ADDENDUM 4.2-B

CLASS I DEEP DISPOSAL

WELL FIELD APPLICATION

CORRESPONDENCE

October 29, 2010

Mr. Tony Simpson
Strata Energy Inc.
406 W. 4th Street
Gillette, WY 82716

RE: Strata Energy, Inc. – Ross Disposal Injection Wells
Draft Permit **10-263**, Class I Non-hazardous Injection Wells
Crook County, Wyoming

Dear Mr. Simpson:

Attached, please find comments developed by the Wyoming Department of Environmental Quality (WDEQ) with respect to the content and adequacy of the Wyoming Water Quality Rules and Regulations, Chapter 13, Class I permit application.

The WDEQ received this application on June 23, 2010 and has until August 23, 2010 to make an initial determination of completeness. Please note that recent work load has increased our response times. Re-submittal of information by an applicant on an incomplete application will begin a new 60 day review process. Pursuant to Chapter 13, Section 6 during any 60 day review period where an application is determined complete, a draft permit for issuance or denial shall be prepared and a public notice provided pursuant to Chapter 13, Section 19.

Please feel free to contact me at (307) 777-5623 should you have any questions related to these comments or the application and review process.

Sincerely,

PROFESSIONAL GEOLOGIST JOHN A. PASSEHL PG-336 WYOMING

John A. Passehl, P.G.
UIC Geological Supervisor
Water Quality Division

JP/rm/10-0978

Attachments: WDEQ Comments

cc: Petrotek Engineering Corporation, Attn: Hal Demuth, 10288 West Chatfield Avenue, Suite 201, Littleton, CO 80127
Kevin Frederick, WDEQ
Wyoming Oil and Gas Conservation Commission, Attn: Ms. Janie Nelson, P.O. Box 2640, Casper, WY 82602
WDEQ UIC file

UNDERGROUND INJECTION CONTROL PROGRAM
REVIEW COMMENTS:
PLANS/SPECIFICATIONS/PROPOSALS/REPORTS

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY DIVISION
Herschler Bldg., 4 West
Cheyenne, Wyoming 82002
307-777-7781

PROJECT: Application 10-263
Strata Energy, Inc: Ross Disposal Injection Wells

LOCATION: Crook County

APPLICANT: Strata Energy, Inc.
406 W. 4th Street
Gillette, WY 82716

OWNER: Tony Simpson

CONSULTANTS:

GEOLOGIST Petrotek Engineering Corporation
Hal Demuth, P.G.

ENGINEER Petrotek Engineering Corporation
Ken Cooper, P.E.

TITLE: *"UIC Permit Application Class I Injection Wells Ross Disposal Wells, Crook County, Wyoming Strata Energy, Inc."*

_X_ PLANS _X_ SPECS _X_ PROPOSAL __ REPORT

DATE ON PROPOSAL/PLANS/REPORT: June 2010

DATE RECEIVED BY WDEQ: June 23, 2010

WDEQ REVIEWER: John A. Passehl, P.G.
GEOLOGIST

DATE OF THIS REVIEW: October 19, 2010

ACTION: **Application Incomplete; See Attached Comments**

I. WDEQ Comments:

Specific Comments - Additional Information Required **(John Passehl:** 777-5623**)**

1. Please explain why the *Depth to Water in USDW* in Table 7 of your report is 0 feet. Also, please explain why you used *Head in USDW from base of Flathead (W)* of 8,755.

2. Please provide an Area of Review calculation using the 9 lb mud method as described in previous ISR permit applications.

3. Please explain why a BHT of 154 F was used for calculating K, when Table 5 of the report indicates a BHT of 121 F-128 F is more appropriate for the injected formations. Please revise K and AOR calculations accordingly.

4. Please explain the final disposition of the Madison test well (API 4901109528). Also, please provide all water quality analysis from this well for all formations that were sampled.

5. Please explain the potential for the Madison formation (updip from the Ross injection site) to be either impacted by pressure fronts or contaminated by injectate from this project (now and in the future).

6. Please explain the potential for <u>each</u> of the following well fields to be either impacted by pressure fronts or contaminated by injectate from this project: City of Gillette well field located in T51N, R66W; Town of Pine Haven/Moorcroft well field located in T50N; R66W; Town of Hulett well field located in T54N, R65W, WWDC wells located in T54N, R61W, and City of Sundance well field located in T51-52N, R63W.

7. The financial assurance amounts for the proposed wells are deemed sufficient. Please contact Jessica Wales of this Department when you are ready to finalize financial assurance requirements of the permit (307-777-7082). Financial assurance requirements must be met for each well prior to commercial injection.

Petrotek

Petrotek Engineering Corporation 10288 West Chatfield Avenue, Suite 201 Littleton, Colorado 80127 (303) 290-9414 (303) 290-9580 Fax

November 16, 2010

John Passehl
Wyoming Department of Environmental Quality
Water Quality Division
Herschler Building, 4 West
Cheyenne, WY 82002
(307) 777-7781

Re: Ross Disposal Wells, Class I UIC Permit Application, Response to WDEQ Comments

Dear Mr. Passehl:

This letter presents the responses to the WDEQ letter dated October 29, 2010 pertaining to the proposed Ross Class I wells. In that letter, you presented comments and questions related to the application of the Class I UIC Draft Permit 10-263 submitted by Strata Energy, Inc. on June 23, 2010. Strata has addressed all of the referenced comments and questions in the attached responses. Please contact the undersigned at (303) 290-9414 with any questions.

Sincerely,

Petrotek Engineering Corporation
Ken Cooper, PE

Professional Engineer (Petroleum)
KENNETH J. COOPER
8428
Date 11/16/2010
WYOMING

Cc: Tony Simpson – Strata Energy, Inc.
Ben Schiffer – WWC Engineering
Hal Demuth, Aaron Payne, Wes Janes - Petrotek Engineering

I. WDEQ Comments:

1. Please explain why the Depth to Water in USDW in Table 7 of your report is 0 feet. Also, please explain why you used Head in USDW from base a/Flathead (W) of 8,755.

Strata Energy, Inc. Response

The ‘Depth to Water in USDW’ in Table 7 refers to the distance from ground surface to the estimated top of native formation water in the Madison Formation. The Madison had been assigned as the lowermost USDW. The value of 0 feet is used, placing Madison water at surface. Strata considers this estimate to be conservative because the Madison is known to be artesian in the region. Probable artesian conditions would yield a "depth" above ground level. In the event that formation testing of the Madison Formation conducted during the drilling process indicates that a different value is appropriate, calculations will be modified accordingly.

As noted in the third full paragraph on Page 19 of the Permit Application,

> *Based on an estimated water level at ground surface for the Madison, which is known to be artesian in the region, it is calculated that the head (W) in the overlying lowermost USDW (Madison) is approximately 8,755 feet per Chapter XIII, Section 5, of the WDEQ Water Quality Regulations. The head was calculated from the base of the Flathead Sandstone (estimated at 8,755 ft bgs from log correlations).*

Projected formation tops for the Ross Disposal Wells are based on log correlations and are noted in Table 6 of the permit application.

2. Please provide an Area of Review calculation using the 9lb mud method as described in previous ISR permit applications.

Strata Energy, Inc. Response

AOR calculations conducted in accordance with WDEQ WQD Regulations Chapter XIII, indicate that the AOR for the Ross Disposal wells is ¼ mile. There are no penetrations to the proposed injection zone within that AOR. The nearest known penetration to the Deadwood Formation is located approximately 14 miles from the project.

Table 1 (attached) shows the additional calculation of the COI using the 9 lb. mud method per WDEQ request. This calculation assumes a 9 lb. mud to surface in an abandoned bore hole. Other input parameters are as listed on Table 1. The calculation results in 902 feet of excess head at the top of the injection zone due to mud weight. In order for fluid to migrate vertically and potentially impact overlying USDWs, fluid in the injection zone must overcome the hydrostatic pressure of the mud column to enter the borehole and move vertically.

3. Please explain why a BHT of 154 F was used for calculating K, when Table 5 of the report indicates a BHT of 121 F-128 F is more appropriate for the injected formations. Please revise K and AOR calculations accordingly.

Strata Energy, Inc. Response

Table 5 in the application includes information from four different wells with depths ranging from 4,111 to 11,000 feet and measured bottom hole temperatures (BHT) ranging from 119 F to 166 F. The temperature range of 121 F to 128 F referenced in the comment for the proposed injection zone refers only to the extrapolated conditions in the Madison Test Well #1 in Table 5 of the application.

These temperatures are a result of a calculated temperature gradient based on total depth and the measured BHT of each well. It is the gradient that must be used to estimate BHT at depth; the injection formation temperature at a much different depth, either measured or calculated, in a well located 29 miles away is not necessarily applicable. If the temperature gradient for the Madison Test Well # 1 (0.021125 deg/ft) had been used when calculating K, the result would have been 185 F at a depth of 8,163 feet, thereby generating a smaller cone of influence than that which was calculated in Table 7 (1 foot) in the application. The 154 F temperature was calculated using a more moderate gradient (0.01325 deg/ft) comparable to other wells in the region.

Attachment 1 of this document is a revised Table 5. Strata requests that it replace the original in the application as typographical errors were noted while reviewing the original Table 5 for this response. Note that these typographical errors were the result of misplaced data but had no effect on the calculations presented for the proposed injection zone.

4. Please explain the final disposition of the Madison test well (API 4901109528). Also, please provide all water quality analysis from this well for all formations that were sampled.

Strata Energy, Inc. Response

According to the WOGCC, the current status of the Madison test well (API 4901109528) is plugged and abandoned (PA). It is noted that the specified well is located approximately 29 miles from the project area. As discussed in the second paragraph of page 24 of the permit application (provided below), the water quality in the injection zone in the Madison test well is not likely to be representative of the injection zone below the Ross Project.

The primary sources for recharge in the region are the upland areas of the Black Hills uplift (Figure 26). Generalized TDS concentration maps in the upper and lower Paleozoic section are presented as Figures 27 and 28, respectively. These maps indicate that the location of the Madison Test Well No. 1 (northern Crook County, Wyoming) is more directly influenced by recharge from the Black Hills than intervals below the Ross Project and a marked variance in water quality should be expected moving westward toward the Powder River Basin. Further, there is major structural change due to the Black Hills monocline and a reverse/thrust fault between the two locations. Figure 17 presents a map of the structure on top of the Precambrian basement. It indicates a structural change of nearly 4,000 feet at the base of the proposed injection zone between the Ross Project and the Madison Test Well No. 1 (T57N, R67W). This structural change is in agreement with the projected formation top of the Precambrian for the Ross Disposal Wells (Table 6) which is approximately 3,860 feet deeper than in the Madison Test Well No. 1. As such, it is unlikely that the water quality at the Madison Test Well No. 1 is representative of the Deadwood/Flathead below the Ross Project. Proposed injection interval water quality on site will be assessed during the drilling and completion process of the Ross Disposal Wells.

As requested, available water quality analyses from the well are provided in the well report included as Attachment 2.

5. Please explain the potential for the Madison formation (updip from the Ross injection site) to be either impacted by pressure fronts or contaminated by injectate from this project (now and in the future).

Strata Energy, Inc. Response

Please refer to Strata's response to question six below.

6. Please explain the potential for each of the following well fields to be either impacted by pressure fronts or contaminated by injectate from this project: City of Gillette well field located in T51N, R66W; Town of Pine Haven/Moorcroft well field located in T50N; R66W; Town of Hulett well field located in T54N, R65W, WWDC wells located in T54N, R61 W, and City of Sundance well field located in T51-52N, R63W.

Strata Energy, Inc. Response

It is noted that the proposed injection zone does not include the Madison and is hydraulically isolated from it. The base of the Madison occurs approximately 476 feet above the injection zone below the Ross Project. The closest known artificial penetration (according to the WOGCC and noted in the fourth full paragraph on page 16 of the application) that penetrates the receiver and the

Madison is approximately 14 miles from the project area. Referenced well fields are structurally updip, hydraulically upgradient, and in closer proximity to recharge than the proposed Ross Class I wells (Table 2).

As defined in Chapter XIII, Section 5(b)(iv), the cone of influence (COI) and ultimate limit of emplaced waste (ULEW) of 1 foot and 1,037 feet, respectively, were calculated for the individual wells. Outside the COI, insufficient pressure is projected to allow injectate to migrate vertically into the USDW, even if hypothetical pathways were assumed to exist. The distance from the Ross Project to each of the specified well fields is shown on the attached figure (Figure 1). The closest of the municipal water supply well fields (City of Gillette) is approximately 10.1 miles (53,328 feet) away from the nearest 1,037' ULEW at Ross. As such, based on pressures, distance, and stratigraphic separation, no scenarios have been projected that result in the specified well fields being negatively impacted by pressure fronts or contaminated by injectate from the Ross project Class I wells.

7. The financial assurance amounts for the proposed wells are deemed sufficient. Please contact Jessica Wales of this Department when you are ready to finalize financial assurance requirements of the permit (307-777-7082). Financial assurance requirements must be met for each well prior to commercial injection.

Strata Energy, Inc. Response

Strata acknowledges the instructions.

Table 1
Calculation of 9lb. Mud Method
Ross Disposal Wells

Calculations to Overcome Mud Weight in Borehole		Value	Unit	Basis
Top of Deadwood	Dt	8163	feet; bgs	Permit Application, Table 6
Depth to Top of Mud in Borehole	Dd	0	feet; bgs	Assumed
Pressure Gradient of Deadwood/Flathead	$Grad_{est}$	0.42	psi/ft	Estimated (pg 19, ¶ 2)
Pressure, Top of IZ	Pt ($Grad_{est}$*Dt)	3428.5	psi	Calculated
Density of Mud (lb/gal)	ρ_{mud1}	9.0	lb/gal	WDEQ
Specific Gravity of Mud	ρ_{mud2}/ρ_{water} (ρ_{mud1} / 8.33lb/gal)	1.08		Calculated
Gradient of IZ Fluid	$Grad_{IZ}$	0.433	psi/ft	Estimated
Gradient of Mud Fluid	$Grad_{mud}$ (ρ_{mud2} * $Grad_{IZ}$)	0.468	psi/ft	Calculated
Excess Press. of Mud at Top of IZ	($Grad_{mud}$(Dt - Dd) - Pt)	390	psi	Calculated
Excess Head of Mud at Top of IZ	(Excess Press. of Mud / $Grad_{IZ}$)	902	feet	Calculated

Note: IZ refers to injection Zone

Table 2
Specified Madison Water Supply Well Fields

Well Field	**Distace from ULEW (mi)**	**Top of Madison (ft bgs)**
City of Gillette	10.1	2,250
Pine Haven/Moorcroft	15.8	2700
Town of Hulett	17.5	1,425
City of Sundance	29.0	640
WWDC	37.3	1,810
Ross Disposal Wells	*n/a*	*7,049*

Notes: 'Distance from ULEW' is the distace from the Ultimate Limit of Emplaced Waste of the eastern most Ross DW to the nearest section line bordering the specified well field.
Top of Madison is approximate and is based on USGS topo and Swenson, et al., 1976. In addition, exact formation depth may vary from well to well in the referenced well field.

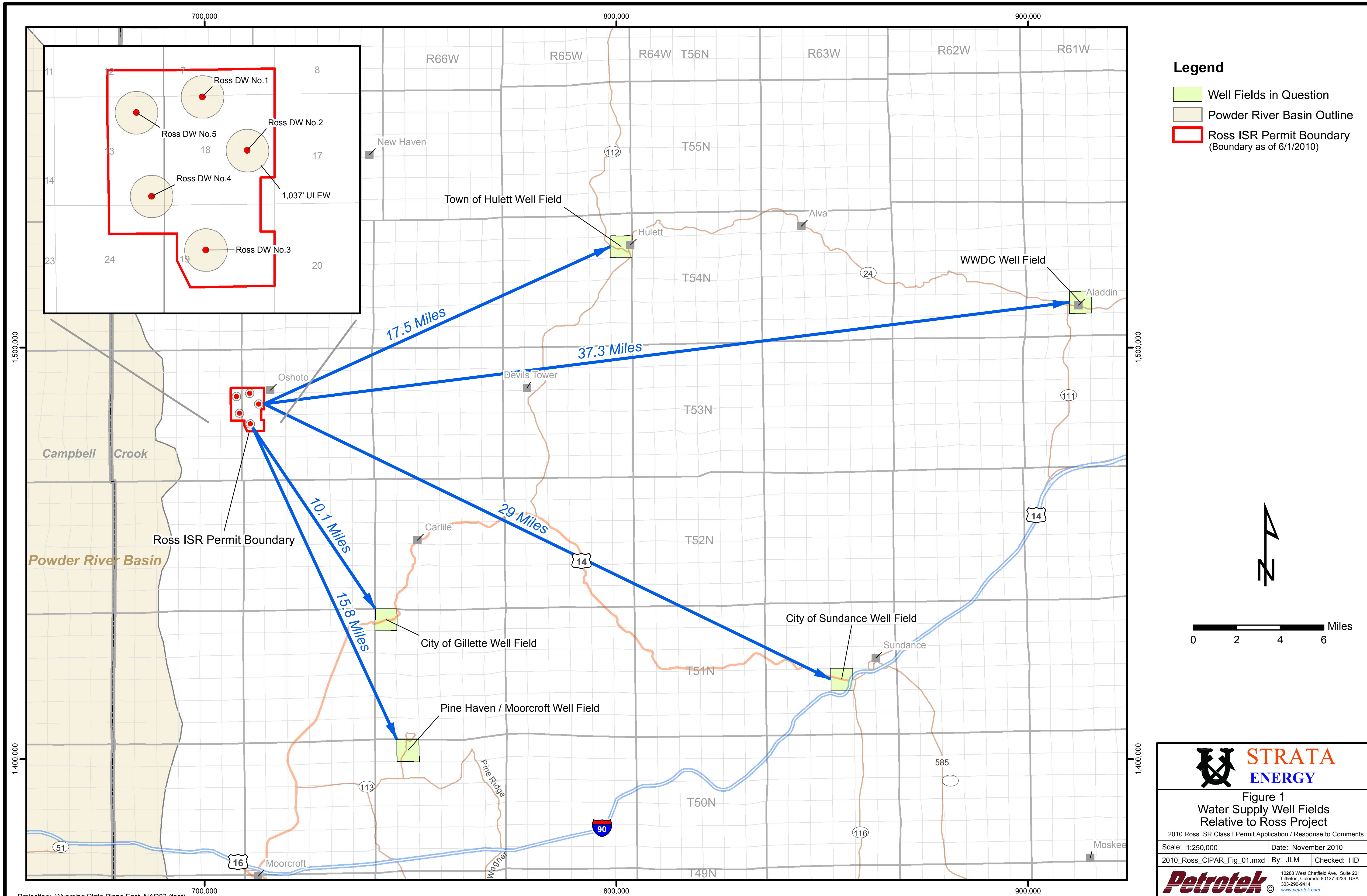
Legend
Well Fields in Question
Powder River Basin Outline
Ross ISR Permit Boundary
(Boundary as of 6/1/2010)
Ross DW No.1
Ross DW No.2
Ross DW No.3
Ross DW No.4
Ross DW No.5
1,037' ULEW
Town of Hulett Well Field
WWDC Well Field
City of Gillette Well Field
Pine Haven / Moorcroft Well Field
City of Sundance Well Field
Ross ISR Permit Boundary
17.5 Miles
37.3 Miles
29 Miles
10.1 Miles
15.8 Miles
Powder River Basin
Campbell
Crook
R66W
R65W
R64W
T56N
R63W
R62W
R61W
T55N
T54N
T53N
T52N
T51N
T50N
T49N
New Haven
Hulett
Alva
Aladdin
Oshoto
Devils Tower
Carlile
Sundance
Moorcroft
Moskee
Pine Ridge
Wagner
Miles
0 2 4 6
N
Projection: Wyoming State Plane East, NAD83 (feet)
STRATA ENERGY
Figure 1
Water Supply Well Fields
Relative to Ross Project
2010 Ross ISR Class I Permit Application / Response to Comments
Scale: 1:250,000
Date: November 2010
2010_Ross_CIPAR_Fig_01.mxd
By: JLM
Checked: HD
Petrotek
10288 West Chatfield Ave., Suite 201
Littleton, Colorado 80127-4239 USA
303-290-9414
www.petrotek.com

Table 5
Calculated NaCl Concentrations in Select Zones of the Minnelusa to Flathead Formation

Temp ground surface (deg F)	38		
Temp at bottom hole (deg F)	166	API	4900525366
Calculated gradient (deg/ft)	0.01164	T, R, S	52N, 71W, 22
Log TD (ft)	11,000	Dist. to Ross	~22 miles

Fieldgrove No. A-1	Top Depth (ft; RKB)	Bottom Depth (ft; RKB)	Rt deep (Ohm-M)	R shallow (Ri) (Ohm-M)	Neutron Porosity %	Density Porosity %	Assumed (Avg) Porosity	Calculated Rw Resistivity (Ohm-M)	Gen-9 NaCl (ppm)	Temp (deg F)
Formation										
Minnelusa (8,627' KB)	8,660	8,660	8	2.3	26	18	18.0	0.26	12,500	138.8
	8,694	8,694	4	1.6	19	14	14.0	0.08	45,000	139.2
	8,800	8,800	3.3	1	24	22	22.0	0.16	21,000	140.4
Madison (9,488' KB)	9,718	9,718	80	8.5	35	22	22.0	3.87	650	151.1
	9,868	9,868	60	15	29	18	18.0	1.94	1,300	152.8
	9,967	9,967	80	18	29	15.5	15.5	1.92	1,350	154.0
Englewood (10,012' KB)	10,012	10,033	105	60	30	19	19.0	3.79	650	154.6
Red River (10,033' KB)	10,074	10,074	90	28	22	9	9.0	0.73	5,000	155.2
	10,112	10,112	15	2.3	28	16	16.0	0.38	7,500	155.7
	10,220	10,220	75	15	21.5	11	11.0	0.91	2,800	156.9
Winnipeg Group (10,351' KB)	10,361	10,361	35	35	4	9.5	9.5	0.32	9,000	158.6
	10,370	10,370	10	10	10	19.5	19.5	0.38	7,500	158.7
Deadwood (10,420' KB)	10,480	10,480	45	55	4.5	5	5.0	0.11	30,000	159.9
	10,613	10,613	5.5	6.5	27	16	16.0	0.14	21,000	161.5
	10,735	10,735	3	3.5	30	28.5	28.5	0.24	11,500	162.9
	10,420	10,820	20	20	30	13	13.0	0.34	11,500	161.6
Flathead (10,820' KB)	10,858	10,858	5	5.5	22	25	25.0	0.31	8,500	164.3
	10,931	10,931	2.5	2.5	16.5	22.5	22.5	0.13	22,000	165.2
	10,978	10,978	2.7	2.7	10	17	17.0	0.08	37,000	165.7
	10,832	11,000	5	5	13	13	13.0	0.08	37,000	165.0

Temp ground surface (deg F)	38		
Temp at bottom hole (deg F)	119	API	4901120332
Calculated gradient (deg/ft)	0.01256	T, R, S	53N, 67W, 19
Log TD (ft)	6,449	Dist. to Ross	On site

No. 22-19 Reynolds	Top Depth (ft; RKB)	Bottom Depth (ft; RKB)	Rt deep (Ohm-M)	R shallow (Ri) (Ohm-M)	Neutron Porosity %	Density Porosity %	Assumed (Avg) Porosity	Calculated Rw Resistivity (Ohm-M)	Gen-9 NaCl (ppm)	Temp (deg F)
Formation										
Minnelusa (6,290' KB)	6,346	6,346	35	15	17	8	17.0	1.01	3,500	117.7
	6,389	6,389	25	20	20	9	20.0	1.00	3,500	118.2
	6,432	6,432	25	20	24	14	24.0	1.44	2,500	118.8

Temp ground surface (deg F)	38		
Temp at bottom hole (deg F)	130	API	4901106100
Calculated gradient (deg/ft)	0.02238	T, R, S	55N, 67W, 9
Log TD (ft)	4,111	Dist. to Ross	~14 Miles

Little Missouri Federal #1	Top Depth (ft; RKB)	Bottom Depth (ft; RKB)	Rt deep (Ohm-M)	R shallow (Ri) (Ohm-M)	Neutron Porosity %	Density Porosity %	Assumed (Avg) Porosity	Calculated Rw Resistivity (Ohm-M)	Gen-9 NaCl (ppm)	Temp (deg F)
Formation										
Minnelusa (2,072' KB)	2,100	2,100	7	7	26	18	18.0	0.23	25,000	85.0
	2,282	2,282	6	6	19	18	18.0	0.19	28,000	89.1
Madison (2,750' KB)	2,800	2,800	25	25	35	18.5	18.5	0.86	5,000	100.7
	3,118	3,118	18	18	29	18.5	18.5	0.62	6,500	107.8
	3,448	3,448	15	15	29	18.5	18.5	0.51	7,300	115.2
Englewood (3,503' KB)	3,520	3,520	15	15	30	19	19.0	0.54	7,000	116.8
Red River (3,530' KB)	3,590	3,590	14	14	22	12	12.0	0.20	20,000	118.3
	3,875	3,875	17	17	28	12	12.0	0.24	15,500	124.7
	3,912	3,912	16	16	21.5	12	12.0	0.23	16,000	125.5
Winnipeg Group (3,940' KB)	3,952	3,952	10	10	4	14.5	14.5	0.21	17,500	126.4
	3,968	3,968	12	12	10	14.5	14.5	0.25	15,000	126.8
Deadwood (4,047' KB)	4,053	4,053	20	20	4.5	5	5.0	0.05	85,000	128.7
	4,082	4,082	18	18	27	5	5.0	0.05	85,000	129.4

Table 5
Calculated NaCl Concentrations in Select Zones of the Minnelusa to Flathead Formation

Temp ground surface (deg F)	38		
Temp at bottom hole (deg F)	130	API	4901109528
Calculated gradient (deg/ft)	0.021125	T, R, S	57N, 65W, 15
Log TD (ft)	4,355	Dist. to Ross	~29 Miles

Madison Test Well #1	**Top Depth (ft; RKB)**	**Bottom Depth (ft; RKB)**	**Rt deep (Ohm-M)**	**R shallow (Ri) (Ohm-M)**	**Neutron Porosity %**	**Density Porosity %**	**Assumed (Avg) Porosity**	**Calculated Rw Resistivity (Ohm-M)**	**Gen-9 NaCl (ppm)**	**Temp (deg F)**
Formation										
Minnelusa (1,570' KB)	1,610	1,610	5	5	26	18	18.0	0.16	42,000	72.0
	1,800	1,800	9	9	19	18	18.0	0.29	21,000	76.0
	2,010	2,010	28	28	24	18	18.0	0.91	5,200	80.5
Madison (2,292' KB)	2,480	2,480	40	40	35	18.5	18.5	1.37	3,400	90.4
	2,670	2,670	28	28	29	18.5	18.5	0.96	4,500	94.4
	3,000	3,000	18	18	29	18.5	18.5	0.62	7,200	101.4
Englewood (3,030' KB)	3,050	3,050	25	25	30	19	19.0	0.90	4,600	102.4
Red River (3,070' KB)	3,100	3,100	65	65	22	12	12.0	0.94	4,300	103.5
	3,200	3,200	60	60	28	12	12.0	0.86	4,800	105.6
	3,400	3,400	50	50	21.5	12	11.0	0.61	6,300	109.8
Winnipeg Group (3,530' KB)	3,620	3,620	17	17	4	14.5	14.5	0.36	10,500	114.5
Deadwood (3,692' KB)	3,780	3,780	19	19	4.5	16.5	16.5	0.52	7,000	117.9
	3,950	3,950	10	10	27	16.5	16.5	0.27	14,000	121.4
	4,050	4,050	6.5	6.5	30	16.5	16.5	0.18	21,000	123.6
Flathead (4,096' KB)	4,150	4,150	40	40	22	21.5	21.5	1.85	1,800	125.7
	4,215	4,215	47	47	16.5	21.5	21.5	2.17	1,450	127.0
	4,280	4,280	28	28	10	21.5	21.5	1.29	2,700	128.4

Notes: Equations adapted from Archie (SW^2 = FRw/RT; F = 1/porosity^2 ; Rw = Rt*porosity^2)
This table is meant to replace the original Table 5 submitted with the permit aplication.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

This report has not been edited or reviewed for conformity with Geological Survey stratigraphic nomenclature

REPORT ON PRELIMINARY DATA FOR MADISON LIMESTONE TEST WELL NO. 1,

NE¼SE¼ SEC. 15, T. 57 N., R. 65 W., CROOK COUNTY, WYOMING

By

R. K. Blankennagel, W. R. Miller, D. L. Brown, and E. M. Cushing

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Open-File Report 77-164

Study of Madison aquifer in cooperation with
Montana Bureau of Mines and Geology
Montana Department of Natural Resources and Conservation
North Dakota State Water Commission
South Dakota Division of Geological Survey
Wyoming State Engineer

Denver, Colorado
February 1977

CONTENTS

ILLUSTRATIONS
(Plates are in pocket)

TABLES

CONVERSION FACTORS

In this report, figures for measures are given only in English units. Factors for converting English units to metric units are shown in the following table:

English	Multiply by	Metric
in (inches)	25.4	mm (millimeters)
ft (feet)	.305	m (meters)
ft^3 (cubic feet)	.02832	m^3 (cubic meters)
mi^2 (square miles)	2.59	km^2 (square kilometers)
gal (gallons)	3.785	L (liters)
gal/min (gallons per minute)	.0631	L/s (liters per second)
(gal/min)/ft (gallons per minute per foot)	.207	(L/s)/m (liters per second per meter)
lb (pounds)	.4536	kg (kilograms)
lb/in^2 (pounds per square inch)	6.8948	kPa (kilopascals)
md (millidarcys)	.000987	μm^2 (square micrometers)

REPORT ON PRELIMINARY DATA FOR MADISON LIMESTONE TEST WELL NO. 1, NE¼SE¼ SEC. 15, T. 57 N., R. 65 W., CROOK COUNTY, WYOMING

by

R. K. Blankennagel, W. R. Miller, D. L. Brown, and E. M. Cushing

Abstract

This report provides the preliminary data for the Madison Limestone test well no. 1 including test-well history, geology of the test well, hydrologic testing, and geochemistry. It also discusses the preliminary results and future testing plans.

The test well was drilled as part of the study to determine the water-resource potential of the Madison Limestone and associated rocks to meet future water needs in a 188,000-mi^2 region that includes the coal-rich area of the Northern Great Plains. Drilling and testing were designed to yield a maximum of stratigraphic, structural, geophysical, and hydrologic information.

The test well was drilled in the NE¼SE¼ sec. 15, T. 57 N., R. 65 W., Crook County, Wyo., to a depth of 4,341 ft below land surface. The well is cased with 13-3/8-in diameter casing from land surface to about 1,490 ft, and 9-5/8-in casing from about 1,390 to 2,320 ft. It is 7-7/8-in diameter open hole from about 2,320 ft to its total depth of 4,341 ft. The well is so constructed that additional hydrologic tests and geophysical logs can be made at a later date.

Twenty-two cores were taken from selected intervals totaling 650 ft; 607 ft of core was recovered. The cores were photographed, slabbed, plugged, and selected parts were tested for density, porosity, and vertical and horizontal permeability. Gamma and density scans of the cores were made, and thin sections are being prepared for detailed examination.

Sixteen conventional drill-stem tests and packer-swabbing tests were attempted. Ten of these tests give clues to the pressure heads of water in the intervals tested; flowing water was obtained during seven of the tests. All significant water-bearing units encountered in the test well, except the Hulett Sandstone Member of the Sundance Formation, have sufficient heads to cause the water in them to flow at the land surface.

Water from the open-hole part of the well has a shut-in pressure of 48 lb/in^2, and flowed about 250 gal/min through a 2-in valve with a head loss of 16 lb/in^2. If the well could flow freely at the land surface, the yield would probably be 650 to 700 gal/min. This quantity would be the minimum flow from the well under free-flow conditions.

All significant water-bearing units contain relatively freshwater (less than 2,000 mg/L dissolved solids).

Three water-bearing units, which are now cased off, may be potential sources of ground water in the area of the test well. These are the Hulett Sandstone Member of the Sundance Formation, the Minnekahta Limestone, and the upper sandy part of the Minnelusa Formation.

Additional geophysical logs and tests will be made in the test well this spring. The logs will include televiewer, gamma spectrometer, trace ejector, and spinner-surveys. Packers will be set to isolate zones for individual development (removal of drilling fluid) and testing. The individual zones will be tested for head, temperature, water quality, and quantity. After development, flow and discharge tests will be made to determine the quantity of water that the well would yield under various conditions of flow and pumping.

Introduction

Development of coal in the Northern Great Plains will place a heavy demand on the region's available water resources. Surface water is poorly distributed in time and space. Its use for coal development in parts of the region would require storage reservoirs and distribution systems; in the rest of the region, surface water is fully appropriated and its use would deprive present users of their supply. Many people contend that the Paleozoic rocks which underlie most of the region contain water-bearing zones that might supply, at least on a temporary basis, a significant percentage of the total water requirements for coal development. The unit most frequently mentioned as a possible source of water is the Madison Limestone and associated rocks.

In 1975 the U.S. Geological Survey, in cooperation with the Old West Regional Commission, prepared a plan of study (U.S. Geological Survey, 1975) for evaluating the water-supply potential of the Madison Limestone and associated rocks. This report not only presents a plan of study for the Madison, but also gives references relating to the regional geology and hydrology, cites the current geohydrologic studies being made by Federal and State agencies and by private companies, and summarizes the available data and the deficiencies of these data.

During the development of the study plan, a liaison committee was formed. The members were drawn from agencies of State governments that have an active interest in or responsibility for control or development of water from the Madison aquifer. These agencies include Montana Bureau of Mines and Geology, Montana Department of Natural Resources and Conservation, North Dakota State Water Commission, South Dakota Division of Geological Survey, and Wyoming State Engineer. The purpose of the committee is to maintain communication between investigating hydrologists and State officials relative to all aspects of the U.S. Geological Survey's studies of the Madison aquifer.

During the 1976 fiscal year, the U.S. Geological Survey, in cooperation with the States of Montana, North Dakota, South Dakota, and Wyoming, began a study to determine the water-resource potential of the Madison Limestone and associated rocks to meet the future water needs in a 188,000-mi^2 region that includes the coal-rich area of the Northern Great Plains, and to evaluate these rocks (the Madison aquifer) as a source of water for industrial, agricultural, public, and domestic supplies. The study area includes eastern Montana, western North and South Dakota, a small part of Nebraska, and northeastern Wyoming (fig. 1). The area of greatest interest, however, is the Powder River Basin of Montana and Wyoming, and the area surrounding the Black Hills in Wyoming, Montana, the Dakotas, and Nebraska.

Within the scope of available funds and manpower, the objectives and approach are those outlined in the plan-of-study report. The objectives include:

1. The quantity of water that may be available from the Madison aquifer.

2. The chemical and physical properties of the water.

3. The effects of existing developments on the potentiometric head, storage, recharge and discharge, springs, streamflow, and the pattern of ground-water flow.

4. The probable hydrologic effects of proposed withdrawals of water for large-scale developments at selected rates and locations.

5. The locations of wells and the type of construction and development of deep wells that would obtain optimum yields.

Many oil tests have been drilled to the Madison aquifer in the study area. Most did not completely penetrate the aquifer, but were drilled to develop oil fields or were exploration tests on known geologic structures. Few data from these tests were collected for hydrologic purposes, but they are useful in defining the geologic framework and some of the aquifer characteristics such as water quality, temperature, porosity, and potentiometric head.

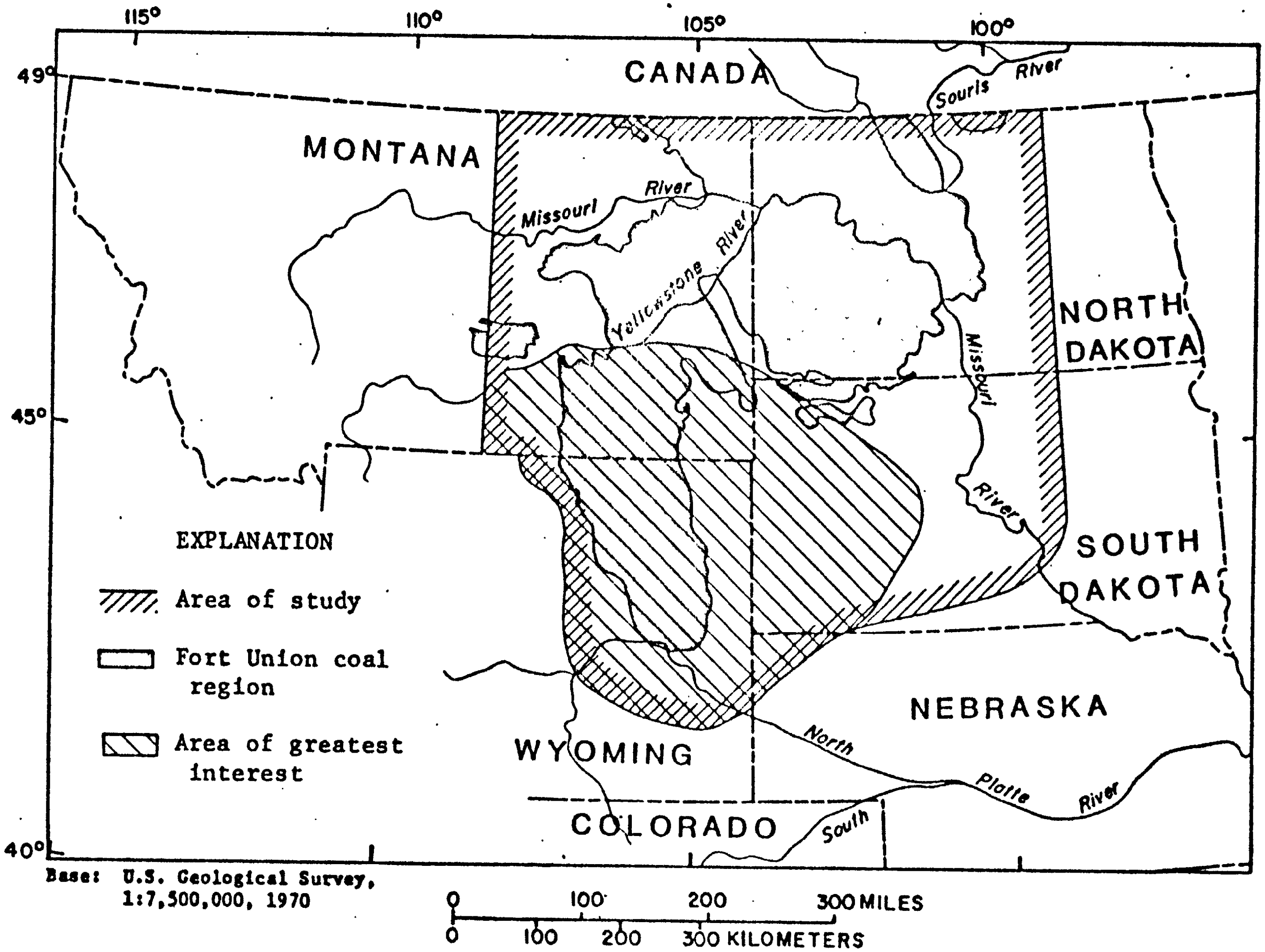

Figure 1.--Location of study area and Fort Union coal region.

To obtain better subsurface hydrologic and geologic information, it was recognized that test wells would have to be drilled. Drilling and testing were designed to yield a maximum of stratigraphic, structural, geophysical, and hydrologic information. Stratigraphic and structural information, obtained from drill cuttings, cores, and geophysical logs, is critical for reconstructing the paleogeologic history of the region as well as defining the present day architecture. Careful analysis of cuttings and cores, and correlation with geophysical log characteristics will have transfer value with data obtained from oil-well tests and surface geophysical surveys.

Hydraulic tests are designed to yield pressure data and subsurface water samples from discrete intervals. These data are used to determine the isolation and (or) interconnection of aquifers, the water yield of isolated zones, the composite yield of the well, and the quality of water.

Using the available data, preliminary geological facies maps were prepared. These showed the area along the eastern part of the Montana-Wyoming border to have a high percentage of dolomite in the Madison and associated rocks, thus indicating possible high primary porosity. Also, because this area was apparently structurally active, good potential for secondary fracture porosity was indicated. Most of the oil tests in this area were not drilled deep enough to reach the Madison, and of those drilled to the Madison only a few completely penetrate the aquifer. For these reasons the area was considered favorable for the initial hydrologic test well.

The U.S. Geological Survey assigned geologists and hydrologists with knowledge of the area from its district office in Cheyenne, Wyo., to review available data and select several potential drilling sites in northeastern Wyoming near the State boundaries of Montana and South Dakota. Prime considerations in site selection were (1) depth to Precambrian rocks about 5,000 ft, (2) adequate pressures to be reasonably certain that the well would flow at land surface, (3) location on State- or Federally-owned land, (4) good accessibility to the drilling site, (5) availability of water for drilling and an area for disposal of water from the well, and (6) nearness to source of electrical power. Seven sites were considered and the site selected best met the above requirements.

Madison test well no. 1 was drilled in the NE¼SE¼ sec. 15, T. 57 N., R. 65 W., Crook County, Wyo. (fig. 2 and 3). It is about half a mile north of the Little Missouri River and along an all-weather gravel-surfaced road used by trucks hauling bentonitic shale. The well is about 30 mi north of Hulett, Wyo., and 50 mi northwest of Belle Fourche, S. Dak.

The well was spudded in the Fall River Formation of Early Cretaceous age on July 16, 1976, and bottomed 60 ft below the top of Precambrian rocks at 4,341 ft below land surface on October 13, 1976. It is cased with 13-3/8-in diameter casing from land surface to about 1,490 ft, and 9-5/8-in casing from about 1,390 to 2,320 ft. It is 7-7/8-in diameter open hole from about 2,320 ft to its total depth of 4,341 ft (fig. 4).

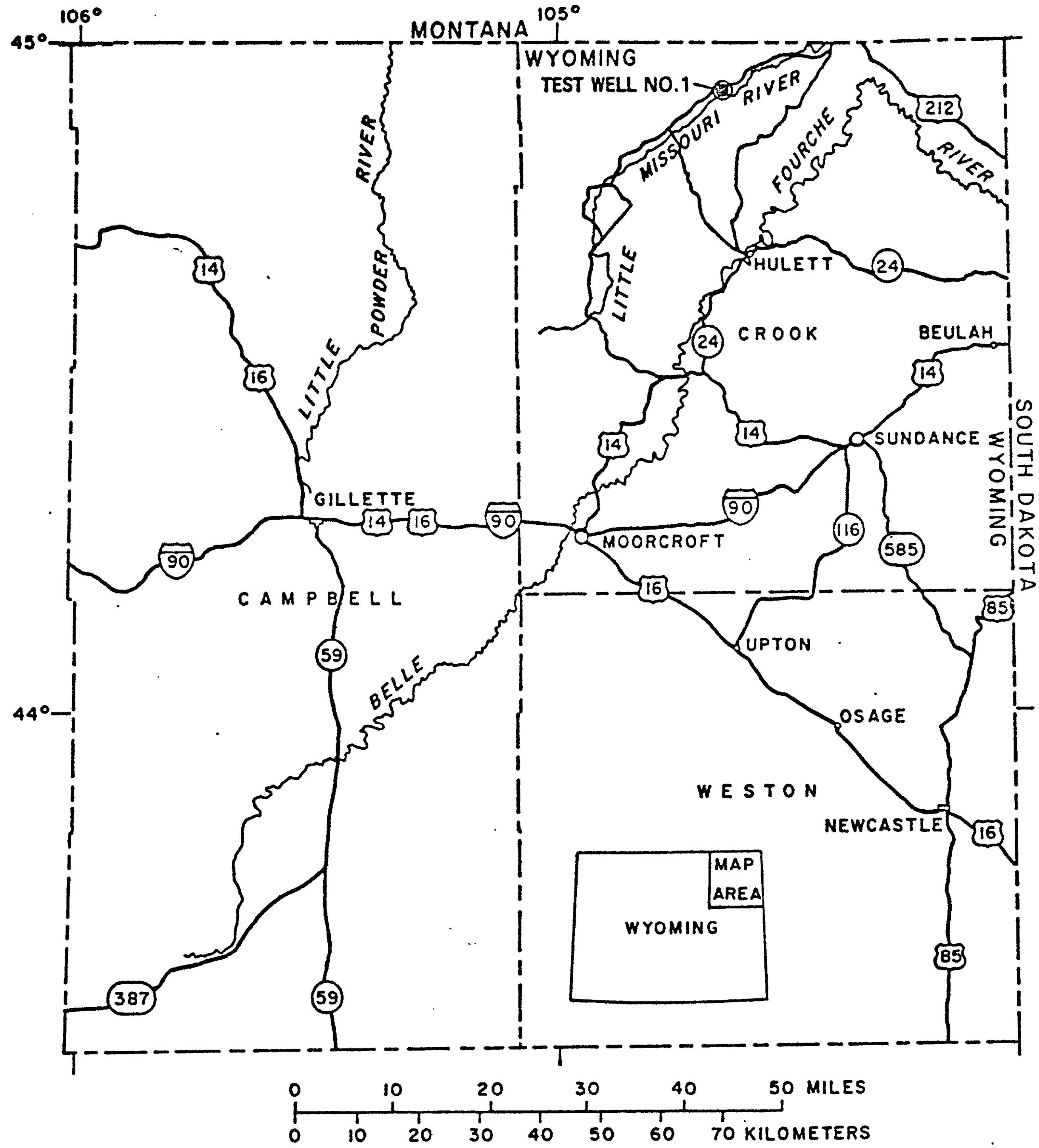

Figure 2.--Northeastern Wyoming showing location of Madison test well no. 1.

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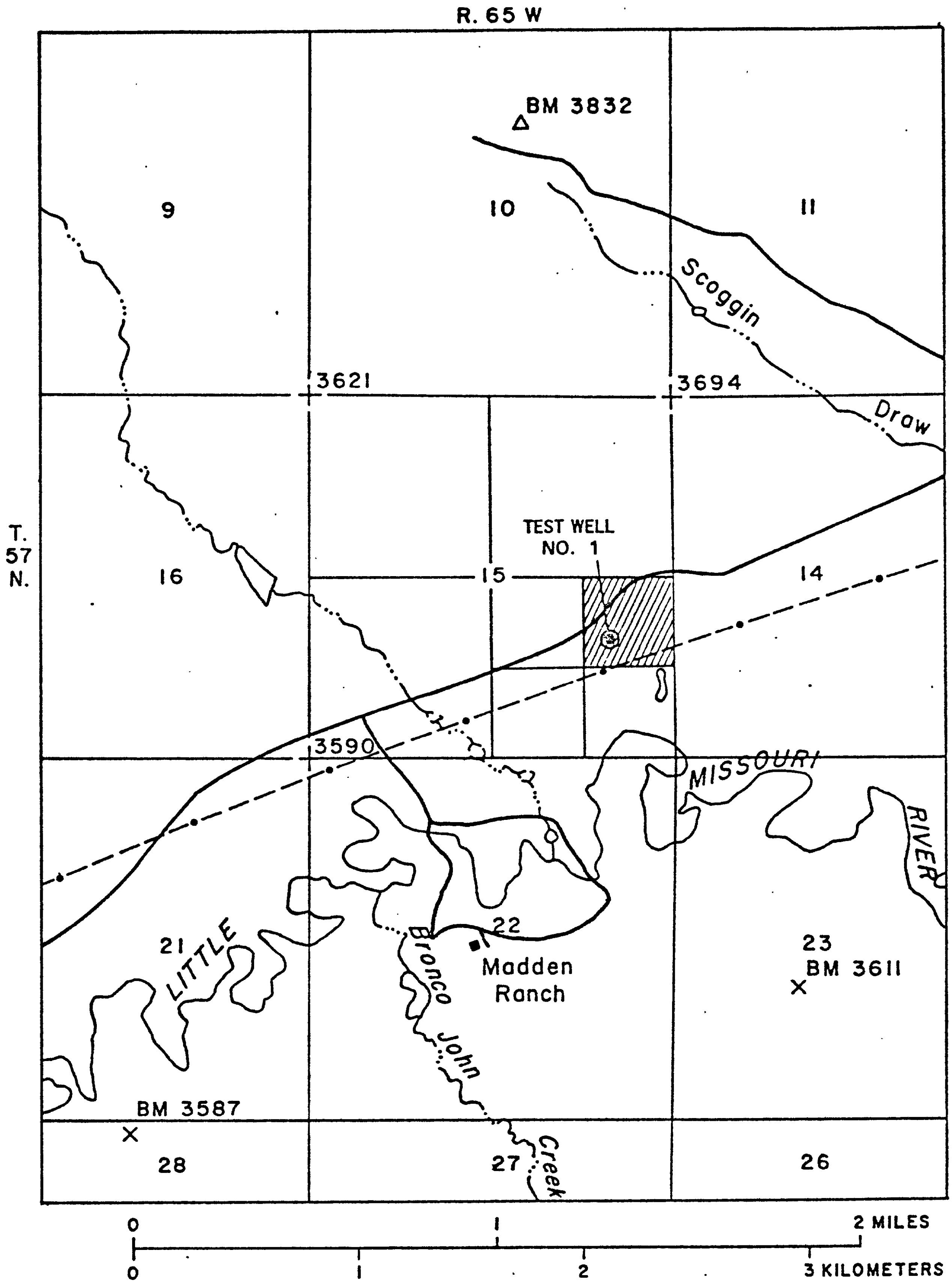

Figure 3.—Location of drilling site for Madison test well no. 1.

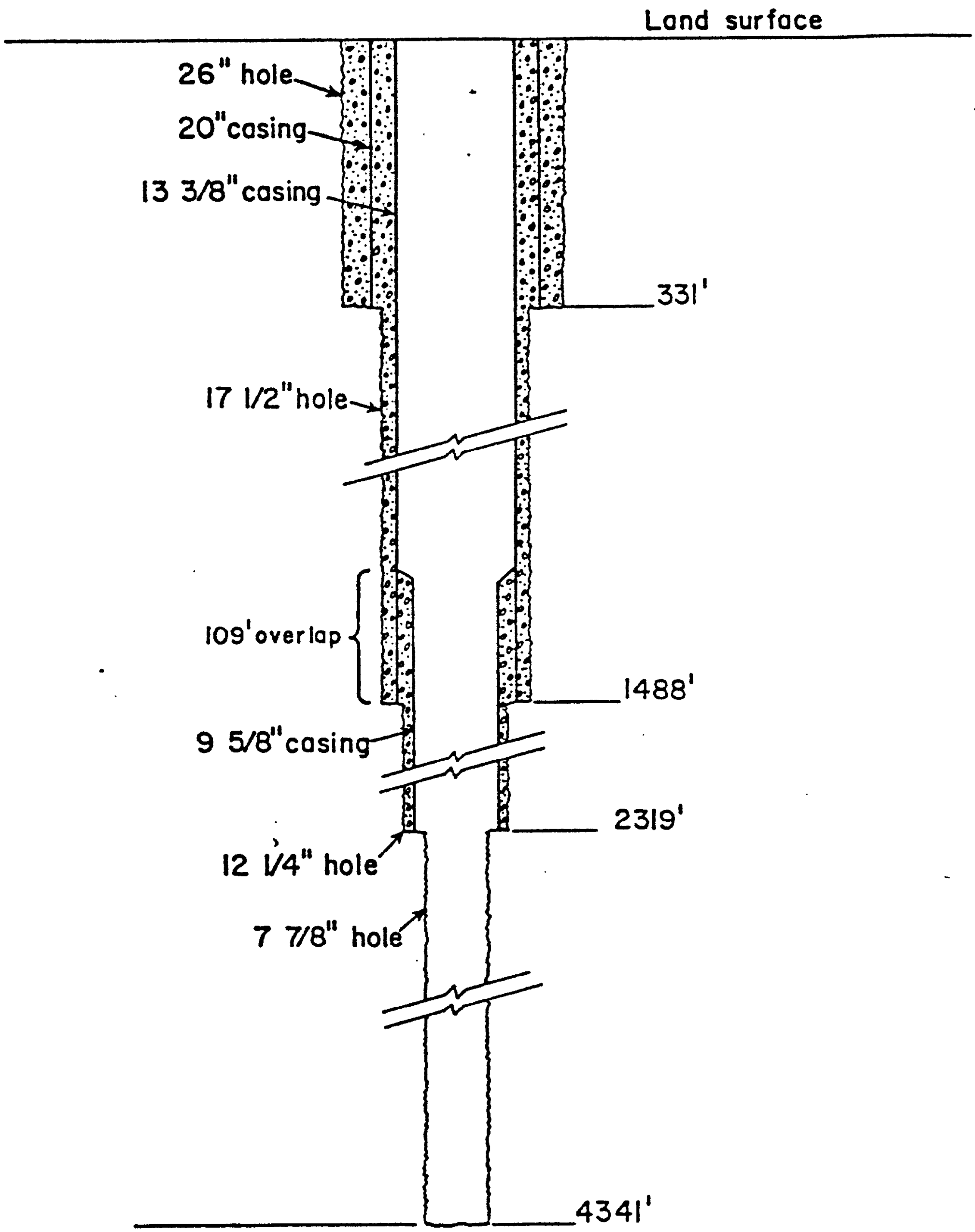

Figure 4.--Construction of Madison test well no. 1 (depths are from land surface).

The well is so constructed that additional hydrologic tests and geophysical logs can be run at a later date (figs. 5 and 6).

Sixteen drill-stem and packer-swabbing tests were attempted; only 10 yielded head information for the interval tested. Based on the test data, all water-bearing units in the Paleozoic rocks have sufficient heads to cause the water in them to flow at land surface. Water from the uncased part of the well, about 2,320 to 4,341 ft, has a head of 48 lb/in^2 above land surface.

Twenty-two cores were taken from selected intervals totaling 650 ft; 607 ft of core was recovered. The cores were photographed, slabbed, plugged, and selected parts were tested for density, porosity, and vertical and horizontal permeability. Gamma and density scans of the cores were made, and thin sections are being prepared for detailed examination.

This report provides the preliminary data for Madison Limestone test well no. 1 including test-well history, geology of the test well, hydrologic testing, and geochemistry, and discusses the preliminary results and future testing plans.

Selected references of geological and hydrological publications on the Northern Great Plains area are listed in the plan of study of the hydrology of the Madison Limestone and associated rocks in parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming, U.S. Geological Survey Open-File Report 75-631, December 1975.

Many individuals from the U.S. Geological Survey, other Federal agencies, State agencies, and industry contributed to the successful completion of the Madison test well no. 1. No attempt will be made to list all of the U.S. Geological Survey personnel involved in the operation; however, special recognition must be given to James A. Peterson, Thad W. Custis, William J. Head, James R. Marie, Robert B. Brekke, Bruce B. Hanshaw, John F. Busby, Roger W. Lee, Lewis W. Howells, and J. E. Weir, Jr.

Fenix and Scisson, Inc., of Tulsa, Okla., prime contractor for the Energy and Research Development Administration (ERDA) at Las Vegas, Nev., assisted with preparation of the drilling specifications and provided a drilling specialist, David Hoppes, at the drill site. Fenix and Scisson prepared the well history included in this report.

J. R. Kerns and J. D. Traut of Hegna, Kerns, and Traut, consulting geologists, Casper, Wyo., were employed by the drilling contractor during drilling operations. They assisted with selection of cored intervals and identified formation tops. Their descriptions of cuttings and cores are included in this report.

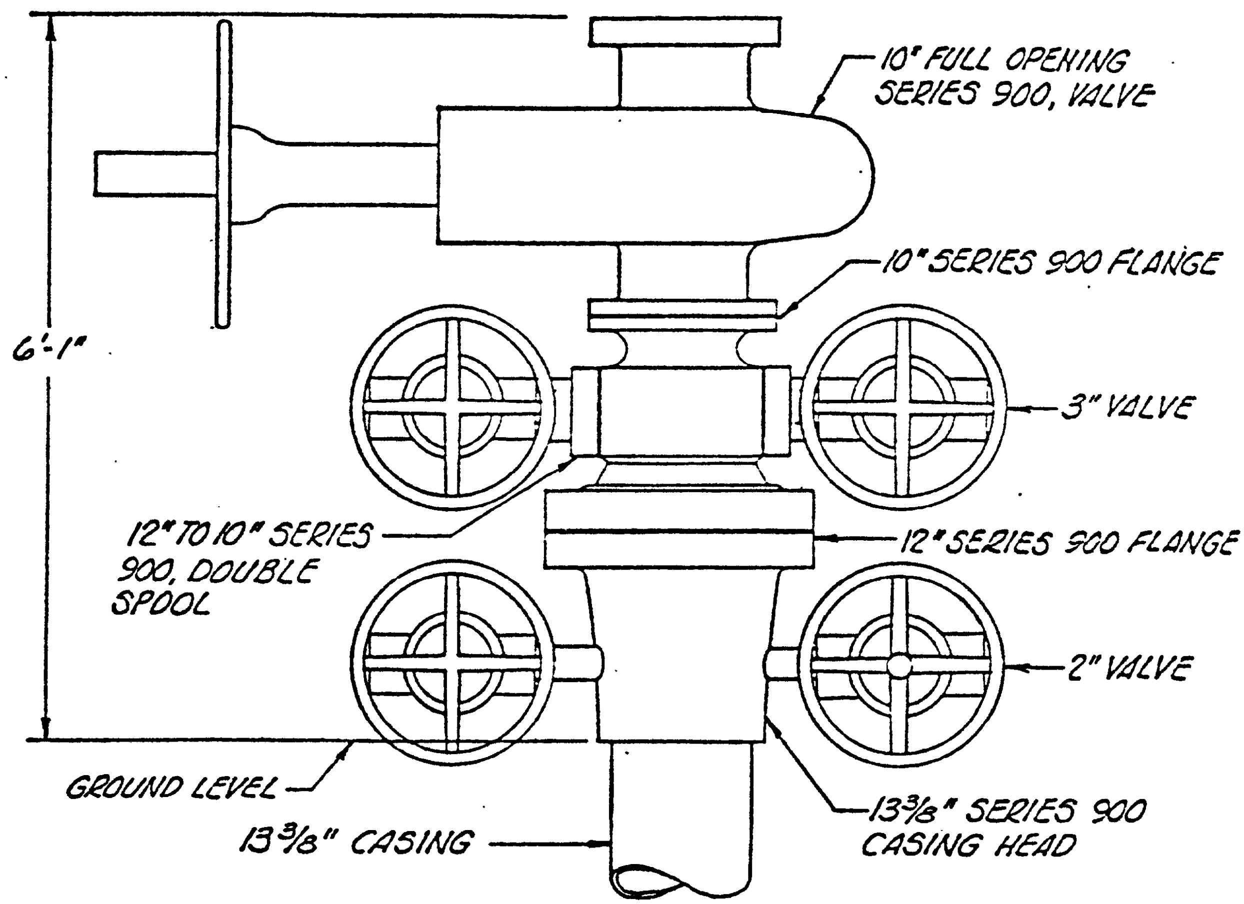

Figure 5.--Well-head equipment of Madison test well no. 1.

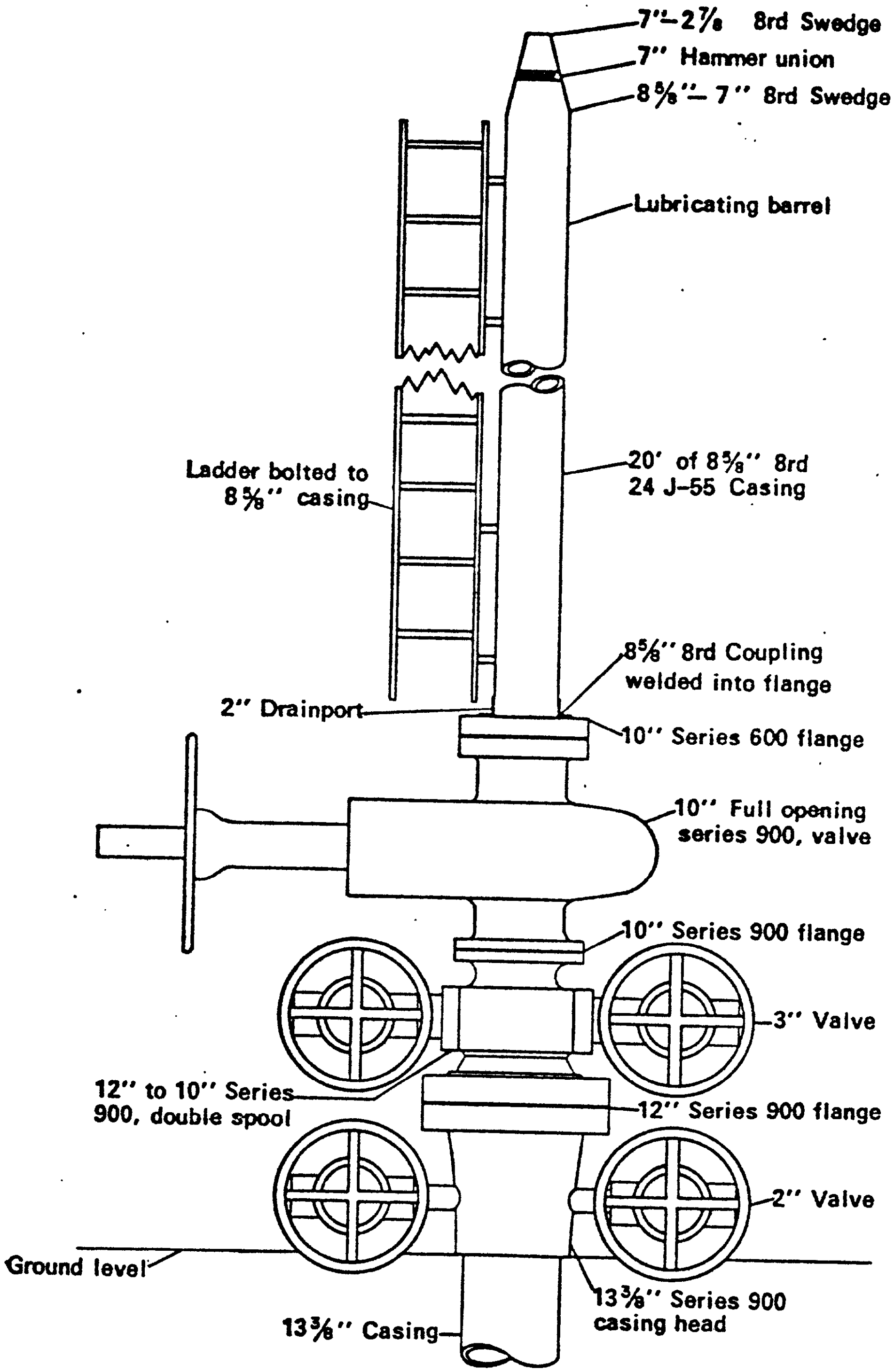

Figure 6.—Well-head equipment of Madison test well no. 1, with lubricating barrel attached.

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Geophysical logging was done by Birdwell Division, Seismograph Service Corp., and Dresser Atlas. Packer tests were run by Lynes, Inc., with interpretation by Roger L. Hoeger. Other companies, too numerous to mention, were involved in the drilling, coring, fishing, and cementing operations.

Core preparation, photographs, and gamma-ray-attenuated-porosity-evaluator (GRAPE) logs were provided by Marathon Oil Research Center, Denver, Colo. Analysis of core and hydrologic parameters was by Core Laboratories, Denver, Colo.

Test-well history

The following historical data on the test well including time breakdown, hole history, core record, bit record, deviation surveys, and log index sheet are taken from the Fenix and Scisson report furnished to the U.S. Geological Survey at the completion of the drilling, coring, and preliminary logging and testing of Madison Limestone test well no. 1. The mud report is from the Hegna, Kerns, and Traut report.

FENIX & SCISSON, INC.

HOLE HISTORY DATA

DATE: December 17, 1976   APPROVED:

HOLE NO.: Madison #1, Wyoming	W. O. NO.:		I. D. NO.:
USER: USGS	TYPE HOLE: Exploratory		
LOCATION: Wyoming	COUNTY: Crook	AREA: Hulett	
SURFACE COORDINATES: NE/4 SE/4, Sec.15, T57N, R65W			
GROUND ELEVATION: 3604'	PAD ELEVATION:	TOP CASING ELEVATION:	
RIG ON LOCATION: 7-7-76	SPUDDED: 7-16-76	COMPLETED: 10-25-76	
CIRCULATING MEDIA: Mud			
MAIN RIG & CONTRACTOR: Emsco GB500. Thomson Drilling Inc.	NO. OF COMPRESSORS & CAPACITY:		

BORE HOLE RECORD			CASING RECORD							
FROM	TO	SIZE	I.D.	WT./FT.	WALL	GRADE	CPL'G.	FROM	TO	CU. FT. CMT.
0'	49'	36"	29.25"*	118.65#	3/8"			0'	49'	135
49'	335'	26"	19.124"	94.00#		K-55		0'	331'	513
335'	1505'	17½"	12.615"	54.50#		K-55	ST&C	0'	1502'	1976**
1505'	2353'	12¼"	8.835"	40.00#		K-55	ST&C	1393'	2333'	960***
2353'	4355'									

TOTAL DEPTH: 4355'   AVERAGE MANDREL DEPTH: FROM REFERENCE ELEVATION:

JUNK & PLUGS LEFT IN HOLE:

SURVEYS PAGE: 13   CORING PAGE: 11   CU. FT. CMT. TOTAL IN PLUGS, ETC:

LOGGING DATA: Page 14.

BOTTOM HOLE COORDINATES: REFERENCE:

RIGS USED *(Site Prep Rigs *)*

RIG NO.	NAME	TYPE	CLASS	DAYS OPERATING	SECURED W CREW	SECURED W/O CREW	TOTAL DAYS ON LOC.
20	Thomson Drilling Inc.	Emsco GB500		100.50	-	-	100.50

REMARKS: * *Site Prep Items*

** 200 ft^3 circulated to surface.

*** Liner perforated at 1572' and squeeze cemented out perforations and around liner top with a total of 1631 ft^3 of cement in 4 stages.

NOTE: All depths shown are from kelly bushing 14' above ground level.

PREPARED BY: WDS:sjw   TIME BREAKDOWN ON NEXT PAGE

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Madison #1, Wyoming
TIME BREAKDOWN

SITE PREPARATION

DRILLING OPERATION TIME (DOT)		OTHER SCHEDULED TIME (OST)		OPERATIONAL DELAY TIME (ODT)	
DRILL		MOVE		RIG REPAIRS	
TRIPS		RUN CASING		W. O. DRILLING SUPPLIES	
SURVEYS		CEMENT CASING		CLEAN OUT FILL	
				SECURED WITH CREWS	
SITE DOT ____ DAYS		SITE OST ____ DAYS		SITE ODT ____	

TOTAL SITE PREP TIME ____ DAYS | REMARKS:

MAIN HOLE CONSTRUCTION

DRILLING OPERATION TIME (DOT)		OTHER SCHEDULED TIME (OST)		OPERATIONAL DELAY TIME (ODT)	
DRILL	10.88	MOBILIZATION & DEMOBILIZATION		RIG REPAIRS	0.02
TRIPS	5.89	CORE	12.74	W. O. EQUIPMENT	4.09
DRESS DRILLING ASSEMBLY		LOG	5.75	FISH	10.51
SINGLE SHOT DEV. SURVEYS	0.15	CASED HOLE DIR. SURVEYS		CLEAN OUT FILL	2.07
OPEN HOLE DIRECTION SURVEYS		UNLOAD CASED HOLE		UNLOAD WATER INFLOW	
Open Hole	13.76	RUN MANDREL		REAM CROOKED HOLE	
		HYDROLOGICAL TESTS	14.67	PLUG BACK	
		Nipple Up	1.19	DRILL OUT PLUGS	
MAIN HOLE DOT 30.68 DAYS		Circulate Samples	0.53	SECURED WITH CREWS	
CASING OPERATION TIME (COT)				Ream Out of Gauge Hole	0.34
RUN 20" CASING	0.50			Mix & Condition Mud	3.06
RUN 13-3/8" CASING	0.53			Recement Liner	10.31
CEMENT 20" CASING	0.38				
CEMENT 13-3/8" CASING	0.90				
DRILL OUT SHOE	0.32				
*	1.91				
MAIN HOLE COT 4.54 DAYS		MAIN HOLE OST 34.88 DAYS		MAIN HOLE ODT 30.40 DAYS	

TOTAL MAIN HOLE CONST. TIME 100.50 DAYS | REMARKS:

TOTAL ELAPSED TIME

TOTAL SITE PREP TIME		DAYS
TOTAL MAIN HOLE CONST. TIME	100.50	DAYS
SEC. W/O CREW SITE PREP		DAYS
SEC. W/O CREW MAIN HOLE CONST.		DAYS
TOTAL SUSPENDED (NO RIG)		DAYS
TOTAL ELAPSED TIME	100.50	DAYS

REMARKS:

* Run 9-5/8" Liner 0.79 Days
Cement 9-5/8" Liner 1.12 Days

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Madison #1, Wyoming
HOLE HISTORY

Prior to starting drilling operations 30" O.D., 3/8" wall casing was set at 35' ground level in a 36" hole and the annulus filled with 135 ft^3 of ready-mix cement.

Thomson Drilling Inc., rig #20, was moved in on 7-7-76 and was rigged up at 1900 hours on 7-16-76.

Note: All depths reported are from kelly bushing 14' above ground level (GL) unless otherwise shown.

7-16-76 Ran 17½" bit in the hole and drilled from 49' to 97' using conventional circulation with water.

7-17-76 Drilled 17½" hole from 97' to 330' and opened to 26" from 49' to 72' using 17½" bit and a 26" reamer.

7-18-76 Opened 17½" hole to 26" from 72' to 282' using mud as a drilling fluid.

7-19-76 Opened 17½" hole to 26" from 282' to 330' and drilled 26" hole to 335'. Ran 8 joints (330.76') of 20" O.D., 94#, K-55 casing in the hole with a B&W latch-in type float shoe on bottom.

7-20-76 Continued running casing and landed at 331' (317' GL) with centralizers at 321', 243' and 43'. Ran a latch-in tool on 4½" drill pipe and latched into shoe. Cemented annulus to surface using BJ with 40 barrels of water ahead of 450 sacks (513 ft^3) of type "G" cement + 2% calcium chloride. Cement in place at 0430 hours. Full returns during cementing. Pulled drill pipe. Cut off 20" O.D. casing and welded on a casinghead Installed a 20" Hydril blow out preventer.

7-21-76 Ran in hole and tagged cement at 322'. Tested blow out preventer to 1000 psi. Drilled out cement and shoe from 322' to 331' using 7-7/8" bit, 12¼" reamer and a 17½" reamer. Drilled 17½" hole to 340'. Laid down hole opener and ran 7-7/8" bit in the hole and drilled 7-7/8" hole from 340' to 650'. Circulated samples at 630' and 650'. Made trip for core barrel.

7-22-76 Ran Christensen core barrel with 7-7/8" diamond core bit in the hole and washed 15' to bottom. Cut core #1 from 650' to 680', recovered 29'. Reamed core hole and drilled 7-7/8" hole from 680' to 1293'.

7-23-76 Made trip for bit, washed and reamed 120' to bottom. Drilled 7-7/8" hole from 1293' to 1502'. Ran core bit in the hole, cleaned out 15' of fill and cut core #2 from 1502' to 1528', recovered 26'. Ran 7-7/8" bit in the hole.

7-24-76 Washed 30' to bottom, reamed core hole and drilled 7-7/8" hole from 1528' to 1568'. Measured out of hole and corrected depth to 1572'. Ran Birdwell density, neutron, gamma-induction, electric, acoustic log, and 3-D velocity logs to 1560'.

7-25-76	Continued running 3-D, guard, caliper and temperature logs to 1560'. Made trip with 7-7/8" bit and conditioned hole for a drill stem test. Ran Lynes drill stem test tool with a 7" packer in the hole on 2-7/8" O.D. tubing and set packer at 1504' with 18.50' of tool below the packer to test zone from 1500' to 1575'. Opened tool at 1415 hours and ran hydrologic test #1 as directed.
7-26-76	Completed test #1 at 0120 hours. Pulled out of hole. Ran hydrologic test #2 with straddle packers set at 650' and 725'. Opened tool at 1000 hours and ran test as directed to 1715 hours. Pulled out of hole with test tool. Made up hole opener with 7-7/8" bit, 12¼" reamer and a 17½" reamer. Ran in hole.
7-27-76	Opened 7-7/8" hole to 17½" from 340' to 391'. Pulled out of hole and removed 17½" reamer. Opened 7-7/8" hole to 12¼" from 391' to 814'.
7-28-76	Opened 7-7/8" hole to 12¼" from 814' to 1000'.
7-29-76	Opened 7-7/8" hole to 12¼" from 1000' to 1236'.
7-30-76	Opened 7-7/8" hole to 12¼" from 1236' to 1355'. Made trip at 1302' to change out reamer, washed and reamed 210' to bottom.
7-31-76	Opened 7-7/8" hole to 12¼" from 1355' to 1510'.
8-1-76	Made trip, removed 7-7/8" bit and added 17½" reamer to hole opener. Opened 12¼" hole to 17½" from 391' to 781'.
8-2-76	Opened 12¼" hole to 17½" from 781' to 978'. Made trip at 854' and changed out 17½" reamer.
8-3-76	Opened 12¼" hole to 17½" from 978' to 1273'.
8-4-76	Opened 12¼" hole to 17½" from 1273' to 1392'. Made trip at 1345' and changed out 17½" reamer.
8-5-76	Opened 12¼" hole to 17½" from 1392' to 1505'. Pulled out of hole and started running 13-3/8" O.D. casing.
8-6-76	Ran 49 joints (1502.77') of 13-3/8" O.D., 54.50#, K-55, ST&C casing with a B&W latch-in type float shoe on bottom. Landed casing at 1488.27' GL (1502.27 KB) with a centralizer at 1478' GL, metal petal basket at 1473' GL and centralizers at 1428', 1364' and 1305' GL. Ran latch-in tool on 4½" drill pipe and latched into shoe. Cemented annulus using BJ with 1500 gallons of mud sweep ahead of 1240 sacks (1748 ft^3) of Lite cement with 1/2# per sack of Cello-Flake and 2% calcium chloride followed by 200 sacks (228 ft^3) of type "G" cement with 1/2# per sack of Cello-Flake. Cement in place at 0940 hours. 200 ft^3 of cement circulated to surface. Pulled drill pipe out of the hole and nippled up.

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8-7-76 Welded a casinghead on the 13-3/8" O.D. casing and installed blow out preventer. Tested blind rams to 1000 psi. Ran 7-7/8" bit and 12½" reamer in the hole and tested drill pipe rams to 1000 psi. Drilled out cement and shoe from 1499' to 1502' and cleaned out to 1510'. Pulled out of hole and removed reamer. Ran 7-7/8" bit and junk sub in the hole and washed to 1520'. Circulated and built up mud viscosity.

8-8-76 Continued building up mud viscosity. Washed and reamed to 1572' and drilled 7-7/8" hole to 1582'. Pulled out of hole and recovered several small pieces of iron in junk sub. Ran back in hole and built up mud viscosity and volume. Made second trip and recovered small pieces of iron. Drilled 7-7/8" hole from 1582' to 1738' and lost circulation. Lost 153 barrels of mud. Pulled drill pipe to 1609' and had full returns. Built up mud volume and viscosity. Ran in hole to 1735' with full returns. Ran to 1738' and lost circulation. Lost 130 barrels of mud.

8-9-76 Pulled bit to 1706' pumped in lost circulation materials with no returns, lost 230 barrels of mud. Mixed mud and lost circulation materials. Pulled drill pipe into casing and pumped mud in the hole, fluid level 20' down in casing. Pulled out of hole. Ran Dresser Atlas caliper and induction logs, tool stopped at 1579'. Ran in hole to 1389', pumped 270 barrels of mud in the hole with no returns. Mixed up mud and regained full circulation at 1389'. Ran in hole, washed and reamed 124' to 1738' with full returns. Circulated to condition mud, lost 108 barrels while circulating. Pulled out of hole.

8-10-76 Ran Dresser Atlas induction and caliper logs, tool stopped at 1600'. Made trip in hole and did not hit any bridges. Attempted to log again and tool stopped at 1600'. Ran Lynes inflatable packer on 4½" drill pipe in the hole for hydrologic test #3 and set at 1540'. Ran test from 0756 to 0920 hours. Picked up Lynes 7" production packer and ran in hole on 2-7/8" O.D. tubing for hydrologic test #4. Set packer at 1542' and ran test as directed.

8-11-76 Completed test at 0400 hours. Pulled out of hole. Ran 7-7/8" bit in the hole, washed 150' to bottom and drilled 7-7/8" hole from 1738' to 1768' and lost returns. Lost 210 barrels of mud. Pulled 3 stands of drill pipe. Mixed mud and lost circulation materials. Lost 200 barrels of mud and regained 70% returns. Drilled 7-7/8" hole from 1768' to 1924', regained 100% returns at 1821'.

8-12-76 Drilled 7-7/8" hole from 1924' to 2084'. Pulled out of hole and ran 7-7/8" diamond core bit in the hole. Tagged fill at 1839' and cleaned out to 1984'.

8-13-76 Cleaned out fill from 1984' to 2062' and pulled out of hole. Ran 7-7/8" bit in the hole and washed 60' to bottom. Made short trip to check for fill and cleaned out 10' of fill. Pulled out of hole and made up 7-7/8" bit, 6 point reamer, 2 stabilizers and jars. Ran in hole and cleaned

8-14-76	Reamed out of gauge hole from 1870' to 2084' and drilled 7-7/8" hole from 2084' to 2087'. Made short trip to check for fill and cleaned out 5' of fill. Pulled out of hole and made up 7-7/8" core bit and barrel. Cleaned out 6' of fill and cut core #3 from 2087' to 2093'.
8-15-76	Completed core #3 from 2093' to 2117', recovered 30'. Washed and reamed core hole and drilled 7-7/8" hole from 2117' to 2195'.
8-16-76	Drilled 7-7/8" hole from 2195' to 2280'. Pulled out of hole. Made up core barrel and cut 7-7/8" core #4 from 2280' to 2301'.
8-17-76	Completed core #4 from 2301' to 2335', recovered 53'. Cut core #5 from 2335' to 2370'.
8-18-76	Completed core #5 from 2370' to 2388', recovered 53'. Ran Birdwell electric log, tool stopped at 1605'. Pulled tool and recovered a 2' x 6" piece of the drill pipe stripper rubber. Ran tool back in the hole and stopped at 1627'. Made trip with bit to clean out hole. Attempted to run guard log, tool not working.
8-19-76	Ran Birdwell electric, induction, density, guard, 3-D, caliper, sonic and temperature logs.
8-20-76	Ran Birdwell neutron log. Made trip with 7-7/8" bit to condition hole for testing. Made up Lynes 7" inflatable packer on 4½" drill pipe and set at 2299'. Ran hydrologic test #5 as directed at 1830 hours.
8-21-76	Completed test at 0230 hours. Made trip with 7-7/8" bit to condition hole for testing. Ran Lynes straddle packers in the hole on 4½" drill pipe, set packers from 2218' to 2298' and ran hydrologic test #6 from 0935 hours to 1530 hours. Made trip with 7-7/8" bit to condition hole and cleaned out 15' of fill. Picked up test tools and 2-7/8" O.D. tubing.
8-22-76	Ran Lynes straddle packers in the hole on 2-7/8" O.D. tubing, set packers from 2217' to 2305' and ran hydrologic test #7. Started swabbing at 0415 hours and completed test at 1800 hours. Could not release packers. Worked stuck packers up the hole 20' and could not move any further. Circulated thru ports in top packer to free.
8-23-76	Continued circulating and working tubing, could not free. Ran McCullough free point indicator inside the 2-7/8" O.D. tubing to fill at 2240', tubing free above this point. Ran 103' of 1-3/4" O.D. wash out pipe inside the 2-7/8" O.D. tubing on McCullough's wire line and attempted to wash out sand inside the tubing with no results. Pulled pipe, repaired same and welded a seal ring on the outside of the pipe.
8-24-76	Ran the wash out pipe back inside the tubing and washed out sand to 2274' by circulating down the tubing lowering the wash out pipe. Ran McCullough free point indicator and set down on fill at 2267', tubing free above this point. Lengthened wash out pipe to 133' and ran back inside the tubing, circulated and washed to 2287'. Ran free point indicator, tubing free above 2280'. Perforated bottom packer and worked loose. Bottom packer had been worked up to 2284'. Pulled out of hole.

8-25-76	Laid down test tools. Made trip with 7-7/8" bit to 1590' and conditioned hole for test. Made up Lynes straddle packers on 2-7/8" O.D. tubing. Ran in hole and set packers from 1482' to 1525'. Started swabbing for hydrologic test #8 and packers would not hold. Pulled out of hole and left bottom packer, 1 joint of tubing and 2 recorders in the hole. Ran a 6½" overshot in the hole on 4½" drill pipe. Worked over fish and deflated packer. Started out of hole.
8-26-76	Pulled out of hole and recovered all of fish. Made up 12¼" hole opener with a 7-7/8" pilot bit and opened 7-7/8" hole to 12¼" from 1505' to 1910'.
8-27-76	Opened 7-7/8" hole to 12¼" from 1910' to 2061'.
8-28-76	Opened 7-7/8" hole to 12¼" from 2061' to 2167'. Pulled out of hole and left 7-7/8" bit, 2' of guide below the 12¼" cones and all cones and bearings in the hole. Measured out of the hole and corrected depth to 2159'. Waited on fishing tools.
8-29-76	Ran 10½" magnet in the hole, cleaned out 20' of fill and worked magnet to bottom at 2159', recovered 8 bearings. Ran 7-5/8" mill in the hole and cleaned out 10' of fill. Attempted to push junk to bottom with no success. Lost 100 barrels of mud. Pulled mill and ran 11-3/4" x 3' Bowen junk basket. Drilled over junk from 2159' to 2162', no recovery. Left bottom set of fingers in the hole. Repaired junk basket and ran back in hole and worked over fish.
8-30-76	Pulled out of hole, no recovery. Ran 7-5/8" flat bottom mill in the hole and milled on junk at 2162'. Lost circulation, mixed mud and lost circulation materials. Milled on junk at 2162' and pushed to 2285'. Pulled out of hole and ran 7-5/8" wash over shoe. Washed over junk and pushed to 2289'.
8-31-76	Continued milling and washing over junk at 2289'. Pulled out of hole and ran 7-3/8" overshot to 2289' and attempted to work over fish, no recovery. Ran in hole with a magnet to 2289', recovered part of a 12¼" reamer cone.
9-1-76	Ran 7-5/8" flat bottom mill in the hole and milled on junk to 2290'. Pulled out of hole and ran McCullough junk shot to 2290'. Ran 7-5/8" magnet to 2290', no recovery. Mixed mud and lost circulation materials. Ran 12¼" hole opener and 7-7/8" pilot bit in the hole, reamed 100' of out-of-gauge hole and opened 7-7/8" hole to 12¼" from 2159' to 2164'.
9-2-76	Opened 7-7/8" hole to 12¼" from 2164' to 2284'.
9-3-76	Laid down hole opener and ran 12¼" bit. Opened 7-7/8" hole to 12¼" from 2284' to 2290' and hit junk. Pulled out of hole and made up 11-3/4" Bowen junk basket without fingers. Washed to bottom and worked over junk, no recovery. Ran a magnet in the hole and worked to bottom, no recovery.

9-4-76 Ran Bowen junk basket back in the hole and washed over junk from 2290' to 2294', no recovery. Added fingers to junk basket and worked over junk, no recovery. Made 3 runs with McCullough junk shot to 2294' and cleaned out fill after each shot. Ran 9" magnet in the hole, no recovery.

9-5-76 Ran 11-3/4" flat bottom mill with junk sub in the hole and milled on junk from 2294' to 2296', no recovery. Ran 7-5/8" mill in the hole and attempted to push junk down the hole with no success. Picked up 11-3/4" Bowen junk basket and washed over junk at 2294'.

9-6-76 Continued washing over junk to 2296', recovered bottom part of 7-7/8" bit, 2 cones and shanks. Top 1/3 of body had been milled off. Ran 11-3/4" mill in the hole and milled from 2296' to 2305'.

9-7-76 Milled on junk from 2305' to 2309'. Pulled out of hole and ran 7½" mill. Circulated mill to 2380' and milled on junk from 2380' to 2385'.

9-8-76 Milled on junk from 2385' to 2387'. Pulled out of hole and ran 7-5/8" Bowen junk basket. Washed over junk from 2387' to 2389', no recovery. Ran 12¼" reamer in the hole, washed and reamed 27' to 2289'.

9-9-76 Washed and reamed from 2289' to 2296'. Opened 7-7/8" hole from 2296' to 2353'. Pulled out of hole and ran Dresser Atlas caliper log. Made trip with bit to condition hole. Prepared to run casing.

9-10-76 Ran 9-5/8" O.D. casing in the hole on 4½" drill pipe, could not set liner hanger. Laid down casing and sent hanger to be modified.

9-11-76 Ran 31 joints (940.05') of 9-5/8" O.D., 40#, K-55, ST&C casing for a liner. Set liner hanger at 1393' (1379' GL) with the bottom of the liner at 2333' (2319' GL). Liner had a float shoe on bottom and a float collar on top of the bottom joint. Centralizers at 2328' and 2399', cement basket at 2147', centralizers at 2060' and 1724', cement basket at 1694', centralizers at 1547', 1457' and 1401'. Cemented annulus using BJ with 560 sacks (789 ft^3) of Lite cement with 1/4# per sack of Cello-Flake followed by 150 sacks (171 ft^3) of type "G" cement with 1/4# per sack of Cello-Flake. Cement in place at 0600 hours. Released liner running tool and pulled drill pipe. Waited on cement until 1900 hours. Ran Dresser-Atlas temperature and bond logs. Bonding indicated from 1572' to 2284'.

9-12-76 Waited on cement until 0800 hours. Perforated 9-5/8" O.D. liner using Dresser Atlas with 4 holes per foot at 1572'. Ran Johnson wire line squeeze packer and set at 1530'. Ran 4½" drill pipe in the hole and latched into packer. Squeezed perforations using BJ with 190 sacks (268 ft^3) of Lite cement. Cement in place at 1645 hours. Reversed out approximately 40 sacks (56 ft^3) of cement. Pulled drill pipe out of hole.

9-13-76 Ran Dresser Atlas bond and temperature log, top of cement in casing at 1438'. Washed and drilled cement from 1438' to packer at 1530'. Pressured up on squeeze packer, no pressure. Started drilling out packer.

9-14-76 Drilled out packer and cement to 1571'. Ran Dresser Atlas bond log. Set Baker cement retainer at 1440'. Waited on retrievable squeeze packer.

9-15-76 Waited on packer to 0600 hours. Ran 13-3/8" retrievable packer in the hole on 4½" drill pipe and set at 1279'. Pressured up on annulus to 150 psi for 15 minutes, packer held. Cemented squeeze #2 using BJ with 470 sacks (536 ft^3) of type "G" cement + 2% calcium chloride and 1/4# per sack of Cello-Flake. Displaced cement with water. Cement in place at 0930 hours. Held pressure for 30 minutes. Released packer and reversed out excess cement. Waited on cement to 1800 hours. Reseated packer and cemented squeeze #3 with 575 sacks (656 ft^3) of type "G" cement + 3% calcium chloride and 1/2# per sack of Cello-Flake. Cement in place at 2100 hours. Released packer and reversed out excess cement. Reseated packer and pressured up to 1400 psi for 30 minutes. Released packer and waited on cement.

9-16-76 Waited on cement to 1030 hours. Ran 12¼" bit in the hole and tagged cement at 1347'. Circulated and conditioned mud to 2115 hours. Drilled out cement from 1347' to 1378'.

9-17-76 Drilled out cement from 1378' to liner top at 1393'. Pressured up on 9-5/8" liner to 1190 psi for 30 minutes. Made trip for 8½" bit and drilled out cement from 1393' to 1401'. Pressured up on liner to 1240 psi for 30 minutes. Reamed and washed to Baker cement retainer at 1440'. Pulled bit and ran Baker sub in the hole. Screwed into retainer and pressured up on perforations at 1572'. Pumped into perforations between 1200 psi and 1400 psi, pressure would hold at 800 psi. Released sub and circulated hole.

9-18-76 Rigged up to squeeze. Sub would not latch into retainer. Pressured up to 1400 psi using BJ pump truck, pressure held. Pulled out of hole and ran 8½" bit, drilled out cement retainer at 1440' and ran bit to 2271'. Pumped 10 barrels of fluid at 600 psi in perforations at 1572'. Stopped pump and pressure dropped to 0 psi. Pulled out of hole and ran Dresser Atlas cement bond log.

9-19-76 Ran Halliburton 9-5/8" RTTS packer in the hole on 4½" drill pipe and set at 1630', pressured up to 950 psi and pressure held. Reset packer at 1540' and pressured up to 500 psi in the annulus, pressure held. Reset packer at 1473' and pumped 30 barrels of fluid into perforations at 1572' with 950 psi at a rate of 3 bpm. Cemented squeeze #4 in stages using BJ with 150 sacks (171 ft^3) of type "G" cement, maximum squeeze pressure 1500 psi. Cement in place at 1815 hours. Released packer and reversed out excess cement. Reset packer and pressured up to 1500 psi for 15 minutes. Pulled out of hole.

9-20-76 Waited on cement to 0945 hours. Ran 8½" bit in the hole and drilled out cement from 1511' to 1588'. Pressured up on casing to 800 psi and pressure held. Ran bit to 2277' and drilled on junk and cement to float collar at 2290'.

9-21-76 Pulled out of hole and cleaned out junk sub, recovered 20# of iron. Made 2 trips with a 7" magnet and junk sub, recovered 20# of iron both times. Ran 7-7/8" bit and junk sub in the hole and drilled on junk and cement from 2290' to 2301'. Pressured up on casing to 800 psi for 15 minutes, pressure held. Drilled on junk and cement from 2301' to 2321'. Pressure tested casing to 800 psi, pressure held. Pulled out of hole and recovered 20# of iron. Ran 7" magnet and junk sub in the hole to 2321'. Pressure tested casing to 1000 psi for 20 minutes, pressure held. Pulled out of hole and recovered 20# of iron. Made trip with magnet and junk sub.

9-22-76 Recovered 20# of iron. Ran 7-7/8" bit in the hole and drilled out cement and shoe from 2321' to 2333'. Cleaned out to 2388' and drilled 7-7/8" hole from 2388' to 2449'. Circulated out samples and pulled out of hole. Cleaned out junk sub and recovered 10# of iron. Made 2 trips with a magnet and junk sub, recovered a total of 15# of iron. Ran 7½" Globe basket and cored from 2449' to 2450'.

9-23-76 Cored with junk basket from 2450' to 2451', recovered 6" of core and 1 piece of iron. Ran 7-7/8" bit in the hole, reamed 60' of hole to bottom and reamed 7½" hole from 2449' to 2450'. Made 2 trips with a magnet and junk sub and recovered approximately 8# of iron on each trip. Ran 7-7/8" bit in the hole and worked by iron. Drilled 7-7/8" hole from 2450' to 2452'.

9-24-76 Drilled 7-7/8" hole from 2452' to 2455' and pulled bit. Cut 6-1/8" core #6 from 2455' to 2474', recovered 19'. Ran 7-7/8" bit in the hole and washed from 2413' to 2455'. Reamed core hole from 2455' to 2463'.

9-25-76 Reamed core hole from 2463' to 2474' and pulled bit. Cut 6-1/8" core #7 from 2474' to 2500', recovered 23.5'. Ran 7-7/8" bit in the hole and reamed core hole to 2500'.

9-26-76 Cut 7-7/8" core #8 and #9 from 2500' to 2525', cored 25', recovered 24'.

9-27-76 Ran 7-7/8" bit in the hole and drilled from 2525' to 2635'. Lost 400 barrels of mud at 2554'. Measured out of hole and corrected depth to 2632'. Cut 7-7/8" core #10 from 2632' to 2646'.

9-28-76 Recovered 13.5' on core #10. Cut 7-7/8" core #11 from 2646' to 2676', recovered 28.5'. Ran 7-7/8" bit in the hole, washed and reamed 30' to bottom and drilled 7-7/8" hole from 2676' to 2760'. Circulated samples out of the hole.

9-29-76 Pulled out of hole. Cut 7-7/8" core #12 from 2760' to 2820', recovered 60'.

9-30-76	Cut 7-7/8" core #13 from 2820' to 2845', recovered 25'. Ran 7-7/8" bit in the hole, reamed from 2785' to 2845' and drilled to 2958'.
10-1-76	Drilled 7-7/8" hole from 2958' to 3015'. Circulated samples out of the hole and pulled bit. Cleaned out 17' of fill and cut 7-7/8" core #14 from 3015' to 3070'.
10-2-76	Recovered 54' on core #14. Ran 7-7/8" bit in the hole, washed and reamed 35' to bottom. Drilled 7-7/8" hole from 3070' to 3102' and pulled bit. Cut 7-7/8" core #15 from 3102' to 3132', recovered 30'. Ran 7-7/8" bit in the hole and reamed to bottom.
10-3-76	Drilled 7-7/8" hole from 3132' to 3185' and pulled bit. Cut 7-7/8" core #16 from 3185' to 3191', recovered 6'. Ran 7-7/8" bit in the hole and drilled from 3191' to 3272'. Circulated samples to surface.
10-4-76	Pulled out of hole. Cut 7-7/8" core #17 from 3272' to 3302', recovered 29.5'. Ran 7-7/8" bit in the hole and washed to bottom. Drilled 7-7/8" hole from 3302' to 3390'.
10-5-76	Drilled 7-7/8" hole from 3390' to 3491', lost 450 barrels of mud. Mixed up mud and lost circulation materials. Pulled out of hole. Ran 7-7/8" core bit in the hole and reamed 6' to bottom. Cut core #18 from 3491' to 3497'.
10-6-76	Completed core #18 from 3497' to 3521', recovered 29.5'. Ran 7-7/8" bit in the hole and drilled from 3521' to 3610'. Circulated samples out of the hole and pulled bit.
10-7-76	Cut 7-7/8" core #19 from 3610' to 3643' and lost 80 barrels of mud, recovered 2'. Ran 7-7/8" bit in the hole and drilled from 3643' to 3796'. Circulated samples at 3705'.
10-8-76	Drilled 7-7/8" hole from 3796' to 3964'.
10-9-76	Drilled 7-7/8" hole from 3964' to 4064'. Made trip at 4053' to lay down and load out 2-7/8" O.D. tubing.
10-10-76	Drilled 7-7/8" hole from 4064' to 4145'. Circulated samples to surface and pulled bit. Washed and reamed 33' to bottom and cut 7-7/8" core #20 from 4145' to 4175', recovered 30'. Ran 7-7/8" bit in the hole, washed and reamed 60' to bottom. Drilled 7-7/8" hole from 4175' to 4200'.
10-11-76	Drilled 7-7/8" hole from 4200' to 4292'. Circulated samples to surface and pulled bit. Reamed 8' to bottom and cut 7-7/8" core #21 from 4292' to 4326'.
10-12-76	Recovered 34' on core #21. Ran 7-7/8" bit in the hole and reamed 34' to bottom. Drilled 7-7/8" hole from 4326' to 4346'. Circulated samples to surface and pulled bit. Cut core 7-7/8" core #22 from 4346' to 4350'.

10-13-76	Completed core #22 from 4350' to 4355', recovered 7½'. Laid down core barrel. Ran Birdwell logs.
10-14-76	Ran Birdwell logs.
10-15-76	Ran Birdwell logs. Ran 7-7/8" bit in the hole and conditioned mud.
10-16-76	Conditioned hole and pulled bit. Ran 7" Lynes packer in the hole on 4½" drill pipe and set at 4094'. Ran hydrologic test #9 from 4094' to 4355' from 0915 to 1445 hours. Pulled out of hole. Picked up 7" Lynes production packer and 2-7/8" O.D. tubing.
10-17-76	Ran Lynes production packer in the hole and set packer at 4092' after the third trip. Swabbed tubing and ran hydrologic test #10, well flowing at 55 gpm. Started test at 1900 hours.
10-18-76	Completed test at 1130 hours. Pulled out of hole. Ran Lynes 7" inflatable packers in the hole on 4½" drill pipe. Set packers from 3579' to 3694' and ran hydrologic test #11 from 2015 to 2315 hours. Picked up packers and set from 3329' to 3440'.
10-19-76	Ran hydrologic test #12 from 0 to 0130 hours, tool plugged. Pulled out of hole and cleaned up tool. Ran back in hole and set packers from 3579' to 3694'. Ran hydrologic test #13, tool open from 0600 to 0730 hours and could not close. Pull tool and dressed packers. Ran back in hole and set packers from 3300' to 3480'. Ran hydrologic test #14 from 1545 to 1930 hours. Pulled out of hole and picked up tools for test #15.
10-20-76	Ran in hole and set packers from 2530' to 2570'. Ran hydrologic test #15 from 0415 to 1515 hours, hole flowing 18 gpm. Pulled tool and dressed packers. Ran back in hole and set packers from 2434' to 2530'. Started hydrologic test #16 at 2230 hours, hole flowing 20 gpm.
10-21-76	Completed test #16 at 1515 hours and laid down tools. Ran 7-7/8" bit in the hole to 4355' and conditioned mud.
10-22-76	Laid down drill pipe and removed blow out preventers. Waited on well head.
10-23-76	Installed well head and connected up. Ran 2-7/8" O.D. tubing in the hole to 3600'. Swabbed tubing and flowed hole. Raised tubing to 2100', swabbed tubing and flowed hole. Raised tubing to 1700' and swabbed.
10-24-76	Raised tubing to 1200', swabbed and flowed hole. Raised tubing to 880', swabbed and flowed hole. Laid down tubing. Hole flowed 250 gpm at 29 psi. Temperature of water was 124° F. Shut in from 1430 to 1600 hours. Opened up and flowed at 250 gpm at 32 psi. Temperature was 124° F. Shut in at 1800 hours. Shut in pressure was 48 psi.
10-25-76	Hole shut in. Released rig for demobilization at 0700 hours.

CORE RECORD

Core No.	Interval	RPM	Weight On Bit 1000#	Circulating Pressure psi	Feet Cored	Feet Recovered	% Recovery
1	650' - 680'	52	8-12	-	30	29	97
2	1502' - 1528'	52	8-14	650	26	26	100
3	2087' - 2117'	52	6-16	800	30	30	100
4	2280' - 2335'	52	8-16	1050	55	53	96
5	2335' - 2388'	52	10-18	1000	53	53	100
6	2455' - 2474'	44	8-16	800	19	19	100
7	2474' - 2500'	44	8-16	825	26	23.5	90
8	2500' - 2513'	44-48	8-16	825	13	12.5	96
9	2513' - 2525'	48	10-14	750-850	12	11.5	96
10	2632' - 2646'	48	8-16	850	14	13.5	96
11	2646' - 2676'	48	8-16	900	30	28.5	95
12	2760' - 2820'	48	8-18	850-950	60	60	100
13	2820' - 2845'	48	8-18	850-900	25	25	100
14	3015' - 3070'	48	8-18	800-950	55	54	98
15	3102' - 3132'	48	8-18	800-950	30	30	100
16	3185' - 3191'	48	10-18	850	6	6	100
17	3272' - 3302'	56-48	8-18	850	30	29.5	98
18	3491' - 3521'	48	8-18	900-1000	30	29.5	98
19	3610' - 3643'	48	8-15	750-950	33	2	6
20	4145' - 4175'	48-40	8-12	900-1000	30	30	100
21	4292' - 4326'	48	10-18	1100-1200	34	34	100
22	4346' - 4355'	48	14-20	1000	9	7.5	83
	TOTAL				650	607	93

BIT RECORD

Bit No.	Make	Size	Type	Depth Out	Feet Drilled	Rotating Hours	
1	Security	17½"	S3ST	335'	286'	16-3/4	
2	Reed	26"	Hole Opener	335'	286'	33	& Bit #1
3	Reed	7-7/8"	Y11	340'	5'	6	Cement
4	Reed	7-7/8"	Y11	650'	310'	4-1/4	
5	Christensen	7-7/8"	MC20	680'	30'	2-1/2	
4 Rerun				1293'	613'	14-1/4	
6	Reed	7-7/8"	Y12	1502'	209'	6-1/2	
5 Rerun		7-7/8"		1528'	26'	4-3/4	
6 Rerun		7-7/8"		1572'	44'	2-1/4	
7	Reed	17½"	Hole Opener	391'	56'	9-3/4	& Bit #6
8	Reed	12¼"	Hole Opener	1302'	967'	61	& Bit #6
9	Reed	12¼"	Hole Opener	1510'	208'	31-1/4	& Bit #6
7 Rerun		17½"		854'	463'	30-1/2	
10	Security	12¼"	S3J				Pilot Bit
11	Reed	17½"	Hole Opener	1345'	491'	43	& Bit #10
12	Reed	17½"	Hole Opener	1505'	160'	20-3/4	& Bit #10
13	Reed	7-7/8"	Y13	1738'	166'	3-1/4	
14	Smith	7-7/8"	F2	2084'	346'	24-1/4	
15	Security	7-7/8"	H7SGJ	2087'	3'	1/4	
5 Rerun		7-7/8"		2117'	30'	7-1/4	
15 Rerun		7-7/8"		2280'	163'	27-1/4	
5 Rerun		7-7/8"		2388'	108'	30-3/4	
16	Reed	12¼"	Hole Opener	2159'	649'	51-1/2	
17	Security	12¼"	Hole Opener	2284'	125'	24	
18	Security	12¼"	S4TJ	2290'	6'	2-1/2	
19	Reed	12¼"	Hole Opener	2353'	63'	6	
20	Security	8½"	M4NGJ	(Drilled cement & retainer)			
21	Security	8½"	M4NGJ				Circulate
18 Rerun		12¼"		(Drilled cement)			
21 Rerun		8½"		(Drilled cement & retainer)			
22	Security	8½"	M4NGJ	(Drilled cement & retainer)			
23	Security	8½"	H77SG	(Drilled cement & junk)			
24	Reed	7-7/8"	Y21G	(Drilled cement & junk)			
25	Reed	7-7/8"	Y21G	2449'	128'	7-1/4	Cem.& Shoe
26	Reed	7-7/8"	H7SG	2450'	1'	2	Junk
27	Reed	7-7/8"	Y31G	2455'	5'	2	Junk
28	Christensen	6-1/8"	MC23	2474'	19'	9-1/4	
26 Rerun		7-7/8"		2474'	19'	3-3/4	Reaming
28 Rerun		6-1/8"		2500'	26'	10-1/4	
27 Rerun		7-7/8"		2500'	26'	3	Reaming
5 Rerun		7-7/8"		2525'	25'	10-1/2	
29	Reed	7-7/8"	Y31GJ	2632'	107'	11-3/4	
5 Rerun		7-7/8"		2676'	44'	11-1/2	
30	Smith	7-7/8"	F4	2760'	84'	9-1/4	

BIT RECORD (Cont'd.)

Bit No.	Make	Size	Type	Depth Out	Feet Drilled	Rotating Hours
5 Rerun		7-7/8"		2845'	85'	24
30 Rerun		7-7/8"		3015'	170'	12-1/4
5 Rerun		7-7/8"		3070'	55'	14-1/2
30 Rerun		7-7/8"		3102'	32'	3-3/4
5 Rerun		7-7/8"		3132'	30'	7-1/2
30 Rerun		7-7/8"		3185'	53'	5-1/2
5 Rerun		7-7/8"		3191'	6'	3-3/4
30 Rerun		7-7/8"		3272'	81'	3-1/4
5 Rerun		7-7/8"		3302'	30'	9-1/4
30 Rerun		7-7/8"		3491'	189'	14-1/2
31	Christensen		MC23	3521'	30'	11-1/4
30 Rerun		7-7/8"		3610'	89'	9-1/4
31 Rerun		7-7/8"		3643'	33'	3-3/4
30 Rerun		7-7/8"		4145'	502'	59
31 Rerun		7-7/8"		4175'	30'	2-1/4
30 Rerun		7-7/8"		4292'	117'	6-1/2
31 Rerun		7-7/8"		4326'	34'	10-3/4
32	Security	7-7/8"		4346'	20'	3-1/2
31 Rerun		7-7/8"		4355'	9'	11-1/4

DEVIATION SURVEYS (TOTCO)

Date	Depth-Ft.	Inclination-Degrees
7-16-76	80	0
7-17-76	112	0
	237	1/8
	330	1/2
7-21-76	650	3/4
7-23-76	1293	1
8-13-76	2084	3/4
8-18-76	2380	1-1/2
9-2-76	2154	1-1/2
9-3-76	2284	1
9-26-76	2500	1
9-29-76	2760	1-1/2
10-1-76	3015	1-3/4
10-4-76	3272	1-3/4
10-7-76	3610	2
10-8-76	3805	1-3/4
10-11-76	4292	2
10-12-76	4346	1-3/4

LOG INDEX SHEET

Type Log	Date	Run No.	Depth Driller	Depth Logger	Logged From	Logged To
BIRDWELL LOGS						
Acoustic Borehole Compensated	7-24-76	1	1572'	1560'	331'	1555'
Acoustic Borehole Compensated	8-19-76	2	2387'	2381'	1503'	2368'
Acoustic Borehole Compensated	10-14-76	3	4355'	4351'	2150'	4336'
Caliper	7-25-76	1	1572'	1560'	300'	1560'
Caliper	8-19-76	2	2387'	2382'	1503'	2380'
Caliper	10-14-76	3	4355'	4348'	2330'	4347'
Density Borehole Compensated	7-24-76	1	1572'	1560'	331'	1559'
Density Borehole Compensated	8-19-76	2	2387'	2384'	50'	2382'
Density Borehole Compensated	10-14-76	3	4355'	4348'	1400'	4347'
Electric	7-24-76	1	1572'	1560'	331'	1558'
Electric	8-19-76	2	2387'	2384'	1503'	2382'
Electric	10-13-76	3	4355'	4353'	2337'	4351'
Induction Electric	8-19-76	2	2387'	2384'	1503'	2379'
Gamma Ray-Induction	7-24-76	1	1572'	1560'	331'	1554'
Gamma Ray-Induction	10-13-76	3	4355'	4348.5'	2336'	4343'
Guard	7-25-76	1	1572'	1560'	334'	1553'
Gamma-Guard	8-19-76	2	2387'	2382'	1503'	2374'
Gamma-Guard	10-13-76	3	4355'	4348'	2340'	4344'
Micro-Contact	10-13-76	3	4355'	4353'	2333'	4351'
Neutron Borehole Compensated	7-24-76	1	1572'	1560'	331'	1559'
Neutron Borehole Compensated	8-19-76	2	2387'	2381'	1503'	2378'
Neutron Borehole Compensated	10-14-76	3	4355'	4348'	2250'	4347'
NCTL	10-15-76	3	4355'	N/R	300'	2400'
Temperature	7-25-76	1	1572'	1560'	0'	1560'
Temperature	8-19-76	2	2387'	2382'	0'	2382'
Temperature	10-15-76	3	4355'	4348'	200'	4340'

LOG INDEX SHEET (Cont'd.)

Type Log	Date	Run No.	Depth Driller	Depth Logger	Logged From	Logged To
BIRDWELL LOGS (Cont'd.)						
3-D Velocity - 3'	7-24-76	1	1572'	1560'	100'	1550'
3-D Velocity - 6'	7-24-76	1	1572'	1560'	100'	1550'
3-D Velocity - 3'	8-19-76	2	2387'	2382'	1400'	2377'
3-D Velocity - 6'	8-19-76	2	2387'	2382'	100'	2378'
3-D Velocity - 3'	10-15-76	3	4355'	4348'	2300'	4350'
3-D Velocity - 6'	10-15-76	3	4355'	4348'	430'	4344'

NOTE: Finished prints of the above logs furnished by USGS.

Type Log	Date	Run No.	Depth Driller	Depth Logger	Logged From	Logged To
DRESSER ATLAS LOGS						
Acoustic Cement Bond VDL	9-11-76	1	2289'	2282'	1370'	2379'
Acoustic Cement Bond VDL	9-14-76	2	2285'	2286'	300'	2283'
Induction Electrolog	8-9-76	1	1738'	1600'	1503'	1595'
Differential Temperature	9-11-76	1	2389'	2383'	0'	2382'
Differential Temperature	9-13-76	2	2389'	1438'	0'	1437'

NOTE: Field prints of the above logs furnished by USGS.

MUD REPORT

Date	Depth	Wt.	Vis.	Yld.	pH	Wtr. Loss	Chlorides PPM	Solids
7-17-76	200	8.4	28					
18	102	(reaming)						
		8.8	28					
19	325	(reaming)						
		8.8	50					
21	335							
22	650							
23	1395	9.2	37	10	10.5	6.4	300	6.0%
24	1586	9.6	59	18	11.0	5.6	300	9.0%
25	1572	9.5	60	22	11.0	5.2	300	8.5%
26	317							
27	380	9.2	49	12	12.0	5.2	300	6.5%
28	866	9.2	45	13	11.0	6.0	300	6.0%
29	1071	9.4	44	13	9.5	6.8	300	7 3/4%
30	1300	9.3	37	7	11.0	6.0	300	7.0%
31	1392	9.2	37	8	9.5	5.2	300	6.0%
8- 1-76	443	9.1	34	8	9.5	5.2	300	5.0%
2	832	9.5	37	12	10.5	5.6	350	9.0%
3	1014	9.9	49	18	10.5	7.0	300	12.0%
4	1305	10.2	38	18	10.0	8.0	350	13.0%
5	1460	9.9	36	4	10.5	7.0	200	11.0%
6	1502	(running casing)						
8	1574	8.9	37	4	12.0	6.0	300	4.0%
9	1738	9.2	52	11	12.0	8.8	300	6.0%
12	1991	9.0	37	8	10.5	6.8	300	5.0%
13	2084	9.1	63	15	11.5	5.6	350	5.5%
14	2087	9.1	75	26	11.5	6.0	300	5.0%
15	2117	9.2	73	27	10.5	6.0	350	6.0%
16	2230	9.1	46	10	10.5	6.0	400	5.0%
17	2280	9.1	53	11	10.0	6.0	400	5.0%
18	2387	9.1	60	13	10.5	6.5	400	5.0%
20	2388	9.0	53	18	9.0	6.0	300	5.0%
25	1550	9.3	47	10	12.0	6.8	350	7.0%
26	1554	8.9	42	6	11.0	6.0	350	4.0%
27	1948	9.1	50	12	10.5	5.6	350	5.5%
28	2157	9.1	38	5	10.5	6.0	350	5.0%
29	1259	9.1	39	4	10.0	6.0	350	5.0%
9- 2-76	2200	9.0	45	9	10.0	8.0	350	5.0%
5	2294	9.3	43	8	11.0	7.2	350	6.5%
6	2296	9.2	53	14	11.0	6.4	350	6.5%

Mud Report - 2

Date	Depth	Wt.	Vis.	Yld.	pH	Wtr. Loss	Chlorides PPM	Solids
9- 7-76	2309	9.2	50	11	10.5	5.6	350	6.5%
8	2387	9.3	66	20	11.0	6.8	300	7.0%
9	2306	9.3	60	15	11.0	7.2	300	7.0%
14	2326	8.3	53	10	10.0	5.0	400	7.0%
17		9.0	43	6	10.5	8.0	350	6.0%
20	2284	9.0	45	6	11.5	9.2	400	6.0%
22	2398	9.1	43	8	11.0	7.6	350	6.5%
23	2449	9.2	46	6	11.5	5.2	350	7.0%
24	2455	9.2	45	8	11.0	5.8	400	7.0%
25	2476	9.2	45	9	10.0	5.2	500	7.0%
26	2513	9.2	47	9	10.5	5.0	500	7.0%
27	2580	9.2	45	10	11.0	4.8	600	7.0%
28	2676	9.2	45	9	10.5	5.0	500	7.0%
29	2767	9.1	43	11	11.0	4.4	400	6.0%
30	2840	9.1	43	6	11.0	5.0	400	6.0%
10- 1-76	3015	9.1	44	8	10.0	5.0	400	6.0%
2	3090	9.1	49	12	10.0	5.0	400	6.0%
3	3185	9.2	56	22	11.0	5.5	400	7.0%
4	3278	9.1	44	8	10.5	5.5	400	6.0%
5	3470	9.2	44	4	10.5	6.0	400	7.0%
6	3516	9.2	60	22	10.0	5.0	400	7.0%
7	3610	9.2	52	16	10.0	5.0	400	7.0%
8	3858	9.2	52	14	10.0	5.4	400	7.0%
9	4050	9.2	51	10	10.0	5.2	400	7.0%
10	4115	9.2	50	7	10.0	5.0	400	7.0%
11	4292	9.1	48	8	10.0	5.0	400	6.0%
12	4339	9.4	58	22	10.5	5.2	400	8.0%
10-13-76	4355	9.4	65					

Geology of test well

The following log tops and lithology are from the report from Hegna, Kerns, and Traut. The stratigraphic nomenclature from their report and that on table 1 have not been checked for conformance with the nomenclature presently used by the U.S. Geological Survey.

The core-analysis results are from the report furnished by the Core Laboratories, Inc., Denver, Colo.

Table 1.--Core intervals

(Depths are from kelly bushing (3,618 ft above sea level), which is 14 ft above land surface)

Core No.	Interval (depth in ft)	Cored (ft)	Recovered (ft)	Formation
1	650-680	30	29	Sundance (Hulett SS Mbr.)
2	1502-1528	26	26	Minnekahta Ls.
3	2087-2117	30	30	Amsden
4	2280-2335	55	53	Amsden and Madison
5	2335-2388	53	53	Madison
6	2455-2474	19	19	Madison
7	2474-2500	26	23.5	Madison (Mission Canyon)
8	2500-2513	13	12.5	Madison (Mission Canyon)
9	2513-2525	12	11.5	Madison (Mission Canyon)
10	2632-2646	14	13.5	Madison (Mission Canyon)
11	2646-2676	30	28.5	Madison (Mission Canyon)
12	2760-2820	60	60	Madison (Lodgepole)
13	2820-2845	25	25	Madison (Lodgepole)
14	3015-3070	55	54	Madison, Devonian, and Stony Mountain
15	3102-3132	30	30	Red River
16	3185-3191	6	6	Red River
17	3272-3302	30	29.5	Red River
18	3491-3521	30	29.5	Red River (Hecla Mbr.)
19	3610-3643	33	2	Winnipeg SS
20	4145-4175	30	30	Flathead SS
21	4292-4326	34	34	Flathead SS and Precambrian
22	4346-4355	9	7.5	Precambrian

LOG TOPS

	BIRDWELL	DRESSER ATLAS
SUNDANCE	444'	
HULETT SANDSTONE	616'	
GYPSUM SPRING	808'	
GOOSE EGG	1294'	
MINNEKAHTA	1500'	1506'
OPECHE	1530'	1534'
MINNELUSA-AMSDEN		1570'
BELL SANDSTONE	2280'	
MADISON	2292'	
MISSION CANYON	2482'	
LODGEPOLE	2754'	
ENGLEWOOD	3030'	
DEVONIAN (?)	3042'	
STONY MOUNTAIN	3060'	
RED RIVER	3070'	
WINNIPEG		
ROUGHLOCK SANDSTONE	3530'	
ICEBOX SHALE	3542'	
ALLADIN-WINNIPEG SANDSTONE	3596'	
DEADWOOD	3692'	
FLATHEAD	4096'	
PRECAMBRIAN (ELLISON ?)	4295'	

LITHOLOGY

10' samples begin @ 50'

50- 80	Sandstone, light gray, very fine grained/fine grained, subangular, clean, quartzose, mostly unconsolidated grains w/some dark gray/ black and orange chert grains, noncalcareous
80- 110	Sandstone as above w/decreasing chert grains, very clean
110- 120	Sandstone as above w/some dark gray and tan claystone
120- 140	Sandstone, tan, fine grained, subangular, unconsolidated, very clean, quartzose
140- 150	Sandstone, light gray/tan, very fine grained, subangular, abundant Fe stain
150- 190	Claystone, light gray, soft, noncalcareous
190- 200	Claystone as above w/some mottled red, yellow and purple
200- 210	Sandstone, light gray, very fine grained/medium grained, subround/ well rounded, unconsolidated w/some dark gray shale
210- 260	Claystone, greenish gray, red, tan, green and dark gray
260- 270	Sandstone, clear, medium grained/coarse, well rounded, unconsolidated w/varicolored claystone as above
270- 300	Claystone, light green, soft, subwaxy w/some tan, red and gray, trace pyrite
300- 310	Sandstone, clear, fine grained, well rounded, very friable
310- 330	Claystone, light green/greenish gray, soft, subwaxy, SLM 335'
330- 340	Mostly cavings sandstone and claystone as above
340- 370	Claystone, brick red and light gray, silty, subwaxy
370- 380	Claystone, light gray and green, soft, waxy
380- 470	Siltstone, light yellowish gray, noncalcareous, argillaceous w/ green and red claystone w/few coarse, subangular, free chert grains in red claystone matrix
470- 500	Claystone, greenish gray, waxy w/light gray bentonite
500- 630	Claystone as above w/some gray glauconitic siltstone and thin lenses sandstone, light gray, very fine grained, friable, glauconitic, calcareous

HULETT SANDSTONE

630	Circulating Sandstone, light brownish gray, very fine grained, soft, subround, friable, some clay infill, abundant bentonite
630- 650	Sandstone, white/light gray, very fine grained, well sorted, friable, soft
650- 680	Core #1 (Hulett) - recovered 29'

Sandstone, white/greenish white, very fine grained, subangular, well sorted, calcareous, friable w/green clay infilled matrix, locally glauconitic, some thin greenish gray claystone partings

Lithology - 2

680- 750	Sandstone, white, very fine grained, friable, clay infilled, fair/good porosity
750- 770	Sandstone, white/light gray, very fine grained, glauconitic, soft, clay infill
770- 820	Claystone, greenish gray, soft, bentonitic w/pyrite, trace sandstone, white, very soft, very fine grained, glauconitic

GYPSUM SPRING-SPEARFISH

820- 850	Shale, brick red, silty w/white/clear anhydrite
850- 880	Dolomite, tan, dense, chalky
880- 900	Shale, brick red, anhydritic, clear, and dolomite, tan, interbedded
900- 940	Limestone, tan, chalky w/gypsum and anhydrite w/few tan chert inclusions
940- 960	Anhydrite, white w/maroon, green and yellow shale
960-1010	Shale and siltstone, brick red w/white anhydrite
1010-1110	Siltstone, brick red, decreasing anhydrite, some green mottling
1110-1150	Siltstone, brick red
1150-1200	Shale, brick red, occasionally silty
1200-1300	Siltstone, brick red, trace white anhydrite

GOOSE EGG

1300-1380	Siltstone as above w/greenish gray, waxy shale
1380-1410	Limestone, light gray/pinkish white, hard, dense w/green and red siltstone
1410-1500	Siltstone, brick red w/some green, waxy claystone, trace white anhydrite

MINNEKAHTA

1502	Circulating Dolomite, white/tan, dense, hard

1502-1528 Core #2 - recovered 26'

Dolomite, light gray/cream, dense, micritic, hard, vuggy at top, lavender, argillaceous @ base, locally fractured, vertical fractures @ 1504', 1507-1510', and 1524', shattered rubble zones @ 1518-1519', 1521-1523', and 1526-1528', vugs @ 1504', 1507-1510' (partially filled w/calcite and pyrite), stylolite @ 1505', bleeding water @ 1514-1517'

OPECHE

1530-1550	Shale, green, soft, subwaxy w/some brownish red siltstone

Lithology - 3

1550-1568	Siltstone, purple, soft, calcareous

MINNELUSA-AMSDEN

1568	Circulating Sandstone, white/light gray, very fine grained, friable, dolomitic, fair porosity
1568-1596	No samples
1596-1710	Sandstone, light gray, very fine grained/coarse, poor sorting, well rounded, coarse frosted grains, some spotty light greasy stain, very weak fluorescence, good strong cut, no odor, good porosity, dolomitic
1710-1730	Sandstone as above, becoming weak, very light stain, light fluorescence, slow cut, good porosity
1730-1840	Sandstone, white, medium grained/coarse, well rounded, frosted grains, calcareous, unconsolidated grains, clean
1840-1910	Dolomite, white/pink w/sandstone, white, very fine grained/medium grained, well rounded, frosted, unconsolidated/friable
1910-1960	Dolomite, white/cream/pink, dense/sucrosic, locally limestone, trace pyrite
1960-1980	Shale, greenish gray, silty, red and maroon
1980-2050	Dolomite, white, pink and tan, dense, micritic w/some clear anhydrite inclusions, locally sandy, very fine grained, white, friable, white clay infill
2050-2070	Sandstone, very fine/fine grained/white clay-dolomitic cement, clean and porous in part w/some dolomite as above
2070-2084	Dolomite, light tan to pink, dense, micritic w/some sandstone as above
2084	Circulating - 1½ hrs. Dolomite as above
2084-2087	Dolomite as above
2087-2117	Core #3 - cut and recovered 30'
	(field description - from unchipped core on catwalk)
2087-2088	Dolomite, gray-tan, micrite w/good fine vuggy porosity from fossil mold
2088-2093	Dolomite, fragmental, mudstone w/clasts to 2", interclast areas finely sucrosic, matrix w/good vuggy porosity, vugs enhanced by plucking from coring, but range 1-20 mm., vertical to near vertical fractures 1-2 mm. in width w/partial filling by clear calcite

Lithology - 4

2093-2099	Dolomite, mudstone as above, mostly dense w/minor areas of vuggy porosity as above, highly fractured (vertical) w/calcite filling as above
2099-2102	Dolomite, dense, gray, mudstone w/an occasional vug, very stylolitic
2102-2110	Dolomite, fragmented as above @ 2088' w/some clasts, 2" x 4" zones of excellent vuggy porosity @ 2105', @ 2106' some vugs to 1½", stylolitic
2110-2117	Dolomite as above, reddish in part w/green shale partings, soft clay, highly fractured and brecciated
2117-2140	Dolomite, tan-gray w/traces of lavender, traces of fine, vuggy porosity, poor sample, abundant cavings - trip
2140-2150	Dolomite as above w/traces of red, silty-sandy dolomite, caving (?)
2150-2190	Dolomite as above w/fair, fine vuggy porosity, slightly more cream than above, some white chert and clear calcite, probably vein filling, some pink chert 2160-2170'
2190-2200	No sample
2200-2210	Dolomite, mudstone, tan-brown-darker w/some cream as above, increase in pink-reddish dolomite, fair, vuggy porosity as above
2210-2220	Dolomite as above w/abundant pink, sandy, argillaceous dolomite, and sandstone, white to pink, dolomitic cement, traces of pyrite
2220-2230	Sandstone as above, cream to red w/abundant loose quartz grains, subrounded, fine to medium, probably porous w/dolomite as above, traces of red, silty shale, some fine vuggy porosity as above
2230-2250	Sandstone, pink to white, mostly loose grains w/thin interbeds of pink to cream, very sandy dolomite
2250-2260	As above w/increase in cream to pink dolomite and brick red silty shale
2260-2280	Sandstone, fine to medium as above, abundant loose grains, probably w/red silt matrix, red silty shale as above w/some pink, lavender and cream sandy dolomite, some w/fine vuggy porosity

BELL SANDSTONE

2280	Circulating - 1 hr. As above
2280-2335	Core #4 - recovered 53'
	(lost estimated 2' sandstone)
2280-2282	Dolomitic silt and sandstone w/swirl and wavy bedding, red, tan and yellow
2282-2284	Sandstone, dolomitic w/15-20° crossbeds
2284-2292	Sandstone, red, fine to medium grained, mostly porous and friable

Lithology - 5

2292 -2292.8	Dolomite, purplish, very argillaceous

MADISON

2292.8-2299.4	Limestone, tan, fragmental w/interclast areas filled w/silty shale and sand, red stylolites and fractures @ 2297-2298', vuggy solution porosity @ 2298-2299'
2299.4-2305.6	Shale, red w/some clasts of limestone as above
2305.6-2311	Limestone, cream, tan, mudstone, stylolitic w/some slightly dipping red shale laminations
2311 -2320.6	Limestone, tan, cream, mudstone, very dense, hard, stylolitic, red shale break @ 2314-2314.6', highly vertical fractured @ 2316-2318'
2320.6-2327.8	Limestone and shale as above, excellent large vuggy porosity @ 2326-2327.2', vugs to 2" to 1"
2327.8-2330	Limestone as above, very stylolitic w/fine micro laminations of red shale, large vugs @ 2329.6' w/½" calcite crystals
2330 -2331.6	Red shale as above, dolomitic
2331.6-2335	Dolomite, gray, earthy, very broken w/abundant red shale as above

2335-2388 Core #5 - cut and recovered 53'

2335-2345	Dolomite, very earthy, dirty, very argillaceous, red to yellow, mottled, wavy bedding w/abundant vertical fractures healed w/ calcite
2345-2349	Limestone, very dense, hard, mudstone w/crenulate shale parting, gray-tan to purple
2349-2350	Limestone, dolomitic as above w/fair fossil moldic porosity, more tan
2350-2357	Dolomite, brown, rusty, mudstone w/micro vuggy porosity, less than 1 mm., poor permeability (?), vertical fractures, mostly calcite healed
2357-2367	Dolomite, very argillaceous w/horizontal to swirl laminations
2367-2370	As above, mostly green
2370-2372	Dolomite, tan, gray, mudstone w/streaks of vuggy porosity, 1-2 mm.
2372-2388	Limestone, gray, tan, mudstone w/abundant vertical fractures, completely shattered between 2377-2382'
2388-2410	Limestone, white/tan, micrite, dense, hard, low porosity
2410-2430	Limestone, tan/pink, dolomitic, mudstone w/some fair/good intergranular porosity, locally earthy
2430-2449	Dolomite, white/tan, sucrosic, good intergranular porosity, few pinpoint vugs

Lithology - 6

2449-2450	**Core #6A - recovery from Bowen junkbasket**
	Dolomite, pink, argillaceous w/vugs up to ½" x ½", mostly filled w/clear calcite, large brown resinous chert nodules, breccia texture
2450-2455	Dolomite, pink, dense, mudstone w/clear/white/tan chert
2455-2474	**Core #6 - recovered 19'**
2455-2460	Dolomite, pink, breccia, argillaceous around clasts of limestone, some chert, solution vugs 1" x 2" w/dogtooth calcite in vugs, fractured @ 2457-2458.5', fair/good porosity
2460-2463	Dolomite, pink/lavender, very argillaceous, dense, low porosity
2463-2464	Dolomite, pink, breccia, vugs to 1" x ½", fractured, good porosity
2464-2466	Dolomite, pink/tan, breccia, limestone clasts w/red shale around clasts, very fractured @ 2465', clear calcite crystals in small vugs, fair porosity
2466-2471	Dolomite, tan/pink, argillaceous, breccia, abundant clear calcite crystals in vugs up to 1" x 1", intense fracturing @ 2468.5' to 2470' and 2471', some light brown chert, good porosity
2471-2474	Dolomite, tan, breccia w/pink shale partings around clasts, vugs nearly completely filled w/clear calcite crystals, vertical fracture @ 2472', fair porosity
2474-2500	**Core #7 - recovered 23½'**
2474-2478	Dolomite, pink, breccia w/limestone clasts, argillaceous, nearly unconsolidated @ 2474.8', vugs up to 1" x 3" (2476.7'), fractured, fair/good porosity
2478-2479	Marlstone, pink/lavender, mottled, greenish gray, dolomitic, fractured

MISSION CANYON

2479-2481	Dolomite, pink, breccia, fractured (2479-2480'), fair/good porosity, very argillaceous, pink, mottled, light gray
2481-2485	Dolomite, white, chalky, limy, earthy, dense, low porosity
2485-2488	Limestone, tan, fragmental, pelletoidal (possibly algal) w/some clear calcite infill, chalky, bleeding water, low/fair porosity
2488-2491	Dolomite, tan/pink breccia, argillaceous, fractured @ 2489', poorly consolidated @ 2491', very argillaceous, few isolated pinpoint vugs, good porosity
2491-2497½	Dolomite, pink, breccia w/limestone clasts, locally argillaceous, vuggy (1½" x ½" @ 2492.5'; 2492-2494'), partially filled w/large dogtooth calcite crystals, dense matrix, fair/good porosity, few dark gray/black inclusions (½ - 1 mm.), hard

Lithology - 7

2500-2513	Core #8 - recovered 12½'
2500-2504	Dolomite, tan/pink, breccia w/limestone clasts, fractured @ 2501' and 2502', dense, hard matrix
2504-2510	Dolomite, pink/tan, breccia texture decreasing, hard, dense, mudstone matrix w/low porosity, fractured @ 2506', bleeding water
2510-2512½	Dolomite, pink, breccia, fractured @ 2511', hard, dense matrix, stylolite @ 2512'
2513-2525	Core #9 - recovered 11½'
2513-2516	Dolomite, pink, very argillaceous, maroon, dense, hard w/large clear calcite crystals nearly plugging all porosity
2516-2520	Dolomite, pink, breccia w/vertical vugs (1 x 3 mm.) w/calcite infill (possibly syringopora coral), intensely fractured @ 2518½', and 2519½-2520'
2520-2521	Dolomite, pink, argillaceous, hard, vertical fracture
2521-2524½	Dolomite, pink, breccia, intensely fractured @ 2522½', 2524' and 2524½'
2525-2555	Dolomite, white/pink/tan, locally limestone, sucrosic w/vuggy porosity, partially plugged w/clear calcite crystals, fair/good porosity
2555-2575	Dolomite, tan, dense, hard, low intercrystalline porosity
2575-2630	Dolomite, tan, sucrosic, good intergranular porosity, some calcite infill
2632-2646	Core #10 - recovered 13½'
2632-2634½	Dolomite, pink/tan, breccia, vugs to 1½" x 2" w/no apparent interconnections w/large calcite crystals partially infilling, vertical fracture @ 2634'
2634½-2640	Dolomite, tan/pink/white, crystalline, very fine grained, hard, low matrix porosity, few small vugs @ 2636-2637½', fractured @ 2639-2640'
2640-2645½	Dolomite, light brown/tan, hard, dense, mudstone, abundant vertical fractures w/small clear calcite crystals in fractures, breccia texture @ 2644-2645½'
2646-2676	Core #11 - recovered 28½'
2646-2647	Dolomite, tan, limy, chalky, earthy, breccia texture, few small disconnected vugs w/calcite crystals along margins
2647-2651	Limestone, tan, dolomitic, chalky, poor porosity
2651-2656	Limestone as above w/some breccia texture, pink shale partings locally to 1" thick

Lithology - 8

2656-2657½	Limestone, tan/light gray w/red shale, breccia texture, stylolitic, algal, low matrix porosity, fractured @ 2657½'
2657½-2664	Dolomite, tan, mushy/chalky, some breccia, few vugs @ 2663½', partially infilled w/clear calcite crystals
2664-2671	Limestone, tan, very dolomitic, chalky, thin red shale partings, locally internal sedimentation (burrows ?), fractured @ 2664-2666', secondary calcite completely infilling matrix porosity
2671-2675½	Limestone as above w/isolated vugs to ½" x ½"
2676-2680	Dolomite, tan/white, sucrosic w/clear calcite, fair intergranular porosity
2680-2700	Limestone, white, oolites/pisolites, some algal, low porosity
2700-2730	Limestone, white/tan, mudstone, chalky w/secondary calcite, few oolites, low porosity
2730-2740	Dolomite, light brown, sucrosic, yellow fluorescence, no cut, low/fair porosity
2740-2750	Limestone, white/tan, chalky, oolites/pisolites, fair porosity
2760	Circulating Dolomite, light brown, sucrosic, fair porosity, some scattered dead oil stain, yellow/blue mineral fluorescence, no cut

LODGEPOLE

2760-2820 Core #12 - recovered 60'

2760-2768	Dolomite, light gray/brownish gray, argillaceous, stylolite @ 2762', bleeding water (2764-2768'), pinpoint vugs, fair porosity
2768-2773½	Limestone, gray, anhydritic, argillaceous, stylolitic, white anhydrite nodes (2769½') w/swirl bedding, red/greenish gray shale (2772')
2773½-2782	Dolomite, tan, sucrosic w/some gray shale, some fossil shells, bleeding water (2780-2782'), burrows (2781'), poor/fair porosity
2782-2784	Shale, greenish gray, calcareous
2784-2787	Dolomite, gray, anhydritic, argillaceous, very stylolitic
2787-2788	Limestone, gray, anhydritic, stylolitic, bleeding water, low porosity
2788-2790	Anhydrite, gray/white, calcareous, argillaceous
2790-2795	Limestone, light gray, anhydritic, argillaceous, dense, stylolitic, low porosity, few white anhydrite nodes, brachiopod casts and molds locally
2795-2797	Dolomite, gray, dense, burrows, low porosity
2797-2801	Limestone, light gray, anhydritic, argillaceous, stylolitic w/ few thin (½") gray shale interbeds

Lithology - 9

2801-2802	Anhydrite, white/light gray, nodular nodes surrounded by brownish gray dolomite
2802-2805	Limestone, light gray, argillaceous, dense, very stylolitic, burrows (2804-2805')
2805-2808	Dolomite, pinkish gray, sucrosic, fair/good intergranular porosity, bleeding water
2808-2811	Limestone, light gray, anhydritic, stylolitic, dense, low porosity
2811-2820	Dolomite, light brownish gray, argillaceous w/few thin (1") gray shale interbeds, bleeding water, fair/good intergranular porosity

<u>2820-2845 Core #13 - recovered 25'</u>

2820-2826½	Dolomite, light gray w/few white anhydrite nodes, bleeding water (2820-2821', and 2824-2826½'), fair/good intergranular porosity, small hairline fractures filled w/red shale (2823-2824')
2826½-2829	Limestone, light gray w/thin gray shale interbeds, stylolitic, anhydrite, dense, low porosity
2829-2831	Dolomite, light brownish gray, argillaceous, bleeding water, low porosity
2831-2845	Limestone, light gray/tan, and shale, red/gray/tan, dolomitic, anhydritic, stylolitic, dense, low porosity, few 1 mm. vugs (2836-2837'), oolite w/calcite infill @ base

2845-2880	Limestone, tan/cream, chalky, micritic, low porosity
2880-2930	Limestone, tan/cream, mostly micrite, some oolite and pisolite, low porosity w/some interbeds dolomite, tan, sucrosic, yellow fluorescence, no cut, good intergranular porosity
2930-3015	Dolomite, light brown/tan, crystalline, sucrosic, strong yellow fluorescence, no cut, good intergranular porosity

<u>3015-3070 Core #14 - recovered 54'</u>

3015-3026	Dolomite, tan/light brown, medium crystalline, bleeding water, fair/good porosity, no fluorescence, vertical fracture (3017½-3018½'), few isolated vugs to 1" x ½"
3026-3028	Limestone, gray, anhydritic, dense, stylolitic, low porosity

<u>ENGLEWOOD (?)</u>

3028-3036½	Dolomite, pinkish tan/red, burrows w/calcite and dolomite infill, generally low porosity, good intergranular porosity @ 3030-3033', bleeding water, possible disconformity @ base
3036½-3040½	Dolomite, red, argillaceous w/few burrows filled w/crystalline dolomite and calcite, low porosity, possible disconformity @ base

Lithology - 10

3040½-3059	Dolomite, pink, and shale, red, interbedded w/some burrows dense anhydrite node (3047'), low porosity

STONY MOUNTAIN

3059-3060	Dolomite, pink w/yellow and red clay, unconformity @ surface
3060-3066	Dolomite, pinkish gray, coarse crystalline w/some red and yellow shale mottling
3066-3067½	Shale, red and yellow mottled, subwaxy, dolomitic, unconformity @ base

RED RIVER

3067½-3069	Dolomite, gray, rubble zone, some large solution vugs partially filled w/crystalline dolomite and calcite, good porosity
3070-3090	Dolomite, tan, finely crystalline, yellow fluorescence, no cut, fair porosity, few pieces limestone, tan, pisolite
3090-3102	Dolomite, white/tan/pink, fine/coarse crystalline, fair/good porosity, no fluorescence

3102-3132 Core #15 - recovered 30'

3102-3104	Dolomite, tan, thin bedding, hard, possible chert, low porosity
3104-3110	Dolomite, tan/cream, sucrosic/earthy w/some red shale in breccia texture, vuggy w/vugs to 3" x 3", good porosity
3110-3123	Dolomite, tan/cream, earthy, vuggy, numerous small vugs from solution of shell and coral material, some breccia texture, good porosity
3123-3126	Dolomite, light gray/tan w/red, argillaceous clasts in breccia texture, poor/fair porosity, small pinpoint vugs
3126-3130	Dolomite, light gray/tan, some pink, argillaceous, medium crystalline, fair/good intergranular porosity, locally breccia texture, vertical fracture (3127-3129')
3130-3132	Dolomite, light gray/tan, dense/coarse crystalline, low/fair porosity, speckled blue fluorescence
3132-3185	Dolomite, white/cream/tan, mostly mudstone w/few oolites and pellets, low/fair porosity, trace white chert

3185-3191 Core #16 - recovered 6' (?)

Dolomite, tan/cream, sucrosic, finely crystalline, intense conchoidal fracture, hard, fair matrix porosity top 6", poor below, breccia texture

3191-3210	Dolomite, pink/tan, mudstone, trace tan chert, low porosity

Lithology - 11

3210-3272	Dolomite, tan/cream, sucrosic, fine/medium crystalline w/some white/clear chert, fair/good porosity, no fluorescence, water flow on connection @ 3211'
<u>3272-3302</u>	<u>Core #17 - recovered 30'</u>
	Dolomite, tan/light gray, earthy, mudstone, breccia w/dolomite and red shale clasts, mottled, vugs to 1" x 2", mostly isolated, low/fair porosity, increasing red, argillaceous content (3285-3289'), possible dolomitized shells (3291'), possible burrows (3289½-3293'), tubular coral debris (3288'), very angular clasts decreasing in size (3297-3302')
3302-3400	Dolomite, tan/pink/cream, medium/finely crystalline, fair/good intergranular porosity
3400-3460	Dolomite, pink/tan, mudstone, finely crystalline, low matrix porosity
3460-3470	Dolomite, pink/salmon, argillaceous, low porosity
3470-3480	Shale, red, very calcareous
3480-3491	Limestone, white, mottled, pink, chalky, low porosity
3491	Circulating Limestone as above w/trace shale, grayish green, soft, silty
<u>3491-3521</u>	<u>Core #18 - recovered 29½'</u>
3491-3514	Limestone, light gray and red mottled, hard, very low porosity, argillaceous, vertical fracture (3498½-3502') healed w/crystalline calcite, shell molds and casts (3512')
3514-3520½	Shale and limestone, red/maroon, some mottling (burrows ?), very low porosity, hard
3521-3540	Shale, red, and limestone, gray, mottled, red

<u>ROUGHLOCK SANDSTONE</u>

3540-3560	Sandstone, white, very fine grained, subround, very calcareous, hard w/some sandstone, fine grained, maroon, argillaceous, soft, low porosity, trace apple green waxy shale
3560-3570	Sandstone, white, fine grained, subangular, very calcareous, white clay infill, low porosity w/shale greenish gray, splintery

<u>ICEBOX SHALE</u>

3570-3610	Shale, greenish and reddish gray, very splintery, slightly calcareous, subwaxy

Lithology - 12

WINNIPEG-ALLADIN SANDSTONE

3610	Circulating Sandstone, clear, medium/coarse, well rounded, frosted, fair/good sort, unconsolidated, excellent porosity
3610-3643	Core #19 - recovered 2'
3610-3612	Sandstone, white, medium/coarse, well rounded, unconsolidated, very clean, fair/well sorted, slightly calcareous w/trace calcareous cement, frosted grains, excellent porosity
3643-3650	Sandstone as above
3650-3680	Sandstone as above w/shale, greenish gray, splintery
3680-3700	Shale, gray, waxy, mottled, green and red w/sandstone, white, fine grained, subround/subangular, clean, friable, very calcareous, fair/low porosity

DEADWOOD SANDSTONE

3705	Circulating 30 min. - shale, red, mottled, green, waxy, very splintery w/sandstone, white, fine grained/very fine grained, glauconitic, calcareous w/white clay infill, low porosity 60 min. - sandstone, light gray/clear as above
3705-3750	Sandstone, white, fine grained, subangular, fair/well sorted, slightly dolomitic, glauconitic, low/fair intergranular porosity
3750-3770	Sandstone as above w/shale, green and reddish gray, splintery, waxy
3770-3790	Shale, red and greenish gray, splintery w/limestone, cream, dolomitic, hard, and sandstone as above
3790-3810	Sandstone, white, subround, very fine grained/fine grained, glauconitic, calcareous, low porosity
3810-3880	Shale, green, waxy w/pink dolomite, limy, hard, dense, and sandstone as above, low porosity
3880-3910	Sandstone, light gray, very fine grained/coarse, poor sort, glauconitic, clay infill, low porosity w/pink dolomite, hard, low porosity
3910-3930	Dolomite, pink, hard, dense, low porosity w/green shale and siltstone
3930-3960	Sandstone, very fine grained/siltstone, light gray, glauconitic, calcareous, low porosity, trace pyrite w/some green, purple and red shale
3960-4000	Shale, gray green, splintery, fissile w/white limestone interbedded, silty w/some chert

Lithology - 13

4000-4050	Shale, green, yellow and purple w/siltstone, white, very calcareous, chalky
4050-4080	Shale, gray-green, red and maroon, waxy w/limestone, white, chalky, and dolomite, pink, dense, low porosity
4080-4100	Shale as above w/increasing limestone and dolomite as above

FLATHEAD

4100-4120	Siltstone, light gray, very glauconitic, calcareous w/gray-green and maroon shale, trace white chalky limestone
4120-4145	Sandstone, light gray/clear, fine grained/medium grained, subround/well rounded, calcareous, friable, slightly glauconitic, good/fair porosity, w/white, dense limestone @ top of sand unit

4145-4175 Core #20 - recovered 30'

4145-4147	Sandstone, light brown/brownish red, calcareous, medium/coarse, subangular/well rounded, very friable, planar crossbedding 10-20°, few frosted grains, good porosity, water wet
4147-4175	Sandstone, light reddish brown, fine grained/coarse, calcareous, subangular/well rounded, locally abundant clay infill, friable, some frosted grains, 99% quartz grains w/rare dark rock fragments, fair/good porosity, water wet, 2-4" shale, greenish gray, calcareous w/free quartz grains (4163½' and 4165'), small vertical fractures (4151-4151½', 4154-5154½', 4157-4157½', 4166½-4167', and 4171-4172')
4175-4190	Sandstone, fine grained/coarse, clear, subangular/well rounded, clay infill, slightly calcareous, low/fair porosity
4190-4210	No samples
4210-4230	Sandstone, clear, loose grains, medium/coarse, subround/well rounded, some frosted grains, good porosity
4230-4240	Shale, gray green/green, splintery
4240-4250	Sandstone, medium/coarse, clear, unconsolidated, subangular/round, frosted grains, good porosity
4250-4260	No sample
4260-4270	Shale, green w/coarse, well rounded quartz grains
4270-4292	Sandstone, clear, unconsolidated, medium/coarse, round/well rounded w/few calcareous and green shale fragments, good porosity

Lithology - 14

<u>4292-4325</u>	<u>Core #21 - recovered 34'</u>
4292-4299	Sandstone, light reddish brown, angular/well rounded, fine grained/very coarse, clay infill, calcareous, fair porosity, becoming coarse grained @ basal unconformity w/3" cobbles, water wet

<u>PRECAMBRIAN ELLISON FORMATION (?)</u>

4299-4310	Greenschist, near vertical foliations, green, pink and purple, orthoclase altering to kolin, chlorite and talc, biotite and quartz common, vertical fracture (4301-4302' and 4306-4308')
4310-4311	Zone of large angular inclusions, possible unconformity
4311-4326	Gneiss (granodiorite composition), banded, pink, orange and gray, vertical fractures (4318-4319' and 4324-4326'), prematamorphism mini faulting with displacement up to 1" (4320-4321')
4326-4346	Gneiss (?), mostly quartz, pyroxenes and orthoclase
<u>4346-4355</u>	<u>Core #22 - recovered 8'</u>
4346-4354	Gabbroic gneiss, dark gray/greenish gray, foliated, more than 50% calcic plagioclase, w/pyroxenes, no fractures, probably younger than gneiss described above

CL-311-8

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation AS NOTED Page 1 of 8

Well MADISON NO. 1 Cores DIAMOND 4" File RP-2-5208

Field WILDCAT Drilling Fluid WATER BASE MUD Date Report 10-27-76

County CROOK State WYOMING Elevation 3618' KB Analysts BL:RG

Location NE¼ SE¼ SEC. 15-T57N-R65W Remarks

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	WHOLE CORE PERMS. 90°.	WHOLE CORE PERMS. VERT.
1	650.0	14	3.9	20.6	HULETT		2.61			
2	651.0	0.31	0.06	11.0						
3	655.0	1.9	0.34	16.8						
4	656.0	191	107	26.7						
5	657.5	240	184	27.6			2.62			
6	660.5	503	390	29.8						
7	663.6	199	136	24.7						
8	664.6	35	0.26	19.3						
9	666.2	112	91	21.6						
10	669.3	32	15	19.3						
11	671.3	19	29	18.4						
12	673.6	3.8	0.35	15.6			2.66			
13	675.0	338	381	26.7						
14	676.4	52	9.5	20.6						
15	1503.3	<0.01	<0.01	4.8	MINNEKAHTA					
16	1504.8	<0.01	<0.01	3.7			2.82			
17	1506.6	0.22		4.7						
18	1510.0	<0.01		1.9						
19	1510.6	0.03	0.02	4.3			2.71			
20	1511.6	0.01	<0.01	1.5						
21	1513.2	<0.01	<0.01	1.2			2.71			
22	1513.8	0.18		8.1						
23	1514.2	2.6		13.1						
24	1515.0	50F		10.2			2.79			
25	1515.3	109F		26.9						
26	1516-17			4.0	3.0	44.0	2.82	1.2	1.1	*
27	1518.7	2.1	3.9	15.0						
28	1520.5	1.6	0.40	15.5			2.81			
29	1522.8	<0.01	<0.01	4.1			2.70			
30	1525.5	<0.01	<0.01	1.5			2.69			

F=FRACTURED PERMEABILITY PLUG
*UNSUITABLE FOR PERMEABILITY MEASUREMENT

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULT

CL-511-2

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation AS NOTED Page 2 of 8

Well MADISON NO. 1 Cores DIAMOND 4" File RP-2-5208

Field WILDCAT Drilling Fluid WATER BASE MUD Date Report 10-27-76

County CROOK State WYOMING Elevation 3618' KB Analysts BL:RG

Location NE¼ SE¼ SEC. 15-T57N-R65W Remarks

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	WHOLE CORE PERMS. 90°	WHOLE CORE PERMS. VERT.
31	2088.1	0.29	0.05	5.5	MINNELUSA		2.83			
32	2089.0	17	204	12.3						
33	2091.8	452	2.2	8.5						
34	2092.7	17	9.1	4.0						
35	2093.7	592	316	4.0						
36	2094.6	0.63	2.0	6.9						
37	2096.0	1.4	0.22	6.0						
38	2096.8	0.56	0.73	6.9						
39	2098.2	3.7	0.32	4.8						
40	2100.5	0.33	21	4.4						
41	2102.3	1.5	0.39	6.6						
42	2104.3	0.74	0.32	6.5						
43	2105.0	53	191	4.6			2.79			
44	2105.9	<0.01	0.11	2.1			2.83			
45	2107.1	25	9.2	7.5						
46	2108.2	0.10	0.08	1.0						
47	2110.4	0.01	31F	2.4						
48	2110.8	0.01	<0.01	0.8			2.84			
49	2280.0	0.03	0.47	0.9						
50	2280.5	0.15	*	3.6						
51	2281.4	0.28	<0.01	6.1						
52	2281.9	0.53	6.4	10.0						
53	2282.7	9.0	42	18.5						
54	2284.0	18	0.47	18.3			2.64			
55	2284.6	119	34	21.0						
56	2285.2-86.2			20.0	0.0	71.4	2.80	45	44	31
57	2289.0	0.41	0.82	10.0			2.69			
58	2292.5	0.01	<0.01	3.8						
59	2293.0	<0.01	<0.01	1.8						
60	2294.5	0.82	<0.01	3.6	CHARLES		2.75			
61	2295.5	0.02	0.59	6.3						
62	2296.1	<0.01		2.0			2.84			
63	2296.6	210	43	8.3						
64	2297.2	<0.01	0.15F	3.4						
65	2298.9	10		1.9						

F=FRACTURED PERMEABILITY PLUG

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS

CL-311-2

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company	UNITED STATES GEOLOGICAL SURVEY	Formation	AS NOTED	Page 3 of 8	
Well	MADISON NO. 1	Cores	DIAMOND 4"	File	RP-2-5208
Field	WILDCAT	Drilling Fluid	WATER BASE MUD	Date Report	10-27-76
County	CROOK State WYOMING	Elevation	3618' KB	Analysts	BL:PG
Location	NE¼ SE¼ SEC. 15-T57N-R65W	Remarks			

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	WHOLE CORE PERMS. 90°	WHOLE CORE PERMS. VERT.
66	2300.3	<0.01		5.8			2.80			
67	2301.1	<0.01		0.7			2.71			
68	2302.7	<0.01		3.5			2.80			
69	2304.3	<0.01		2.6			2.72			
70	2305.8	<0.01		5.6			2.82			
71	2307.4	<0.01		1.1			2.70			
72	2310.6	<0.01		0.6			2.70			
73	2311.7	<0.01		1.3			2.70			
74	2315.7	<0.01		1.2			2.68			
75	2321.1	<0.01		1.4			2.70			
76	2327.3	<0.01								
77	2328.6	<0.01		1.1			2.71			
78	2330.3	<0.01	<0.01	13.7						
79	2311.9	0.72	0.59				2.83			
80	2335.4	0.07								
81	2336.4	0.08								
82	2337.1			11.5			2.63			
83	2337.5			15.4			2.82			
84	2339.7	0.04	0.04	13.3						
85	2340.5	0.09	0.05	16.5						
86	2340.9	0.05	0.07	16.4						
87	2342.4	0.14	0.13	18.6						
88	2344.4	0.88	0.57	21.9			2.82			
89	2345.3	4.1	0.80	21.5						
90	2345.8	<0.01	<0.01	1.7						
91	2346.5	<0.01		1.2						
92	2348.2	0.02		6.1						
93	2348.6-49.3			5.7	0.0	86.7	2.67	21	0.13	17
94	2350.8	0.94	0.43	14.0						
95	2351.8	2.2	2.7	15.2						
96	2353.6-54.1			11.8	1.9	49.6	2.84	*	*	*
97	2355.6-56.2			27.4	0.5	72.4	2.84	7.8	6.2	8.4
98	2358.0	<0.01		0.6						
99	2359.4	<0.01		4.5						
100	2364.0			8.9			2.75			

*UNSUITABLE FOR PERMEABILITY MEASUREMENT

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS

CL-911-2

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company	UNITED STATES GEOLOGICAL SURVEY	Formation	AS NOTED	Page	4 of 8
Well	MADISON NO. 1	Cores	DIAMOND 4"	File	RP-2-5208
Field	WILDCAT	Drilling Fluid	WATER BASE MUD	Date Report	10-27-76
County	CROOK State WYOMING	Elevation	3618' KB	Analysts	BL;PG
Location	NE¼ SE¼ SEC. 15-T57N-R65W	Remarks			

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	WHOLE CORE PERMS. 90°	WHOLE CORE PERMS. VERT.
101	2366.3	<0.01		9.6			2.79			
102	2368.8	<0.01		10.7			2.81			
106	2370-70.6			6.8	1.6	68.1	2.82	4.5	4.2	*
103	2375.7	0.77F		2.3			2.76			
104	2385.0	0.02		1.3			2.70			
105	2385.5	<0.01		0.9			2.68			
107	2458.6-60.1			3.8	0.0	45.8	2.81	3.4	1.3	1.7
108	2463.9	0.95	0.15	4.9						
109	2466-67.3			5.6	0.0	59.6	2.83	1.5	0.91	*
110	2476.5-77.8			8.3	0.0	62.0	2.82	*	*	*
111	2481.3	<0.01	<0.01	7.4			2.75			
112	2483.2	0.01	<0.01	11.5	MISSION CANYON					
113	2485.9-86.7			18.5	0.0	50.6	2.79	9.1	8.5	13
114	2487.8	5.6	1.8	23.9			2.83			
115	2488.4	4.6	1.8	20.7						
116	2490.3	1.7	2.6	19.1			2.83			
117	2491.4	3.4	4.5							
118	2494.7	0.07	0.38	8.2						
119	2497.2	2.6	12	8.8			2.82			
120	2503.5	5.6	1.3	9.0			2.82			
121	2505.4	276	900	15.4						
122	2507.9	36	143	13.9						
123	2509.2	0.80	2.2	7.6			2.78			
124	2513.9	35	27	15.2			2.82			
125	2517.5	315	481	17.7						
126	2518.4	789	234	23.9						
127	2523.7	390	385	22.8			2.80			
128	2632.2	255	26	25.8			2.82			
129	2634.3	99	338F	22.2						
130	2636.8	5.0	3.2	13.7						
131	2638.8	50	93	21.9						
132	2648.0	14	10	30.4			2.97			
133	2650.2	1.4		21.8						
134	2653.2	0.37		18.7						
135	2655.0	0.37		20.0						

F=FRACTURED PERMEABILITY PLUG
*UNSUITABLE FOR PERMEABILITY MEASUREMENT

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS

CL-911-2

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation AS NOTED Page 5 of 8
Well MADISON NO. 1 Cores DIAMOND 4" File RP-2-5208
Field WILDCAT Drilling Fluid WATER BASE MUD Date Report 10-27-76
County CROOK State WYOMING Elevation 3618' KB Analysts BL:RG
Location NE¼ SE¼ SEC. 15-T57N-R65W Remarks

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	WHOLE CORE PERMS. 90°	WHOLE CORE PERMS. VERT.
136	2657.9	9.2	5.4	27.9			2.80			
137	2659.9-60.7			35.5	0.5	83.9	2.81	*	*	*
138	2662.5	8.1	6.8	22.8						
139	2666.4	129	44	13.4			2.66			
140	2669.4	236	8.4	18.6			2.73			
141	2671.6	68	48	31.4						
142	2673.3	96	107	30.2						
143	2674.3	320	213	34.0						
144	2761.3	12	6.8	13.7	LODGEPOLE		2.84			
145	2763.2	0.07	0.07	11.4						
146	2766.1	4.8	3.9	15.9						
147	2768.6	0.01		0.9			2.73			
148	2769.1	0.01		3.2			2.81			
149	2770.2	0.01		1.7			2.77			
150	2771.4	<0.01		0.7			2.69			
151	2772.4	<0.01		0.1			2.68			
152	2776.5	0.15		13.1						
153	2779.2	0.43								
154	2780.7	0.80	2.0	15.5			2.81			
155	2787.9	11	9.9	13.1			2.82			
156	2793.9	<0.01					2.76			
157	2794.2	<0.01					2.79			
158	2795.2	0.01					2.83			
159	2797.2	<0.01					2.82			
160	2797.6	<0.01					2.71			
161	2800.4	<0.01		0.9						
162	2801.0	0.02		10.2						
163	2806.2-07			10.5	0.0	34.8	2.81	0.48	0.40	0.3
164	2811.6	21		18.4						
165	2814.7	1.4	0.49	14.1						
166	2815.6	2.2		11.4						
167	2820-21.1			15.7	0.6	51.1	2.81	4.3	3.7	1.1
168	2822.4	0.02		11.6			2.81			
169	2824.9	0.23		11.0						
170	2830.1	0.13	0.09	12.4						

*UNSUITABLE FOR PERMEABILITY MEASUREMENT

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS

CL-811-2

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company: UNITED STATES GEOLOGICAL SURVEY	Formation: AS NOTED	Page 6 of 8	
Well: MADISON NO. 1	Cores: DIAMOND 4"	File: RP-2-5208	
Field: WILDCAT	Drilling Fluid: WATER BASE MUD	Date Report: 10-27-76	
County: CROOK State: WYOMING	Elevation: 3618' KB	Analysts: BL:RG	
Location: NE¼ SE¼ SEC. 15-T57N-R65W	Remarks:		

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	WHOLE CORE PERMS. 90°	WHOLE CORE PERMS. VERT.
171	2832.6	0.01					2.81			
172	2835.5-36.6			2.8	0.0	60.7	2.82	0.11	0.02	<0.01
173	3015.7	145	92	25.0						
174	3017.2	52	73	20.9			2.81			
175	3018.7	81	40	22.8						
176	3020.2	130	214	26.0						
177	3021.6	46		17.6						
178	3023.8	303	168	26.4						
179	3025.2	6.0		13.0						
180	3030.2-31.3			13.4	0.8	50.8	2.71	0.18	0.13	0.2
181	3036.5	4.4		15.8	ENGLEWOOD					
182	3038.4	4.5	0.43	17.7			2.81			
183	3040.9	0.10	0.06	11.8	DEVONIAN					
184	3042.9	0.09		15.4						
185	3047.8	0.04	<0.01	12.8			2.79			
186	3053.7	<0.01		10.9						
187	3060.5	0.24		7.7	STONY MOUNTAIN		2.82			
188	3060.9	0.11		8.3			2.80			
189	3062.9	0.15	0.06	8.0			2.79			
190	3064.9	0.88		12.4						
191	3067.9	11	2.6	12.4			2.83			
192	3103.9	194	198	20.5	RED RIVER					
193	3104.8	2490	3.2	18.4						
194	3106.7	4890	25	24.8						
195	3107-07.5			15.3	0.0	86.1	2.81	56	6.7	*
196	3110.5	4.5	1.1	9.6						
197	3113.1	83	106	17.8			2.79			
198	3115.0	176	8.1	19.1						
199	3119-19.6			23.2	0.0	88.5	2.79	17	2.9	*
200	3121.5	140	170	15.3						
201	3123.4	14	4.6	10.3						
202	3126.2	603	64	21.6						
203	3128.1	17	5.8	15.7						
204	3273.9	12	12	11.3			2.81			
205	3276.2	9.5		13.5						

*UNSUITABLE FOR PERMEABILITY MEASUREMENT

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULT

CL-911-2

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation AS NOTED Page 7 of 8

Well MADISON NO. 1 Cores DIAMOND 4" File RP-2-5208

Field WILDCAT Drilling Fluid WATER BASE MUD Date Report 10-27-76

County CROOK State WYOMING Elevation 3618' KB Analysts BL:PG

Location NE¼ SE¼ SEC. 15-T57N-R65W Remarks

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	90°	VERT.
206	3278.6	8.6	21	12.5			2.83			
207	3281.1	62								
208	3281.9						2.82			
209	3282.6	53	7.4	17.7						
210	3285.6	46		15.4						
211	3289.1	76	17	14.9						
212	3291-92			13.8	0.0	90.9	2.80	11	7.9	20
213	3295.7	49	0.82	15.3			2.82			
214	3297.5	91	0.09	12.4						
215	3300.8	55	4.1	11.6			2.82			
216	3491.9	<0.01		1.9	HECLA		2.75			
217	3495.0			1.2			2.72			
218	3497.9	<0.01		1.6						
219	3502.6	<0.01		2.4			2.74			
220	3505.9	<0.01		1.6						
221	3512.4	<0.01		3.2			2.82			
222	3514.3	<0.01		3.2						
223	3515.8						2.78			
224	3516.7				WINNIPEG		2.75			
225	3610.5-11			#	#	#	2.62	#	#	#
226	4145.4-46.4			20.2	0.0	85.6	2.62	329	268	5.5
227	4152.0	271	297	18.0	FLATHEAD		2.63			
228	4155.6	521	269	18.6						
229	4157.7-58.4			16.0	0.0	84.8	2.62	177	158	3.9
230	4160.0	93	1.4	13.3						
231	4161.7	274	17	19.9						
232	4163.5			1.4			2.85			
233	4166.0	523	907	17.2						
234	4170.0	103	2.4	12.9			2.64			
235	4172.3	341		19.6						
236	4174.3	351	321	14.5						
237	4292.5	982	223	12.9			2.71			
238	4293.7	0.01	<0.01	3.4			2.70			
239	4295.7	16	2.4	6.7	PRECAMBRIAN					
240	4296.5	204	217	12.8						

*UNSUITABLE FOR PERMEABILITY MEASUREMENT
#UNSUITABLE FOR ANALYSIS

NOTE:
(*) REFER TO ATTACHED LETTER
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULT

CL-811-2

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company UNITED STATES GEOLOGICAL SURVEY Formation ______ Page 8 of 8
Well MADISON NO. 1 Cores ______ File RP-2-5208
Field WILDCAT Drilling Fluid ______ Date Report 10-27-76
County CROOK State WYOMING Elevation ______ Analysts BL:RG
Location NE¼ SE¼ SEC. 15-T57N-R65W Remarks ______

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HORIZONTAL (K_A)	PERMEABILITY MILLIDARCYS VERTICAL	POROSITY PERCENT	RESIDUAL SATURATION OIL % VOLUME % PORE	TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	90°	VERT.
241	4308.6			11.5			2.67			
242	4311.7			4.3			2.63			
243	4313.1			4.0			2.62			
244	4315.0			1.5			2.61			
245	4316.5			2.3			2.63			
246	4320.9			1.2			2.65			
247	4346.2	NOT AVAILABLE FOR ANALYSIS								
248	4349.5						2.71			
249	4352.4			1.4			3.06			

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESULTS

Hydrologic testing

Sixteen conventional drill-stem tests and packer-swabbing tests were attempted. Ten of these tests gave clues to pressure heads of water in the intervals tested and flowing water was obtained during seven of the tests (table 2). The discharge or flow obtained from these tests of short duration is not a valid indication of the water-yielding potential of the intervals because of probable deep invasion of the formations by drilling mud, chemicals, and loss-of-circulation materials. Failure to obtain data from six of the tests was due to packer malfunction, plugging of ports by poorly consolidated sandstone and shale, or failure of packer seats in incompetent rocks.

Intervals for testing with packers were selected after preliminary interpretation of geophysical logs and examination of cores. Primary considerations were the presence of interstitial and (or) fracture porosity, suitable hole diameter, and a representation of each of the major rock types and formations penetrated in the hole. The intervals tested covered approximately 40 percent of the Paleozoic section below the 13-3/8-in casing (1488-4341 ft).

Inflatable packers were used in testing the intervals. These packers can be run with significantly greater hole clearance than the hard rubber packers often used on standard drill-stem testing tools; timewise they also provide a seal more than twice as long as the hard rubber packers. Two tool assemblies were used during the testing. Inflatable straddle packer assemblies (fig. 7) similar to those used by the oil industry were run on 4-1/2-in drill pipe. A single packer, when practical, with tail pipe for extra support, was used in place of the straddle packers which have a tendency to slip down the hole when they are being inflated. The data from these tests are important for comparison with similar tests made in oil and gas test holes.

When the weight of the mud and muddy water in the drill pipe was too great to permit the well to flow from a test interval, the conventional packers were deflated and removed from the hole. Single or straddle inflatable production injection packers (fig. 8) were then lowered into the hole on 2-7/8-in EUE 8-round tubing and hydraulically set over the interval previously tested with the conventional equipment. After the ports were opened, the drilling mud and muddy water were removed from the hole by swabbing. In most instances, water from the isolated interval flowed to the surface after 1,000 to 1,500 gallons of the mud and muddy water were swabbed from the tubing.

Table 2.--Summary of drill-stem-test data

(Kelly bushing (KB) is 14 ft above land surface and 3,618 ft above sea level.)

Test	Formation	Interval (ft below KB)	Shut-in pressure (lb/in^2)	Depth to pressure recorder (ft below KB)	Discharge or flow (gal/min)	Remarks
*1	Minnekahta Limestone	1,500-1,575	682	1,480	12	Began flowing after swabbing. Shut-in pressure at KB 44 lb/in^2.
2	Sundance (Hulett Sandstone Member)	650-725	203	635	---	Test questionable--packer deflated prior to a final shut in.
3	Upper part of Minnelusa	1,540-1,738	694	1,525	---	Recovered 750 ft mud, 690 ft slightly water cut mud, 30 ft sand and lost-circulation material.
*4	Do.	1,542-1,738	39	0	75	Ran packer on 2-7/8-in tubing and swabbed.
5	Upper part of Madison	2,299-2,388	1,015	2,288	1/4	
*6	Amsden	2,218-2,298	985	2,203	1/2	
7	Do.	2,217-2,305	-----	-----	---	Tool plugged--40 ft of sand on top of bottom packer.
8	Minnekahta Limestone	1,482-1,525	-----	-----	---	Test failed--mandrel broke on top packer. Had to fish out straddle pipe and bottom packer.
9	Flathead Sandstone	4,094-4,355	1,796	4,104	---	
10	Flathead Sandstone	4,092-4,355	-----	-----	55	Began flowing after swabbing.
11	Winnipeg Sandstone	3,579-3,694	-----	-----	---	Tool plugged with sand.
12	Red River	3,329-3,440	-----	-----	---	Do.
13	Winnipeg Sandstone	3,579-3,694	-----	-----	---	Packer seat failed after 2 min.
*14	Red River	3,300-3,480	1,470	3,314	---	
*15	Mission Canyon	2,530-2,570	1,126	2,540	18	Shut-in pressure at KB 33 lb/in^2 after 9 hrs of flow.
*16	Charles and Mission Canyon	2,434-2,530	1,092	2,444	20	

* Original drill-stem-test data included in report.

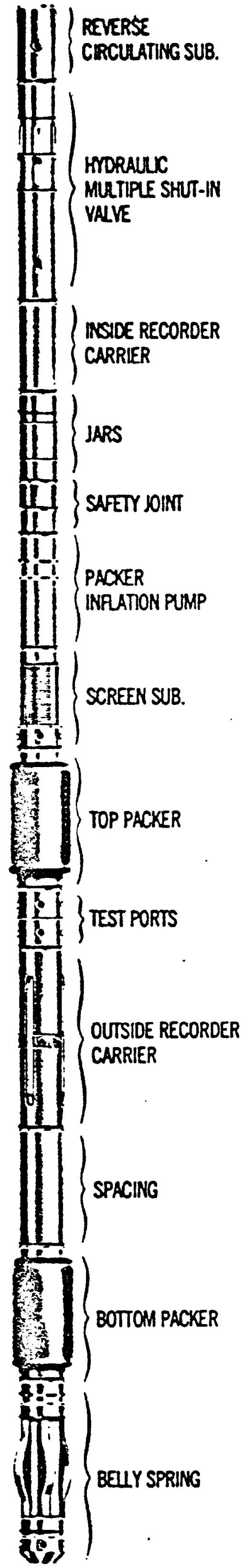


Figure 7.--Inflatable straddle packer tool for conventional drill-stem tests. (Courtesy Lynes, Inc., Houston, Texas)

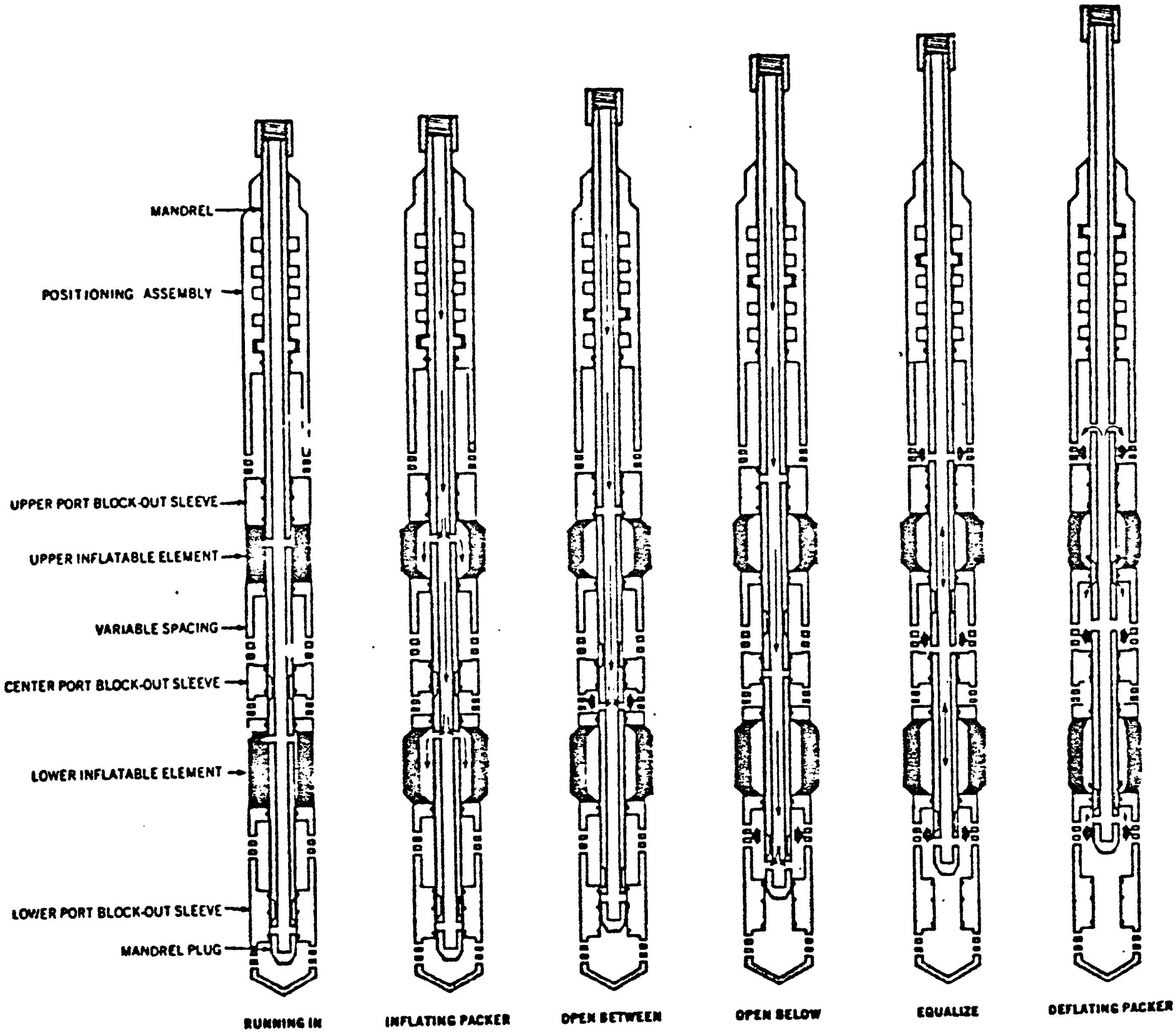


Figure 8.--Inflatable straddle packer used in open hole or casing. (Courtesy Lynes, Inc., Houston, Texas)

After completing all packer testing, a well head (figs. 5 and 6) was installed. The mud was removed from the hole and the well began to flow. It flowed about 250 gal/min through a 2-in valve in the well head with about 32 lb/in back pressure. Measured at the well head, the shut-in pressure was 48 lb/in and the temperature of the water was about 50°C.

Table 2 summarizes the drill-stem and packer-swabbing tests run in Madison test well no. 1 and indicates the test data that are included in this report.

Phone
522-1206 Area 303

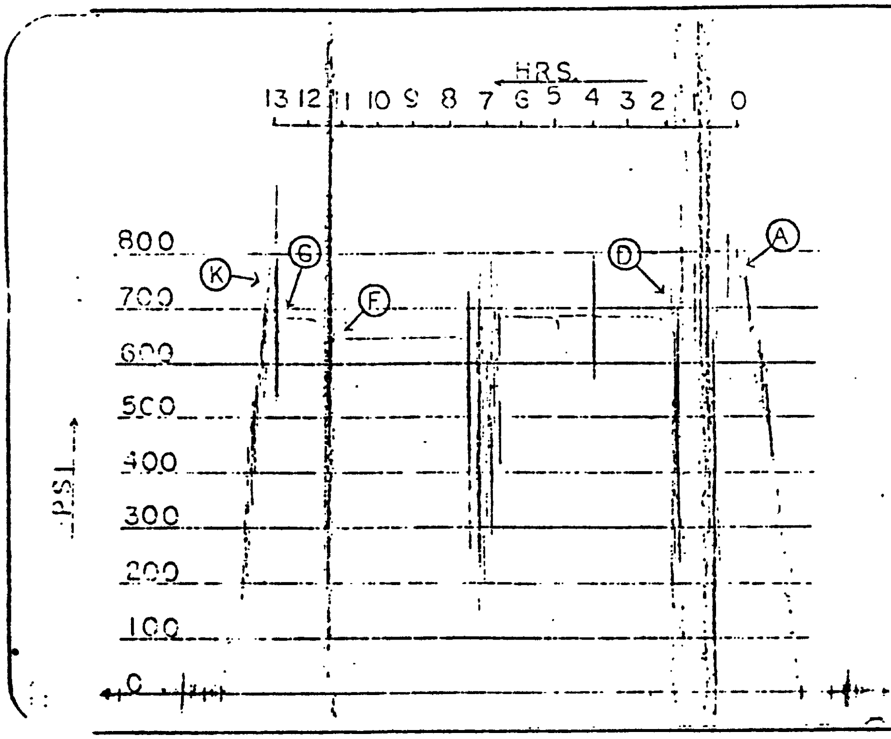
LYNES, INC.

Box 712
Sterling, Colo. 80751

Operator: U.S.G.S.
Address: See Distribution
Well Name and No.: Madison-Limestone #1
Ticket No.: 2997
Date: 7-25-76
DST No.: 1
No. Final Copies: 5

Contractor	Thomson Drlg., Inc.	Top Choke	1"
Rig No.	20	Bottom Choke	9/16"
Spot	NE-SE	Size Hole	7 7/8"
Sec.	15	Size Rat Hole	--
Twp.	57 N	Size & Wt. D. P.	2 7/8" Tubing
Rng.	65 W	Size Wt. Pipe	--
Field	Wildcat	I. D. of D. C.	--
County	Crook	Length of D. C.	--
State	Wyoming	Total Depth	1575'
Elevation	3618' "K.B."	Interval Tested	1500-1575'
Formation	Minnekhata	Type of Test	Inflate

Flow No. 1	20 Min.
Shut-in No. 1	37 Min.
Flow No. 2	610 Min.
Shut-in No. 2	120 Min.
Flow No. 3	-- Min.
Shut-in No. 3	-- Min.
Bottom Hole Temp.	102° F
Mud Weight	9.5
Gravity	--
Viscosity	60
Tool opened @	2:20 PM.



Inside Recorder

PRD Make Kuster AK-1
No. 5978 Cap. 1200 @ 1480'

		Press Corrected
Initial Hydrostatic	A	757
Final Hydrostatic	K	750
Initial Flow	B	**
Final Initial Flow	C	**
Initial Shut-in	D	690
Second Initial Flow	E	**
Second Final Flow	F	645
Second Shut-in	G	682
Third Initial Flow	H	
Third Final Flow	I	
Third Shut-in	J	

Our Tester: Rick Hanson
Witnessed By: Rudy Ollila

Did Well Flow — Gas No Oil No Water No

RECOVERY IN PIPE: 1000' Water

REMARKS:

1st Flow - Tool opened with a weak blow, increased to 3" underwater blow and remained thru flow period.

2nd Flow - Tool opened with a strong blow, to bottom of bucket immediately. Tool slid 6". Re-opened with very good blow died in 30 minutes. Remained dead while hooking up swabbing unit. Started to swab at 7:33 PM. Started flowing at 8:17 PM. Shut tool in at 1:27 AM.

Well flowed about 10-12 gallons per minute after pulling 10 swabs. Tool was shut in after 5 hours. Pressure at "K.B." (kelly bushing) was 44 psi (pounds per square inch).

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LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

Fluid Sample Report

Date 7-25-76 Ticket No. 2997

Company U.S.G.S.

Well Name & No. Madison Limestone #1 DST No. 1

County Crook State Wyoming

Sampler No. -- Test Interval 1500-1575'

Pressure in Sampler 75 PSIG BHT 102 °F

Total Volume of Sampler: 2500 cc.

Total Volume of Sample: 2500 cc.

Oil: None cc.

Water: 2500 cc.

Mud: None cc.

Gas: None cu. ft.

Other: None

Resistivity

Water: 2.8 @ 76°F of Chloride Content 1850 ppm.

Mud Pit Sample ______ @ ______ of Chloride Content 400 ppm.

Gas/Oil Ratio ______ Gravity ______ °API @ ______ °F

Where was sample drained On location

Remarks:

LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

BOX 712
STERLING, COLORADO 80751
PHONE 303-522-1206

Comments relative to the analysis of the pressure chart from DST #1, Interval: 1500-1575', in the U.S.G.S., Madison Limestone #1, NE SE Section 15, T57N-R65W, Crook County, Wyoming:

For purposes of this analysis, the following reservoir and fluid properties, and test parameters have been used:

BHT = 102°F, μ = 1.0 cp., t = 40 minutes (estimated),
h = 10 feet (estimated), m = 2.8 psi/cycle.

1. The conditions which were applied to this formation test differ significantly from the normal procedures which are used in a conventional drill-stem test. A 610-minute Final Flow period was used during which swabbing of the fluid in the tubing was done; however, the volume of swabbed fluid was not reported.

   For purposes of this analysis, an estimated effective flowing time of 40 minutes has been used to determine the production rate of 312.7 BPD. The pressure record obtained in this test indicates that an essentially full fill-up of fluid occurred during the estimated 40 minutes of flowing time. The production rate of 312.7 BPD, based upon the above estimates, has been used in the basic equation to calculate a numerical value for the transmissibility of the formation within the test interval.

   Although it is indicated that a maximum reservoir pressure of 683 psi was recorded mechanically during the last 60 minutes of the Final Shut-in period, extrapolation of the pressure build-up curve has been made using 9 points on the extrapolation plot. This has been done in order to provide an "m" value which is a key factor used in the basic equation to calculate a numerical value for transmissibility. Because of the questionable reliability concerning the "m" value and the Average Production Rate, the numerical results which were obtained in this analysis should be considered as indicators rather than quantitative values.

U.S.G.S., Madison Limestone #1
Interval: 1500-1575' (DST #1)

Comments - Page 2

2. The Initial Shut-in pressure record which was obtained in this test is poorly legible, but indicates that a maximum reservoir pressure of 690 psi was recorded during this shut-in period. Extrapolation of the Final Shut-in pressure build-up curve indicates a maximum reservoir pressure of 682 psi at the recorder depth of 1480 feet. The difference between the extrapolated Initial and Final Shut-in pressures (8 psi) is considered insignificant. The indicated maximum reservoir pressure is reasonably consistent with original reservoir pressures which were found in the Minnekahta and Minnelusa formations at earlier dates and comparable depths in the general area of this formation test.

3. The calculated Damage Ratio of 2.62 indicates that significant well-bore damage was present at the time of this formation test. Because of the relatively high volume-rate of fluid production which occurred during this test, it is suggested that the indicated well-bore damage is due to the choke effect of the tool rather than formation damage.

4. The calculated Effective Transmissibility of 18158.9 md.-ft./cp. indicates an Average Permeability to the produced fluid of 1815.9 md. for the estimated 10 feet of effective porosity within the total 75 feet of interval tested. The indicated Average Permeability of the formation within the total 75 feet of tested interval is 242.1 md.

5. The radius of investigation of this test is indicated by the relationship, $b \approx \sqrt{kt_o}$ to be about 270 feet if the thickness of the effective zone of porosity is 10 feet.

6. The evaluation criteria used in the DST Analysis System indicate that the tools and recorder functioned properly; however, because of the deviation from normal drill-stem-test procedures, the numerical results obtained in this analysis should be considered as indicators rather than quantitative values.

Roger L. Hoeger
Consultant for Lynes, Inc.

LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Limestone #1 DST No. 1

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	656
12.0	53.5000	676
24.0	27.2500	680
36.0	18.5000	681
48.0	14.1250	682
60.0	11.5000	683
72.0	9.7500	683
84.0	8.5000	683
96.0	7.5625	683
108.0	6.8333	683
120.0	6.2500	683

EXTRAPLN OF FIRST SHUT IN : 690.0 M : 2.8

RESERVOIR PARAMETERS:

COLLAR RECOV	1.000	PIPE RECOV	1500.000	INT FLO TIM	20.000
FINL FLO TIM	610.000	MUD EXPANS	1.000	BTM HOL TMP	102.000
API GRAVITY	10.000	SPEC GRAVTY	1.000	VISCOSITY	1.000
PAY THICKNES	10.000	SUBSEA DPTH	2138.000	WATR GRADNT	0.433

CALCULATIONS: FIRST SHUT IN

EXTRAP PRESS(PSIG)............	685.2
NO OF PTS ENTERED..........	11.0
NO OF PTS USED............	9.0
RMS DEVIATION(PSI).........	0.198
TOTL FLO TIM(MIN)..........	40.0
AVE PROD RATE(BBLS/DAY).......	312.7
TRANSMISS(MD-FT/CP)...........	18158.9
IN SITU CAP(MD-FT)............	18158.9
AVE EFFECT PERM(MD)...........	1815.9
PROD INDX(BBLS/DAY-PSI).......	10.71
DAMAGE RATIO..................	2.62
PROD INDX-DAMAGE(BBLS/DAY-PSI)	28.06
RAD OF INVEST(FT).............	270.0
DRAWDOWN(PERCENT).............	0.0
POTENMETRC SURF(FT)...........	3720.4

U.S. Geological Survey
DST No. 4 (Swab Test)
Date 8/10-8/11/1976

Spot NE-SE	Csg. Size & Grade 13 3/8" From surface to 1502'
Sec. 15	Tubing Size 2 7/8" 6.5# EUE 8 Rd.
Twp. 57 N	Tool Depth 1542'-1738'
Rng. 65 W	On Location @ 4:00 pm. 8/10/76
Field Wildcat	Off Location @ —
County Crook'	Lynes Rep. Hollis Magruder
State Wyoming	Well Owners Rep. Roger Miller

Tool Description 7 3/8" X 2 1/2" X 66" Production Injection Packer

Fm Minnelusa

Summary:

Ran 7 3/8" Lynes packer in hole on 2 7/8" OD tubing and set packer at 1542' below KB at 8:30 p.m. Opened below packer and began swabbing at 9:45 p.m. Swabbed about 1650 gallons of mud and LCM with 12 swabs. Well began to flow water-cut mud and LCM at 11:30 p.m. Initial flow was 16 gpm. Flow increased to 60 gpm at 1:50 a.m., and to 75 gpm at 2:30 a.m. Temperature of water while flowing was 100.4°F. Test was stopped at 3:13 a.m. Final shut in pressure after 30 minutes was 39 psi.

Note: All depths and pressure from KB.

Phone
522-1206 Area 303

LYNES, INC.

Box 712
Sterling, Colo. 80751

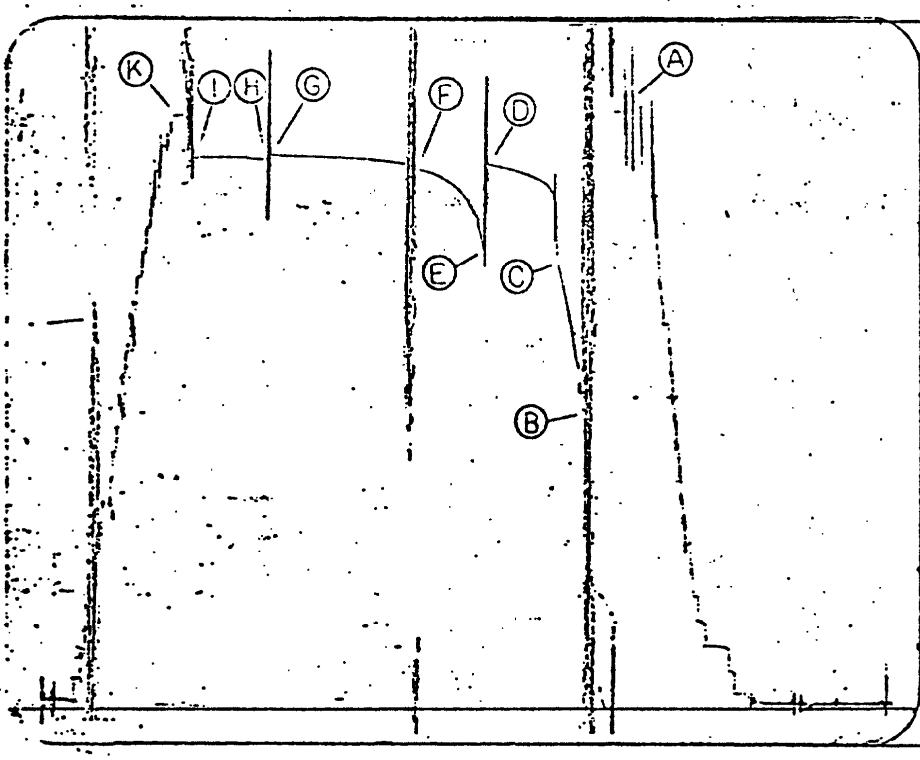
Operator: U.S.G.S.
Address: See Distribution
Well Name and No.: Madison Limestone #1
Ticket No.: 2227
Date: 8-21-76
DST No.: 6
No. Final Copies: 5

Contractor	Thompson Drlg. Co.	Top Choke	1"
Rig No.	20	Bottom Choke	9/16"
Spot	NE-SE	Size Hole	7 7/8"
Sec.	15	Size Rat Hole	--
Twp.	57 N	Size & Wt. D. P.	4½" 16.60
Rng.	65 W	Size Wt. Pipe	--
Field	Wildcat	I. D. of D. C.	2¼"
County	Crook	Length of D. C.	464'
State	Wyoming	Total Depth	2388'
Elevation	3618' "K.B."	Interval Tested	2218-2298'
Formation	Ansden	Type of Test	Inflate Straddle

Flow No. 1	30	Min.
Shut-in No. 1	60	Min.
Flow No. 2	60	Min.
Shut-in No. 2	120	Min.
Flow No. 3	67	Min.
Shut-in No. 3	--	Min.

Bottom Hole Temp. --
Mud Weight 9.1
Gravity --
Viscosity 60

Tool opened @ 9:53 AM.



Inside Recorder

PRD Make Kuster AK-1
No. 5978 Cap. 1200 @ 2203'

Press		Corrected
Initial Hydrostatic	A	1065
Final Hydrostatic	K	1055
Initial Flow	B	528
Final Initial Flow	C	794
Initial Shut-in	D	969
Second Initial Flow	E	814
Second Final Flow	F	960
Second Shut-in	G	985
Third Initial Flow	H	978
Third Final Flow	I	950
Third Shut-in	J	--

Our Tester: James O'Conner

Witnessed By: --

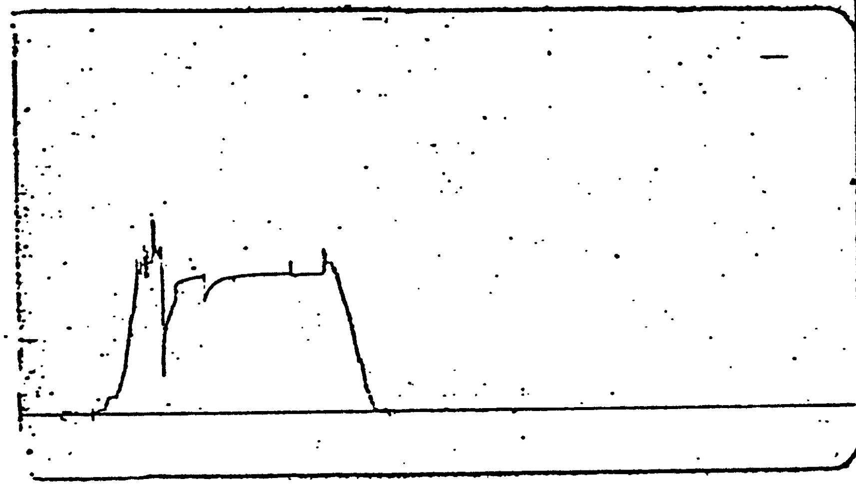
Did Well Flow – Gas No Oil No Water Yes

RECOVERY IN PIPE: 2218' Total Fluid
180' Muddy water = 2.56 Bbl.
2028' Clear Water = 24.55 Bbl.
10' Sand

REMARKS:
1st Flow - Tool opened with very strong blow and remained thru flow period.
2nd Flow - Tool opened with very strong blow, decreased slightly and remained thru flow period.
3rd Flow - Tool opened with strong blow, water to surface in 20 minutes. Flowed ½ gallon per minute.

LYNES, INC.

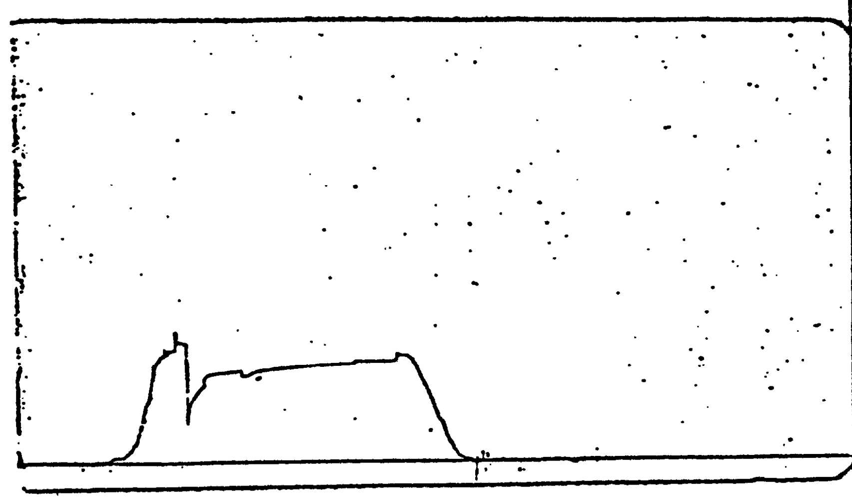
Operator U.S.G.S. Lease & No. Madison Limestone #1 DST No. 6



Outside Recorder

PRD Make Kuster K-3
No. 12768 Cap. 3000 @ 2228'

Press		Corrected
Initial Hydrostatic	A	1116
Final Hydrostatic	K	1066
Initial Flow	B	439
Final Initial Flow	C	803
Initial Shut-in	D	779
Second Initial Flow	E	823
Second Final Flow	F	970
Second Shut-in	G	993
Third Initial Flow	H	931
Third Final Flow	I	958
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



Outside Recorder

PRD Make Kuster K-3
No. 7097 Cap. 4000 @ 2228'

Press		Corrected
Initial Hydrostatic	A	1130
Final Hydrostatic	K	1013
Initial Flow	B	418
Final Initial Flow	C	739
Initial Shut-in	D	872
Second Initial Flow	E	819
Second Final Flow	F	887
Second Shut-in	G	934
Third Initial Flow	H	957
Third Final Flow	I	960
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

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LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

BOX 712
STERLING, COLORADO 80751
PHONE 303-522-1206

Comments relative to the analysis of the pressure chart from DST #6, Interval: 2218-2298', in the U.S.G.S., Madison Limestone #1, NE SE Section 15, T57N-R65W, Crook County, Wyoming:

For purposes of this analysis, the following reservoir and fluid properties have been used:

BHT = 85°F (estimated), μ = 1.0 cp., t = 90 minutes,
h = 10 feet (estimated), m = 37.3 psi/cycle.

1. Extrapolation of the Initial Shut-in pressure build-up curve indicates a maximum reservoir pressure of 993.4 psi at the recorder depth of 2203 feet. Extrapolation of the Final Shut-in pressure build-up curve indicates a maximum reservoir pressure of 994.1 psi. The difference between the extrapolated Initial and Final Shut-in pressures (0.7 psi) is considered insignificant.

   The indicated maximum reservoir pressure is reasonably consistent with original reservoir pressures which were found in the Amsden and stratigraphically related formations at comparable depths and earlier dates in the general area of this formation test.

2. The calculated Average Production Rate which was used in this analysis, 434.0 BPD, is based upon the total fluid recovery of 27.11 barrels and 90 minutes of flowing time (flow period #1 plus flow period #2).

3. The calculated Damage Ratio of 0.2 indicates that no significant well-bore damage was present at the time of this formation test.

4. The calculated Effective Transmissibility of 1889.8 md.-ft./cp. indicates an Average Permeability to the produced fluid of 189 md. for the estimated 10 feet of effective porosity within the total interval of 80 feet. The average effective permeability for the formation within the total interval of the test is 23.6 md.

70

U.S.G.S., Madison Limestone #1
Interval: 2218-2298' (DST #6)

Comments - Page 2

5. The Radius of Investigation of this test is indicated by the relationship, $b \approx \sqrt{kt_o}$ to be about 130 feet.

6. The evaluation criteria used in the Drill-Stem-Test Analysis System indicate that the results obtained in this analysis should be reliable within reasonable limits relative to the assumptions which have been made.

Roger L. Hoeger
Roger L. Hoeger,
Consultant for Lynes, Inc.

LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Limestone #1 DST No. 6

Recorder No. 5978 @ 2203'

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	794
6.0	6.0000	924
12.0	3.5000	938
18.0	2.6667	945
24.0	2.2500	950
30.0	2.0000	954
36.0	1.8333	958
42.0	1.7143	961
48.0	1.6250	964
54.0	1.5556	967
60.0	1.5000	969

EXTRAPLN OF FIRST SHUT IN : 993.4

SECOND SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	960
12.0	8.5000	971
24.0	4.7500	974
36.0	3.5000	977
48.0	2.8750	979
60.0	2.5000	980
72.0	2.2500	981
84.0	2.0714	982
96.0	1.9375	983
108.0	1.8333	984
120.0	1.7500	985

EXTRAPLN OF SECOND SHUT IN : 994.1 M : 37.3

LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

Operator U.S.G.S. Lease & No. Madison Limestone #1 DST No. 6

Recorder No. 5978 @ 2203'

RESERVOIR PARAMETERS:

COLLAR RECOV	464.000	PIPE RECOV	1754.000	INT FLO TIM	30.000
FINL FLO TIM	60.000	MUD EXPANS	1.000	BTM HOL TMP	85.000
API GRAVITY	10.000	SPEC GRAVTY	1.000	VISCOSITY	1.000
PAY THICKNES	10.000	SUBSEA DPTH	1315.000	WATR GRADNT	0.433

CALCULATIONS: SECOND SHUT IN

EXTRAP PRESS(PSIG)............	994.1
NO OF PTS ENTERED..........	11.0
NO OF PTS USED.............	6.0
RMS DEVIATION(PSI).........	0.011
TOTL FLO TIM(MIN)..........	90.0
AVE PROD RATE(BBLS/DAY).......	434.0
TRANSMISS(MD-FT/CP)...........	1889.8
IN SITU CAP(MD-FT)............	1889.8
AVE EFFECT PERM(MD)...........	188.98
PROD INDX(BBLS/DAY-PSI).......	12.736
DAMAGE RATIO..................	0.2
PROD INDX-DAMAGE(BBLS/DAY-PSI)	2.127
RAD OF INVEST(FT).............	130.4
DRAWDOWN(PERCENT).............	0.0
POTENMETRC SURF(FT)...........	3711.4

LYNES, INC.

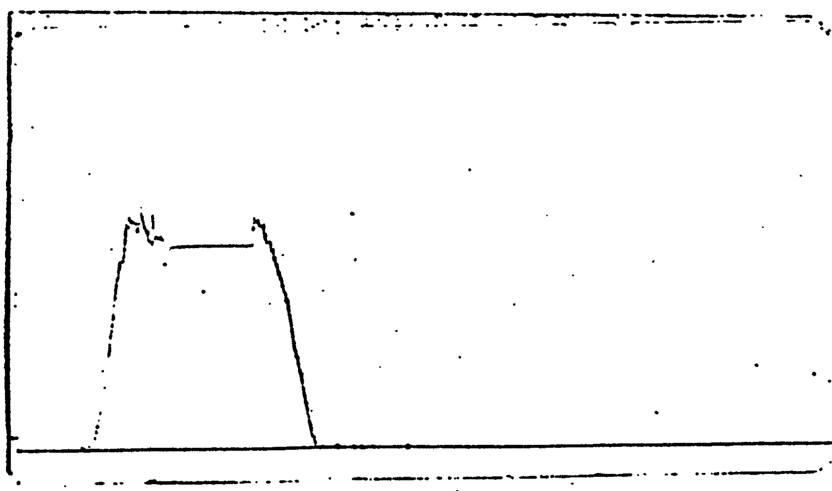
Phone
522-1206 Area 303

Box 712
Sterling, Colo. 80751

Operator U.S.G.S.
Address Box 25046, Denver Federal Center, Stop 412
Lakewood, Colorado 80225
Well Name and No. Madison-Limestone #1
DST No. 14
Ticket No. 4132
Date 10-14-76
No. Final Copies 5

Contractor	Thomson Drlg., Inc.	Top Choke	1"	Flow No. 1	30 Min.
Rig No.	20	Bottom Choke	1"	Shut-in No. 1	60 Min.
Spot	NE-SE	Size Hole	7 7/8"	Flow No. 2	30 Min.
Sec.	15	Size Rat Hole	--	Shut-in No. 2	60 Min.
Twp.	57 N	Size & Wt. D. P.	4½" 16.60	Flow No. 3	-- Min.
Rng.	65 W	Size Wt. Pipe	--	Shut-in No. 3	-- Min.
Field	Wildcat	I. D. of D. C.	2¼"		
County	Crook	Length of D. C.	277'	Bottom Hole Temp.	150°F
State	Wyoming	Total Depth	4355'	Mud Weight	9.5
Elevation	3615' "K.B."	Interval Tested	3300-3480'	Gravity	--
Formation	Red River	Type of Test	Inflate Straddle	Viscosity	46

Tool opened @ 4:20 PM.



Outside Recorder

PRD Make Kuster K-3
No. 13137 Cap. 2950 @ 3314'

Press		Corrected
Initial Hydrostatic	A	1653
Final Hydrostatic	K	1646
Initial Flow	B	1335
Final Initial Flow	C	1470
Initial Shut-in	D	1470
Second Initial Flow	E	1470
Second Final Flow	F	1470
Second Shut-in	G	1470
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--

Our Tester: Paul Robbins
Witnessed By: Dave Hoppes

Did Well Flow — Gas No Oil No Water No

RECOVERY IN PIPE: 3300' Total Fluid
360' Drilling mud = 5.11 Bbl.
450' Water cut drilling mud = 6.39 Bbl.
2440' Water = 32.07 Bbl.

REMARKS:

1st Flow - Tool opened with strong blow, decreased to dead in 22 minutes and remained thru flow period.

2nd Flow - Tool opened with no blow and remained dead thru flow period.

Shut-in pressures were static, therefore breakdown of shut-in pressures not practical for Horner Extrapolations.

UNITED SERVICES
DIVISION OF LYNES, INC.

BOX 712
STERLING, COLORADO 80751
PHONE 303-522-1206

Comments relative to the analysis of the pressure chart from DST #14 Interval: 3300-3480', in the U.S.G.S., Madison Limestone #1, NE SE Section 15, T57N-R65W, Crook County, Wyoming:

For purposes of this analysis, the following reservoir and fluid properties and test parameters have been used:

BHT = 150°F., μ = 1.0 cp., t = 60 minutes, h = 10 feet (estimated), m = 1.3 psi/cycle.

1. The character of the pressure record which was obtained in this test indicates that the maximum reservoir pressure of 1470 psi was recorded mechanically during both shut-in periods. A slope of 1.3 psi/log cycle has been applied to the extrapolation plot of the Final Shut-in pressure build-up curve to provide a value for "m" for use in the basic Horner equation to permit the calculation of numerical values for the various reservoir properties shown below and on the summary page. Because of the questionable reliability of this "m" value, these numerical results should be considered as indicators rather than quantitative values.

   The potentiometric surface elevation of the formation within this test interval, based upon the static reservoir pressure of 1470 psi at the recorder depth of 3314 feet and the use of the gradient constant of 2.33 ft./psi, is 3729 feet above sea level. This value of potentiometric surface is in close agreement with that which was determined for the Flat Head sandstone in DST #10 in this same well. It is therefore suggested that hydraulic continuity may exist between these two formations.

2. The calculated Average Production Rate which was used in this analysis, 2851.2 BPD, is based upon the total fluid recovery of 43.6 barrels and 22 minutes of the Initial flow period, at which time it was reported that the surface blow died.

U.S.G.S., Madison Limestone #1
Interval: 3300-3480' (DST #14)

Comments - Page 2

3. The calculated Damage Ratio of 0.3 indicates that no significant well-bore damage was present at the time of this formation test.

4. The calculated Effective Transmissibility of 351397.8 md.-ft./cp. indicates an Average Permeability to the produced fluid of 35139.8 md. for the estimated 10 feet of effective porosity within the total 180 feet of interval tested.

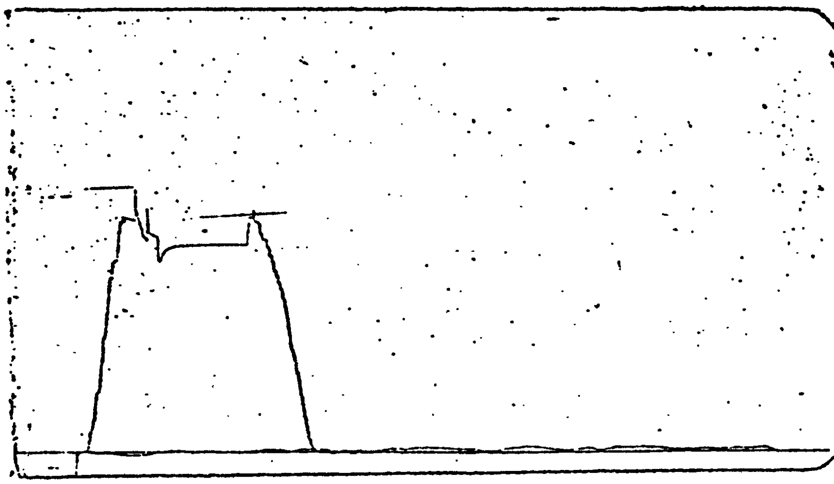
5. The radius of investigation of this test is indicated by the relationship, $b \approx \sqrt{kt_o}$, to be about 1452 feet.

6. The evaluation criteria used in the Drill-Stem-Test Analysis System indicate that the tools and recorder functioned properly; however, because of the questionable reliability concerning the measured slope of the extrapolation plot, as noted above, the numerical results obtained in this analysis should be considered as indicators only.

Roger L. Hoeger
Consultant for Lynes, Inc.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison-Limestone #1 DST No. 14

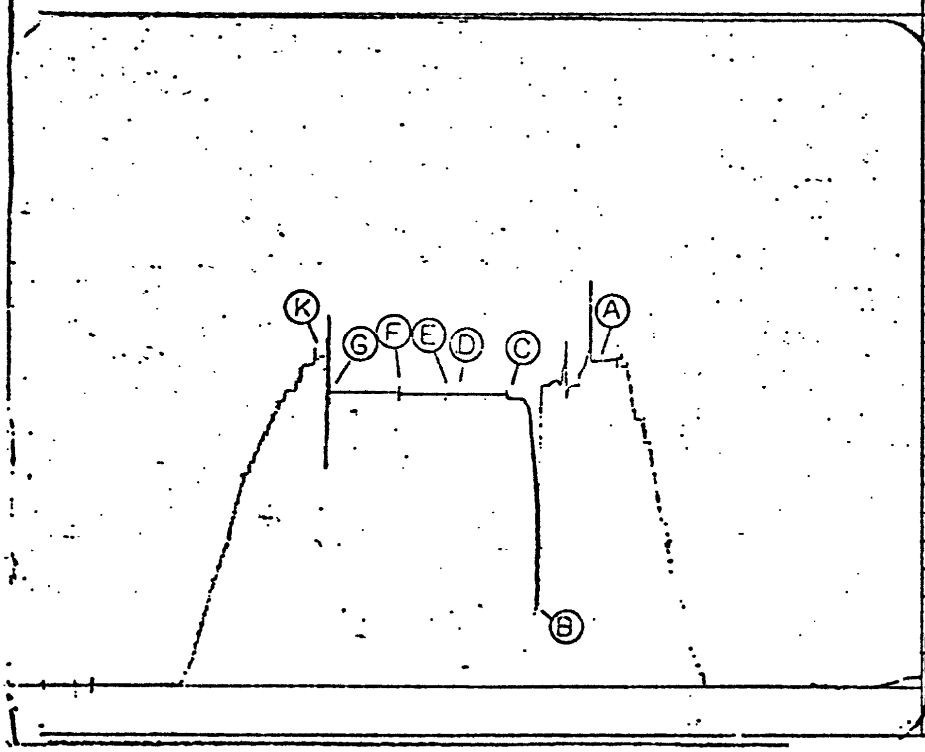


Outside Recorder

PRD Make Kuster K-3

No. 13005 Cap. 2900 @ 3313'

Press		Corrected
Initial Hydrostatic	A	1633
Final Hydrostatic	K	1621
Initial Flow	B	1347
Final Initial Flow	C	1464
Initial Shut-in	D	1464
Second Initial Flow	E	1464
Second Final Flow	F	1464
Second Shut-in	G	1464
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



Inside Recorder

PRD Make Kuster AK-1

No. 1050 Cap. 3100 @ 3288'

Press		Corrected
Initial Hydrostatic	A	1636
Final Hydrostatic	K	1626
Initial Flow	B	412
Final Initial Flow	C	1455
Initial Shut-in	D	1464
Second Initial Flow	E	1464
Second Final Flow	F	1464
Second Shut-in	G	1464
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Form 3

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison-Limestone #1 DST No. 14

Recorder No. 13137 @ 3314'

RESERVOIR PARAMETERS:

COLLAR RECOV	277.000	PIPE RECOV	3023.000	INT FLO TIM	30.000
FINL FLO TIM	30.000	MUD EXPANS	1.000	BTM HOL TMP	150.000
API GRAVITY	10.000	SPEC GRAVTY	10.000	VISCOSITY	1.000
PAY THICKNES	10.000	SUBSEA DPTH	304.000	WATR GRADNT	0.433

CALCULATIONS: SECOND SHUT IN

EXTRAP PRESS(PSIG)............	1470.4
NO OF PTS ENTERED..........	11.0
NO OF PTS USED.............	9.0
RMS DEVIATION(PSI).........	0.137
TOTL FLO TIM(MIN)..........	60.0
AVE PROD RATE(BBLS/DAY).......	2851.2
TRANSMISS(MD-FT/CP)...........	351397.8
IN SITU CAP(MD-FT)............	351397.8
AVE EFFECT PERM(MD)...........	35139.78
PROD INDX(BBLS/DAY-PSI).......	1189.410
DAMAGE RATIO..................	0.3
PROD INDX-DAMAGE(BBLS/DAY-PSI)	395.485
RAD OF INVEST(FT).............	1452.0
DRAWDOWN(PERCENT).............	0.0
POTENMETRC SURF(FT)...........	3699.8

Form 2

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison-Limestone # 1 DST No. 14

Recorder No. 13137 @ 3314'

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T+PHI) /PHI	PSIG
0.0	0.0000	1468
6.0	6.0000	1468
12.0	3.5000	1469
18.0	2.6667	1469
24.0	2.2500	1470
30.0	2.0000	1470
36.0	1.8333	1470
42.0	1.7143	1470
48.0	1.6250	1470
54.0	1.5556	1470
60.0	1.5000	1470

EXTRAPLN OF FIRST SHUT IN : 1470.3

SECOND SHUT IN PRESSURE:

TIME(MIN) PHI	(T+PHI) /PHI	PSIG
0.0	0.0000	1468
6.0	11.0000	1468
12.0	6.0000	1469
18.0	4.3333	1469
24.0	3.5000	1470
30.0	3.0000	1470
36.0	2.6667	1470
42.0	2.4286	1470
48.0	2.2500	1470
54.0	2.1111	1470
60.0	2.0000	1470

EXTRAPLN OF SECOND SHUT IN : 1470.4 M : 1.3

Form 2

LYNES, INC.

Phone
522-1206 Area 303

Box 712
Sterling, Colo. 80751

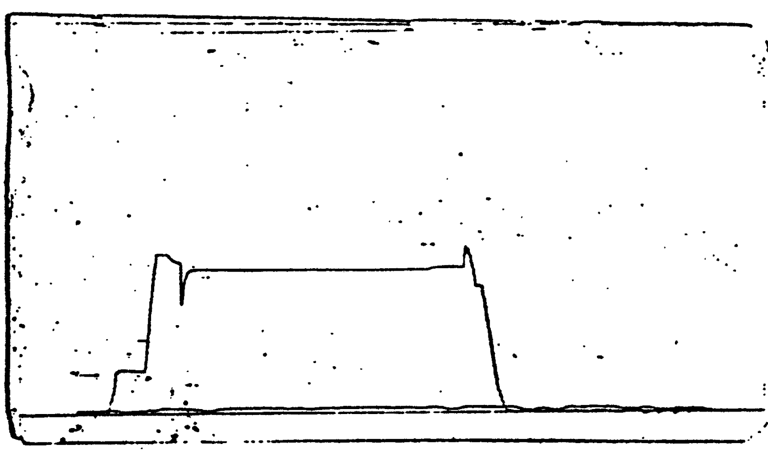
Operator: U.S.G.S.
Address: Box 25046, Denver Federal Center, Stop 412
Lakewood, Colorado 80225
Well Name and No.: Madison-Limestone #1
Ticket No.: 4133
Date: 10-20-76
DST No.: 15
No. Final Copies: 5

Contractor	Thomson Drlg., Inc.	Top Choke	1"
Rig No.	20	Bottom Choke	1"
Spot	NE-SE	Size Hole	7 7/8"
Sec.	15	Size Rat Hole	--
Twp.	57 N	Size & Wt. D. P.	4½" 16.60
Rng.	65 W	Size Wt. Pipe	--
Field	Wildcat	I. D. of D. C.	2¼"
County	Crook	Length of D. C.	437'
State	Wyoming	Total Depth	4355'
Elevation	3618' "K.B."	Interval Tested	2530-2570'
Formation	Mission Canyon	Type of Test	Inflate Straddle

Flow No. 1	877	Min.
Shut-in No. 1	60	Min.
Flow No. 2	--	Min.
Shut-in No. 2	--	Min.
Flow No. 3	--	Min.
Shut-in No. 3	--	Min.

Bottom Hole Temp. 106° F
Mud Weight 9.5
Gravity --
Viscosity 46

Tool opened @ 4:50 AM.



Outside Recorder
PRD Make Kuster K-3
No. 13005 Cap. 2900 @ 2540'

Press		Corrected
Initial Hydrostatic	A	1266
Final Hydrostatic	K	1254
Initial Flow	B	834
Final Initial Flow	C	1108
Initial Shut-in	D	1126
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--

Our Tester: Paul Robbins
Witnessed By: Dave Hoppes

Did Well Flow – Gas No Oil No Water Yes

RECOVERY IN PIPE: 2530' Formation water & drilling mud = 31.86 Bbl.

1st Flow - Tool opened with a strong blow, fluid to surface in 15 minutes.

REMARKS:

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LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

BOX 712
STERLING, COLORADO 80751
PHONE 303-522-1206

Comments relative to the analysis of the pressure chart from DST #15, Interval: 2530-2570', in the U.S.G.S., Madison Limestone #1, NE SE Section 15, T57N-R65W, Crook County, Wyoming:

For purposes of this analysis, the following reservoir and fluid properties and test parameters have been used:

BHT = 106°F, μ = 1.0 cp., t = 15 minutes, h = 10 feet (estimated), m = 0.4 psi/cycle.

1. The character of the pressure record which was obtained in this test indicates that the maximum reservoir pressure of 1130 psi was recorded mechanically during the 60-minute shut-in period. An estimated slope of 0.4 psi/log cycle has been applied to the extrapolation plot of the shut-in pressure build-up curve in order to make it possible to calculate numerical values for the effective transmissibility and average permeability. The application of this estimated "m" value places some question on the reliability of the above calculated results. These numerical values should therefore be considered as indicators rather than quantitative results.

   The indicated maximum reservoir pressure of 1130 psi at the recorder depth of 2540 feet (+1078') indicates a potentiometric surface elevation of 3711 feet above sea level. A conversion constant of 2.33 ft./psi has been used to convert the indicated static reservoir pressure to its equivalent potentiometric surface elevation. This value of potentiometric surface is in close agreement with that which was determined for the Flat Head sandstone in DST #10 and the Red River formation in DST #14 in this same well. It is therefore suggested that hydraulic continuity may exist between these three formations.

2. The calculated Average Production Rate which was used in this analysis, 3052.8 BPD, is based upon a total fluid recovery of 31.86 barrels (a total fill-up of fluid in the pipe from the recorder depth to the rig floor) and a total flowing time of 15 minutes (the amount of flowing time at which fluid reached the surface).

U.S.G.S., Madison Limestone #1
Interval: 2530-2570' (DST #15)

Comments - Page 2

3. The calculated Damage Ratio of 7.9 indicates that significant well-bore damage was present at the time of this formation test; however, because of the magnitude of the production rate which occurred in this test, the indicated well-bore damage is probably due to the choke effect of the test tool rather than actual formation damage. The damage ratio implies that the average production rate should have been 7.9 times greater than that which occurred if well-bore damage had not been present.

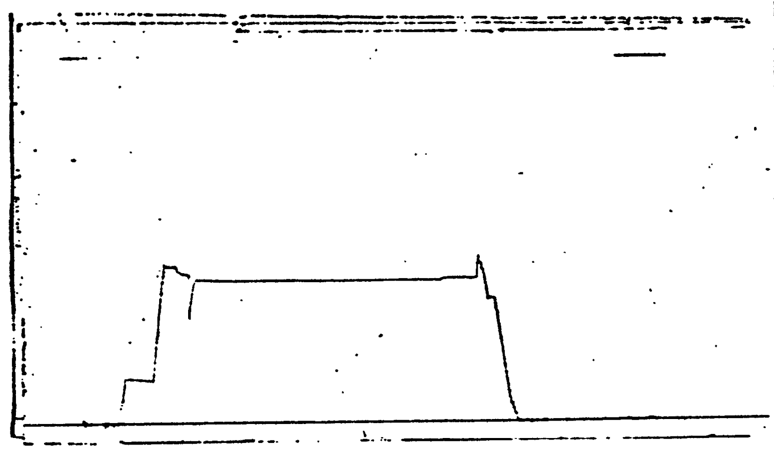
4. The calculated Effective Transmissibility of 1,160,675.3 md.-ft./cp. indicates an Average Permeability to the produced fluid of 116,067.5 md. for the estimated 10 feet of effective porosity within the total 40 feet of interval tested.

5. The evaluation criteria used in the Drill-Stem-Test Analysis System indicate that the tools and recorder functioned properly; however, because of the questionable reliability of the estimated "m" value which was used to calculate the above numerical results, these results should be considered as indicators only.

Roger L. Hoeger
Consultant for Lynes, Inc.

LYNES, INC.

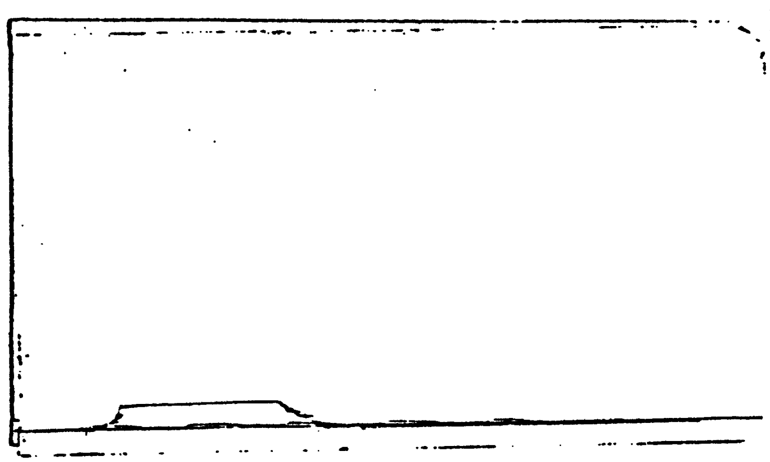
Operator U.S.G.S. Lease & No. Madison-Limestone #1 DST No. 15



Outside Recorder

PRD Make Kuster K-3
No. 13137 Cap. 2950 @ 2540'

Press		Corrected
Initial Hydrostatic	A	1263
Final Hydrostatic	K	1247
Initial Flow	B	819
Final Initial Flow	C	1112
Initial Shut-in	D	1130
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



PRD Make Kuster K-3
No. 5626 Cap. 34-399 @ --

Press		Corrected
Initial Hydrostatic	A	
Final Hydrostatic	K	
Initial Flow	B	
Final Initial Flow	C	
Initial Shut-in	D	
Second Initial Flow	E	
Second Final Flow	F	
Second Shut-in	G	
Third Initial Flow	H	
Third Final Flow	I	
Third Shut-in	J	
Maximum Temperature		106
Pressure Below Bottom Packer Bled To		

Form 3

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LYNES, INC.

Operator U.S.G.S. Lease & No. Madison-Limestone #1 DST No. 15

Recorder No. 13137 @ 2540'

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	1112
6.0	147.1667	1128
12.0	74.0833	1129
18.0	49.7222	1130
24.0	37.5417	1130
30.0	30.2333	1130
36.0	25.3611	1130
42.0	21.8810	1130
48.0	19.2708	1130
54.0	17.2407	1130
60.0	15.6167	1130

EXTRAPLN OF FIRST SHUT IN : 1130.5 M : 0.4

RESERVOIR PARAMETERS:

COLLAR RECOV	437.000	PIPE RECOV	2093.000	INT FLO TIM	877.000
FINL FLO TIM	877.000	MUD EXPANS	1.000	BTM HOL TMP	106.000
API GRAVITY	10.000	SPEC GRAVTY	10.000	VISCOSITY	1.000
PAY THICKNES	10.000	SUBSEA DPTH	1078.000	WATR GRADNT	0.433

CALCULATIONS: FIRST SHUT IN

EXTRAP PRESS(PSIG)............	1130.5
NO OF PTS ENTERED..........	11.0
NO OF PTS USED.............	10.0
RMS DEVIATION(PSI).........	0.213
TOTL FLO TIM(MIN)..........	877.0
AVE PROD RATE(BBLS/DAY).......	3052.8
TRANSMISS(MD-FT/CP)...........	1160675.3
IN SITU CAP(MD-FT)............	1160675.3
AVE EFFECT PERM(MD)...........	116067.53
PROD INDX(BBLS/DAY-PSI).......	164.923
DAMAGE RATIO..................	7.9
PROD INDX-DAMAGE(BBLS/DAY-PSI)	1306.295
RAD OF INVEST(FT).............	10089.2
DRAWDOWN(PERCENT).............	0.0
POTENMETRC SURF(FT)...........	3688.9

Form 2

Phone
522-1206 Area 303

LYNES, INC.

Box 712
Sterling, Colo. 80751

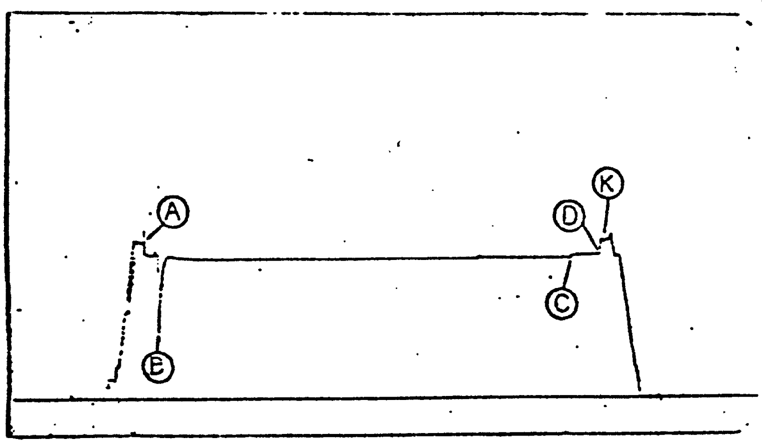
Operator: U.S.G.S.
Address: Box 25046, Denver Federal Center, Stop 412, Lakewood, Colorado 80225
Well Name and No.: [illegible]
Ticket No. 4135
Date 10-20-76
No. Final Copies 5

Contractor	Thomson Drlg., Inc.	Top Choke	1"
Rig No.	20	Bottom Choke	1"
Spot	¼E-SE	Size Hole	7 7/8"
Sec.	15	Size Rat Hole	--
Twp.	57 N	Size & Wt. D. P.	4½" 16.60
Rng.	65 W	Size Wt. Pipe	--
Field	Wildcat	I. D. of D. C.	2¼"
County	Crook	Length of D. C.	437'
State	Wyoming	Total Depth	4355'
Elevation	3618' "K.B."	Interval Tested	2434-2530'
Formation	Madison	Type of Test	Inflate Straddle

Flow No. 1	877	Min.
Shut-in No. 1	60	Min.
Flow No. 2	--	Min.
Shut-in No. 2	--	Min.
Flow No. 3	--	Min.
Shut-in No. 3	--	Min.

Bottom Hole Temp. 109° F
Mud Weight 9.5
Gravity --
Viscosity 46

Tool opened @ 10:21



Outside Recorder
PRD Make Kuster K-3
No. 13005 Cap. 2900 @ 2444'

		Press	Corrected
Initial Hydrostatic	A		1227
Final Hydrostatic	K		1200
Initial Flow	B		508
Final Initial Flow	C		1067
Initial Shut-in	D		1092
Second Initial Flow	E		--
Second Final Flow	F		--
Second Shut-in	G		--
Third Initial Flow	H		--
Third Final Flow	I		--
Third Shut-in	J		--

Our Tester: James O'Conner
Witnessed By: --

Did Well Flow — Gas No Oil No Water Yes
RECOVERY IN PIPE: 2434' Formation water = 30.50 Bbl.

Flow - Tool opened with strong blow, increased to bottom of bucket in 3 seconds. Water to surface in 18 minutes. Flowed 14 hours 39 minutes at 20 gallons per minute. Shut-in at surface for 1 hour. 37.2 psig surface pressure.

REMARKS:

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LYNES UNITED SERVICES
DIVISION OF LYNES, INC.

BOX 712
STERLING, COLORADO 80751
PHONE 303-522-1206

Comments relative to the analysis of the pressure chart from DST #16, Interval: 2434-2530', in the U.S.G.S., Madison Limestone #1, NE SE Section 15, T57N-R65W, Crook County, Wyoming:

For purposes of this analysis, the following reservoir and fluid properties and test parameters have been used:

BHT = 109°F, μ = 1.0 cp., t = 18 minutes, h = 10 feet (estimated), m = 2.6 psi/cycle.

1. The character of the pressure record which was obtained in this test indicates that the maximum reservoir pressure of 1092 psi was recorded at a depth of 2444 feet. Extrapolation of the shut-in pressure build-up curve has been made by projecting a straight line through the last 7 points on the extrapolation plot and results in an extrapolated pressure of 1095 psi. The slope of this extrapolation curve has been determined to be 2.6 psi/log cycle. This estimated "m" value has been used in the basic Horner equation to calculate numerical values for the various reservoir properties shown below and on the summary page. Because of the questionable reliability of this estimated "m" value, these numerical results should be considered as indicators rather than quantitative values.

   The indicated static reservoir pressure of 1092 psi at the recorder depth of 2444 feet indicates a potentiometric surface elevation of 3718 feet above sea level. A conversion constant of 2.33 ft./psi has been used to convert the indicated static reservoir pressure to its equivalent potentiometric surface elevation. This value of potentiometric surface is in close agreement with that which was determined for the Flat Head sandstone in DST #10, the Red River formation in DST #14, and the Mission Canyon formation in DST #15 in this same well. It is therefore suggested that hydraulic continuity may exist between these four formations.

U.S.G.S., Madison Limestone #1
Interval: 2434-2530' (DST #16)

Comments - Page 2

2. The calculated Average Production Rate which was used in this analysis, 2439.9 BPD, is based upon the total fluid recovery of 30.5 barrels (a full fill-up of fluid in the pipe from the recorder depth to the rig floor) and a total flowing time of 18 minutes (the flowing time at which water reached the surface).

3. The calculated Damage Ratio of 2.0 indicates that significant well-bore damage was present at the time of this formation test; however, because of the magnitude of the production rate which occurred in this test, it is suggested that the indicated well-bore damage is probably due to the choke effect of the test tool rather than actual formation damage. The damage ratio implies that the average production rate should have been 2.0 times greater than that which occurred if well-bore damage had not been present.

4. The calculated Effective Transmissibility of 153,290.4 md.-ft./cp. indicates an Average Permeability to the produced fluid of 15,329.0 md. for the estimated 10 feet of effective porosity within the total 96 feet of interval tested.

5. The radius of investigation of this test is indicated by the relationship, $b \approx \sqrt{kt_o}$, to be about 3667 feet.

6. The evaluation criteria used in the Drill-Stem-Test Analysis System indicate that the tools and recorder functioned properly; however, because of the questionable reliability of the estimated "m" value which was used to calculate the above numerical results, these results should be considered as indicators only.

Roger L. Hoeger
Consultant for Lynes, Inc.

LYNES, INC.

Operator U.S.G.S. Lease & No. Madison-Limestone #1 DST No. 16

Recorder No. 13005 @ 2444'

FIRST SHUT IN PRESSURE:

TIME(MIN) PHI	(T"PHI) /PHI	PSIG
0.0	0.0000	1067
6.0	147.1667	1087
12.0	74.0833	1088
18.0	49.7222	1089
24.0	37.5417	1090
30.0	30.2333	1091
36.0	25.3611	1092
42.0	21.8810	1092
48.0	19.2708	1092
54.0	17.2407	1092
60.0	15.6167	1092

EXTRAPLN OF FIRST SHUT IN : 1095.1 M : 2.6

RESERVOIR PARAMETERS:

COLLAR RECOV	437.000	PIPE RECOV	1997.000	INT FLO TIM	877.000
FINL FLO TIM	877.000	FLUID EXPANS	1.000	BTM HOL TMP	109.000
API GRAVITY	10.000	SPEC GRAVTY	1.000	VISCOSITY	1.000
PAY THICKNES	10.000	SUBSEA DPTH	1174.000	WATR GRADNT	0.433

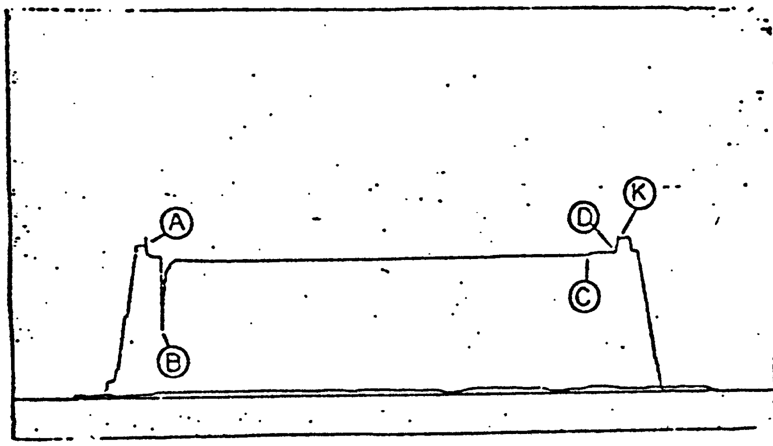
CALCULATIONS: FIRST SHUT IN

EXTRAP PRESS(PSIG)............	1095.1
NO OF PTS ENTERED..........	11.0
NO OF PTS USED.............	7.0
RMS DEVIATION(PSI).........	0.174
TOTL FLO TIM(MIN)..........	877.0
AVE PROD RATE(BBLS/DAY).......	2439.9
TRANSMISS(MD-FT/CP)...........	153290.4
IN SITU CAP(MD-FT)............	153290.4
AVE EFFECT PERM(MD)...........	15329.04
PROD INDX(BBLS/DAY-PSI).......	86.863
DAMAGE RATIO..................	2.0
PROD INDX-DAMAGE(BBLS/DAY-PSI)	172.522
RAD OF INVEST(FT).............	3666.5
DRAWDOWN(PERCENT).............	0.0
POTENMETRC SURF(FT)...........	3703.1

Form 2

LYNES, INC.

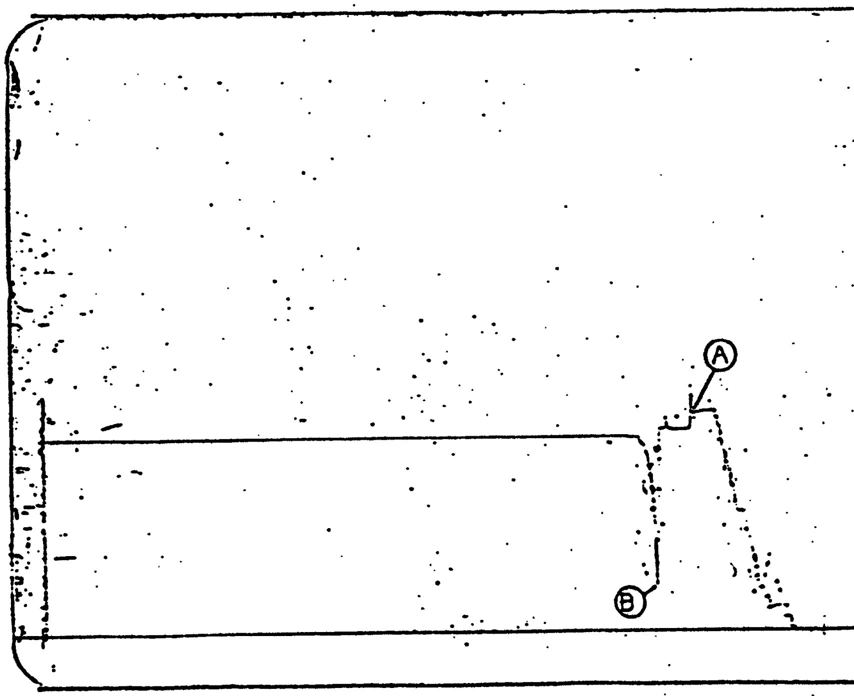
Operator U.S.G.S. Lease & No. Madison-Limestone #1 DST No. 16



Outside Recorder

PRD Make Kuster K-3
No. 13137 Cap. 2950 @ 2444'

Press		Corrected
Initial Hydrostatic	A	1221
Final Hydrostatic	K	1196
Initial Flow	B	521
Final Initial Flow	C	1062
Initial Shut-in	D	1084
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		



Inside Recorder

PRD Make Kuster AK-1
No. 1050 Cap. 3100 @ 2424'

Press		Corrected
Initial Hydrostatic	A	1050
Final Hydrostatic	K	--
Initial Flow	B	635
Final Initial Flow	C	--
Initial Shut-in	D	--
Second Initial Flow	E	--
Second Final Flow	F	--
Second Shut-in	G	--
Third Initial Flow	H	--
Third Final Flow	I	--
Third Shut-in	J	--
Pressure Below Bottom Packer Bled To		

Clock ran out after 510 min.

Form 3

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Geochemistry

The water chemistry from selected intervals in Madison test well no. 1 and subsequent tests will be used as control points for interpreting regional geologic, geophysical, isotopic, and chemical data. Water samples were collected from drill-stem test zones that were selected to represent major rock types, formation age, and types of porosity.

After the inflatable packers were set above and below the zone to be sampled, if the interval flowed, measurements were made of the pH and conductivity of the fluid until both a stability of these values and clearing of the water were obtained, indicating formation water was being monitored. If the interval did not flow, swabbing was begun to remove sufficient heavy drilling mud from the water column and formation to develop the zone. If possible, water samples were collected for analysis only after it was determined by pH and conductivity measurements that the water would represent the formational fluid in the interval tested. Characteristics subject to variation in time such as pH, temperature, alkalinity, and conductance were measured in the field at the time of collection. Alkalinity was determined in a potentiometric titration using sulfuric acid and preparing a titration curve. The field data are included with the laboratory data in the analyses tables.

The analysis of water samples from the Flathead Sandstone (Cambrian), Charles and Mission Canyon Formations (Mississippian), and a composite water sample from Madison into Precambrian are shown in tables 3, 4, and 5.

Table 3.--Water-quality analysis--Flathead Sandstone

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 303901 RECORD # 22949

SAMPLE LOCATION: 57N 065W 15DA
STATION ID: 445546104382700 LAT.LONG.SEQ.: 445546 1043827 00
DATE OF COLLECTION: BEGIN--761018 END-- TIME--1000
STATE CODE: 56 COUNTY CODE: 011 PROJECT IDENTIFICATION: 46560033
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 374FLTD
COMMENTS: FLATHEAD SANDSTONE (CAMBRIAN)

ALK,TOT (AS CACO3)	MG/L	184	MERCURY DISSOLVED	UG/L	0.0
ALUMINUM DISSOLVED	UG/L	20	MOLYBDENUM DISSOLVED	UG/L	1
ARSENIC DISSOLVED	UG/L	7	NITROGEN TOTKJD AS N	MG/L	1.1
BARIUM DISSOLVED	UG/L	200	PH FIELD		6.9
BICARBONATE	MG/L	224	PH LAB		7.7
BORON DISSOLVED	UG/L	340	PHOSPHORUS DIS AS P	MG/L	0.00
BROMIDE	MG/L	0.2	POTASSIUM DISS	MG/L	23
CADMIUM DISSOLVED	UG/L	0	POTASSIUM 40,D.PCI/L		17
CALCIUM DISS	MG/L	70	RA-226 BY RN PCI/L		14
CARBONATE	MG/L	0	RESIDUE DIS CALC SUM	MG/L	802
CHLORIDE DISS	MG/L	290	RESIDUE DIS TON/AFT		1.08
CHROMIUM DISSOLVED	UG/L	10	RESIDUE DIS 180C	MG/L	793
COPPER DISSOLVED	UG/L	1	RESIDUE TOT FIL 105C	MG/L	1200
DENSITY AT 20 C		0.999	RESIDUE TOTNONFIL105	MG/L	278
FLUORIDE DISS	MG/L	4.5	SAR		5.1
GROS-B,D,CS137 PCI/L		19	SELENIUM DISSOLVED	UG/L	1
GROS-B,D,SR-90-PCI/L		12	SILICA DISSOLVED	MG/L	31
GROS-B,S,CS137 PCI/L	DETR.	DELETED	SODIUM DISS	MG/L	180
GROS-B,S,SR-90 PCI/L	DETR.	DELETED	SODIUM PERCENT		60
GROSS ALPHA DIS.U-NA	UG/L	25	SP. CONDUCTANCE FLD		1320
GROSS ALPHA SUS.U-NA	DETR.	DELETED	SP. CONDUCTANCE LAB		1380
HARDNESS NONCARB	MG/L	56	STRONTIUM DISSOLVED	UG/L	2400
HARDNESS TOTAL	MG/L	240	SULFATE DISS	MG/L	74
IODIDE	MG/L	0.00	SULFUR 34/32 RATIO	DETR.	DELETED
IRON DISSOLVED	UG/L	80	TURBIDITY (JTU)		85
LEAD DISSOLVED	UG/L	0	U,DIS,DIR.FLUOR-UG/L	UG/L <	0.4
LITHIUM DISSOLVED	UG/L	400	VANADIUM DISSOLVED	UG/L	1.5
MAGNESIUM DISS	MG/L	15	WATER TEMP (DEG C)		42.0
MANGANESE DISSOLVED	UG/L	50	ZINC DISSOLVED	UG/L	10

CONTINUED ON NEXT PAGE

Table 3.--Water-quality analysis--Flathead Sandstone--Continued

WATER QUALITY ANALYSIS CONTINUED
LAB ID # 303901 RECORD # 22949

SAMPLE LOCATION: 57N 065W 15DA
STATION ID: 445546104382700 LAT.LONG.SEQ.: 445546 1043827 00
DATE OF COLLECTION: BEGIN--761018 END-- TIME--1000

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	70	3.493	BICARBONATE	224	3.672
MAGNESIUM DISS	15	1.234	CARBONATE	0	0.000
POTASSIUM DISS	23	0.589	CHLORIDE DISS	290	8.181
SODIUM DISS	180	7.830	FLUORIDE DISS	4.5	0.237
			SULFATE DISS	74	1.541
	TOTAL	13.145		TOTAL	13.630

PERCENT DIFFERENCE = -1.81

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Table 4.--Water-quality analysis--Charles and Mission Canyon Formations

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 303902 RECORD # 22952

SAMPLE LOCATION: 57N 065W 15DA
STATION ID: 445546104382700 LAT.LONG.SEQ.: 445546 1043827 00
DATE OF COLLECTION: BEGIN--761021 END-- TIME--1000
STATE CODE: 56 COUNTY CODE: 011 PROJECT IDENTIFICATION: 46560033
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: 331MSNC
COMMENTS: UPPER MADISON (CHARLES AND MISSION CANYON)

ALK,TOT (AS CACO3)	MG/L	176	MANGANESE DISSOLVED	UG/L	100
ALUMINUM DISSOLVED	UG/L	30	MERCURY DISSOLVED	UG/L	0.0
ARSENIC DISSOLVED	UG/L	11	MOLYBDENUM DISSOLVED	UG/L	11
BARIUM DISSOLVED	UG/L	100	NITROGEN TOTKJD AS N	MG/L	3.2
BICARBONATE	MG/L	214	PH FIELD		6.6
BORON DISSOLVED	UG/L	210	PH LAB		7.1
BROMIDE	MG/L	0.2	PHOSPHORUS DIS AS P	MG/L	0.01
CADMIUM DISSOLVED	UG/L	0	POTASSIUM DISS	MG/L	9.2
CALCIUM DISS	MG/L	180	POTASSIUM 40,D.PCI/L		6.9
CARBON TOT ORGANIC	MG/L	15	RA-226 BY RN PCI/L		0.70
CARBONATE	MG/L	0	RESIDUE DIS CALC SUM	MG/L	973
CHLORIDE DISS	MG/L	66	RESIDUE DIS TON/AFT		1.44
CHROMIUM DISSOLVED	UG/L	20	RESIDUE DIS 180C	MG/L	1060
COPPER DISSOLVED	UG/L	0	RESIDUE TOT FIL 105C	MG/L	1200
DENSITY AT 20 C		0.999	RESIDUE TOTNONFIL105	MG/L	41
FLUORIDE DISS	MG/L	1.9	SAR		1.2
GROS-B,D,CS137 PCI/L		15	SELENIUM DISSOLVED	UG/L	8
GROS-B,D,SR-90-PCI/L		13	SILICA DISSOLVED	MG/L	25
GROS-B,S,CS137 PCI/L		2.3	SODIUM DISS	MG/L	70
GROS-B,S,SR-90 PCI/L		1.9	SODIUM PERCENT		20
GROSS ALPHA DIS.U-NA	UG/L	14	SP. CONDUCTANCE FLD		1345
GROSS ALPHA SUS.U-NA	UG/L	3.0	SP. CONDUCTANCE LAB		1380
HARDNESS NONCARB	MG/L	440	STRONTIUM DISSOLVED	UG/L	4500
HARDNESS TOTAL	MG/L	620	SULFATE DISS	MG/L	470
IODIDE	MG/L	0.00	TURBIDITY (JTU)		10
IRON DISSOLVED	UG/L	310	U,DIS,DIR.FLUOR-UG/L	UG/L	6.3
LEAD DISSOLVED	UG/L	0	VANADIUM DISSOLVED	UG/L	8.7
LITHIUM DISSOLVED	UG/L	40	WATER TEMP (DEG C)		35.5
MAGNESIUM DISS	MG/L	40	ZINC DISSOLVED	UG/L	40

CONTINUED ON NEXT PAGE

Table 4.--Water-quality analysis--Charles and Mission Canyon Formations --Continued

WATER QUALITY ANALYSIS CONTINUED
LAB ID # 303902 RECORD # 22952

SAMPLE LOCATION: 57N 065W 15DA
STATION ID: 445546104382700 LAT.LONG.SEQ.: 445546 1043827 00
DATE OF COLLECTION: BEGIN--761021 END-- TIME--1000

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	180	8.982	BICARBONATE	214	3.508
MAGNESIUM DISS	40	3.291	CARBONATE	0	0.000
POTASSIUM DISS	9.2	0.236	CHLORIDE DISS	66	1.862
SODIUM DISS	70	3.045	FLUORIDE DISS	1.9	0.101
			SULFATE DISS	470	9.786
TOTAL		15.553	TOTAL		15.255

PERCENT DIFFERENCE = 0.97

Table 5.--Water-quality analysis--Composite of waters from Madison into Precambrian

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CENTRAL LABORATORY, DENVER, COLORADO

WATER QUALITY ANALYSIS
LAB ID # 304901 RECORD # 24075

SAMPLE LOCATION: 57N 065W 15DA
STATION ID: 445546104382700 LAT.LONG.SEQ.: 445546 1043827 00
DATE OF COLLECTION: BEGIN--761024 END-- TIME--1700
STATE CODE: 56 COUNTY CODE: 011 PROJECT IDENTIFICATION: 033
DATA TYPE: 2 SOURCE: GROUND WATER GEOLOGIC UNIT: MADISON TO PRE-CAMBRIAN COMPOSITE SAMPLE
COMMENTS:

ALK,TOT (AS CACO3)	MG/L	206	NITROGEN NH4 ASN TOT	MG/L	0.46
ALUMINUM DISSOLVED	UG/L	0	NITROGEN TOT AS N	MG/L	1.7
ANTIMONY DISSOLVED	UG/L	1	NITROGEN TOT AS NO3	MG/L	7.6
ARSENIC DISSOLVED	UG/L	13	NITROGEN TOT ORG N	MG/L	1.0
BARIUM DISSOLVED	UG/L	100	NITROGEN TOTKJD AS N	MG/L	1.5
BICARBONATE	MG/L	251	NO2 + NO3 AS N TOT	MG/L	0.22
BORON DISSOLVED	UG/L	430	PH FIELD		7.5
BROMIDE	MG/L	0.1	PHOSPHORUS TOT AS P	MG/L	0.05
CADMIUM DISSOLVED	UG/L	1	POTASSIUM DISS	MG/L	4.8
CALCIUM DISS	MG/L	95	RESIDUE DIS CALC SUM	MG/L	688
CARBONATE	MG/L	0	RESIDUE DIS TON/AFT		0.94
CHLORIDE DISS	MG/L	37	RESIDUE TOTNONFIL105	MG/L	220
CHROMIUM DISSOLVED	UG/L	90	RESIDUE VOLAT. SUSP.	MG/L	68
COPPER DISSOLVED	UG/L	6	SAR		1.8
DENSITY AT 20 C		0.998	SELENIUM DISSOLVED	UG/L	0
FLUORIDE DISS	MG/L	1.7	SILICA DISSOLVED	MG/L	26
HARDNESS NONCARB	MG/L	180	SODIUM DISS	MG/L	82
HARDNESS TOTAL	MG/L	380	SODIUM PERCENT		32
IRON DISSOLVED	UG/L	330	SP. CONDUCTANCE FLD		1000
LEAD DISSOLVED	UG/L	13	SP. CONDUCTANCE LAB		997
LITHIUM DISSOLVED	UG/L	20	STRONTIUM DISSOLVED	UG/L	1900
MAGNESIUM DISS	MG/L	35	SULFATE DISS	MG/L	280
MANGANESE DISSOLVED	UG/L	90	TURBIDITY (JTU)		35
MOLYBDENUM DISSOLVED	UG/L	17	ZINC DISSOLVED	UG/L	80

CATIONS	(MG/L)	(MEQ/L)	ANIONS	(MG/L)	(MEQ/L)
CALCIUM DISS	95	4.741	BICARBONATE	251	4.11
MAGNESIUM DISS	35	2.880	CARBONATE	0	0.00
POTASSIUM DISS	4.8	0.123	CHLORIDE DISS	37	1.04
SODIUM DISS	82	3.567	FLUORIDE DISS	1.7	0.09
			SULFATE DISS	280	5.83
TOTAL		11.309	TOTAL		11.07

PERCENT DIFFERENCE = 1.04

Preliminary results and future testing plans

Preliminary analysis of some of the information obtained during the drilling, coring, and testing of Madison Limestone test hole no. 1 follows:

Based on the drill-stem and packer-swabbing tests, all significant water-bearing units encountered in the test well, except the Hulett Sandstone, have sufficient heads to cause the water in them to flow at the land surface, 3,604 ft above sea level.

The chemical quality tests indicate that all significant water-bearing units contain relatively freshwater (less than 2,000 mg/L dissolved solids).

Three water-bearing units, now cased and cemented in the well, warrant further investigation as to their potential as sources of ground water in the vicinity of the well. These are the Hulett Sandstone Member of the Sundance Formation, the Minnekahta Limestone, and the upper sandy section of the Minnelusa Formation. Packer tests were attempted on all three of these units, but only the two on the Minnekahta and Minnelusa were successful; the packer deflated prior to obtaining a test on the Hulett. The packer tests give clues to the pressure heads of water in the interval tested, and in some instances an indication of the water quality and temperature. Both the Minnekahta and the sandy section in the Minnelusa yielded water that was contaminated with drilling fluid and the discharge from both did not clear in the short time of the tests. However, the Minnekahta Limestone test resulted in a flow of 12 gal/min; the water conductivity was about 2,200 micromhos, water temperature at the well head was 34.4°C, and the head was 110 to 115 ft above land surface. The Minnekahta is only 28 to 30 ft thick.

The test in the upper part of the Minnelusa Formation resulted in a flow of 75 gal/min; the water conductivity was about 2,400 micromhos, water temperature at the well head was about 37°C, and the head was about 90 to 105 ft above land surface.

Units in the open-hole part of the test well, which are water-bearing, include the Madison, Red River, Winnipeg, and Flathead. Preliminary results of the test in the Madison Group (Charles and Mission Canyon Formations) show a yield of about 20 gal/min, water conductivity of about 1,350 micromhos, water temperature at the well head of 35.5°C, and a head of about 75 to 100 ft above land surface. (See table 4 for complete chemical analysis of water.) One packer test in the Red River was unsuccessful because the tool plugged with sand; the other test showed a head of about 85 to 105 ft above land surface, but because of the heavy mud in the drill stem, there was no flow. The two packer tests in the Winnipeg were unsuccessful due to the tool plugging and the packer-seat failing. Preliminary results of the test in the Flathead show a yield of 55 gal/min, water conductivity about 1,220 micromhos, water temperature at the well head of 42°C, and a head of about 60 to 115 ft above land surface. (See table 3 for complete chemical analysis of water.)

Water from the open-hole part of the well, which begins about 40 ft below the top of the Madison and ends about 60 ft below the top of Precambrian, has a head of 48 lb/in^2 or about 110 ft above land surface. Because of the well-head equipment, the water cannot flow freely from the 13-3/8-in casing at the land surface. However, one of the 2-in valves in the well head was opened and the well flowed about 250 gal/min with a head loss of about 16 lb/in^2. Using these values the specific capacity of the well is about 6.8 (gal/min)/ft of drawdown. If the well could flow freely at the land surface, and assuming a slight decline in specific capacity due to increased flow, the yield would probably be 650 to 700 gal/min. This quantity is the minimum flow that the well would yield under free-flow conditions. No attempt has been made to develop the well and there are two zones, one in the Madison and one in the Red River, where drilling fluid was lost during the drilling in the amounts of 400 and 300 barrels respectively. When these zones are straddle packed and developed, an increase in yield is expected. Also no attempt has been made to pump the well. However, assuming a specific capacity of 4 (gal/min)/ft of drawdown, the quantity of water that could be obtained from the well, if the pumping level were 300 ft below land surface, is 1,640 gal/min. This figure is speculative. If the head in the well is partly the result of gas drive, then pumping the well probably would cause a considerable decrease in the yield per foot of drawdown.

Additional geophysical logs and tests will be run in the test well this spring. The logs will include televiewer, gamma spectrometer, trace ejector, and spinner-surveys. Packers will be set to isolate zones for individual development (removal of drilling fluid) and testing. The individual zones will be tested for head, temperature, water quality and quantity. In addition a vertical seismic profile and gravity profile will be run.

The well construction and well-head equipment are such that the well can be used for several years as an observation point, a test laboratory, and for geophysical-tool calibration.

Reference

U.S. Geological Survey, 1975, Plan of study of the hydrology of the Madison Limestone and associated rocks in parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming: U.S. Geol. Survey Open-File Report 75-631, 35 p.

ADDENDUM 6.4-A

RESRAD MODEL

SUPPORTING DOCUMENTATION

RESRAD Input Parameters

This addendum identifies site-specific parameters that were employed instead of RESRAD defaults. These site-specific parameters were used in all RESRAD calculations. All parameters not specifically identified in this addendum or in the definition of the critical group should be assumed as RESRAD defaults.

Pathways

Pathways for external gamma, inhalation and ingestion of plants , meat, aquatic foods, drinking water and soil were included in the calculations. Milk ingestion was not included as the area is not suitable for dairy farming.

Contaminated Zone

The surface soil was characterized and is summarized in Table 3.3-1 of the Environmental Report for the Ross ISR site. The contamination was considered to be in the surface soil and was modeled as a "sandy loam" based on the majority of the soil types provided by the soil survey. The contaminated zone hydraulic conductivity and zone b parameter (soil specific exponential parameter) were altered to match the values provided in Table E-2 of the RESRAD manual for "Sandy Loam." The total porosity was also altered, however the porosity value chosen was for fine sand, as there was no option in the manual (Table E8) for loam or sandy loam. In addition the runoff coefficient of the soils found for "open sandy loam" in Table E-1 of the RESRAD manual was used (ANL, 2001).

The contaminated zone section also allows for some site specific general meteorological data. The average wind speed was raised to 4.5 m/s to better match onsite meteorological data collected. The annual precipitation was lowered to 0.3175 m/yr (12.5 in/yr) per local meteorological data provided in 2.5.1 of the Technical Report.

Saturated and Unsaturated Zones

The unsaturated and saturated zones were assumed to be sandstones per information on the rock formations provided in Section 2.6.1.2 of the Technical Report. For both zones, porosity values for sandstone were used per Table E8 of the RESRAD manual and a density of 2.1 g/cm^3 was used per site specific data. The unsaturated zone thickness was set to 39 m (~128 ft), the depth of the shallowest well used for stock water in the permit area. This is the recommended method in Appendix E of NUREG 1569.

Occupancy

It is likely that the resident rancher would spend significantly more time outdoors than a typical person. The indoor time fraction was lowered from 0.50 to 0.25 and the outdoor fraction was raised from 0.25 to 0.50. The remaining time is assumed to be offsite.

Ingestion

As some local residents have reported having had or currently having home vegetable gardens, it is reasonable to assume that a local rancher might have a personal garden for home use. The value for the fraction of the "plant food" coming from the contaminated zone was thus raised to 0.25 from 0.10. Despite the Oshoto Reservoir not serving as a major pathway for ingestion at this time, the pathway was not eliminated completely for conservatism, however it was lowered from 0.50 to 0.10 (i.e., 10% of ingested fish). Because the scenario was set for a resident who produces livestock full time, the contaminated fraction of meat was set to 1.

Sensitivity Analysis

Uranium Inhalation Class

The RESRAD default calculation applies the Class Y inhalation classification to natural uranium. However, since no process specific data to indicate the solubility class of the uranium at this site was available, the Radium Benchmark Dose was applied to all three solubility classes of uranium. Inhalation class based Dose Conversation Factors were applied from Federal Guidance Report 11. The appropriate uranium soil standard limit, provided in Table 6.4-A-1, will be applied as a result of process specific inhalation class studies that will be completed during operations of the Ross facility.

Table 6.4-A-1 Uranium Soil Standard Limits

Inhalation Class	**Dose resulting from [U-nat]=100 pCi/g**	**Uranium Soil Standard Limit**
Class Y	7.409 mrem	451 pCi/g
Class W	6.978 mrem	479 pCi/g
Class D	6.960 mrem	480 pCi/g

In general, the uranium soil standard limits were very similar for all inhalation classes particularly the Class W and D limits. This is a likely a result of the fact that the inhalation pathway results in a small (less than 10%) fraction of the total dose. The contribution of pathways to total dose is provided in Table 6.4-A-2.

Table 6.4-A-2 Pathway Contribution to Total Dose as a Result of Natural Uranium Contamination in Surface Soil

Inhalation Class	**Fraction of Total Dose by Pathway**				
	Ground	**Inhalation**	**Plant (water independent)**	**Meat (water independent)**	**Soil (ingestion)**
Class Y	0.7290	0.0619	0.0668	0.0417	0.1006
Class W	0.7741	0.0039	0.0709	0.3088	0.1069
Class D	0.7761	0.0014	0.0711	0.0444	0.1071

Figures 6.4-A-1 through 6.4-A-5 present the dose as a function of time for each of the additional dose sensitivity parameters analyzed which included the fraction of time spent outdoors, fraction of ingested plant food, average wind speed, mass loading in air and the size of the contaminated area.

Figure 6.4-A-1 Dose Sensitivity to Fraction of Time Spent Outdoors for Surface Contamination Scenario

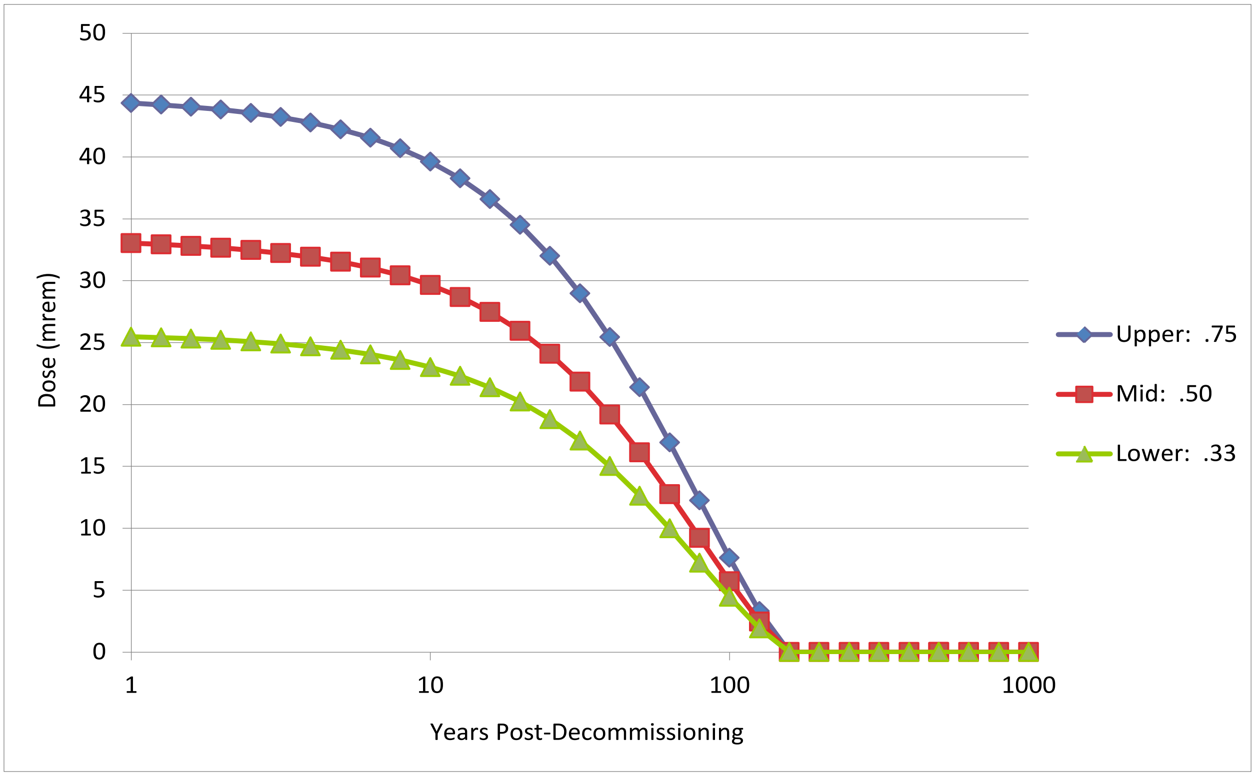

Figure 6.4-A-2 Dose Sensitivity to Contaminated Fraction of Plant Food Ingested

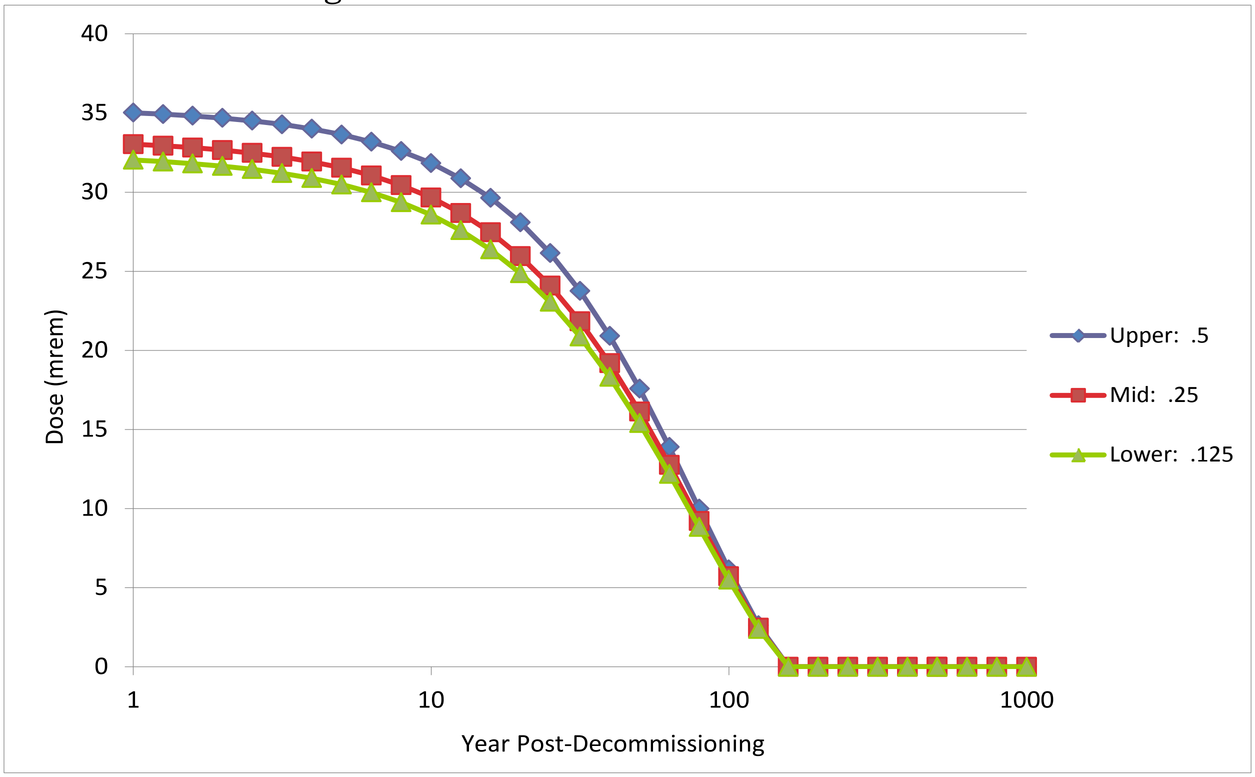

Figure 6.4-A-3 Dose Sensitivity to Average Wind Speed

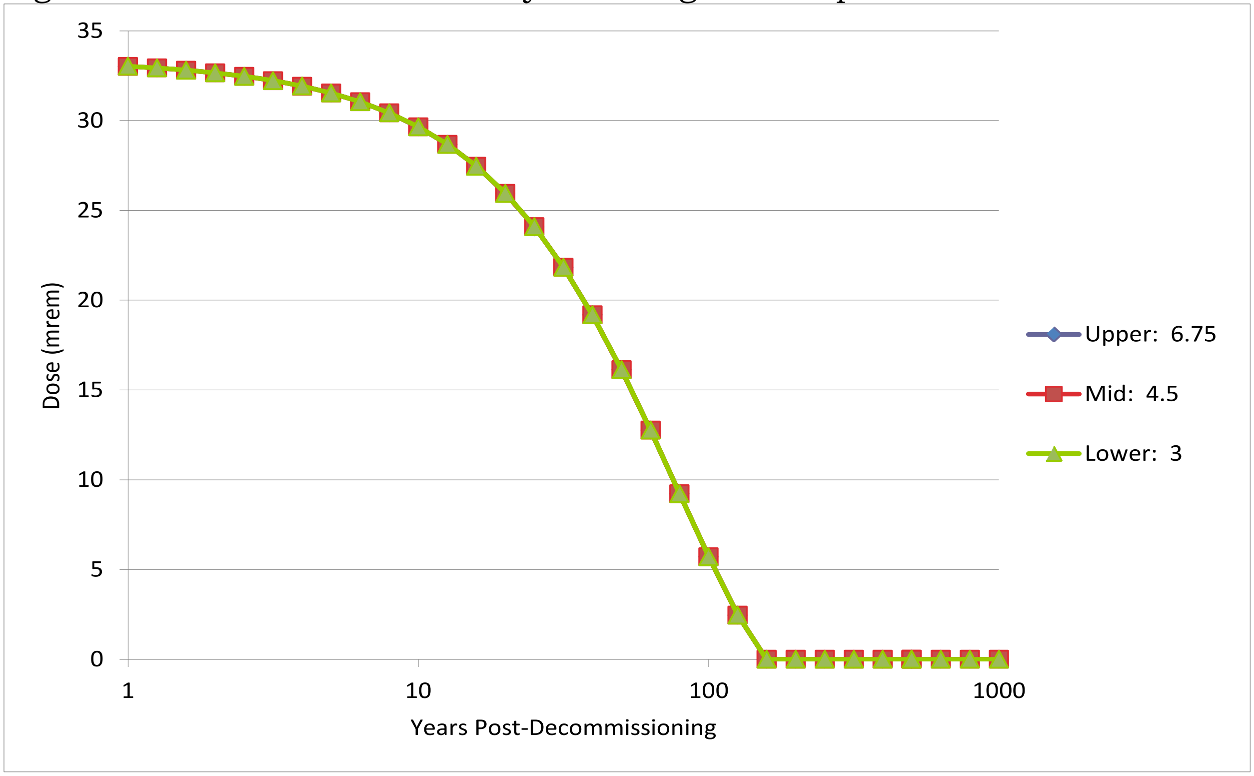

Figure 6.4-A-4 Dose Sensitivity to Mass Loading for Inhalation

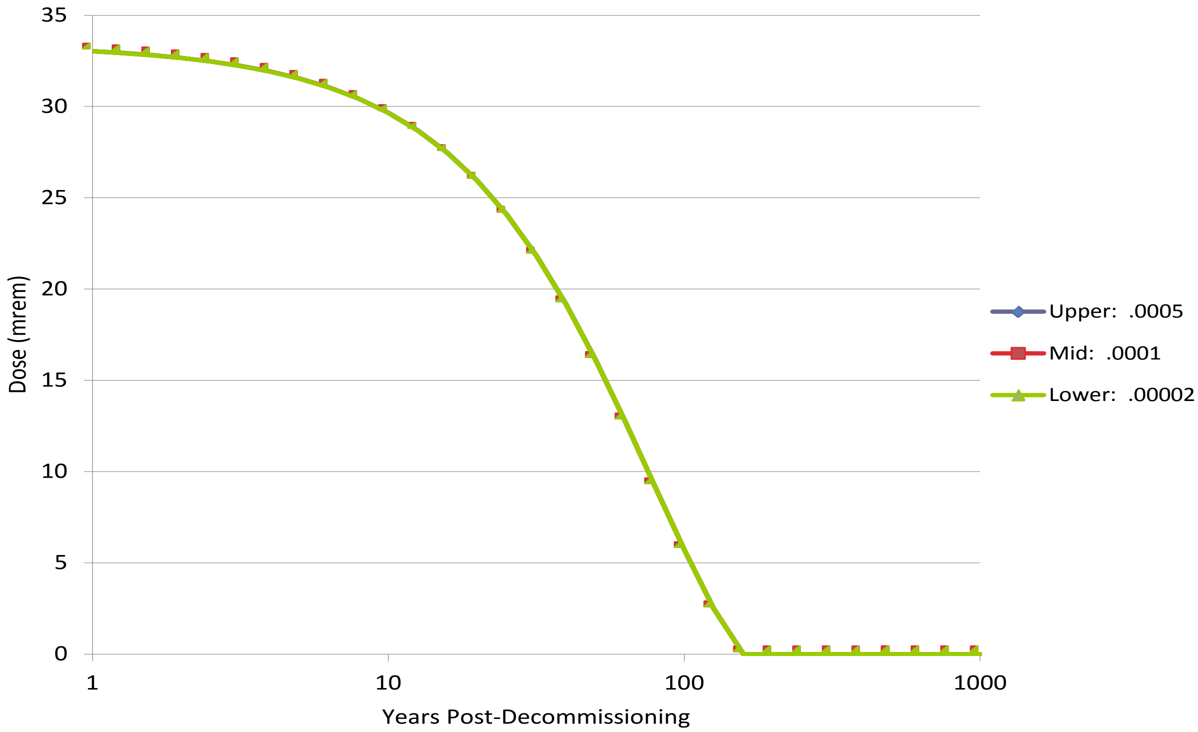

Figure 6.4-A-5 Dose Sensitivity to Contaminated Area in Surface Contamination Scenario