04008943/100

40-8943

Ferret
Exploration
Company of
Nebraska, Inc.

Suite 400
1800 Glenarm Place
Denver, Colorado 80202

Telephone (303) 295-0238
Telecopy (303) 292-6461

RETURN ORIGINAL TO PDR, HQ.

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March 28, 1988

Mr. Scott Grace
U.S. Nuclear Regulatory Commission
Box 25325
Denver, Colorado 80225

Dear Mr. Grace:

Enclosed please find corrected replacement pages for the Application and Supporting Environmental Report for USNRC Commercial Source Material License. Please replace the original pages with the corrected pages. These changes were made as a result of the NDEC completeness Review.

If you have any questions regarding these replacement pages, please do not hesitate to contact me.

Sincerely,

Stephen P. Collings

Stephen P. Collings
Vice President

8804280469 880328
PDR ADOCK 04008943
C PDR

FEE NOT REQUIRED
Addl Info
88-0657

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

2/29/88

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.

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.

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.

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.

NEBRASKA DEPARTMENT OF ENVIRONMENTAL CONTROL

Application Number

Year	Mo.	Day

FOR OFFICE USE ONLY

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

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)

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.

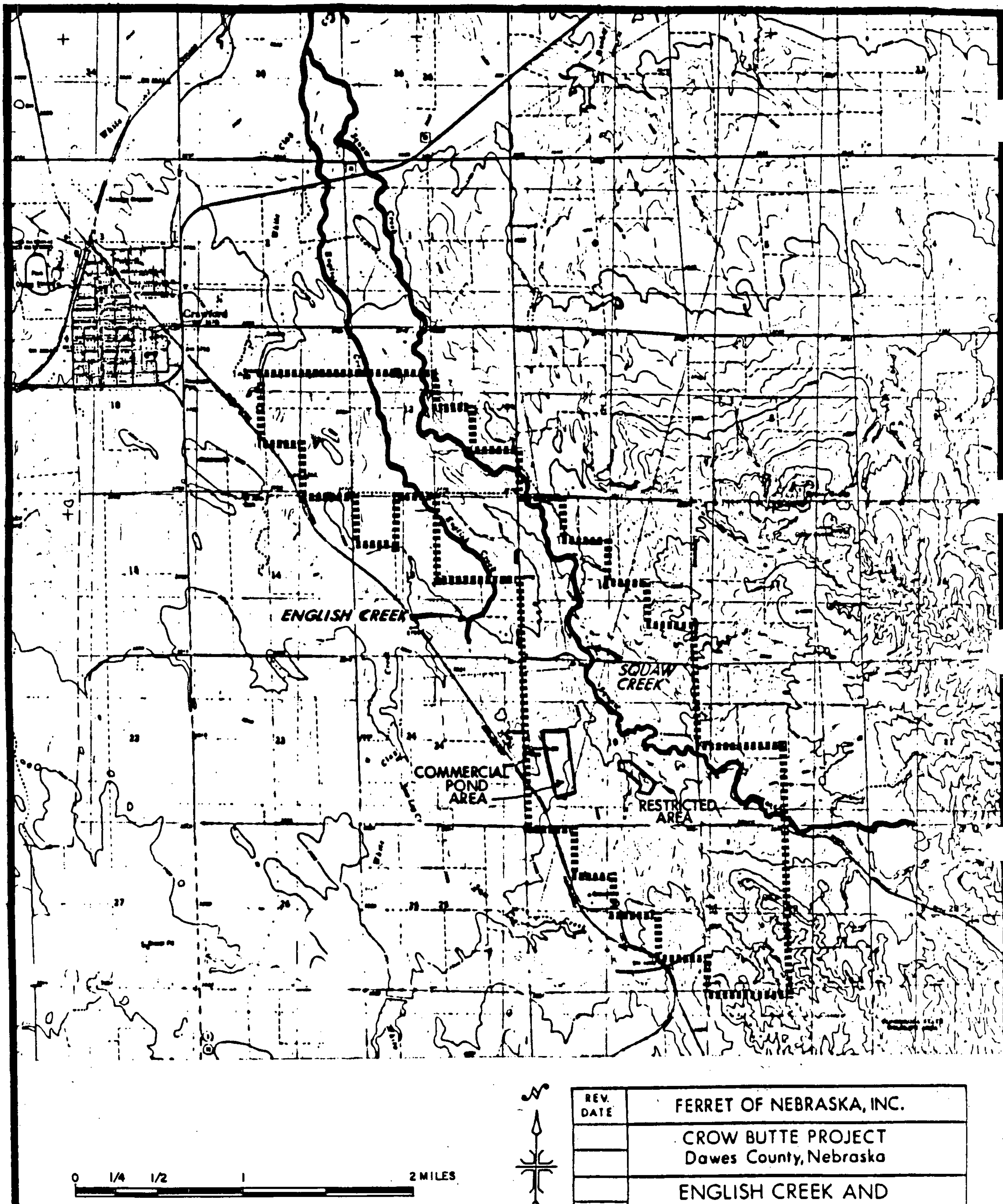
TABLE 4.4-1

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.



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

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 $7.8x10^{-7}$ ft/day ($2.8x10^{-10}$ cm/sec), and that of the underlying confining layer is about $9.6x10^{-8}$ ft./day ($3.4x10^{-11}$ 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.

<u>Movement of Groundwater:</u>

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 $4X10^{-4}$ 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 $0.16ft^3$/day per unit width of the aquifer.

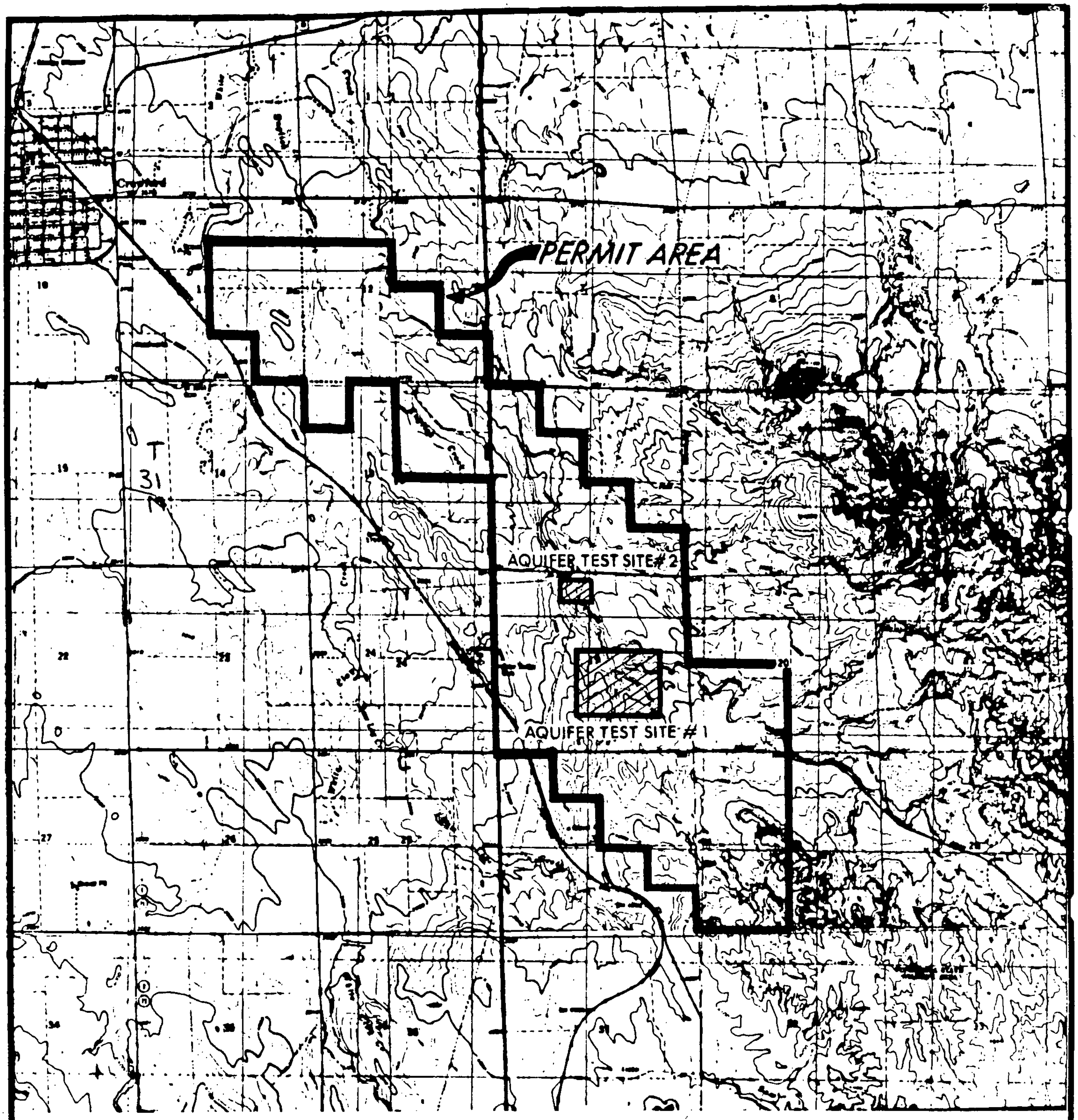
The details of the first aquifer test, including a description of the test, test data, as well as analysis and intepretation of the data are presented in Appendix 4.4(B).

Second Aquifer Test:

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 hydrogeo-geologic 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).

Site Hydrostratigraphy:

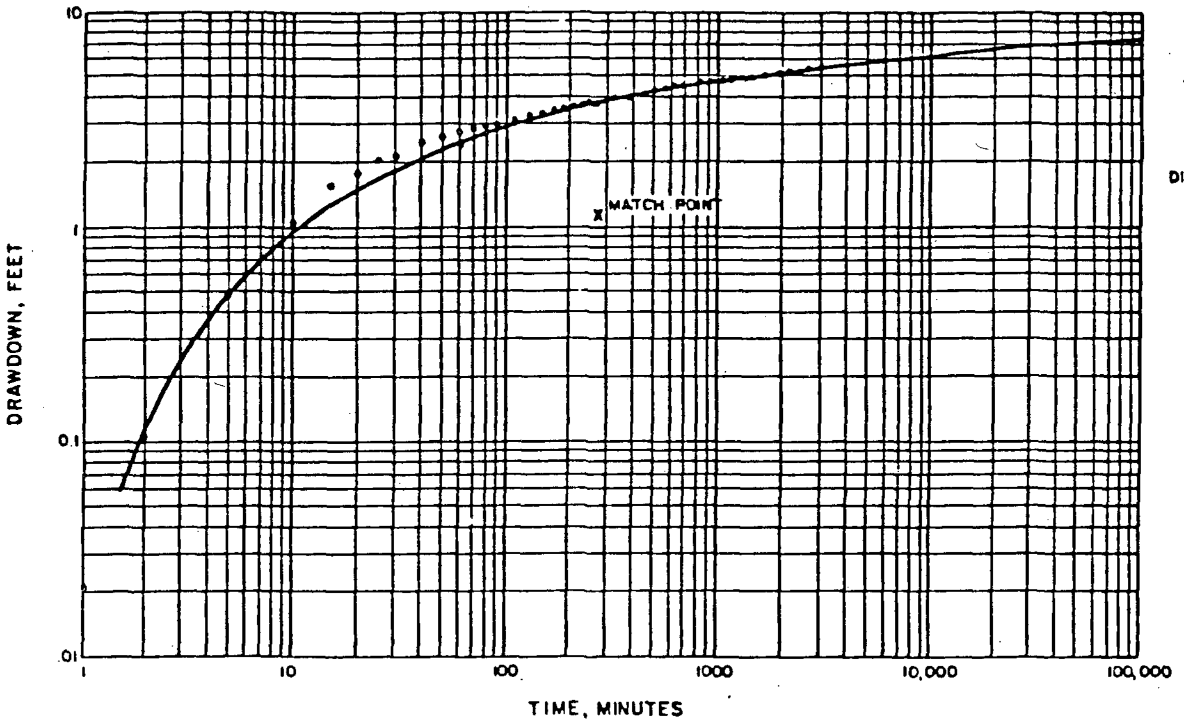
The uranium-bearing aquifer is formed by a coarse-grained arkosic sandstone which is locally known as the Basal Sandstone Member of the Chadron Formation. The Basal Sandstone is believed to be the depositional product of a large, vigorous, braided-stream system which occurred during the early Oligocene 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.



0 1/4 1/2 1 2 MILES

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

4.4(16) 09/30/87



$\beta = 0.05$

$H(u, \beta) = 1.0$

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

$s = 1.2$ ft

$t = 275$ min

DISTANCE FROM THE PUMPING WELL:

$r = 93.69$ ft

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

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

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

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

FIGURE 4.4B-7

AQUIFER ANALYSIS BY
MODIFIED HANTUSH METHOD
OBSERVATION WELL PT-8

PREPARED FOR

WYOMING FUEL COMPANY.
LAKEWOOD, COLORADO

D'APPOLONIA

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 $9.9x10^{-5}$ to $2.7x10^{-4}$ (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).

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 4.4-4

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	$6.65x10^{-5}$	$2.75x10^{-2}$	$4.46x10^{-7}$	$2.22x10^{-11}$
UCP-1	550.6	red clay	.328	$1.13x10^{-4}$	$2.69x10^{-2}$	$4.37x10^{-7}$	$3.78x10^{-11}$
UCP-1	555.6	red clay	.284	$1.78x10^{-4}$	$1.94x10^{-2}$	$3.15x10^{-7}$	$4.46x10^{-11}$
UCP-1	Average		.318	$1.19x10^{-4}$	$2.46x10^{-2}$	$3.99x10^{-7}$	$3.49x10^{-11}$
LCP-1	617.0	shale	.317	$1.04x10^{-4}$	$2.28x10^{-2}$	$3.70x10^{-7}$	$2.89x10^{-11}$
LCP-1	621.8	shale	.333	$9.10x10^{-5}$	$4.04x10^{-2}$	$6.56x10^{-7}$	$4.36x10^{-11}$
LCP-1	Average		.325	$9.70x10^{-5}$	$3.16x10^{-2}$	$5.13x10^{-7}$	$3.63x10^{-11}$

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

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 3.99×10^{-7} cm^2/g and the calculated average vertical hydraulic conductivity is 3.49×10^{-11} cm/sec. Using these consolidation test data, the calculated specific storage of the red clay portion of the overlying confining layer is 3.08×10^{-7} cm^{-1} and the calculated hydraulic diffusivity is 1.13×10^{-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 confinining 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 ($cm^2 g/$)	3.99×10^{-7}	5.13×10^{-7}
Specific storage, S_s', (cm^{-1})	3.08×10^{-7}	2.78×10^{-7}
Diffusivity, α', (cm^2/sec)	1.13×10^{-4}	5.22×10^{-3}
Vertical hydraulic conductivity, K_v', (cm/sec)		
Lab Data	3.49×10^{-11}	3.63×10^{-11}
Field Data	-----	1.45×10^{-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.

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

	Sample Collection				Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	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

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			USEPA Stds.[d] for Drinking Water
		Drinking	Irrigation	Livestock	
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 4.4-18

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.

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

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

SUBSECTION 4.5

GEOLOGY AND SEISMOLOGY

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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.

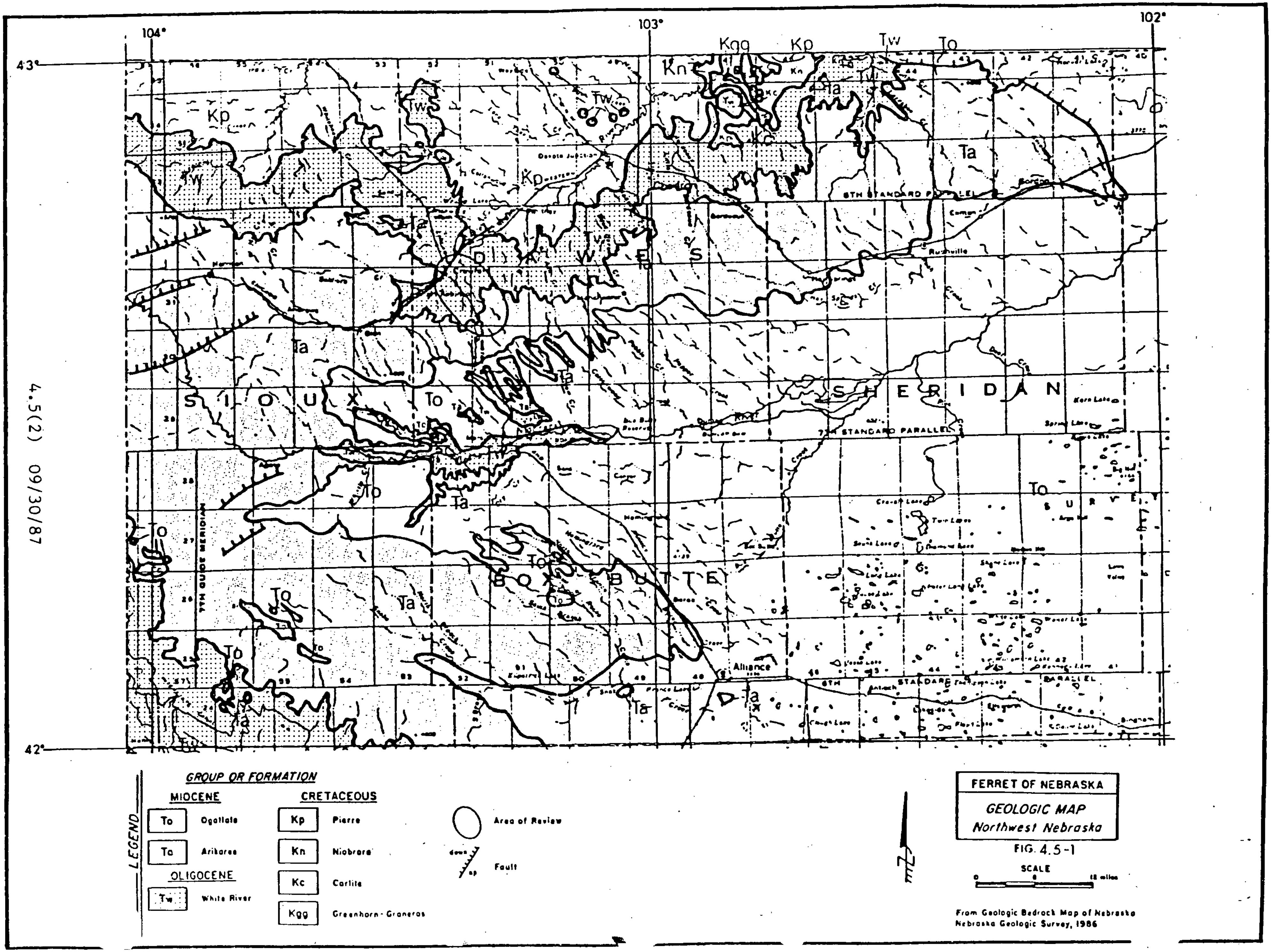
General Stratigraphy

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

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
Pennyslvan-ian	Virgil	Shawnee	Ls	80
	Missouri	Kansas City	Ls, Sh	80
	Des Moines	Marmaton/ Cherokee	Ls, Sh	130
	Atoka	Upper/Lower	Ls, Sh	200
Mississip-pian	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 Basal Member 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 Faults, Pine Ridge Fault, and Toadstool Park Faults 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

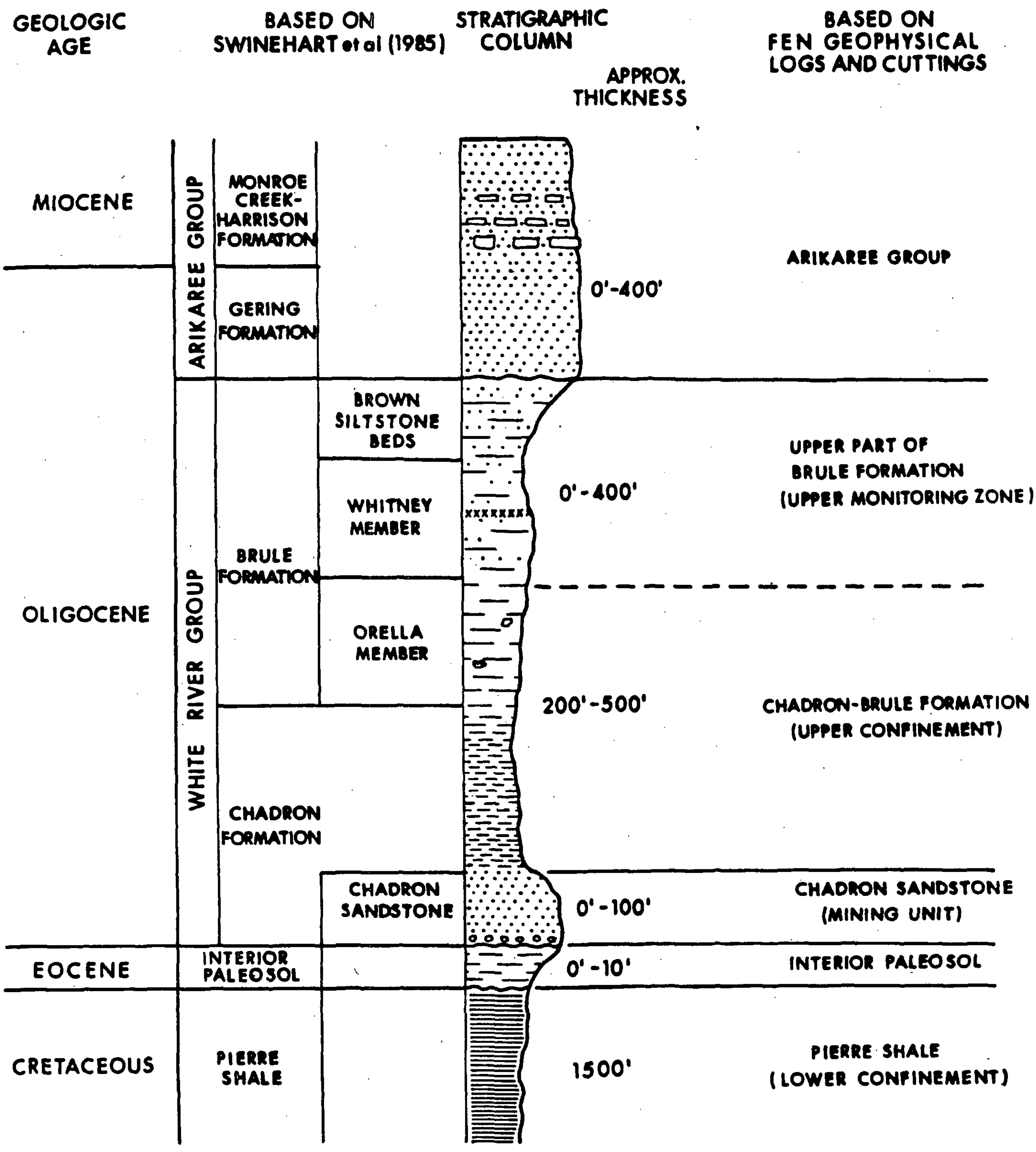
Introduction

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.

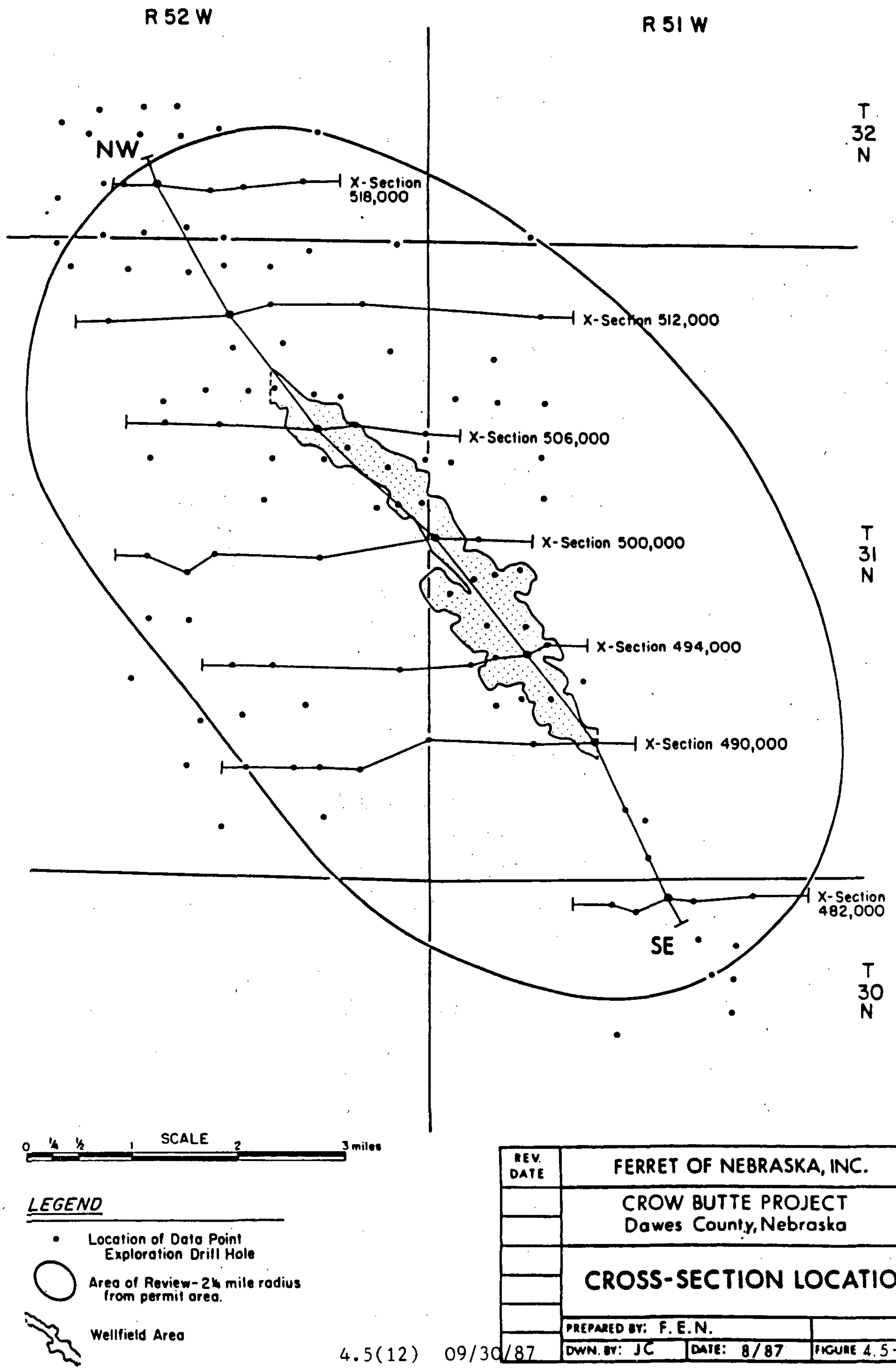
A series of seven east-west cross sections have been constructed through the proposed wellfield area and the Area of Review to demonstrate the geology of the Chadron Sandstone and its relationship to the confining horizons (Figures 4.5-3 to 4.5-10). One northwest-southeast cross section is included to 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

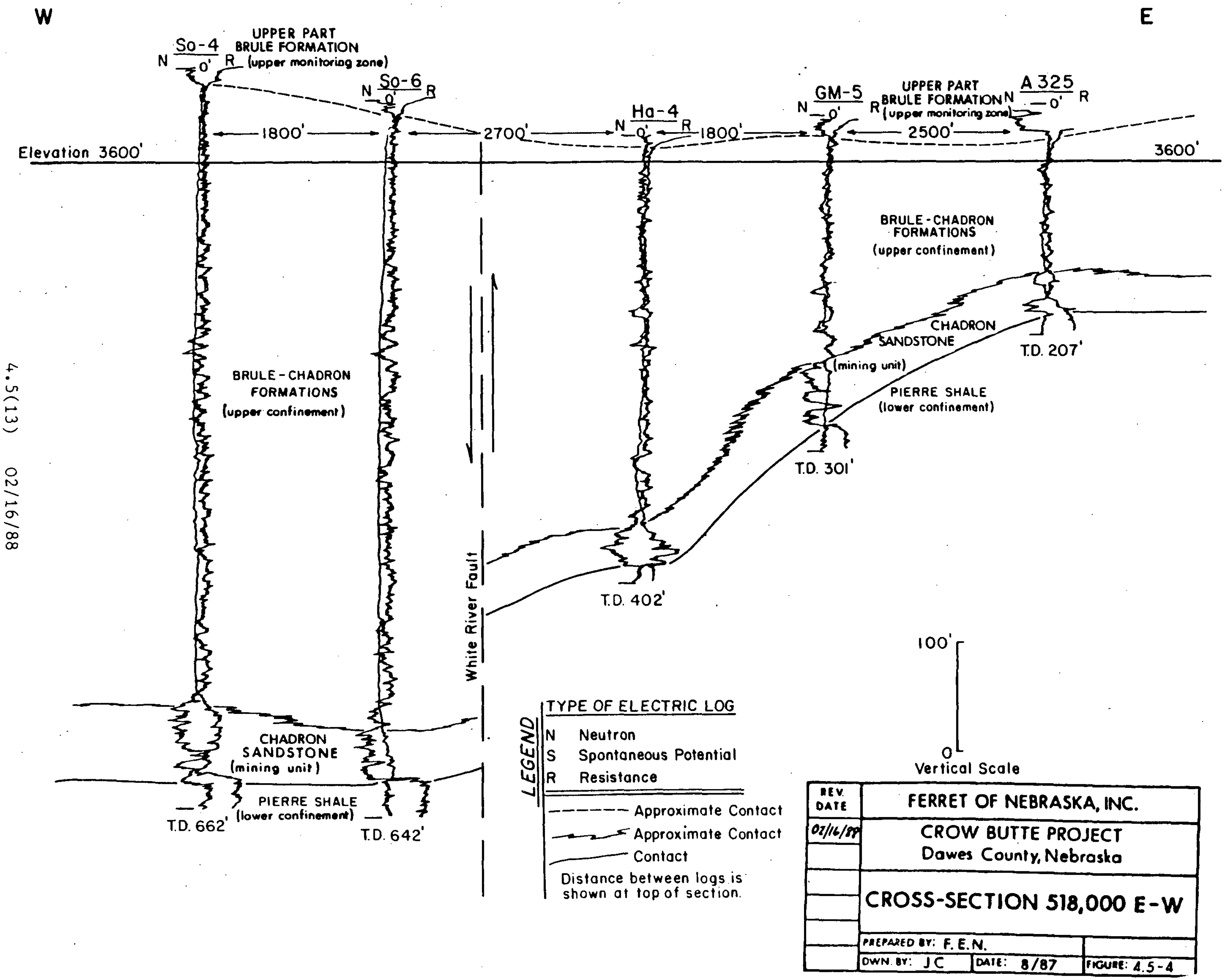


REV. DATE	
	FERRET OF NEBRASKA, INC.
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska
	AREA OF REVIEW STRATIGRAPHIC COLUMN
	PREPARED BY: F.E.N.
	DWN. BY: JC — DATE: 2/88 — FIGURE: 4.5-2



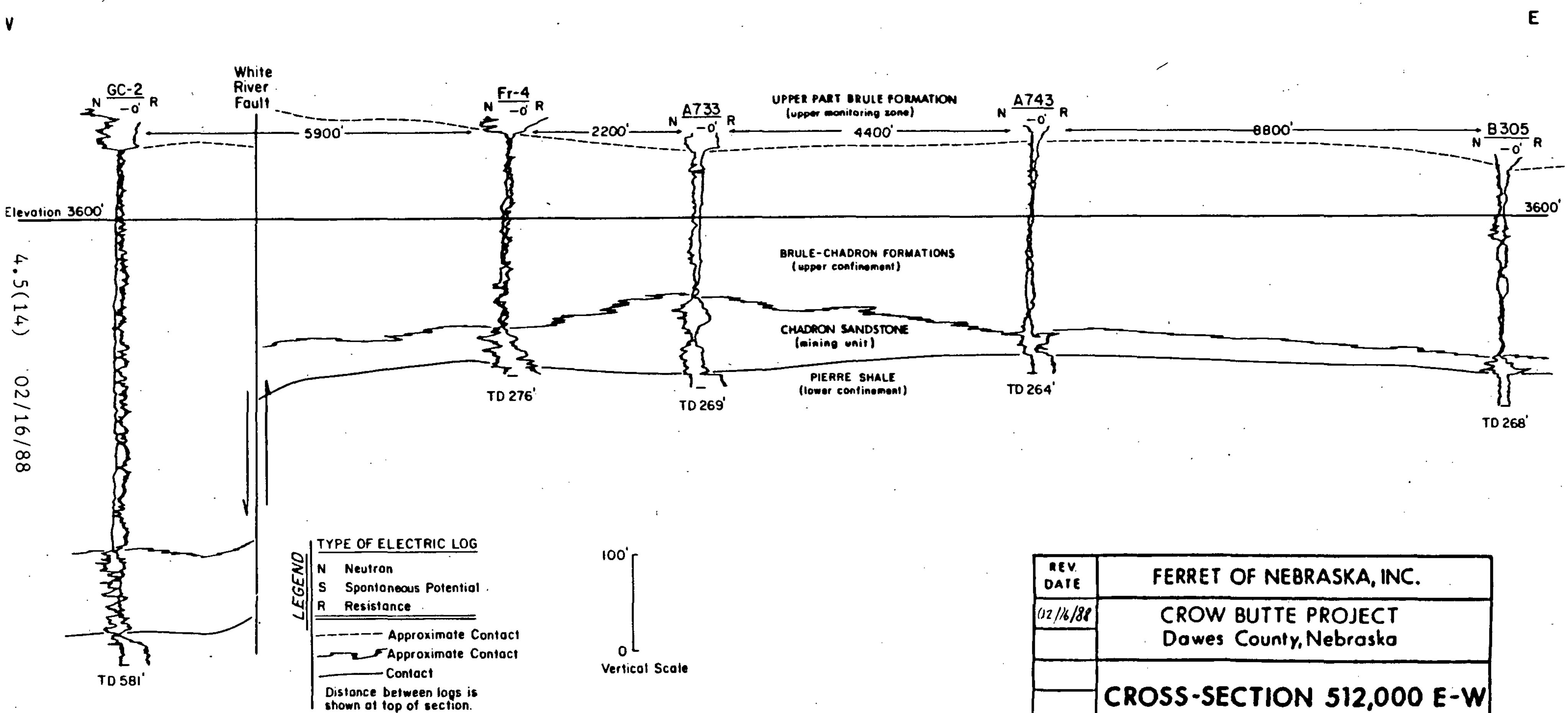
REV. DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	CROSS-SECTION LOCATION	
	PREPARED BY: F.E.N.	
	DWN. BY: JC DATE: 8/87	FIGURE 4.5-3

4.5(13) 02/16/88



W
E
So-4
So-6
Ha-4
GM-5
A 325
N
R
0'
UPPER PART
BRULE FORMATION
(upper monitoring zone)
1800'
2700'
1800'
2500'
Elevation 3600'
3600'
BRULE - CHADRON
FORMATIONS
(upper confinement)
BRULE - CHADRON
FORMATIONS
(upper confinement)
CHADRON
SANDSTONE
(mining unit)
PIERRE SHALE
(lower confinement)
CHADRON
SANDSTONE
(mining unit)
PIERRE SHALE
(lower confinement)
White River Fault
T.D. 662'
T.D. 642'
T.D. 402'
T.D. 301'
T.D. 207'
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
02/16/88
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

4.5(14) 02/16/88



REV. DATE	FERRET OF NEBRASKA, INC.	
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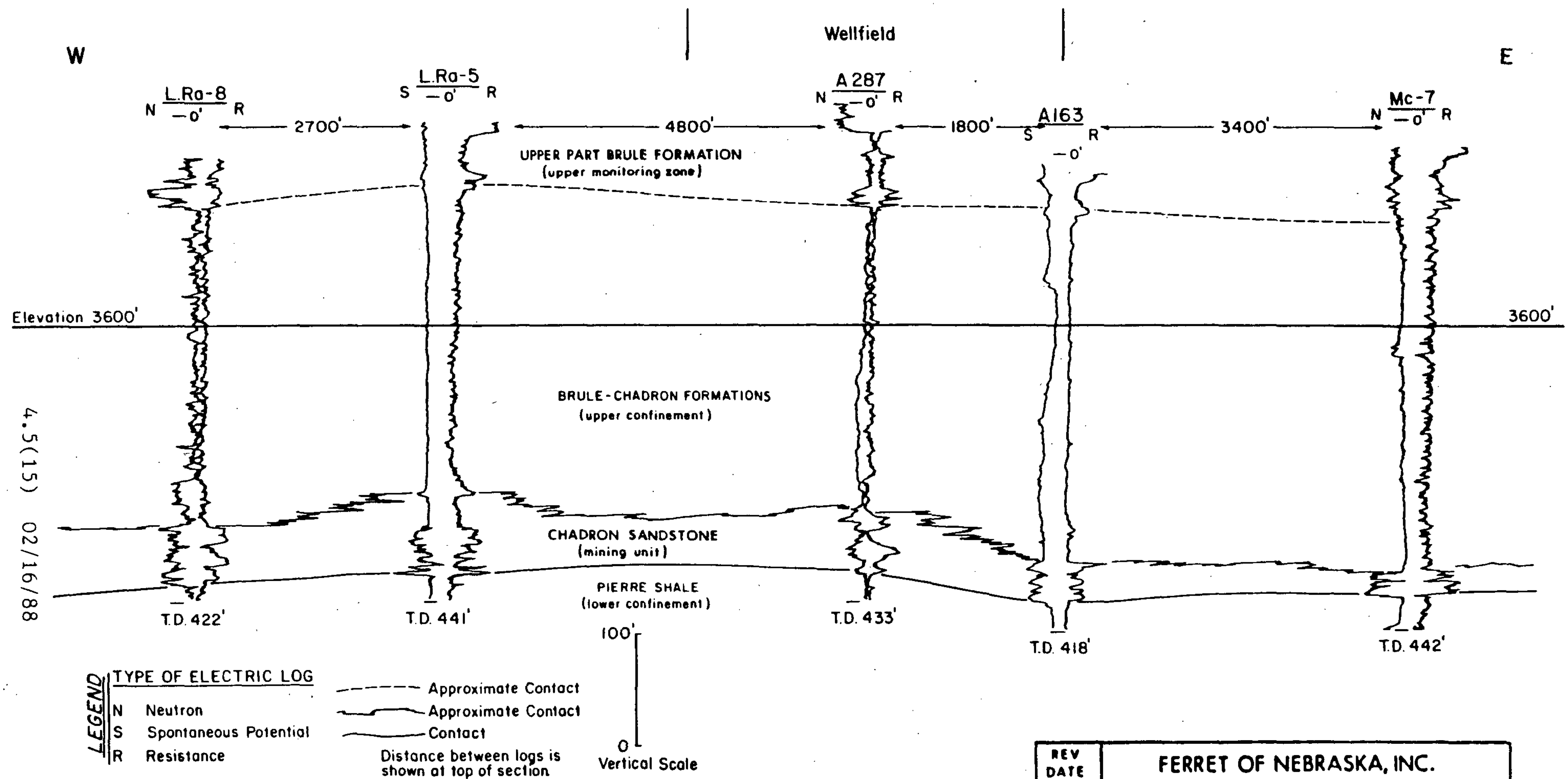
	PREPARED BY: F.E.N.	
	DWN. BY: JC	DATE: 8/87 — FIGURE: 4.5-5



4.5(15) 02/16/88

REV DATE	FERRET OF NEBRASKA, INC.		
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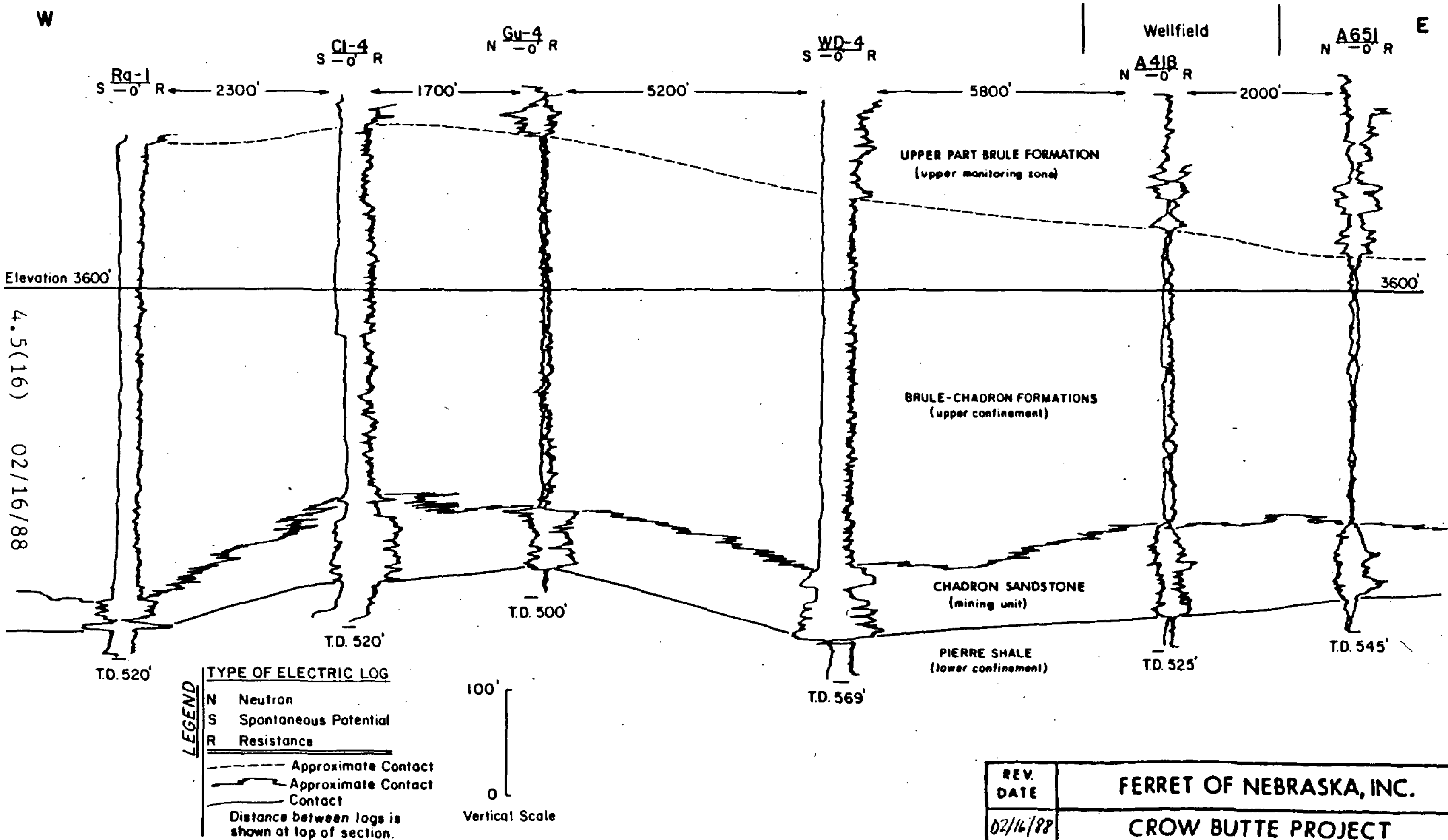
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/87	FIGURE: 4.5-6

4.5(16) 02/16/88



REV. DATE	FERRET OF NEBRASKA, INC.	
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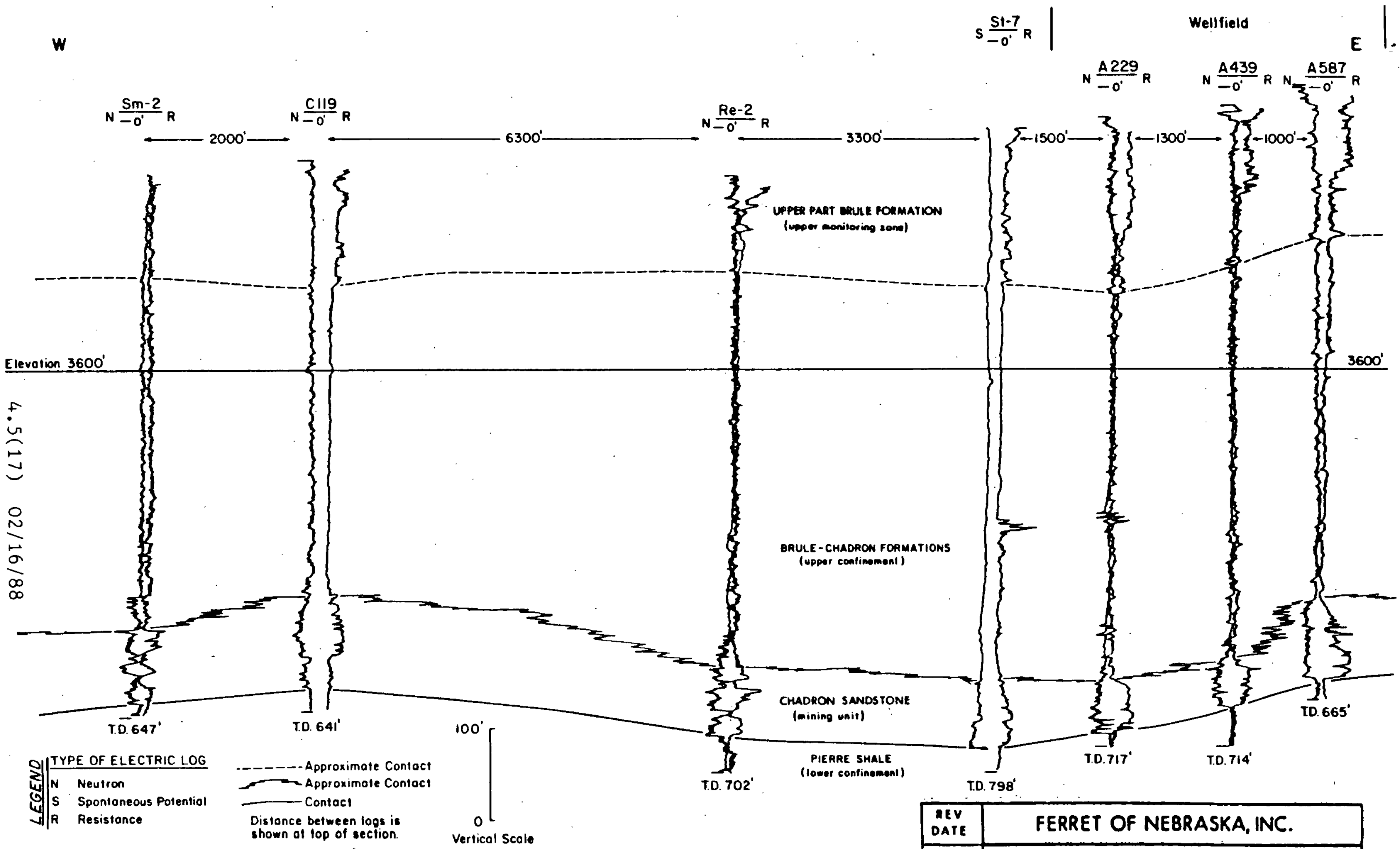
	CROSS-SECTION 500,000 E-W	
	PREPARED BY: F.E.N.	
	DWN. BY: JC	DATE: 8/87	FIGURE: 4.5-7

4.5(17) 02/16/88



REV DATE	FERRET OF NEBRASKA, INC.		
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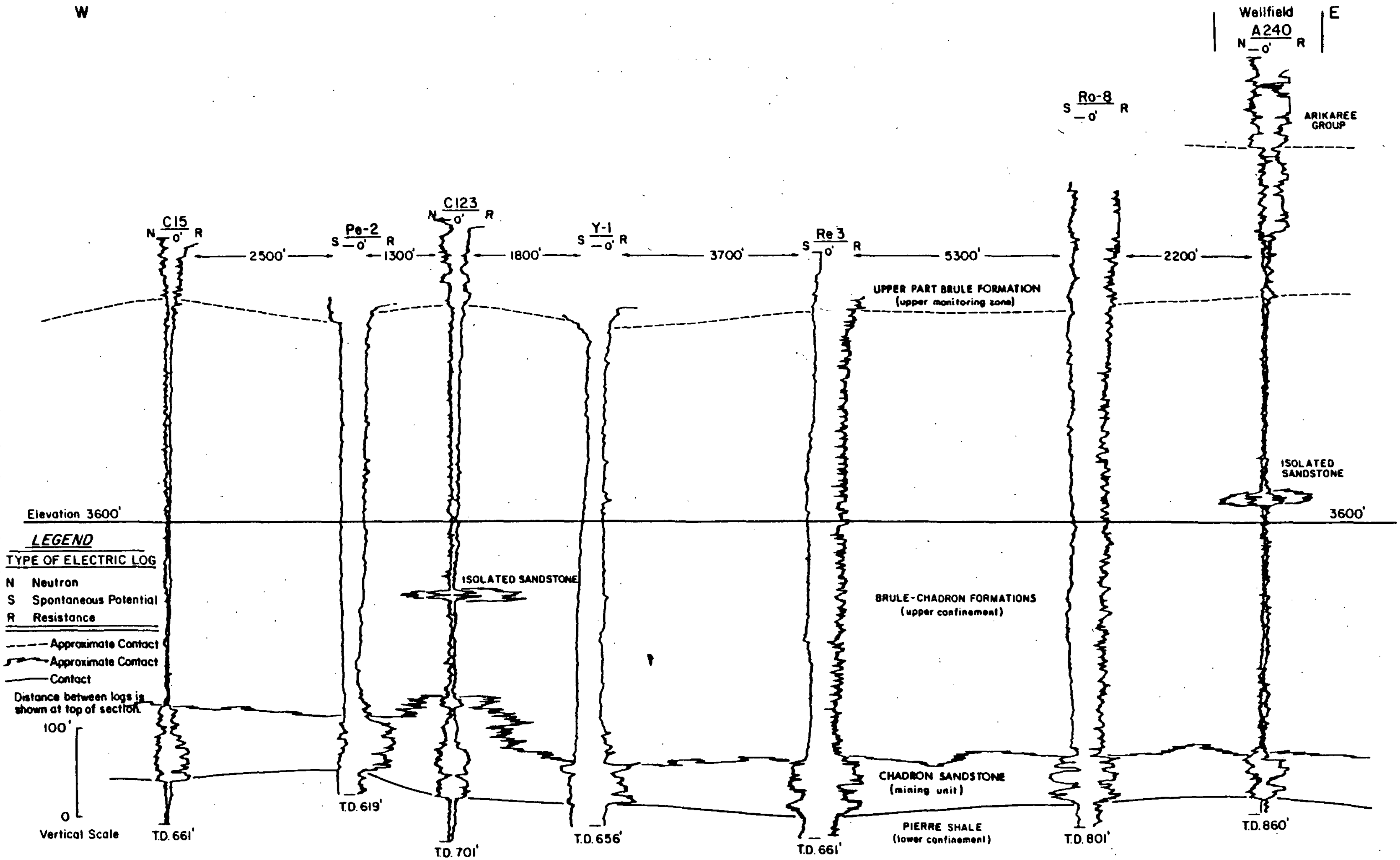
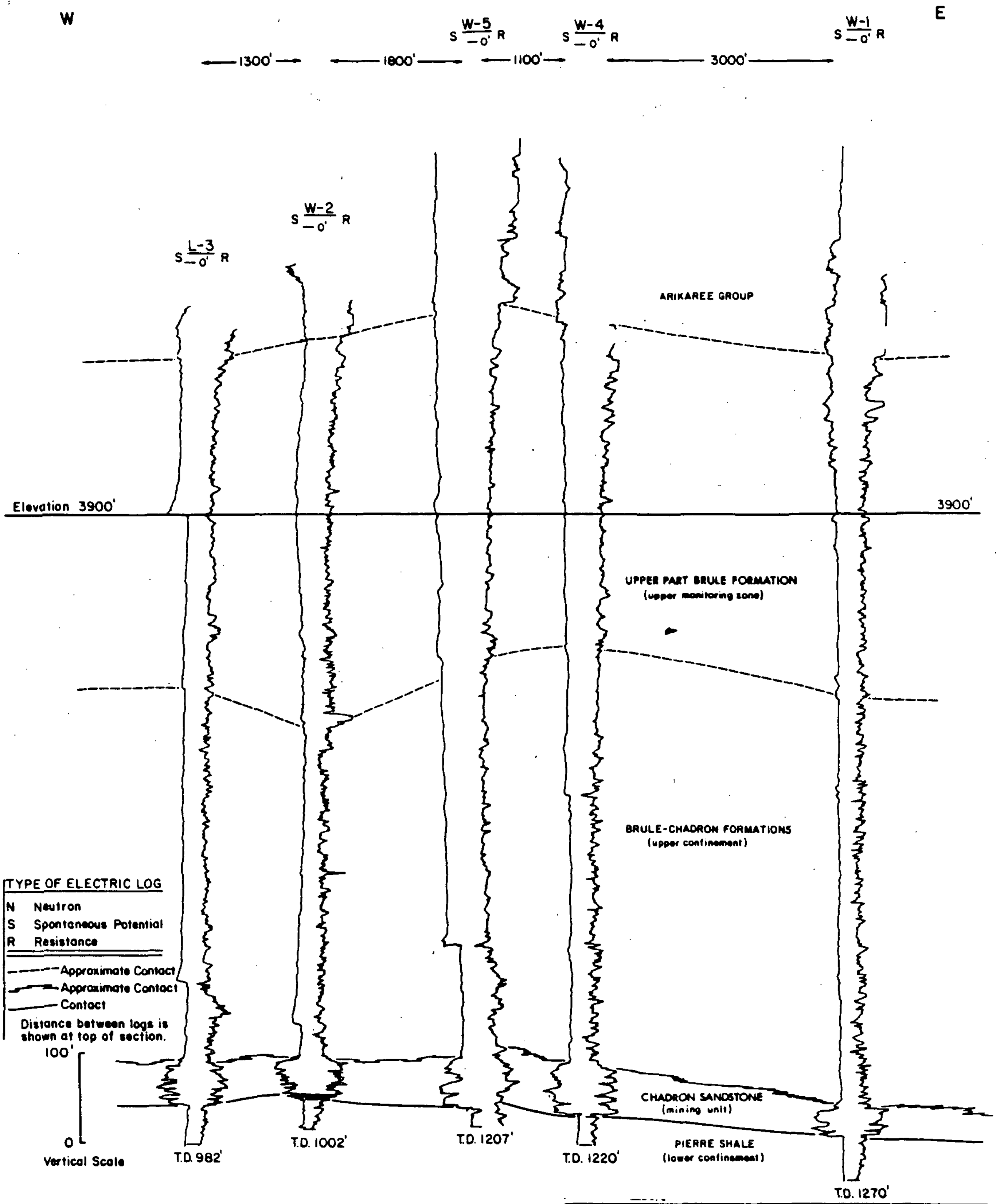
	CROSS-SECTION 494,000 E-W		
	PREPARED BY: F.E.N.		
	DWN. BY: JC	DATE: 8/87	FIGURE: 4.5-8

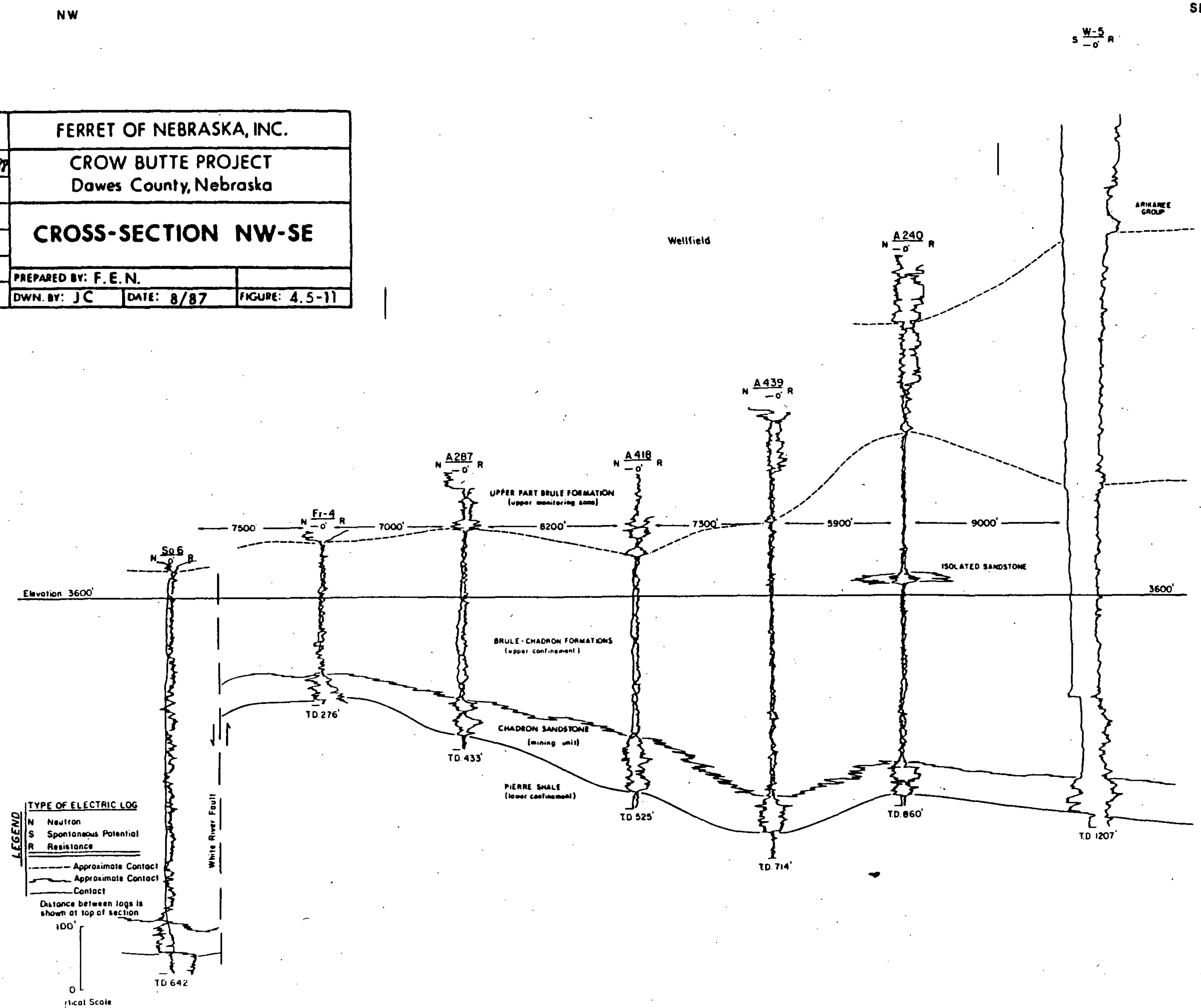


REV. DATE	FERRET OF NEBRASKA, INC.
02/16/88	CROW BUTTE PROJECT Dawes County, Nebraska
	CROSS-SECTION 490,000 E-W
	PREPARED BY: F.E.N.
	DWN. BY: JC · DATE: 8/87 · FIGURE: 4



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



4.5(20) 02/16/88

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.

Chadron Sandstone - Mining Unit

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).

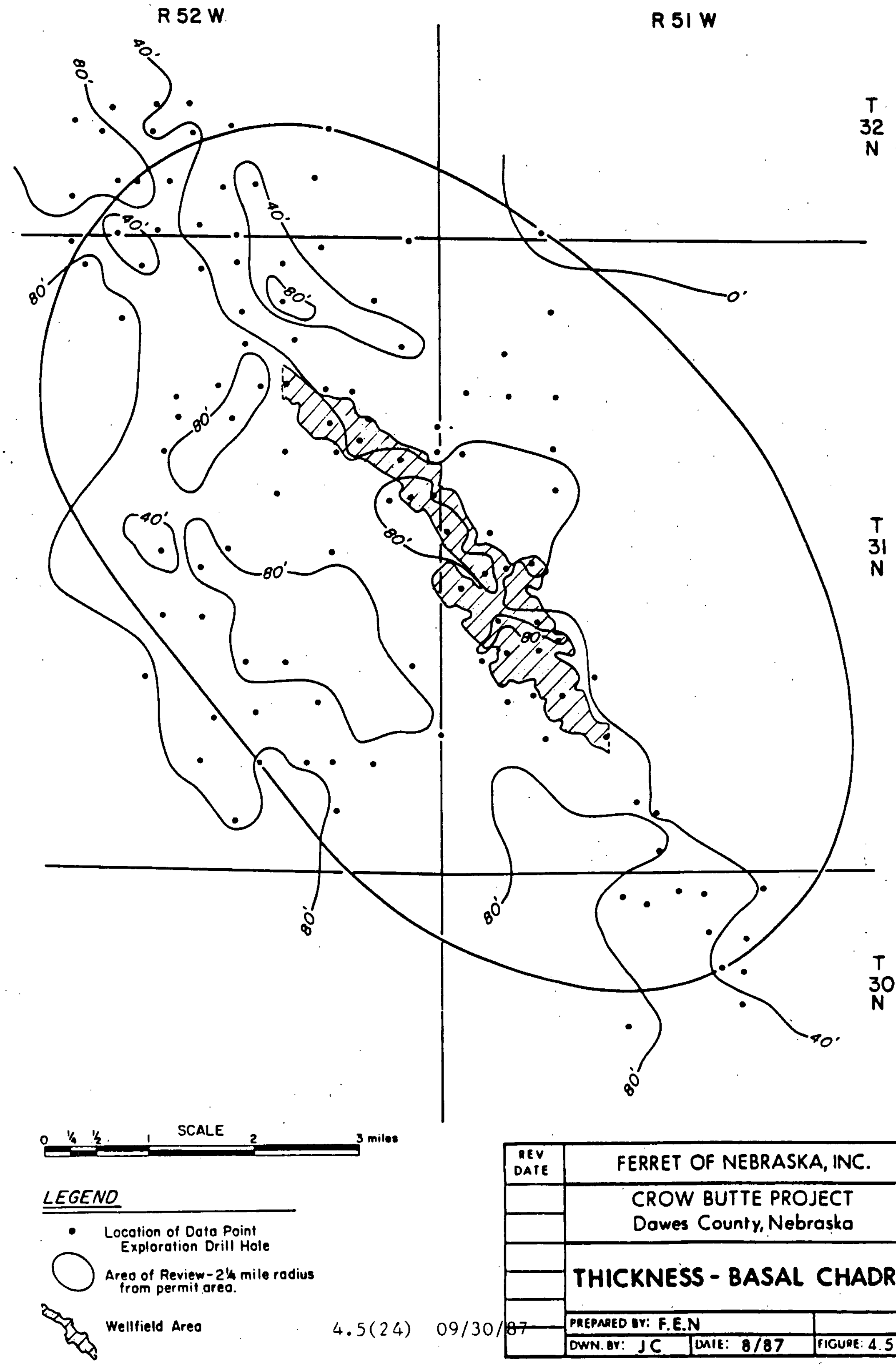
A persistent clay horizon typically brick red in color generally marks the upper limit of the Chadron Sandstone. Occasionally a younger sandstone immediately overlies the red clay and is well enough developed to be included in the Chadron Sandstone unit. This upper sandstone is similar in appearance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

Chadron-Brule Formations, Upper Confinement

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



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: JC	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

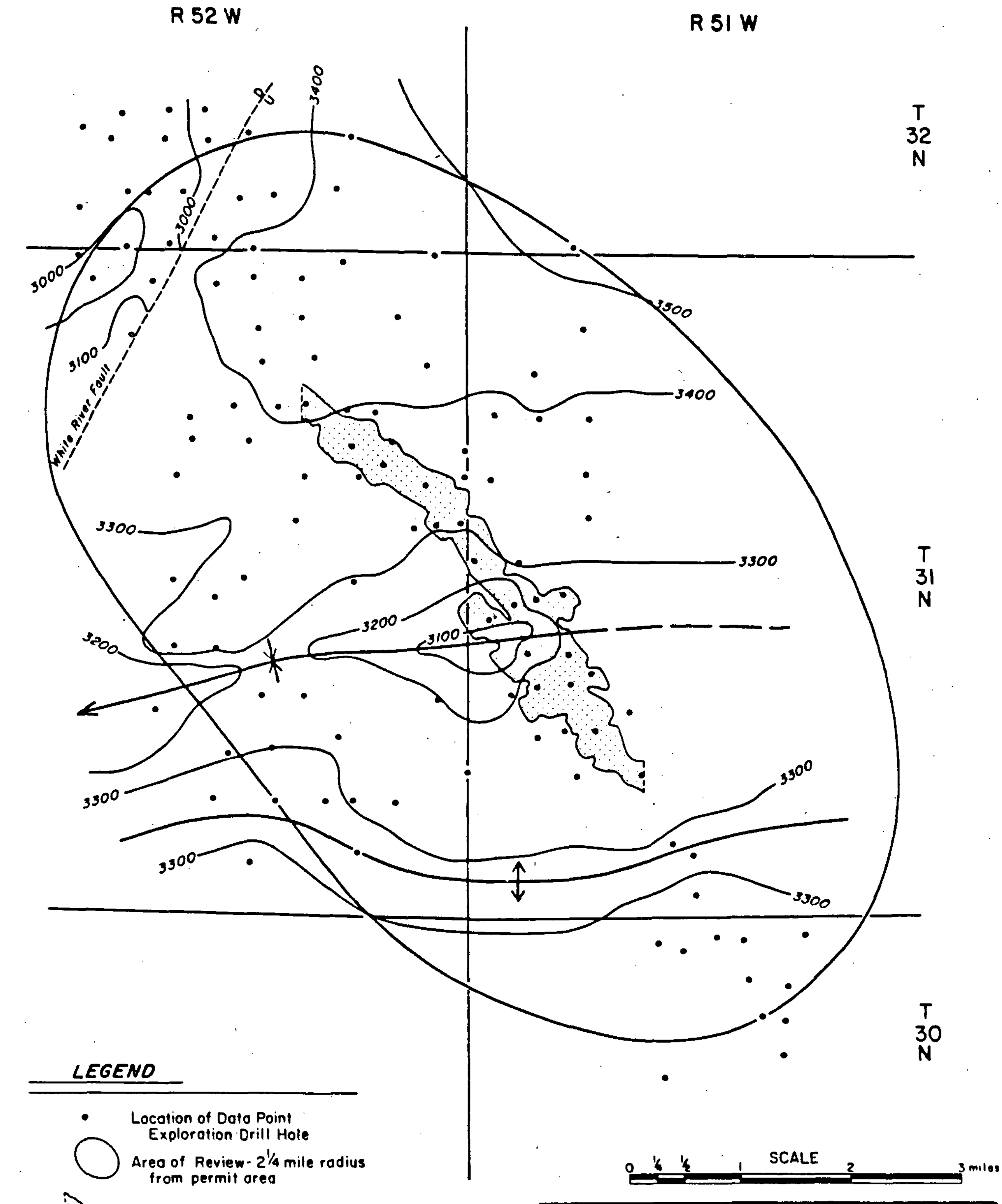
The upper part of the Brule Formation is primarily buff to brown siltstones which have a larger grain size than the lower part of the Brule Formation. Occasional sandstone units are encountered in the upper part of the Brule Formation. The small sand units have limited lateral continuity and, although 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, illustrates 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, Univirsity 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.



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.

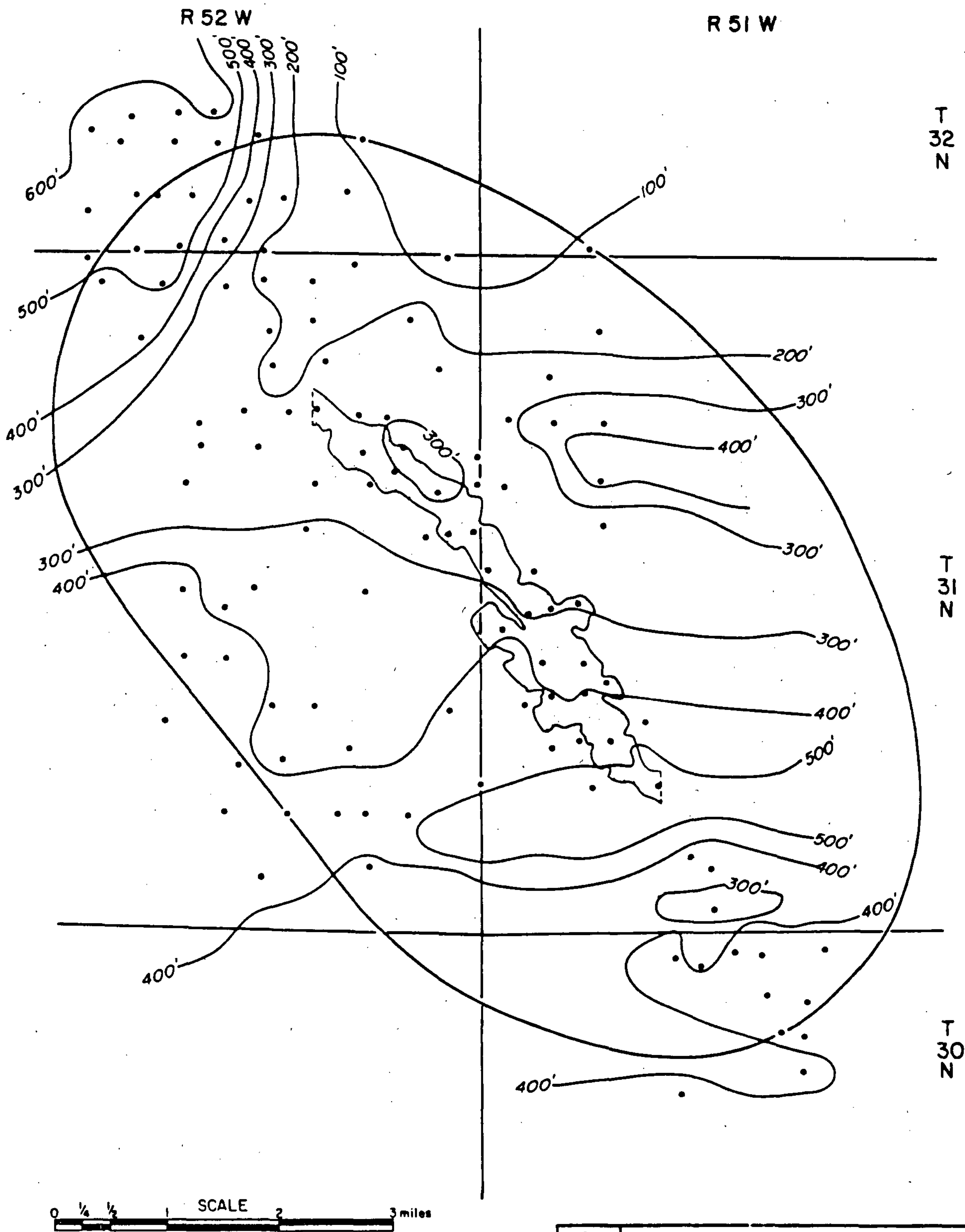
4.5.3 SEISMOLOGY

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

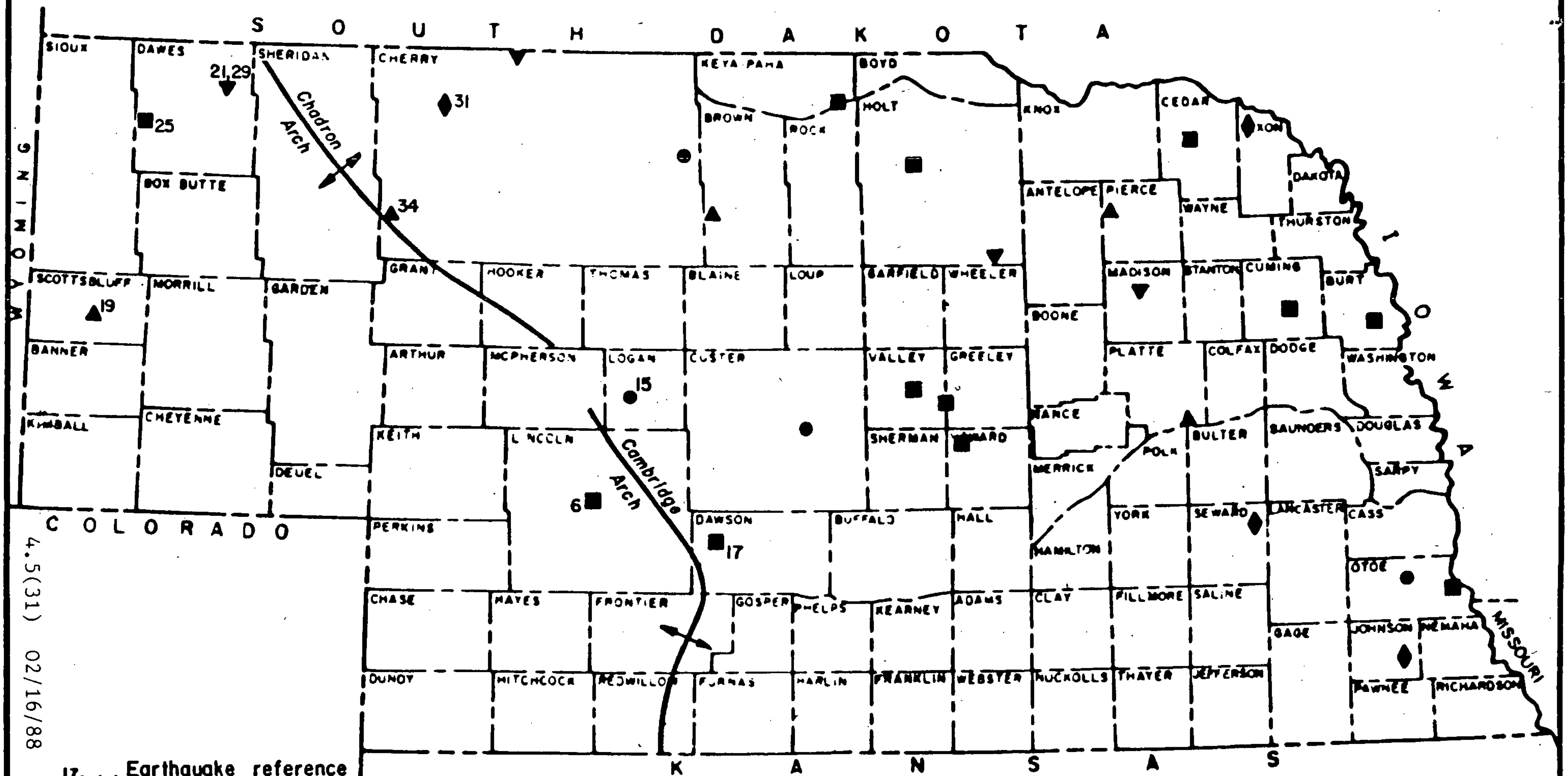
• Location of Data Point Exploration Drill Hole

Area of Review - 2¼ 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

0 10 20 30 40 50 MILES

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	
02/16/88	FERRET OF NEBRASKA, INC.
	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

4.5(31) 02/16/88

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.

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<u>OIL AND GAS LOGS IN THE AREA OF REVIEW</u>

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 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.

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.

<u>Roads</u>. 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.

<u>Jobs</u>. 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.

<u>Housing</u>. 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.

<u>Schools</u>. 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

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.

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.

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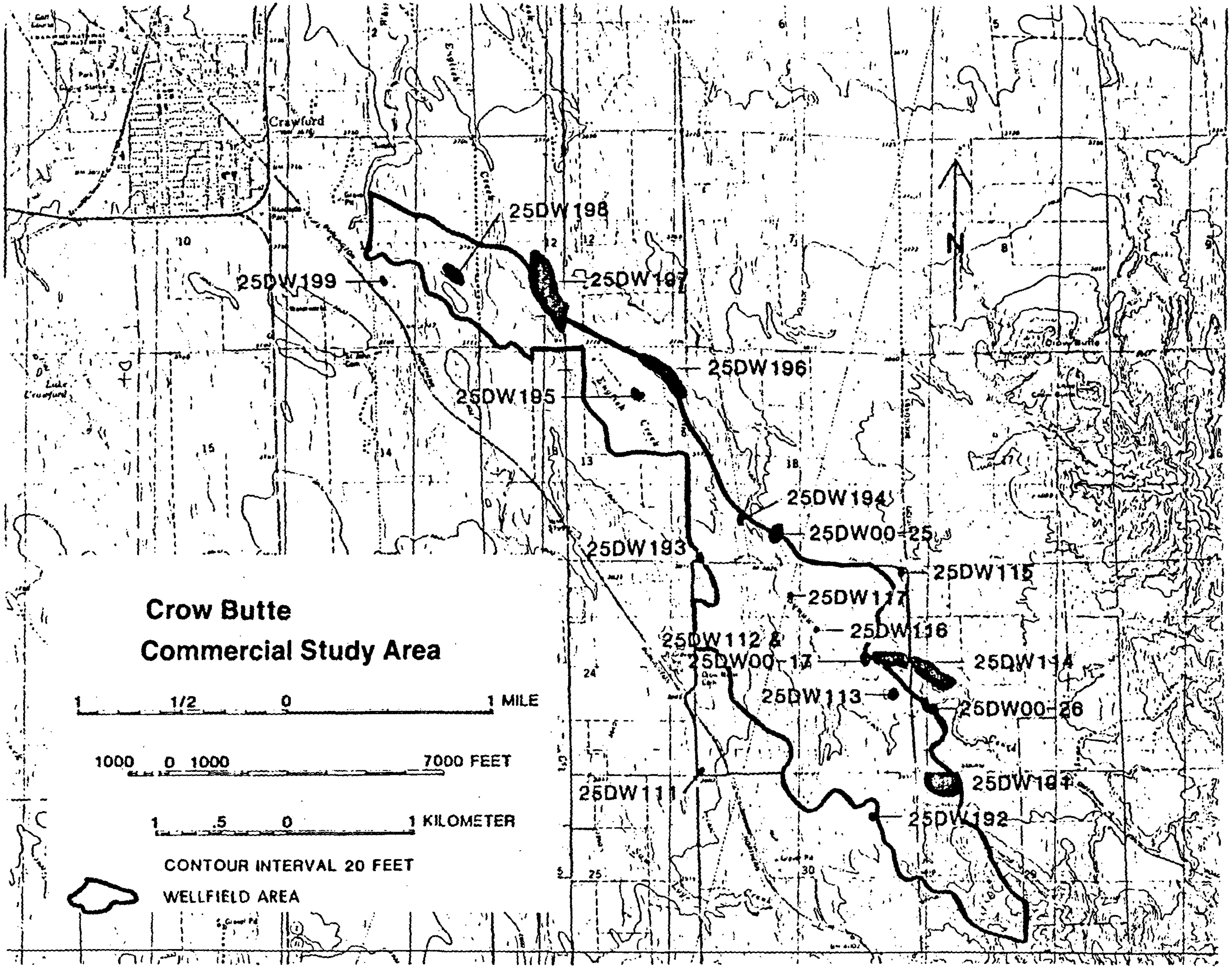

Figure 4.8-1 Location of cultural resources identified during 1982 and 1987 investigations within the Crow Butte Project; Dawes County, Nebraska.

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.

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)

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.

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

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.

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	B-1	B-2	B-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.

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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 /sw

Ross A. Lock
Nongame Specialist

RAL/FA/rw
cc: Fred A. Harrington, Jr.

APPENDIX 4.9(B)

Fish Population Data

FRED A. HARRINGTON Ph.D.

CONSULTING BIOLOGIST

BIOLOGICAL STUDIES • NATURAL RESOURCE PLANNING • IMPACT ASSESSMENTS

Telephone
(307) 672-6626

P.O. Box 521
Sheridan, Wyoming 82801

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 samplied 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

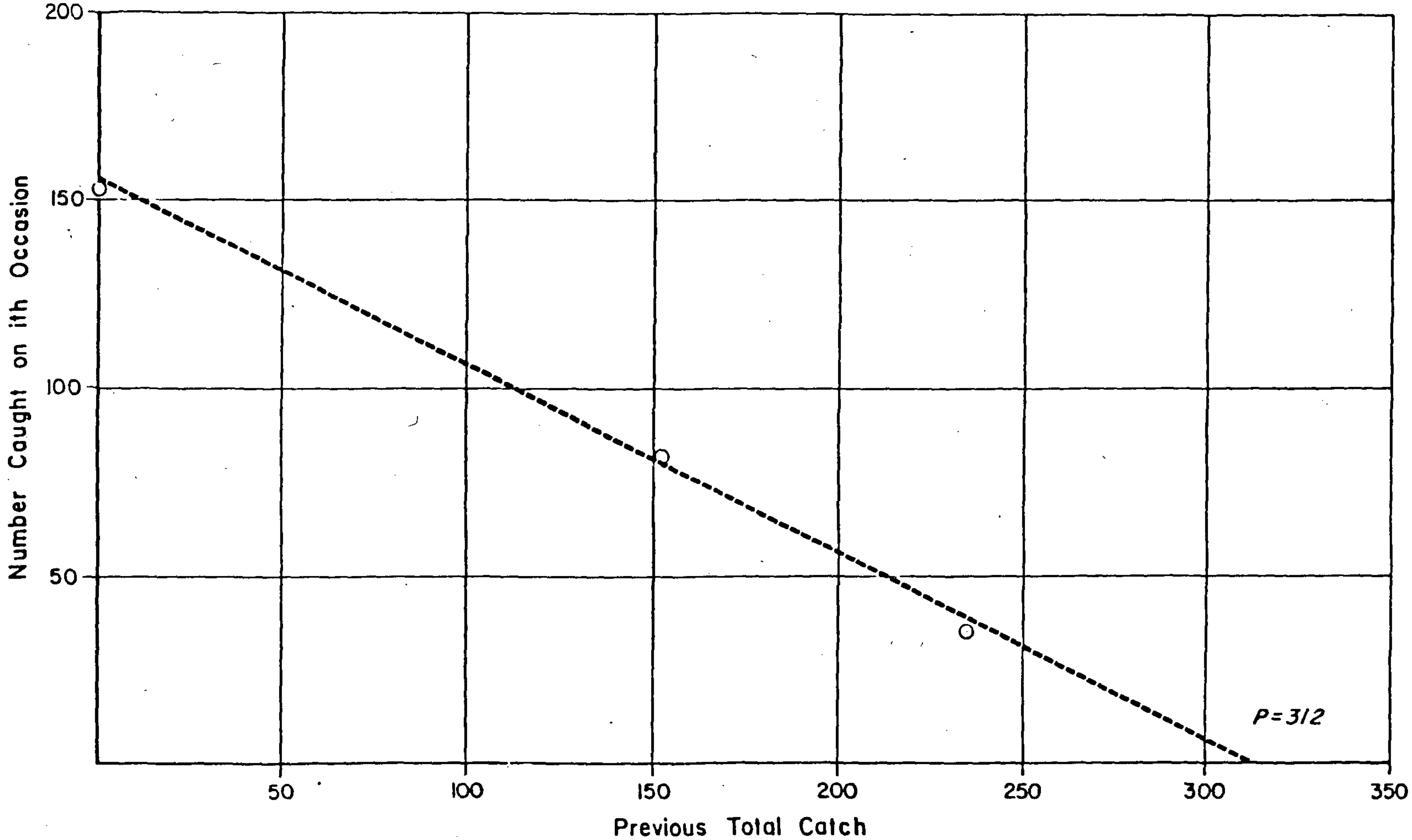
Table 4.9(B)-2

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
** $p < 0.05$

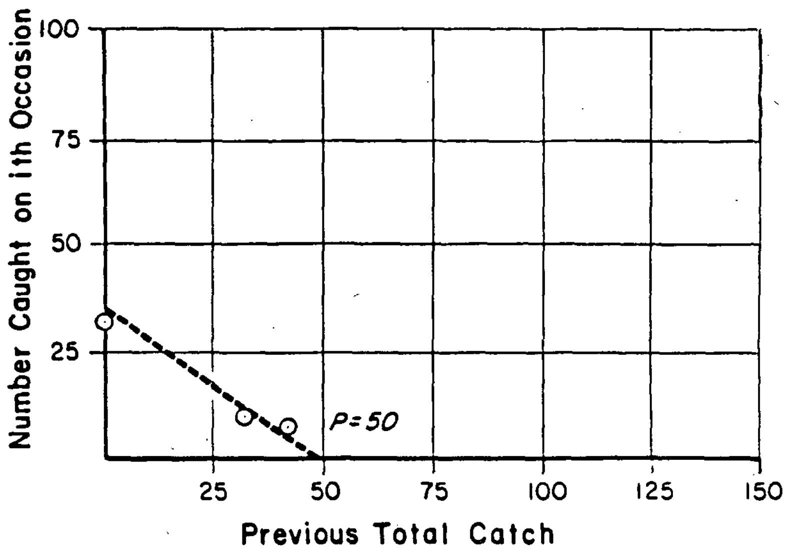
Figure 4.9(B)-1



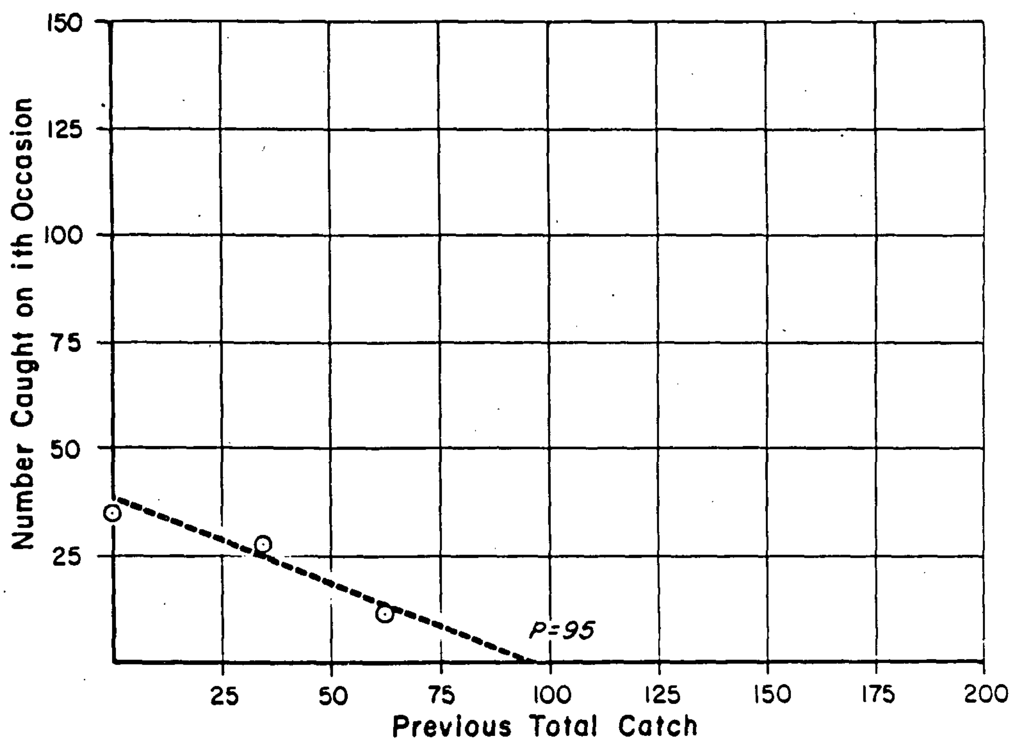
W-3 Fathead Minnow 2 Nov 83

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)-1

Figure 4.9(B)-2

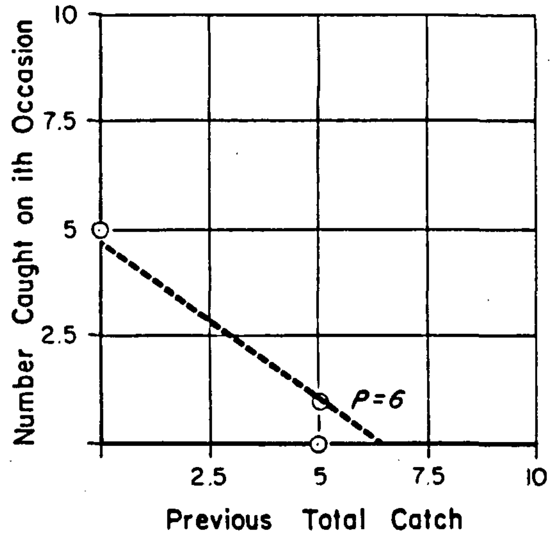


W-3 Creek Chub 2 Nov 83

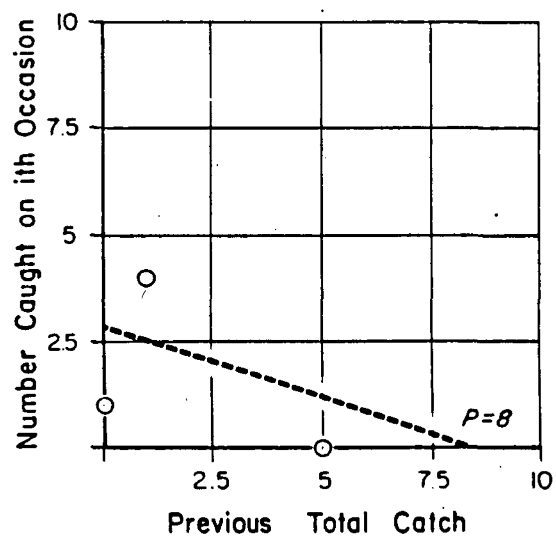


W-3 Longnose Dace 2 Nov 83

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



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. Stont, 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 NOV 83

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
Mad Tom	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 / 276,935

270^2 - 307(307-270) [(3x0.50)^2/(1-.50)]

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 / -1.51

5^2 - 8.33(8.33-5) [(3x0.22)^2/(1-0.22)]

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 = 160176/5798.1
71^2 - 95(95-71) [(3x0.38)2/(1-0.38)]
5041 - 2280 [1.30/.62]
1761 [2.10]

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 = 16800/13071
50^2 - 56(56-50) [(3x0.55)2/(1-0.55)]
2500 - 336 [2.72/0.45]
2164 [6.04]

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 = 7.06/511.85
6^2 - 6.19 (6.29-6) [(3x0.70)2/(1-0.70)]
36 - 1.18 [4.41/.30]
34.82 [14.7]

S.E. of P = 0.01

95% confidence limits of population estimates are: 6.19 +/- 2 x 0.01 = 6.19 +/- 0.02

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.

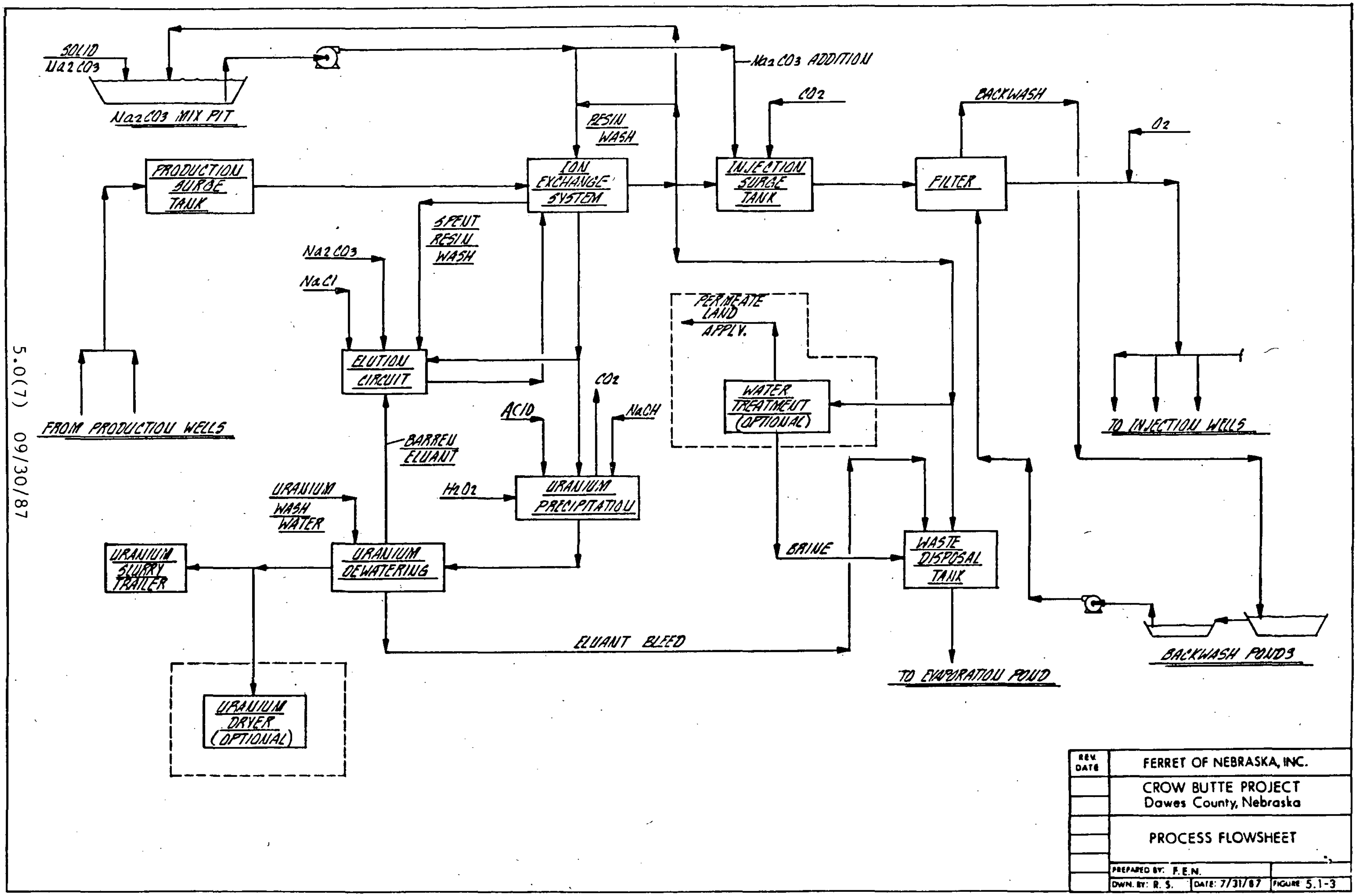
The process flow sheet for the above steps is shown in Figure 5.1-3. The anticipated process plant layout is shown in Figure 5.1-4. The plant will be designed to operate at an average capacity of 2500 gallons per minute. Because of operational considerations at times, the flow will be in excess of 2500 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.

$$2\ R\ HCO_3 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$
$$2\ RCl + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2Cl^-$$
$$R_2SO_4 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

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

5.0(7) 09/30/87



SOLID Na_2CO_3
Na_2CO_3 MIX PIT
Na_2CO_3 ADDITION
CO_2
BACKWASH
O_2
RESIN WASH
PRODUCTION SURGE TANK
ION EXCHANGE SYSTEM
INJECTION SURGE TANK
FILTER
SPENT RESIN WASH
Na_2CO_3
NaCl
ELUTION CIRCUIT
PERMEATE LAND APPLY.
WATER TREATMENT (OPTIONAL)
TO INJECTION WELLS
FROM PRODUCTION WELLS
CO_2
ACID
NaOH
BARREN ELUANT
URANIUM WASH WATER
H_2O_2
URANIUM PRECIPITATION
BRINE
WASTE DISPOSAL TANK
URANIUM SLURRY TRAILER
URANIUM DEWATERING
ELUANT BLEED
TO EVAPORATION POND
BACKWASH PONDS
URANIUM DRYER (OPTIONAL)
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

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

* 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 conentration 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.

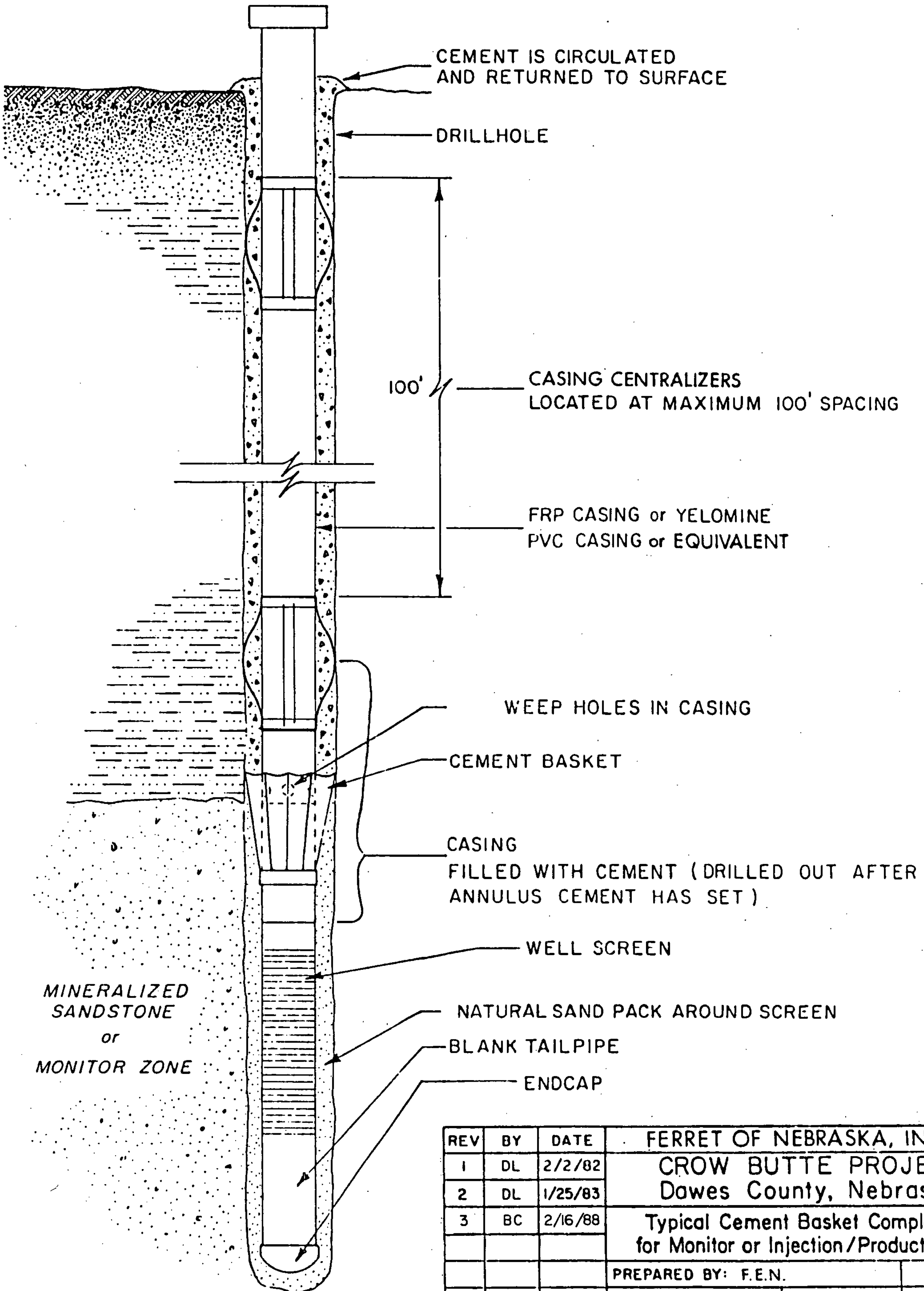
The lixiviant recovery system consists of recovery surge tanks and ion exchange feed pumps. The surge tanks are fiberglass reinforced plastic (FRP) construction and the pumps are centrifugal type.

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.

WELL COMPLETION METHOD No. I



REV	BY	DATE	
			FERRET OF NEBRASKA, INC.
1	DL	2/2/82	CROW BUTTE PROJECT
2	DL	1/25/83	Dawes County, Nebraska
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

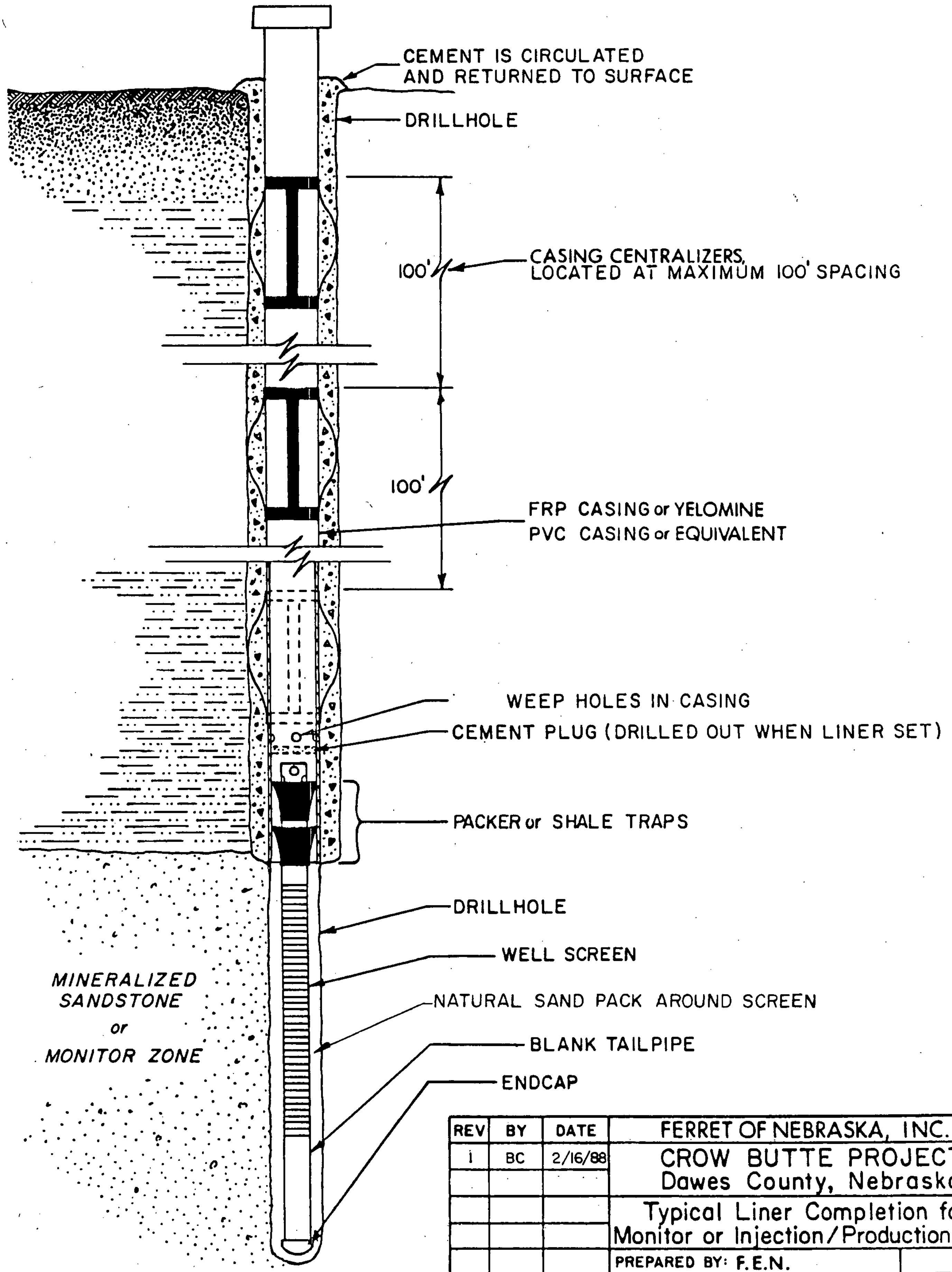
hole to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is placed in the hole. A cement basket is attached to the blank casing just above the screen to prevent blinding of the screen interval during cementing. The cement is then pumped 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	FERRET OF NEBRASKA, INC.	
1	BC	2/16/88	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

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: __________________

DATE: ____________

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FIGURE 10.2-4

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

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 FEN 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.