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 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, 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).

<u>Strata Energy, Inc. Response</u>

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.

<u>Strata Energy, Inc. Response</u>

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

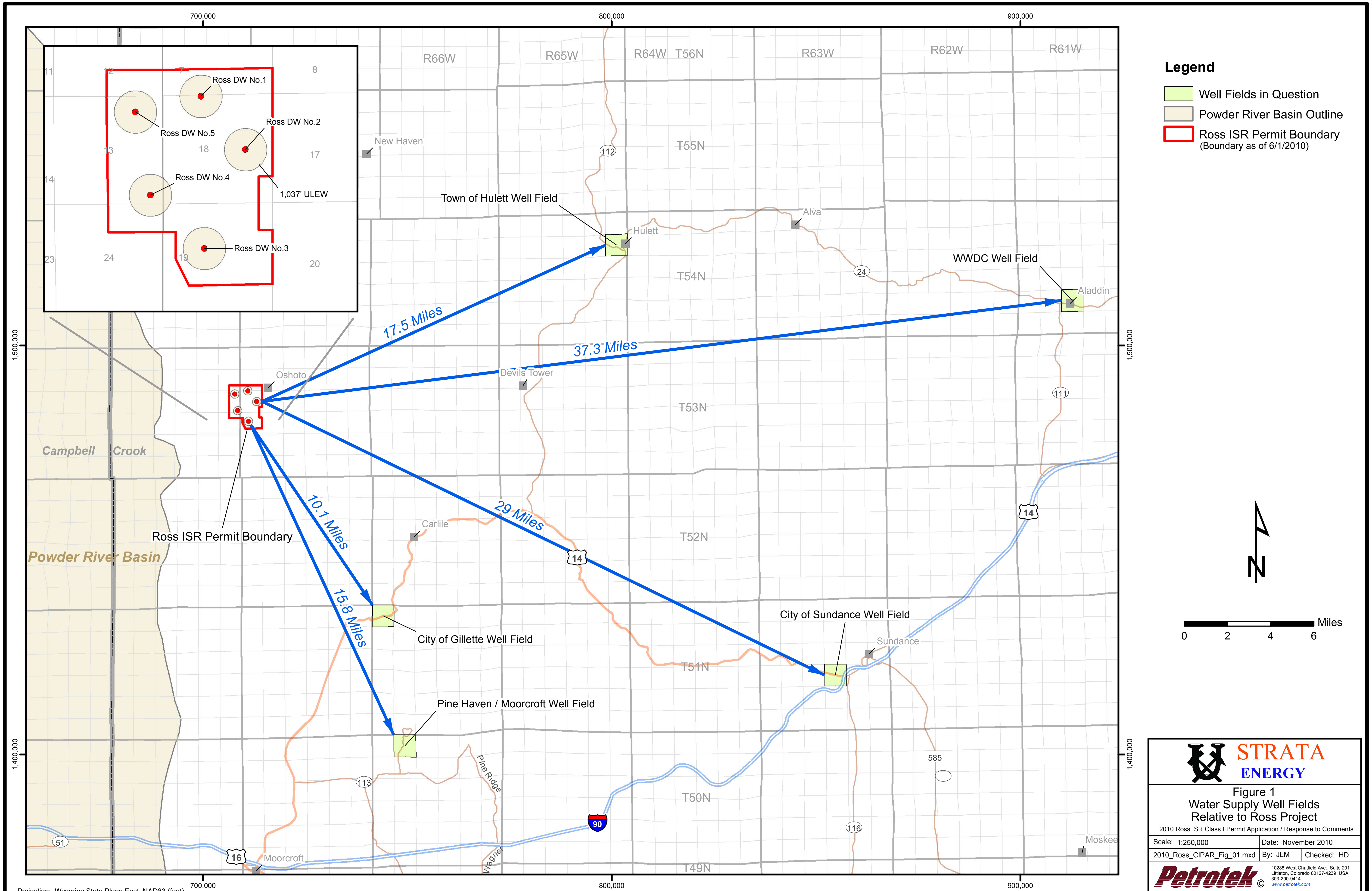
Calculations to Overcome Mud Weight in Borehole		Value	Unit	Basis
Top of Deadwood	Dt	8163	feet; bgs	Permit Application, Table 6
Depth to Top of Mud in Borehole	Dd	0	feet; bgs	Assumed
Pressure Gradient of Deadwood/Flathead	$Grad_{est}$	0.42	psi/ft	Estimated (pg 19, ¶ 2)
Pressure, Top of IZ	Pt ($Grad_{est}$*Dt)	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 Sundance Well Field
City of Gillette Well Field
Pine Haven / Moorcroft 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
New Haven
Hulett
Alva
Aladdin
Oshoto
Devils Tower
Carlile
Sundance
Moorcroft
Moskee
R66W
R65W
R64W
R63W
R62W
R61W
T56N
T55N
T54N
T53N
T52N
T51N
T50N
T49N
700,000
800,000
900,000
1,500,000
1,400,000
Miles
0 2 4 6
N
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
Projection: Wyoming State Plane East, NAD83 (feet)

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.

(200)
R 29o

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

---

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

U. S. GEOLOGICAL SURVEY
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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.

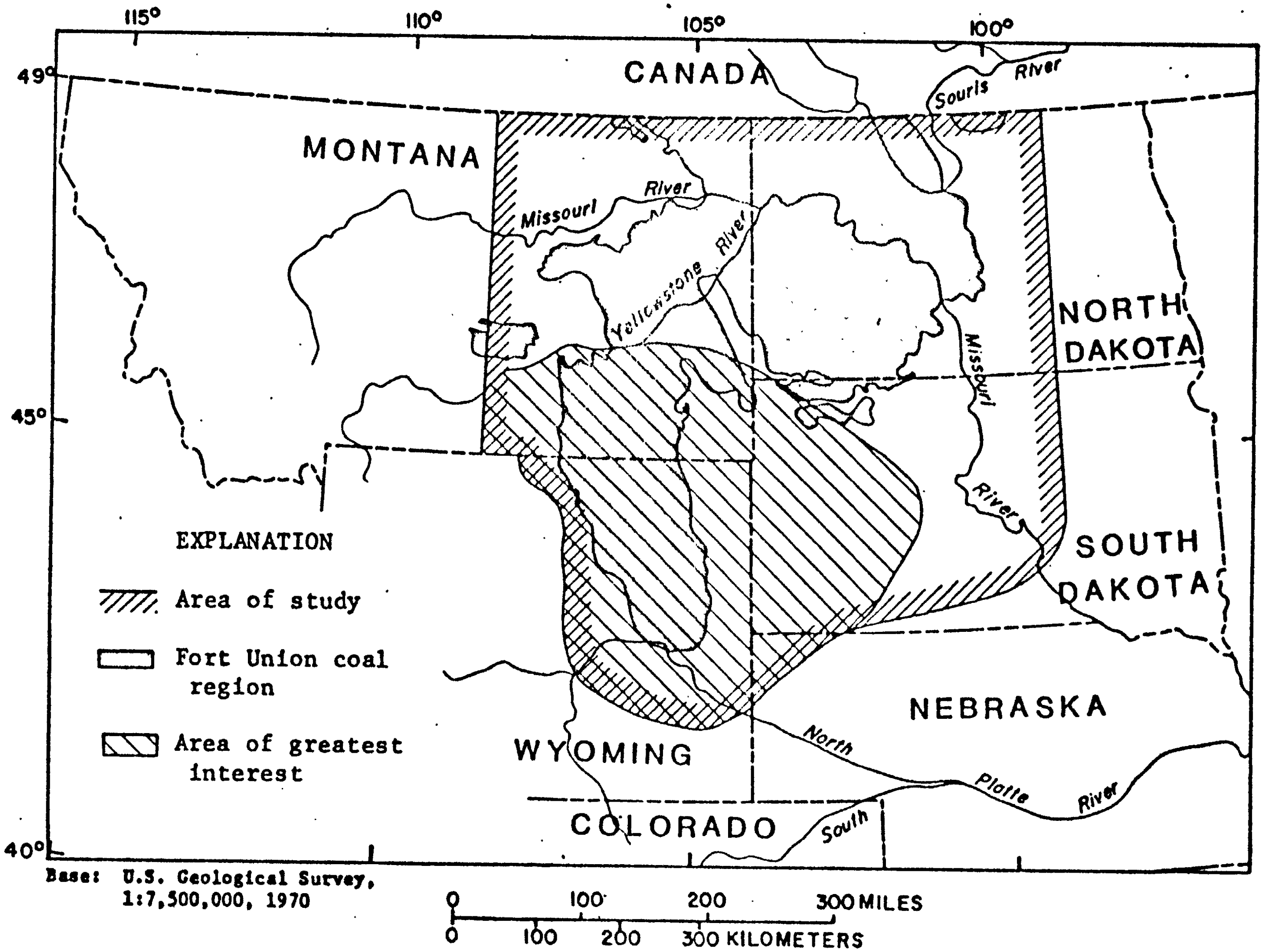

Figure 1.--Location of study area and Fort Union coal region.

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).

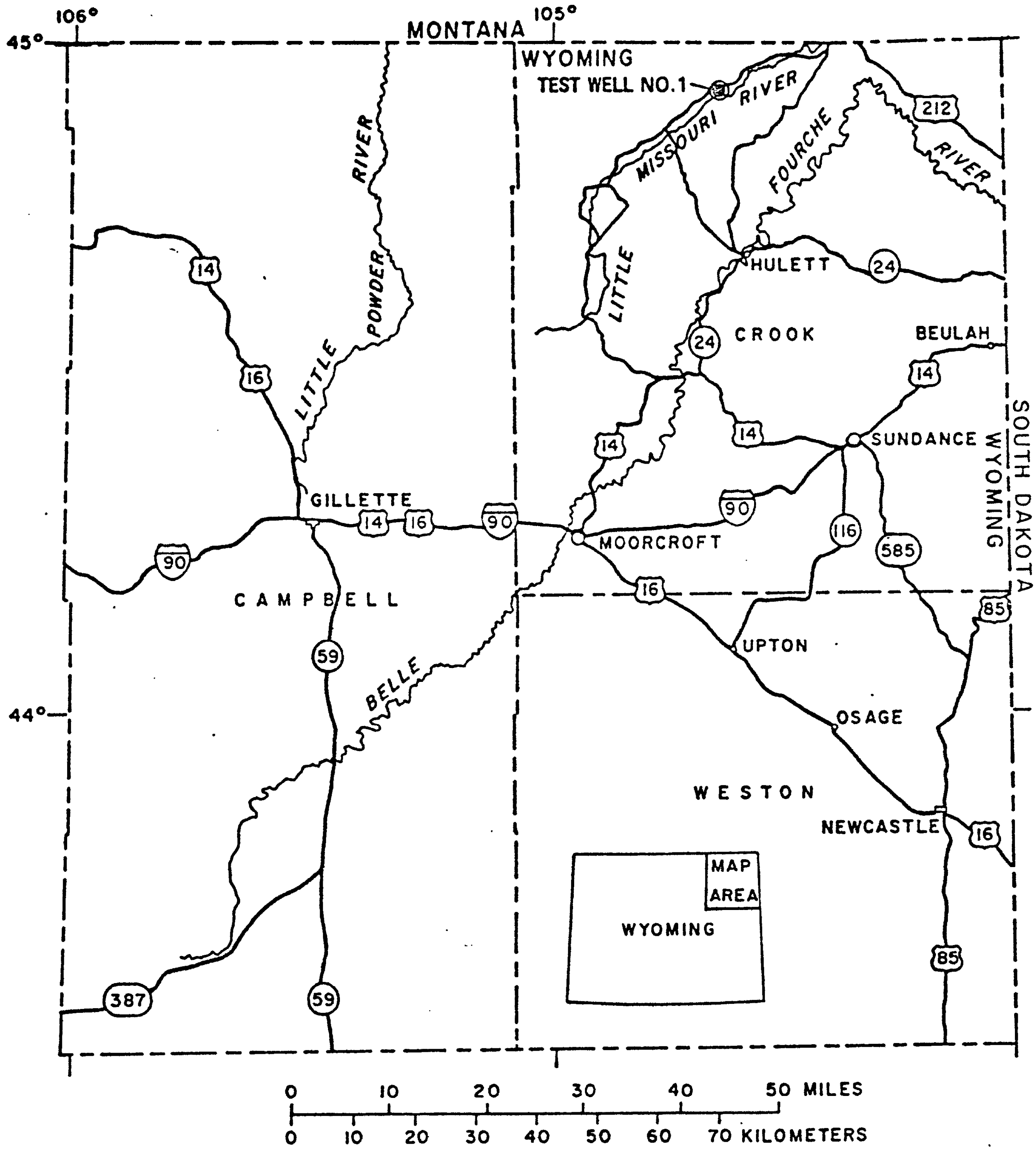

Figure 2.--Northeastern Wyoming showing location of Madison test well no. 1.

6

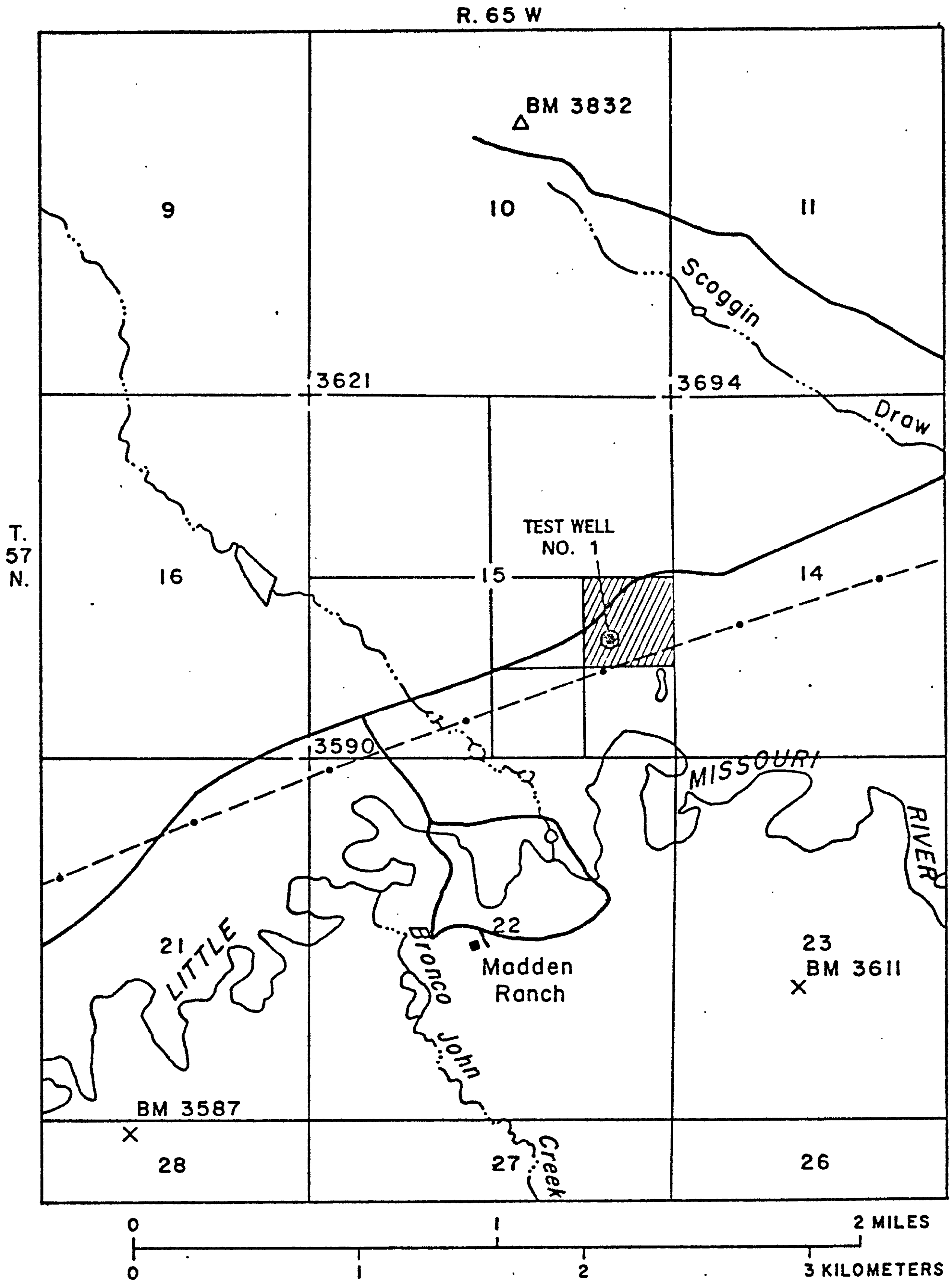

Figure 3.—Location of drilling site for Madison test well no. 1.

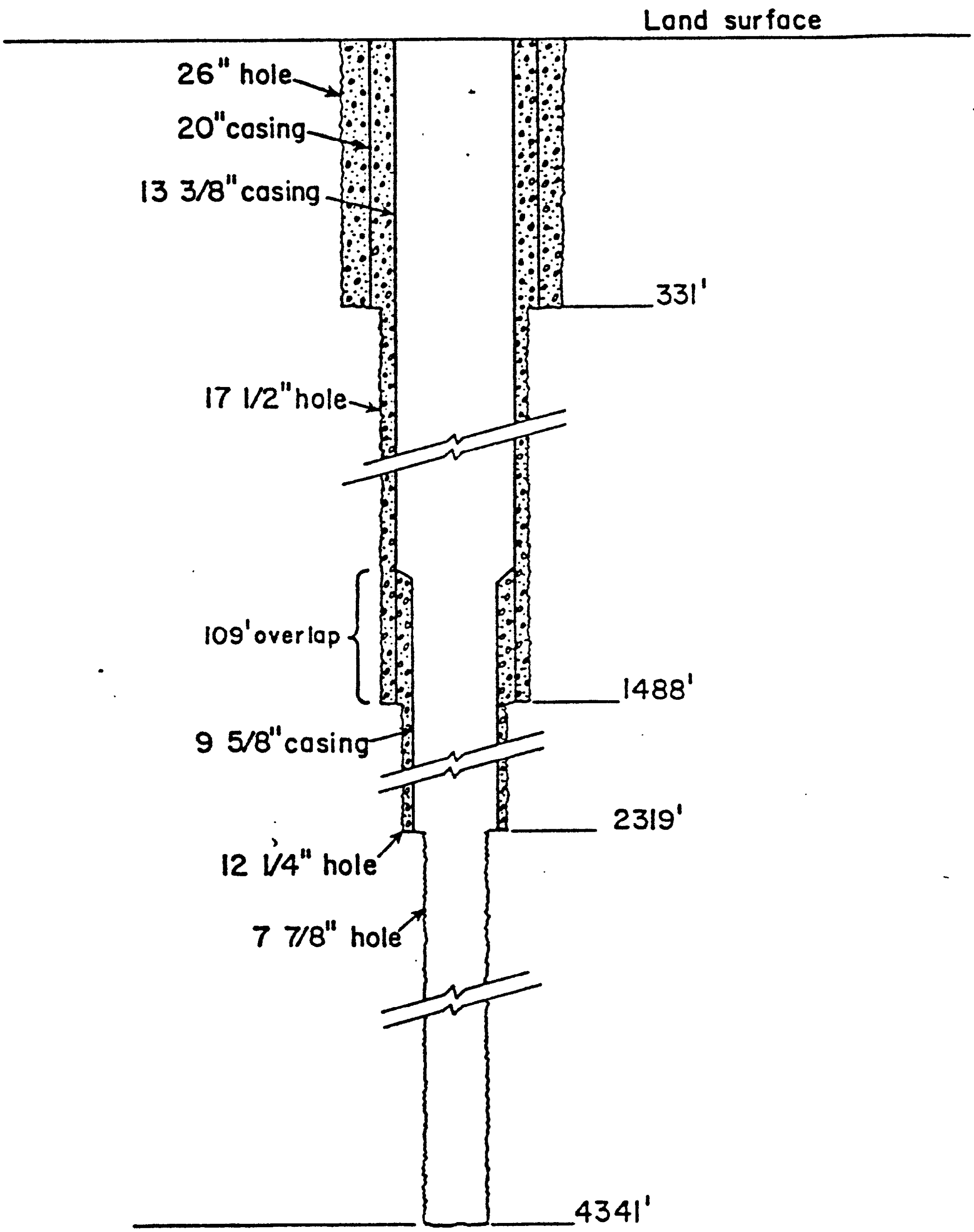

Figure 4.--Construction of Madison test well no. 1 (depths are from land surface).

8

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.

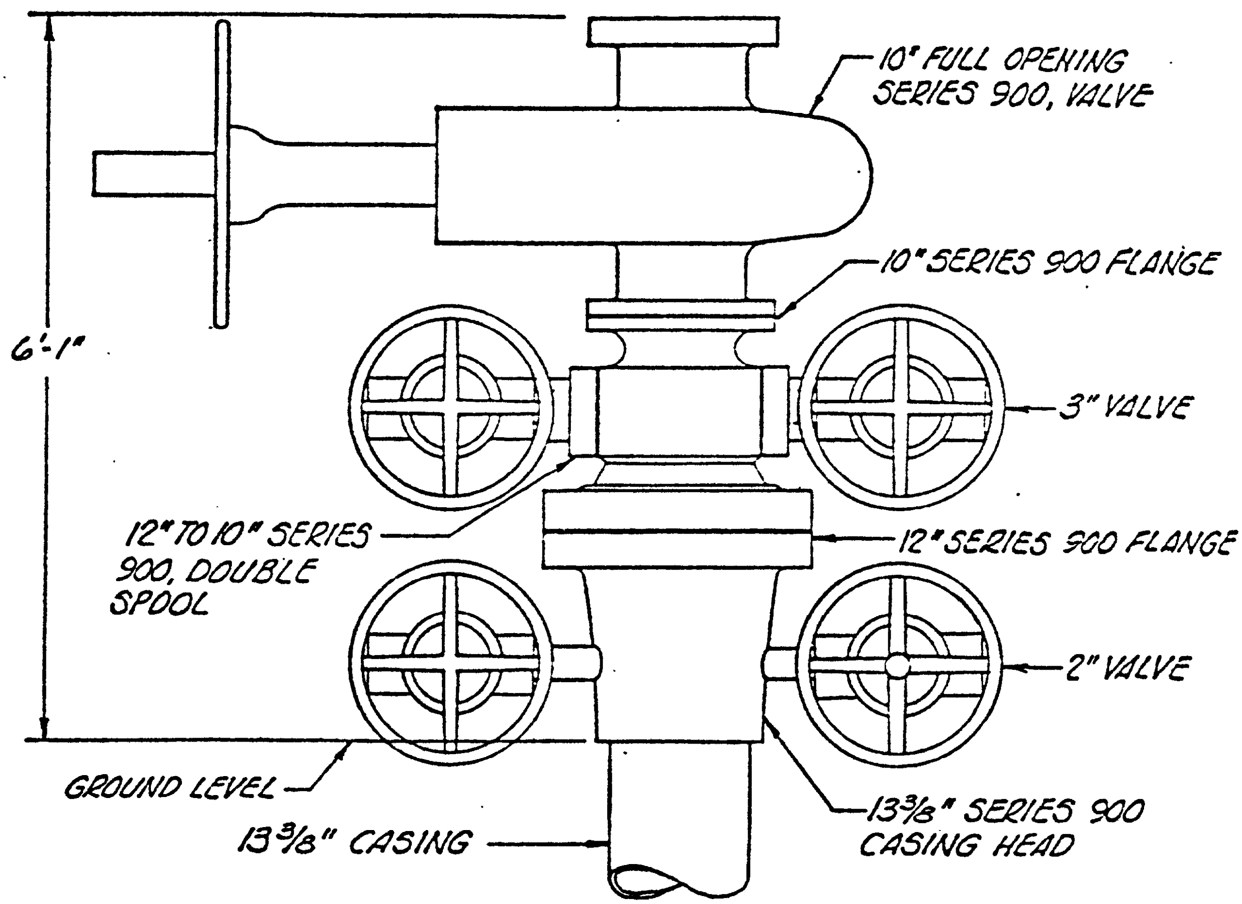

Figure 5.--Well-head equipment of Madison test well no. 1.

10

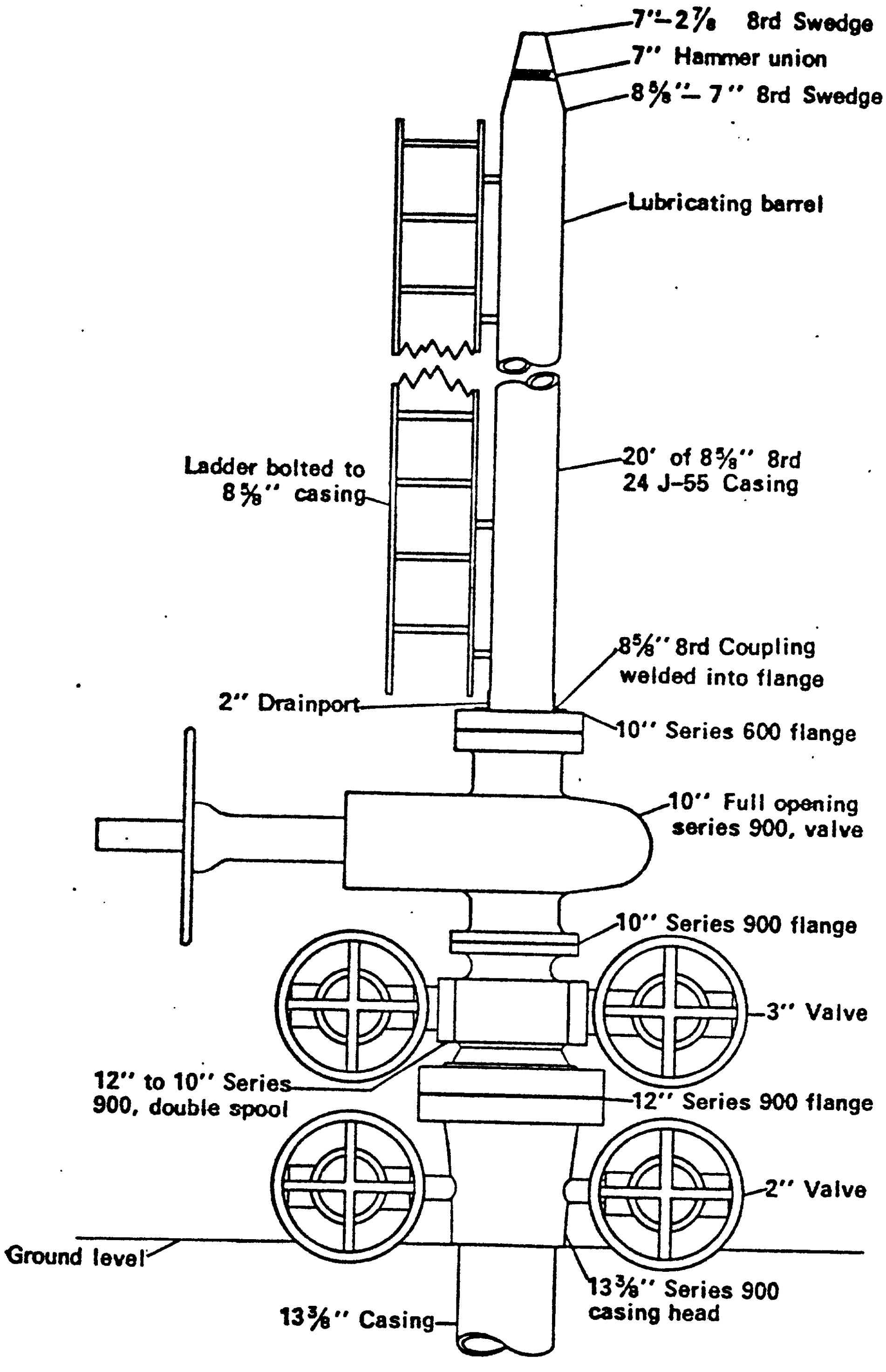

Figure 6.—Well-head equipment of Madison test well no. 1, with lubricating barrel attached.

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

13

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	REMARKS:
TOTAL MAIN HOLE CONST. TIME	100.50 DAYS	* Run 9-5/8" Liner 0.79 Days
SEC. W/O CREW SITE PREP	____ DAYS	Cement 9-5/8" Liner 1.12 Days
SEC. W/O CREW MAIN HOLE CONST.	____ DAYS	
TOTAL SUSPENDED (NO RIG)	____ DAYS	
TOTAL ELAPSED TIME	100.50 DAYS	

14

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.

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 12¼" 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 6¼" 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'
3272-3302	Core #17 - recovered 30'
	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
3491-3521	Core #18 - recovered 29½'
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

ROUGHLOCK SANDSTONE

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

ICEBOX SHALE

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

4292-4325	Core #21 - recovered 34'
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

PRECAMBRIAN ELLISON FORMATION (?)

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'), premata-morphism mini faulting with displacement up to 1" (4320-4321')
4326-4346	Gneiss (?), mostly quartz, pyroxenes and orthoclase
4346-4355	Core #22 - recovered 8'
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

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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	2234.0	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:
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CL-911-2

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		POROSITY PERCENT	RESIDUAL SATURATION		GRN. DNS.	WHOLE CORE PERMS.		
		HORIZONTAL (KA)	VERTICAL		OIL % VOLUME % PORE	TOTAL WATER % PORE		MAX.	90°	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	2331.9	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	85.7	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

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CL-911-3

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

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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	TOTAL WATER % PORE	GRN. DNS.	WHOLE CORE PERMS. MAX.	90°	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	2324.9	0.23		11.0						
170	2830.1	0.13	0.09	12.4						

*UNSUITABLE FOR PERMEABILITY MEASUREMENT

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CL-011-2

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

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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
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Location NE¼ SE¼ SEC. 15-T57N-R65W Remarks

CORE ANALYSIS RESULTS

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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.
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

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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: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.
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			

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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.

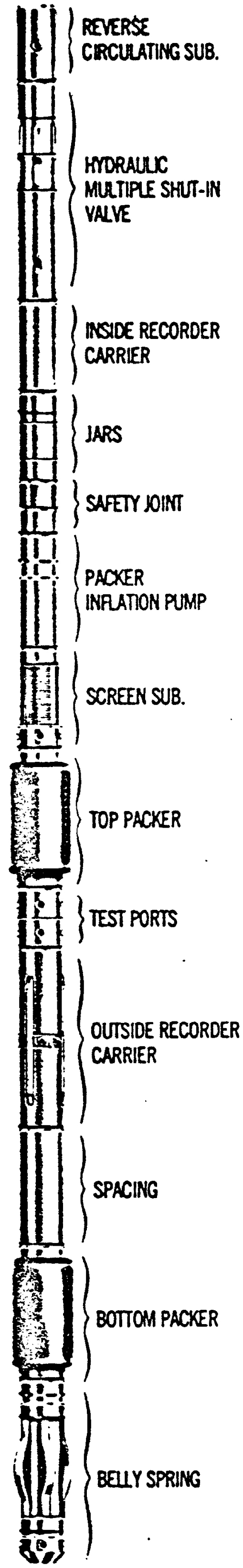


Figure 7.--Inflatable straddle packer tool for conventional drill-stem tests. (Courtesy Lynes, Inc., Houston, Texas)

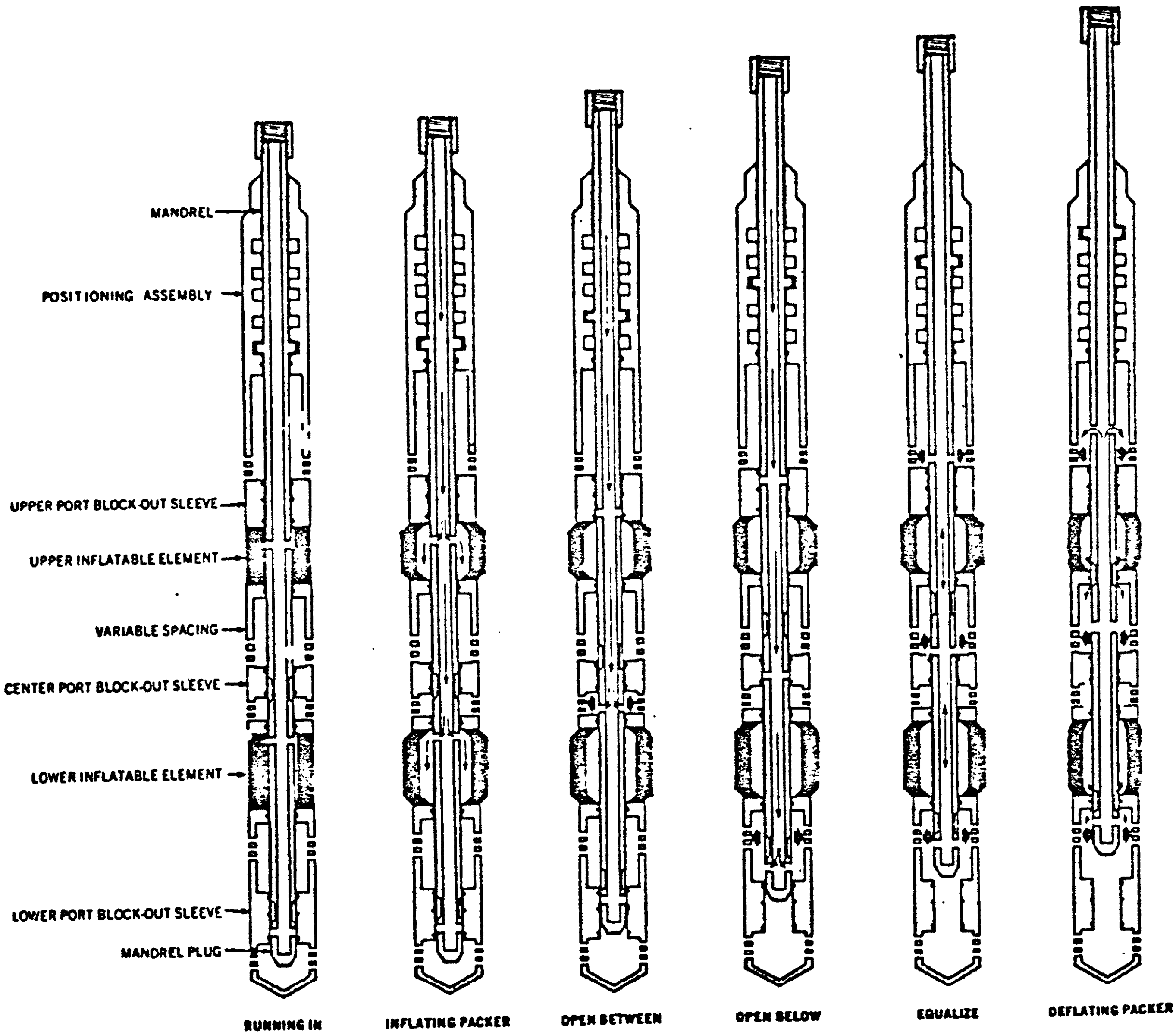


Figure 8.--Inflatable straddle packer used in open hole or casing. (Courtesy Lynes, Inc., Houston, Texas)

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

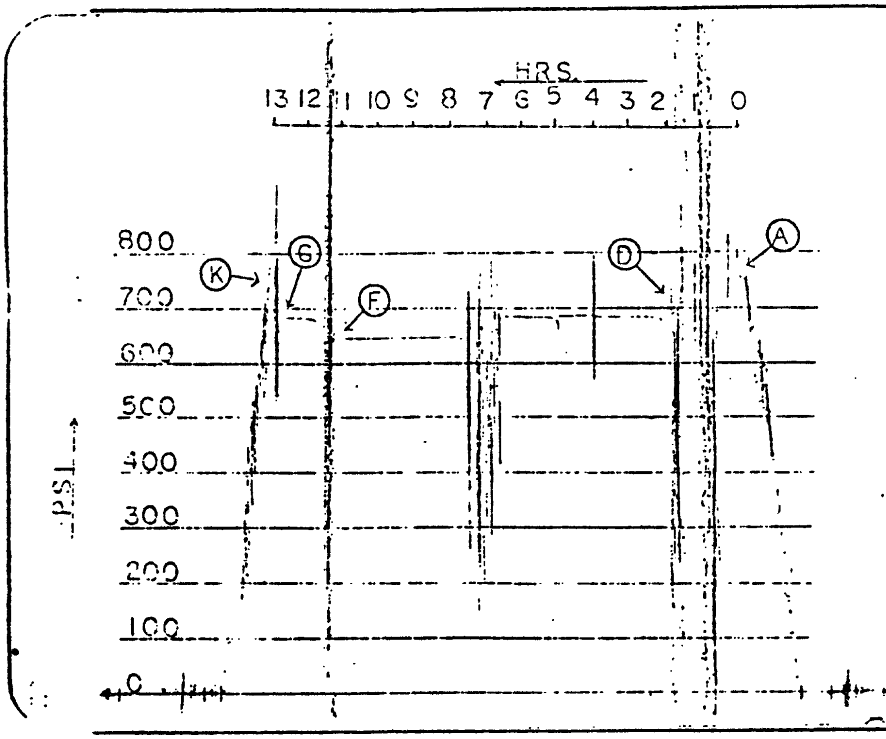
LYNES, INC.

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"	Flow No. 1	20 Min.
Rig No.	20	Bottom Choke	9/16"	Shut-in No. 1	37 Min.
Spot	NE-SE	Size Hole	7 7/8"	Flow No. 2	610 Min.
Sec.	15	Size Rat Hole	--	Shut-in No. 2	120 Min.
Twp.	57 N	Size & Wt. D. P.	2 7/8" Tubing	Flow No. 3	-- Min.
Rng.	65 W	Size Wt. Pipe	--	Shut-in No. 3	-- Min.
Field	Wildcat	I. D. of D. C.	--		
County	Crook	Length of D. C.	--		
State	Wyoming	Total Depth	1575'	Bottom Hole Temp.	102° F
Elevation	3618' "K.B."	Interval Tested	1500-1575'	Mud Weight	9.5
Formation	Minnekhata	Type of Test	Inflate	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

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.

REMARKS:

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).

62

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:

63

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
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.

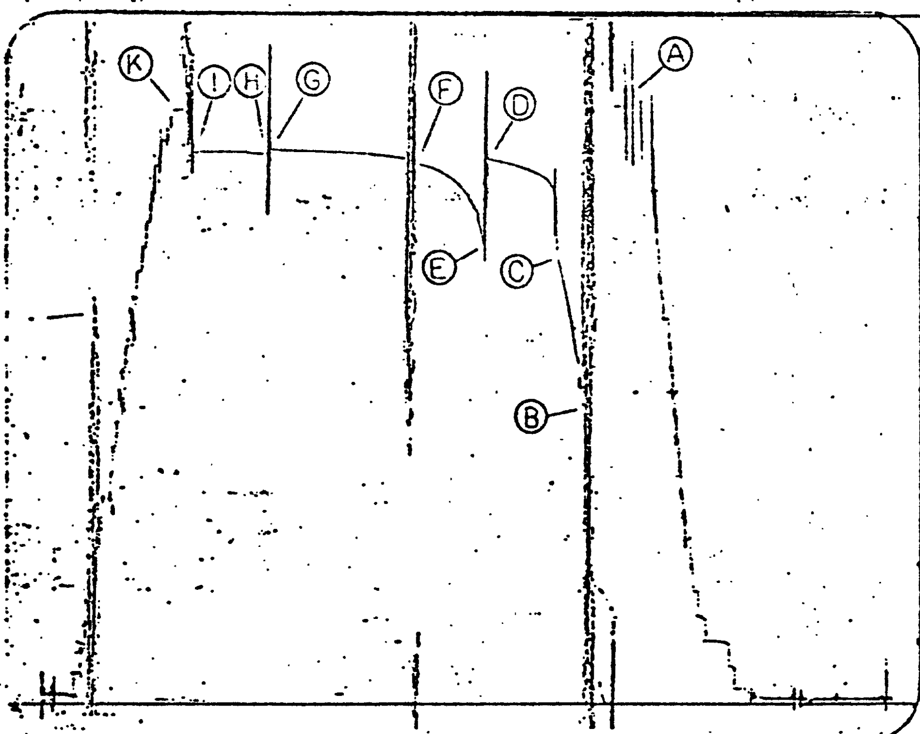
Box 712
Sterling, Colo. 80751

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	2358'
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

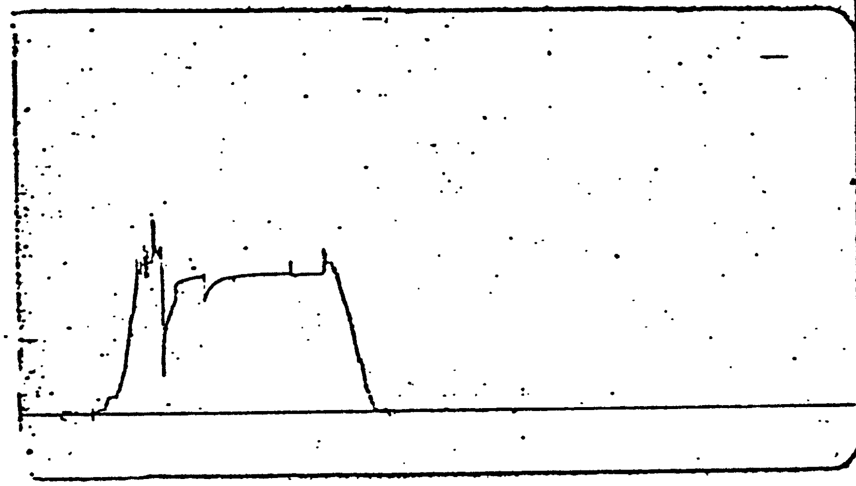
RECOVERY IN PIPE: 2218' Total Fluid
180' Muddy water = 2.56 Bbl.
2028' Clear Water = 24.55 Bbl.
10' Sand

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.

68

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 @ 2226'

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

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.

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
Consultant for 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	MID 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

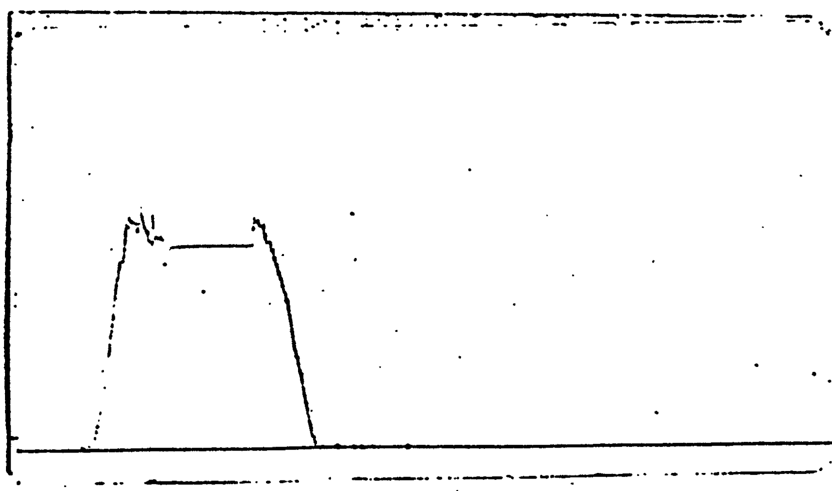
Phone
522-1206 Area 303

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.: Madison-Limestone #1
Ticket No.: 4132
Date: 10-14-76
DST No.: 14
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	3618' "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.

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 #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.

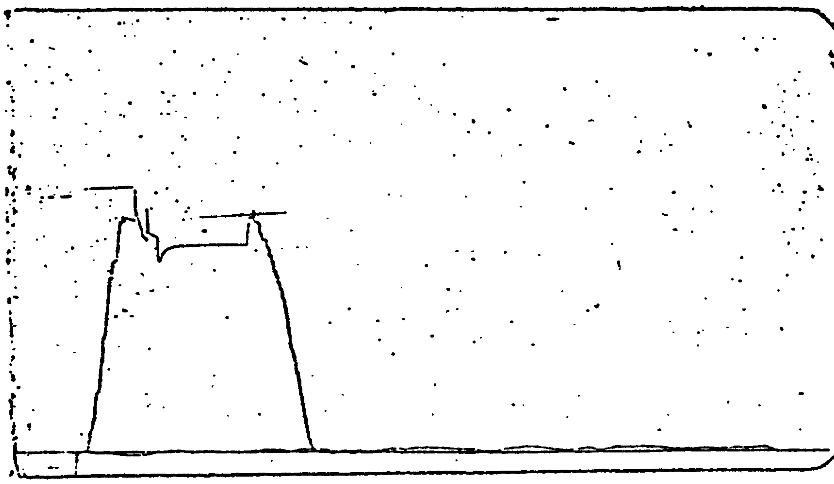
5. The radius of investigation of this test is indicated by the relationship, $b \approx \sqrt{kt_o}$, to be about 1452 feet.

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
Roger L. Hoeger
Consultant for Lynes, Inc.

LYNES, INC.

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

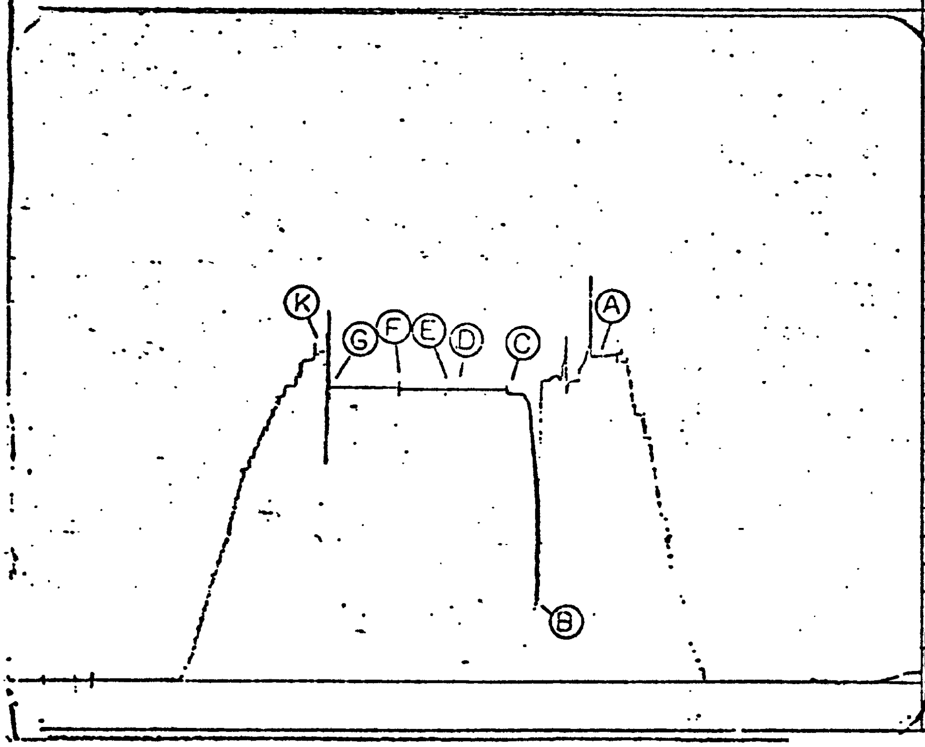


Outside Recorder

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

77

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

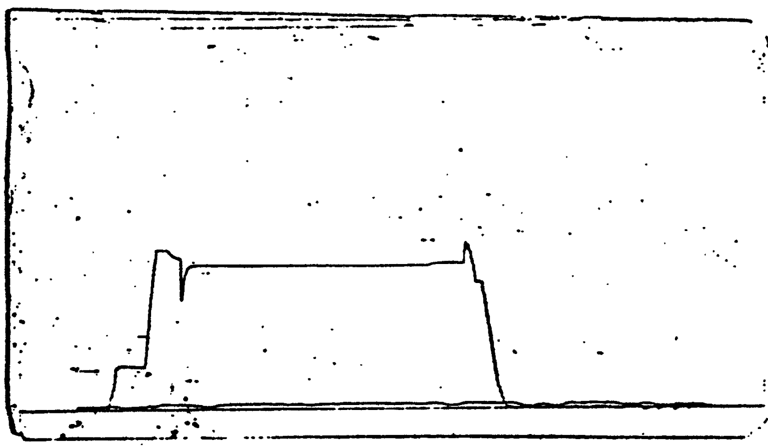
Phone
522-1206 Area 303

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.: Madison-Limestone #1
Ticket No.: 4133
Date: 10-20-76
No. Final Copies: 5
DST No.: 15

Contractor	Thomson Drlg., Inc.	Top Choke	1"	Flow No. 1	877 Min.
Rig No.	20	Bottom Choke	1"	Shut-in No. 1	60 Min.
Spot	NE-SE	Size Hole	7 7/8"	Flow No. 2	-- Min.
Sec.	15	Size Rat Hole	--	Shut-in No. 2	-- 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.	437'		
State	Wyoming	Total Depth	4355'	Bottom Hole Temp.	106° F
Elevation	3618' "K.B."	Interval Tested	2530-2570'	Mud Weight	9.5
Formation	Mission Canyon	Type of Test	Inflate Straddle	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:

80

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.

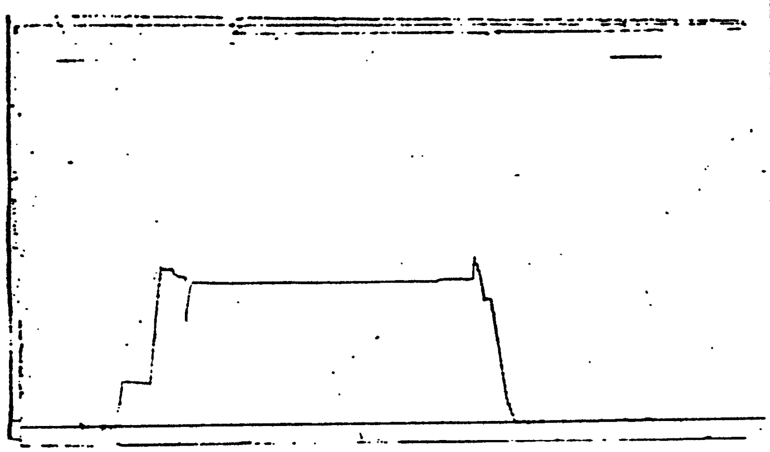
4. The calculated Effective Transmissibility of 1, 160, 675.3 md.-ft./cp. indicates an Average Permeability to the produced fluid of 116, 067.5 md. for the estimated 10 feet of effective porosity within the total 40 feet of interval tested.

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

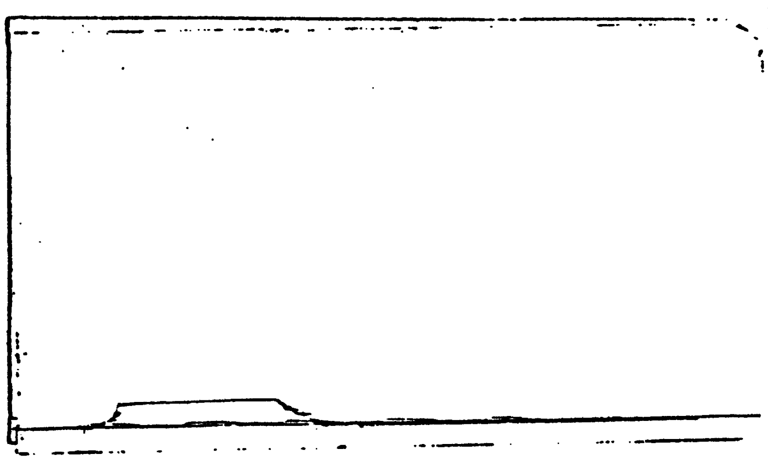


Outside Recorder

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

83

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	19.2798	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

84

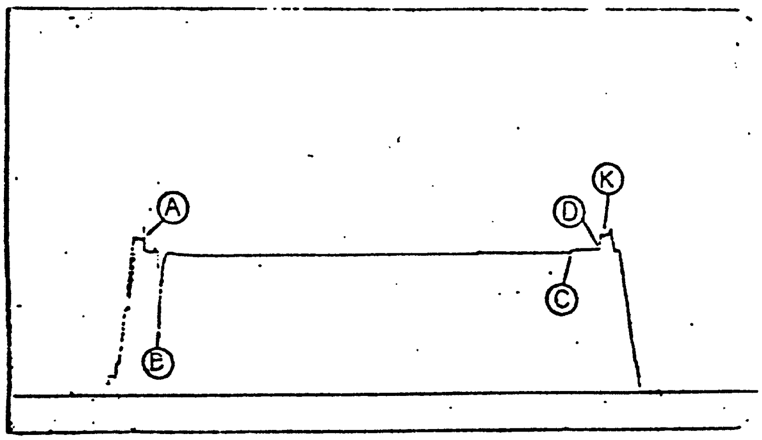
Phone
522-1206 Area 303

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"	Flow No. 1	877 Min.
Rig No.	20	Bottom Choke	1"	Shut-in No. 1	60 Min.
Spot	NE-SE	Size Hole	7 7/8"	Flow No. 2	-- Min.
Sec.	15	Size Rat Hole	--	Shut-in No. 2	-- 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.	437'	Bottom Hole Temp.	109° F
State	Wyoming	Total Depth	4355'	Mud Weight	9.5
Elevation	3618' "K.B."	Interval Tested	2434-2530'	Gravity	--
Formation	Madison	Type of Test	Inflate Straddle	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:

85

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.

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	MUD 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

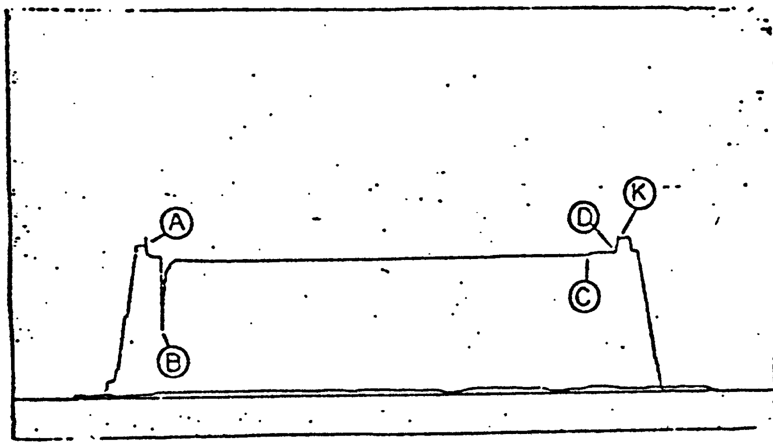
CALCULATIONS: FIRST SHUT IN

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.

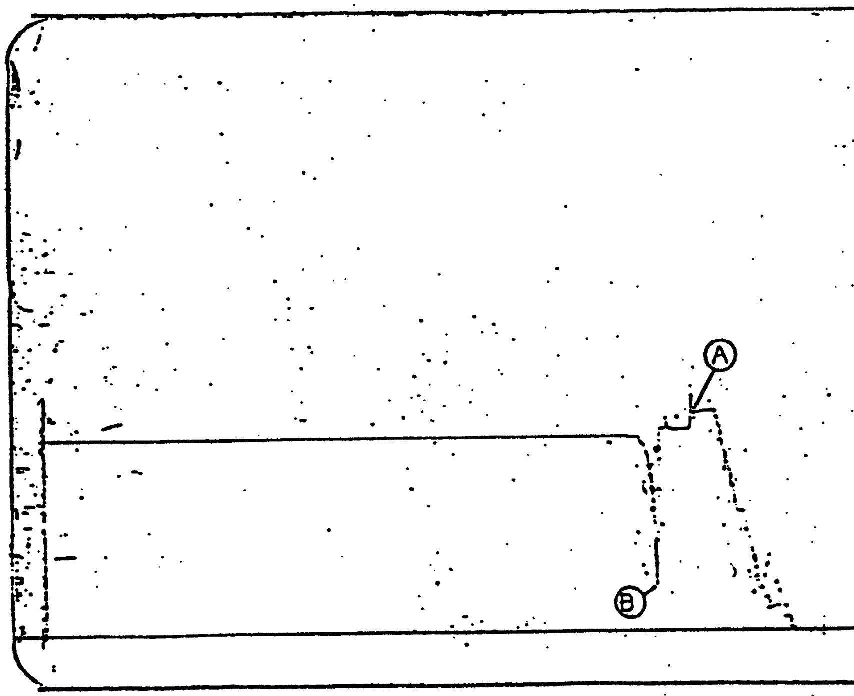
Operator U.S.G.S. Lease & No. Madison-Limestone #1 DST No. 16



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

89

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

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

95

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 6.1-A

RESTORATION ACTION PLAN

WITH FINANCIAL ASSURANCE ESTIMATE

PREAMBLE

This preamble is intended to provide NRC staff with a brief legal and regulatory discussion of the contents of the attached restoration action plan (RAP) for Strata Energy, Ltd.'s (Strata) proposed Ross *in-situ* leach uranium recovery (ISR) project near Oshoto in the State of Wyoming. Strata is submitting this RAP as a stand-alone document so that NRC staff reviewing Strata's license application will be able to address relevant decommissioning and decontamination (D&D) requirements and related financial assurance cost estimates associated with aquifer restoration and surface reclamation at the proposed Ross ISR Project in one document rather than having to search the entirety of the license application for all relevant D&D and financial assurance information. In addition, preparation of the attached RAP is in accordance with the NRC's requirements for ISR licensing as defined in 10 CFR Part 40, Appendix A, Criterion 9 and all regulations deemed to apply to ISR site D&D. Given that as discussed below previous RAPs were submitted as stand-alone documents, Strata has determined that submission of a stand-alone RAP is appropriate.

Under the Commission's regulations, RAPs find their origin in the Commission's interpretation of 10 CFR Part 40, Appendix A, Criterion 9 in the Hydro Resources, Inc. (HRI) administrative litigation regarding HRI's proposed ISR project at Church Rock and Crownpoint, New Mexico (hereinafter the Crownpoint Uranium Project or "CUP"). Beginning in 1997, HRI and several interveners entered into administrative litigation before NRC's Atomic Safety and Licensing Board (Licensing Board) to determine whether several aspects of HRI's CUP license application and NRC Staff review of that application satisfied the Atomic Energy Act of 1954 as amended (AEA) and the NRC's implementing regulations pursuant thereto. During this litigation, in 1998, NRC staff issued HRI License SUA-1508 to construct and operate the proposed CUP. After concluding the initial litigation regarding the Licensing Board's determination that the proposed CUP adequately addressed groundwater restoration and

financial assurance, in 2000, the NRC considered an appeal to that decision. In 2000, the NRC determined that a license applicant for an ISR project must have an NRC-approved RAP, including a detailed financial assurance calculation methodology and preliminary cost estimates, prior to being issued a license to operate any proposed ISR project. Importantly, while it determined that a license applicant must have the aforementioned RAP in place prior to being issued a license, the NRC also determined that the actual financial assurance mechanism (e.g., surety bond, letter of credit, cash deposit, etc.) need not be in place until the licensee is prepared to commence licensed operations. Accordingly, when submitting a license application for a new ISR project, a license applicant is required to prepare and submit a detailed financial assurance calculation methodology and preliminary cost estimates based solely on the information permitted to be obtained pre-license issuance by the applicant under NRC regulations; however, a license applicant is not required to have a final financial assurance cost estimate and a financial assurance mechanism in place until right before it is ready to commence licensed operations and after issuance of an NRC license.

The HRI litigation also provided ISR license applicants with additional guidance on the methodology for preparing RAPs and for calculating preliminary financial assurance cost estimates for such RAPs. For example, the Licensing Board, the NRC, and the United States Court of Appeals for the Tenth Circuit all have agreed that 10 CFR Part 40, Appendix A, Criterion 9 permits ISR license applicants to account for and rely upon the use of existing site equipment such as the central processing plant (CPP), existing wellfields, wellfield equipment, and other already-available site equipment when calculating financial assurance cost estimates for groundwater restoration. The NRC's interpretation logically implements the provisions of Criterion 9 as independent contractors likely will rely on the availability of existing wellfields, the CPP, and other site facilities to initiate and/or continue and complete groundwater restoration at an ISR site. In addition, existing 11e.(2) byproduct material storage areas and site equipment such as front-end loaders will be

required to complete site D&D, including surface reclamation tasks such as soil cleanup in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6).

The HRI decision also permits licensees to utilize qualified site employees for the performance of multiple, unrelated site tasks during the course of groundwater restoration and site D&D in developing financial assurance cost estimates. ISR sites are highly automated, and standard industry practices dictate that a single site employee can perform multiple tasks based on the training they receive and expertise they possess.

In addition to the aforementioned requirements, NRC regulations at 10 CFR Part 40, Appendix A, Criterion 9 also require that a *licensee* submit updates to its financial assurance cost estimates on an *annual* basis and that such estimates must account for a variety of economic and site-specific factors such as inflation (Consumer Price Index), changes in costs of materials and for personnel, changes in costs of 11e.(2) byproduct material or other waste disposal, changes in costs of required site processes such as well plugging, and changes in site-specific factors such as the level of effort and duration required for groundwater restoration (e.g., pore volumes). This requirement is intended to ensure that all financial assurance mechanisms posted by a licensee remain current and sufficient to perform required groundwater restoration and site D&D as required and in a timely fashion. Based on this requirement, ISR license applicants also are only required to present financial assurance cost estimates in license applications that account for the first year of proposed activities or the first stage of licensed operations, including construction of the CPP and the initial wellfield(s). To require otherwise would be unnecessary as an ISR license applicant will not proceed beyond certain initial site activities in the first year and given the aforementioned NRC interpretation that a financial assurance mechanism need not be in place until the commencement of operations and that an ISR licensee will be required to update its initial financial assurance cost estimates from its license application prior to posting its financial assurance mechanism and commencing licensed operations. Accordingly, ISR licensees will continue to post adequate financial assurance

cost estimates in accordance with NRC's mission of protecting public health and safety and the environment.

To comply with the NRC's directive above in the HRI litigation, HRI proposed four (4) RAPs, one for each of its proposed CUP ISR sites and each of which was approved by NRC staff subject to minor adjustments by the Licensing Board. Each of these RAPs, with the Licensing Board's adjustments, was approved by the NRC and the Tenth Circuit over the full course of that litigation.

Using these RAPs as guidance and considering that NRC staff does not currently have guidance for the composition of stand-alone RAPs, Strata is proposing a RAP for its proposed Ross ISR Project that closely follows the HRI RAPs' format. However, Strata has used updated assumptions reflecting current standard industry practices and included the work required and associated costs to reclaim all facilities associated with the CPP and the first five (5) wellfield modules, rather than just the first year's estimated construction. This is conservative in that uranium recovery operations are unlikely to occur in five modules during the first year of licensed activities. In the attached RAP, Strata is including a comprehensive site D&D plan, including aquifer restoration for the first five wellfield modules and D&D of the CPP and all other site activities required to be completed to return the Ross site to unrestricted use. These activities include D&D of site equipment, demolition of the CPP, reclamation of the initial wellfield modules, and off-site disposal of all wastes, including 11e.(2) byproduct material. The RAP also includes preliminary financial assurance cost estimates for all site D&D activities.

As can be seen from the RAP, Strata has accounted for all NRC interpretations offered in the HRI case to reflect the most current NRC practices for financial assurance. Strata believes that this RAP provides NRC staff with a user-friendly, stand-alone guide to Strata's approach to site D&D and financial assurance.

Strata Energy, Inc.
RESTORATION ACTION PLAN
License No: SUA-++++
December 2010

RESTORATION ACTION PLAN

A. INTRODUCTION

The following summarizes the Restoration Action Plan for the CPP, first five (5) wellfield modules and all related facilities anticipated to be constructed during the first year of licensed activities of the Ross ISR Project near Oshoto, Wyoming. The estimate puts the costs of restoration to be performed by an independent contractor at $9,822,600.63 over an approximately 3-year period during which the CPP, the initial five (5) wellfield modules, and associated infrastructure would be reclaimed to a condition agreed upon by NRC that would return the site to unrestricted use. The RAP encompasses the full cycle of activities necessary for:

- Facility decommissioning,
- Aquifer restoration and well plugging,
- Radiological survey and environmental monitoring,
- Project management and miscellaneous costs, and
- Labor and equipment overhead and contractor profit.

Strata's submittal presented herein employs assumptions that are based on best professional judgment given the data currently available. Annual reviews would provide the iterative format by which NRC can continually update the financial assurance amount based on work completed at the site and newly available information.

B. FINANCIAL ASSURANCE MECHANISM

The financial assurance mechanism to be used by Strata is shown in Attachment RAP-1.

C. CONSOLIDATION OF STATE, EPA AND NRC FINANCIAL ASSURANCE INSTRUMENTS

In addition to being crafted to comply with NRC criteria, Strata's proposed financial assurance estimate is designed to address the U.S. Environmental Protection Agency (EPA) Underground Injection Control criteria and the Wyoming Environmental Quality Act requirements for a reclamation

performance bond. These multi-compliant sureties will require multi-agency concurrence as to amounts and surety forms. The bond examples shown in Attachment RAP-1 are designed to be consistent with 10 CFR Part 40, Appendix A, Criterion 9 (Financial Criteria) which allows for consolidation of State and Federal financial or surety arrangements established to meet restoration, reclamation, and decommissioning costs provided that "the portion of the surety which covers the decommissioning and reclamation of the mill, mill tailings site and associated areas is clearly identified and committed for use in accomplishing these activities." Absent a mill or tailings, essentially all of the process facility, wellfield, and ancillary components of the operations would be subject to the decommissioning requirements of the Wyoming Department of Environmental Quality, U.S. Environmental Protection Agency and the NRC.

D. COST DETAILS FOR RESTORATION AND RECLAMATION ACTIVITIES

1. Introduction

Attachment RAP-2 contains details concerning cost basis figures and assumptions, calculations and methodologies used in deriving cost estimates for the full cycle of groundwater restoration, well plugging and abandonment, surface decommissioning and reclamation, closure and ultimate license termination. Cost references are provided in Attachment RAP-3. This information is designed to be descriptive enough for the NRC staff to determine the acceptability of Strata's proposed cost figures and is based on the estimated costs for an independent contractor to perform the decommissioning and reclamation work in accordance with 10 CFR Part 40, Appendix A, Criterion 9 and the Wyoming Environmental Quality Act and its accompanying rules and regulations and guidelines. Strata has developed its cost estimates to address all items in Appendix C of the NRC's "Standard Review Plan for In Situ Leach Uranium Extraction License Applications" (NUREG-1569, dated June 2003).

The following tabulation summarizes the costs necessary to hire an independent contractor to assume all decommissioning and reclamation activities required after full development of the CPP, first five (5) wellfield modules and associated facilities. Descriptions of the work are provided below, and detailed costs estimates for each major item of work are provided in attachments RAP-2(A) through (G).

Item	Cost
Aquifer restoration	$ 2,940,923.42
Facilities area reclamation	$ 2,344,689.50
Wellfield equipment & disposal	$ 1,653,423.27
Well abandonment	$ 1,030,261.08
Radiological surveys	$ 37,857.50
Revegetation	$ 66,000.00
Misc. reclamation activities	$ 268,082.14
Subtotal	$ 8,395,385.15
Project management @ 2%	$ 167,907.70
Contingency @ 15%	$ 1,259,307.77
Total	$ 9,822,600.63

1. Aquifer Restoration

1.1. Introduction

Aquifer restoration costs for the first five wellfield modules are presented in Attachment RAP-2(A). The costs are broken down into separate phases of work:

- Groundwater sweep,
- Reverse osmosis (RO) with permeate injection,
- Groundwater recirculation,
- Monitoring,
- Labor, and
- Miscellaneous.

For each phase of work, the estimated number of pore volume displacements (PVDs) required to complete that phase is provided in the attachment. The tables also provide the assumptions and unit prices for all the work necessary to complete each phase of work for the first five wellfield

modules. A summary sheet is provided showing the total costs for each phase, followed by detailed calculation sheets to show how the total costs were derived. For the first five wellfield modules, the PVDs of water to be handled and the aquifer restoration costs are estimated to be as follows:

Item	PVDs	Cost
Groundwater sweep	0.5	$ 52,669.28
RO with permeate injection	8.0	$ 596,091.13
Groundwater recirculation	1.0	$ 12,613.01
Monitoring	---	$ 94,500.00
Labor	---	$1,943,550.00
Miscellaneous	---	$ 241,500.00
Total for groundwater restoration	9.5	$2,940,923.42

Restoration progress is typically measured on the basis of the number of PVDs processed during each phase of groundwater restoration. A pore volume is a term used by the ISR industry to define an indirect measurement of a unit volume of aquifer affected by ISR recovery or restoration (ISR GEIS, NRC 2009). This report distinguishes between the *in-situ* pore volume (PV) and the pore volume displacement (PVD), which is used to describe the volume of water displaced during ISR uranium recovery and aquifer restoration. Following industry standard, Strata proposes to calculate a PVD as follows:

PVD = thickness x wellfield area x porosity x flare x conversion factor

The **thickness** is the average completion thickness for the recovery and injection wells. Based on exploration drilling, the ore zone thickness ranges from 5 to 30 feet and averages approximately 9 feet across the proposed project area. The average completion thickness is typically about 20% greater than the average ore zone thickness and is expected to average approximately 11 feet. This method of calculation is consistent with currently permitted and operating ISR production facilities (COGEMA 2008, CBR 2000).

The **wellfield area** is the surficial area of the injection and recovery well patterns for each wellfield module. Based on the delineation of recoverable

resources within the proposed project area, the average area per wellfield module is estimated to be 248,000 square feet.

The **porosity** or pore space is defined as the collective open spaces of the formation or a measure of the amount of liquid or gas that may be absorbed or produced by a particular formation (ISR GEIS). The porosity of the ore zone within the proposed project area was determined by laboratory analysis of core samples collected during exploration drilling. The porosity is estimated to average 34% across the proposed project area.

The **flare** is a proportionality factor that estimates the amount of aquifer water outside of the pore volume that has been affected by lixiviant flow during the recovery phase (GEIS). Flare estimates usually include a horizontal and vertical flare factor. The horizontal flare is the volume of water affected by lixiviant outside the edge of the wellfield pattern. The vertical flare is the volume of water affected by lixiviant above and below the completion interval. Strata estimates the horizontal flare at 35% and the vertical flare at 20%. This is consistent with other ISRs as described in TR Section 6.1.6. The horizontal flare estimate is also supported by the results and simulations presented in the groundwater model report as described in TR Addendum 2.7-H.

An estimate of the PVD of a typical wellfield module is calculated as follows, where 7.48 is the conversion factor for cubic feet to gallons of water:

$$\text{PVD} = 11.0 \text{ feet} \times 248{,}000 \text{ ft}^2 \times 0.34 \times 1.62 \times 7.48 = 11.2 \text{ million gallons}$$

The duration of the aquifer restoration phase was based on the processing and circulation of 9.5 pore volumes of groundwater at the liquid processing rates specified in the calculation work sheets for each phase in Attachment RAP-2(A). The financial assurance will be maintained at this level until the number of pore volumes required to satisfactorily complete each phase has been demonstrated.

Strata will adjust the financial assurance budget for aquifer restoration during each annual update review to reflect experience gained from actual

operation. Because the restoration equipment such as wellfield pumps, lined retention ponds, the deep disposal wells, the RO units, laboratory equipment, trucks, and field equipment will have been incurred for production process operations, they are considered operational capital and are not included as capital requirements in any of the RAP budget items. NRC will be able to verify the availability of the restoration equipment during routine inspections.

2.2 Description of Work

The first stage of aquifer restoration is groundwater sweep, in which groundwater is pumped from the wellfield module with no reinjection. This causes water from the formation surrounding the wellfield module to sweep through the wellfield toward the recovery wells. Based on the anticipated aquifer restoration schedule (refer to S-1 in Attachment RAP-3), during most aquifer restoration normal operations, when some wellfield modules are undergoing groundwater sweep while others are in RO treatment with permeate injection, the water removed from the groundwater sweep is taken to the RO units (see below) and the purified water (RO permeate) is reinjected into the wellfield module(s) undergoing RO treatment with permeate injection. The brine from the RO units is taken to the lined retention ponds and then to a deep disposal well. For the first wellfield module undergoing groundwater sweep, it is assumed there are no wells concurrently in RO treatment with permeate injection. Thus, the groundwater from the groundwater sweep will be taken to the RO units, the high-quality permeate will be discharged (assuming a temporary WYPDES permit can be obtained) and the brine will be taken to the deep disposal wells. It is estimated that the groundwater sweep will remove about 0.5 PVD from the wellfield at a rate of 75 gpm per wellfield module. Only one wellfield will typically be in this phase of restoration at one time. The duration of the sweep will be about two months per module.

RO is a water treatment process whereby the majority of dissolved ions, which are too large to pass through a filter that passes pure water molecules, are concentrated into brine. The product water that passes through the filter

typically meets drinking water standards and during most restoration activities is reinjected back into the wellfield. This reinjection of relatively pure water mixes with formation water and helps bring the quality of the underground solutions toward baseline quality. During restoration the brine is pumped to a surge tank or lined retention pond to level out flow rates and then pumped to one of the disposal wells. Groundwater recovered from a depleted portion of the ore zone will be treated with an antiscalant and/or sulfuric acid to prevent fouling; these are the only pretreatment chemicals budgeted. The water will also pass through a pre-filtration system for particulate removal. To achieve RO purification, the pretreated solution is pressurized and directed to the first step of a two-stage RO process. Approximately 70 percent of the total feed volume will be converted to product water in the first stage. The brine water of the first stage will then act as the feed for the second stage, which yields an overall permeate recovery rate of approximately 85 percent. The RO equipment is sized to operate at a nominal capacity of 1,100 gpm. This is sufficient to treat the approximately 515 gpm from each of two modules typically in the RO treatment with permeate injection phase and one module in the groundwater sweep phase. It is estimated that each module will require RO treatment with permeate injection for about 4 months. With two modules at a time undergoing RO treatment with permeate injection for a 4-month period, the time to sequentially complete this process for the five initial wellfield modules will be about 12 months. The total time for groundwater sweep plus RO treatment with permeate injection is anticipated to be 14 months (refer to reference S-1 in Attachment RAP-3).

The third phase of aquifer restoration is groundwater recirculation, which begins after completion of the RO treatment with permeate injection phase. In this phase, water from the production zone will be pumped from recovery wells and recirculated into injection wells in the same module. This recirculation will homogenize the groundwater and help reduce the risk of "hot spots," or areas of unusually high concentrations of dissolved constituents. The only treatment that will occur during recirculation will be filtration and/or

uranium/vanadium removal. It is expected that one PVD will be removed from the wellfield during this phase, at a rate of 300 gpm per module. The total duration of active aquifer restoration (groundwater sweep, RO treatment with permeate injection, and groundwater recirculation) is estimated to be 15 months for the first five wellfield modules.

There will be up to five deep disposal wells at the Ross ISR Project used for disposal of brine and any other waste water that does not meet criteria for discharge. However, only three deep disposal wells are anticipated to be installed during the first year of licensed activities. The capital costs will have been borne by Strata during construction of the plant facilities, but there will be operating and maintenance costs and costs for antiscalant and corrosion inhibitors. The lined retention ponds will be used to store the water until it is ready for deep well disposal. Ponds will have excess capacity to handle variations in water production, since the capacity of each deep disposal well will be relatively fixed by formation characteristics.

The final step in aquifer restoration will be the stability monitoring phase, which will be used to ensure that chemical species of concern do not increase in concentration subsequent to restoration. The stability monitoring phase is described in Section 6.1.2.5 of the TR and includes well sampling, data analysis and reporting. If the stability monitoring indicates that one or more dissolved parameters in the restored wellfield is trending above the target restoration value (TRV) for that parameter, it may be necessary to repeat one or more of the active restoration phases (groundwater sweep, RO with reinjection, or recirculation).

3. Facilities Area Decommissioning and Reclamation

Following wellfield restoration and stability monitoring, when it is certain that the water treatment equipment is no longer needed, reclamation can begin on the surface facilities. Procedures are fully described in Sections 6.2 and 6.3 of the TR. Detailed cost estimates for the facilities area decommissioning and

reclamation are provided in Attachment RAP-2(B). The following tabulation shows a summary of the major cost items for this phase of work.

Item	Cost
Buildings	$ 411,373.56
Equipment	$ 516,538.25
Concrete	$ 860,964.28
Ponds	$ 243,288.99
Earthwork	$ 366,672.66
Total Facilities Reclamation Cost	$ 2,398,837.74

3.1 Buildings

Structures and equipment will be decontaminated or deposited at an NRC or agreement state approved waste facility site. Details regarding disposal of structures and equipment are discussed in Section 6.3 of the TR. Buildings to be removed include the CPP, chemical storage building, warehouse/maintenance building, administration building, and security building. Decontamination of salvageable building materials, equipment, pipe, and other materials to be released for unrestricted use will be accomplished by completing a preliminary radiological survey to determine the location and extent of the contamination and to identify any hazards as described in Section 6.3.3 of the TR. Processing and water treatment equipment, including tanks, filters, IX columns, pipes, and pumps, will be prepared, including decontamination if necessary, for use at another location or dismantled and disposed of in accordance with applicable regulations. Materials contaminated with other industrial constituents will be disposed of at an appropriately licensed facility. Decontaminated and non-contaminated materials will be removed for salvage or disposed of at an appropriately licensed solid waste facility. Structures will be decontaminated, if necessary, and moved to a new location and salvaged or disposed at an appropriately licensed solid waste facility. Concrete flooring, foundations, and foundation materials will be decontaminated, if necessary, broken up, and disposed of at an appropriately licensed facility.

3.2 Ponds

Work required to reclaim the ponds will include brine disposal in the deep disposal wells, removal of the liner and brine residue to a licensed 11.e(2) disposal site, disposal of all non-11.e(2) solid waste from the leak detection piping to an approved landfill, regrading to restore original topography, topsoil replacement and revegetation. This work is described in Section 6.2 of the TR and the detailed quantities and unit prices used to estimate the reclamation costs are provided in Attachment RAP-2(B).

3.2 Earthwork

After the buildings and ponds are demolished and removed, the entire site will be regraded to restore the original topography, topsoil will be replaced to approximate its original depth, and the area will be regraded. Earthwork costs to complete the regrading of the CPP, parking areas, and access roads are provided in Attachment RAP-2(B). The work is described in detail in Section 6.2 of the TR.

3.3 Containment Barrier Wall

The containment barrier wall (CBW) at the CPP will be reclaimed to the extent necessary to restore the flow pattern of shallow groundwater. Reclamation of this wall will be accomplished by creating a series of breaches, also known as finger drains, along the CBW. Each finger drain will consist of a 1.5 ft wide by ~25 ft long trench that is cut through the CBW at a right angle and to a depth that is ~2 ft below the lowest historical ground water level. Gravel will be placed in the trench from the bottom to a point ~2 ft above the highest recorded ground water level such that a highly permeable flow path is created through the CBW. The remaining trench will be backfilled with topsoil and seeded.

This method of CBW reclamation was selected as a means of effectively restoring the ground water flow system in the CPP area, while minimizing surface and environmental disturbance. The cost estimate for this phase of work is included in Attachment RAP-2(B).

4. Wellfield Equipment Removal and Disposal

Decommissioning and reclamation of the wellfields will include removal of the module buildings and all pipes and utilities connecting the wells to the module buildings and the CPP, shredding or chipping the solid materials to reduce the volume, and disposing of these materials in an approved municipal landfill or licensed 11e.(2) waste site as appropriate, and reclaiming the surface as described for the other surface facilities. The unit quantities and prices for each item of work in this task are included in Attachment RAP-2(C). The costs for this phase of work are summarized as follows:

Item	Cost
Wellfield piping	$1,480,069.23
Module buildings	$ 80,643.90
Valve manholes	$ 53,560.40
Wellheads	$ 14,910.00
Access roads	$ 24,239.74
Total wellfield reclamation cost	$1,653,423.27

5. Well Abandonment

All injection, recovery and monitor wells will be cemented from total depth to the surface as described in TR Addenda 2.6-E and 4.2-A. This work includes reclamation and abandonment of the 450 wellfield wells, 162 monitor wells and the 3 deep disposal wells that will be constructed during development of the initial five wellfield modules. The unit quantities and prices for each item of work in this task are included in Attachment RAP-2(D). The costs for this phase of work are summarized as follows:

Item	Cost
Recovery, injection and monitor wells	$ 717,931.08
Deep disposal wells	$ 312,330.00
Total well abandonment cost	$1,030,261.08

6. Radiological Surveys

During equipment decontamination, smear samples of building and equipment surfaces will be collected and analyzed for radiological contamination. The results of these samples will drive decontamination efforts. Following removal of all structures and regrading of the site to approximate original contours, and before topsoil is spread on the regraded area, a gamma survey and soil sampling will be conducted as described in Section 6.4 of the TR. Soils will be cleaned up in accordance with the requirements of 10 CFR Part 40, Appendix A, including consideration of ALARA goals and the chemical toxicity of uranium. The proposed limits and ALARA goals for cleanup of soils are summarized in section 6.4-3 of the TR. Any areas which do not meet these limits will be remediated by removing contaminated soils to an appropriately licensed site and regraded. This process will be repeated until all sites meet the ALARA goals for cleanup. The unit costs and areas subject to these surveys are provided in Attachment RAP-2(E). The total cost for this item of work is estimated to be $37,857.50.

7. Revegetation

At the completion of the previous tasks, and after topsoil has been spread across all regraded areas, all of the disturbed lands will be seeded with vegetation species that will return the lands to their pre-project conditions. The surface reclamation plan goals will be to return the land to equal or better condition than existed prior to uranium recovery, thus making it available for "unrestricted use." The reclaimed land will be capable of supporting livestock grazing, dry land farming and wildlife habitat. Baseline soils, vegetation, and radiological data will be used to guide the reclamation activities. Unit prices and the area to be revegetated are provided in Attachment RAP-2(F). The estimated cost to revegetate the area is $66,000.

8. Miscellaneous Reclamation Activities

Costs for miscellaneous reclamation activities not covered in the preceding sections are provided in Attachment RAP-2(G) and are summarized as follows:

Item	Cost
Fence removal	$ 36,361.62
Overhead power line removal	$ 0.00
Buried electrical line removal	$ 89,100.00
Buried gas line removal	$ 49,686.00
Transformer removal and disposal	$ 14,080.00
Surface water monitoring sta. removal	$ 7,035.60
Air quality/met. sta. removal	$ 6,205.36
Culvert removal	$ 5,613.56
Chipper/shredder rental/operation	$ 60,000.00
Total miscellaneous costs	$268,082.14

9. References

CBR (Crow Butte Resources, Inc.), 2000, Mine Unit 1 Restoration Report, Crow Butte Uranium Project, January 10, 2000, NRC ADAMS Accession No. ML003677938.

COGEMA Mining, Inc., 2008, Irigaray and Christensen Ranch Projects U.S. NRC License Renewal Application, Source Material License SUA-1341, May 2008, NRC ADAMS Accession No. ML081890414.

NRC (U.S. Nuclear Regulatory Commission), 2009, NUREG-1910, Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities, Final Report, May 2009.

ATTACHMENT RAP-1
FORM OF FINANCIAL ASSURANCE

The financial assurance funding mechanism is currently unknown; however, Strata will provide a mechanism for the approved financial assurance estimate in accordance with the conditions as set forth in 10 CFR Part 40, Appendix A, Criterion 9, prior to beginning active uranium recovery operations.

ATTACHMENT RAP-2
DETAILED COST ESTIMATES

RECLAMATION SUMMARY

	Item	Attachment	Worksheets	Cost
I.	Aquifer Restoration	RAP-2(a)	AR-1 through AR-8	$ 2,940,923.42
II.	Facilities Area	RAP-2(b)	FAC-1 through FAC-12	$ 2,398,837.74
III.	Wellfield Equipment	RAP-2(c)	WF-1 through WF-12	$ 1,653,423.27
IV.	Well Abandonment	RAP-2(d)	WA-1	$ 1,030,261.08
V.	Radiological Survey	RAP-2(e)	RAD-1	$ 37,857.50
VI.	Revegetation	RAP-2(f)	VEG-1	$ 66,000.00
VII.	Miscellaneous	RAP-2(g)	MISC-1 through MISC-2	$ 268,082.14
	Subtotal			$ 8,395,385.15
VIII.	Project Management @ 2%			$ 167,907.70
IX.	Contingency @ 15%			$ 1,259,307.77
	Total Reclamation Cost			**$ 9,822,600.63**

Attachment RAP-2(A)
Costs for Aquifer Restoration

I. AQUIFER RESTORATION SUMMARY AR-1

	Item	Cost	
I.	Groundwater Sweep	$	52,669.28
II.	Reverse Osmosis with Permeate Injection	$	596,091.13
III.	Groundwater Recirculation	$	12,613.01
IV.	Monitoring	$	94,500.00
V.	Labor	$	1,943,550.00
VII.	Miscellaneous	$	241,500.00
	Total Aquifer Restoration Cost	**$**	**2,940,923.42**

TECHNICAL ASSUMPTIONS			
Item		**Unit**	**Notes**
Average wellfield module area	248,000	sq-ft	Refer to RAP text
Average wellfield module area	5.7	ac	Calculated
Average completed thickness	11	ft	Refer to RAP text
Affected volume			
Vertical flare factor	20%		Refer to RAP text
Horizontal flare factor	35%		Refer to RAP text
Porosity	34%		Refer to RAP text
Gallons per cubic foot	7.48		Conversion factor
Gallons per pore volume displacement (PVD)	11,239,316	gal	Calculated
Total number of wellfield modules	5		Refer to RAP text
Number of injection, recovery, and monitor wells			
Average recovery wells per module	36		Preliminary wellfield design
Average injection wells per module	54		1.5 injection wells: 1 recovery well
Average recovery/injection wells per module	90		Calculated
Total recovery/injection wells per 5 modules	450		Calculated
Monitor wells (total all modules)	162		Assumes all monitor wells will be installed for both mine units (114 perimeter, 24 overlying, 24 underlying)
Total recovery/injection/monitor wells	612		Calculated
Average well depth	500	ft	TR Table 6.1-7 (OZ depth = 410-700 ft)

GROUNDWATER SWEEP COST ESTIMATE PER MODULE			
Operating Assumptions			**References**
Flow rate	75	gpm	TR Table 6.1-4
PVDs required	0.5	PVD	Refer to RAP text
Total groundwater sweep volume	5,619,658	gal	Calculated
Total groundwater sweep volume	5,620	kgal	Calculated
Duration of Groundwater Sweep			
Minutes	74,929	min	Calculated
Days	52	days	Calculated
Recovery Well Pumping Costs			
Average flow rate per pump	17	gpm	Estimated average recovery rate based on aquifer tests
Number of pumps required	5		Calculated
Power input per pump	4.0	kW	Reference P-1
Electrical requirement	20.0	kW	Calculated
Electrical consumption	24,976	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Total Recovery Well Pumping Cost	$ 999.05		
Recovery Booster Pumps			
Average flow	75	gpm	
Electrical requirement	5.0	kW	Reference P-2; reduced by 75% due to much lower flow rate
Electrical consumption	6,244	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Total Recovery Booster Pumping Cost	$ 249.76		
Reverse Osmosis Treatment			
2-Stage RO treatment cost	$ 0.88	/kgal	Reference RO-1
Total RO Treatment Cost	$ 4,945.60		
Permeate Disposal			
Permeate volume after Stage 1 RO	3,934	kgal	70% recovery (TR Fig. 3.1-13)
Permeate volume after Stage 2 RO	4,777	kgal	50% recovery (TR Fig. 3.1-13)
Excess permeate Module 1*	100%		
Excess permeate Modules 2-5*	0%		
Average excess permeate	20%		Calculated
Average excess permeate	955	kgal	Calculated
Cost of permeate disposal	$ 0.15	/bbl	Estimated disposal cost (land application, WYPDES discharge, etc.)
Cost of permeate disposal	$ 3.57	/kgal	Calculated
Total Permeate Disposal Cost	$ 3,412.14		
Brine Disposal			
Brine volume after Stage 1 RO	1,686	kgal	30% of influent (TR Fig. 3.1-13)
Brine volume after Stage 2 RO	843	kgal	50% of influent (TR Fig. 3.1-13)
Deep disposal well cost	$ 1.10	/kgal	See DDW-1 worksheet
Total Brine Disposal Cost	$ 927.30		
TOTAL COST PER MODULE	**$ 10,533.86**		
TOTAL COST FOR 5 MODULES	**$ 52,669.28**		

*Excess permeate will only be generated when the first module undergoes groundwater sweep. After that all permeate will be reinjected into modules undergoing RO treatment with permeate injection. Therefore, the volume has been divided by 5 to in order to find the total cost per module.

I. AQUIFER RESTORATION - RO TREATMENT WITH PERMEATE INJECTION

REVERSE OSMOSIS TREATMENT WITH PERMEATE INJECTION COST PER MODULE			
Operating Assumptions			
Average flow rate	515	gpm	TR Table 6.1-4
PVDs required	8	PVDs	Refer to RAP text
Total RO/permeate injection volume	89,914,528	gal	Calculated
Total RO/permeate injection volume	89,915	kgal	Calculated
Duration of RO treatment with permeate injection			
Minutes	174,591	min	Calculated
Days	121	days	Calculated
Recovery Well Pumping Costs			
Average flow rate per pump	17	gpm	Estimated average recovery rate based on aquifer tests
Number of pumps required	31		Calculated
Power input per pump	4.0	kW	Reference P-1
Electrical requirement	124.0	kW	Calculated
Electrical consumption	360,822	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Total Recovery Well Pumping Cost	$ 14,432.88		
Recovery Booster Pumps			
Average flow rate	515	gpm	
Electrical requirement	20.0	kW	Reference P-2
Electrical consumption	58,197	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Total Recovery Booster Pumping Cost	$ 2,327.88		
Reverse Osmosis Treatment			
2-Stage RO treatment cost	$ 0.88	/kgal	Reference RO-1
Total RO Treatment Cost	$ 79,124.78		
Brine Disposal			
Brine volume after Stage 1 RO	26,974	kgal	30% of influent (TR Fig. 3.1-13)
Brine volume after Stage 2 RO	13,487	kgal	50% of influent (TR Fig. 3.1-13)
Cost per kgal	$ 1.10	/kgal	Reference DDW-1
Total Brine Disposal Cost	$ 14,835.90		
CPP Permeate Pumps			
Average flow rate per pump	467.5	gpm	TR Figure 3.1-13 (935 gpm/2 - 2 modules in RO treatment/permeate injection at once)
Electrical requirement	15	kW	Reference P-4
Electrical consumption	43,648	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Total CPP Permeate Pump Cost	$ 1,745.91		
Injection Booster Pump			
Average flow rate per pump	467.5	gpm	See above
Electrical requirement	58	kW	Reference P-3
Electrical consumption	168,772	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Total Injection Booster Pump Cost	$ 6,750.86		
TOTAL COST PER MODULE	**$ 119,218.23**		
TOTAL COST FOR 5 MODULES	**$ 596,091.13**		

RECIRCULATION COST PER MODULE			
Operating Assumptions			
Average flow rate	300	gpm	TR Table 6.1-4
PVDs required	1	PVD	TR Table 6.1-3
Total recirculation volume	11,239,316	gal	Calculated
Total recirculation volume	11,239	kgal	Calculated
Duration of recirculation			
Minutes	37,464	min	Calculated
Days	26	day	Calculated
Recovery Well Pumping Costs			
Average flow rate per pump	17	gpm	Estimated average recovery rate based on aquifer tests
Number of pumps required	18		Calculated
Power input per pump	4.0	kW	Reference P-1
Electrical requirement	72.0	kW	Calculated
Electrical consumption	44,957	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Total Recovery Well Pumping Cost	$ 1,798.29		
Injection Booster Pump			
Average flow rate per pump	300	gpm	
Electrical requirement	29.0	kW	Reference P-2; reduced by 50% due to lower flow rate
Electrical consumption	18,108	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Total Injection Booster Pump Cost	$ 724.31		
TOTAL COST PER MODULE	**$ 2,522.60**		
TOTAL COST FOR 5 MODULES	**$ 12,613.01**		

MONITORING			
Monitoring during Active Restoration			
Excursion Monitoring			
Monitoring period	7	months	Reference S-1; 2 months groundwater sweep plus 4 months RO/permeate injection plus 1 month recirculation
Number of wells to sample	10	wells	Estimated monitor wells per module
Number of samples per month per well	2		Based on sampling every 2 weeks
Price per sample	$ 50.00		Approximate 2011 contract laboratory cost
Excursion monitoring cost	$ 7,000.00		Calculated
Restoration Verification Monitoring			
Monitoring period	7	months	Reference S-1; 2 months groundwater sweep plus 4 months RO/permeate injection plus 1 month recirculation
Number of wells to sample	2	wells	Based on 1 per 3-4 acres (5.7 acres/4)
Number of samples per month per well	1		Based on sampling every month
Price per sample	$ 330.00		Approximate 2011 contract laboratory cost
Verification monitoring cost	$ 4,620.00		Calculated
Total Active Restoration Monitoring Cost	$ 11,620.00		
Stability Monitoring			
Excursion Monitoring			
Monitoring period	12	months	Reference S-1
Number of wells to sample	10	wells	Estimated monitor wells per module
Number of samples per month per well	0.33		Based on sampling quarterly
Price per sample	$ 50.00		Approximate 2011 contract laboratory cost
Excursion monitoring cost	$ 2,000.00		
Stability Verification Monitoring			
Monitoring period	12	months	Reference S-1
Number of wells to sample	2	wells	Based on 1 per 3-4 acres (5.7 acres/4)
Number of samples per well	8		TR Section 6.1.2.5
Price per sample	$ 330.00		Approximate 2011 contract laboratory cost
Verification monitoring cost	$ 5,280.00		Calculated
Total Stability Monitoring Cost	$ 7,280.00		
TOTAL MONITORING COST PER MODULE	**$ 18,900.00**		
TOTAL COST FOR 5 MODULES	**$ 94,500.00**		

LABOR			
Operating Assumptions			
Time of active aquifer restoration	15	months	Reference S-1
Time of stability monitoring/decommissioning without active restoration	21	months	Reference S-1
Employees			
Active Aquifer Restoration			
Number of employees	20		Reference ER Table 4.2-1
Annual salary	$ 50,000.00		Reference ER Section 4.10.1.2
Overhead multiplier	1.0		Benefits and payroll taxes included in salary
Profit multiplier	1.12		Estimate
Total employee annual cost	$ 56,000.00		Calculated
Total Employee Cost during Active Restoration	$ 1,400,000.00		
Stability Monitoring/Decommissioning			
Number of employees	5		
Annual salary	$ 50,000.00		Reference ER Section 4.10.1.2
Overhead multiplier	1.0		Benefits and payroll taxes included in salary
Profit multiplier	1.12		Estimate
Total employee annual cost	$ 56,000.00		Calculated
Total Employee Cost During Stability Monitoring/Decommissioning	$ 490,000.00		
Total Employee Cost	$ 1,890,000.00		
Vehicles			
Number of vehicles	10		From emissions spreadsheet
Miles per day per vehicle	10	miles	Estimate (within licensed area)
Cost per mile	$ 0.51	/mile	Based on IRS mileage rate for 2011
Number of days per year	350	days	Based on vehicles running 50 weeks out of the year
Number of years	3.0	years	Calculated
Total Vehicle Cost	$ 53,550.00		
TOTAL LABOR COST	**$1,943,550.00**		

I. AQUIFER RESTORATION - MISCELLANEOUS AR-8

MISCELLANEOUS			
Operating Assumptions			
Time of active aquifer restoration	15	months	Reference S-1
Time of stability monitoring/decommissioning without active restoration	21	months	Reference S-1
Utilities			
Active Aquifer Restoration			
Monthly electricity cost	$ 8,000.00		From preliminary plant design (excludes process-related electrical consumption)
Monthly gas cost	$ 6,000.00		From preliminary plant design (excludes process-related gas consumption)
Active restoration utilities	$ 210,000.00		During 15 months of aquifer restoration
Stability Monitoring/Decommissioning			
Monthly electricity cost	$ 1,000.00		Estimate for administration building, warehouse, etc.
Monthly gas cost	$ 500.00		Estimate for administration building, warehouse, etc.
Stability monitoring/ decommissioning utilities	$ 31,500.00		During 21 months of stability monitoring/decommissioning without active restoration
Total Utilities Cost	$ 241,500.00		
Capital			
Pumping systems	$ -		Pumping systems in place during operation phase
RO systems	$ -		RO units in place during operation phase
Deep disposal wells			Deep disposal wells in place during operation phase
Excursion cleanup cost	$ -		Cost estimates will be updated in the event an excursion occurs
Total Capital Cost	$ -		
TOTAL MISCELLANEOUS COST	**$ 241,500.00**		

Attachment RAP-2(B)
Costs for Facilities Area Decommissioning and Reclamation

II. FACILITIES AREA - SUMMARY

FAC-1

	Item	Cost
I.	Buildings	$ 411,373.56
II.	Equipment	$ 516,538.25
III.	Concrete	$ 860,964.28
IV.	Lined Retention Ponds	$ 243,288.99
V.	Earthwork	$ 366,672.66
	Total Facilities Cost	**$ 2,398,837.74**

I. Buildings (Excludes Concrete)			
CPP			
Dimensions			
Length	370	ft	TR Fig. 3.2-1
Width	200	ft	TR Fig. 3.2-1
Height	30	ft	Preliminary CPP design
Volume	2,220,000	ft^3	Calculated
Demolition			
Demolition unit cost	$ 0.125	$/ft^3$	WDEQ/LQD Guideline 12, Appendix K (Ref. LQD-K), less 50% for lack of interior building walls per RSMeans 02 41 16.13.5000
Demolition cost	$ 277,500.00		
Transportation			
Unit building weight	15	lb/ft^2	ASCE 7-05
Building weight	555	tons	Calculated
Salvage %	60%		Conservatively assumes zero net salvage value
Weight of material to dispose	222	tons	Calculated
Density of construction debris	2,000	lb/yd^3	Typical of construction debris
Volume of material for disposal	222	yd^3	Calculated
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	12	trucks	Calculated
Distance to landfill	23	miles	Moorcroft landfill
Cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 828.00		
Disposal			
Disposal fee	$ 56.80	/ton	Reference L-1
Disposal cost	$ 12,609.60		Calculated
Total CPP Cost	**$ 290,937.60**		
Chemical Storage Building			
Dimensions			
Length	98	ft	TR Fig. 3.2-8
Width	50	ft	TR Fig. 3.2-8
Height	30	ft	Preliminary design
Volume	147,000	ft^3	Calculated
Demolition			
Demolition unit cost	$ 0.125	$/ft^3$	WDEQ/LQD Guideline 12, Appendix K (Ref. LQD-K), less 50% for lack of interior building walls per RSMeans 02 41 16.13.5000
Demolition cost	$ 18,375.00		
Transportation			
Unit building weight	15	lb/ft^2	ASCE 7-05
Building weight	37	tons	Calculated
Salvage %	60%		Conservatively assumes zero net salvage value
Weight of material to dispose	15	tons	Calculated
Density of construction debris	2,000	lb/yd^3	Typical of construction debris
Volume of material for disposal	15	yd^3	Calculated
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	1	trucks	Calculated
Distance to landfill	23	miles	Moorcroft landfill
Cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 69.00		
Disposal			
Disposal fee	$ 56.80	/ton	Reference L-1
Disposal cost	$ 834.96		Calculated
Total Chemical Storage Building Cost	**$ 19,278.96**		

Warehouse/Maintenance Building			
Dimensions			
Length	150	ft	TR Fig. 3.1-16
Width	100	ft	TR Fig. 3.1-16
Height	30	ft	Estimate
Volume	450,000	ft^3	Calculated
Demolition			
Demolition unit cost	$ 0.125	$\$/ft^3$	WDEQ/LQD Guideline 12, Appendix K (Ref. LQD-K), less 50% for lack of interior building walls per RSMeans 02 41 16.13.5000
Demolition cost	$ 56,250.00		
Transportation			
Unit building weight	15	lb/ft^2	ASCE 7-05
Building weight	113	tons	Calculated
Salvage %	60%		Conservatively assumes zero net salvage value
Weight of material to dispose	45	tons	Calculated
Density of construction debris	2,000	lb/yd^3	Typical of construction debris
Volume of material for disposal	45	yd^3	Calculated
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	3	trucks	Calculated
Distance to landfill	23	miles	Moorcroft landfill
Cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 207.00		
Disposal			
Disposal fee	$ 56.80	/ton	Reference L-1
Disposal cost	$ 2,556.00		Calculated
Total Warehouse/Maint. Bldg. Cost	**$ 59,013.00**		
Administration Building			
Dimensions			
Length	100	ft	TR Fig. 3.1-16
Width	100	ft	TR Fig. 3.1-16
Height	15	ft	Estimate
Volume	150,000	ft^3	Calculated
Demolition			
Demolition Unit Cost	$ 0.25	$\$/ft^3$	From WDEQ/LQD Guideline 12, Appendix K (Ref. LQD-K)
Demolition Cost	$ 37,350.00		
Transportation			
Unit building weight	15	lb/ft^2	ASCE 7-05
Building weight	75	tons	Calculated
Salvage %	25%		Conservatively assumes zero net salvage value
Weight of material to dispose	56	tons	Calculated
Density of construction debris	2,000	lb/yd^3	Typical of construction debris
Volume of material for disposal	56	yd^3	Calculated
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	3	trucks	Calculated
Distance to landfill	23	miles	Moorcroft landfill
Cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 207.00		
Disposal			
Disposal fee	$ 56.80	/ton	Reference L-1
Disposal cost	$ 3,195.00		Calculated
Total Administration Building Cost	**$ 40,752.00**		

Security Building			
Dimensions			
Length	20	ft	Preliminary design
Width	20	ft	Preliminary design
Height	12	ft	Estimate
Volume	4,800	ft^3	Calculated
Demolition			
Demolition Unit Cost	$ 0.25	$\$/ft^3$	Reference LQD-K
Demolition Cost	$ 1,195.20		
Transportation			
Unit building weight	15	lb/ft^2	ASCE 7-05
Building weight	3	tons	Calculated
Salvage %	25%		Conservatively assumes zero net salvage value
Weight of material to dispose	2	tons	Calculated
Density of construction debris	2,000	lb/yd^3	Typical of construction debris
Volume of material for disposal	2	yd^3	Calculated
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	1	trucks	Calculated
Distance to landfill	23	miles	Moorcroft landfill
Cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 69.00		
Disposal			
Disposal fee	$ 56.80	/ton	Reference L-1
Disposal cost	$ 127.80		Calculated
Total Security Building Cost	**$ 1,392.00**		
TOTAL BUILDING DEMOLITION/DISPOSAL COST	**$ 411,373.56**		

II. Equipment Removal/Disposal				
CPP	Quantity	Unit Volume	Volume	
Equipment List		(ft^3/unit)	(ft^3)	
Lab equipment	1	75	75	Estimate
Caustic soda tank	4	2,271	9,082	TR Figure 3.2-1
RO unit	4	1,389	5,556	TR Table 3.2-2
Restoration guard column	1	1,350	1,350	TR Table 3.2-2
Waste water (brine) tank	1	10,857	10,857	TR Table 3.2-2
Pumps	12	4	48	Estimate
Backwash tank	2	1,696	3,393	TR Table 3.2-2
De-sanding tank	3	1,696	5,089	TR Table 3.2-2
Thickener tank	2	26,179	52,358	TR Table 3.2-2
Uranium precipitation tank	10	942	9,425	TR Table 3.2-2
Vanadium precipitation tank	5	226	1,131	TR Table 3.2-2
Elution tank	6	2,375	14,250	TR Table 3.2-2
IX column	15	1,350	20,250	TR Table 3.2-2
Resin conditioning/resin water tank	2	2,036	4,072	TR Table 3.2-2
Resin screen	6	128	768	Preliminary CPP design from Lyntek
Yellowcake dryer	1	15,000	15,000	Estimate
Filter press	1	288	288	Preliminary CPP design from Lyntek
Wet scrubber	1	300	300	Preliminary CPP design from Lyntek
Vanadium dryer	1	15,000	15,000	Preliminary CPP design from Lyntek
Vanadium filter	1	300	300	Preliminary CPP design from Lyntek
		Total volume =	168,593	ft^3
		Total volume =	6,244	yd^3
Dismantling/Demolition/Decontamination				
Dismantling/demolition duration	90	days	Estimate	
Daily dismantling/demolition cost	$ 1,525.00	/day	RSMeans 2011, 02 42 10.20.9000, cost for hydraulic crane and crew	
Dismantling/demolition cost	$ 137,250.00			
Dismantled/demolished volume	3,122	yd^3	50% of total volume, estimate	
Decontamination unit cost	$ 31.00	/yd^3	From industry comparison	
Total Decontamination Cost	$ 96,782.00		Calculated	
Total Cost	$ 234,032.00			
Transportation				
Salvage percentage	50%		Estimate	
Salvage volume	1,561	yd^3	Assume no net salvage value	
Volume to landfill	1,171	yd^3	75% of demolished, non-salvaged volume, estimate	
Volume to 11e.(2) disposal site	390	yd^3	25% of demolished, non-salvaged volume, estimate	
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1	
Number of trucks to landfill	59	trucks	Calculated	
Distance to landfill	23	miles	To Moorcroft	
Number of trucks to 11e.(2) disposal site	20	trucks	Calculated	
Distance to 11e.(2) disposal site	235	miles	To Pathfinder Shirley Basin Facility	
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler	
Total transportation cost	$ 18,171.00			
Disposal				
Landfill disposal fee	$ 56.80	/ton	Reference L-1	
Equipment debris bulk density	2,000	lb/yd^3	Typical of construction debris	
Equipment weight	1,171	tons	Calculated	
Landfill cost	$ 66,498.60		Calculated	
11e.(2) disposal fee	$ 405.00	/yd^3	Industry comparison, $15/$ft^3$	
11e.(2) disposal cost	$ 158,051.25		Calculated	
Total disposal cost	$ 224,549.85		Calculated	
Total CPP Equipment Cost	$ 476,752.85			

Chemical Storage	Quantity	Unit Volume	Volume	
Equipment List		(ft^3/unit)	(ft^3)	
Sulfuric Acid	1	1,357	1,357	TR Table 3.2-2
Hydrogen Peroxide	1	1,357	1,357	TR Table 3.2-2
Ammonium Sulfate Mix	2	2,232	4,464	TR Table 3.2-2
Bicarbonate Mix	3	2,232	6,696	TR Table 3.2-2
Ammonia	1	419	419	TR Table 3.2-2
Carbon Dioxide	1	419	419	TR Table 3.2-2
Oxygen	2	419	838	Preliminary design from Lyntek
		Total Volume =	15,551	ft^3
		Total Volume =	576	yd^3
Dismantling/Demolition				
Dismantling/demolition duration	15	days	Estimate	
Daily dismantling/demolition cost	$ 1,525.00	/day	RSMeans 2011, 02 42 10.20.9000, cost for hydraulic crane and crew	
Dismantling/demolition cost	$ 22,875.00			
Dismantled/demolished volume	288	yd^3	50% of total volume, estimate	
Decontamination unit cost	$ 31.00	/yd^3	Industry comparison	
Total decontamination cost	$ 8,928.00		Calculated	
Total Demolition Cost	$ 31,803.00			
Transportation				
Salvage percentage	50%		Estimate	
Salvage volume	144	yd^3	Assume no net salvage value	
Volume to landfill	144	yd^3	100% of demolished, non-salvaged volume, estimate	
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1	
Number of trucks to landfill	8	trucks	Calculated	
Distance to landfill	23	miles	To Moorcroft	
Cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler	
Total Transportation Cost	$ 552.00			
Disposal				
Landfill disposal fee	$ 56.80	/ton	Reference L-1	
Equipment debris bulk density	2,000	lb/yd^3	Typical of construction debris	
Equipment weight	144	tons	Calculated	
Landfill cost	$ 8,179.20		Calculated	
Landfill disposal fee	$ 56.80	/yd^3	Reference L-1	
Total Disposal Cost	$ 16,358.40			
Total Chemical Storage Cost	$ 39,785.40			
Warehouse/Maintenance	$ -		Equipment costs included in building cost	
Administration Building	$ -		Equipment costs included in building cost	
Security	$ -		Equipment costs included in building cost	
TOTAL EQUIPMENT REMOVAL/DISPOSAL COST	**$ 516,538.25**			

III. Concrete Removal/Disposal			
CPP			
Dimensions			
Floor slab			
Length	370	ft	Refer to TR Fig. 3.2-1
Width	200	ft	Refer to TR Fig. 3.2-1
Thickness	0.5	ft	Estimate
Footers			
Length	1,140	ft	Building perimeter
Width	2	ft	Estimate
Thickness	3	ft	Estimate
Demolition			
Floor slab area	74,000	ft^2	Calculated
Floor slab demolition unit cost	$ 5.05	$/ft^2$	WDEQ/LQD Guideline 12 Appendix K (Ref. LQD-K)
Floor slab milling unit cost	$ 0.20	$/ft^2$	From RSMeans 2011, 32 01 16.71.5200
Floor slab demolition cost	$ 373,700.00		Calculated
Floor slab milling cost	$ 14,504.00		Calculated
Footer demolition unit cost	$ 18.14	/ft	WDEQ/LQD Guideline 12 Appendix K (Ref. LQD-K)
Footer demolition cost	$ 20,679.60		
Total demolition cost	$ 408,883.60		
Transportation			
Volume to landfill	1,933	yd^3	Volume of footer plus 90% of floor slab, estimate; includes 30% swell factor for void space
Volume to 11e.(2) disposal site	178	yd^3	10% of floor slab volume, estimate; includes 30% swell factor for void space
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	97	trucks	Calculated
Distance to landfill	23	miles	Moorcroft
Number of trucks to 11e.(2) disposal site	9	trucks	Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total transportation cost	$ 13,038.00		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of concrete	100	lb/ft^3	Estimate for demolished concrete
Landfill cost	$ 148,222.44		
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3$
11e.(2) disposal cost	$ 72,150.00		
Total Disposal Cost	$ 220,372.44		
Total CPP Concrete Cost	$ 642,294.04		

Chemical Storage Area			
Dimensions			
Floor slab			
Length	98	ft	TR Figure 3.2-8
Width	50	ft	TR Figure 3.2-8
Thickness	0.5	ft	Estimate
Curb			
Length	296	ft	TR Figure 3.2-8
Height	4	ft	TR Figure 3.2-8
Thickness	1	ft	TR Figure 3.2-8
Curb area	1,184	ft^2	Calculated
Demolition			
Floor slab/curb area	6,084	ft^2	Calculated
Floor slab/curb demolition unit cost	$ 5.05	$/ft^2$	WDEQ/LQD Guideline 12 Appendix K (Ref. LQD-K)
Floor slab milling unit cost	$ -	$/ft^2$	No radiological contamination
Floor slab demolition cost	$ 30,724.20		
Floor slab milling cost	$ -		No radiological contamination
Total Demolition Cost	$ 30,724.20		
Transportation			
Volume to landfill	175	yd^3	Volume of slab/curb; includes 30% swell factor for void space
Volume to 11e.(2) disposal site	0.0	yd^3	No contamination
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	9	trucks	Calculated
Distance to Landfill	0	trucks	Calculated
Number of trucks to 11e.(2) disposal site	23	miles	Moorcroft
Distance to 11e.(2) Disposal Site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total transportation cost	$ 621.00		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of concrete	100	lb/ft^3	Estimate for demolished concrete
Landfill cost	$ 13,416.73		
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3
11e.(2) disposal cost	$ -		
Total Chemical Storage Concrete Cost	$ 31,345.20		

Warehouse/Maintenance/Admin Building			
Dimensions			
Floor slab			
Length	250	ft	TR Figure 3.1-16
Width	100	ft	TR Figure 3.1-16
Thickness	0.33	ft	Estimate 4" slab
Footers			
Length	700	ft	Perimeter length
Width	2	ft	Estimate
Thickness	3	ft	Estimate
Demolition			
Floor slab area	25,000	ft^2	Calculated
Floor slab demolition unit cost	$ 5.05	$/ft^2$	WDEQ/LQD Guideline 12 Appendix K (Ref. LQD-K)
Floor slab milling unit cost	$ -	$/ft^2$	No radiological contamination
Floor slab demolition cost	$ 126,250.00		Calculated
Floor slab milling cost	$ -		Calculated
Footer demolition unit cost	$ 18.14	/ft	WDEQ/LQD Guideline 12 Appendix K (Ref. LQD-K)
Footer demolition cost	$ 12,698.00		
Total demolition cost	$ 138,948.00		
Transportation			
Volume to landfill	603	yd^3	Volume of footer plus floor slab; includes 30% swell factor for void space
Volume to 11e.(2) disposal site	0	yd^3	10% of floor slab volume, estimate; includes 30% swell factor for void space
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	31	trucks	Calculated
Distance to landfill	23	miles	Moorcroft
Number of trucks to 11e.(2) disposal site	0	trucks	No radiological contamination
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total transportation cost	$ 2,139.00		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of concrete	100	lb/ft^3	Estimate for demolished concrete
Landfill cost	$ 46,238.04		
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3
11e.(2) disposal cost	$ -		
Total Disposal Cost	$ 46,238.04		
Total Warehouse/Maintenance/ Admin. Building Concrete Cost	$ 187,325.04		
TOTAL CONCRETE COST	**$ 860,964.28**		

IV. Pond Removal/Disposal			
Liner Demolition/Disposal			
GSE Fabrinet Geocomposite Liner (used for leak detection)			
Demolition			
Surface area	640,407	ft^2	Preliminary lined retention pond design
Liner demolition unit cost	$ 0.11	$\$/ft^2$	10% of the installation cost of HDPE liner; RSMeans 2011 33 47 13.53.1100
Total Liner Demolition Cost	$ 70,444.77		Calculated
Thickness	220	mil	Mfr. Specifications
Volume	435	yd^3	Calculated
Liner swell factor	50%		Estimate
Liner disposal volume	652	yd^3	Calculated
Transportation			
Volume of material	652	yd^3	
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	33	trucks	Calculated
Distance to landfill	23	miles	To Moorcroft; no radiological contamination since this is a secondary liner
Transportation cost	$ 3.00	$/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 2,277.00		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of demolished liner	9	lb/ft^3	Calculated from mass per unit area of 0.162 lb/ft^2 and volume
Total Disposal Cost	$ 3,000.95		
Total Geocomposite Liner Cost	$ 75,722.72		
HDPE Liner (primary liner)			
Demolition			
Surface area	640,407	ft^2	Preliminary lined retention pond design
Liner demolition unit cost	$ 0.11	$\$/ft^2$	10% of the installation cost of HDPE liner; RSMeans 2011 33 47 13.53.1100
Total Liner Demolition Cost	$ 70,444.77		Calculated
Thickness	36	mil	Preliminary lined retention pond design
Volume	71	yd^3	Calculated
Liner swell factor	50%		Estimate
Liner disposal volume	107	yd^3	Calculated
Transportation			
Volume of material	107	yd^3	
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	6	trucks	Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	$/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 4,230.00		
Disposal			
11e.(2) disposal fee	$ 405.00	$\$/yd^3$	Industry comparison, $\$15/ft^3$
Disposal cost	$ 43,227.47		
Total Primary Liner Cost	$ 117,902.24		

HDPE Liner (secondary liner)			
Demolition			
Surface area	640,407	ft^2	Preliminary lined retention pond design
Liner demolition unit cost	$ 0.055	$\$/ft^2$	10% of the installation cost of HDPE liner; RSMeans 2011 33 47 13.53.1100; halved due to demolition concurrent with geocomposite liner
Total Liner Demolition Cost	$ 35,222.39		Calculated
Thickness	36	mil	Preliminary lined retention pond design
Volume	71	yd^3	Calculated
Liner swell factor	50%		Estimate
Liner disposal volume	107	yd^3	Calculated
Transportation			
Volume of material	107	yd^3	
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	6	trucks	Calculated
Distance to landfill	23	miles	To Moorcroft; no radiological contamination since this is a secondary liner
Transportation cost	$ 3.00	$/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 414.00		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of demolished liner	59	lb/ft^3	Calculated from mass per unit area of 0.176 lb/ft^2 and volume
Total Disposal Cost	$ 3,219.20		
Total Secondary Liner Cost	$ 38,855.58		
Total Liner Demolition/Disposal Cost	**$ 232,480.54**		

Leak Detection Pipes			
Demolition			
Pipe length	5,172	ft	Preliminary lined retention pond design
Pipe size	4	in	Preliminary lined retention pond design
Outside diameter	4.5	in	Assume SCH 40 PVC
Demolition unit cost	$ 2.02	/ft	RSMeans 2011, 02 41 13.38.1600
Total Demolition Cost	$ 10,447.44		Calculated
Volume	571	ft^3	Calculated
Chipped volume reduction	50	%	Estimate based on use of chipper/shredder
Chipped volume	286	ft^3	Calculated
Transportation			
Volume of material	11	yd^3	
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	1	truck	Calculated
Distance to landfill	23	miles	To Moorcroft
Cost per mile	$ 3.00	$/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 69.00		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of chipped pipe	36	lb/ft^3	Calculated from mass per unit length of 2 lb/ft and disposal volume
Total Disposal Cost	$ 292.01		
Total Leak Detection Pipe Demolition/Disposal Cost	**$ 10,808.45**		
Leak Detection Sand	$ -		Accounted for in earthwork cost
Clay Liner	$ -		Accounted for in earthwork cost
TOTAL POND COST	**$ 243,288.99**		

V. Earthwork			
Asphalt			
Area			
Parking lot	1.03	ac	TR Figure 3.1-16
Central plant area	3.93	ac	Preliminary site design
Primary access road	0.00	ac	Gravel surface
Demolition			
Area	5.0	ac	Calculated
Asphalt ripping cost	$ 702.87	/ac	WDEQ/LQD Guideline 12, Appendix I (Ref. LQD-I)
Asphalt ripping cost	$ 3,514.35		
Pulverizing; prep for recycling	$ 3.83	$/yd^2$	RSMeans 2011, 32 01 16.73.5040
Pulverizing; prep for recycling	$ 92,686.00		
Total Asphalt Demolition/Recycling Cost	$ 96,200.35		Assumes pulverized asphalt will be made available to county at no net cost or salvage value
Total Asphalt Cost	**$ 96,200.35**		
Regrading			
Backfill			
Volume	148,088	yd^3	Volume is 50% of total cut/fill difference calculated between pre and post mine modeled surfaces
Unit cost	$ 0.913	$/yd^3$	WDEQ/LQD Guideline 12, Appendix C, level ground, 500 ft distance (Ref. LQD-C)
Total cost	$ 135,204.34		
Topsoil			
Volume	133,455	yd^3	Volume is from facilities disturbed area x 2' of topsoil
Unit Cost	$ 0.913	$/yd^3$	WDEQ/LQD Guideline 12, Appendix C, level ground, 500 ft distance (Ref. LQD-C)
Total Cost	$ 121,844.42		
Final Regrading			
Area	55	ac	ER Table 4.1-1
Unit Cost	$ 68.61	/ac	WDEQ/LQD Guideline 12, Appendix G (Ref. LQD-G)
Total Cost	$ 3,773.55		
Total Regrading Cost	**$ 260,822.31**		
Containment Barrier Wall Reclamation			
Reclamation cost	$ 7,650.00		RSMeans 2011, 31 23 16.13.6392; 4 day reclamation period
Gravel for finger drains	$ 2,000.00		Estimate
Total CBW Reclamation Cost	**$ 9,650.00**		
TOTAL EARTHWORK COST	**$ 366,672.66**		

Attachment RAP-2(C)
Costs for ISR Wellfield
Equipment Removal and Disposal

III. WELLFIELD EQUIPMENT REMOVAL AND DISPOSAL SUMMARY **WF-1**

	Item	Cost	
I.	Wellfield Piping	$	1,480,069.23
II.	Module Buildings	$	80,643.90
III.	Valve Manholes	$	53,560.40
IV.	Wellheads	$	14,910.00
V.	Access Roads	$	24,239.74
	Total Wellfield Cost	**$**	**1,653,423.27**

I. Wellfield Piping			
Production Trunklines			
Pipe Data			
Total length of recovery trunklines	5,400	ft	From preliminary site layout
Total length of injection trunklines	5,400	ft	From preliminary site layout
Total production trunkline length	10,800	ft	Calculated
Outside diameter	24	in	24" SDR 11 HDPE
Wall thickness	2.18	in	PPI Design Handbook for PE Pipe
Unit weight	65.2	lb/ft	PPI Design Handbook for PE Pipe
Pipe material volume	11,207.9	ft^3	Calculated
Chipped/shredded volume	16,811.8	ft^3	Estimated as 1.5 x pipe material volume
Bulk weight	42.0	lb/ft^3	Calculated
Volume per truck load	540	ft^3	ER Section 4.13.1.1.2.1
Total number of truck loads	32		Calculated
Removal			
Unit cost of removal	$ 9.33	/ft	RSMeans 2011; 02 41 13.38.1900, 31 23 16.13.0120 and 31 23 16.13.3080; excavation and backfill cost reduced by 50% to account for common trenches
Total cost of removal	$ 100,764.00		
Transport and Disposal			
Landfill - Transportation			
Percent to be shipped	50%		0% of recovery trunklines; 100% of injection trunklines
Loads to landfill	16		Calculated
Distance to landfill	23	miles	Distance to Moorcroft
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 1,104.00		Calculated
Landfill - Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Chipped pipe bulk density	42	lb/ft^3	See calculation above
Chipped pipe weight	176.5	tons	Calculated
Landfill disposal cost	$ 10,026.54		Calculated
Total Landfill Cost	$ 11,130.54		
11e.(2) Disposal Site			
11e.(2) - Transportation			
Percent to be shipped	50%		100% of recovery trunklines; 0% of injection trunklines
Loads to 11e.(2) disposal site	16		Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 11,280.00		Calculated
11e.(2) - Disposal			
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3
11e.(2) disposal cost	$ 126,088.33		See calculation above
Total 11e.(2) Disposal Cost	$ 137,368.33		
Total Transportation and Disposal Cost	$ 148,498.88		
Total Production Trunkline Cost	**$ 249,262.88**		

Restoration Trunklines			
Pipe Data			
Total length of recovery trunklines	5,400	ft	From preliminary site layout
Total length of injection trunklines	5,400	ft	From preliminary site layout
Total restoration trunkline length	10,800	ft	Calculated
Outside diameter	12.75	in	12" SDR 11 HDPE
Wall thickness	1.16	in	PPI Design Handbook for PE Pipe
Unit weight	18.4	lb/ft	PPI Design Handbook for PE Pipe
Pipe material volume	3,167.8	ft^3	Calculated
Chipped/shredded volume	4,751.6	ft^3	Estimated as 1.5 x pipe material volume
Bulk weight	42.0	lb/ft^3	Calculated
Volume per truck load	540	ft^3	ER Section 4.13.1.1.2.1
Total number of truck loads	9		Calculated
Removal			
Unit cost of removal	$ 6.99	/ft	RSMeans 2011; 02 41 13.38.1800, 31 23 16.13.0120 and 31 23 16.13.3080; excavation and backfill cost reduced by 50% to account for common trenches
Total cost of removal	$ 75,492.00		
Transport and Disposal			
Landfill - Transportation			
Percent to be shipped	50%		0% of recovery trunklines; 100% of injection trunklines
Loads to landfill	5		Calculated
Distance to landfill	23	miles	Distance to Moorcroft
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 310.50		Calculated
Landfill - Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Chipped pipe bulk density	42	lb/ft^3	See calculation above
Chipped pipe weight	49.9	tons	Calculated
Landfill disposal cost	$ 2,833.88		Calculated
Total Landfill Cost	$ 3,144.38		
11e.(2) Disposal Site			
11e.(2) - Transportation			
Percent to be shipped	50%		100% of recovery trunklines; 0% of injection trunklines
Loads to 11e.(2) disposal site	5		Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 3,172.50		Calculated
11e.(2) - Disposal			
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3
11e.(2) disposal cost	$ 35,637.32		See calculation above
Total 11e.(2) Disposal Cost	$ 38,809.82		
Total Transportation and Disposal Cost	$ 41,954.20		
Total Restoration Trunkline Cost	**$ 117,446.20**		

Module Feeder Lines			
Pipe Data			
Total length of recovery feeder lines	4,500	ft	Estimate 900' per module
Total length of injection feeder lines	4,500	ft	Estimate 900' per module
Total feeder line length	9,000	ft	Calculated
Outside diameter	8.625	in	8" SDR 11 HDPE
Wall thickness	0.78	in	PPI Design Handbook for PE Pipe
Unit weight	8.43	lb/ft	PPI Design Handbook for PE Pipe
Pipe material volume	1,201.5	ft^3	Calculated
Chipped/shredded volume	1,802.2	ft^3	Estimated as 1.5 x pipe material volume
Bulk weight	42.0	lb/ft^3	Calculated
Volume per truck load	540	ft^3	ER Section 4.13.1.1.2.1
Total number of truck loads	4		Calculated
Removal			
Unit cost of removal	$ 5.10	/ft	RSMeans 2011; 02 41 13.38.1700, 31 23 16.13.0120 and 31 23 16.13.3080; excavation and backfill cost reduced by 50% to account for common trenches
Total cost of removal	$ 45,900.00		
Transport and Disposal			
Landfill - Transportation			
Percent to be shipped	50%		0% of recovery feeder lines; 100% of injection feeder lines
Loads to landfill	2		Calculated
Distance to landfill	23	miles	Distance to Moorcroft
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 138.00		Calculated
Landfill - Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Chipped pipe bulk density	42	lb/ft^3	See calculation above
Chipped pipe weight	18.9	tons	Calculated
Landfill disposal cost	$ 1,074.85		Calculated
Total Landfill Cost	$ 1,212.85		
11e.(2) Disposal Site			
11e.(2) - Transportation			
Percent to be shipped	50%		100% of recovery feeder; 0% of injection feeder lines
Loads to 11e.(2) disposal site	2		Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 1,410.00		Calculated
11e.(2) - Disposal			
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3
11e.(2) disposal cost	$ 13,516.68		See calculation above
Total 11e.(2) Disposal Cost	$ 14,926.68		
Total Transportation and Disposal Cost	$ 16,139.52		
Total Feeder Line Cost	**$ 62,039.52**		

Individual Well Flow Lines			
Pipe Data			
Total length of recovery flow lines	90,000	feet	36 recovery wells x 500' per well
Total length of injection flow lines	135,000	feet	54 injection wells x 500' per well
Total well flow line length	225,000	feet	Calculated
Outside diameter	2.375	inches	2" SDR 11 HDPE
Wall thickness	0.216	inches	PPI Design Handbook for PE Pipe
Unit weight	0.64	lb/ft	PPI Design Handbook for PE Pipe
Pipe material volume	2,289.2	ft^3	Calculated
Chipped/shredded volume	3,433.7	ft^3	Estimated as 1.5 x pipe material volume
Bulk weight	42.0	lb/ft^3	Calculated
Volume per truck load	540	ft^3	ER Section 4.13.1.1.2.1
Total number of truck loads	7		Calculated
Removal			
Unit cost of removal	$ 3.16	/ft	RSMeans 2011; 02 41 13.38.1600, 31 23 16.13.0120 and 31 23 16.13.3080; excavation and backfill cost reduced by 75% to account for common trenches
Total cost of removal	$ 711,000.00		
Transport and Disposal			
Landfill - Transportation			
Percent to be shipped	50%		0% of recovery flow lines; 100% of injection flow lines
Loads to landfill	4		Calculated
Distance to landfill	23	miles	Distance to Moorcroft
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 241.50		Calculated
Landfill - Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Chipped pipe bulk density	42	lb/ft^3	See calculation above
Chipped pipe weight	36.1	tons	Calculated
Landfill disposal cost	$ 2,047.88		Calculated
Total Landfill Cost	$ 2,289.38		
11e.(2) Disposal Site			
11e.(2) - Transportation			
Percent to be shipped	50%		100% of recovery flow lines; 0% of injection flow lines
Loads to 11e.(2) disposal site	4		Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 2,467.50		Calculated
11e.(2) - Disposal			
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $\$15/ft^3$
11e.(2) disposal cost	$ 25,753.06		See calculation above
Total 11e.(2) Disposal Cost	$ 28,220.56		
Total Transportation and Disposal Cost	$ 30,509.94		
Total Individual Well Flow Line Cost	**$ 741,509.94**		

Downhole Well Pipe, Pumps and Electrical Wire			
Pipe Data			
Total length of recovery pipes	90,000	ft	36 recovery wells x 500' per well x 5 modules
Total length of injection pipes	135,000	ft	54 injection wells x 500' per well x 5 modules
Total downhole pipe length	225,000	ft	Calculated
Outside diameter	2.375	in	2" SDR 11 HDPE
Wall thickness	0.216	in	PPI Design Handbook for PE Pipe
Unit weight	0.64	lb/ft	PPI Design Handbook for PE Pipe
Pipe material volume	2,289.2	ft^3	Calculated
Chipped/shredded volume	3,433.7	ft^3	Estimated as 1.5 x pipe material volume
Bulk weight	42.0	lb/ft^3	Calculated
Volume per truck load	540	ft^3	ER Section 4.13.1.1.2.1
Total number of truck loads	7		Calculated
Electrical Wire and Pump Data			
Length of downhole wire	90,000	ft	Same as recovery well downhole pipe
Unit volume	0.002	ft^3/ft	Estimate
Volume of downhole wire	180	ft^3	
Number of pumps	180	pumps	36 recovery wells x 5 modules
Unit volume	0.5	ft^3/ea	Estimate
Volume of pumps	90	ft^3	
Volume per truck load	540	ft^3	ER Section 4.13.1.1.2.1
Total number of truck loads	1		Calculated
Downhole Pipe and Pump Removal			
Unit cost of removal	$ 1.01	/ft	RSMeans 2011; 02 41 13.38.1600; reduced by 50% due to ease of removal
Total cost of removal	$ 227,250.00		
Transport and Disposal			
Landfill - Transportation			
Percent to be shipped	50%		0% of recovery pipes; 100% of injection pipes
Loads to landfill	4		Calculated
Distance to landfill	23	miles	Distance to Moorcroft
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 276.00		Calculated
Landfill - Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Chipped pipe bulk density	42	lb/ft^3	See calculation above
Chipped pipe weight	36.1	tons	Calculated
Pump and wire bulk density	2,000	lb/ft^3	Typical for construction debris
Pump and wire weight	10.0	tons	Calculated
Landfill disposal cost	$ 4,095.77		Calculated
Total Landfill Cost	$ 4,371.77		
11e.(2) Disposal Site			
11e.(2) - Transportation			
Percent to be shipped	50%		100% of recovery pipes; 0% of injection pipes
Loads to 11e.(2) disposal site	4		Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 2,820.00		Calculated
11e.(2) - Disposal			
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $\$15/ft^3$
11e.(2) disposal cost	$ 27,778.06		
Total 11e.(2) Disposal Cost	$ 30,598.06		
Total Transportation and Disposal Cost	$ 34,969.82		
Total Downhole Well Pipe Cost	**$ 262,219.82**		

Deep Disposal Well Pipe			
Pipe Data			
Total length of pipeline	9,155	ft	From preliminary site layout
Outside diameter	4.50	in	4" SDR 11 HDPE
Wall thickness	0.409	in	PPI Design Handbook for PE Pipe
Unit weight	2.29	lb/ft	PPI Design Handbook for PE Pipe
Pipe material volume	334.2	ft^3	Calculated
Chipped/shredded volume	501.3	ft^3	Estimated as 1.5 x pipe material volume
Bulk weight	42.0	lb/ft^3	Calculated
Volume per truck load	540	ft^3	ER Section 4.13.1.1.2.1
Total number of truck loads	1		Calculated
Removal			
Unit cost of removal	$ 4.30	/ft	RSMeans 2011; 02 41 13.38.1600, 31 23 16.13.0120 and 31 23 16.13.3080; excavation and backfill cost reduced by 50% to account for common trenches
Total cost of removal	$ 39,366.50		
Transport and Disposal			
Landfill - Transportation			
Percent to be shipped	0%		100% 11e.(2) byproduct material
Loads to landfill	0		Calculated
Distance to landfill	23	miles	Distance to Moorcroft
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ -		Calculated
Landfill - Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Chipped pipe bulk density	42	lb/ft^3	See calculation above
Chipped pipe weight	0.0	tons	Calculated
Landfill disposal cost	$ -		Calculated
Total Landfill Cost	$ -		
11e.(2) Disposal Site			
11e.(2) - Transportation			
Percent to be shipped	100%		100% 11e.(2) byproduct material
Loads to 11e.(2) disposal site	1		Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 705.00		Calculated
11e.(2) - Disposal			
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $\$15/ft^3$
11e.(2) disposal cost	$ 7,519.36		See calculation above
Total 11e.(2) Disposal Cost	$ 8,224.36		
Total Transportation and Disposal Cost	$ 8,224.36		
Total Deep Disposal Well Pipeline Cost	**$ 47,590.86**		
TOTAL WELLFIELD PIPING COST	**$ 1,480,069.23**		

II. Module Buildings			
Building Demolition - Excludes Foundation			
Length	40	ft	TR Section 3.1.4
Width	15	ft	TR Section 3.1.4
Height	9	ft	TR Section 3.1.4
Volume	5,400	ft^3	Calculated
Demolition			
Demolition Unit Cost	$ 0.125	$/ft^3$	From WDEQ/LQD Guideline 12, Appendix K (Ref. LQD-K), less 50% for lack of interior building walls per RSMeans 02 41 16.13.5000
Demolition Cost	$ 675.00		
Transportation			
Unit building weight	15	lb/ft^2	ASCE 7-05
Building weight	5	tons	Calculated
Salvage %	50%		Conservatively assumes zero net salvage value
Weight of material to dispose	2	tons	Calculated
Density of construction debris	2,000	lb/yd^3	Typical of construction debris
Volume of material for disposal	2	yd^3	Calculated
Volume per truck	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks	1	trucks	Calculated
Distance to landfill	23	miles	Moorcroft landfill
Cost per mile	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 69.00		
Disposal			
Disposal fee	$ 56.80	/ton	Reference L-1
Disposal cost	$ 127.80		Calculated
Total Building Demolition Cost	**$ 871.80**		
Concrete Demolition and Disposal			
Dimensions			
Base			
Length	40	ft	TR Section 3.1.4
Width	15	ft	TR Section 3.1.4
Thickness	0.5	ft	Estimate
Walls			
Length	110	ft	Perimeter length
Height	6	ft	TR Figure 3.1-9
Thickness	0.5	ft	Estimate
Demolition			
Base/wall area	1,260	ft^2	Calculated
Concrete demolition unit cost	$ 5.05	$/ft^2$	WDEQ/LQD Guideline 12 Appendix K (Ref. LQD-K)
Concrete demolition cost	$ 6,363.00		
Transportation			
Volume to landfill	15.2	yd^3	50% of volume of slab/walls; includes 30% swell factor for void space
Volume to 11e.(2) disposal site	15.2	yd^3	50% of volume of slab/walls; includes 30% swell factor for void space
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	1	trucks	Calculated
Distance to landfill	23	miles	Moorcroft
Number of trucks to 11e.(2) disposal site	1	trucks	Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$708.00		

Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of concrete	100	lb/ft^3	Estimate for demolished concrete
Landfill cost	$ 1,162.98		
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $\$15/ft^3$
11e.(2) disposal cost	$ 6,142.50		
Total Disposal Cost	$ 7,305.48		
Total Concrete Cost	**$ 14,376.48**		
Piping and Equipment Disposal			
Quantity			
Volume	2	yd^3	Conservatively high estimate
Demolition			
Unit cost	$ -	$/ft^3$	Included in building demolition cost
Transportation			
Volume to landfill	0.0	yd^3	100% disposed as 11e.(2) byproduct material
Volume to 11e.(2) disposal site	2.0	yd^3	100% disposed as 11e.(2) byproduct material
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	0.0	trucks	Calculated
Distance to landfill	23	miles	Moorcroft
Number of trucks to 11e.(2) disposal site	0.10	trucks	Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$ 70.50		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of equipment	2,000	lb/ft^3	Estimate
Landfill cost	$ -		
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $\$15/ft^3$
11e.(2) disposal cost	$ 810.00		
Total Disposal Cost	$ 810.00		
Total Piping and Equipment Cost	**$ 880.50**		
Total Cost per Module	**$ 16,128.78**		
Number of Modules	**5**		
Total Module Building Cost	**$ 80,643.90**		
III. Valve Manholes			
Concrete Demolition and Disposal			
Dimensions			
Base			
Length	12	ft	Preliminary design
Width	8	ft	Preliminary design
Thickness	0.5	ft	Preliminary design
Top			
Length	12	ft	Preliminary design
Width	8	ft	Preliminary design
Thickness	0.67	ft	Preliminary design
Walls			
Length	40	ft	Perimeter length
Height	6	ft	TR Figure 3.1-10
Thickness	0.5	ft	Estimate
Demolition			
Base/top/wall area	432	ft^2	Calculated
Concrete demolition unit cost	$ 5.05	$/ft^2$	WDEQ/LQD Guideline 12 Appendix K (Ref. LQD-K)
Concrete demolition cost	$ 2,181.60		

Transportation			
Volume to landfill	4.4	yd^3	50% of volume of slab/walls; includes 30% swell factor for void space
Volume to 11e.(2) disposal site	4.4	yd^3	50% of volume of slab/walls; includes 30% swell factor for void space
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	0.22	trucks	Calculated
Distance to landfill	23	miles	Moorcroft
Number of trucks to 11e.(2) disposal site	0.22	trucks	Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$156.56		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of concrete	100	lb/ft^3	Estimate for demolished concrete
Landfill cost	$ 340.25		
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3
11e.(2) disposal cost	$ 1,797.12		
Total Disposal Cost	$ 2,137.37		
Total Concrete Cost	**$ 4,475.54**		
Piping and Equipment Disposal			
Quantity			
Volume	2	yd^3	Conservatively high estimate
Demolition			
Unit cost	$ -	$/ft^3$	Included in valve manhole demolition cost
Transportation			
Volume to landfill	0.0	yd^3	100% disposed as 11e.(2) byproduct material
Volume to 11e.(2) disposal site	2.0	yd^3	100% disposed as 11e.(2) byproduct material
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	0.0	trucks	Calculated
Distance to landfill	23	miles	Moorcroft
Number of trucks to 11e.(2) disposal site	0.10	trucks	Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$70.50		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of equipment	2,000	lb/ft^3	Estimate
Landfill cost	$ -		
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3
11e.(2) disposal cost	$ 810.00		
Total Disposal Cost	$ 810.00		
Total Piping and Equipment Cost	**$ 880.50**		
Total Cost per Valve Manhole	**$ 5,356.04**		
Number of Valve Manholes	**10**		
Total Valve Manhole Cost	**$ 53,560.40**		

IV. Wellheads			
Recovery and Injection Wellheads			
Wellhead Data			
Number of injection/recovery wellheads	450		36 recovery wells and 54 injection wells per module, 5 modules
Weight of equipment per wellhead	200	lb	Estimate
Bulk density of wellhead equipment	100	lb/ft^3	Estimate
Weight of equipment for disposal	45	tons	
Volume of equipment for disposal	33	yd^3	
Transportation			
Volume to landfill	0.0	yd^3	100% disposed as 11e.(2) byproduct material
Volume to 11e.(2) disposal site	33.3	yd^3	100% disposed as 11e.(2) byproduct material
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	0.0	trucks	Calculated
Distance to landfill	23	miles	Moorcroft
Number of trucks to 11e.(2) disposal site	2	trucks	Calculated
Distance to 11e.(2) disposal site	235	miles	Pathfinder Shirley Basin Facility
Transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Total Transportation Cost	$1,410.00		
Disposal			
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of equipment	100	lb/ft^3	Estimate
Landfill cost	$ -		
11e.(2) disposal fee	$ 405.00	$/yd^3$	Industry comparison, $15/ft^3$
11e.(2) disposal cost	$ 13,500.00		
Total Disposal Cost	$ 13,500.00		
Total Wellhead Cost	**$ 14,910.00**		

V. Roads			
Access Roads			
Gravel Removal			
Length of primary access road	1,320	ft	Preliminary site layout
Width of primary access road	32	ft	ER Section 4.2.1.1
Area of primary access road	1.0	ac	Calculated
Length of secondary access roads	10,000	ft	Preliminary site layout
Width of secondary access roads	16	ft	ER Section 4.1.1.1.1
Area of secondary access roads	3.7	ac	Calculated
Gravel thickness	1.0	ft	Estimate
Gravel volume	7,490	yd^3	Calculated
Blade grading unit cost	$ 68.61	/ac	WDEQ/LQD Guideline 12, Appendix G (Ref. LQD-G)
Blade grading cost	$ 320.62		
Scraper hauling unit cost	$ 1.41	/cy	WDEQ/LQD Guideline 12, Appendix C, level grade, 2,000 ft haul (Ref. LQD-C)
Scraper hauling cost	$ 10,561.42		
Gravel disposal	$ -		Assumes gravel will be made available to county at no net cost or salvage value
Gravel Removal Cost	$ 10,882.04		
Earthwork			
Area Required	0.0	ac	Cost included in Earthwork Costs
Revegetation Cost	$ -		
Scarification			
Area of graveled access roads	3.7	ac	See above
Scarification unit cost	$ 62.93	/ac	WDEQ/LQD Guideline 12, Appendix P (Ref. LQD-P)
Scarification Cost	$ 231.15		
Topsoil Replacement			
Topsoil volume	11,851.9	yd^3	Assumes 2' thickness
Topsoil replacement unit cost	$ 1.09	$/yd^3$	WDEQ/LQD Guideline 12, Appendix C, level grade, 1,000 ft haul (Ref. LQD-C)
Topsoil Replacement Cost	$ 12,918.52		
Revegetation			
Area Required	0.0	ac	Cost included in Revegetation Costs
Revegetation Cost	$ -		
Total Graveled Road Reclamation Cost	**$ 24,031.71**		
Tertiary Roads			
Scarification			
Length of tertiary access roads	18,000	ft	Preliminary site layout
Width of tertiary access roads	8	ft	ER Section 4.1.1.1.1
Area of tertiary access roads	3.3	ac	Calculated
Scarification unit cost	$ 62.93	/ac	WDEQ/LQD Guideline 12, Appendix P (Ref. LQD-P)
Scarification Cost	$ 208.03		
Revegetation			
Area Required	0.0	ac	Cost included in Revegetation Costs
Revegetation Cost	$ -		
Total Tertiary Road Reclamation Cost	**$ 208.03**		
Total Access Road Reclamation Cost	**$ 24,239.74**		
TOTAL WELLFIELD EQUIPMENT REMOVAL AND DISPOSAL	**$ 1,653,423.27**		

Attachment RAP-2(D)
Costs for Well Abandonment

Recovery, Injection and Monitor Wells			
Assumptions			
Number of wells	612	wells	Refer to AR-2
Average depth	500	ft	Refer to AR-2
Diameter	5	in	Refer to TR Section 3.1.2.1
Materials per Well			
Volume of cement required	68.2	ft^3/well	Calculated
Cement Sacks Required per Well	58.2		Based on actual quantities used during exploration drill hole plugging
Cement Sack Cost	$ 11.65		Based on actual prices during exploration drill hole plugging
Cement Cost per Well	$ 678.03		Calculated
Bentonite Sacks Required per Well	4.4		Based on actual quantities used during exploration drill hole plugging
Bentonite Bag Cost	$ 7.40		Based on actual prices during exploration drill hole plugging
Bentonite Cost per Well	$ 32.56		Calculated
Total Materials Cost Per Well	$ 710.59		
Equipment Rental			
Hours required per well	2.5	hours	Based on actual quantities used during exploration drill hole plugging
Backhoe cost per hour	$ 85.00		Based on actual prices during exploration drill hole plugging
Cementer cost per hole	$ 250.00		Based on actual prices during exploration drill hole plugging
Total Equipment Cost Per Well	$ 462.50		
Total Cost to Plug & Abandon Recovery, Injection & Monitor Wells	**$ 717,931.08**		
Deep Disposal Wells			
Assumptions			
Number of wells	3	wells	3 wells planned for first 5 modules
Cost per well	$ 104,110.00	/well	TR Addendum 4.2-A Table 15
Total Deep Disposal Well Cost	**$ 312,330.00**		
TOTAL WELL ABANDONMENT COST	**$ 1,030,261.08**		

Notes:
1. These values assume that all wells have passed the most recent MIT
2. Screens will be left in place

Attachment RAP-2(E)
Costs for Radiological Surveys

Gamma Survey			
Area required	71.5	ac	Based on anticipated disturbed wellfield area (28.5 acres) and CPP area (43 acres)
Survey cost per acre	$ 205.00	/ac	Based on pre-application baseline survey
Total Gamma Survey Cost	$ 14,657.50		
Soil Samples			
Number of samples required	20	samples	Assume 8 in central plant area and 12 in wellfield
Cost per sample	$ 660.00	/sample	Based on pre-application soil sampling
Total Soil Sampling Cost	$ 13,200.00		
Equipment & Building Smear Samples			
Number of samples required	100	samples	Estimate
Cost per sample	$ 100.00	/sample	Estimate
Total Smear Sample Cost	$ 10,000.00		
TOTAL RADIOLOGICAL SURVEY COST	**$ 37,857.50**		

Attachment RAP-2(F)
Costs for Revegetation

VI. REVEGETATION **VEG-1**

Area Require	110	ac	ER Table 4.1-1
Cost per Acr	$ 600.00		Based on previous experience on an industrial ash landfill in northeastern Wyoming
Total Revegetation Cost	**$ 66,000.00**		

Attachment RAP-2(G)
Costs for Miscellaneous Reclamation Activities

I. Fence Removal			
Chainlink Security Fence			
Length around central plant area	6,117	ft	From preliminary site layout
Length around 11e.(2) Byproduct Storage Ar	2,500	ft	From preliminary site layout
Total chainlink security fence	8,617		Calculated
Unit cost for removal	$ 3.86		RSMeans 2011 02 41 13.60.1700
Chainlink fence removal	$ 33,261.62		
Barbed Wire Fence			
Length	10,000	ft	Based on 5 modules at 5.7 acres each
Unit cost for removal	$ 0.31		WDEQ/LQD Guideline 12, Appendix H (Ref. LQD-H)
Barbed wire fence removal	$ 3,100.00		
Total Fence Removal Cost	$ 36,361.62		
II. Overhead Power Line Removal			
Length	5,400	ft	Based on trunkline length
Unit cost for removal	$ -		WDEQ/LQD Guideline 12, Appendix H (Ref. LQD-H); distribution lines would typically be owned by power company and removed at no cost for their salvage value
Total Overhead Power Line Removal Cost	$ -		
III. Buried Electrical Line Removal			
Length	90,000	ft	Based on recovery well flow line length
Unit cost for removal	$ 0.99	/ft	RSMeans 2011; 02 41 13.54.100
Unit cost for excavation/backfill	$ -	/ft	Included in cost of individual flow lines
Total Buried Electrical Line Removal Cost	$ 89,100.00		
IV. Buried Gas Line Removal			
Length	9,100	ft	Preliminary site layout
Unit removal cost	$ 2.26	/ft	RSMeans 2011; 02 41 13.50.100
Unit excavation cost	$ 3.20	/ft	RSMeans 2011; 31 23 16.13.0120 and 31 23 16.13.3080 (assume 0.5 cuyd/ft)
Unit disposal cost	$ -	/ft	Assumes salvaged with no net salvage value or disposal cost
Total Gas Line Removal Cost	$ 49,686.00		
V. Transformer Removal & Disposal			
Number of transformers	32		Based on 3 per module (15), 3 per ddw (9), and 8 for the facilities
Unit removal/disposal cost	$ 440.00		RSMeans 2011, 26 05 05.10.1520
Total Transformer Removal and Disposal Cost	$ 14,080.00		
VI. Surface Water Monitoring Station Removal			
Number of surface water monitoring stations	3		From ER Section 6.2.1.1
Unit removal/disposal cost	$ 2,345.20		WDEQ/LQD Guideline 12, Appendix N (Ref. LQD-N)
Total Surface Water Monitoring Station Cost	$ 7,035.60		
VII. Air Quality/Meteorological Monitoring Station Removal			
Number of monitoring stations	7		Includes 6 air quality stations and 1 MET station
Unit removal/disposal cost	$ 886.48		WDEQ/LQD Guideline 12, Appendix N (Ref. LQD-N)
Total Monitoring Removal Cost	$ 6,205.36		

VIII. Culvert Removal			
Primary Access Road Culvert			
Length	80	ft	5' tall x 10' wide concrete box culvert
Unit removal cost	$ 15.35		Based on RSMeans 02 41 13.43.0100
Volume of concrete for disposal	57.8	yd^3	Calculated; includes 30% swell factor for void space
Volume per truckload	20	yd^3	ER Section 4.13.1.1.2.1
Number of trucks to landfill	3	trucks	Calculated
Distance to landfill	23	miles	Moorcroft
Unit transportation cost	$ 3.00	/mile	Actual 2010 costs from northeast Wyoming contract waste hauler
Transportation cost	$ 207.00		
Landfill disposal fee	$ 56.80	/ton	Reference L-1
Density of concrete	100	lb/ft^3	Estimate for demolished concrete
Landfill cost	$ 4,430.40		
Total Primary Access Road Culvert Cost	$ 4,637.40		
Wellfield Access Road Culverts			
Total length	160		Based on four 40' culverts
Unit cost	$ 6.10		WDEQ/LQD Guideline 12, Appendix J (Ref. LQD-J)
Total Wellfield Access Road Cost	$ 976.16		
Total Culvert Removal Cost	$ 5,613.56		
IX. Chipper/Shredder			
Number of days of operation	30	days	Estimate
Unit cost for rental/operation	$ 2,000.00	/day	Estimate
Total Chipper/Shredder Cost	$ 60,000.00		
TOTAL MISCELLANEOUS RECLAMATION ACTIVITIES COST	**$ 268,082.14**		

ATTACHMENT RAP-3
COST REFERENCES

C-1	Sulfuric acid cost
DDW-1	Deep well disposal
L1	Moorcroft landfill disposal costs
LQD-C	Material moving*
LQD-G	Final grading*
LQD-H	Fence and power line removal*
LQD-I	Ripping asphalt*
LQD-J	Culvert removal*
LQD-K	Building demolition*
LQD-N	Surface, air quality, and met station removal*
LQD-P	Scarification of compacted surfaces*
P1 - P9	Pumping system operation calculations
RO-1	RO operation costs
S1	Schedule

*From WDEQ/LQD Guideline 12, Standardized Reclamation Performance Bond Format and Cost Calculation Methods, November 2010

C-1

Subject: SULFURIC AND ANTI-SCALENT
From: JRaffelson@brenntag.com
Date: Thu, 30 Dec 2010 15:10:46 -0700
To: jfritz@wwcengineering.com
CC: bfjelstad@brenntag.com, JSTALEY@brenntag.com

Jack,
I was able to get a price for the sulfuric acid. We will quote $327.50/Ton delivered to the mine site. I wasn't able to get a price for the anti-scalent as we don't have enough information to quote that yet.

If you have any questions, please give me a call.

Jo Raffelson
Customer Service/Purchasing
Brenntag Pacific/Billings, MT
(406) 628-3640
(406) 628-2072 Fax

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Deep Well Disposal Cost Estimate

Operating Assumptions			
Total brine volume from groundwater sweep	4,215	kgal	15% of total volume of groundwater sweep
Total brine volume from RO treatment with permeate injection	59,006	kgal	15% of total volume of RO treatment
Brine and other 11e.(2) liquid waste in ponds*	26,100	kgal	Based on 80 acre-ft normal operating pond capacity (see Figure 4.2-1 of the TR)
Total volume for disposal	89,321	kgal	Calculated
Time for operation			
Months for disposal	24	months	Based on 15 months of active aquifer restoration and 9 months of decommissioning
Average days per month	30.4		
Days for operation	730	days	Calculated
Brine Pumps to Deep Disposal Well			
Average flow rate	85	gpm	Calculated
Electrical requirement	11	kW	Reference P-8
Electrical consumption	192,614	kWh	Calculated
Power cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
Brine Pumping Cost	$ 7,704.58		
Brine Pumping Cost	$ 0.09	/kgal	
High Pressure Disposal Well Pumps			
Average total flow	85	gpm	Calculated
Number of wells/pumps required	2		Flow range is 35 to 80 gpm per well per TR Section 4.2.3.2.1. Although 3 wells will be constructed, only 2 will typically be required at one time.
Electrical requirement per pump	55	kW	Reference P-9
Electrical consumption	1,926,144	kWh	Calculated
Power Cost	$ 0.04	/kWh	Tiered rate is $0.03 to $0.04 per PRECorp
High Pressure Disposal Well Pumping Cost	$ 77,045.76		
High Pressure Disposal Well Pumping Cost	$ 0.86	/kgal	
Chemicals			
Antiscalant	$ 0.10	/kgal	Reference RO-1; 4.4 ppm dose
Disinfectant/corrosion inhibitor	$ 0.05	/kgal	Estimate
Total Chemical Cost	$ 0.15	/kgal	
Total Chemical Cost	$ 13,398.15		
Total Brine Disposal Cost	**$ 98,148.49**		
Total Brine Disposal Cost per Kilogallon	**$ 1.10**		

*Includes decontamination water, plant washdown water, and minor amounts of prodution eluate. Brine is accounted for in quantities calculated for groundwater sweep and RO treatment with permeate injection.

L-1

Moorcroft Landfill

MOORCROFT LANDFILL:

The Moorcroft Landfill is located approximately 5 miles east of Moorcroft off Interstate 90 on the Wind Creek exit, then 1 mile north. The Summer hours are:

TUESDAY, WEDNESDAY & FRIDAY:	**1:00 pm - 7:00 pm**
SATURDAY:	**11:00 am - 7:00 pm**

LANDFILL RATES:

ALL GARBAGE HAULED TO THE MOORCROFT LANDFILL WILL BE CHARGED $2.84 PER 100 POUNDS WITH A MINIMUM $5.00 FEE.

All vehicles entering the landfill must stop at the landfill scale building to receive dumping instructions. All vehicles leaving the landfill must stop at the office to pay for the load.

ALL VEHICLES MUST WEIGH IN AND OUT EVERY TRIP.

All loads must be secured during transport. An additional fee of $15.00 will be assessed for dumping of loads which arrive unsecured.

Close Window

Appendix C
Calculations for Moving Materials With a Caterpillar 637G Push-Pull Scraper Fleet

NOTE: DRILLING AND BLASTING COSTS ARE NOT INCLUDED IN THESE CALCULATIONS. THE LQD DOES NOT CONSIDER DRILLING AND BLASTING COSTS NECESSARY WHEN USING APPENDIX C.

Material Movement By Scrapers

1) Caterpillar 637E Push-Pull Scraper		
2) Material Density	2,850. LB/BCY	CPH 40
3) Payload	75,000. LB	CPH 40
	25.0 BCY	
4) Maximum Vehicle Speed Loaded	33.0 MPH	CPH 40
5) Operating Efficiency Factor (50 Min./Hr.)	0.83 %	CPH 40
6) 637G PP Operating Costs	$276.22 Per Hour	100% E-W
7) Labor Costs	$40.92 Per Hour	WYDOT-WDD
8) Supervision Labor Costs	$5.74 Per Hour	1/8 of WYDOT-WDD
9) Supervisor Transportation	$2.84 Per Hour	1/8 of 100% E-W
10) 1/8 of 1 - 14,000 Gal. Water Trucks + 1 Operator	$29.23 Per Hour	1/8 of 100% E-W
11) 1/8 of 1 – 16M Blade for Road Work + 1 Operator	$21.74 Per Hour	1/8 of 100% E-W
12) . - D9R for Ripping Ovb. and Misc. Work + 1 Operator	$100.79 Per Hour	. of 100% E-W
13) Total Hourly Costs	$477.48	

TO USE TABLE: Locate your approximate grade by reference to case number. Determine cost per BCY by using distance column that approximates your distance. No calculations are necessary.

Case #1: Level Ground — Loaded (0% grade + 4% rolling = 4% total) — Empty (0% grade + 4% rolling = 4% total)

One-Way Distance (Ft.)	Load Time (Min.)	Travel Time Loaded (Min.)	Maneuver & Spread Time (Min.)	Travel Time Empty (Min.)	Total Cycle Time (Min.)	Trips Per Hour	Payload (BCY)	Efficiency Factor (50 min/hr)	Adjusted Productivity (BCY/Hr)	Operating Costs ($/BCY)
500	1.0	0.42	0.60	0.36	2.38	25.2	25.0	0.83	523	$0.913
1000	1.0	0.68	0.60	0.57	2.85	21.1	25.0	0.83	438	$1.090
1500	1.0	0.92	0.60	0.75	3.27	18.4	25.0	0.83	382	$1.250
2000	1.0	1.15	0.60	0.92	3.67	16.3	25.0	0.83	338	$1.413
2500	1.0	1.37	0.60	1.09	4.06	14.8	25.0	0.83	307	$1.555
3000	1.0	1.59	0.60	1.26	4.45	13.5	25.0	0.83	280	$1.705
3500	1.0	1.81	0.60	1.44	4.85	12.4	25.0	0.83	257	$1.858
4000	1.0	2.02	0.60	1.61	5.23	11.5	25.0	0.83	239	$1.999
4500	1.0	2.22	0.60	1.78	5.60	10.7	25.0	0.83	222	$2.151
5000	1.0	2.43	0.60	1.95	5.98	10.0	25.0	0.83	208	$2.296
5500	1.0	2.64	0.60	2.13	6.37	9.4	25.0	0.83	195	$2.449
6000	1.0	2.85	0.60	2.30	6.75	8.9	25.0	0.83	185	$2.581
6500	1.0	3.05	0.60	2.47	7.12	8.4	25.0	0.83	174	$2.744
7000	1.0	3.26	0.60	2.64	7.50	8.0	25.0	0.83	166	$2.876

Appendix G
Calculations for Final Grading With a Caterpillar 16M Motor Grader

Final Grading

	INPUT, UNIT AS INDICATED	COMMENT/ SOURCE
Caterpillar 16M Motor Grader		
Speed in Miles Per Hour (Second Gear)	3.3 Miles/Hour	CPH 40
Width of Grading Per Pass	8 Feet	CPH 40
Feet Per Mile	5,280 Feet	
Square Feet Per Acre	43,560 Sq. Ft.	
Operating Efficiency Factor 50 Min./Hr.	0.83 %	CPH 40
Operating Costs	$132.99 Per Hour	100% of E-W
Labor Costs	$40.92 Per Hour	WYDOT-WDD
Supervision Labor Costs	$5.74 Per Hour	1/8 of WYDOT-WDD
Supervisor Transportation	$2.84 Per Hour	1/8 of 100% of E-W
Total Hourly Costs	$182.49	
Grading Rate		
(3.3 Miles/Hour)x(5,280 Ft./Mile)x(8 Ft./Pass)	139,392 Ft^2/Hour	
(139,392 Ft^2/Hour)/(43,560 Ft^2/Acre)	3.2 Acres/Hour	
(3.2 Acres/Hour)x(0.83 Efficiency Factor)	2.66 Acres/Hour	
Operating Costs		
($182.49/Hour)/(2.66 Acres/Hour)	$68.61 Per Acre	

Appendix H
Cost Estimates for Handling Wire Fencing and Electrical Power Lines

FENCING		SOURCES
Construction 4-Strand Barbed	Overall Average - $1.87/LF	Wyoming Highway Department Weighted Average Bid Prices, 2009
Removal	Overall Average - $0.31/LF	Wyoming Highway Department, Average Bid Prices, 2009
	Power Line Removal	
Distribution Lines: Transmission Lines:	No Charge No Charge	From: Tri-County Electric From: Tri-County Electric

Note: Cost estimates for power line removal are based on phone contact with Tri-County Electric. Distribution lines are owned by Tri-County Electric and would be removed upon request at no charge by Tri-County Electric. Transmission lines (lines which go from the main metering point to various electrical substations and are not owned by Tri-County Electric) would be removed by Tri-County Electric at no cost for their salvage value.

Appendix I
Cost Estimate for Ripping Asphalt Using a Caterpillar D9R Dozer

Asphalt Ripping (3"-4" Mat)

	INPUT, UNIT AS INDICATED	COMMENT/ SOURCE
Caterpillar D9R Dozer With 3 Shank Ripper		
Speed in Miles Per Hour	1 Mile/Hour	CPH 40
Width of Ripping Pass	3 Feet	CPH 40
Feet Per Mile	5,280 Feet	
Square Feet Per Acre	43,560 Sq. Ft.	
Operating Efficiency Factor 50 Min./Hr.	0.83 %	CPH 40
Operating Costs	$160.66 Per Hour	100% of E-W
Labor Costs	$40.92 Per Hour	WYDOT-WDD
Supervision Labor Costs	$5.74 Per Hour	1/8 of WYDOT-WDD
Supervisor Transportation	$2.84 Per Hour	1/8 of 100% of E-W
Total Hourly Costs	$210.16	
Ripper Productivity		
(1.0 Mile/Hour)x(5,280 Ft./Mile)x(3 Ft./Pass)	15,840 Ft^2/Hour	
(15,840 Ft^2/Hour)/(43,560 Ft^2/Acre)	0.36 Acres/Hour	
(0.36 Acres/Hour)x(0.83 Efficiency Factor)	0.299 Acres/Hour	
Operating Costs		
($210.16/Hour)/(0.299 Acres/Hour)	$702.87 Per Acre	

Appendix J
Cost Estimate for Culvert Removal

Culvert Removal

	INPUT, UNIT AS INDICATED	COMMENT/ SOURCE
Average Length of CMP Section	20 Feet	
Assumed Culvert Diameter	48 Inches	
Time to Cut One Band	10 Minutes	
Time to Load One 20' Section (2 People)	20 Minutes	
Average Haul, Dump and Return Time	30 Minutes	
Number of Sections of CMP Per Load	2	
Operating Efficiency Factor 50 Min./Hr.	0.83 %	
Labor	$40.92 Per Hour	WYDOT-WDD
Dump Truck (10-12 yd^3)	$64.33 Per Hour	100% of E-W
Caterpillar 980G Front-End Loader	$106.06 Per Hour	100% of E-W
Cost to Remove One 20' Section of CMP		
Labor Cost x Time to Cut One Band	$6.82	
+ ((Labor Cost x 2) + FEL Cost) x Time to Load 1 Section	$62.57	
+ (Labor Cost + Truck Cost) x Haul Time	$52.63	
Cost to Remove One 20' Section of CMP (not including dirt removal)	$122.02	

Note: Culverts may be smashed and buried in place when feasible.

Appendix K
Cost Estimates for Demolition and Removal of Railroad Spurs and Facilities Buildings

TASK	COST PER UNIT ($)	REGIONAL COST ADJUSTMENT[1]	ADJUSTED COST PER UNIT ($)
Track Removal	8.57/lin. ft.	95.7%	8.20/lin. ft.
Ballast Removal	4.12/cy	95.7%	3.94/cy
Building Demolition and Disposal[1, 2, 3]			
Mixture of Types	0.26/ft^3	95.7%	0.249/ft^3
Explosive Demolition, Concrete or Steel	0.24/ft^3	95.7%	0.230/ft^3
Disposal (Average)	8.48/cy	95.7%	8.12/cy
City Landfill Dump Charges	$100.00/ton	95.7%	$95.70/ton
Concrete Footings and Foundations			
6" Thick With Rebar	5.28sq. ft.	95.7%	5.05/sq. ft.
Footings - 2' Thick, 3' Wide	18.95/lin. ft.	95.7%	18.14/lin. ft.
Concrete Disposal On-Site	7.28/cy	95.7%	6.97/cy

Note: Operators may also provide a verifiable cost estimate from a qualified contractor for these demolition tasks. This estimate may be used for one to three consecutive years, assuming few substantial changes in mine facilities.

1 Costs From: 2011 Means Heavy Construction Cost Data & Building Construction Cost Data
2 Based on Total Volume of Building, does not include disposal cost
3 Based on Concrete Structures Volume Only, does not include disposal cost

Appendix N
Cost Estimates for Demolition and Removal of One "Standard" Surface Water Monitoring Station

	INPUT, UNIT AS INDICATED	COMMENT/ SOURCE
Assumed Time to Remove One Station	8 Hours	
Labor	$40.92 Per Hour	WYDOT-WDD
Dump Truck (10-12 yd^3)	$64.33 Per Hour	100% of E-W
Caterpillar 980G Front-End Loader	$106.06 Per Hour	100% of E-W
Cost to Remove One Surface Water Station = (Labor Cost x Time to Remove Station) + (Labor Cost + Truck Cost) x Time to Remove Station + (Labor Cost + Loader Cost) x Time to Remove Station	 $327.36 $842.00 $1,175.84	
Cost to Remove One Surface Water Station =	$2,345.20	

Appendix O
Cost Estimates for Demolition and Removal of One
"Standard" Meteorological or Air Quality Monitoring Site

	INPUT, UNIT AS INDICATED	COMMENT/ SOURCE
Assumed Time to Remove One Station	4 Hours	
Labor	$40.92 Per Hour	WYDOT-WDD
Dump Truck (10-12 yd^3)	$64.33 Per Hour	100% of E-W
Caterpillar 430D (4WD) Backhoe Loader	$31.53 Per Hour	100% of E-W
Cost to Remove One Meteorological or Air Quality Station = (Labor Cost x Time to Remove Station) + (Labor Cost + Truck Cost) x Time to Remove Station + (Labor Cost + Loader Cost) x Time to Remove Station	 $163.68 $421.00 $301.80	
Cost to Remove One Meteorological or Air Quality Station =	$886.48	

Appendix P
Cost Estimate for Scarification of Compacted Surfaces

	INPUT, UNIT AS INDICATED	COMMENT/ SOURCE
CATERPILLAR 16M MOTOR GRADER		
Speed in Miles Per Hour (First Gear)	2.4 Miles/Hour	CPH 40
Width of Scarifying Pass	12 Feet	CPH 40
Feet Per Mile	5,280 Feet	
Square Feet Per Acre	43,560 Sq. Ft.	
Operating Efficiency Factor 50 Min./Hr.	0.83%	CPH 40
Operating Costs	$132.99 Per Hour	100% of E-W
Labor Costs	$40.92 Per Hour	WYDOT-WDD
Supervision Labor Costs	$5.74 Per Hour	1/8 of WYDOT-WDD
Supervisor Transportation	$2.84 Per Hour	1/8 of 100% of E-W
Total Hourly Costs	$182.49	
SCARIFICATION RATE		
(2.4 Miles/Hour)x(5,280 Ft./Mile)x(12 Ft./Pass)	152,064 Ft^2/Hour	
(152,064 Ft^2/Hour)/(43,560 Ft^2/Acre)	3.49 Acres/Hour	
(3.49 Acres/Hour)x(0.83 Efficiency Factor)	2.90 Acres/Hour	
OPERATING COSTS		
($182.49/Hour)/(2.90 Acres/Hour)	$62.93 Per Acre	

Pumping System Description:

Name:	Well Pumps
Location:	Inside recovery wells
Purpose:	Deliver recovery solution to the module buildings

Input Data:

			Source
Flow rate:	20	gpm	High estimate per well
Inlet pressure:	4	psi	Assumes 10 feet min. water column above pump
Delivery pressure:	10	psi	Estimate of pressure required at delivery point
Maximum lift:	500	ft	Based on average 500 foot well depth
Friction head loss:	85	ft	Calculated as 83.6 ft from recovery well pump to module building
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	14	ft
Friction losses:	85	ft
Elevation head:	500	ft
Total dynamic head:	599	ft
Pump power input:	3.6	hp
Motor power input:	4.2	hp
	3.1	kW
For estimate	4.0	kW

Pumping System Description:

Name:	Recovery Solution Booster Pumps
Location:	Inside module buildings
Purpose:	Deliver recovery solution from the recovery wells to the CPP

Input Data:			Source
Flow rate:	800	gpm	High estimate per module based on production
Inlet pressure:	10	psi	Residual pressure from recovery well pumps
Delivery pressure:	50	psi	High estimate of pressure required at delivery point
Pump elevation:	4200	ft	Typical module building elevation
Delivery elevation:	4150	ft	High estimate of final CPP elevation
Friction head loss:	50	ft	Calculated as 43 ft from Module 1 to CPP
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	92	ft
Friction losses:	50	ft
Elevation head:	-50	ft
Total dynamic head:	92	ft
Pump power input:	21.9	hp
Motor power input:	25.8	hp
	19.2	kW
For estimate	20.0	kW

Pumping System Description:

Name:	Injection Booster Pumps
Location:	Inside module buildings
Purpose:	Deliver barren lixiviant to the injection wells during production or permeate during aquifer restoration

Input Data:			Source
Flow rate:	800	gpm	High estimate per module based on production
Inlet pressure:	20	psi	Residual pressure from CPP booster pumps
Delivery pressure:	140	psi	Max. injection pressure at module building (TR Section 3.1.2.3)
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	277	ft
Total dynamic head:	277	ft
Pump power input:	65.9	hp
Motor power input:	77.5	hp
	57.8	kW
For estimate	58.0	kW

Pumping System Description:

Name:	CPP Permeate Pumps
Location:	Inside CPP
Purpose:	Deliver permeate to the module buildings

Input Data:			Source
Flow rate:	467.5	gpm	High estimate per module (see TR Figure 3.1-13 and assume 2 modules in RO treatment with permeate injection)
Inlet pressure:	10	psi	Low estimate of residual pressure after RO
Delivery pressure:	20	psi	High estimate of pressure required at delivery point
Pump elevation:	4150	ft	High estimate of final CPP elevation
Delivery elevation:	4200	ft	Typical module building elevation
Friction head loss:	50	ft	Calculated as 43 ft from Module 1 to CPP
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	23.1	ft
Friction losses:	50	ft
Elevation head:	50	ft
Total dynamic head:	123.1	ft
Pump power input:	17.1	hp
Motor power input:	20.1	hp
	15.0	kW
For estimate	15.0	kW

Pumping System Description:

Name:	Restoration RO Prefiltration Pumps
Location:	Inside CPP
Purpose:	Deliver recovery solution to guard column and RO prefiltration

Input Data:

			Source
Flow rate:	1100	gpm	Typical restoration flow from restoration recovery wells (see TR Figure 3.1-13)
Inlet pressure:	50	psi	Delivery pressure from module buildings
Delivery pressure:	130	psi	From preliminary RO design by Lyntek
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550 e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	184.6	ft
Total dynamic head:	184.6	ft
Pump power input:	60.4	hp
Motor power input:	71.0	hp
	53.0	kW
For estimate	53.0	kW

Pumping System Description:

Name:	Restoration RO Stage 1 Feed Pump
Location:	Inside CPP
Purpose:	Deliver filtered recovery solution to Stage 1 RO

Input Data:			Source
Flow rate:	1100	gpm	Restoration flow from restoration recovery wells (see Figure 3.1-13)
Inlet pressure:	100	psi	Estimated delivery pressure from guard column and prefiltration
Delivery pressure:	385	psi	From preliminary RO design by Lyntek
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	657.7	ft
Total dynamic head:	657.7	ft
Pump power input:	215.1	hp
Motor power input:	253.1	hp
	188.8	kW
For estimate	189.0	kW

Pumping System Description:

Name:	Restoration RO Stage 2 Feed Pump
Location:	Inside CPP
Purpose:	Deliver brine from Stage 1 RO to Stage 2 RO

Input Data:

			Source
Flow rate:	330	gpm	Brine from Stage 1 RO (see TR Figure 3.1-13)
Inlet pressure:	10	psi	Delivery pressure from holding tank and prefiltration
Delivery pressure:	760	psi	From preliminary RO design by Lyntek
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550 e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	1730.8	ft
Total dynamic head:	1730.8	ft
Pump power input:	169.9	hp
Motor power input:	199.8	hp
	149.1	kW
For estimate	150.0	kW

Pumping System Description:

Name:	Brine Pump to Deep Disposal Wells
Location:	Inside CPP
Purpose:	Deliver brine from storage tank to disposal well pumps

Input Data:			Source
Flow rate:	190	gpm	Brine from Stage 2 RO and other liquid waste (see TR Figure 3.1-13)
Inlet pressure:	5	psi	Delivery pressure from storage tank
Delivery pressure:	50	psi	High estimate of pressure required at disposal surge pumps
Pump elevation:	4150	ft	High estimate of final CPP elevation
Delivery elevation:	4190	ft	Typical deep disposal well elevation
Friction head loss:	70	ft	Calculated as 66 ft based on typical deep disposal well distance from CPP
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	103.8	ft
Friction losses:	70	ft
Elevation head:	40	ft
Total dynamic head:	213.8	ft
Pump power input:	12.1	hp
Motor power input:	14.2	hp
	10.6	kW
For estimate	11.0	kW

Pumping System Description:

Name:	High Pressure Disposal Well Pumps
Location:	Adjacent to deep disposal wells
Purpose:	Deliver concentrated brine to deep disposal well

Input Data:			Source
Flow rate:	50	gpm	Typical disposal rate per well (range is 35-80 gpm per TR Section 4.2.3.2.1)
Inlet pressure:	50	psi	Delivery pressure from brine pump
Delivery pressure:	1846	psi	Limiting surface injection pressure per Table 14 in TR Addendum 4.2-A
Pump efficiency:	85%		Estimate
Motor efficiency:	85%		Estimate
Specific weight:	62.4	lb/ft^3	Typical of water

Calculations:

$$hp = \frac{Q\gamma H}{550 e_p}$$

$$P = \frac{hp}{e_m}$$

Where:

hp	=	Pump power input (hp)
Q	=	Flow rate (cfs)
γ	=	Specific weight of fluid (lb/ft^3)
e_p	=	Pump efficiency
P	=	Motor power input
e_m	=	Motor efficiency

Pressure head:	4144.6	ft
Total dynamic head:	4144.6	ft
Pump power input:	61.6	hp
Motor power input:	72.5	hp
	54.1	kW
For estimate	55.0	kW

RO Operation Costs

Name:	2-Stage Restoration RO
Location:	Inside CPP
Purpose:	Treat recovery solution from wellfields during groundwater sweep

Input Data:				Source
Stage 1 RO design feed rate		1100	gpm	See TR Figure 3.1-13
Stage 2 RO design feed rate		330	gpm	See TR Figure 3.1-14
Total groundwater sweep volume		28,098	kgal	0.5 PVD x 5 modules
Total RO with permeate injection volume		393,376	kgal	7.0 PVD x 5 modules
Total volume treated		421,474	kgal	7.5 PVD x 5 modules
Months of operation		14	months	See reference S-1; 14 months total groundwater sweep plus RO treatment with permeate injection
Average monthly Stage 1 feed rate		30,105	kgal/mo	
Average monthly Stage 2 feed rate		9,032	kgal/mo	
Sulfuric Acid (H_2SO_4):				
H_2SO_4 concentration for Stage 1 RO		147	ppm	Modeled using Visual MINTEQ: reduce pH from 8.0 to 7.0
H_2SO_4 concentration for Stage 2 RO		343	ppm	Modeled using Visual MINTEQ: reduce pH from 8.2 to 7.5
H_2SO_4 grade		93%		Concentrated sulfuric acid
H_2SO_4 required for Stage 1 RO		2.59	kgal/mo	
H_2SO_4 required for Stage 2 RO		1.81	kgal/mo	
Total H_2SO_4 required		4.40	kgal/mo	
Unit H_2SO_4 cost	$	327.50	/ton	Quote delivered from Brenntag chemical (see reference C-1)
Monthly H_2SO_4 cost	$	11,048	/month	
Monthly H_2SO_4 cost per kgal feed	$	0.37	/kgal	
Antiscalant:				
Antiscalant concentration for Stage 1 RO		3	ppm	Per recommendation from Avista Technologies
Anti-scalant concentration for Stage 2 RO		4.4	ppm	Per recommendation from Avista Technologies
Cost for Stage 1 RO antiscalant per kgal feed	$	0.07	/kgal	Cost estimate for Vitek 3000 from Avista Technologies
Cost for Stage 2 RO antiscalant per kgal feed	$	0.10	/kgal	Cost estimate for Vitek 3000 from Avista Technologies
Monthly Stage 1 RO antiscalant cost	$	2,047	/month	
Monthly Stage 2 RO antiscalant cost	$	903	/month	
Monthly antiscalant cost	$	2,950	/month	
Monthly antiscalant cost per kgal feed	$	0.10	/kgal	

RO Operation Costs (Continued)

Pre-Filtration Pumping System:

Average power requirement		53	kW	Reference P-5
Electrical consumption per month		38,669	kWh	Calculated
Power cost	$	0.04	/kWh	From PRECorp
Monthly pre-filtration pumping system cost	$	1,546.75		
Monthly cost per kgal feed	$	0.05	/kgal	

Pre-Filtration System Operating Costs:

Monthly cost per kgal feed	$	0.01	/kgal	Estimate

Stage 1 RO Feed Pump

Average power requirement		189	kW	Reference P-6
Electrical consumption per month		137,894	kWh	
Power cost	$	0.04	/kWh	From PRECorp
Monthly pre-filtration pumping system cost	$	5,515.78		
Monthly cost per kgal feed	$	0.18	/kgal	

Stage 2 RO Feed Pump

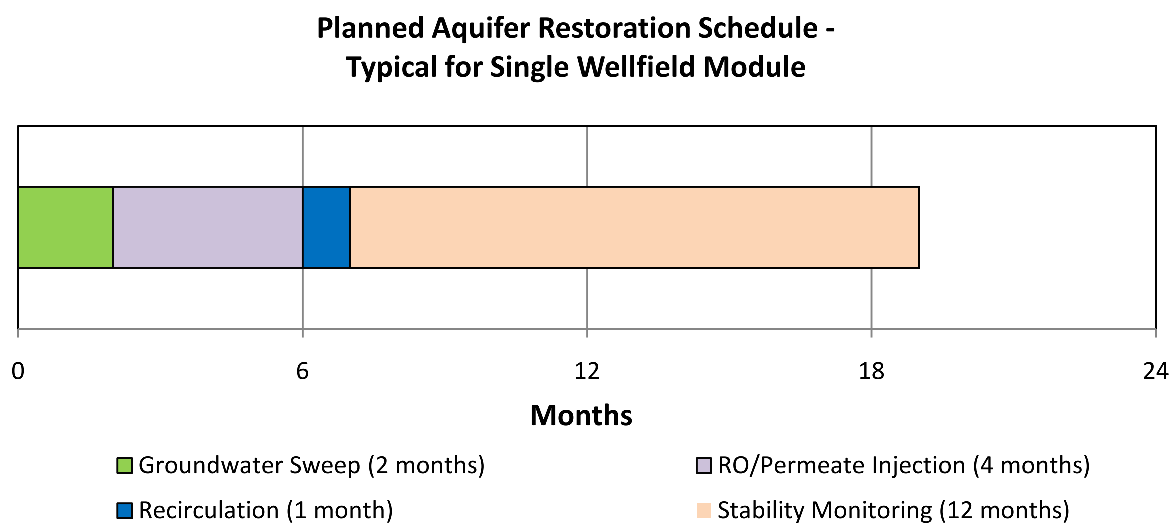
Average power requirement		150	kW	Reference P-7
Electrical consumption per month		109,440	kWh	
Power cost	$	0.04	/kWh	From PRECorp
Monthly pre-filtration pumping system cost	$	4,377.60		
Monthly cost per kgal feed	$	0.15	/kgal	

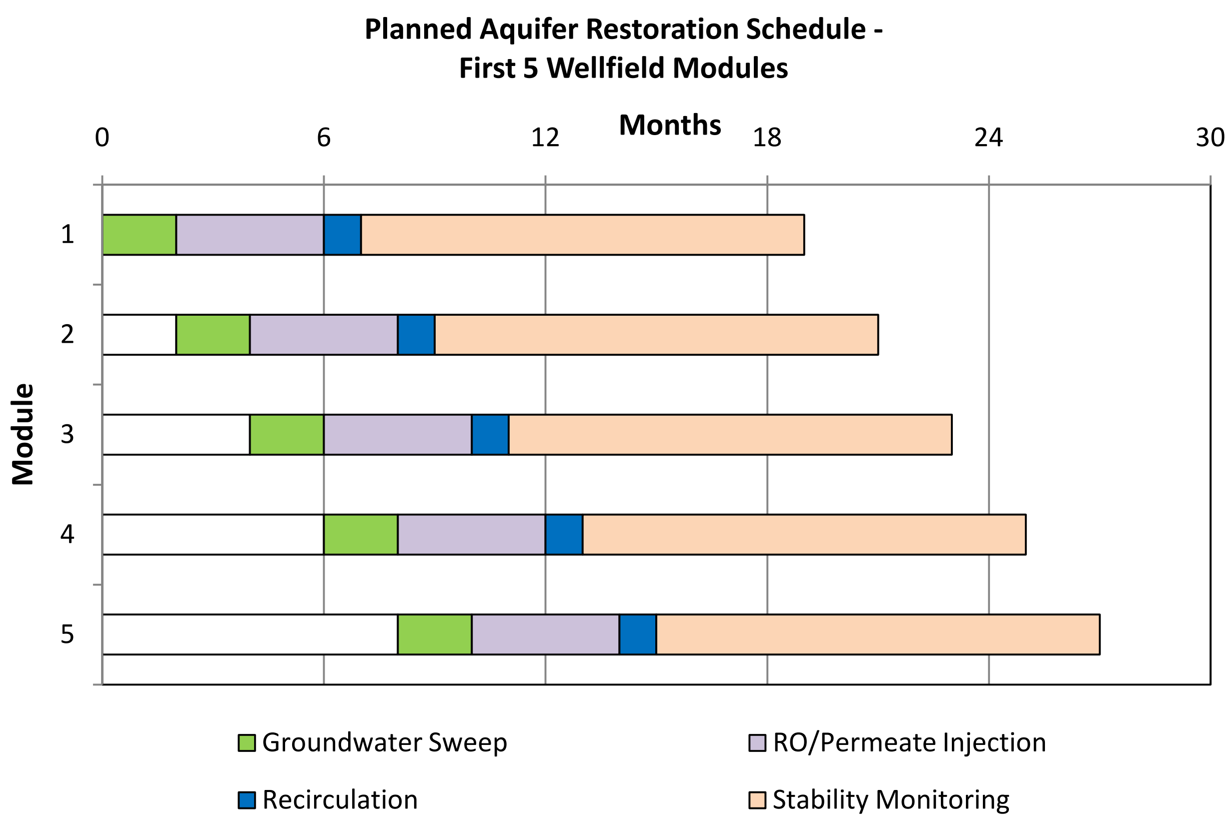
Membranes:

Monthly membrane cost	$	0.02	/kgal	Based on preliminary RO design by Lyntek

Total RO operation cost per month	$	0.88	/kgal

S-1


Planned Aquifer Restoration Schedule -
Typical for Single Wellfield Module
0
6
12
18
24
Months
Groundwater Sweep (2 months)
RO/Permeate Injection (4 months)
Recirculation (1 month)
Stability Monitoring (12 months)


Planned Aquifer Restoration Schedule -
First 5 Wellfield Modules
Months
0
6
12
18
24
30
Module
1
2
3
4
5
Groundwater Sweep
RO/Permeate Injection
Recirculation
Stability Monitoring

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

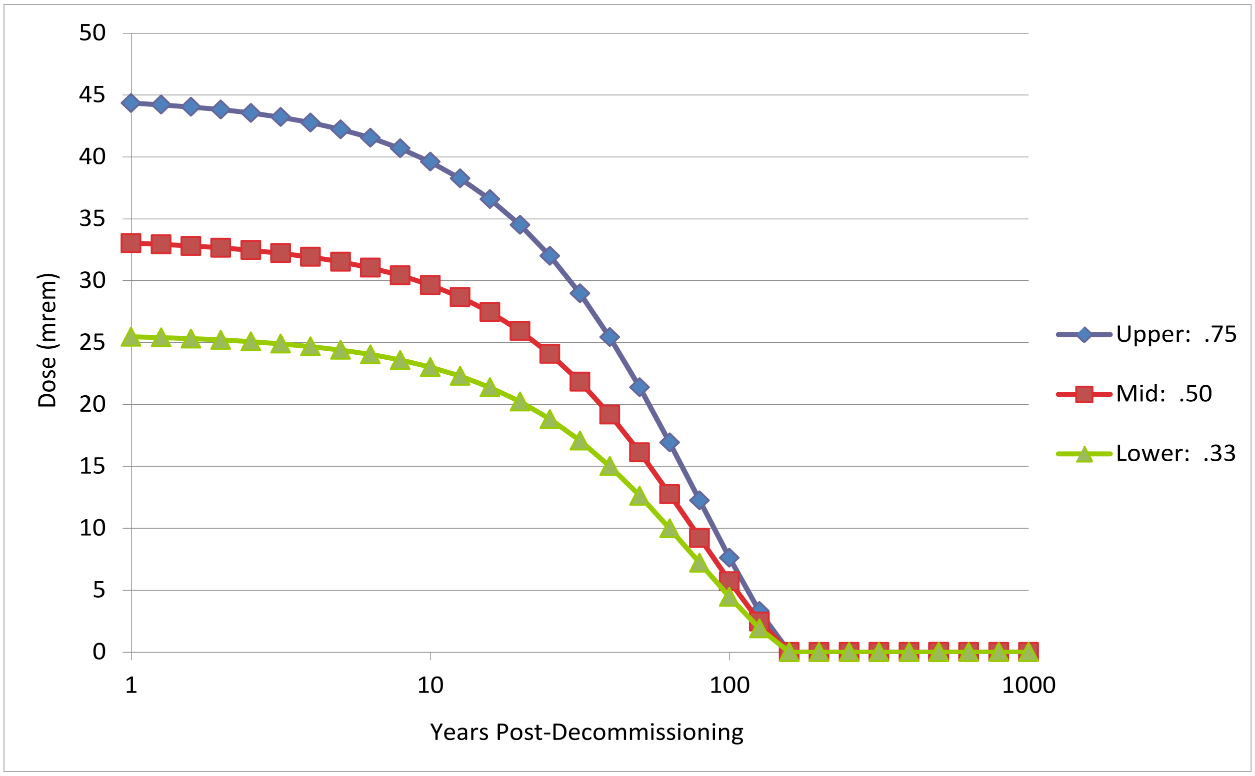


Figure 6.4-A-2 Dose Sensitivity to Contaminated Fraction of Plant Food Ingested

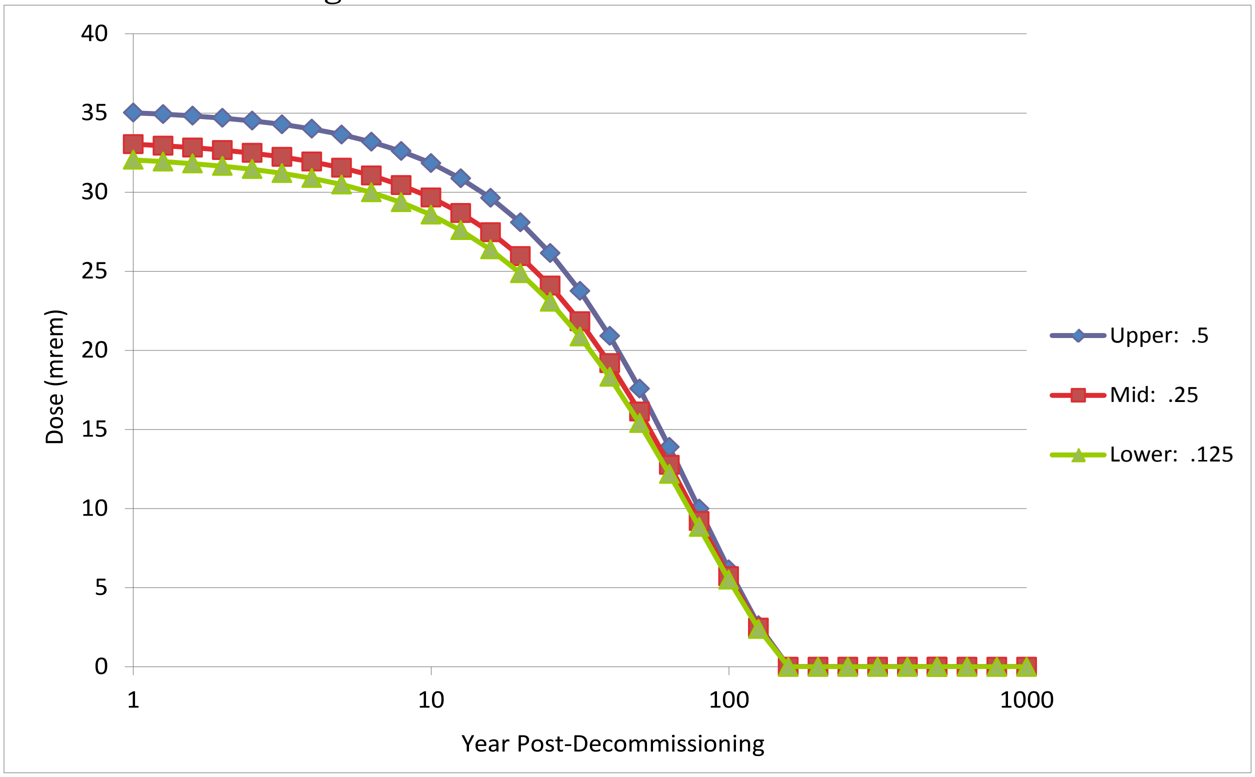


Figure 6.4-A-3 Dose Sensitivity to Average Wind Speed

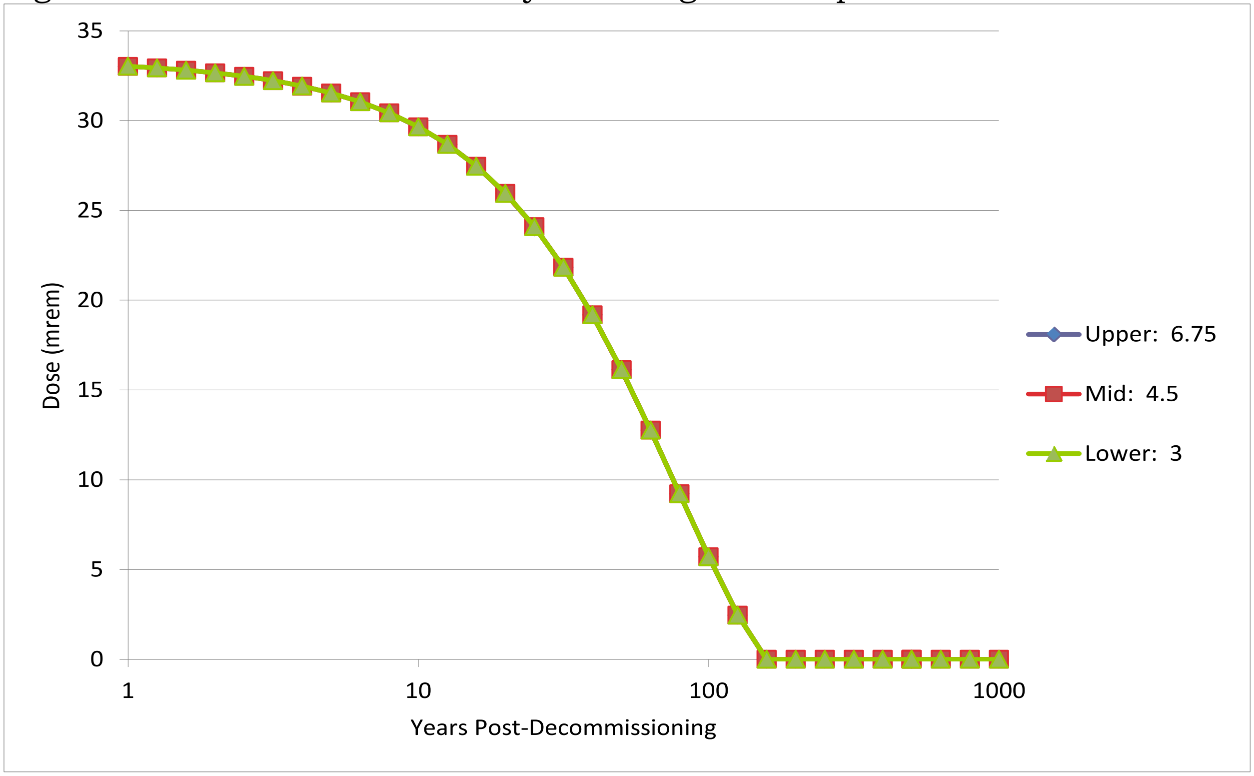


Figure 6.4-A-4 Dose Sensitivity to Mass Loading for Inhalation

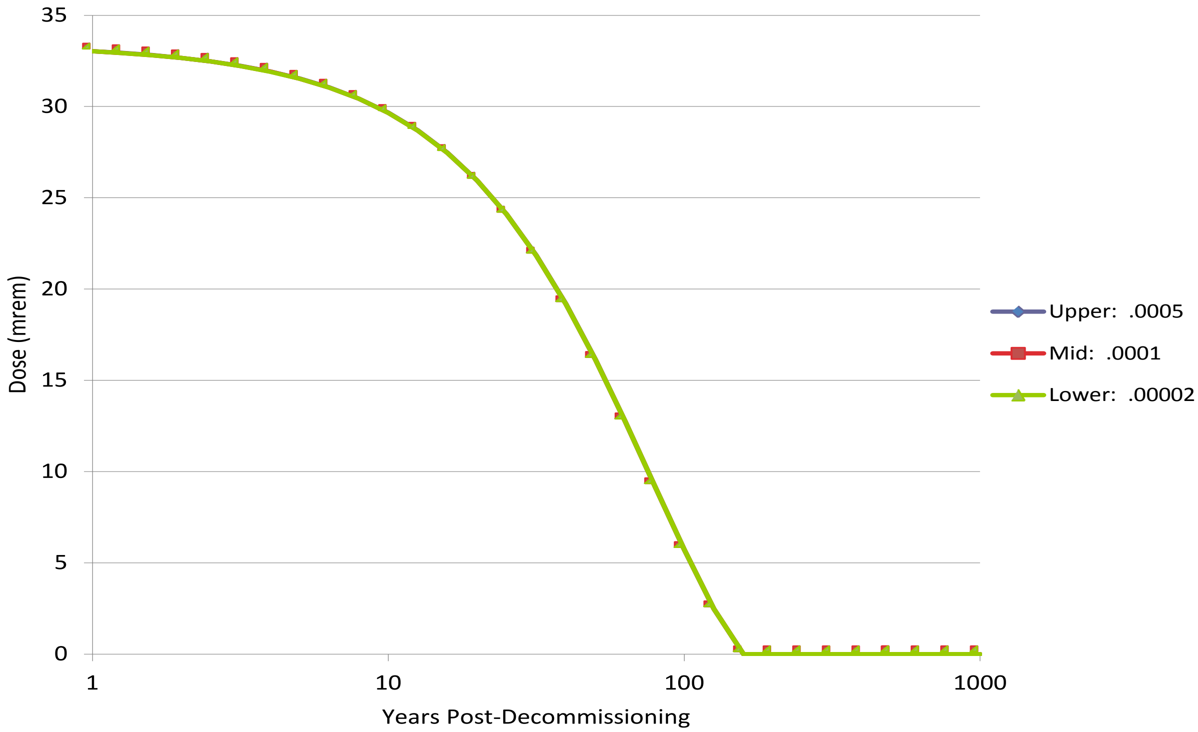


Figure 6.4-A-5 Dose Sensitivity to Contaminated Area in Surface Contamination Scenario