons, will not respond to treatment allowing adequate injections or production. In the event of either of these occurrences, FEN's well abandonment procedures will be used to assure proper plugging.

Should a well failure be detected, the well will be integrity tested to try and determine the nature of the failure. If repair is feasible, the well will be repaired and integrity tested again. If the well passes the integrity testing it will be put back in service and monitored closely. Should the well fail integrity testing or be beyond repair, it will be plugged and abandoned in accordance with Section 11.4.

11.6 Reclamation of Disturbed Lands

At the end of restoration, disturbed lands will be returned to their premining use. A total of approximately 750 acres will have been affected by mining activities. The plant area, ponds site and access roads will experience the greatest amount of disturbance.

Reclamation will consist of several operations. Within the wellfield, disturbance will be minimal. Soil may be compacted in areas from the drilling and maintenance traffic. Closure of the wells will also require some surface disturbance immediately surrounding each well. The non-vegetated or disturbed areas including roads will be plowed or disced to aerate the soil. A grass seed mixture and fertilizer will then be spread. Assistance will be obtained from the U.S. Soil Conservation Service to determine the proper seed mix and rate of application.

Preparation of the plant and pond areas will follow standard land reclamation practices. Excess soil from the built-up plant base and pond embankments will be returned to the ponds as fill. Land surface contours will be similar to original contours. Finally, topsoil will be replaced on all plant and pond disturbed areas. Reseeding and fertilizing will follow U.S. Soil Conservation Service recommendations.

A period of one to two years will be required to firmly establish grass populations. During this time, fences will be maintained to keep livestock out of the area and away from new vegetation. After that time, the land may be returned to its premining use, grazing.

11.7 Plant Decommissioning

Prior to release from the site for unrestricted use, all equipment, buildings and other items will be checked for radioactive surface contamination. Records will be kept of equipment and corresponding surface contamination levels for all items released. If contamination exceeds the limits given in USNRC-Attachment A, further attempts should be made to reduce levels. All items not in compliance with these levels will be disposed of at a site approved for by-product materials, such as an active mill tailings disposal site.

An alternative may be to sell the equipment and building to a source material license holder. If so, then equipment and building parts will be cleaned of easily removable contamination prior to shipping. Those final levels may be higher than for unrestricted release but will comply with D.O.T. shipping restrictions.

Dismantling of the facility and pond closure will take place after groundwater restoration has been confirmed by NRC and NDEC. Reusable equipment will be segregated from worn-out or scrap items, both types cleaned, and distributed appropriately as determined by residual surface contamination levels. Cleaned refuse may be disposed of in sanitary landfills.

Pond closure will be as follows: First, any remaining liquids will be transferred to vessels of suitable construction and shipped to an approved disposal site. Bottom sludge can then be loaded into a tank truck or placed in drums for disposal. The pond liners are then cleaned to the degree possible. If after cleaning they meet the limitations for surface contamination, the liners will be cut into smaller pieces, placed in the pond bottoms and covered with soil to final contours. If contamination limits

are exceeded, the liners will be placed on trucks and hauled to an approved disposal site. Cement from storage pads and the building floor will be decontaminated if necessary, broken up and placed in the pond bottom. Road bed materials and the parking surface area will also go into the pond. Underdrain piping will remain in place or be shipped as appropriate.

Other radioactive solid waste produced by the mining activities will be shipped to an approved by-product disposal site.

11.8 Postreclamation and Decommissioning Radiological Surveys

After the equipment, building and piping have been removed from the wellfield area, a gamma survey will be conducted over the same wellfield grid as was surveyed preoperationally. Piping is below plow depth at 5 feet. FEN plans to remove buried piping to the wells if it is cost effective to reuse the piping for new wellfields. If it cannot be reused FEB will leave the piping buried pending NRC approval. Results will be compared with those detected initially. Soil samples will then be obtained from locations indicated as "hot spots" and areas of significant recorded lixiviant spills. These surface samples will be analyzed for natural uranium and radium-226 content. Based upon the results, contaminated soil will be removed and shipped to a disposal site if necessary.

The plant area will be comprised of compacted earth, some surface covering material, a cement foundation and the building. Once the building and cement pads have been removed, a walk around gamma survey will be made of the compacted area. Any contaminated areas will be sampled and removed for proper disposal. The compacted area will then be dozed for recontouring, excess soil placed in the pond pits and the topsoil replaced. A final gamma survey will be performed and the results compared with the preoperational survey.

11.9 Financial Assessment

Following is an estimate of costs to be incurred by FEN or an independent contractor during Restoration, Decommissioning and Reclamation of the Crow Butte Site:

RESTORATION, RECLAMATION AND DECOMMISSIONING COST ESTIMATE

The following cost estimate is based on the cost per year to restore one mine unit and reclaim one mine unit. The FEN mine plan calls for sequential restoration and reclamation and FEN will have approximately 2 to 3 mine units in restoration, mining or reclamation at any time.

Groundwater Restoration per Mine Unit

Average Mine Unit Size	= 22.5 acres
Average Affected Thickness	= 10.0 feet
Average Porosity	= 0.29
Average Pore Volume (PV)	= 65 acre-feet

Restoration Process

• Remove three PV for Halo Recovery and transfer to existing ponds.		
Pumping cost @ 40,000 KW-hr/PV		$9,500
• Treat two PV with R.O. and reinject permeate @ $2.00/1000 gal;		
R.O. cost plus pumping cost		$91,100
• Recirculate three PV with reductant;		
Pumping cost plus chemical cost @ 1 lbs. reductant/1000 gal.		$41,000
• Treat two PV with R.O. @ $2.00/1000 gal;		
R.O. cost plus pumping cost		$91,100
	Subtotal	$232,700

Sampling and Monitoring

• Phase I (as per NDEC Permit); Assume 20 representative wells per mine unit:	
20 wells x 6 parameters x 6 months @ $6.00/parameter	$4,320
• Phase II: 20 wells x 32 parameters x 2 months @ $6.00/parameter	$7,680
• Phase III: 20 wells x 32 parameters x 6 months @ $6.00/parameter	$23,040
Subtotal	$35,040

Labor

• Two operators per shift + 4 support personnel for 12 personnel total @ $26,400/year	$316,800
Total Restoration per Mine Unit	$584,540

Note: The above Restoration estimate is based on the following assumptions:

(1) 400 gpm R.O. equipment and all plant equipment will be existing,

(2) The $2.00/1000 gal. operating cost for the R.O. includes electrical, chemical and maintenance.

(3) Solar evaporation ponds will be available.

Reclamation Cost per Mine Unit

• Well plugging and abandonment:	
216 mining wells and 20 monitor wells per mine unit @ $100/well	$23,600
• Surface reclamation: 22.5 acres @ $1,200/acre	$27,000
• Roads and other affected areas: 3 acres @ $1,200/acre	$3,600
TOTAL	$54,200

Site and Plant Decommissioning

• Building and Equipment Decontamination and removal	$225,000
• Dryer removal and Disposal	$40,000
• Solar Evaporation Ponds:	
– 30 acres @ $1,200/acre Reclamation	$36,000
– Removal and disposal of liners and contaminated solids.	$125,000
• Plant site, road, parking area, pipeline reclamation	
– 40 acres @ $1,200/acre	$48,000
TOTAL	**$474,000**

TOTALS	**Cost Estimate Per Mine Unit**
Restoration	**$584,540**
Reclamation	**$54,200**
	$638,740

FEN proposes that the surety bond in effect at any time should be determined by the number of mine units that are in operation (operation is defined as mining, restoration or reclamation) at that time. The surety bond will be reviewed annually, and the bond will be adjusted based on the status of operations. The above evaluation indicates that the surety bond for site decommissioning of $474,000 will be in effect over the life of the project, and that a surety bond of $638,740 will be in effect for each mine unit in operation.

At any one time, FEN expects to have three mine units in various stages of operation, restoration or reclamation. On this basis, FEN would anticipate restoration/reclamation cost per mine unit plus the site decommissioning estimate. Using the above cost estimates, the bond would be three times $638,740 plus $474,000 or $2,390,220. The surety bond would be raised accordingly in the event that FEN has more than three mine units in mining, restoration or reclamation.

REFERENCES

Deutsch, W.J. et al, *Aquifer Restoration at In-Situ Leach Uranium Mines, Evidence for Natural Restoration Processes*, Pacific Northwest Laboratory, NUREG/CR-3136-PML-4604.

Guttman, Wilks, and Hunter, 1971, *Introductory Engineering Statistics.* John Wiley and Sons, Inc., 549 pp.

Konwinski, Gary R., *The Nuclear Regulatory Commission and Its Role in Mining Oversight*, Symposium on Class III Wells Proceedings UIPC, April 27, 1988.

Miller, R.E., 1984, *Confidence Intervals and Hypotheses Tests* Chemical Engineering, November 26, 1984, p. 89-93.

Riding, J.R. and Rosswog, F.F., *Restoration of Ground Water Quality After In-Situ Uranium Leaching*, prepared for U.S. Department of the Interior, Bureau of Mines, by Ford, Bacon and Davis Utah, Inc., Contract No. J0275028, August 1979.

Schmidt, R.D. et al, *Geochemical Modeling of In Situ Leaching in a Heteroteneous Porous Medium*, Preprint Number 85-348, Society of Mining Engineers of AIME, October, 1985.

U.S. Nuclear Regulatory Commission, *Guidelines for decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-product, Source, or Special Nuclear Material*, Division of Fuel Cycle and Material Safety, November 1976.

U.S. Nuclear Regulatory Commission, *Health Physics Survey in Uranium Mills*, Regulatory Guide and Value/Impact Statement, Regulatory Guide 8.30, June 1983.

U.S. Nuclear Regulatory Commission, Staff Technical Position Paper, *Ground Water Monitoring at Uranium In-Situ Solution Mines*, #WM-8102, December, 1981.

SECTION 12.0

MONITORING PLANS

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12.0 MONITORING PLANS

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12.0 MONITORING PLANS

12.1 Composition of Injected Fluids

Twenty-four hour composite samples of the injection solution will be analyzed daily to document the composition of the injected solution. The concentration range for each major element in the injection fluid is found in Table 5.1-2 (See Section 5.0).

12.2 Pressure and Volume Monitoring

Pressure will be continuously monitored in the main trunkline from the process facility to the wellfield. The pressure sensor will be located in the wellfield and will be read out in the plant on a chart recorder. The measurement system will have a high pressure alarm which will actuate if the main trunkline pressure exceeds the maximum pressure authorized by permit. The above system assures that over-pressurization of individual wells will not occur. Injection flow measurements will be made on the main trunkline leading from the process plant to the wellfield. The flow meter will be located downstream of the injection filters and before the addition of oxidant, flow will be measured once per 8 hour shift and recorded by the operator. Recovery flows will be measured at the main trunkline returning from the wellfield to the process plant. Recovery flow will be measured once per 8 hour shift and recorded by the operator.

12.3 Well Integrity

As per NDEC regulations, all production and injection wells will be integrity tested prior to operations and retested once every five years. Details on well integrity testing are found in Section 10.0

12.4 Water Monitoring Programs

Three types of unplanned liquid effluents can potentially be released from an in-situ uranium facility: (1) mining solutions which migrate to areas outside the wellfield, (2) waste solutions in the subsoil resulting from loss of evaporation pond liner integrity, and (3) mining solutions released at the surface from leaks or breaks in pipelines and at wellheads.

12.4.1 Groundwater Monitoring

The groundwater excursion monitoring system will be designed to detect excursions of lixiviants into the ore zone aquifer outside of the wellfield area being leached and to detect excursions on lixiviants into the overlying water bearing strata. There is no permeable strata below the ore zone at the Crow Butte site and thus no monitoring will be required.

Results of two aquifer tests (See Section 4.4 ***Hydrology***) indicate that the ore zone aquifer is essentially isotropic and homogeneous. No faults or other conditions which may require special monitoring locations were noted in the hydrologic data analysis.

FEN proposes that ore zone monitoring wells be located approximately 400 feet from the perimeter of the wellfield and that these wells be 500 to 600 feet apart. FEN also proposes that monitoring wells in the overlying Brule sand be installed at a density of one monitoring well per five acres of wellfield.

There are no permeable zones present in the underlying Pierre Shale as indicated by nearby oil and gas holes which penetrate the entire thickness of Pierre. Also FEN holes within the permit area do not indicate any permeable zones within the upper 10 to 50 feet of the Pierre. Therefore, monitoring of the Pierre Shale is not necessary. The deep water-bearing formations below the Pierre Shale are not monitored because they are separated by 2000 to 2400 feet of essentially impermeable units from the production zone in the Basal Chadron Formation. Therefore, they will not

be influenced by in-situ mining activities. In addition, the water quality in these deeper formations is greater than 10,000 TDS. This TDS level exceeds the limit for an underground source of drinking water.

Upon installation of the monitor wells, baseline samples will be taken from each well. The water level in each well will also be measured. Three samples at two week intervals will be taken from each monitor well and analyzed for the parameters found in Table 12.4-1.

The excursion indicators for the monitor wells will be chloride, conductivity, alkalinity, and sodium. The Upper Control Limit (UCL) for the excursion indicators will be set at 20% above the maximum baseline concentration for the excursion indicators.

The ore zone and overlying aquifer monitor wells will be sampled and analyzed at a frequency of once per two weeks. Water level elevations in these wells will be measured and barometric pressure recorded prior to sampling.

All monitor well data will be reported to the appropriate agencies on a quarterly basis using the Mining Monitoring Report Forms shown as Figure 12.4-1. These forms are provided by the NDEC. If two UCL values are exceeded in a well, or if one UCL value is exceeded by 20 percent, take another water sample within twenty-four (24) hours and analyze it for the excursion indicators. If the second sample does not indicate excedence of the UCLs, a third sample shall be taken within forty-eight (48) hours from the first sample. If neither the second or third indicate excedence of the UCLs, the first sample shall be considered in error. If the second or third sample indicates an excedence of the UCLs, the well in question shall be placed on excursion status. An excursion is confirmed if two or more UCL values are exceeded, or if one UCL value is exceeded by 20 percent or more. Corrective action to mitigate the situation shall be initiated by FEN when an excursion is confirmed and the NRC shall be notified by telephone within twenty-four (24) hours and within five (5) days in writing from the time the confirmation sample was taken. Corrective actions shall be continued until the excursion is concluded. In addition to corrective

TABLE 12.4-1

BASELINE WATER-QUALITY INDICATORS TO BE DETERMINED DURING PREMINING DATA COLLECTION

Physical Indicators

Specific Conductivity[1]	Alkalinity	Total Dissolved Solids[3]
Temperature[2]		
pH[1]		

Common Constituents

Ammonia	Chloride	Mercury
Bicarbonate	Magnesium	Sodium
Calcium	Nitrate	Sulfate
Carbonate	Nitrite	Potassium

Trace and Minor Elements

Arsenic	Copper	Mercury
Boron	Fluoride	Molybdenum
Barium	Iron	Nickel
Cadmium	Lead	Selenium
Chromium	Manganese	Vanadium
		Zinc

Radionuclides

Radium-226	Uranium

[1] Field and laboratory determination.
[2] Field only.
[3] Laboratory only.

MINING MONITORING REPORT

19___

Submit to: DEC - T/E
P. O. Box 94877
Lincoln, NE 68509

Submit this report no later than: ____________________

PARAMETERS		WELL/MANIFOLD NUMBERS												
	MIN.													
	AVE.													
	MAX.													
	MIN.													
	AVE.													
	MAX.													
	MIN.													
	AVE.													
	MAX.													
	MIN.													
	AVE.													
	MAX.													
	MIN.													
	AVE.													
	MAX.													

FIGURE 12.4-1

12.0(5) 09/30/87

White-Yellow: DEC

Pink: Your records

CBR-014

NEBRASKA DEPARTMENT OF ENVIRONMENTAL CONTROL

MINING MONITORING REPORT

FIGURE 12.4-1 (Continued)

Month: ______________ Year: ______

Total volume or water level for reporting period: ______________________________

Quality of injected fluid (Discuss any significant change in constituents or concentrations of the injected fluid):

OPERATING CONDITIONS:

1. Have any operational problems occurred during this reporting period? ______________

2. Has any well maintenance (repairs, workovers, etc.) been performed during this period? ______

3. Has any significant change occurred in any of the monitored parameters which might indicate a leak or other failure of any well? ______________________________

If the answer to any of the above is yes, describe below:

I CERTIFY UNDER PENALTY OF LAW THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION SUBMITTED IN THIS APPLICATION AND ALL ATTACHMENTS AND THAT, BASED ON INQUIRY OF THOSE INDIVIDUALS IMMEDIATELY RESPONSIBLE FOR OBTAINING INFORMATION, I BELIEVE THE INFORMATION IS TRUE, ACCURATE, AND COMPLETE. FURTHER, I CERTIFY AWARENESS THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF A FINE AND IMPRISONMENT.

_______________________________ _______________________________

SIGNATURE/DATE NAME/TITLE (PRINTED)

Pink: Your records

actions, sampling frequency and analysis of excursion status wells shall be performed once every seven (7) days for the excursion indicators. An excursion is considered concluded when the concentrations of excursion indicators are below the concentration levels defining an excursion for three (3) consecutive one (1) week samples.

In the event of an excursion, corrective actions will be taken by FEN. Corrective actions may include:

- Over-recovery of leach solutions,
- Under-injection of leach solutions,
- Modification of the injection-recovery well patterns.

12.4-2 Evaporation Pond Monitoring

Leaks of waste solutions through the pond liners will be monitored by use of an underdrain leak detection system and pond level indicators. The latter will consist of marks at half-foot intervals with which the level of fluid in the ponds can be determined.

Leak detection systems will be installed beneath the liners of each evaporation pond. A french drain situated at the lower end of each pond will culminate in a sump with a vertical standpipe.

Pond Monitoring and Action Procedures. Monitoring of the ponds will be performed daily as a routine operator responsibility and the waste fluid level in each pond will be recorded daily.

The underdrain leak detection system will be monitored daily by checking within the standpipe to ascertain if liquid is present. If the depth of the fluid in the standpipe exceeds six inches, a sample will be taken and analyzed for calcium, chloride, alkalinity, sodium, uranium, sulfate, and conductivity.

If the analyses indicate that the pond is leaking, the USNRC shall be notified by telephone within forty-eight (48) hours of verification and the pond level shall be lowered by transferring the contents into another pond. Water quality samples taken from the standpipe shall be analyzed for chloride and TDS once every seven (7) days during the leak period and once every seven (7) days for at least two (2) weeks following repairs. Additionally, water samples collected from the standpipe will be analyzed for calcium, chloride, alkalinity, sodium, uranium, sulfate, and conductivity at least once during the leak period.

FEN will submit a written report within thirty (30) days to the USNRC notifying the USNRC that a leak exists and describing the mitigative actions and the results of that action.

12.4-3 Wellfield Surface Monitoring

Wellfield piping at the Crow Butte Facility will be buried, pitless adapters or insulated well covers will be used at the wellhead. In the event of a leak, a wet area will generally develop and the operators will inspect the wellfield area daily to check for any wet surface areas. The buried trunk lines will have a recording low pressure alarm system which will sound if line pressures drop below the normal operating pressures.

If there is an indication of a leak or rupture, immediate action will be taken to (1) stop liquid flow, (2) contain any liquids, and (3) repair the damaged equipment in a manner to preclude future occurrences.

FEN will then notify the USNRC by telephone within forty-eight (48) hours and a written report detailing the failure conditions, corrective actions and results achieved will be submitted with seven (7) days.

SECTION 13.0

CORRECTIVE ACTIONS

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13.0 CORRECTIVE ACTIONS

Table 13.0-1 lists the wells currently known to be completed in the Chadron Formation within the area of review for the Crow Butte Project. This list does not include the wells installed by WFC/FEN as injection, recovery, monitoring or test wells. These wells with the exception of the wells in the town of Crawford, are shown in Figure 13.0-1. None of these wells other than WFC/FEN installed wells are located within the proposed Area Permit. Should any inadequately completed or abandoned wells, within the Area Permit, completed in the injection zone be identified, the following corrective action will be taken by FEN. For wells which are not adequately completed or abandoned, FEN will, using a drill rig, go back in and reopen the hole and then perform the plugging procedure specified in Section 11.0 of this application.

The closest well to the Area Permit Boundary is Well #55 and it is located approximately 2200 feet from the Area Permit Boundary. Based on the Water Users Survey in the Area of Review, it was determined that this well is not currently in use.

FEN will have two safeguards to prevent movement of lixiviant into the vicinity of this well or any other well completed in the Chadron Formation. These safeguards are:

1. Overrecovery of lixiviant from a wellfield. During normal operations, FEN will recover 0.5% to 1.0% more solution than is injected. This will result in a hydrologic depression in the vicinity of the wellfield and the groundwater flow will tend to be into the wellfield.

TABLE 13.0-1

PRIVATE WELLS IN THE AREA OF REVIEW
COMPLETED IN THE INJECTION ZONE

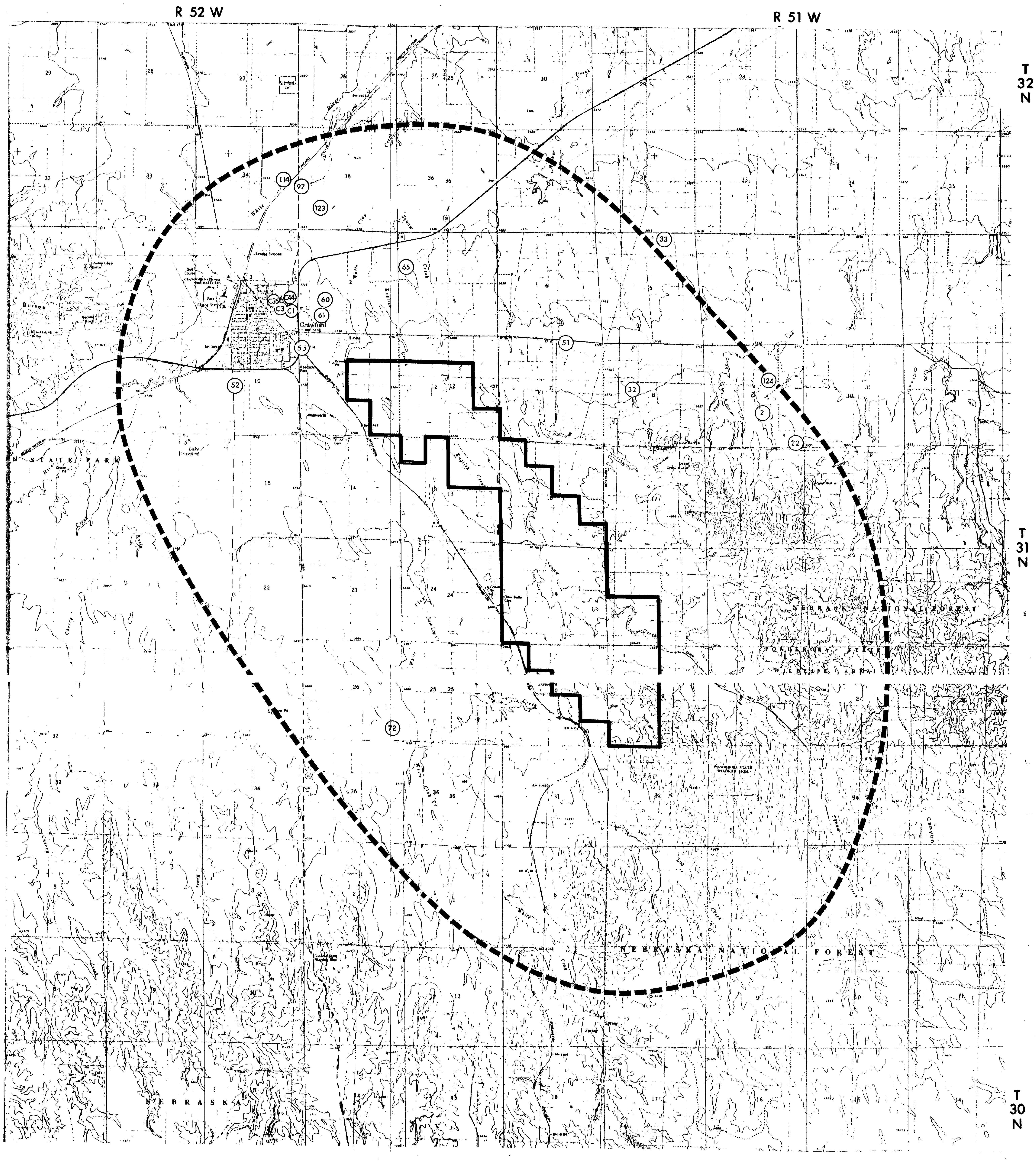
Well No.	Owner	Date Drilled	Depth (ft)	Screen or Open Interval	Usage*
2	E.A. Faney	1966	650	590 - 650	D, L
22	R. Hageman	1960	400	300 - 400	D, L
32	H. Bunch	1947	400	-----	D, L
33	J. Bunch	1979	212	-----	L
51	G. Moore	1979	300	-----	L
52	L. Bauersachs	1956	420	-----	L
55	K. Welling	----	320	-----	N
60	F. Anders	1962	312	-----	N
61	F. Anders	1980	280	-----	D,L,C
65	R. McDowell	1980	260	240 - 260	L
72	S. Pedrick	----	450	-----	N
97	G. Fisher	1976	380	-----	L
114	V. Norgard	1970	470	50 - 470	D, L
123	G. Moore	1979	280	-----	L
124	M. Franey	1984	520	500 - 520	L

WELLS WITHIN THE TOWN OF CRAWFORD IN THE AREA OF REVIEW
COMPLETED IN THE INJECTION ZONE

C- 1	Chubb	1972	280	-----	C
C- 3	Courtain	1964	280	-----	I
C-35	Johnson	1980	285	-----	I, L
C-44	Mansfield	1965	400	-----	N

* D = Domestic, L = Livestock, I = Irrigation,
C = Commercial, N = Seldom Used

----- Indicates information not available.



(97) WATER WELL

PERMIT AREA

AREA OF REVIEW

0 1/4 1/2 1 2 MILES

REV. DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	WELLS IN THE AREA OF REVIEW COMPLETED IN THE INJECTION ZONE	
	PREPARED BY: F.E.N.	
	DWN. BY: J.C. DATE: 8/87	FIGURE: 13.0-1

2. In the event that the overrecovery is not effective or controlled properly, FEN will have a series of monitoring wells located around the perimeter of the wellfield. These wells will be sampled at a frequency specified by the NDEC/NRC and FEN is committed to take corrective action if any indicator species exceeds the upper control limit specified by the NDEC/NRC.

The corrective action taken may include:

- o Increasing the overrecovery rate,
- o Reordering the wellfield,
- o Cease injection of lixiviant or whatever action is necessary to recall the lixiviant.

SECTION 14.0

CERTIFICATION

14.0 CERTIFICATION

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

Stephen P. Collings
Printed Name of Person Signing

Vice President
Title

November 9, 1987
Date Application Signed

Original signed by Stephen P. Collings
Signature of Applicant