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OCCIDENTAL VERTICAL MODIFIED IN SITU PROCESS FOR THE RECOVERY OF OIL FROM OIL SHALE. PHASE II

Quarterly Progress Report for the Period September 1—November 30, 1980

January 1981
Date Published

Work Performed Under Contract No. FC20-79LC10036

Occidental Oil Shale, Inc.
Grand Junction, Colorado

MASTER

U. S. DEPARTMENT OF ENERGY

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Quarterly Progress Report for the Period
September 1, 1980 through November 30, 1980

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Project Manager

OCCIDENTAL OIL SHALE, INC.
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Date Published - January 1981

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Under Contract No. DE-FC20-78LC10036

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I. INTRODUCTION

The progress presented in this report covers the period September 1 through November 30, 1980 under the work scope for Phase II of the DOE/Occidental Oil Shale, Inc. (OOSI) Cooperative Agreement.

The major activities at OOSI's Logan Wash site during the quarter were: mining the voids at all levels for Retorts 7 and 8; blasthole drilling; tracer testing MR4; conducting the start-up and burner tests on MR3; continuing the surface facility construction; and conducting Retorts 7 and 8 related Rock Fragmentation tests.

Environmental monitoring continued during the quarter. The data and analyses are discussed in the environmental section of this report.

Sandia National Laboratory and Laramie Energy Technology Center (LETC) personnel were active in the DOE support of the MR3 burner and start-up tests.

In the last section of this report the final oil inventory for Retort 6 production is detailed. The total oil produced by Retort 6 was 55,696 barrels.

II. RETORTS 7, 8 and 8X PROGRESS

A. MINING

Mining activities to access and create the voids for Retorts 7, 8 and 8X continued during the quarter with progress totaling 5,136' advance and 57,082 cubic yards (107,885 tons) of shale removed. The progress at each location is listed in Table I and illustrated in Figures 1 through 3. The Upper and Lower Level voids were completed and the Intermediate Level voids were nearly completed.

TABLE I

SUMMARY OF MINING PROGRESS

	Average X-Section	Advance	Cu. Yds.
Lower Level			
Retort 7 void	44' x 13'	32'	6,992
	30' x 14'	95'	1,329
Retort 7, slabbing	6' x 14'	12'	44
Retort 8 void	30' x 15'	122'	1,901
	45' x 15'	213'	5,577
Retort 8 pillar slabbing	7' x 16'	197'	828
	5' x 15'	321'	614
1230 Lunch Room	10' x 16'	10'	59
Intermediate Level			
Retort 7 void	44' x 17'	422'	7,455
	26' x 15'	308'	4,520
	28' x 18'	80'	1,460
	3.5' x 17'	45'	96
	7' x 17'	330'	1,336
	25' x 12'	212'	2,314
	7' x 25'	165'	1,123
Retort 8 void	44' x 17'	94'	2,588
	25' x 16'	347'	4,916
	3.5' x 16'	256'	537
	12' x 25'	80'	849
	12' x 44'	116'	2,212
Retort 8 slabbing	—	—	1,859
Upper Level			
Retort 8 void	13' x 17'	112'	1,511
	5' x 17'	265'	740
Retort 8 slabbing	5' x 16'	302'	939
	13' x 17'	166'	1,319
Retort 8x slabbing	5' x 17'	452'	1,844
	13' x 16'	138'	1,064
Product Recovery Level			
Retort 7	14' x 14'	200'	835
L-1430-L	14' x 14'	12'	87
L-1430-R	14' x 14'	12'	87
S. Draw Pocket	9' Dia.	20'	47

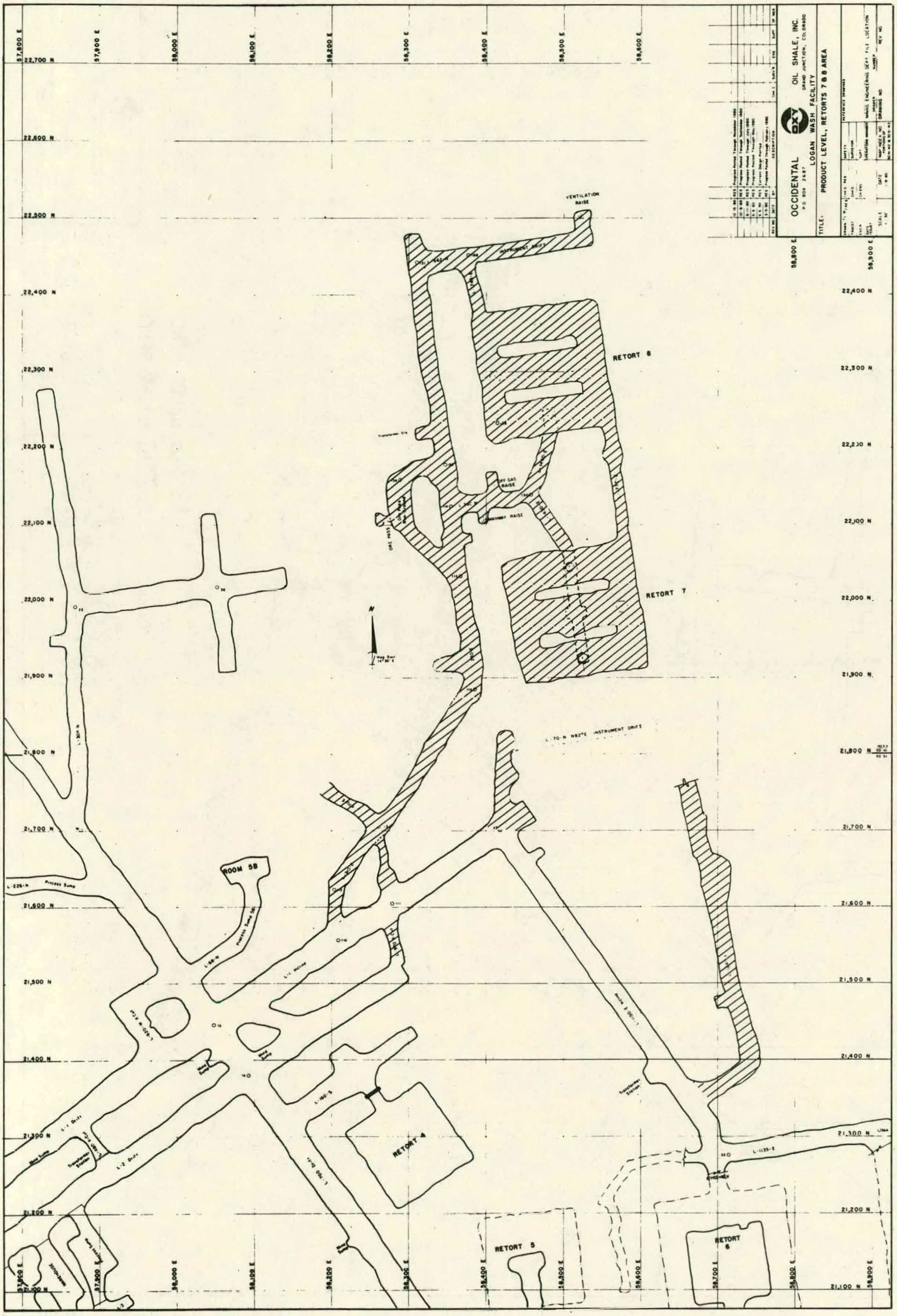


Figure 1. Mining progress at the Lower Level through November, 1980.

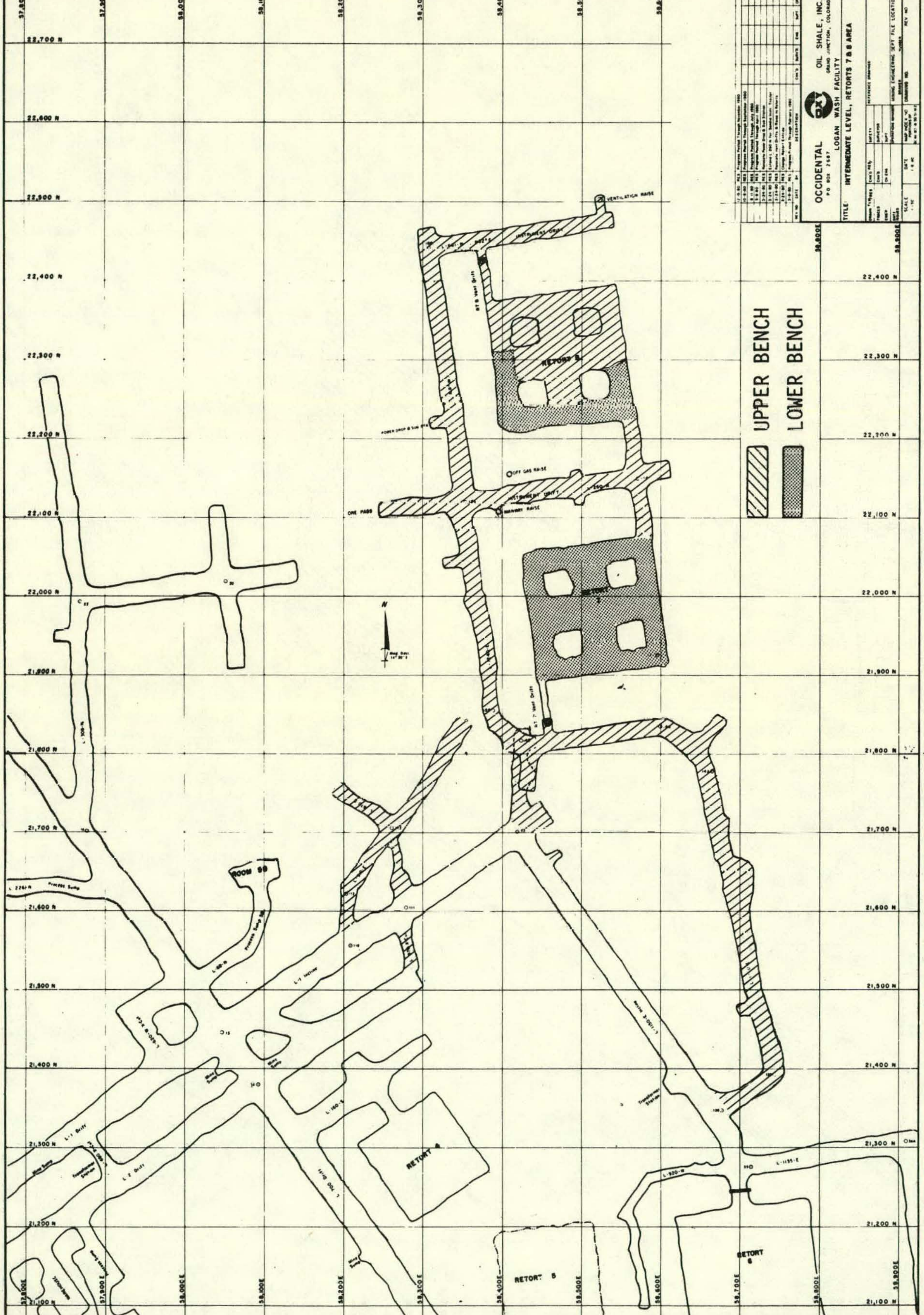


Figure 2. Mining progress at the Intermediate Level through November, 1980.

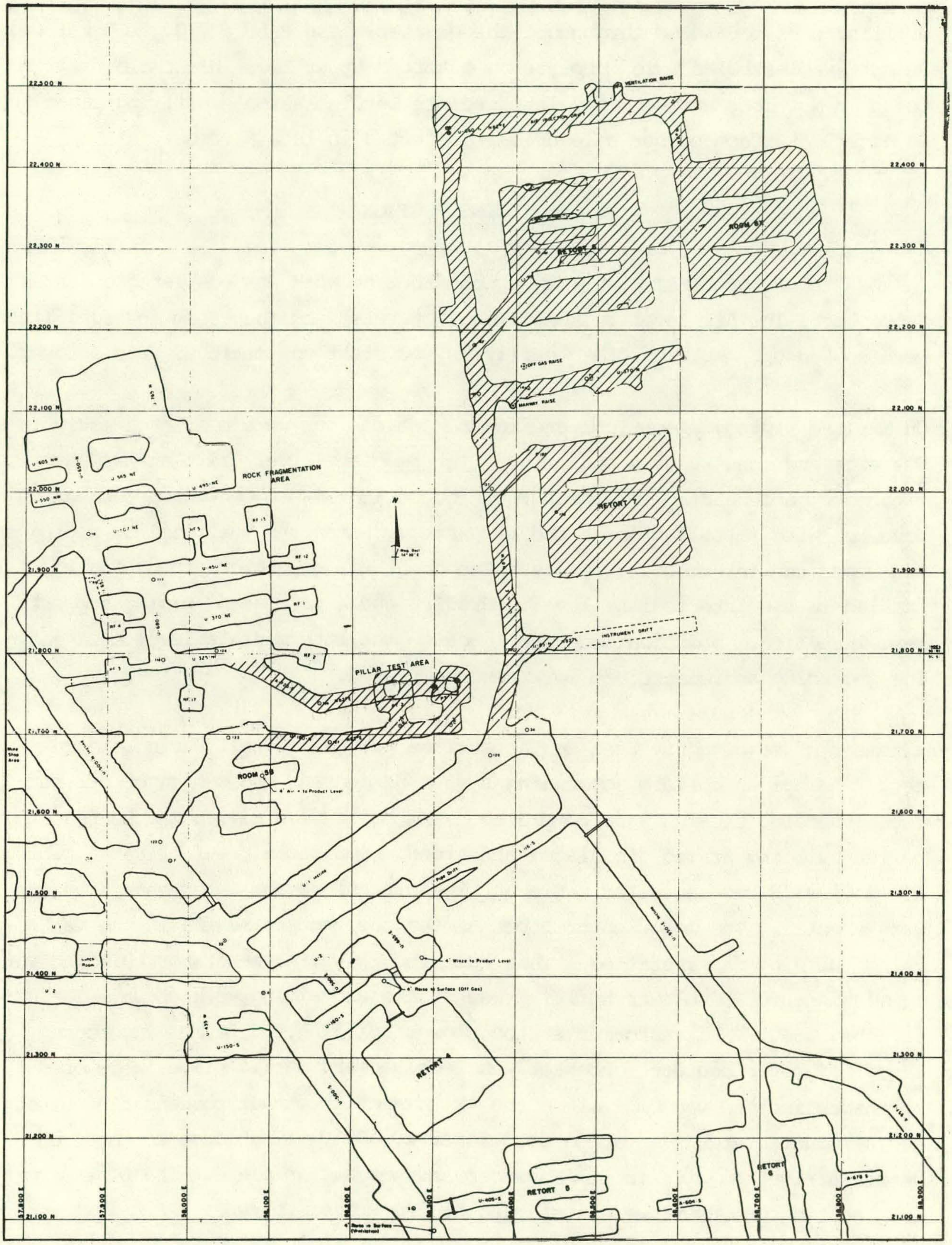


Figure 3. Mining progress at the Upper Level through November, 1980.

Drilling work continued throughout the quarter. The Retort 7 Upper Level and Retort 8x blastholes were completed. Retort 8 Upper Level blasthole drilling began in November and Retort 7 Intermediate Level blasthole drilling began in December. Surface burner hole drilling started in late November.

B. CONSTRUCTION

In the Mini-Retort (MR) area, major construction work was completed on MR3 in September. The Air Level bulkhead was shotcreted and the steam and fuel lines were hooked up. Work on other utilities for start-up continued into October.

On MR4 the piping, electrical and instrument designs were completed early in November and construction began. The intermediate level drift at MR4 was cleaned up and readied for the burner foundation. Work continued throughout November with installation of the air, steam, water and fuel utility piping on the upper and intermediate levels. The inert gas generator piping was installed in the intermediate level. Product check valves and piping supports were installed. Modifications were made to the intermediate level bulkhead. The grounding and electrical work were completed.

A number of major activities on the surface progressed well during the quarter. The boiler building grounding system design and the design of all surface grounding tie-ins were completed. The boiler foundation was poured, the boiler building framed, insulated and sided. Available pre-fabricated piping for Boiler #2 was installed. Eleven pipe stanchions and interconnection steel were erected. The motor control center for the vent raise fan in the vent raise building was installed. That building, plus the generator building were commissioned. The blower building was framed and siding work begun. The pad for the 1,500 KVA transformer at the blower building was formed and poured. The 7' diameter contact condenser was received and set in place in October. An inspection and vacuum test on the 12' diameter contact condenser occurred at the manufacturer's location on October 20, 1980. The large contact condenser arrived on site in mid-November and was set in place. The platforms for the two condensers were installed by the end of November.

At the Heater Treater, the new C.E. Natoc Heater Treater was received in

September and installed on its foundation. In October pipe supports were poured. The design of the tank foundations for the new Heater Treater tank and coalesced water tank were completed. Delivery of the tanks was scheduled for January, 1981.

In September, WESCO was demobilized and The Industrial Company of Steamboat Springs (TIC), the successful bidder on the site electrical contract, was mobilized. Electrical installations on the surface continued. The underground electrical conduits were completed. The generator switchgear was mounted in the generator building. Two total mine power outages were used in mid-October and late November to energize the surface main switchgear and the main underground 4100-volt power system.

Other construction activities included:

- Forming and pouring surface stanchion pads,
- Removing poles from an abandoned electrical line on the surface,
- Receiving the first truckload of offgas/air piping spools,
- Completing the field constructed 2,000 barrel product tank at the Heater Treater,
- Tying in of the Retorts 7 and 8 mine feeder and Heater Treater feeder switchgear,
- Completing design of the offgas piping and expansion space to be prefabricated, and
- Completing all engineering for the Heater Treater.

III. ANALYSIS

A. MR TRACER TESTS

The objective of the MR tracer test program is fourfold:

1. To characterize the rubble in MR's 3 and 4 and attempt to correlate the state of the rubble to the blasting procedure used.

2. To establish an evaluation procedure which will yield reliable information for Retorts 7 and 8.

3. To obtain parameters for use in evaluating pressure drop data.

4. To establish parameters which will allow for the generation of a performance criteria function for MIS retorts.

The tracer injection systems for MR3 and MR4 were constructed in a matrix configuration to allow for both manifold injections over the top area of the rubble and single point injections at various points in the top of the rubble. The product recovery system consisted of three pipes spaced at intervals across the retort bottom and lying in a north-south direction. Three wells were connected to each line and thus made up production manifolds.

The primary purpose of the mini retort program is the prediction of a retort's performance relative to the method in which it was created and the test used to evaluate it prior to retorting. MR3 was evaluated based on the expected advance rate of the flame front.

The propagation of a flame front through a retort is controlled by the mass of air that is available at the combustion front per unit time along with other factors such as presence of water, surface area of the particles, etc. By evaluating the numbers obtained for the first arrival velocities, peak velocities, and standard deviations, the air flow through a retort can be quantitatively defined.

Daily advance rates were calculated for a number of elements of MR3. From these advance rates, locations of the flame front at various points in the retort were calculated at 5, 10 and 15 days into a burn. No corrections were made for conductive and convective heat transfer into the center of the rubble. These heat transfer mechanisms would tend to smooth the advance rates and level the flame front positions.

A core has been obtained from the center of MR3. The coring and tracer tests indicated that MR3 was rubblized fairly well, however, displacement of the rubble may not have been uniform. If conductive and convective heat transfer is considered, we expect MR3 retort to be reasonably efficient.

MR3 and MR4 were evaluated using the same tracer system and the same method of analysis. The retorts were then compared based on tracer response. The conclusions are:

1. MR4 is generally tighter than MR3.

2. MR4 shows improved radial distribution of the tracer.

3. The center of MR4 has about the same tightness as MR3 but flow to the center from the periphery is much improved.

4. Contour maps projecting the position of the flame front with time show that the flame front position for MR4 should be more uniform than that predicted for MR3.

5. Wellhead flow based on tracer dilution techniques generally supported the analysis obtained using tracer data.

B. MR3 BURNER TESTS

The major objective of the MR burner tests is to obtain the information and data needed for the successful ignition of Retorts 7 and 8. In addition, by burning the MR's longer than the time required for burner tests only, more complete information will be acquired on how the retorts are rubblized by monitoring the flame front progress and comparing this information with tracer test results and predictions. Another reason for extending the retorting period was the desire to obtain additional sill temperature effects data.

Over forty people were directly involved in the burner ignition tests conducted November 1 through 5, 1980. These people included process operators, test engineers, supervisors, rock mechanics engineers, technical support from Occidental Research Corporation, sampling team members, computer programmers, data technical support, and Sandia and LETC technical personnel and computer operators.

Pages 11 through 19 are the:

Page

11- MR3 General Piping and Instrument Diagram (P&ID),

12 - Foster Miller Burner System P&ID,

13 - Retort Thermocouple Locations Table,

15 - Thermocouple ID Map,

16 - Air Level Instrumentation Plan,

17 - Sample Tap Locations,

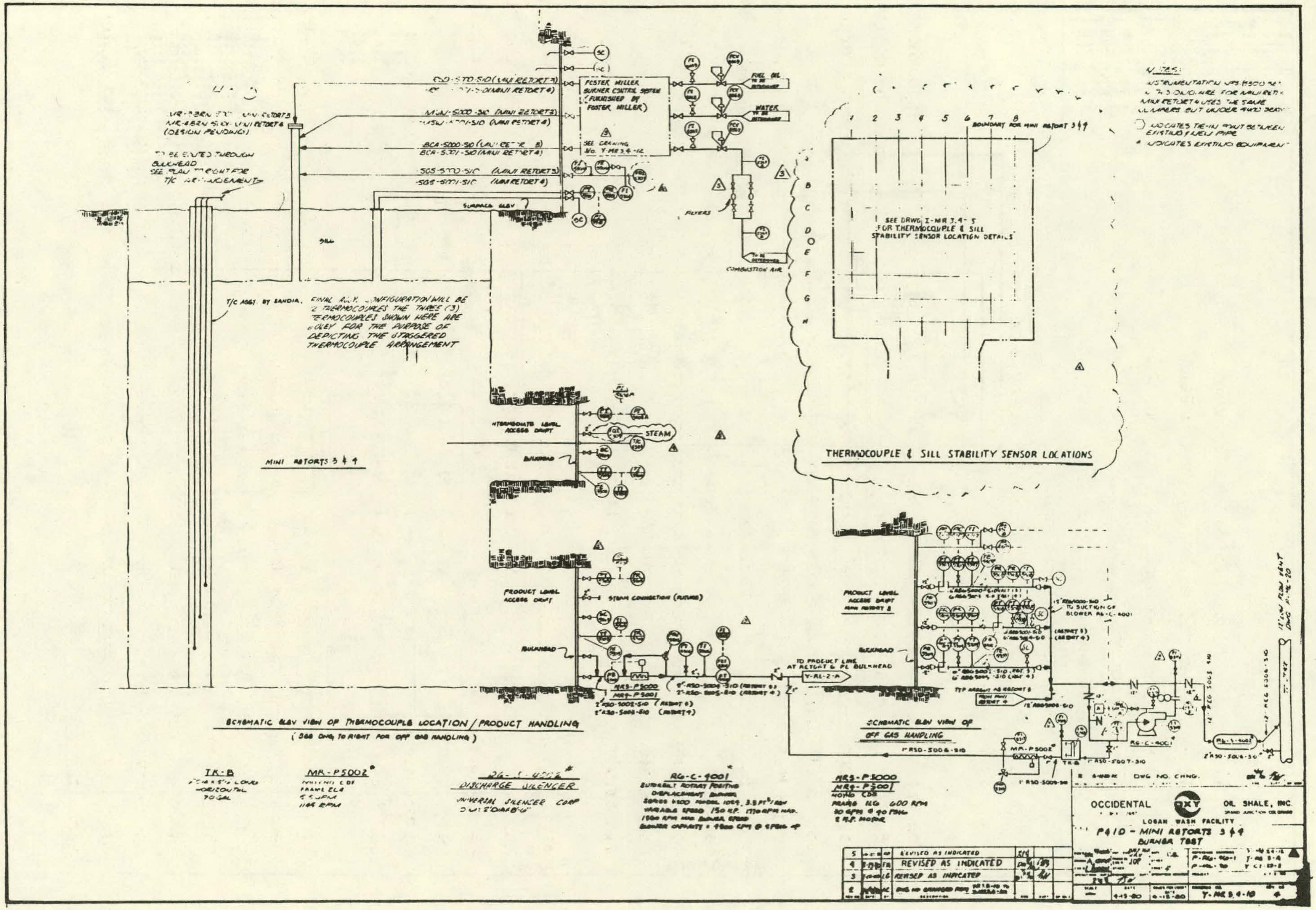
18 - Estimated MR3 & 4 Fischer Assay, and

19 - Plan view of MR3.

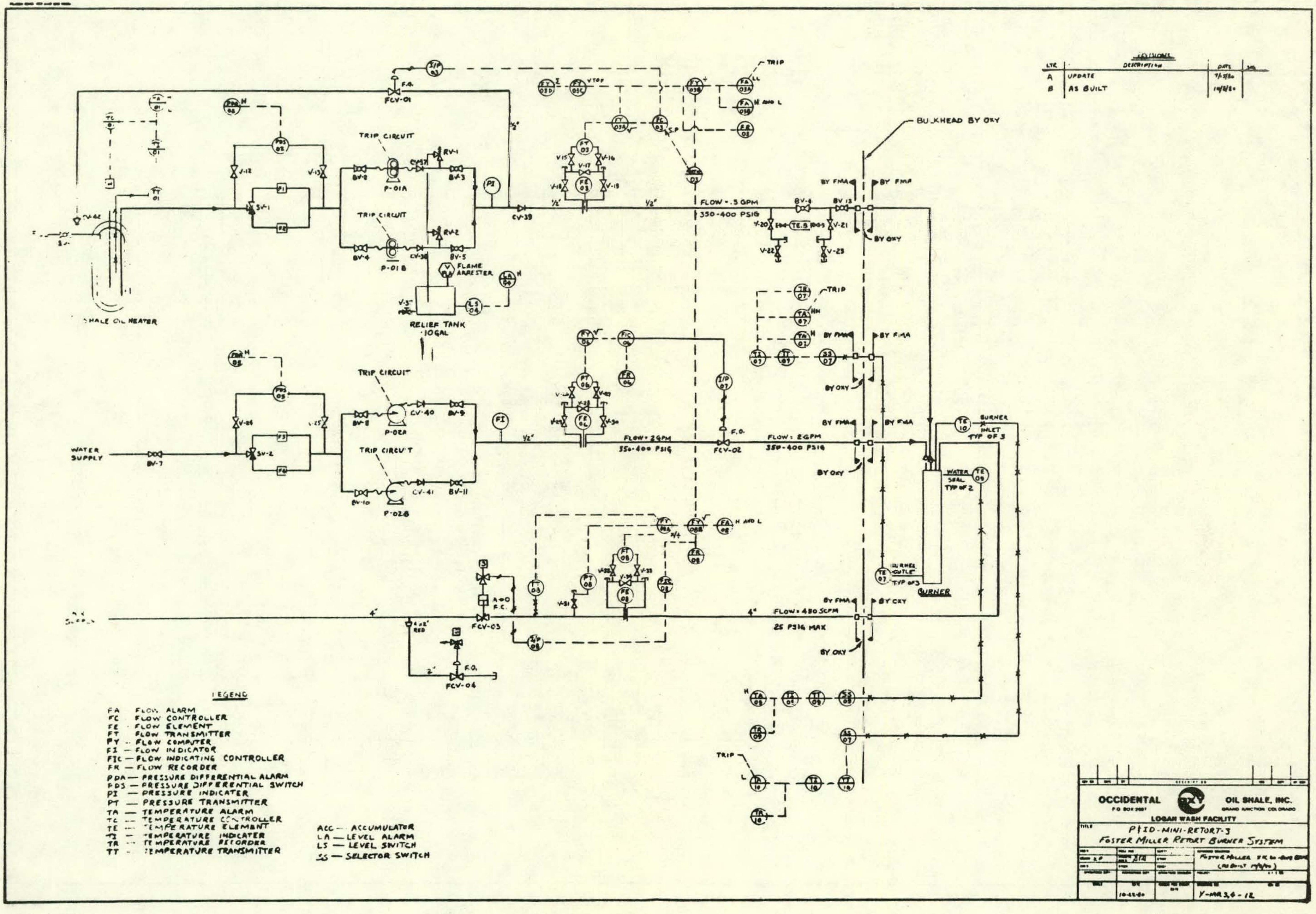
The preliminary results of the MR3 ignition test follow. The first burner "failed" after about 18 hours operation at purge conditions, when the cooling water supply ran out. The second burner failed after about 17 hours operation when a fluctuation in cooling water flow during adjustment of the burner outlet temperature to 1800°F (retort heatup temperature) caused formation of a steam pocket and concomitant severe overpressure in the cooling channel. Both failures are believed to have resulted in mechanical damage to the internal cooling system that prevented burner ignition due to water leakage into the combustion chamber. Foster Miller's fault analysis, to be completed in January, should help explain these failures.

Sill pillar temperatures 1-ft up into the pillar at four locations around the burner, are associated with the first ignition trial on 11/3/80. For the time period 307.8 to 308.4 the burner temperatures were about 200°F and sill pillar temperatures 1-ft into the sill were about 150°F. When these burner temperatures were boosted to about 300°F, sill temperatures rose to about 300°F and remained there more or less until the burner was removed.

It appears that the sill pillar bottom began deteriorating somewhere between temperatures of 150° to 300°F. The thermocouples F4-01, E6-01 and F5-01 were presumed to be fully exposed (in their cased and grouted pipes) to the void at the time the temperature approached 2000°F because they show an almost immediate response to that increase. From an examination of this data and thermocouples deeper (higher up) in these holes it was concluded that an average of 1-ft of rock around the thermocouples mentioned above had fallen into the void.


FOSTER MILLER BURNER CONTROL SYSTEM (FURNISHED BY FOSTER MILLER)
FUEL OIL
WATER
FILTERS
COMBUSTION AIR
SURFACE ELEV
SILL
T/C ASSY BY SANDIA. FINAL ASSY. CONFIGURATION WILL BE 12 THERMOCOUPLES THE THREE (3) THERMOCOUPLES SHOWN HERE ARE ONLY FOR THE PURPOSE OF DEPICTING THE STAGGERED THERMOCOUPLE ARRANGEMENT
SEE DRWG Z-MR 3,4-5 FOR THERMOCOUPLE & SILL STABILITY SENSOR LOCATION DETAILS
BOUNDARY FOR MINI RETORT 3 & 4
THERMOCOUPLE & SILL STABILITY SENSOR LOCATIONS
INTERMEDIATE LEVEL ACCESS DRIFT
STEAM
BULKHEAD
MINI RETORTS 3 & 4
PRODUCT LEVEL ACCESS DRIFT
STEAM CONNECTION (FUTURE)
TO PRODUCT LINE AT RETORT 6 PL BULKHEAD
SCHEMATIC ELEV VIEW OF THERMOCOUPLE LOCATION / PRODUCT HANDLING
(SEE DWG TO RIGHT FOR OFF GAS HANDLING)
SCHEMATIC ELEV VIEW OF OFF GAS HANDLING
TK-B
MR-P5002
DISCHARGE SILENCER
RG-C-4001
MR3-P5000
MR4-P5001
OCCIDENTAL OIL SHALE, INC.
LOGAN WASH FACILITY
P410 - MINI RETORTS 3 & 4 BURNER TEST
REVISED AS INDICATED
REVISED AS INDICATED
REVISED AS INDICATED

11


REVISIONS
LTR | DESCRIPTION | DATE
A | UPDATE
B | AS BUILT
BULKHEAD BY OXY
TRIP
TRIP CIRCUIT
FLAME ARRESTER
RELIEF TANK 10GAL
SHALE OIL HEATER
FLOW = .5 GPM
350-400 PSIG
BY FMA
BY OXY
WATER SUPPLY
FLOW = 2GPM
350-400 PSIG
BURNER INLET TYP OF 3
WATER SEAL TYP OF 2
BURNER OUTLET TYP OF 3
BURNER
FLOW = 480 SCFM
25 PSIG MAX
F.O.
FCV-01
FCV-02
FCV-03
FCV-04
P-01A
P-01B
P-02A
P-02B
LEGEND
FA — FLOW ALARM
FC — FLOW CONTROLLER
FE — FLOW ELEMENT
FT — FLOW TRANSMITTER
FY — FLOW COMPUTER
FI — FLOW INDICATOR
FIC — FLOW INDICATING CONTROLLER
FR — FLOW RECORDER
PDA — PRESSURE DIFFERENTIAL ALARM
PDS — PRESSURE DIFFERENTIAL SWITCH
PI — PRESSURE INDICATER
PT — PRESSURE TRANSMITTER
TA — TEMPERATURE ALARM
TC — TEMPERATURE CONTROLLER
TE — TEMPERATURE ELEMENT
TI — TEMPERATURE INDICATER
TR — TEMPERATURE RECORDER
TT — TEMPERATURE TRANSMITTER
ACC — ACCUMULATOR
LA — LEVEL ALARM
LS — LEVEL SWITCH
SS — SELECTOR SWITCH
OCCIDENTAL OIL SHALE, INC.
GRAND JUNCTION COLORADO
LOGAN WASH FACILITY
P&ID - MINI - RETORT - 3
FOSTER MILLER RETORT BURNER SYSTEM
Y-MR 3,4 - 12

MR-3 RETORT THERMOCOUPLE LOCATIONS

(NOTES EXPLAINING TABLE ARE ON FOLLOWING PAGE)

HOLE NUMBER	M4	E6	F5	D5	E4	F6	D6	D4	F4	E7	C5	G5	F7	E3	G6	C6	G4	D3	C3	C4	G3	F3	G7	H5	E2	G2	H8	E1	A8	H1	A1
HORIZONTAL (RADIAL) DISTANCE FROM BURNER / Tc ELEVATION	4.13	4.64	4.71	5.10	5.24	6.39	6.82	7.05	7.31	9.33	10.10	10.11	10.34	10.50	10.82	10.85	11.09	11.32	11.32	11.33	11.75	11.79	13.64	14.70	15.50	18.38	19.70	20.46	23.65	24.99	26.93
-33																												x			
-32																															
-31																												x			
-30																															
-29																												x			
-28	x	x	x				x		x																x						
-27																												x			
-26	x	x	x				x		x																x						
-25																												x			
-24	x	x	x				x		x																x						
-23																												x			
-22	x	x	x				x		x																x						
-21																												x			
-20	x	x	x				x		x																x						
-19																												x			
-18	x	x	x				x		x																x						
-17																												x			
-16	x	x	x				x		x																x						
-15																												x			
-14	x	x	x				x		x																x			x			
-13																												x			
-12	x	x	x				x		x																x			x			
-11																												x			
-10	x	x	x		x	x	x		x		x										x				x			x			
- 9	x	x	x				x		x													x			x	x		x			
- 8	x	x	x				x		x																x			x			
- 7	x	x	x				x		x																x			x			
- 6	x	x	x				x		x															x	x			x			
- 5	x	x	x		x	x	x		x		x										x				x						
- 4	x	x	x				x		x													x			x	x					
- 3	x	x	x				x		x																x						
- 2	x	x	x		x	x	x		x		x	x									x				x						
- 1	x	x	x		x	x	x		x	x	x	x									x	x	x	x	x	x					
VOID (0.7' ABOVE RUBBLE)										x						x															
0 (0.3		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x				x		x	x	x
2 (1 FOR D5)		x		x	x	x	x	x			x	x	x		x			x	x	x	x		x								
5 (4 FOR D6)		x	x		x	x	x		x		x	x		x	x		x	x			x		x				x		x	x	
8 (7.5)												x	x										x								
10			x		x	x			x		x	x		x			x				x		x				x		x	x	
13 (12.5)												x											x								
15					x	x					x	x		x							x		x						x		x
17 (G7)/18 (H1)																							x							x	
20					x	x					x										x										x
30					x	x					x										x										
40					x	x					x										x										

10/23/80

MR3 RETORT THERMOCOUPLE LOCATIONS

NOTES: Negative TC elevation is height above the sill pillar bottom.

Positive TC elevation is depth from top of rubble.

TC elevation is the computer code for the TC location and is not exact but close. The exact location is shown on the following page.

TC's in holes F3, H5, and G2 were installed by S^3 and will be manually monitored and manually entered into the Sandia computer.

MR-3 RETORT THERMOCOUPLE ID MAP

LEFT COLUMN IS COMPUTER REFERENCE CODE AND RIGHT COLUMN IS ACTUAL DEPTH
NEGATIVE REFERENCED TO SILL BOTTOM AND POSITIVE REFERENCED TO TOP OF RUBBLE

```
A1      * A8        * C3       * C4        * C5        * C6        * D3       *
00  0.3 * 00    0.3 * 00   0.3* 00     0.3 *-10 -10.0 *-00 (-1.0)* 00   0.3 *
15 15.0 * 05    5.0 * 02   2.0* 02     2.0 *-05  -5.0 * 00    0.4 * 02   2.0 *
20 17.9 * 10   10.0 *          *           *-02  -2.0 *           * 05   5.0 *
        * 15   17.4 *          *           *-01  -1.0 *           *          *
*******************            *           * 00   0.3 *           *          *
H1      * H8        *          *           * 02   2.3 *           *          *
00  0.3 * 00    0.3 *          *           * 05   5.3 *           *          *
05  5.0 * 05    5.0 *          *           * 10  10.3 *           *          *
10 10.0 * 13   12.5 *          *           * 15  15.3 *           *          *
18 17.5 *           *          *           * 20  20.3 *           *          *
        *           *          *           * 30  30.3 *           *          *
        *           *          *           * 40  40.3 *           *          *
*****************************************************************************
D4      *  D5       *E3        * E7        * F7        * G4        *G6       *
00  0.3 *  00   0.3 *00    0.3 *-01   -1.0 * 00    0.3 * 00   0.3  *00   0.3 *
02  2.0 *  01   1.0 *05    5.0 *-00 (-1.0)* 02    2.0 * 05   5.0  *02   2.0 *
        *           *10   10.0 * 00    0.3 * 08    7.5 * 10  10.0  *05   5.0 *
        *           *15   15.0 *           *           *           *          *
*****************************************************************************
D6        * E1        * E2        * M4        * E6        * F4        * F5        *
-28 -28.0* -28 -28.0* -28 -28.0* -28 -28.0* -28 -28.0* -28 -28.0* -28 -28.0*
-26 -26.0* -26 -26.0* -26 -26.0* -26 -26.0* -26 -26.0* -26 -26.0* -26 -26.0*
-24 -24.0* -24 -24.0* -24 -24.0* -24 -24.0* -24 -24.0* -24 -24.0* -24 -24.0*
-22 -22.0* -22 -22.0* -22 -22.0* -22 -22.0* -22 -22.0* -22 -22.0* -22 -22.0*
-20 -20.0* -20 -20.0* -20 -20.0* -20 -20.0* -20 -20.0* -20 -20.0* -20 -20.0*
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-01  -1.0* -01  -1.0* -01  -1.0* -01  -1.0* -01  -1.0* -01  -1.0* -01  -1.0*
00    0.3*           *           *           * 00    0.3* 00    0.3* 00    0.3*
02    2.0*           *           *           * 02    2.0* 05    5.0* 05    5.0*
04    4.1*           *           *           * 05    4.6* 10   10.0* 10    9.8*
*******************************************************************************
F6         * G3         * G5         * G7         * E4         * G2         *
-10  -10.0* -10  -10.0* -02   -2.0* -01   -1.0* -10  -10.0* -01   -1.0*
-05   -5.0* -05   -5.0* -01   -1.0* 00     0.3* -05   -5.0*************
-02   -2.0* -02   -2.0* 00     0.3* 02     2.0* -02   -2.0* F3         *
-01   -1.0* -01   -1.0* 02     2.0* 05     5.0* -01   -1.0* -01   -1.0*
00     0.3* 00     0.3* 05     5.0* 08     7.5* 00     0.3*************
02     2.3* 02     2.3* 08     7.5* 10    10.0* 02     2.3* H5         *
05     5.3* 05     5.3* 10    10.0* 13    12.5* 05     5.3* -01   -1.0*
10    10.3* 10    10.3* 13    12.5* 15    15.3* 10    10.3*************
15    15.3* 15    15.3* 15    13.8* 17    16.5* 15    15.3*
20    20.3* 20    20.3*            *            * 20    20.3*
30    30.3* 30    30.3*            *            * 30    30.3*
40    40.3* 40    38.7*            *            * 40    38.4*
```
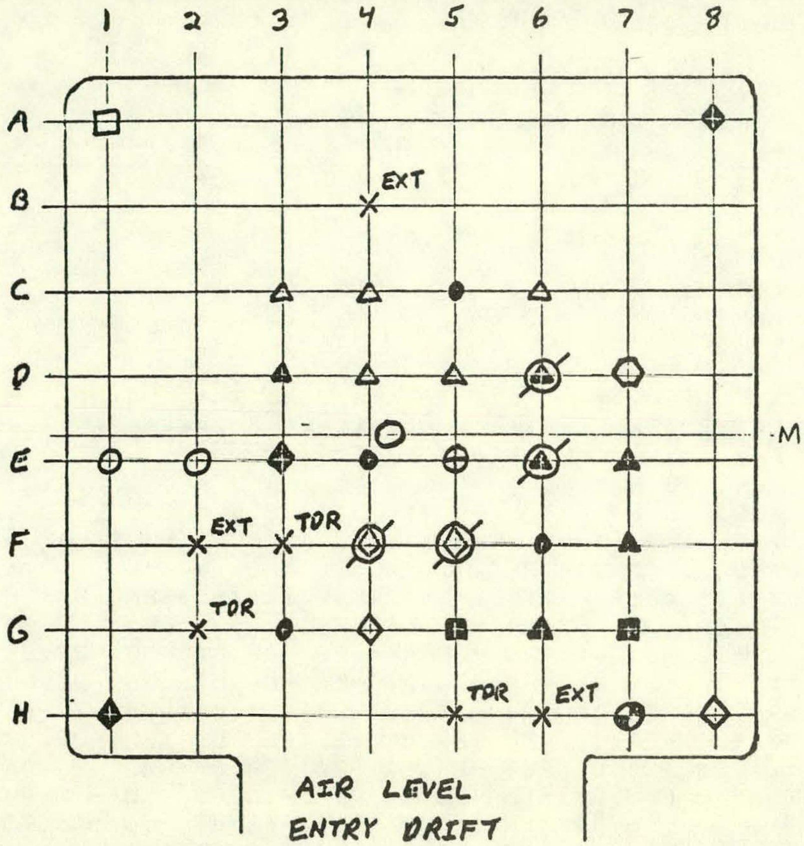

MR 3 RETORT INSTRUMENTATION - AIR LEVEL PLAN



SYMBOL	HOLE DESCRIPTION	INSTRUMENT DESCRIPTION
⊕	BURNER	FOSTER MILLER, 8 TC's ON BURNER
● (with cross)	ALTERNATE AIR/STEAM ADD'N.	
× EXT	ROD EXTENSOMETER	TERRAMETRICS, 4 ANCHORS PER HOLE GROUTED IN PLACE
× TDR	TIME DOMAIN REFLECTOMETER	S^3, ONE TDR CABLE AND ONE TC PER HOLE
○	SILL PILLAR TC's	OXY, 19 TC's PER HOLE GROUTED IN UNCASED HOLE OR GROUTED IN CASING ON SHARED HOLES
●	TC BUNDLE	SANDIA, 12 TC's PER HOLE - 4 IN PILLAR, 8 IN RUBBLE
■	TC BUNDLE	SANDIA, 9 TC's PER HOLE - 1 IN PILLAR, 8 IN RUBBLE
△	TC's AND SAMPLE TAP	SANDIA, 2 TC's IN RUBBLE PER HOLE
▲	TC's AND SAMPLE TAP	SANDIA, 3 TC's IN RUBBLE PER HOLE
◇	TC's AND SAMPLE TAP	SANDIA, 3 TC's IN RUBBLE PER HOLE
◆	TC's AND SAMPLE TAP	SANDIA, 4 TC's IN RUBBLE PER HOLE
□	TC's	SANDIA, 3 TC's IN RUBBLE PER HOLE
/	TC's WITHOUT SAMPLE TAP	
⬡ VOID	PRESSURE AND SAMPLE TAP	OXY, PRESSURE TRANSMITTER

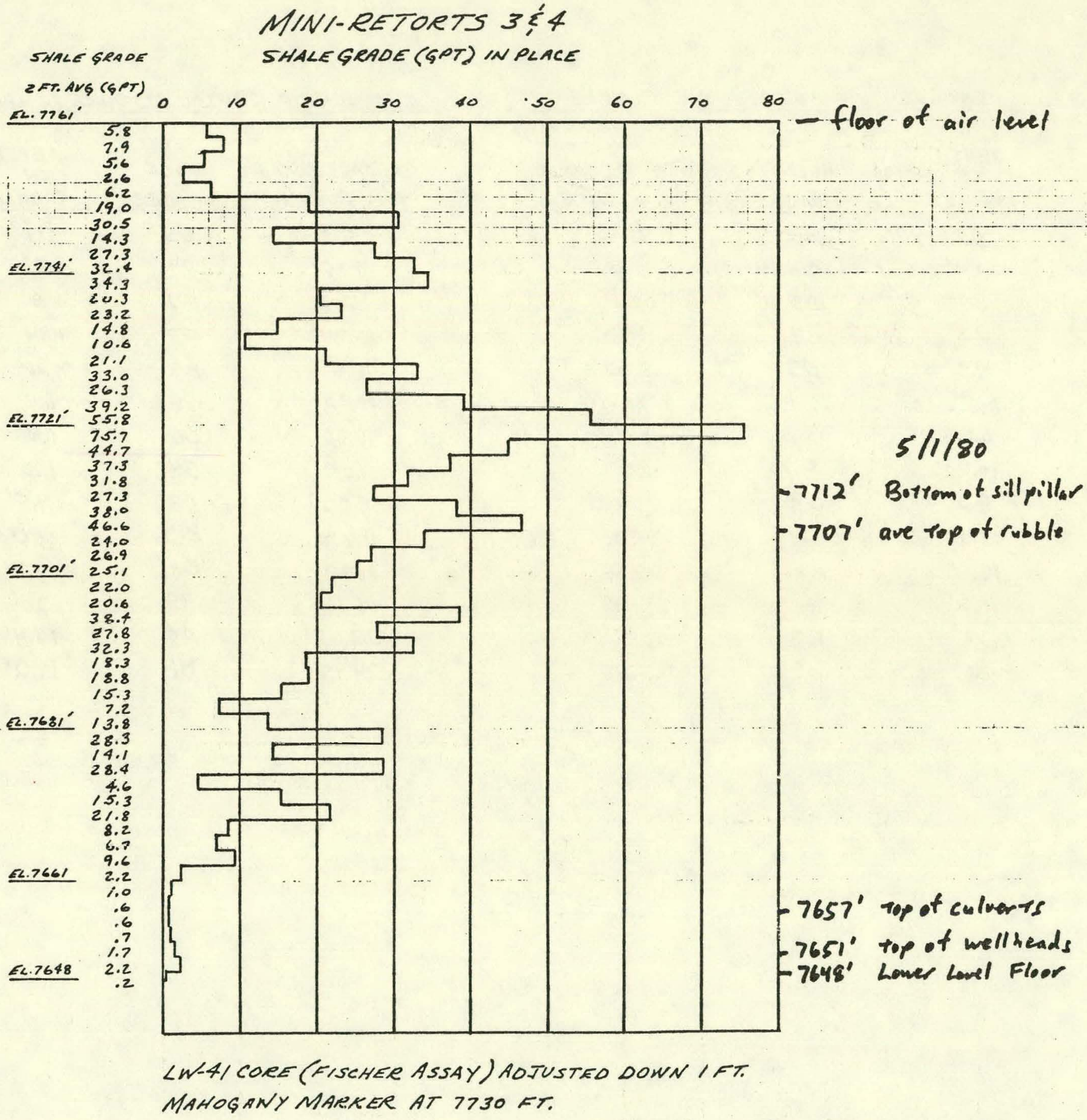
MR-3 RETORT SAMPLE TAP LOCATIONS

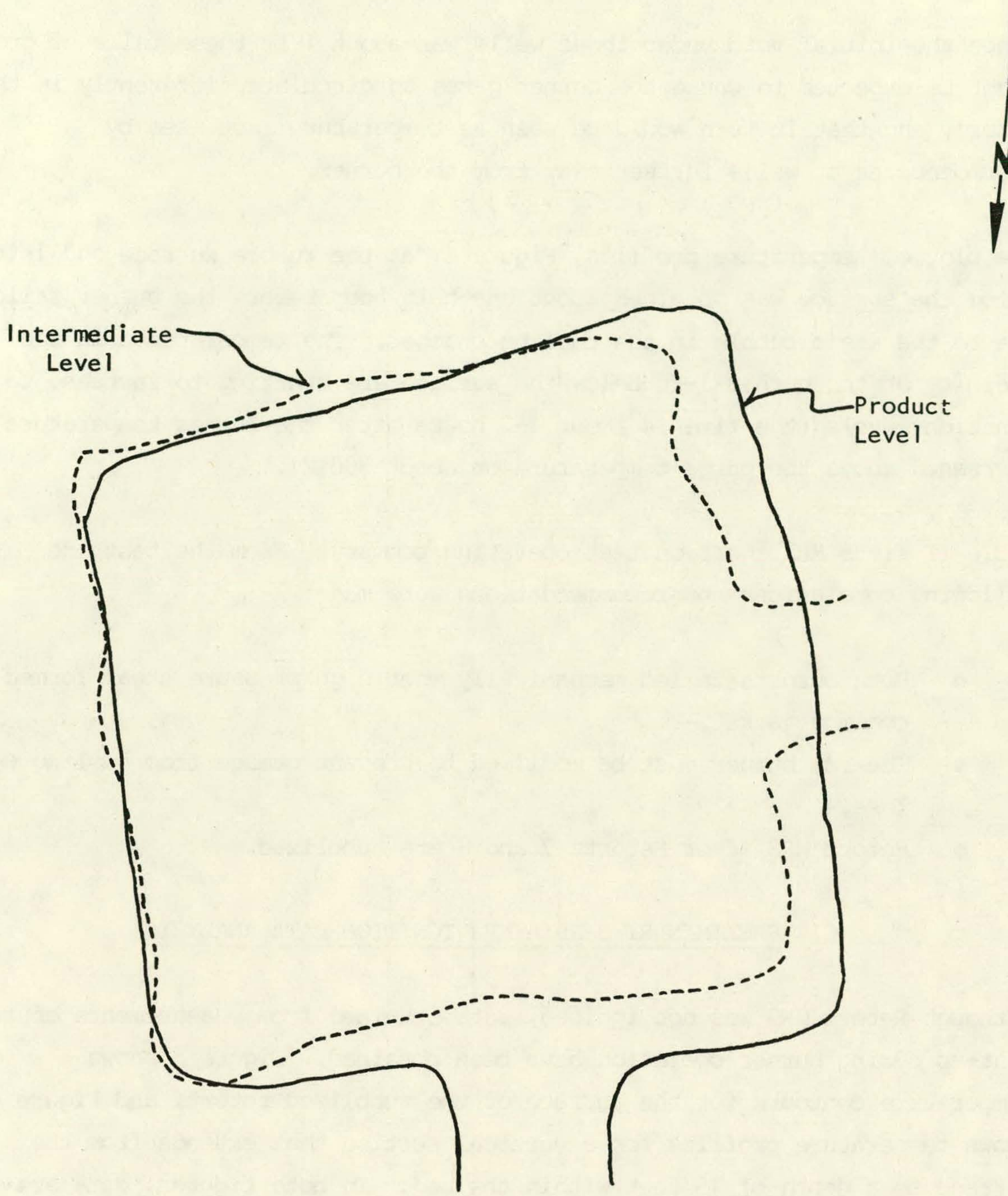
IN ORDER OF DEPTH IN RUBBLE

DEPTH IN RUBBLE	HOLE NUMBER	RADIAL DISTANCE FROM BURNER
0.8'	E7	9.33'
1.4'	C6	10.85'
2.0'	D5	5.1'
3.6'	C3	11.32'
4.5'	D3	11.32'
~5'	D4	7.05'
6.7'	G6	10.82'
10.4'	F7	10.34'
11.2'	G4	11.09'
13.7'	C4	11.33'
18.4'	A8	23.65'
19.2'	H1	24.99'
~20'	E3	10.5'
~20'	H8	23.65'

IN ORDER OF RADIAL DISTANCE FROM BURNER

RADIAL DISTANCE FROM BURNER	HOLE NUMBER	DEPTH IN RUBBLE
5.1'	D5	2.0'
7.05'	D4	~5'
9.33'	E7	0.8'
10.34'	F7	10.4'
10.5'	E3	~20'
10.82'	G6	6.7'
10.85'	C6	1.4'
11.09'	G4	11.2'
11.32'	D3	4.5'
11.32'	C3	3.6'
11.33'	C4	13.7'
19.7'	H8	~20'
23.65'	A8	18.4'
24.99'	H1	19.2'


MINI-RETORTS 3 & 4
SHALE GRADE (GPT) IN PLACE
SHALE GRADE
2 FT. AVG (GPT)
0
10
20
30
40
50
60
70
80
EL. 7761'
EL. 7741'
EL. 7721'
EL. 7701'
EL. 7681'
EL. 7661
EL. 7648
5.8
7.9
5.6
2.6
6.2
19.0
30.5
14.3
27.3
32.4
34.3
20.3
23.2
14.8
10.6
21.1
33.0
26.3
39.2
55.8
75.7
44.7
37.3
31.8
27.3
38.0
46.6
24.0
26.9
25.1
22.0
20.6
38.4
27.8
32.3
18.3
18.8
15.3
7.2
13.8
28.3
14.1
28.4
4.6
15.3
21.8
8.2
6.7
9.6
2.2
1.0
.6
.6
.7
1.7
2.2
.2
— floor of air level
5/1/80
7712' Bottom of sill pillar
7707' ave top of rubble
7657' top of culverts
7651' top of wellheads
7648' Lower Level Floor
LW-41 CORE (FISCHER ASSAY) ADJUSTED DOWN 1 FT.
MAHOGANY MARKER AT 7730 FT.
KEITH PHILLIPS MAY 5, 1980



Plan view of MR3 showing Intermediate and Product Level outlines.

Since the initial void under those wells was about 1-ft these falls of ground might be expected to cause the burner gases to circulate differently in the future, and that in turn would be seen as temperature increases by thermocouples at wells further away from the burner.

The plot of temperature profiles, Figure 4, at the rubble surface and 1-ft below the surface was obtained about one-half hour before the burner failed due to the steam bubble in the cooling chamber. The temperatures in the vicinity of the burner 1-ft below the surface are starting to increase to ignition levels (the time is about 1-2 hours after the burner temperature was increased above the purge temperature or about 300°F).

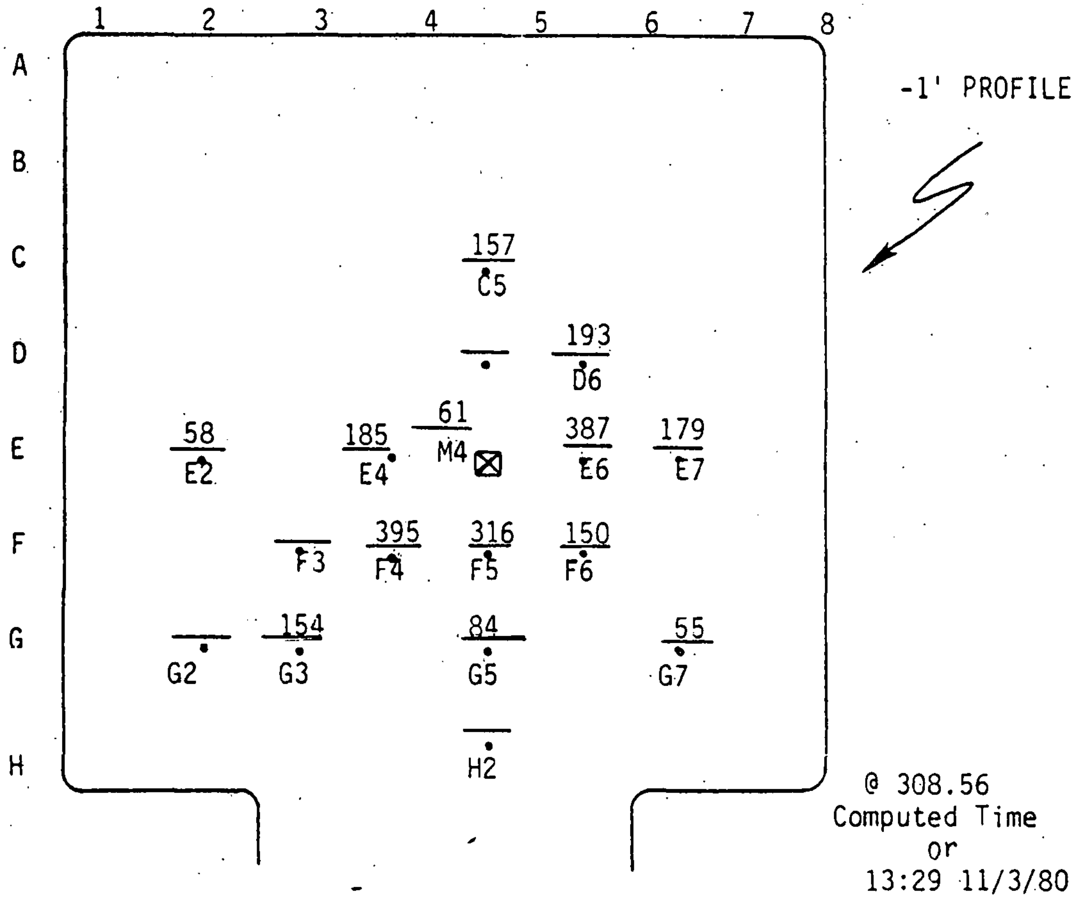
Table II lists MR3 ignition test operating summary. From the test the following conclusions and recommendations were made:

- Both burners failed mechanically when high pressure steam formed in cooling jacket.
- The FMA burner must be modified to prevent damage from cooling water loss.
- Retort MR3 after Retorts 7 and 8 are rubblized.

C. PRELIMINARY SANDIA MR3 IGNITION DATA ANALYSIS[1]

Although Retort MR3 was not ignited, data obtained from measurements of retort heat-up during burner operation have been obtained. Figure 5 shows temperature contours for the surface of the rubblized retort, and Figure 6 shows temperature profiles for a vertical section that extends from the surface to a depth of 15 feet within the bed. In both figures, data are plotted at times corresponding to the end of the first ignition attempt using the second burner. The contours of Figure 5 indicate that heat from the burner exhaust affected a small localized area and spread out from this area in a somewhat uniform fashion. The anomalous shape of the contour in the upper left quadrant is an artifice of the computer program that makes use of an algorithm not well suited to the treatment of regions of sparse data.

1 From Sandia November Monthly report, T. F. Bartel, author.



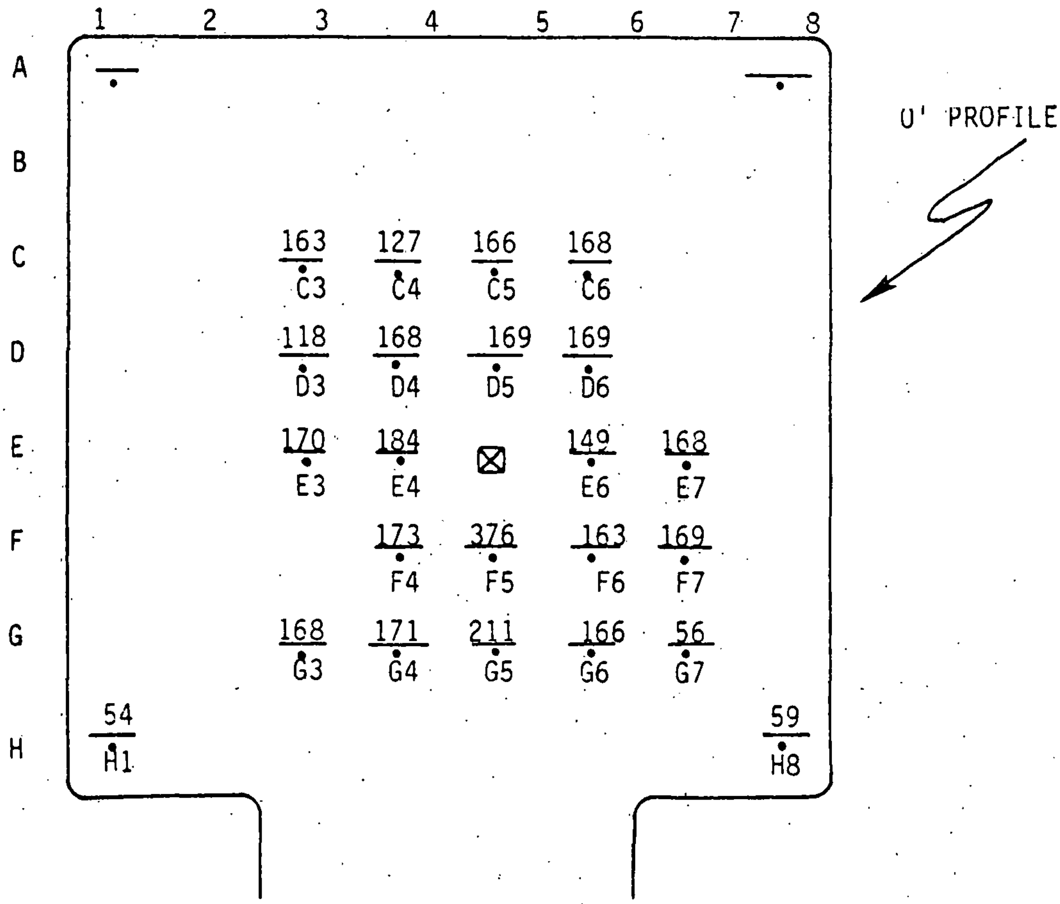


Figure 4. Plot of temperature profiles for MR3 at the rubble surface and one foot below the surface.

TABLE II
MR3 START-UP TEST OPERATING SUMMARY

DATE	TIME	BURNER NO.	RUN NO.	
11/01/80	1500	1	1	Ignited burner, ran at purge condition.
11/02/80	0912	1	1	Lost cooling water, burner shutdown.
11/02/80	1525	1	2	Tried to reignite burner.
	1600	1	2	Vent valve ruptured. Burner seal damaged. Removed burner.
11/02/80	2115	2	1	Ignited burner, air flow 170 scfm
11/03/80	0936			Increased air flow 220 scfm
	1100			Increased air flow 250 scfm
	1330			Increased air flow 300 scfm
	1340			Increased air flow 340 scfm
	1400			Burner flame out. Interlocked down, burner exhaust to 2200°F.
11/03/80	1430	2	1	Removed burner 800 scfm air into MR3 ignited rubble E6-01 up to 1059°F F4-01 up to 1382°F Replaced and reinforced water vent valve
	1560			Shut-off offgas blower, shut-off inlet.
	2000	2	2	Ignited burner. Unstable operation for 15 minutes
	2125			Removed burner and bottled retort.
11/04/80	Day Shift	2		Added separate water lines (2 - Y4 plastic tubes) to seal.
	1840	2	3	Ignited burner, operated about 15 minutes Venturi temperature to 315°F then down at 68°F.
	1900	2	3	Burner stuck in hole, Maintained 10 scfm through retort,
	Swing Shift	1		Rewelded baffles at top of air venturi.
11/05/80	1450	2	3	Removed burner after soaping downhole offgas flow increased from 60 scfm to 2200 scfm. F5-01 increased from 350°F to approximately 400°F. F4-01 increased from 350°F to approximately 400°F.
	2015	1	3	Ignited burner, unstable condition. Venturi temperature to 405°F. Outlet to 360°F. Shutdown after 15 minutes
	2135	1	3	Removed burner.
	2200			Offgas blower shutdown Retort bottled up.

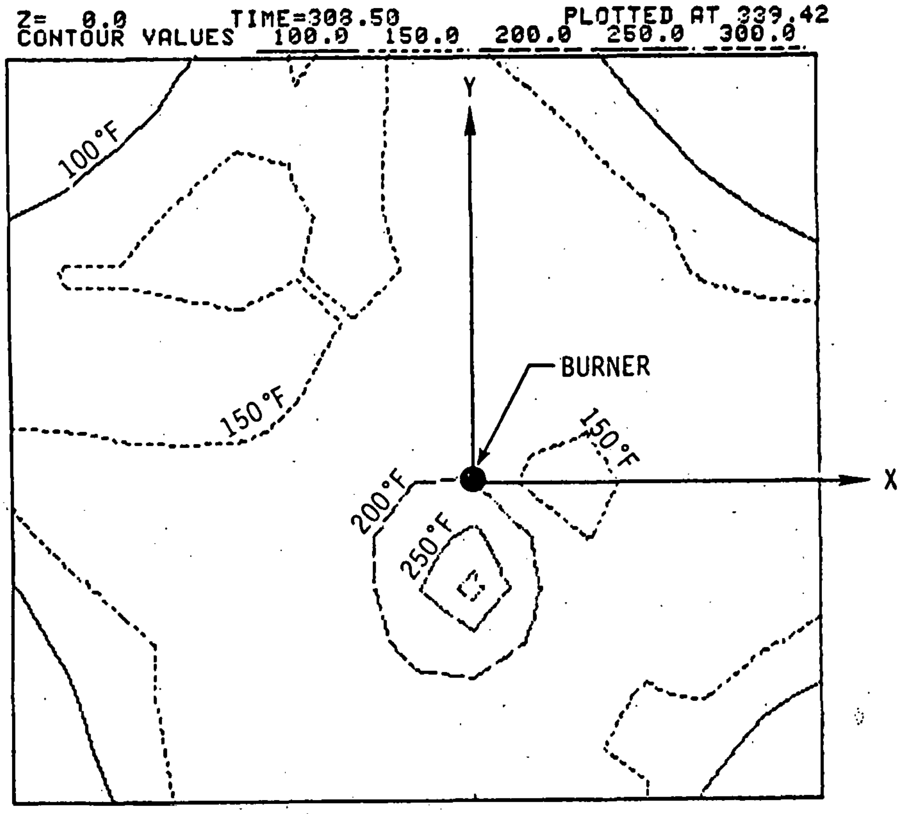


Figure 5. Temperature Contours on the Rubble Surface.

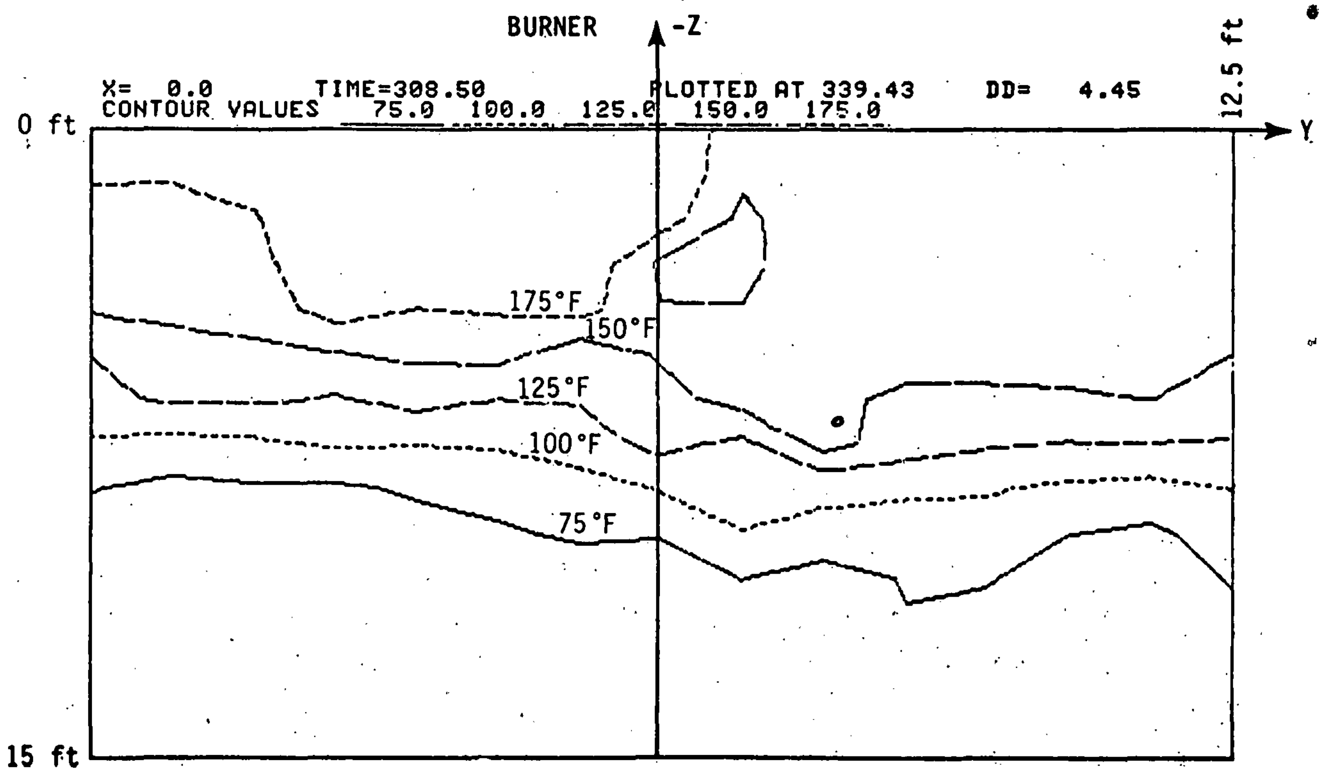


Figure 6. Temperature Contours in the Z-Y Plane.

Figure 6 shows that constant temperature profiles are almost planar at various depths in the bed. Although the effects of coupled convective and conductive heat transport on the temperature distribution have not yet been examined, both Figures 5 and 6 tend to support an argument for a uniform distribution of bed permeability.

Use of data obtained from airflow or tracer measurements may be used to infer the permeability distribution within the unretorted bed. A given distribution can, in turn, be used in the calculation of the bed's three-dimensional velocity field from which predictions of output flow, based on known input flows, can be made. Comparison of predicted and observed flows is the basis for making improvements in the original distribution. This inversion technique, applied iteratively, can provide an improved estimate of the permeability distribution with each iteration. The improved distribution that affords reasonable correspondence between observed and calculated flows may be regarded as a suitable description of bed permeability, but it cannot be regarded as unique. Indeed, the permeability distribution for the unretorted bed that is consistent with tracer data may not be consistent with data obtained from measurements of other bed parameters. In this regard, the MR3 heat-up data (for which contributions from chemical reactions are absent) can be used in conjunction with thermal modeling techniques, which include convective and conductive heat transport, to confirm the reasonableness of the inferred permeability and, hence, to validate an inversion technique that relies solely upon airflow or tracer data*.

D. RETORTS 7 AND 8 CORE

The data and analyses completed through November include the Retorts 7 and 8 core (LW-156) caliper log, core hole location, and the lithologic description of the core. The lithologic description was performed by Larry Trudell at the DOE Laramie Energy Technology Center and is included in Appendix A along with the other data.

* In commercial operation, it is expected that tracer data will provide the principal information from which unretorted bed permeability may be inferred. Therefore, it is useful to seek an independent check on the utility of the inversion technique.

IV. OOSI FUNDED ROCK FRAGMENTATION PROGRAM

On Thursday, August 28, 1980 the second pillar test (PT-2L) was detonated. This was the second of two tests to study pillar destruction prior to Retorts 7 and 8 rubbling. In September the post-shot survey was conducted.

Two full-scale operational test holes (FSOP) were loaded on Monday, September 22 and detonated on Friday, September 26, 1980. These tests, comparing explosive products from various suppliers, simulated the loading conditions and lengthy loading cycle for Retorts 7 and 8. Further full-scale operational tests were conducted during October. Test holes 6, 7, 8 and 9, located underground, were loaded October 28 and detonated on November 3, 1980. Three detonated, but at a low-order velocity; one misfired but was reprimed and shot on November 4, 1980. These holes were loaded with a pumpable DuPont bulk product. After a meeting with DuPont in December on low-order detonation of this explosive, a decision was made to use the packaged product used for Retorts 5 and 6 in Retort 7, 8 and 8x because the low order detonation of the DuPont explosive was confirmed by DuPont.

At the end of November FSOP holes 10, 11 and 12 were loaded with the packaged product for detonation seven days later on December 5, 1980. Pillar test holes loaded pneumatically with a cartridged product and having a seven day wait time are also planned.

A quarter-scale array floor shot (FS-8L) using the DuPont bulk product was conducted in October to compare this product with previous quarter-scale tests in the Rock Fragmentation program that used different explosive products.

V. DOE FUNDED SUPPORT

The Sandia assembly of the MR3 thermocouple strings, begun in August, was completed in September. Following grouting of the castings in the instrument drill holes, the thermocouple assemblies were installed. Cabling was pulled from the enty drift to each zone box. Wiring of each thermocouple lead and uphole cable lead was completed at the zone boxes and entry drift junction boxes.

Software to control and manage the data taken from the thermocouples and process instrumentation was completed and entered into the computer in September. In October, a special phone line was installed for computer communication between Logan Wash and the DOE in Grand Junction and the Sandia Labs in Albuquerque. Pre-start-up data were recorded and software and instrument systems checked out. On September 22, the first Sandia produced mass spectrometer system (10 channels vs. 30) was shipped to Logan Wash from the Sandia Labs to attempt a cold flow test on MR4. Because drilling of the MR4 rubble holes had to start on October 1, significant testing could not be completed due to problems with site electrical power, the need to add a filter system to the trailer gas sample inputs, work to adapt the OOSI injection system to the mass spectrometer system, and the presence of a large amount of water in the MR4 rubble bed. The instrumentation trailer was returned to Sandia for additional work. A program to verify the system in the laboratory with the possibility of running cold tests on MR5 and hot tests on MR4 prior to Retorts 7 and 8 is being pursued.

The data acquisition and recording system for MR3 was completed and tested. Problems that arose during system checkout and during the MR3 ignition attempt were eliminated. The system is capable of collecting and processing information that is pertinent to the monitoring and control of retorting processes. Data that are obtained from measurements such as thermal, flow, and gas composition measurements, as well as manually entered measurements, can be analyzed by the computer to give derived information including information concerning mass balances and burner performance. Results of these calculations can be displayed on two sets of two TV monitors. Real-time control parameters such as retort and burner temperatures and flows can also be displayed on these monitors. Permanent records can be obtained in the form of lists or plots of any measured or known process variable versus another. For example, sectional views of temperature contours in the retort can be plotted for specified process times.

In addition to the four main terminals associated with Trailer B-61, the data acquisition system supports three remote terminals. Each of these remote data links is designed to provide a specialized subset of the information processing capabilities of the main work stations in B-61. These specialized capabilities are tailored to the data display and processing requirements that exist at terminals located in the Grand Junction DOE office, the OOSI control room, and the OOSI gas chromatograph shed.

During the checkout of the data acquisition and recording system, undesirable randomly occurring transients were observed on particular data channels. The cause of the transients was not identified, but the source of the problem was narrowed to the comux system. Replacement of relay cards for the affected channels eliminated this problem.

For no explicable reason, the data acquisition system's Mod Comp computer shut down several times during the first 18 hours of the MR3 ignition attempt. After each shutdown, the system was rebooted with no apparent ill effect upon data collection. Because the system was being severely taxed through constant use of the four main terminals, shutdown as a result of system overload was suspected. By making field modifications to the software that limited terminal access to the main frame and decreased data acquisition scan rates, the shutdowns were halted.

Attempts to ignite MR3 were unsuccessful due to failure of the Foster-Miller Associates' downhole burners as as described in Section III, B.

After termination of MR3 ignition attempts, the cables connecting the data acquisition and recording system with the MR3 thermocouples were cut at the entry drift Nema boxes, and multi-pin connectors were installed to allow connection to MR4 cables. MR3 cables will need to be terminated in mating connectors prior to the resumption of MR3 ignition tests.

The instrumentation and monitoring equipment for MR4 will be essentially the same as that used for the MR3 ignition. Approximately 265 thermocouples, divided between the sill and rubble bed, will sense sill and rubble temperatures. Burner operation, hot gas input, and output gas and liquid parameters will be recorded. Installation and checkout of the sill and rubble temperature sensors is expected to be complete by mid-December.

VI. ENVIRONMENTAL SUPPORT

The purpose of this section is to present a summary of permit status and to update the environmental monitoring performed in conjunction with oil shale retorting research activities at the Occidental Oil Shale, Inc., Logan Wash mine site. Environmental monitoring has been conducted in accordance with requirements of applicable permits and the DOE contract. This report covers data monitored during August through October, 1980 and data not previously reported.

Environmental data currently being collected in the monitoring program for air and water are identified in Tables III and IV. These tables identify stations, the measurements taken at each station, the elevation at the station for collecting meteorological data, and the station codes used with a computerized data base for the data.

The locations of environmental monitoring installations are shown on a map of the area in Figure 7. The various types of monitoring stations are identified by symbols. The locations of past retorts and Retorts 7 and 8 are shown for reference. Several water quality monitoring wells located within the mine or near the retorts are not shown on this map but are presented in Figures 8, 9, 10, and 11. Several photopoints for the photographic monitoring program are shown on the map. These are used for monitoring physical and biological changes that may be related to shale oil retorting.

Figure 12 presents an elevation profile along a cut from alluvial monitoring well 101 to the Retort 6 stack, and then to the meteorological tower to depict the terrain variations. The elevation scale is in feet above mean sea level. While the horizontal scale is compressed in the figure, the steep slope and elevation change within the monitoring areas are quite significant. Elevation contours are shown on the map, Figure 7.

TABLE III

AIR QUALITY/METEOROLOGICAL MONITORING STATIONS AT LOGAN WASH SITE

Station Location	Station Code	Measurment	Elevation Level
Guard Gate	LW04	Temperature) Relative Humidity)	2 Meter
		Evaporation	
		Precipitation	
Heater-Treater	LW01	Wind Direction) Wind Speed) Temperature)	10 Meter
		Inversion Height	
Lower Bench	LW03	Temperature) Relative Humidity)	2 Meter
		Precipitation	
Meteoroligical Tower	LW02	Wind Direction) Wind Speed) Temperature) Delta Temperature) Particulates)	30 Meter
		Temperature) Relative Humidity) Solar Radiation)	2 Meter
		Evaporation	
		Precipitation	

TABLE IV

WATER MONITORING STATIONS AT LOGAN WASH SITE

Water Type	Station	Computer Code
Alluvial Wells	LW22	LWA022
	LW101A	LWA100
	LW101	LWA101
	LW102	LWA102
	LW103	LWA103
	LW104	LWA104
	LW112	LWA112
	LW115	LWA115
	LW121	LWA121
Deep Wells	LW32	LWD032
	LW33	LWD033
	LW45	LWD045
	LW46	LWD046
	LW47	LWD047
	LW106	LWD106
	LW108	LWD108
	LW116	LWD116
Retort 6 Wells	LMB1	LWD601
	PLRL1	LWD602
	LILSW1	LWD603
	LILSW2	LWD604
	LILN3	LWD605
	L2PS1	LWD606
	L2PS2	LWD607
	UIL600	LWD608
	ALN1	LWD609
	UILSW1	LWD610
	UILSE2	LWD611
Retorts 1-6	Top Retort 1	LWR000
	Bottom Retort 1	LWR001
	Bottom Retort 2	LWR002
	Bottom Retort 3	LWR003
	Bottom Retort 4	LWR004
	Bottom Retort 5	LWR005
	Bottom Retort 6	LWR006
Streams	Bowdish Gulch	LWS001
	Logan Wash	LWS002
	Upper Roan Creek	LWS003
	Smith Gulch	LWS004
	Kelly Gulch	LWS005
	Riley Gulch	LWS006
	Upper Parachute Creek	LWS007
	Dry Gulch	LWS008
	Lower Roan Creek	LWS013
	Lower Parachute Creek	LWS017
Mine Discharge	Dry Gulch at Flume	LWM001
	Research Port Hole	LWM002

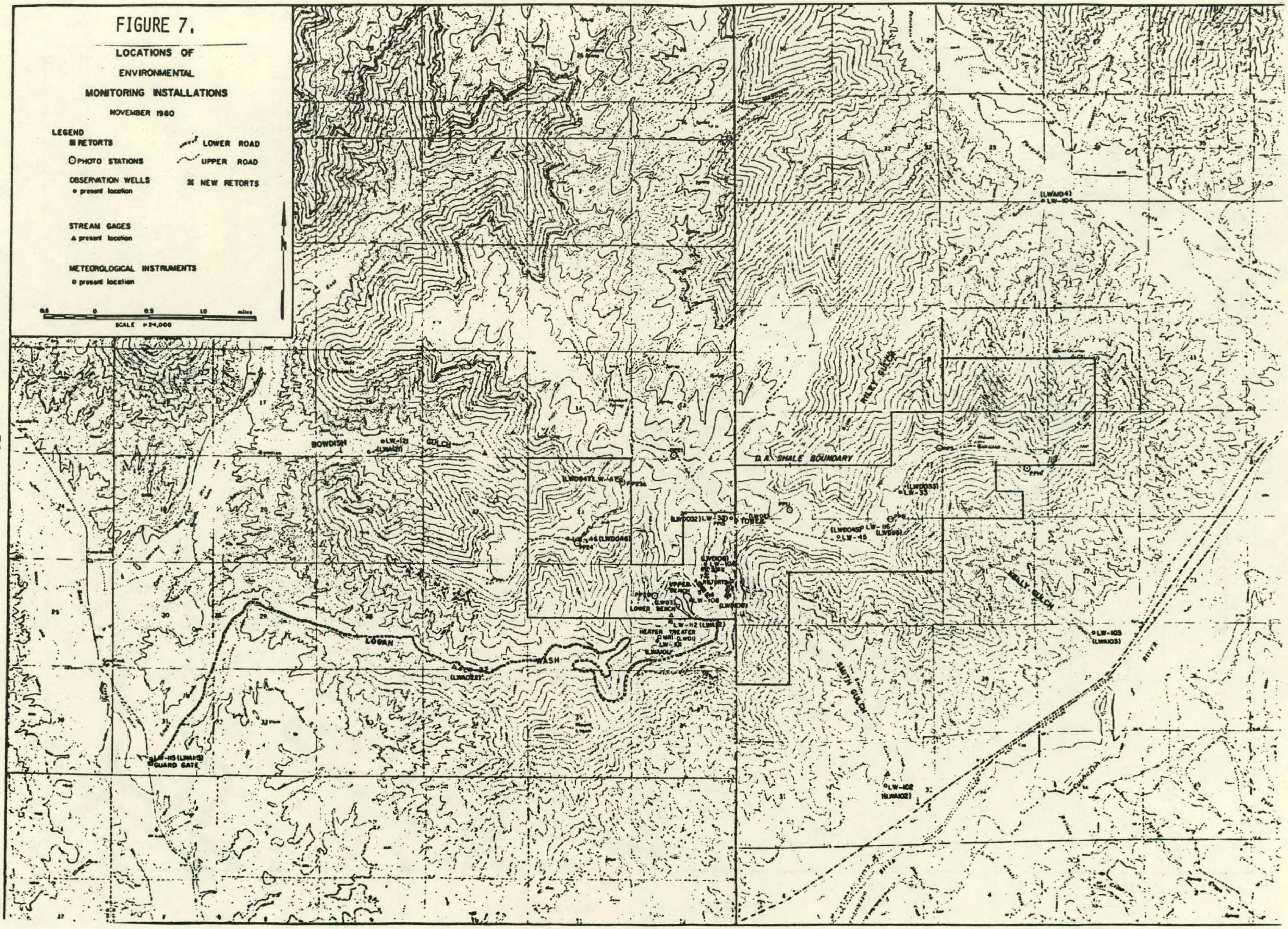


FIGURE 7.

LOCATIONS OF ENVIRONMENTAL MONITORING INSTALLATIONS

NOVEMBER 1980

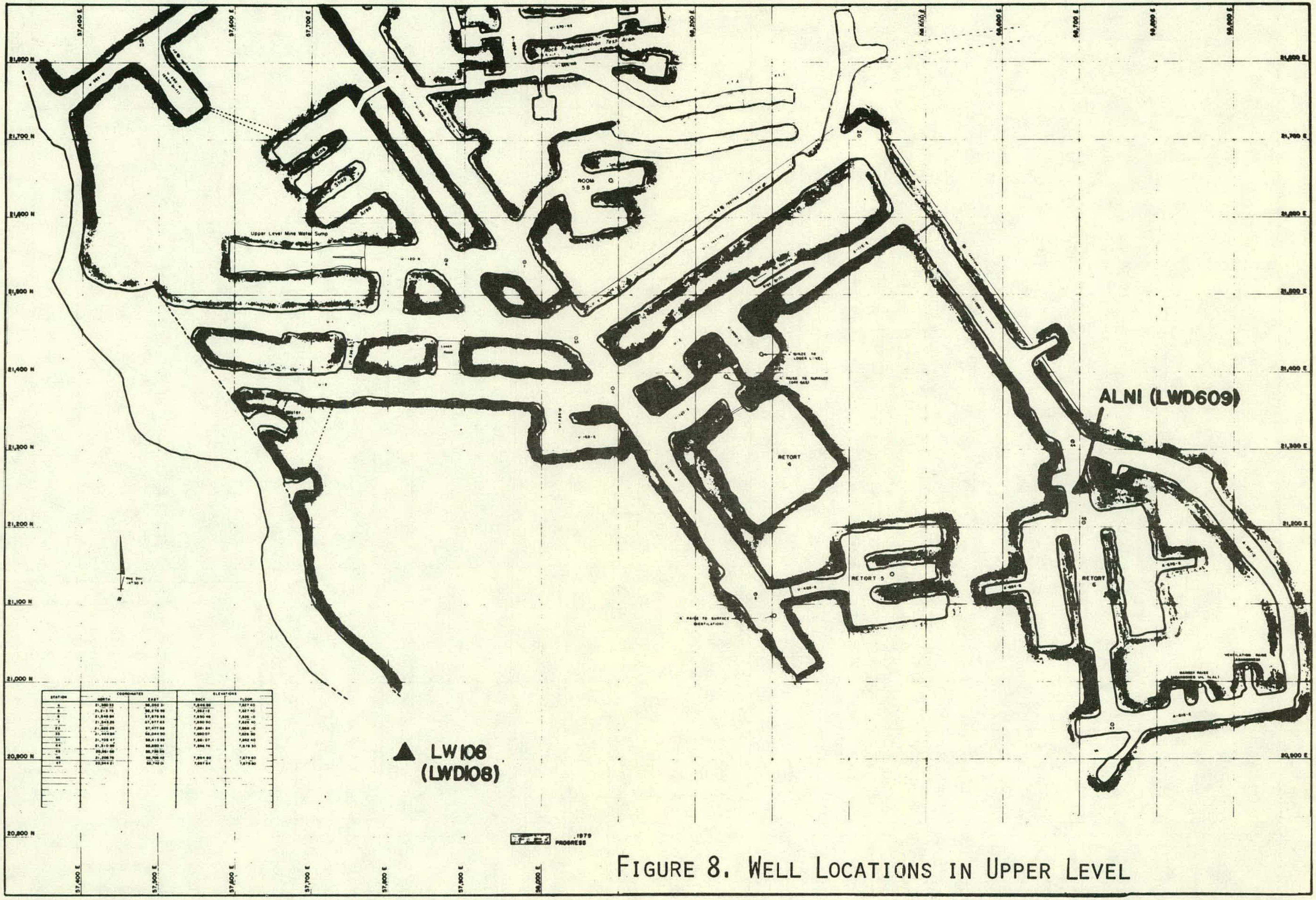


FIGURE 8. WELL LOCATIONS IN UPPER LEVEL

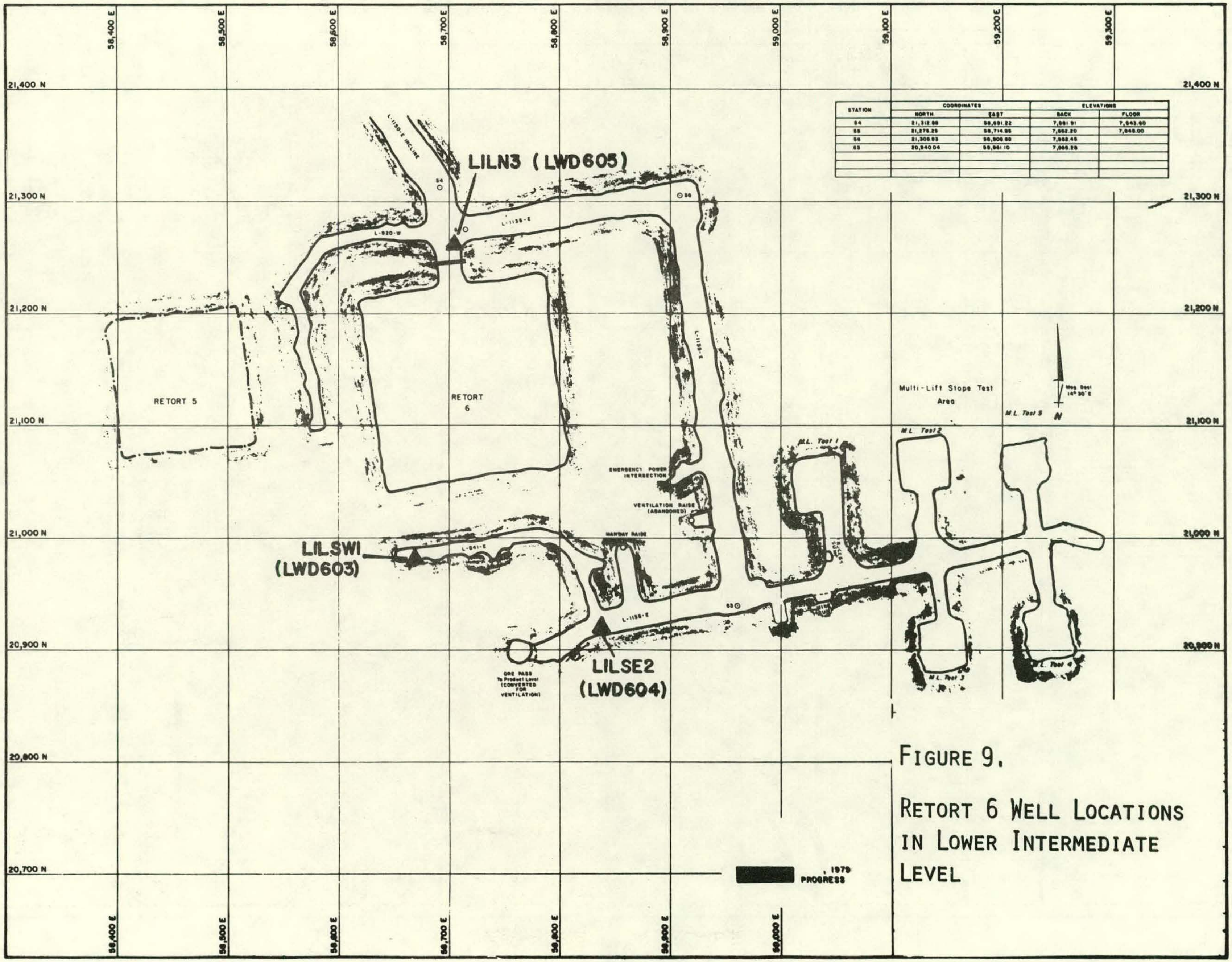


FIGURE 9.

RETORT 6 WELL LOCATIONS IN LOWER INTERMEDIATE LEVEL

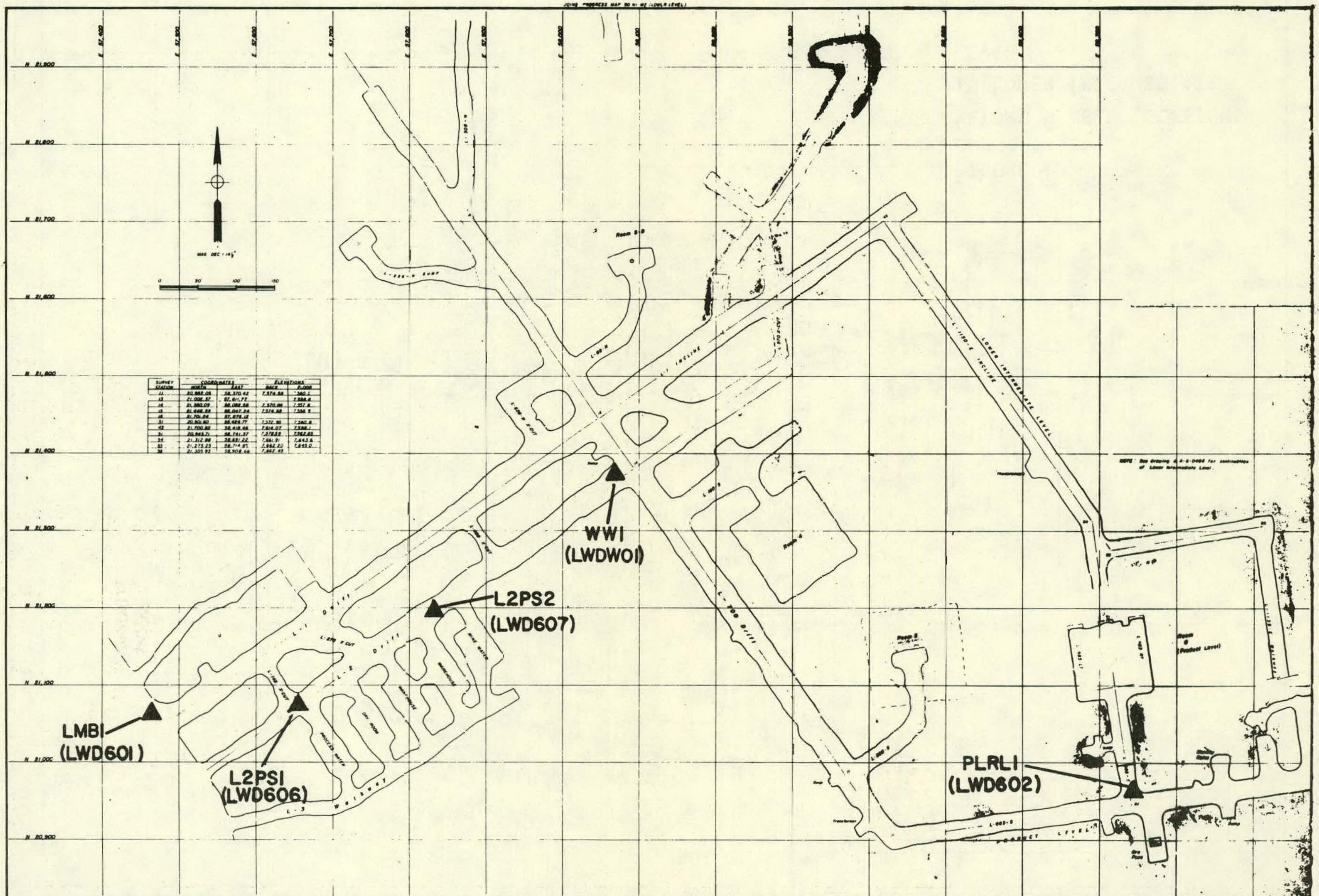


Figure 10. Well Locations in Lower Level

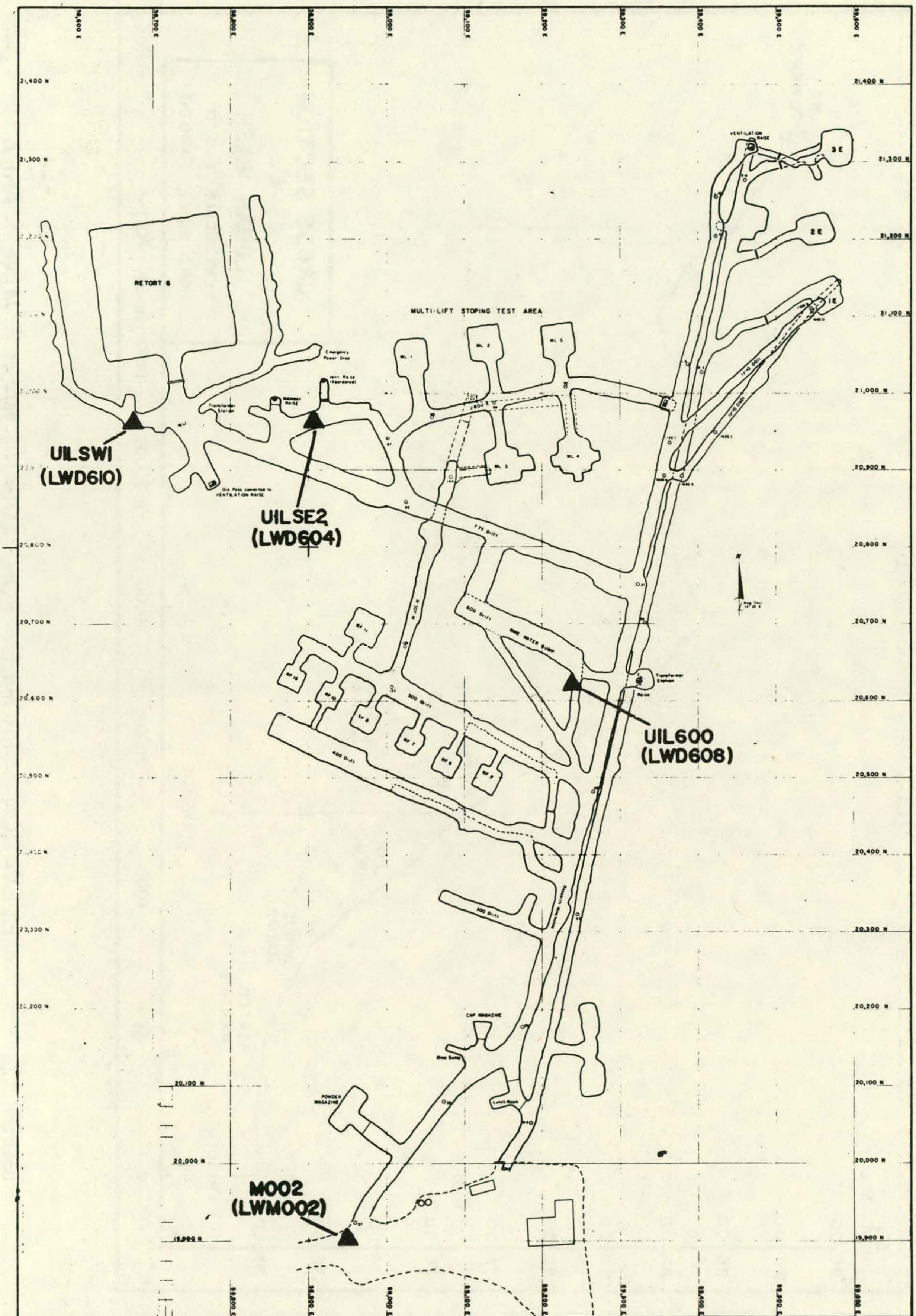


Figure 11. Well and Discharge Location at the Research Mine.

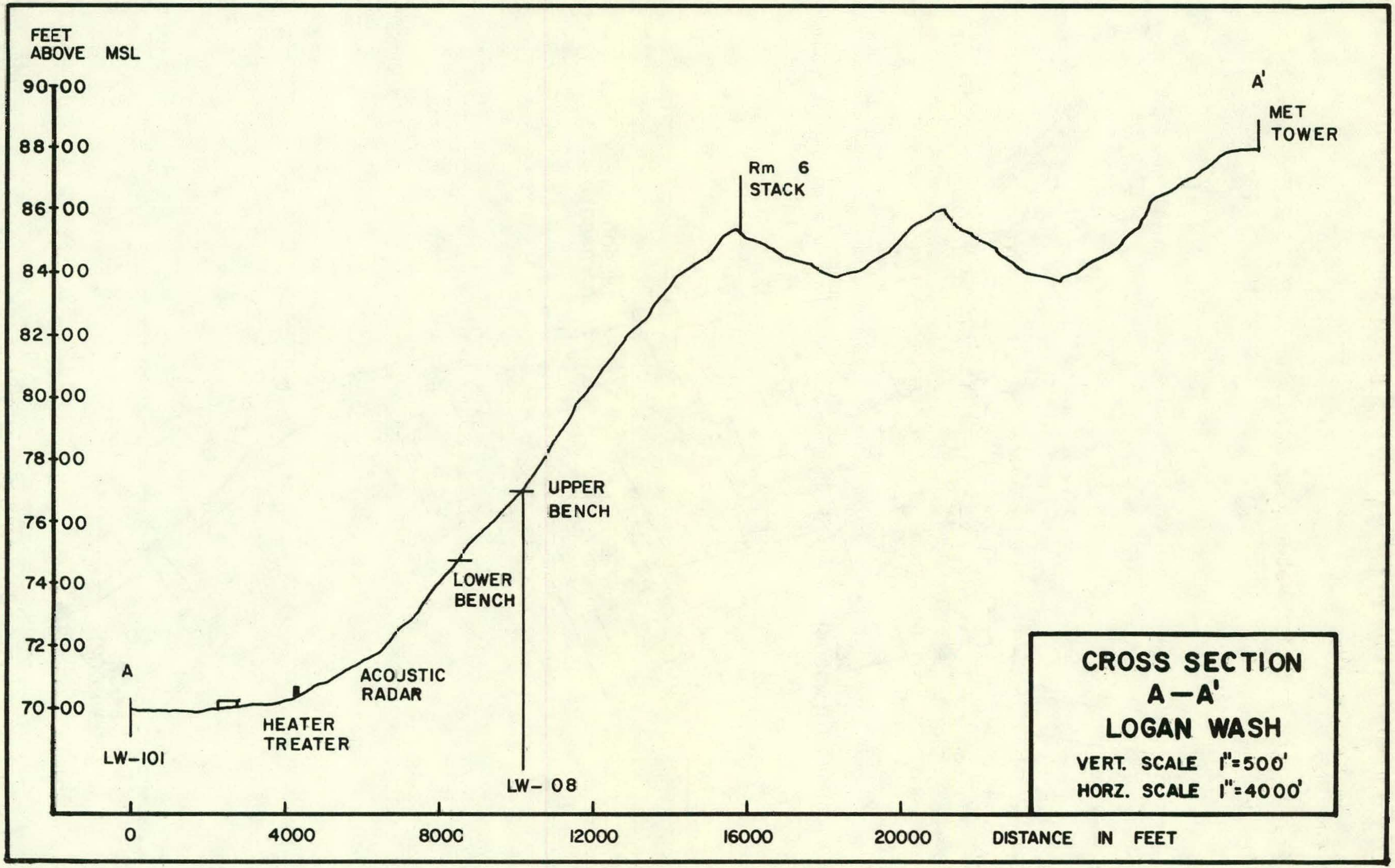


FIGURE 12. ELEVATION PROFILE FOR LOGAN WASH MINE AREA

The operational timeline of Climatological and Hydrological monitoring of Logan Wash for May, 1980 through October, 1980 is shown in Figure 13. Water sampling frequency by site for water year October, 1979 to October, 1980 is shown in Figure 14.

A. MONITORING

1. Air Quality and Meteorology

Air quality and meteorological parameters presently being monitored at the Logan Wash mine site are suspended particulates, wind speed, wind direction, temperature, relative humidity, and solar radiation.

Data are collected at four stations at the site: Guard-Gate, Heater Treater, Lower Mine Bench, and Meteorological Tower. Table III presents the monitoring station parameters measured and the level of the instrumentation for these stations.

The Hi-vol sampling instrument for suspended particulates is co-located at the Meteorological Tower station at the surface of Logan Wash mine site. Monitoring of suspended particulates has continued through this reporting period. Data samples are analyzed by Coors/Spectrol-Chemical Laboratory in Golden, Colorado. Data not previously reported are included in Appendix B of this report.

Wind speed and wind direction are measured at the 10-meter level mechanical weather station located at the Heater Treater. Data not previously reported are included in Appendix B of this report. Figures 15-17 are quarterly wind roses for three seasonal quarters for this station. The winter quarter exhibits prevailing winds from the southeast, principally in the 1-3 meter/sec (m/s) range. Both spring and summer quarters are nearly identical with prevailing winds from the west-northwest, primarily at 1-3 m/s with extremes to 11 m/s. The monthly direction-only roses Figures 18 and 19 exhibit generally WNW-ESE couplets (ie: upvalley-downvalley) consistent with the quarterly roses indicating that winds are principally channeled by the valley walls near the Heater Treater.

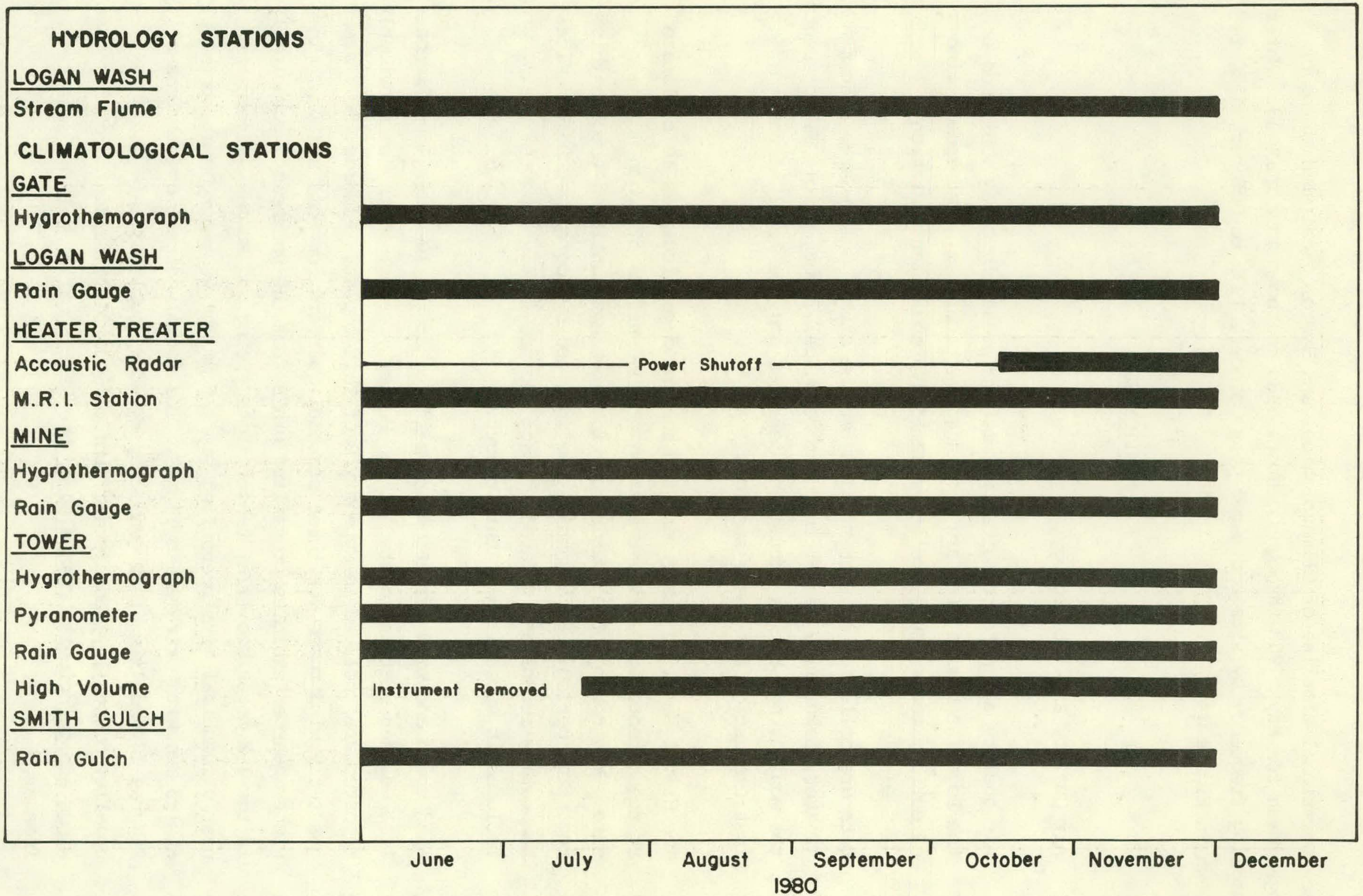


FIGURE 13. OPERATIONAL TIMELINE FOR LOGAN WASH 1980

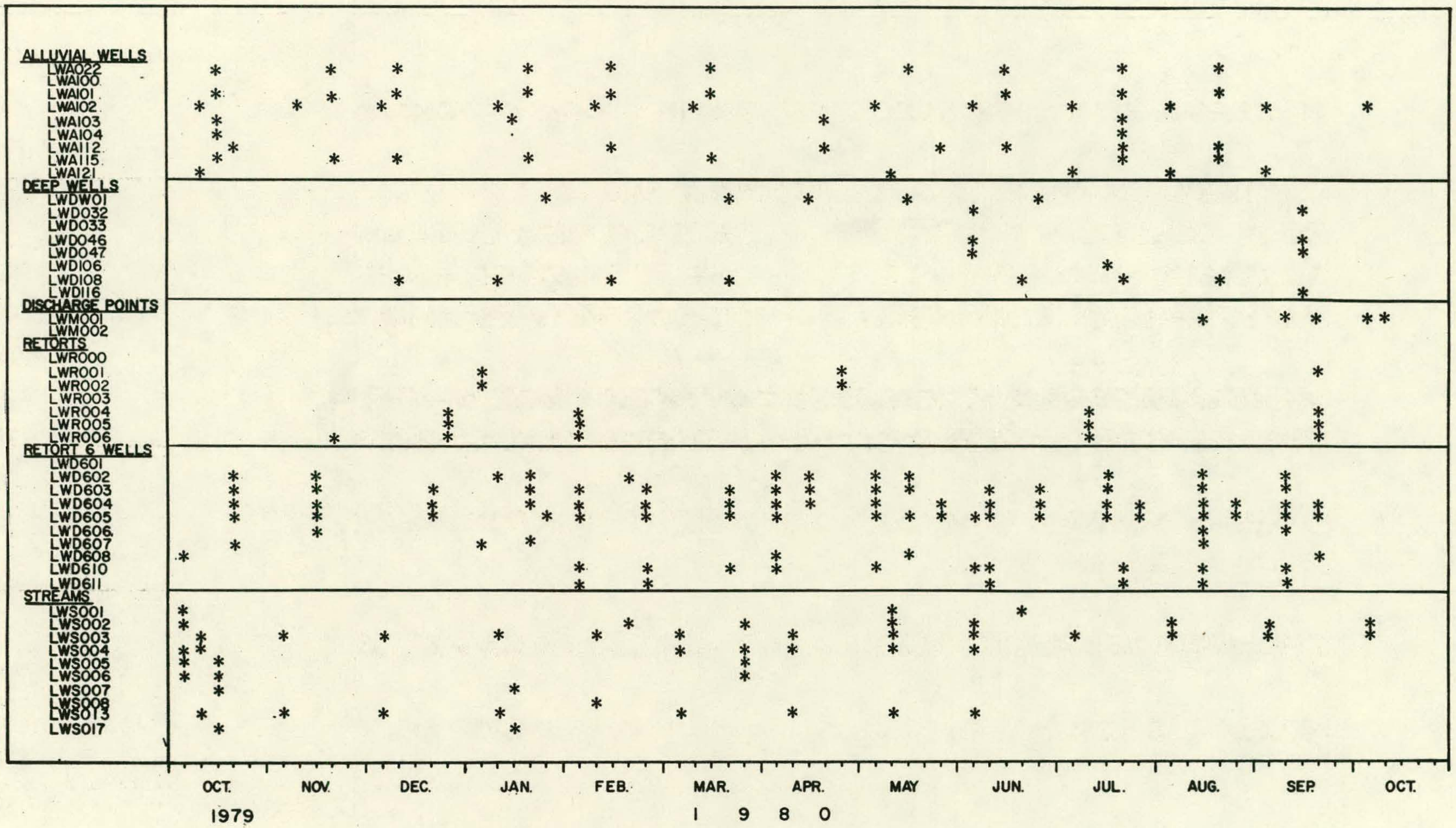


Figure 14. Logan Wash Water Sampling Frequency by Site for Water Years.

Figure 15.

LWO1 QUARTERLY WIND ROSE @ 10M
DECEMBER '79 - FEBRUARY '80

TOTAL % OF CALMS DISTRIBUTED (0.06%)
TOTAL NO. OF 1-HOUR SAMPLES - 1718

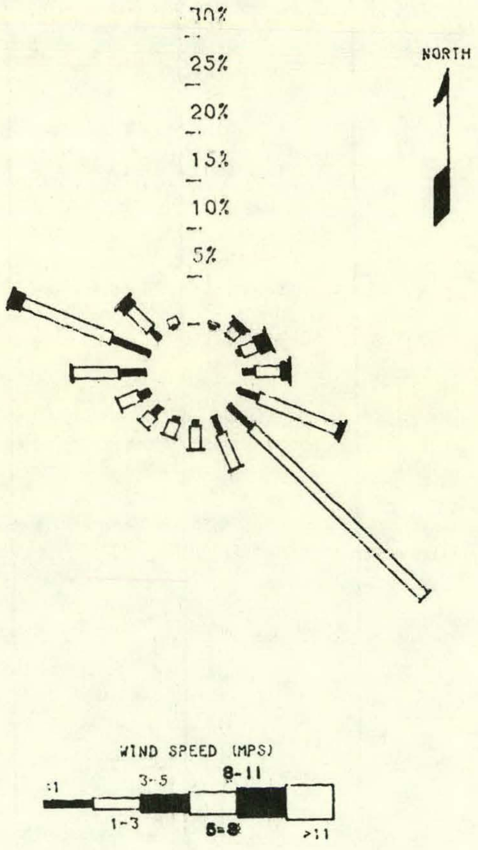


Figure 16.

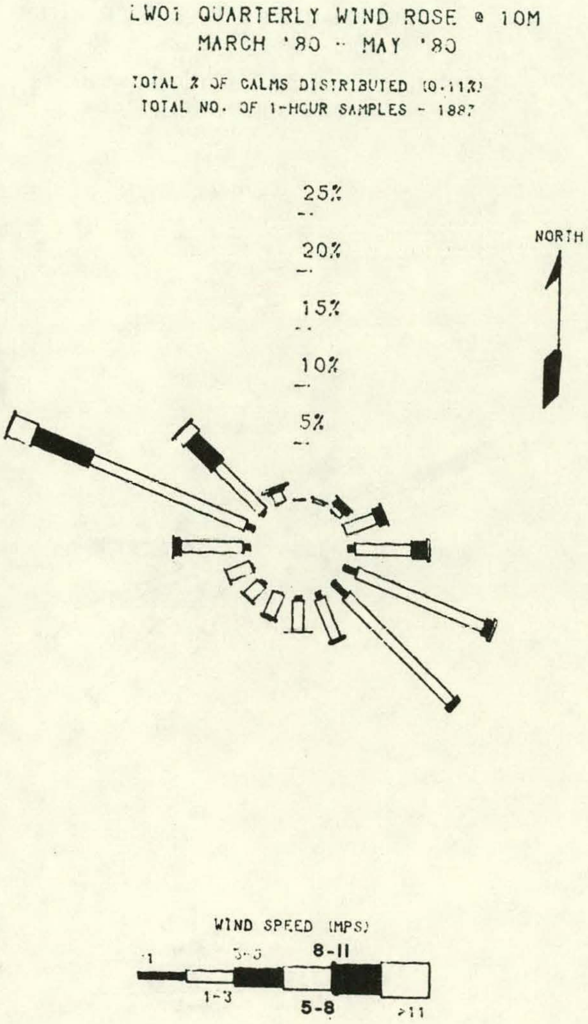
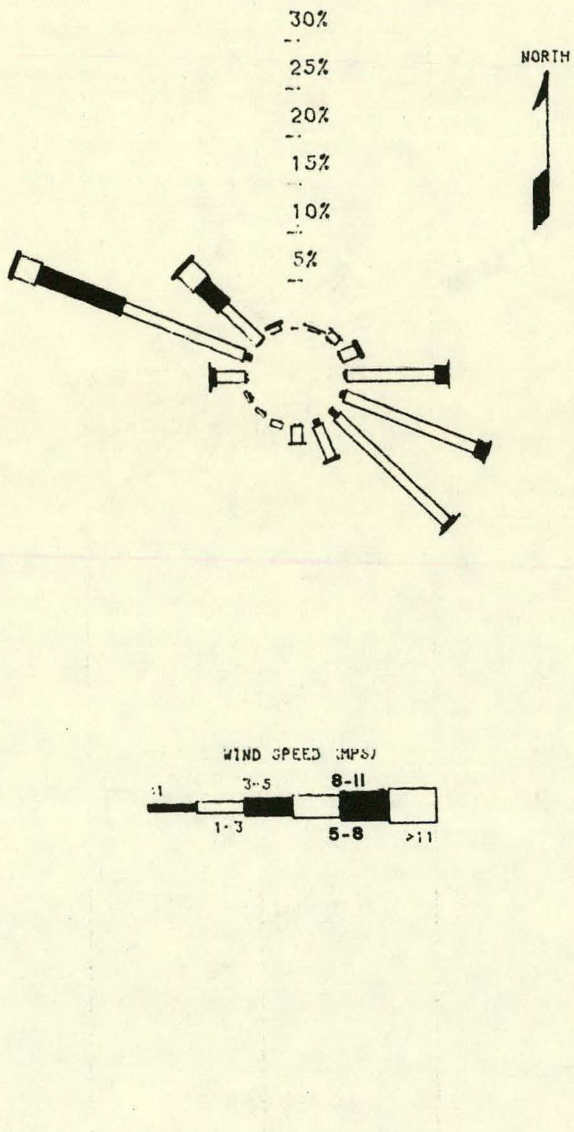

LWO1 QUARTERLY WIND ROSE @ 10M
MARCH '80 - MAY '80
TOTAL % OF CALMS DISTRIBUTED (0.11%)
TOTAL NO. OF 1-HOUR SAMPLES - 1887
25%
20%
15%
10%
5%
NORTH
WIND SPEED (MPS)
8-11
1-3
5-8
>11

Figure 17.

LW01 QUARTERLY WIND ROSE @ 10M
JUNE '80 - AUGUST '80

TOTAL % OF CALMS DISTRIBUTED (0.00%)
TOTAL NO. OF 1-HOUR SAMPLES - 2208



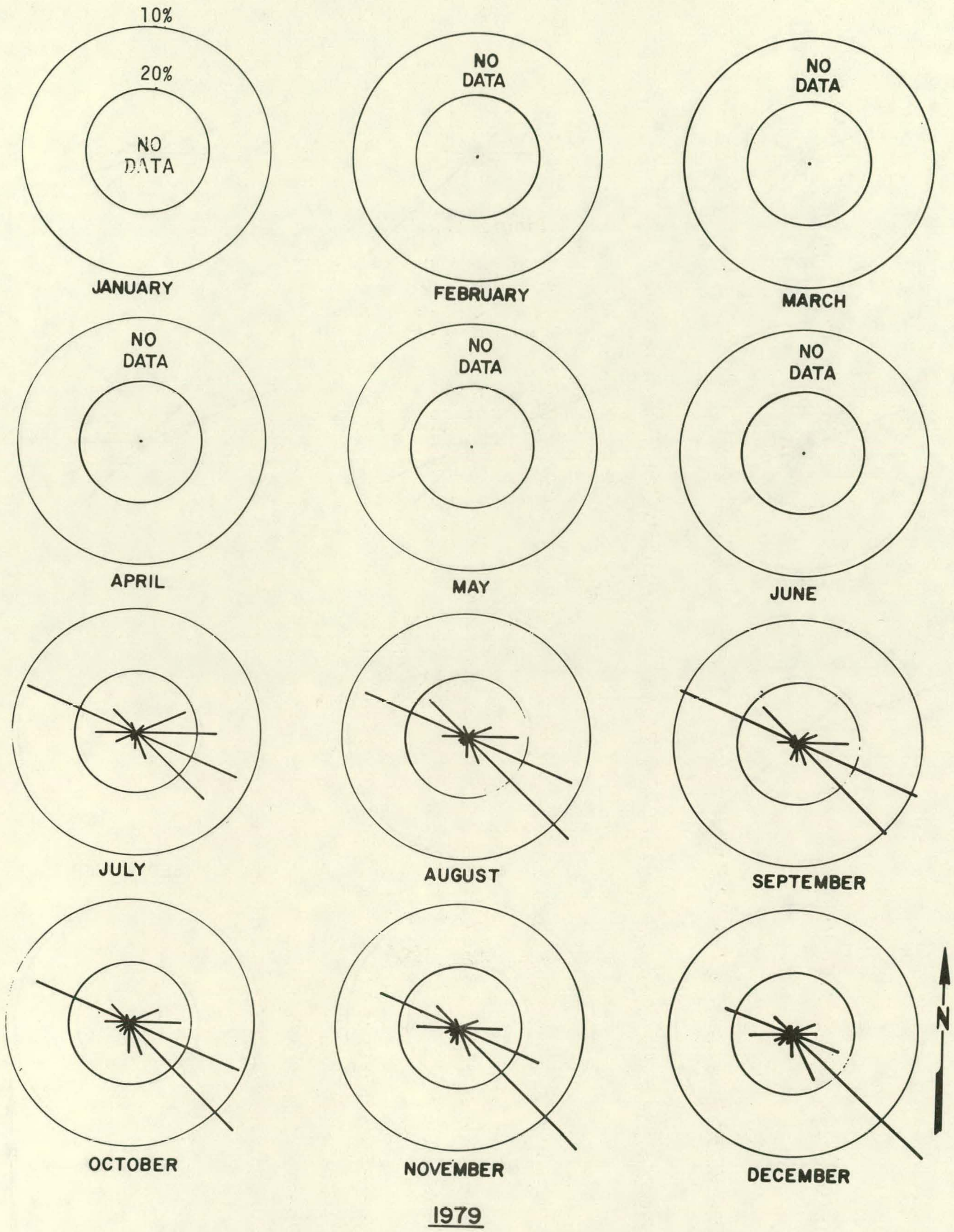
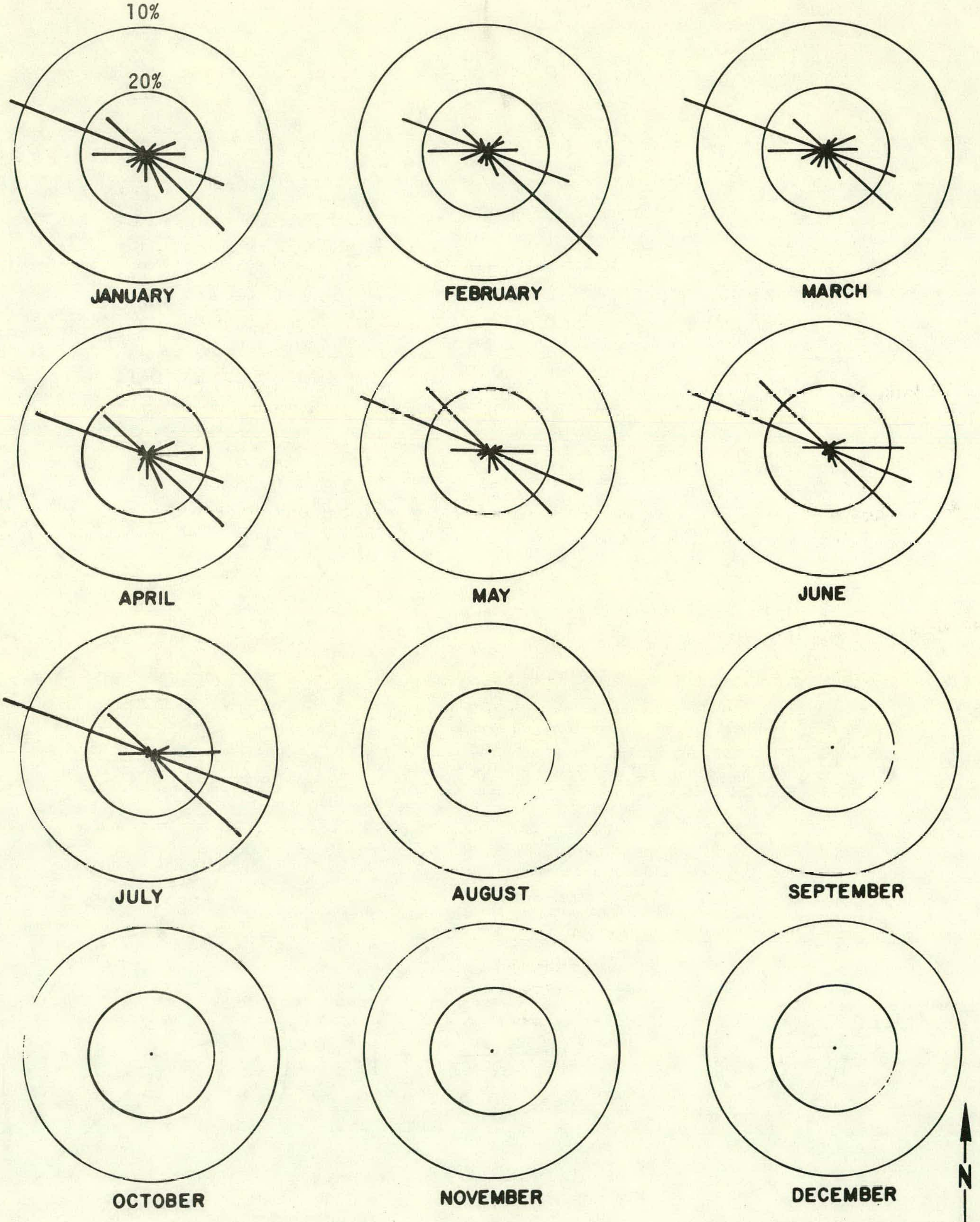


Figure 18. STATION LWOI @ IOM ELEVATION WIND ROSES



1980

Figure 19. STATION LWOI @ 10M ELEVATION WIND ROSES

Air temperature sensors at the 2-meter level are located at the Guard Gate, Lower Mine Bench, and Meteorological Tower stations. A fourth sensor is located at the Heater Treater at the 10-meter level. Typically at the Heater Treater, temperatures have varied from a winter low of -17°C to a summer high of 43°C.

Relative humidity is measured at three locations; the Guard Gate, Lower Mine Bench, and Meteorological Tower stations. In the period from August to October, 1980, covered by the data of this report, relative humidity varied from a maximum of 100% to a minimum of 1%.

Solar radiation is measured by the pyranometer at the Meteorological Tower. Total daily direct-radiation peaked at 752 Langleys during the month of August.

2. Hydrology and Water Quality

Intermittent ground water drainage encountered in the mine is collected and utilized in mining operations. Occasionally some surplus mine water develops and is discharged into adjacent normally dry drainages. These intermittent and infrequent discharges are monitored according to a current National Pollutant Discharge Elimination System (NPDES) permit. Averages of these intermittent discharges are included in the hydrology appendix. Flows are so small and intermittent that it is difficult to obtain accurate measurement of the volume. The peak discharge noted was approximately 0.14 cfs. No discharges have occurred since mid November 1980.

Other field activities during the quarter included:

- Routine repairs were made to monitoring wells. Additionally, surface casing was extended above ground level and the wells were capped.
- Traffic guards and a new flume were installed in Smith Gulch.
- A monitoring program was set up to measure water levels in the air inlet/burner access holes from the surface to the top of Retorts 7 and 8. Water level monitoring will continue until the

retorts are rubblized and the holes are completed to access the rubble. This data will be used to estimate the amount of water percolation from the upper zones into the retorts.

An evaluation of the leaching behavior of spent retorts was reported (C. S. Stover) in March, 1980[2]. Supplemental data from Retorts 1-6 have now been added which verify the original conclusion of Stover's report. Indications are that the levels of soluble inorganics in the water decline rapidly while concentrations of less soluble material are more stable.

The retort sumps are situated in the retort below the rubblized shale. Any waters that enter or are produced in the retort are collected and held in sumps. These waters may originate from one of several sources: condensation of steam in inlet gas, water produced by combustion of organic material, mineral water released from the rock during retorting, and intrusion of groundwater. During processing, these waters mingle with product oil and the gaseous products of retorting as well as contacting varying quantities of raw shale. After retorting is terminated, the first three sources of water are eliminated, although not immediately nor simultaneously, and intruding groundwater makes an ever-increasing contribution to the water collected in the retort sump. This groundwater comes into contact with spent shale as it drains through the spent retort to the retort sump and, therefore, has the opportunity to leach soluble material from the shale. Sampling of retort sump water was begun prior to the start-up period of each retort and continued during and after shut-down. Figure 20 is a time line of retorting periods for Retorts 1-6. Figures 21, 22, and 23 are time series plots of concentration levels of total dissolved solids (TDS), total alkalinity, and (Na+K)/(Ca+Mg). These concentrations show significant trends down to background levels. Total alkalinity and carbonate for Retort 6 (Figures 22 and 24) seem to show a seasonal decrease and increase which can be attributed to an influx of water percolating through into the air level of the retort from the surface. Although the concentrations are irregular, all of these parameters show a definite decreasing trend.

Several parameters, fluorine, nitrate, Kjeldahl nitrogen, and sulfate, show a bimodal trend as seen in Figures 25 through 28. Maximum

[2] "Annual Progress Report for the Period June 1, 1979, through May 31, 1980", Occidental Oil Shale, Inc., Appendix A.

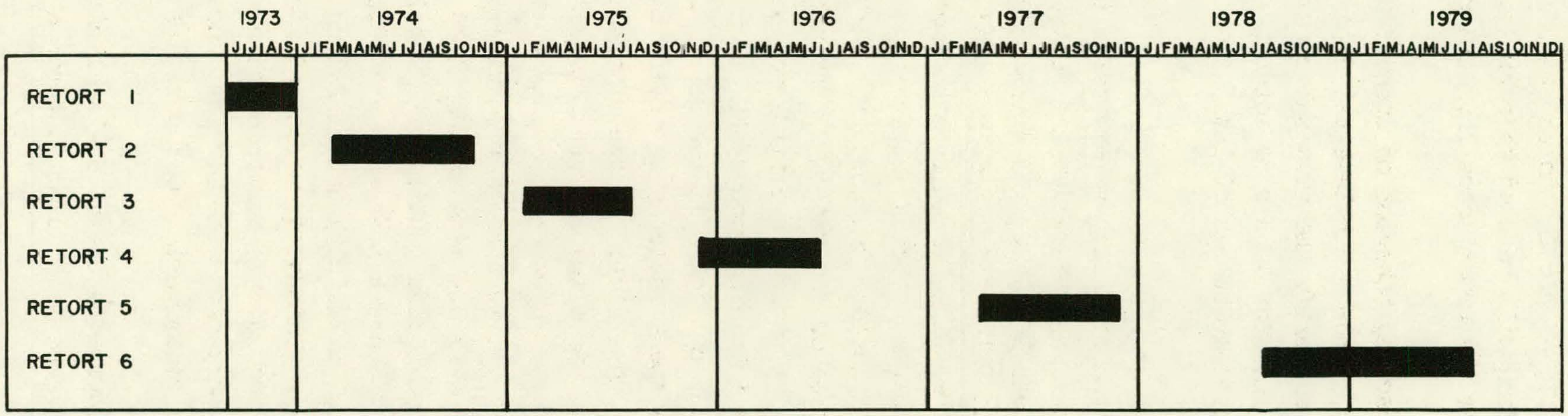
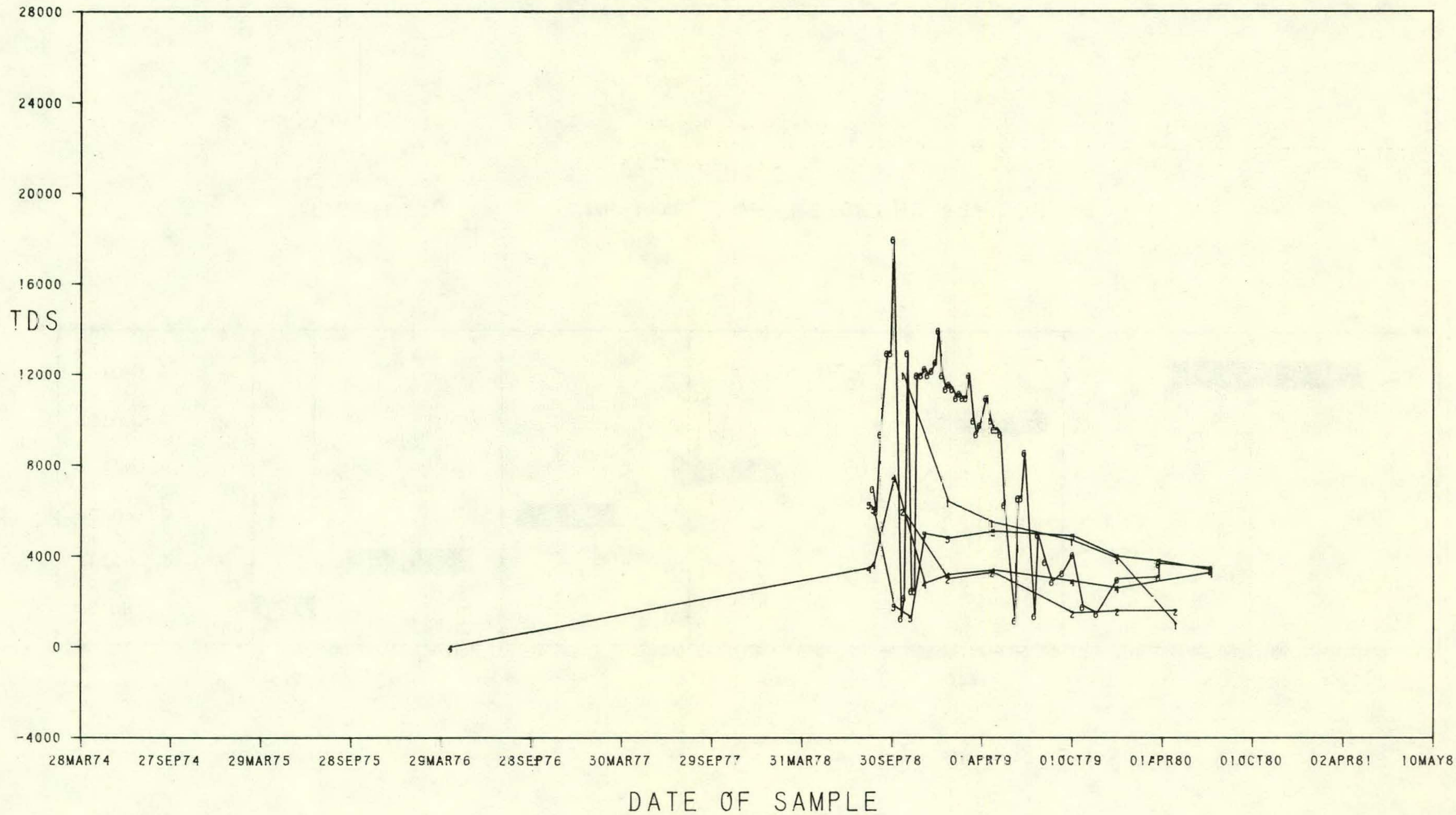


FIGURE 20. TIME LINE FOR RETORTING PERIODS

Figure 21. Time Series Plot of Total Dissolved Solids

RETORT SUMP WATER PARAMETERS VS TIME

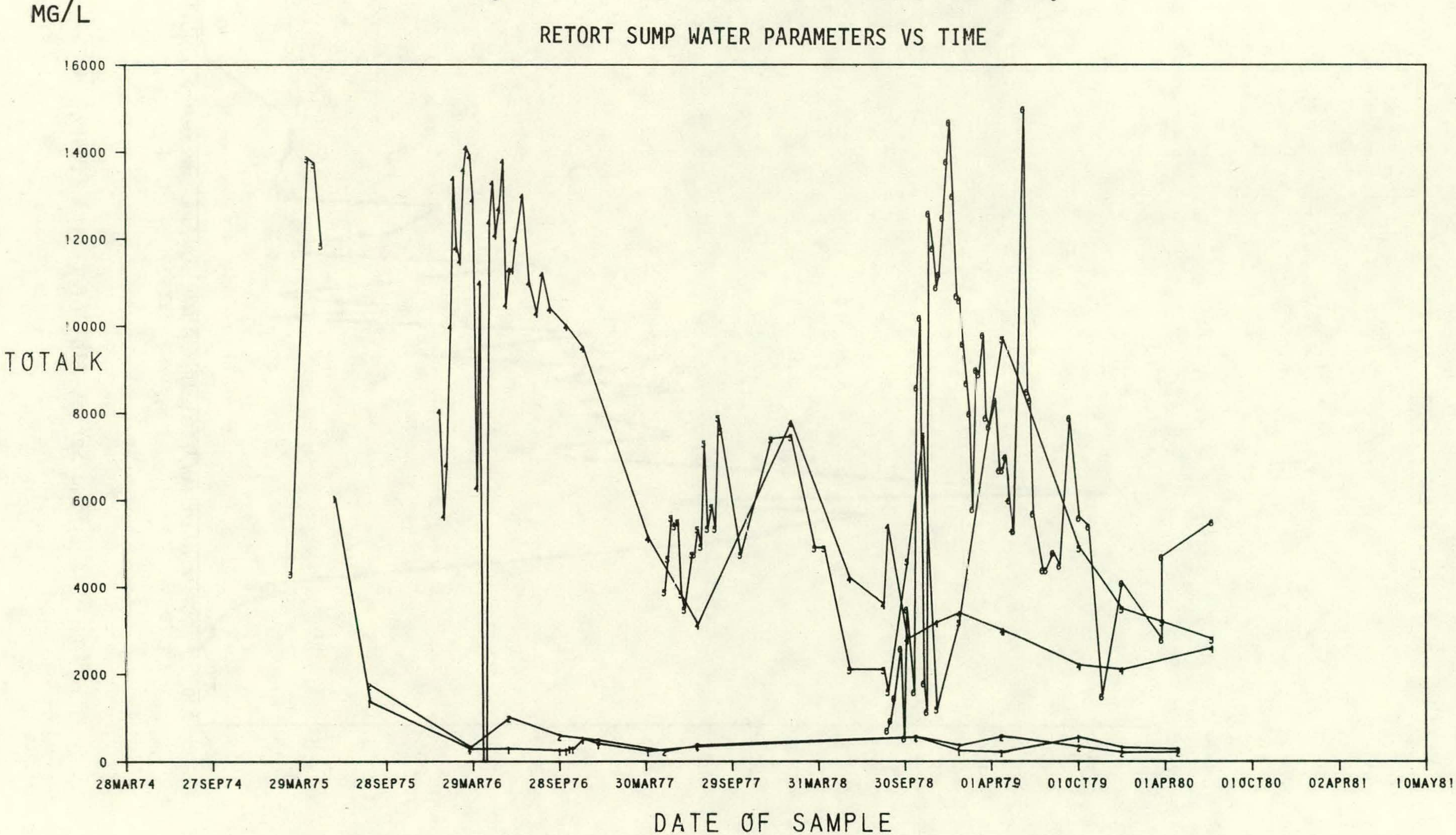
MG/L



Note: 1 - Retort 1
2 - Retort 2
3 - Retort 3
4 - Retort 4
5 - Retort 5
6 - Retort 6

Figure 22. Time Series Plot of Total Alkalinity

RETORT SUMP WATER PARAMETERS VS TIME



Note: 1 - Retort 1
2 - Retort 2
3 - Retort 3
4 - Retort 4
5 - Retort 5
6 - Retort 6

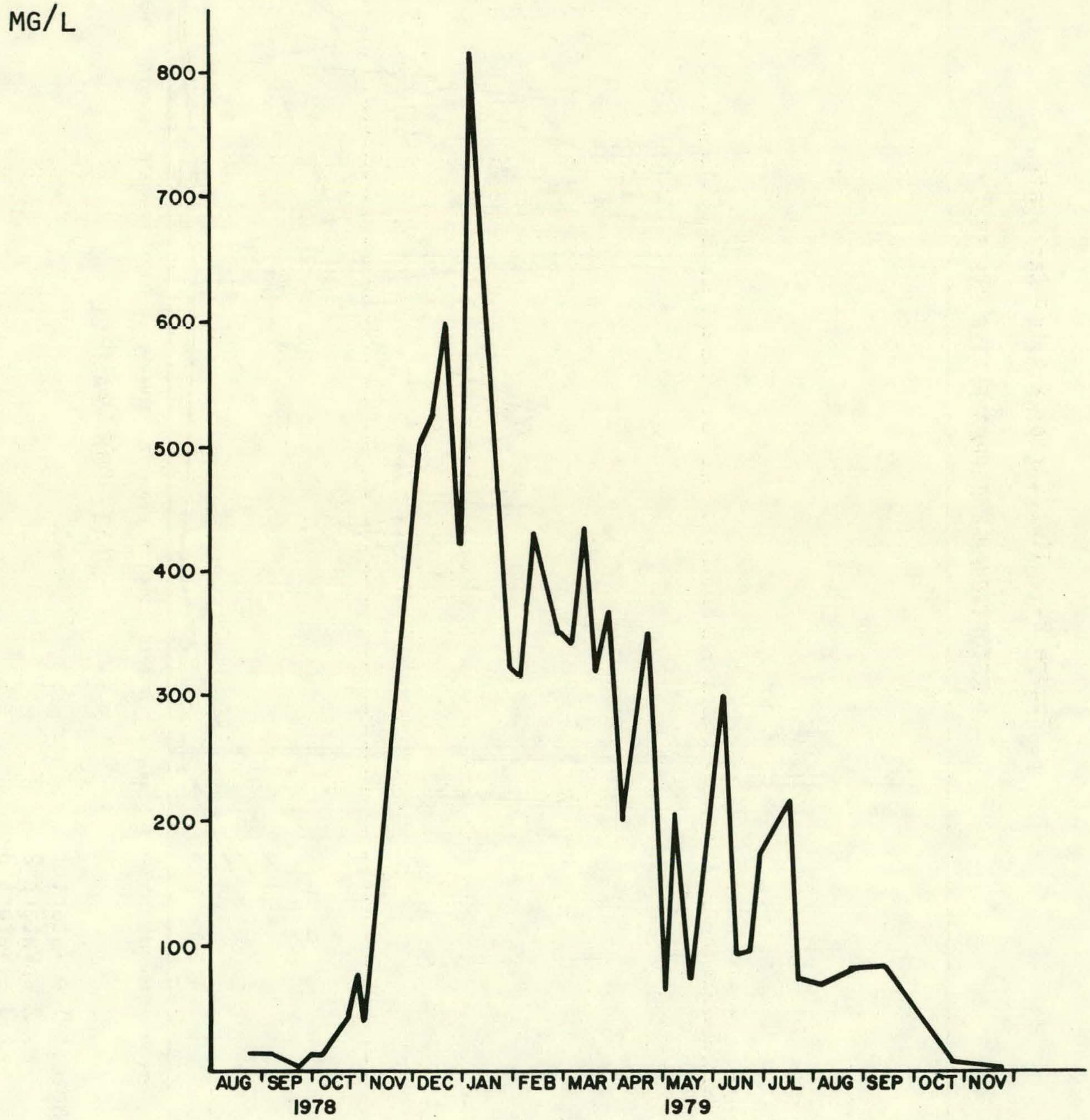
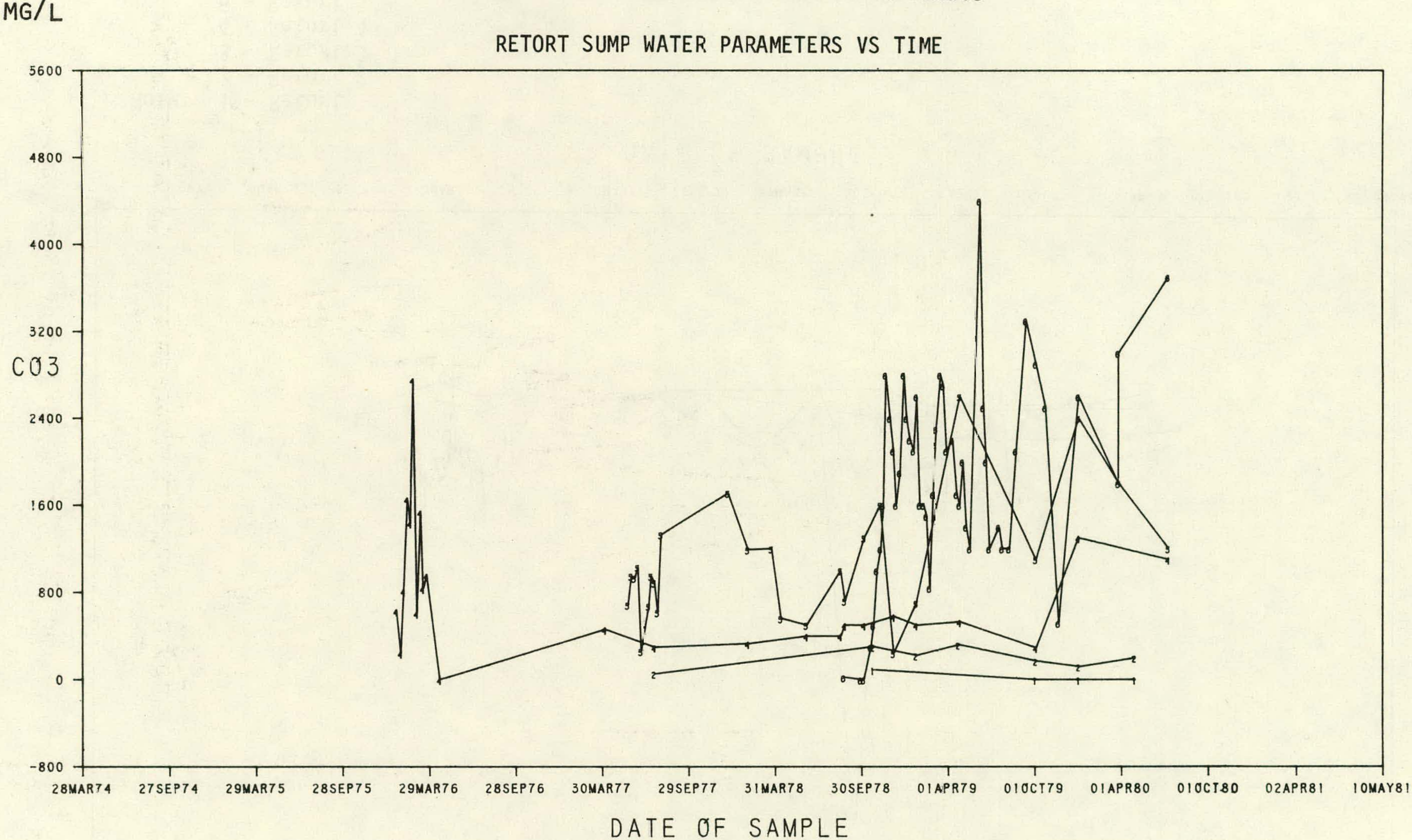


Figure 23. Time Series Plot of (Na+K) (Ca+Mg)

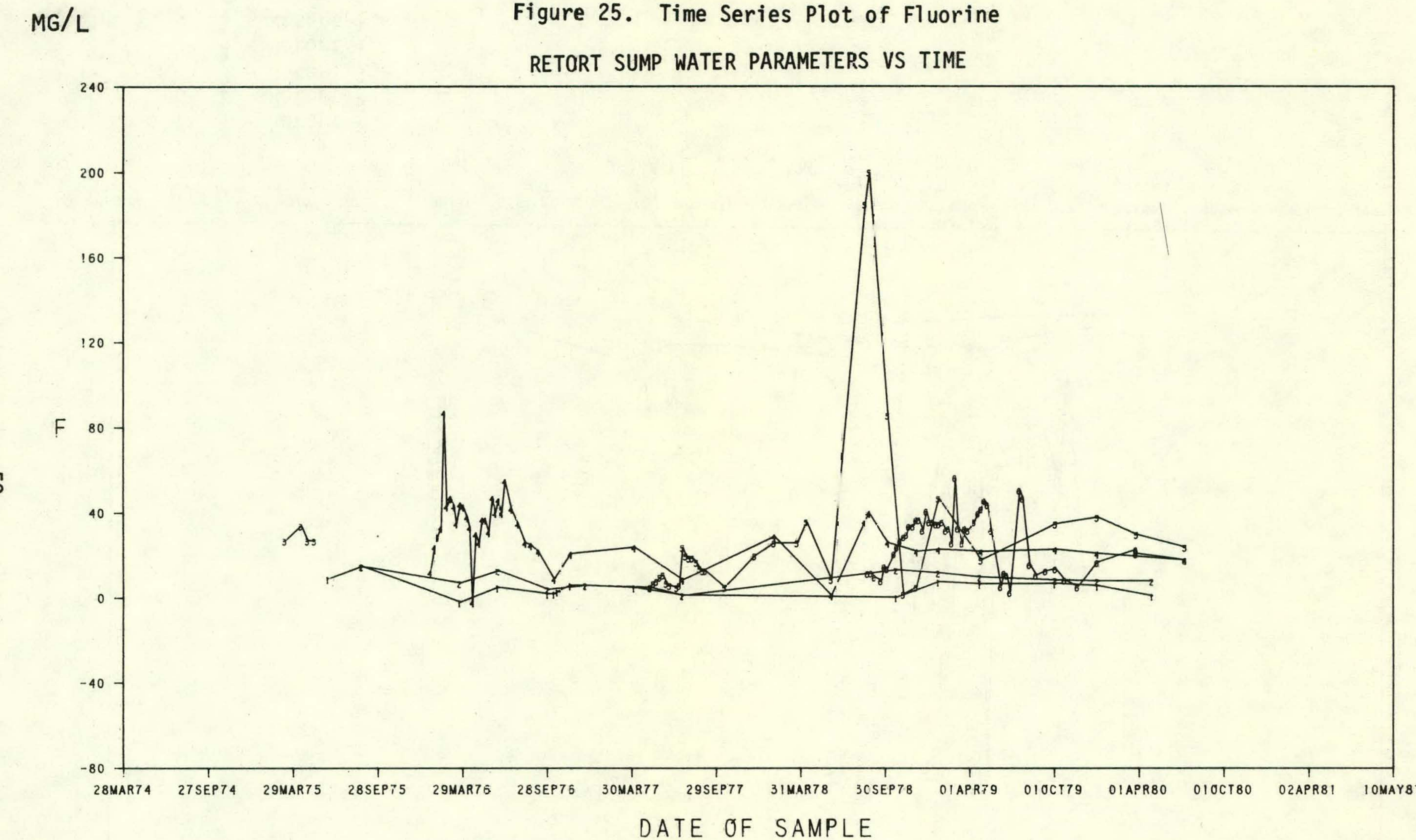
Figure 24. Time Series Plot of Carbonate



Note: 1 - Retort 1
2 - Retort 2
3 - Retort 3
4 - Retort 4
5 - Retort 5
6 - Retort 6

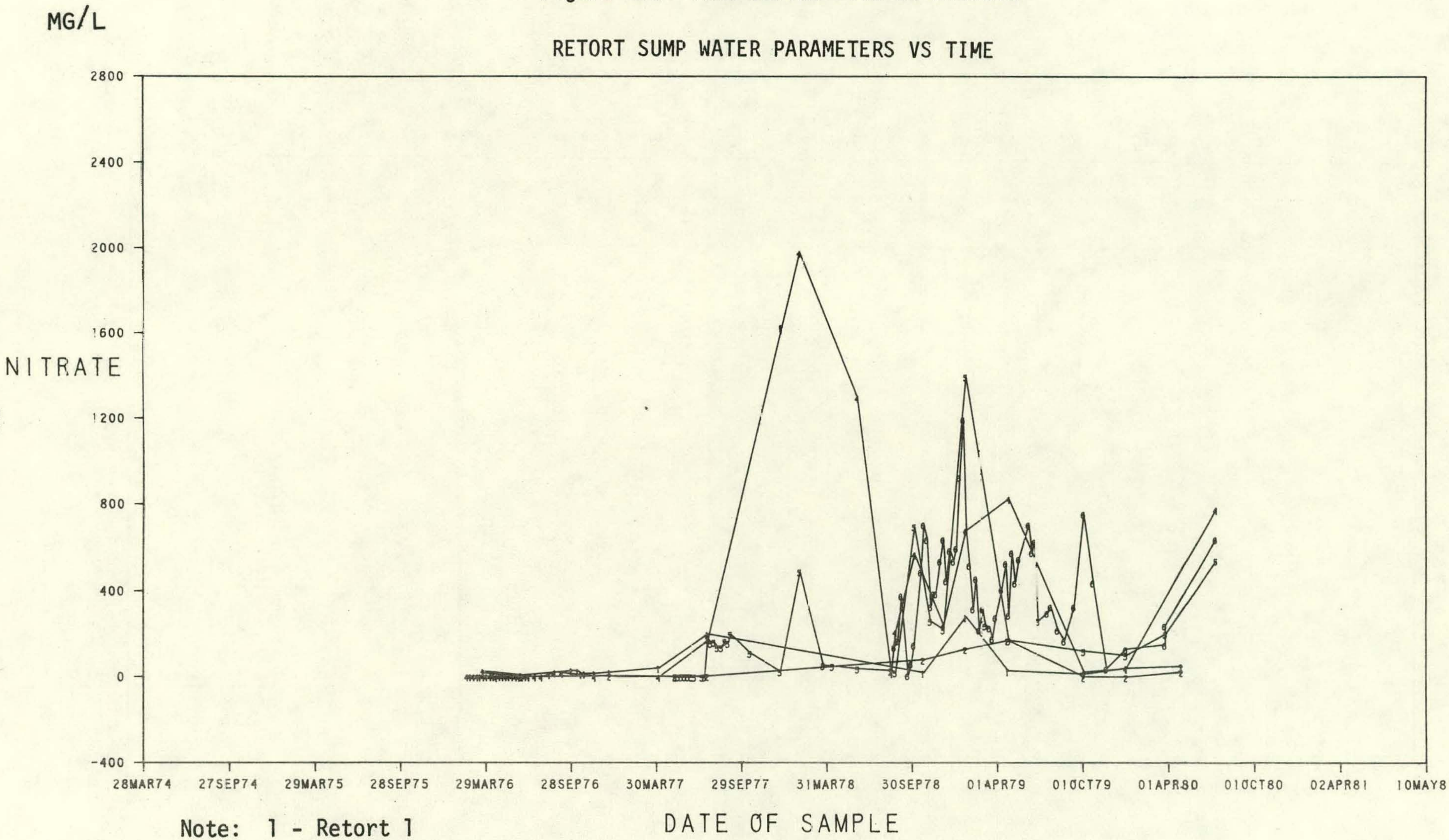
Figure 25. Time Series Plot of Fluorine

RETORT SUMP WATER PARAMETERS VS TIME



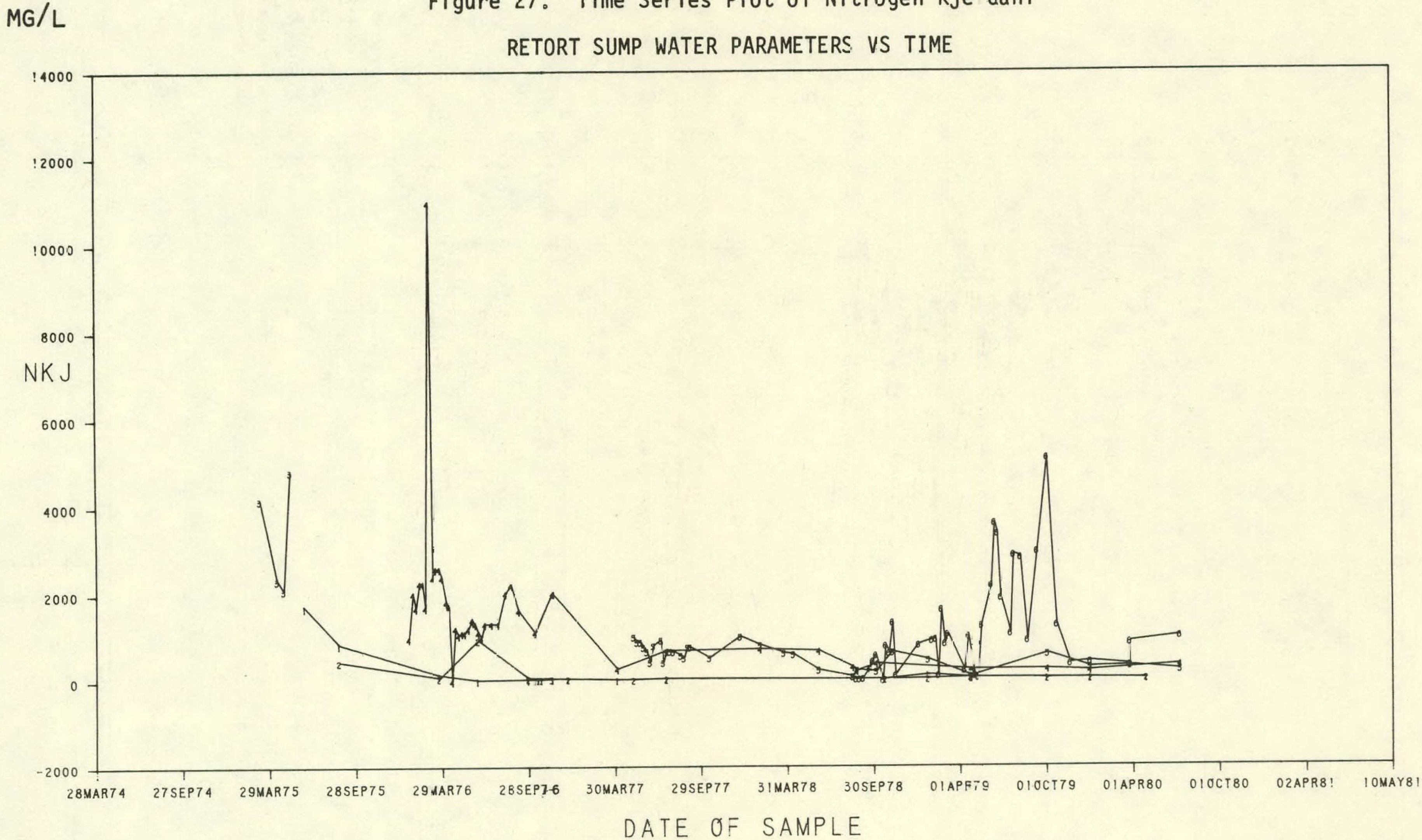
Note: 1 - Retort 1
2 - Retort 2
3 - Retort 3
4 - Retort 4
5 - Retort 5
6 - Retort 6

Figure 26. Time Series Plot of Nitrate



Note: 1 - Retort 1
2 - Retort 2
3 - Retort 3
4 - Retort 4
5 - Retort 5
6 - Retort 6

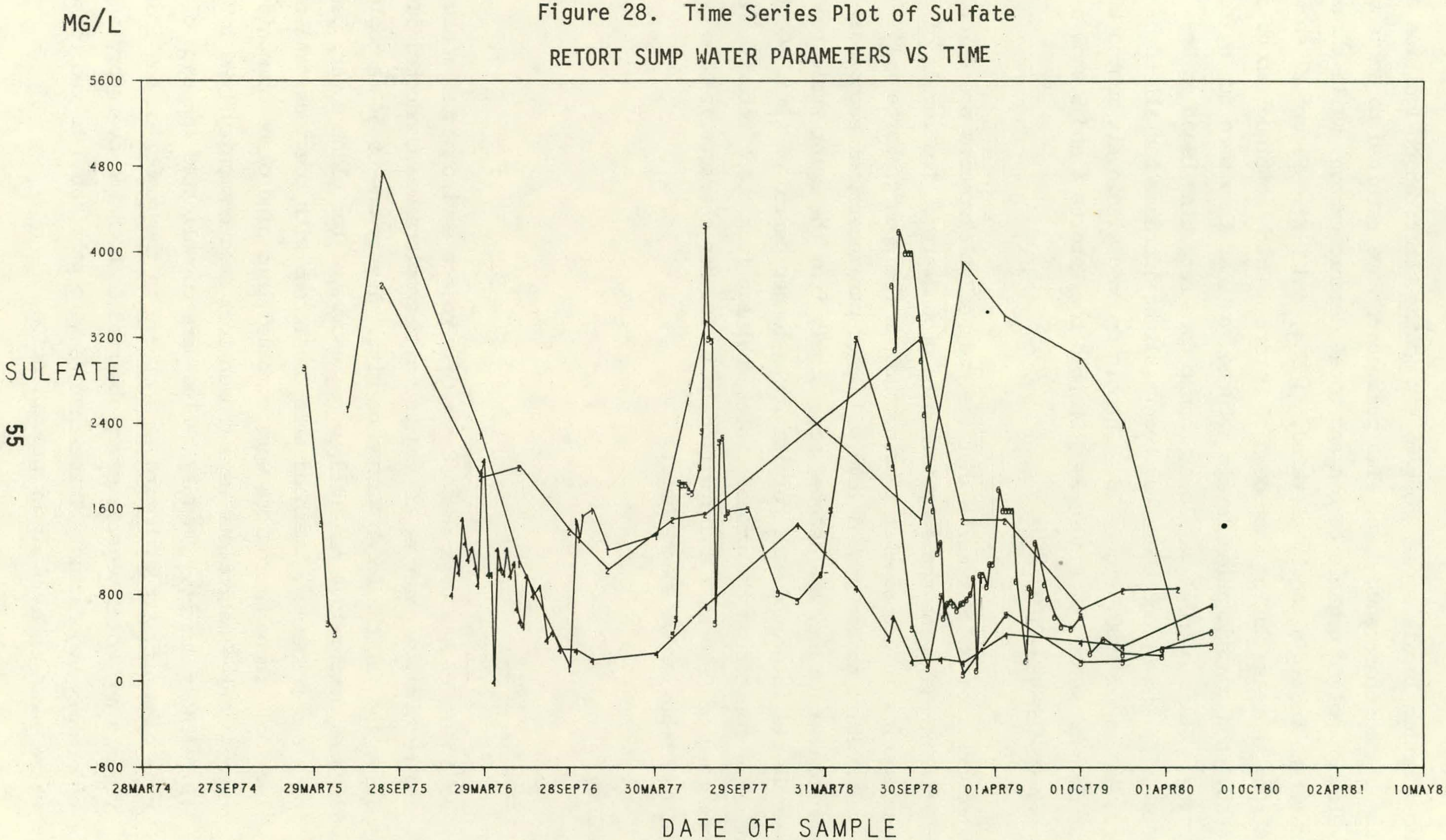
Figure 27. Time Series Plot of Nitrogen Kjeldahl



Note: 1 - Retort 1
2 - Retort 2
3 - Retort 3
4 - Retort 4
5 - Retort 5
6 - Retort 6

Figure 28. Time Series Plot of Sulfate

RETORT SUMP WATER PARAMETERS VS TIME



Note: 1 - Retort 1
2 - Retort 2
3 - Retort 3
4 - Retort 4
5 - Retort 5
6 - Retort 6

concentration levels appear four to six months after retort ignition and again right before shut-down. Two parameters have returned to ambient levels, dissolved organic carbon and total organic carbon, while three parameters remain slightly elevated, F, NH_3, and N-Kj. Figure 27 shows a strong increase during shut-down of Retort 6 which continued about six months, then concentration levels returned to what they were during retorting. Sulfate (SO_4) was lower than before retorting began in Retorts 4, 5, and 6, but there has been a slight increase for all three retorts in Summer 1980, Figure 28. Phenols dropped within six months after shut-down of Retort 6, Figure 29. Phenols for Retorts 4 and 5 show a steady decrease during 1980.

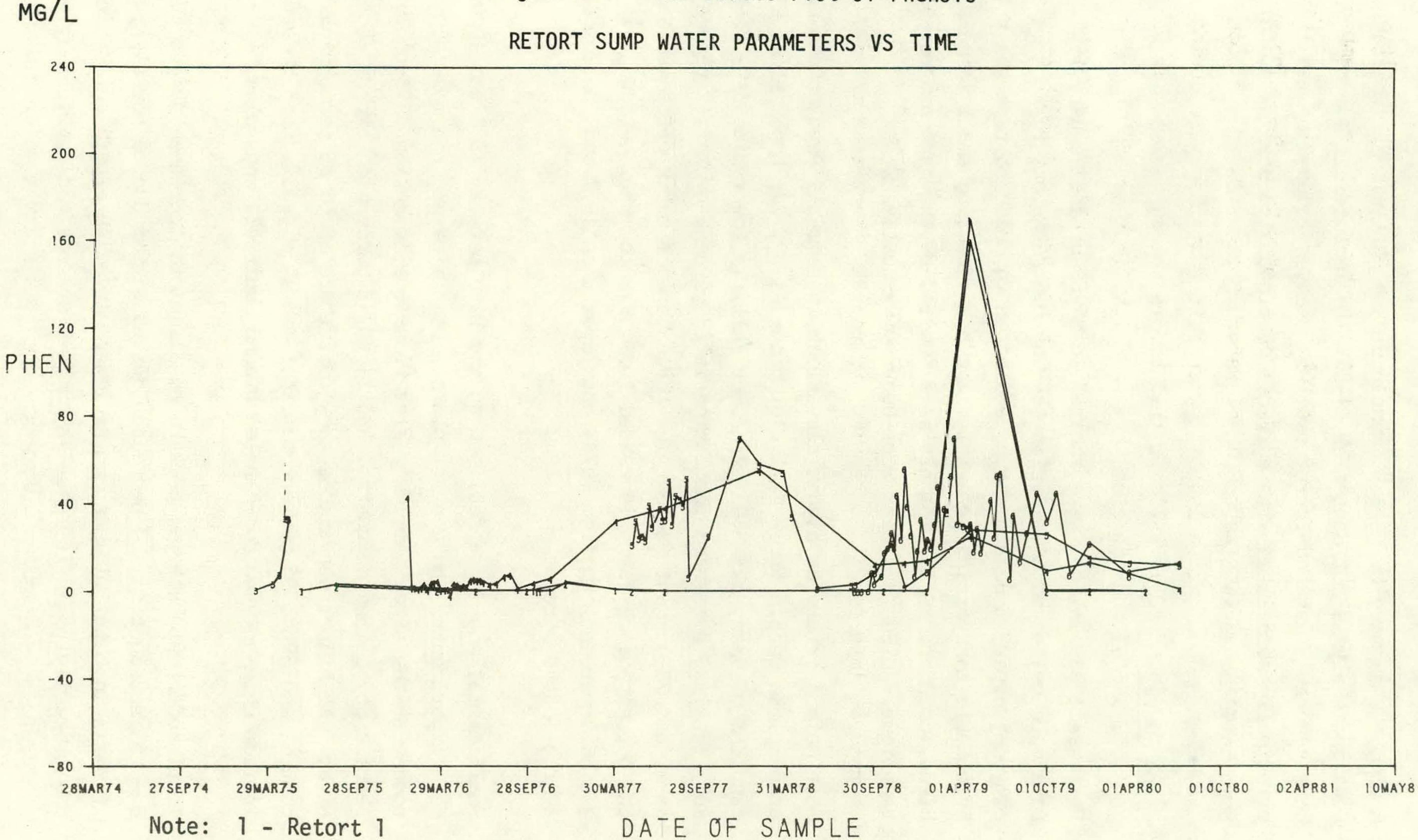
It appears from these results that the most soluble species are quickly depleted in the spent shale by intruding groundwater. The levels of these species in groundwater passing through the spent retorts will quickly return to background levels. Other parameters, of supposedly a less-soluble nature, are leached more slowly from the spent shale and their levels in groundwater persist for a longer period of time. Continuation of monitoring the process water drainage from spent retorts and monitoring of Retorts 7 and 8 will help to further characterize the leaching behavior of spent shale.

3. Biology

a. Flora Survey

As a part of the Logan Wash Shale Oil Project environmental monitoring program, a resurvey of vegetation macroplots was conducted during July, 1980 at the Logan Wash mine site. Twenty-one of 54 macroplots, located during 1974 and 1975, were resurveyed for plant cover, density and frequency. Methods were consistent with previous data collection. These macroplots were combined into nine plant community types. Three macroplots were chosen from each community type for the 1977-1980 resurvey. Summary tables were consolidated for each of the nine community types showing an increase in the number of new individuals and total vegetal cover observed in both the overstory and understory vegetation. These changes were attributed to two consecutive years of high winter precipitation.

Figure 29. Time Series Plot of Phenols



Note: 1 - Retort 1
2 - Retort 2
3 - Retort 3
4 - Retort 4
5 - Retort 5
6 - Retort 6

A complete summary by Neil E. West and James R. Irvine, "Vegetation Data and Analysis for September, 1980", is included as Appendix C of this report. West and Irvine conclude changes induced by man are principally associated with surface distribution caused by mining and road building activities.

b. Fauna Survey

Vertebrate populations were studied in May/June and August, 1980. Data were collected on experimental and control plots in pinyon-juniper, mountain shrub, and aspen in order to test the null hypothesis that mining activities are not affecting small mammals, birds, or deer. Small mammals were studied by the mark and release technique. Birds and deer were censused visually.

Most mule deer are at higher elevations in summer. Populations on study plots were: Upper Fall, 18; Upper Riley, 22; Upper Mine, 21; east end of mesa, 12; 8605, 2; Lower Fall, 1; Lower Mine, 10; total 86. The 1980 estimated population is 29 percent bucks, 42 percent does, and 28 percent fawns. The percentage of bucks decreased and the percentage of fawns increased from 1978 to 1980. Productivity was 66.7 percent, up from 1978, but lower than 1977 and the Colorado average of 90 percent.

Small mammal abundance declined at the site between 1978 and 1980, on both experimental and control plots. Deer mice are the most abundant rodent at the site. At lower elevations they contribute 13 to 100 percent of biomass on control and 11 to 48 percent on experimental sites. At higher elevations they contribute 40 to 85 percent on control and 29 to 95 percent on experimental sites. Other rodents include chipmunk, golden-mantled ground squirrel, and voles.

Total rodent biomass per hectare on all plots increases during summer due to reproduction and decreases during winter due to mortality. An increase in total biomass on the lower elevation experimental site is due primarily to an increase in numbers of deer mice, which may be an effect of mining activity. Total rodent biomass per hectare data tend to support the null hypothesis that mining activity is not affecting populations.

Diversity indices provide a measure of both number of species and distribution of individuals among species. Diversity is greater on lower elevation sites due to the presence of more species. Diversity indices tend to support the null hypothesis of no effect of mining activity on small mammal populations at the Logan Wash site.

Mining activities may be creating habitat more favorable to deer mice and golden-mantled ground squirrels on the lower elevation experimental site. An increase in populations of these two species may also be due to intrinsic differences in habitat between lower elevation control and experimental sites.

In 1980, only 23 species of birds accounted for a major percentage of sightings at the Logan Wash site, but field data indicate that as many as 35 species could have bred there. Twenty species are deemed of special importance at the site: three-species (white-throated swift, board-tailed hummingbird, MacGillivray's warbler) are common at both higher and lower elevations, six (violet-green swallow, scrub jay, blue-gray gnatcatcher, Virginia's warbler, black-throated gray warbler, rufous-sided towhee) are common only at lower elevations, and eleven (American kestrel, common flicker, dusky flycatcher, black-capped chickadee, house wren, robin, mountain bluebird, warbling vireo, Audubon's warbler, green-tailed towhee, gray-headed junco) are common only at higher elevations. The nine species common at lower elevations contribute 40 to 78 percent of all sightings on the control, and 61 to 91 percent on the experimental plot. The fourteen species common at higher elevations contribute 47 to 93 percent of all sightings on control, and 59 to 93 percent of all sightings on the experimental sites.

Patterns of avian abundance for common species are similar for control and experimental sites at both higher and lower elevations.

These data suggest that abundance is a function of some extrinsic factor such as weather.

Avian diversity indices are quite similar on both control and experimental sites at higher elevations. At lower elevations, diversity is lower on the experimental site. This may be a reflection of the impact of mining activities, or it may reflect habitat differences between experimental and control sites.

Eastern fence lizards are present in low densities, and plateau whip-tail lizards are rare in pinyon-juniper. Other mammals found occasionally at lower elevations are desert cottontail rabbit, rock squirrel, and porcupine. Those occasionally observed at higher elevations are white-tailed jackrabbit, yellow-bellied marmot, porcupine, coyote, short-tailed weasel, and long-tailed weasel. Miners observed a mountain lion adult with kitten in Logan Wash in 1980. Four bull elk were utilizing West Riley in August 1980. Cattle were abundant at higher elevations in August and had a significant impact on vegetation around water sources in Upper Fall, West Riley, and Northwest Riley.

In Appendix D of this report is a complete summary by William O. Wirtz and Joel S. Brown, "Vertebrate Populations at the Occidental Oil Shale, Inc. Logan Wash Site Summer, 1980".

c. Reclamation

Reclamation activities, including seeding and mulching, continued along the roads between the guard-gate and Heater Treater area.

4. Environmental Photography

As a qualitative record of general environmental conditions, a photo survey was conducted during the month of August at the eight photo points indicated on Figure 7. Color slides are preserved as part of the permanent project record. Four representative 360° mosaics (horizontal pans) from points 24, 20, 15, and 6 are presented as Figures 30 to 33

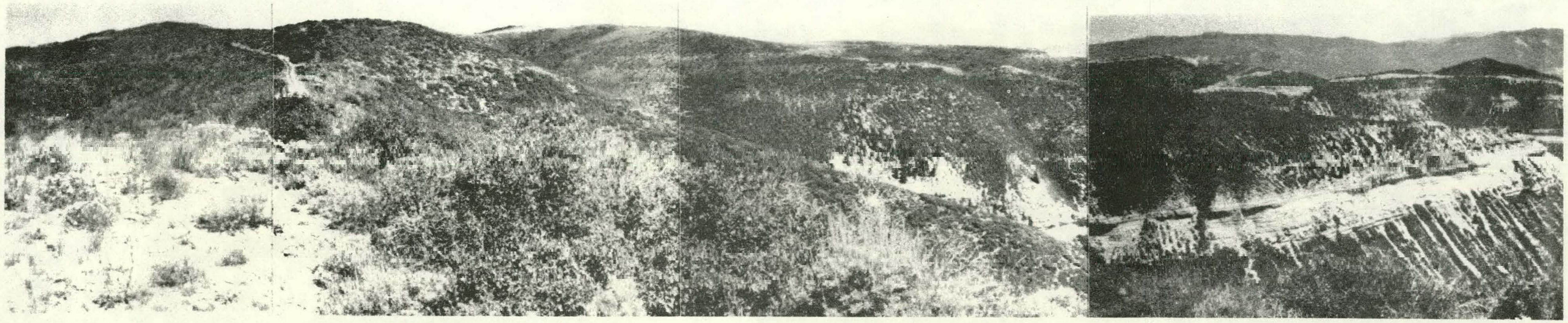


FIGURE 30

360° MOSAIC OF PHOTO POINT 24
I of 4

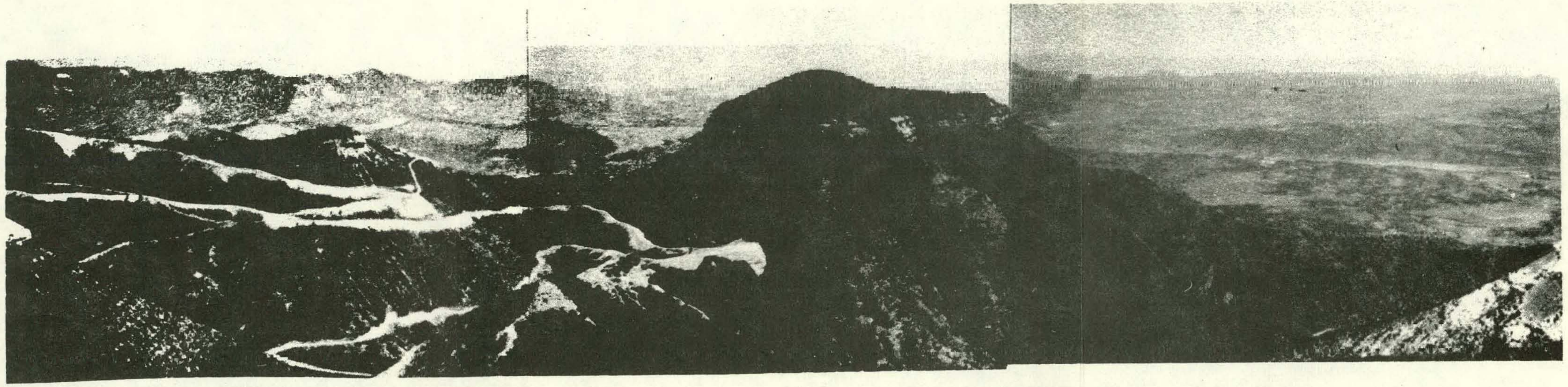


FIGURE 30 (CONT)

360° MOSAIC OF PHOTO POINT 24
2 of 4

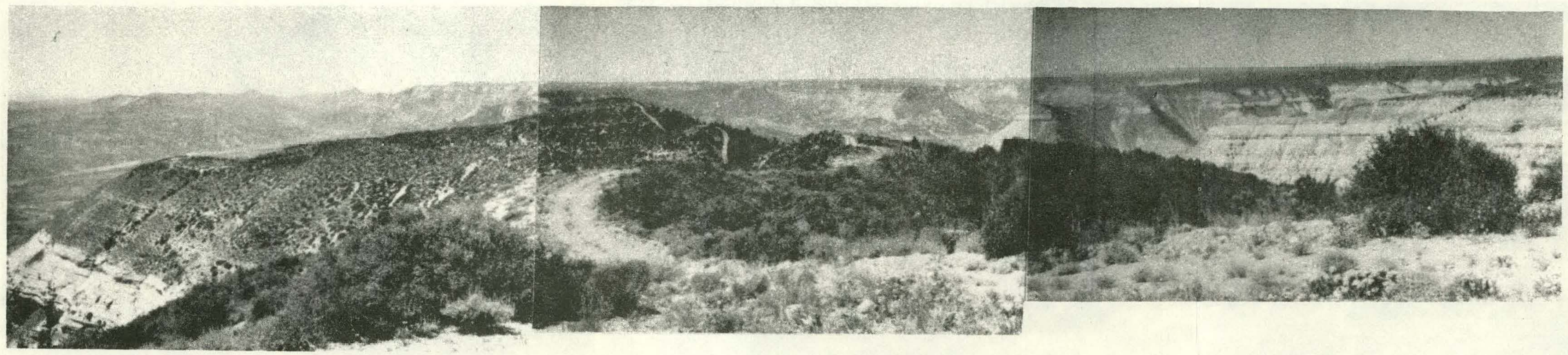


FIGURE 30 (CONT)

360° MOSAIC OF PHOTO POINT 24
3 of 4

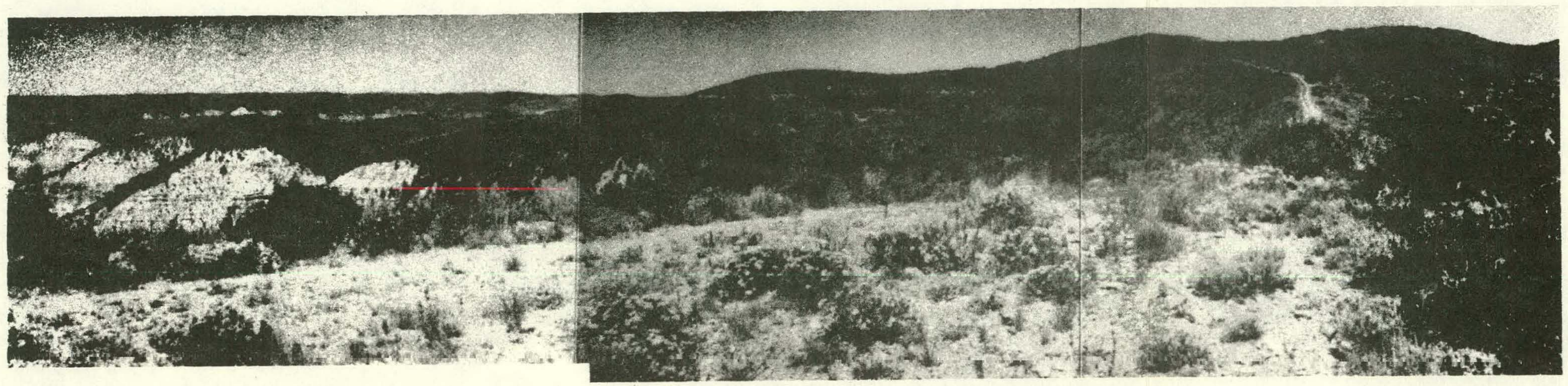


FIGURE 30 (CONT)

360° MOSAIC OF PHOTO POINT 24

4 of 4

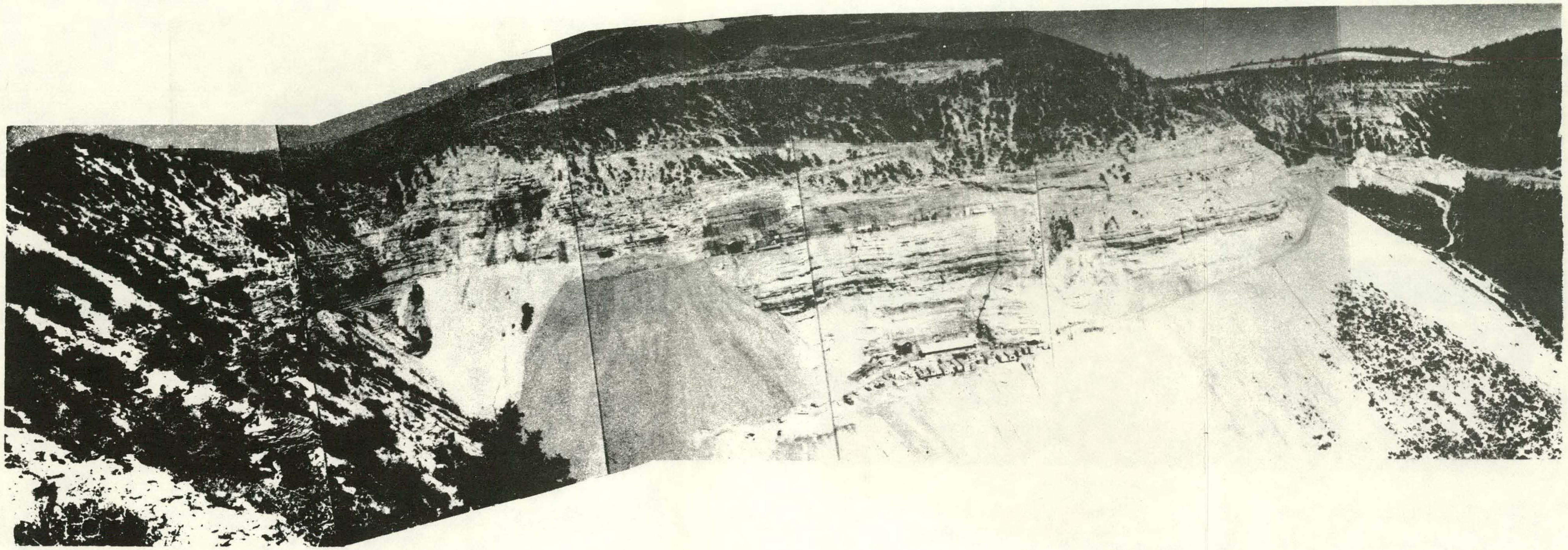


FIGURE 31

360° MOSAIC OF PHOTO POINT 20

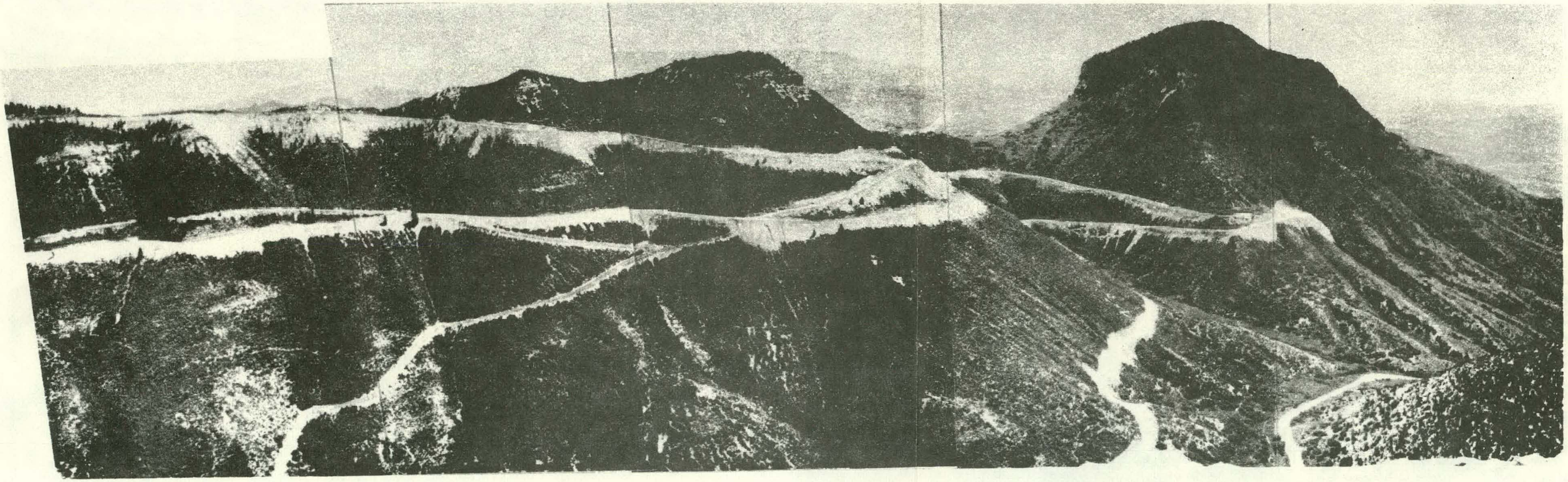


FIGURE 31 (CONT)

360° MOSAIC OF PHOTO POINT 20

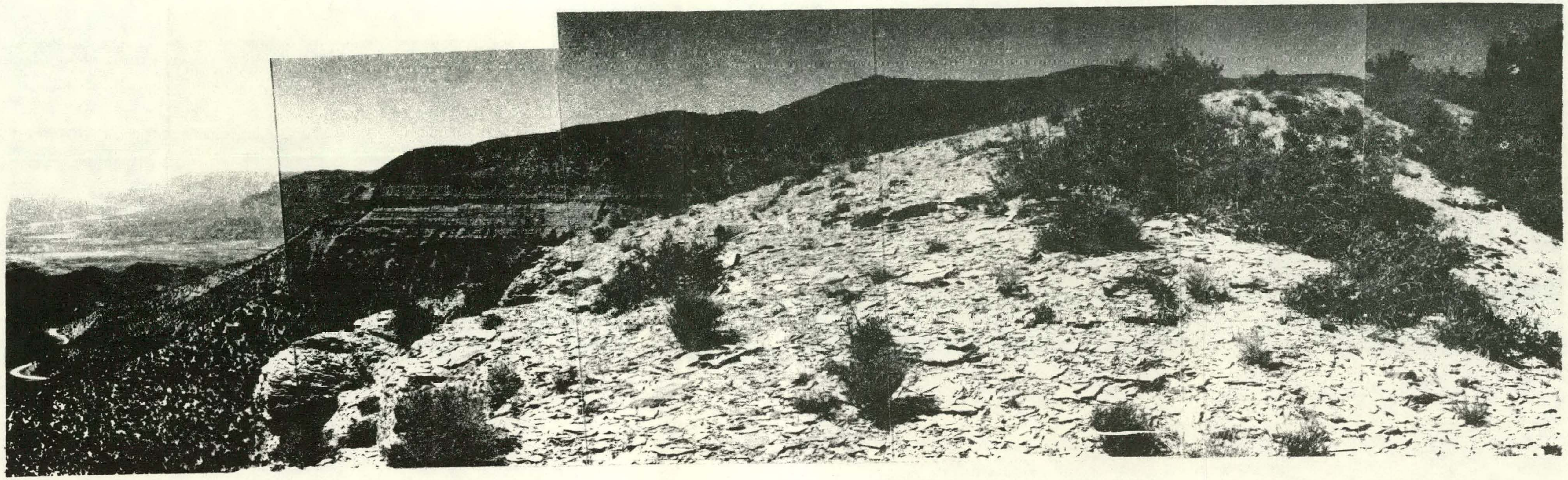


FIGURE 31 (CONT)

360° MOSAIC OF PHOTO POINT 20

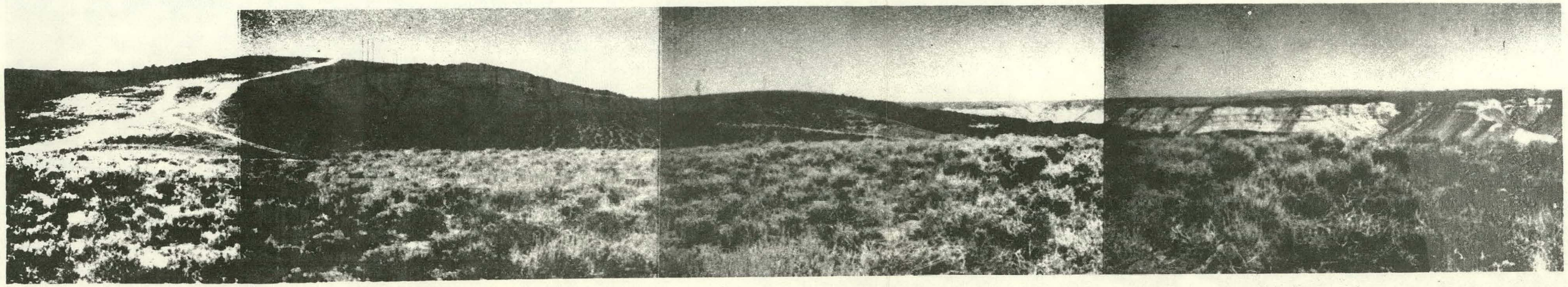


FIGURE 32

360° MOSAIC OF PHOTO POINT 15

1 of 4

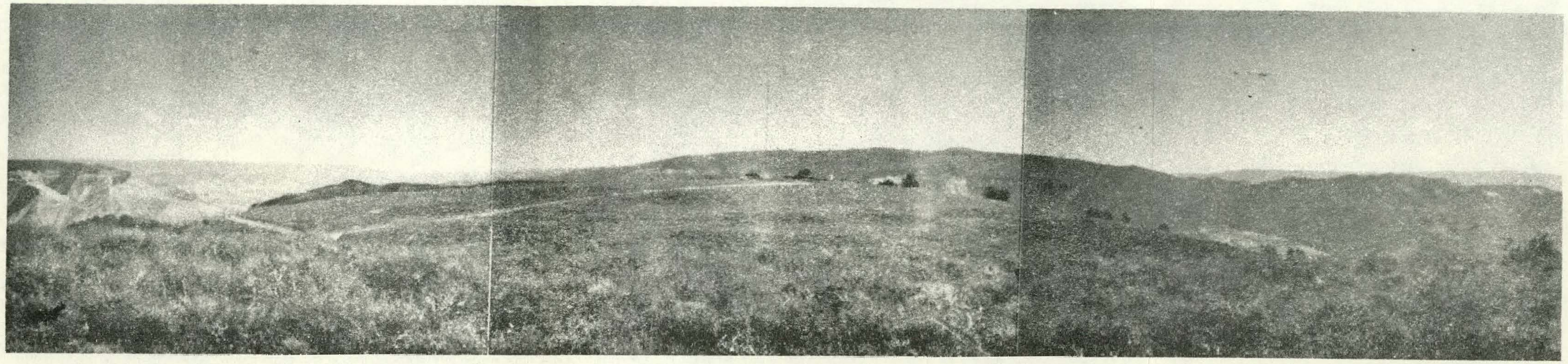


FIGURE 32 (CONT)

360° MOSAIC OF PHOTO POINT 15
2 of 4

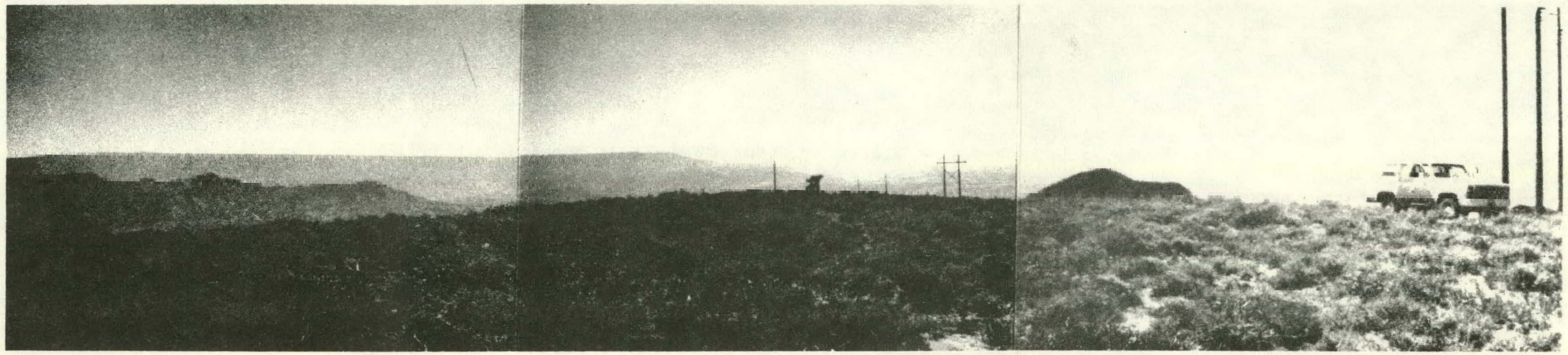


FIGURE 32 (CONT)

360° MOSAIC OF PHOTO POINT 15
3 of 4

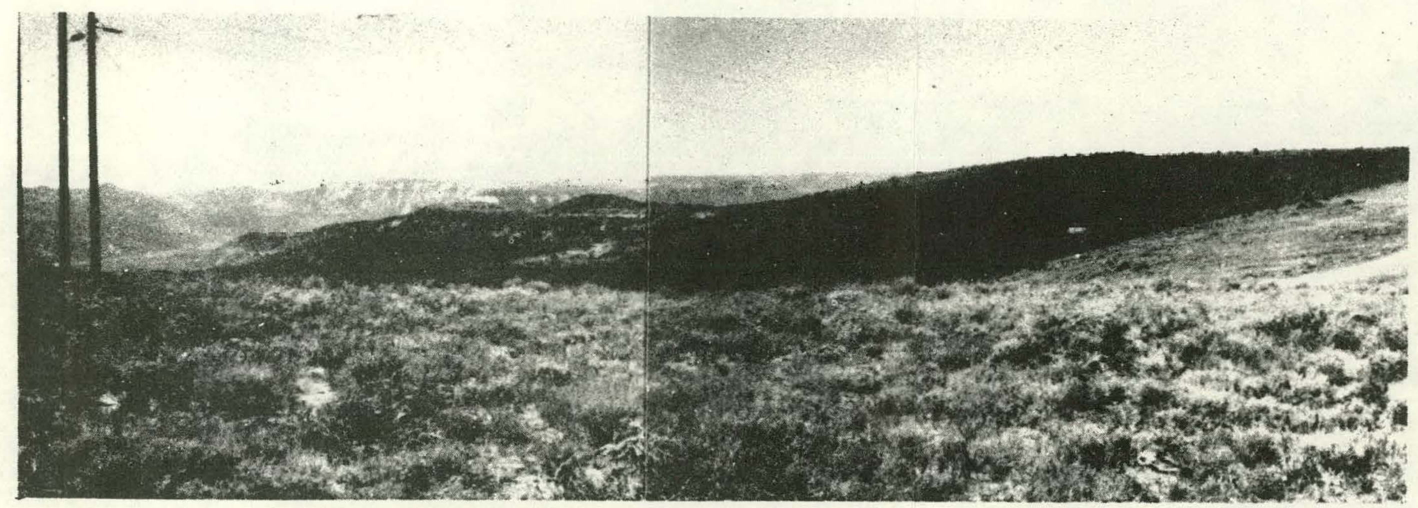


FIGURE 32 (CONT)

360° MOSAIC OF PHOTO POINT 15
4 of 4

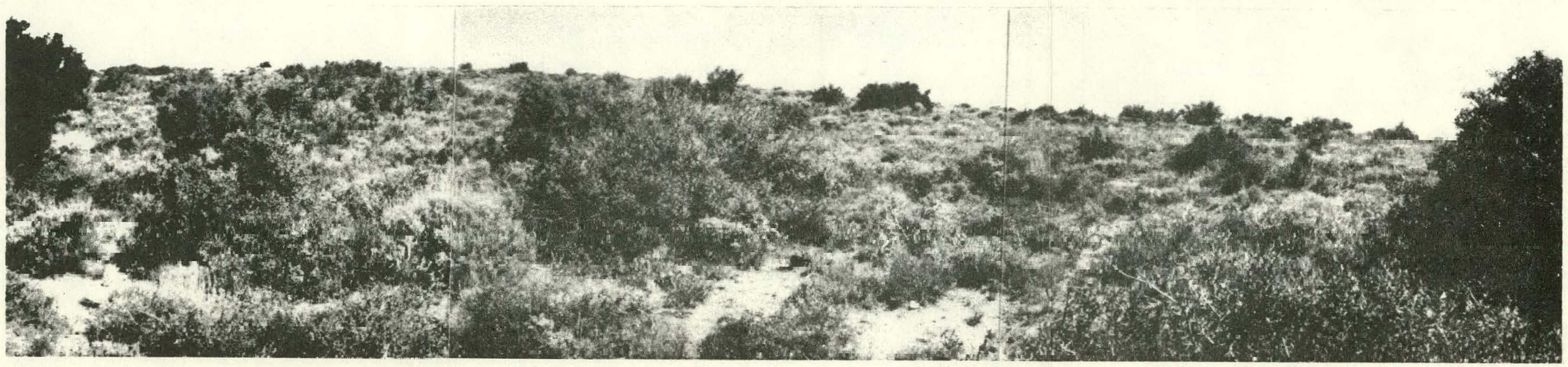


FIGURE 33

360° MOSAIC OF PHOTO POINT 6
1 of 4

FIGURE 33 (CONT)

360° MOSAIC OF PHOTO POINT 6
2 of 4

FIGURE 33 (CONT)

360° MOSAIC OF PHOTO POINT 6
3 of 4

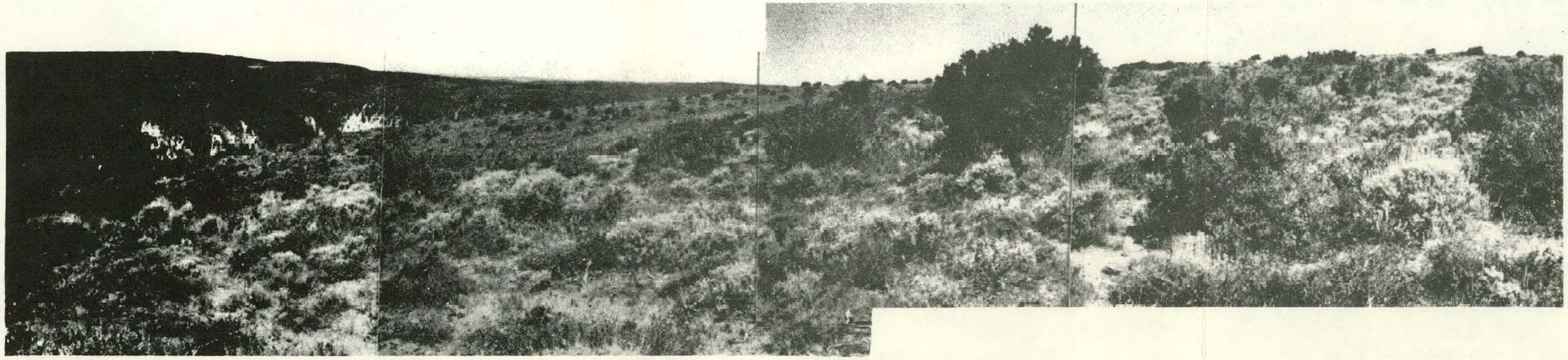


FIGURE 33 (CONT)

360° MOSAIC OF PHOTO POINT 6
4 of 4

respectively. That for point 20 is the most striking and is additionally being made into an enlarged color mosaic.

B. PERMITS

The report on pages 77 through 82 is the current permit status for Logan Wash mine site as of November 7, 1980.

VII. MINE STABILITY

Early in September stress gages were installed in the U-370-N and L-260-N instrument drifts between Retorts 7 and 8 on the Upper and Intermediate levels respectively.

Extensometers were installed in the MR3 sill pillar. In November, rod extensometers were installed in the MR4 sill pillar.

Core samples from the Research mine and the U-370-N and L-662-N instrument drifts were boxed and shipped to OOSI's Grand Junction laboratory for storage. A core from the MR3 upper level was also shipped to the USBM for testing (microfracturing).

VIII. MARKETING STUDIES

A report which builds upon earlier work has been produced under the marketing studies program in Phase II. The report, in Appendix E of this Quarterly Report, is titled "Preliminary Investigation for Transportation of Shale Oil by Pipeline, Phase I: State-of-the Art Literature Search", Williams Brothers Engineering Company, September, 1980. Assembled to provide a data base for subsequent laboratory testing programs and feasibility studies of shale oil transportation, the report suggests a number of pipelining alternatives for consideration.

Compilation Date: 11/7/80

LOGAN WASH PERMIT STATUS REPORT
CURRENT PERMITS

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
Air							
1) PSD	Operate Retorts 7 & 8	EPA		3/24/79	11/01/79		Received EPA revision to permit deleting control and research requirement based on cost effectiveness. EPA has proposed under a separate program, tests, at their expense, of a Stretford unit. Further details of the test are being planned with DOE.
2) Emission Permit (APEN)	Screening Plant	CAPCD	C-10,619	2/19/75	3/03/75	Indefinite	
3) Emission Permit (APEN)	Shale Oil Heater	CAPCD	C-10,761	3/28/75	4/22/75	Indefinite	
4) Emission Permit (APEN)	Hot Water Circulator (HT)	CAPCD	C-10,762	3/28/75	4/22/75	Indefinite	
5) Emission Permit (APEN)	Hot Water Circulator (LB)	CAPCD	C-10,901	7/14/75	8/06/75	Indefinite	
6) Emission Permit (APEN)	Retort 6	CAPCD	C-10,454/C-11,708			indefinite	This permit is in retirement. Mini-retorts are covered under this permit.
7) Emission Permit (APEN)	Retort 7	CAPCD	C-12,319-1(SP)	1/26/79	7/25/79	Indefinite	
8) Emission Permit (APEN)	Retort 8	CAPCD	C-12,319-2(SP)	1/26/79	7/25/68	Indefinite	
9) Emission Permit (APEN)	Process Steam Boiler #1	CAPCD	C-12,319-3(SP)	1/26/79	7/25/79	Indefinite	
10) Emission Permit (APEN)	Process Steam Boiler #2	CAPCD	C-12,319-4(SP)	1/26/79	7/25/79	Indefinite	
11) Emission Permit (APEN)	Process Steam Boiler #3	CAPCD	C-12,319-5(SP)	1/26/79	7/25/79	Indefinite	

Compilation Date: 11/7/80

LOGAN WASH PERMIT STATUS REPORT
CURRENT PERMITS

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
Water							
1) NPDES (National Pollution Discharge Elimination System)	Mine Water Discharge	EPA/CWQCD	CO-0029947			12/31/83	
2) Subsurface Disposal for Retorts 6, 7 & 8, and mini-retorts, subsequent adjacent retorts	Operate Retorts 6,7,& 8	EPA/CWQCD		(6) 4/78 (7&8) 4/80	5/15/78 5/06/80	Indefinite Indefinite	Must complete an abandonment plan before project abandonment. Monitoring is now in maintenance phase. State sent draft permit and monitoring plan. Upon review OXY and DOE agreed that monitoring plan is not acceptable. Jointly-developed plan incorporating recommendations of Oil Shale Task Force submitted to State. Meeting with WQCD to resolve monitoring plan set for 11/24/80.
3) 1900 GPD Sewage Plant	Sewage Treatment	Garfield Co.		10/17/80	6/10/80	Indefinite	The district engineer for the CWQCD has been contacted and a meeting concerning our increase in capacity on the permit will be set by him. He is reviewing our present status.
4) Sewage Plant Site Approval	Sewage Plant Location	Garfield Co.				Indefinite	
5) Water Well #2	Well #2 Construction	Garfield Co.	80320	6/02/75	8/07/75	Indefinite	
6) Water Right	Water Decree	Water Ct. #5	W-1895	5/73	10/24/73	Indefinite	
7) Water Right	Water Decree	Water Ct. #5	W-1896	5/73	10/24/73	Indefinite	
8) Water Right	Water Decree	Water Ct. #5	W-1897	5/73	10/24/73	Indefinite	
9) Water Right	Water Decree	Water Ct. #5	W-2223	5/73	5/21/74	Indefinite	
10) Water Right	Water Decree	Water Ct.	W-2539/WW-1	1/09/75	9/25/75	Indefinite	
11) Subsurface Disposal	Operate mini-retorts	CEQCD		9/80	11/7/80		Interim status approved. Monitoring program being reviewed.

Compilation Date: 11/7/80

LOGAN WASH PERMIT STATUS REPORT
CURRENT PERMITS

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
Land							
1) Special Land Use Permit	Observation Well (LW-112)	BLM	CO-76SL11 (GJ-6-105N)	2/18/76	4/22/76	4/21/81	Application for renewal of Temporary Use Permit submitted. New regulations allow us to seek long term right-of-way which we will apply for after renewals are granted.
2) Temporary Use Permit	Flume - Smith Gulch	BLM	CO-070-TU-78-5	7/22/80	7/24/80	1/24/81	Renewed. Long term right-of-way grant being applied for.
3) Temporary Use Permit	Flume - Riley Gulch	BLM	CO-070-TU-78-6	7/22/80	7/24/80	1/24/81	Renewed. Long term right-of-way grant being applied for.
4) Temporary Use Permit	Observation Well and Flume - Bowdish Gulch	BLM	CO-070-TU-78-21	9/26/80	9/12/78	9/11/80	Application for renewal of Temporary Use Permit submitted. New regulations allow us to seek long term right-of-way which we will apply for after renewals are granted.
5) Right-of-Way	Tramroad	BLM	C-23027	9/09/75	4/20/77	7/19/2007	Gate to mine and experimental adit.
6) Right-of-Way	Heater-Treater and Pipeline	BLM	C-22434	2/07/75	6/16/75	6/16/2005	Annual rental due 6/15/82.
7) Special Land Use	Observation Well LW-101	BLM	CO-76SL4 GJ-6-53	9/26/80	11/01/75	10/31/80	Application for renewal of Temporary Use Permit submitted. New regulations allow us to seek long term right-of-way which we will apply for after renewals are granted.
8) Special Land Use Permit	Observation Well LW-108	BLM	CO-76SL8	1/06/76	2/23/76	2/22/86	Same
9) Special Land Use Permit	Observation Well Shale 2	BLM	CO-76SL9 (GJ6-108)	2/28/76	4/22/76	4/21/81	Same
10) Special Land Use Permit	Observation Well LW-101A	BLM	CO-76SL10	2/18/76	4/22/76	4/21/81	Same

Compilation Date: 11/7/80

LOGAN WASH PERMIT STATUS REPORT
CURRENT PERMITS

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
11) Right-of-Way	Upper Road Access	BLM	CO-23-27/ CO-9246	10/12/79	3/12/80	4/19/2007	The road work is completed.
12) MLRB Permit	Surface Disturbance	CMLRB	77-424	3/28/78	4/01/80	3/27/2038	Annual Report and fee of $275.00 due 4/1/81.
13) Russell and Mary Hugh Scott Mark Longfield, Inv. Mgr.	Observation Well Smith Gulch	Private Property			8/26/75	8/26/85	Annual payment of $200 sent in for 8/80-8/81.
14) Exxon	Observaton Well Kelly Gulch	Private Property			1/19/76	Indefinite	Well appears to be in path of new highway. The road survey was alerted to contact OXY if well will be affected.
15) Union Oil	Observation Well Riley Gulch	Private Property			10/24/75	Indefinite	
16) Mineral Waste Dump	Mine Dump	Garfield Co.	131	1/19/76	5/01/76	When full	Capacity permitted is 8.8×10^6 cu. yds.
17) Conditional Use Permit	Access Road & Benches	Garfield Co.	None Assigned	3/15/74	4/04/74	Indefinite	
18) Conditional Use Permit	Tank Farm & Gate	Garfield Co.	008	8/07/74	9/25/74	Indefinite	
19) Conditional Use Permit	6% Access Road	Garfield Co.	009	10/21/74	12/17/74	Indefinite	
20) Conditional Use Permit	69 KV Substation	Garfield Co.	011	5/75	6/04/75	Indefinite	
21) Conditional Use Permit	Heater-Treater & Pipeline	Garfield Co.	015	3/28/75	6/26/75	Indefinite	
22) Conditional Use Permit	69 KV Powerline	Garfield Co.	016	6/20/75	6/26/75	Indefinite	

Compilation Date: 11/7/80

LOGAN WASH PERMIT STATUS REPORT
CURRENT PERMITS

Permit Title	Purpose	Permitting Agency	Permit No.	Date Submitted	Date Approved	Date of Expiration	Remarks
23) Temporary Trailer	Personnel Trailer	Garfield Co.	161	11/24/75	12/17/75	12/16/80	
24) Lease Agreement	Tank Farm and Gate	R. E. Prather & Getty Oil					
Others							
1) Explosives Storage	Federal Government	Dept. of Treas.	5 CO-03833-AP-90124	9/28/76		12/31 Annually	
2) Explosives Storage	Colo. Government	Co.Bu. Mines	418			12/31 Annually	
3) Communication Station Authorization	Microwave System	FCC	None Issued	4/02/75	5/01/78	Indefinite	
4) Underground Flame Variance	Retorts 4, 5 & 6	CBM & MSHA		2/07/77	4/07/77	Upon shutdown of each retort	
5) Variance to CBM Bulletin 20	Alimak Hoist	CBM					
6) Radioactive Materials License	Krypton	Colo. Dept. Health	267-01		5/10/76	4/30/85	
7) Environmental Assessment	Phase II Cooperative Agreement	DOE	DOE/EA0095	1/79	Issued 11/79		

Compilation Date: 11/7/80

LOGAN WASH PERMIT STATUS REPORT
ADDITIONAL PERMITS REQUIRED

Permit Title	Purpose	Permitting Agency	Target Submittal Date	Date Submitted	Date Approved	Date of Expiration	Remarks
Air							
1) Federal Clear Air Act Emissions Permit	Heater Treater Expansion	CAQCD		9/80			Permit application submitted in July. The CAQCD is reviewing the emissions modeling. Anticipate a response in late November.
Water							
1) Sewage Treatment Facility	Sewage - 2500 GPD	CWQCD					Inquired with CWQCD as to status; awaiting response.
2) Water Right	Roan Creek	Water Ct. #5		2/28/80			Republished in April due to misprint in legal description. Comment period ends in July.
3) Subsurface Disposal	Monitoring program for 7 and 8	CWQCD		9/80			Tentative testing program for Retorts 7 and 8 submitted to DOE.
Solid Waste							
1) RCRA	Generate, store, dispose or treat hazardous waste.	EPA		8/18/80		11/19/80	Filing submitted for three sites: CB-toxic waste, Logan Wash-toxic waste, and Laboratory-hazardous waste by all criteria. Filing of specific status due by 11-19-80.
Land							
1) Right-of-Way	Access to LW 121 and and LW 102	BLM					Permit application has been prepared.
Other							
1) Underground Flame Variance	Mini Retorts	CBM & MSHA					Draft application has been prepared.
2) Underground Flame Var.	Retorts 7 & 8	CBM & MSHA					Draft applicaton has been prepared.
3) DOE/Cooperative Agreement - Monitoring Plan, Phase II	Retorts 7 & 8	DOE/LETC		7/22/80			Monitoring plan submitted to DOE.

IX. SCHEDULE

During the quarter, the major activities remained on schedule with the exception of the MR3 burner (ignition) tests. Under modification A011 to the agreement, the milestones for Phase II in Exhibit A to Appendix C were changed as shown in Table V.

The burner tests on MR3, scheduled to begin in September, were rescheduled for November 1 because of hook-up and shakedown work needed. MR4 ignition has been updated to January 1981 with plans for rubbling 8x to occur following processing MR4.

X. PLANS FOR THE COMING QUARTER

The major activities planned for December 1980 through February 1981 are:

- Conduct inert gas generator ignition test on MR4.
- Rubble Retort 8X in January 1981.
- Rubble Retort 7 in February 1981.
- Continue surface construction.
- Perform hot tracer tests on MR4. (LETC)*
- Conduct HFEM tests on MR4. (ORC)** and (LLNL)***
- Detonate additional full scale and pillar operational tests.

*LETC - Laramie Energy Technology Center
**ORC - Occidental Research Corporation
***LLNL - Lawrence Livermore National Laboratory

TABLE V
AGREEMENT MILESTONES

Original Phase II Milestone Schedule

1.	Commence Phase II	June 1, 1979
2.	Final Design for Retorts 7 and 8	October 1980
3.	Mini Retort Start-up	February 1981
4.	Rubblize Retort 7	May 1981
5.	Rubblize Retort 8	June 1981
6.	Complete Retort 7 and 8 Start-up Plan	February 1982
7.	Complete diagnostic test on Retorts 7 and 8	December 1981
8.	Determine minimum success criteria	October 1981
9.	Ignite Retorts 7 and 8	December 1981
10.	Complete Processing Retorts 7 and 8	October 1982
11.	Terminate Phase II	November 1982
12.	Submit Final Report	February 1983

Mod. A011 Phase II Milestone Schedule

1.	Commence Phase II	June 1, 1979
2.	Ignite Mini-Retort #3	September 1980
3.	Final Design for Retorts 7 & 8	October 1980
4.	Ignite Mini-Retort #4	March 1981
5.	Rubble + Cleanup of Retorts #7, #8 and 8X	October 1980–January 1981
6.	Start Diagnostic Tests of Retorts 7 & 8	June 1981
7.	Complete Retort 7 & 8 Startup Plan	June 1981
8.	Estimate Minimum Success Criteria	September 1981
9.	Ignite Retorts 7 & 8	September 1981
10.	Shutdown of Retorts 7 & 8	April 1982
11.	End of Phase II	July 1982
12.	Submit Final Report	October 1982

XI. RETORT 6 OIL INVENTORY

Detailed below is the Retort 6 oil inventory in gross barrels as of August 28, 1979. Note that the total oil produced by Retort 6 is 1,696 bbls greater than that reported in the Phase I Final Report. The number in the report, 54,000 bbls, was an estimate because (1) a small amount of oil was still being released by the retort; (2) an accounting of oil in the tanks and lines had not been completed; and (3) vapor/aerosol figures had not been verified. The estimate figure was also rounded.

Also note that the shipped gross barrels, 40,093, converts to the net barrels shipped of 38,677 for which the DOE was billed.

	Gross barrels
Shipped	40,093
Used in steam plant	3,288
Oil mist lost	7,529
Samples taken	690
Estimated loss from spills*	80
Estimated in sludge tank	1,200
Oil on site	2,816
TOTAL PRODUCED	55,696 gross barrels

* Handled by procedures defined in the Spill Prevention, Control and Countermeasure Plan, OOSI (July 1978) for Logan Wash.

XII. APPENDICES

APPENDIX A

CORE ANALYSIS

OXY INTER-OFFICE MEMORANDUM

TO:	Distribution	FROM:	R. D. Hutton RDH:80:1
		PROJECT:	OOSI - Logan Wash
SUBJECT:	LW-156	DATE:	March 11, 1980

The following is information pertaining to core hole LW-156.

Elevation	8,613.13
Coordinates	N-22,133.85 E-58,495.87
Location	Centered in pillar between Retorts 7 and 8

A density and caliper log was conducted on March 8, 1980. The log is attached.

R. D. Hutton

RDH:cdg

Distribution:

W. J. Karwoski
C. Nieuwenhuis
J. E. Shaler
H. S. Skogen
R. E. Thomason
L. Trudell

COUNTY	
FIELD	
LOCATION	
WELL	
COMPANY	

Schlumberger

COMPENSATED FORMATION DENSITY LOG

Gamma-Gamma

COMPANY OXY OIL SHALE INC.

WELL LW 156 CORE HOLE

FIELD LOGAN WASH

COUNTY GARFIELD STATE COLORADO

LOCATION			Other Services:
API SERIAL NO.	SEC.	TWP	RANGE
			NONE

Permanent Datum: GROUND LEVEL ; Elev.:

Log Measured From G.L. 0 Ft. Above Perm. Datum

Drilling Measured From G.L.

Elev.: K.B. —
D.F. —
G.L.

Date	MARCH 8,80			
Run No.	ONE			
Depth—Driller	1000			
Depth—Logger	1000			
Btm. Log Interval	998			
Top Log Interval	400			
Casing—Driller	NONE @ —	@	@	@
Casing—Logger	—			
Bit Size	6 1/4			
Type Fluid in Hole	WATER			
Dens. | Visc.	— | —			
pH | Fluid Loss	— | — ml	ml	ml	ml
Source of Sample	—			
Rm @ Meas. Temp.	— @ — °F	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	— @ - °F	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	— @ - °F	@ °F	@ °F	@ °F
Source: Rmf | Rmc	— | —			
Rm @ BHT	— @ — °F	@ °F	@ °F	@ °F
TIME Circulation Stopped	—			
TIME Logger on Bottom	1530			
Max. Rec. Temp.	°F	°F	°F	°F
Equip. | Location	7759 | G.J.			
Recorded By	G. SLIZESKI			
Witnessed By Mr.	~			

FOLD HERE — The well name, location and borehole reference data were furnished by the customer.

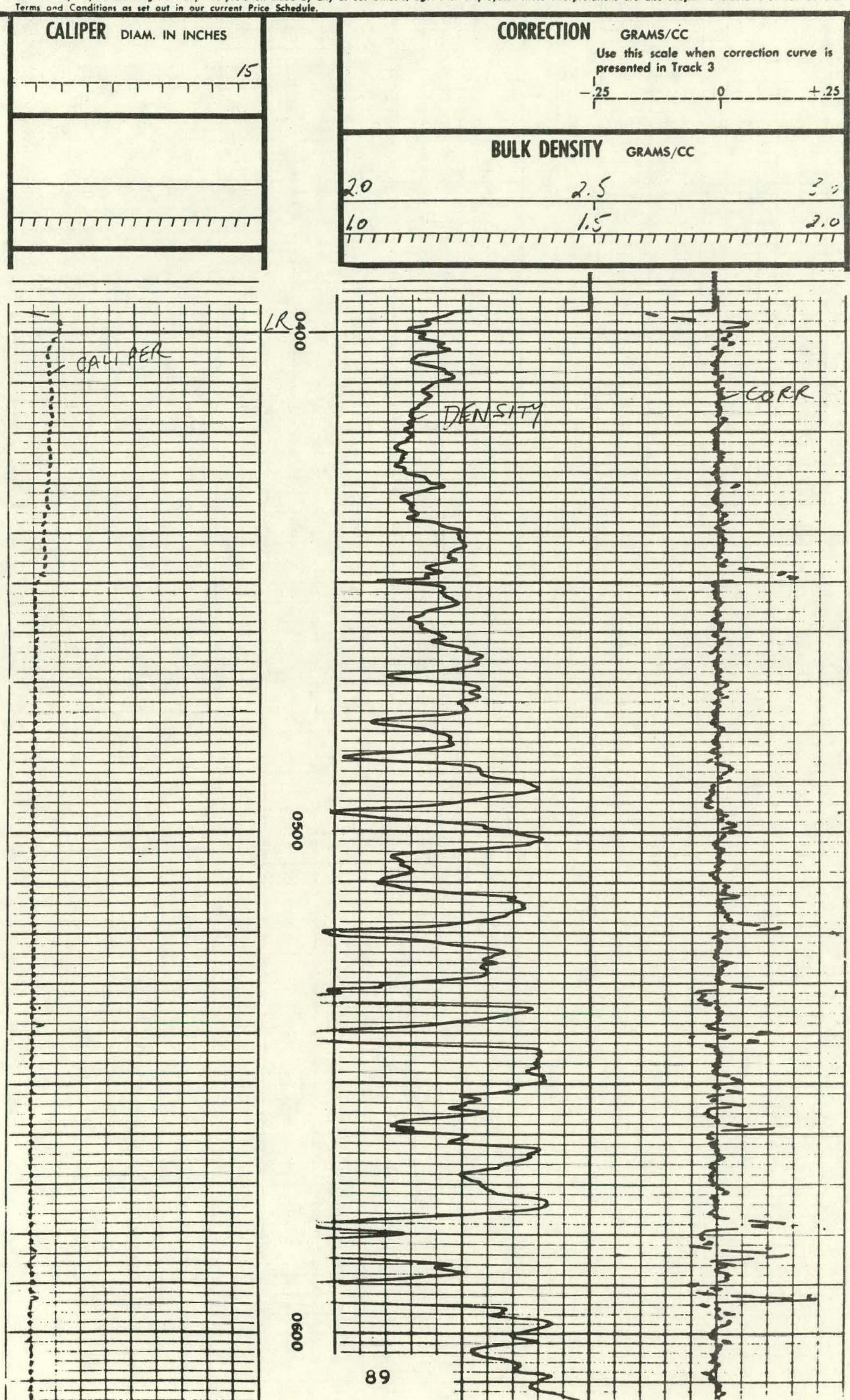
RUN NO.	ONE			
Service Order No.				
Fluid Level	2/3 FULL			
Salinity, PPM CL.	—			
Speed - F.P.M.	30			
EQUIPMENT DATA				
Dens. Panel	EJ 1323			
Dens. Cart.	EB 509			
Dens. Skid.	D 425			
Dens. Sonde	EC 44			
Dens. Source	B 3098			
Dens. Calibrator	RED			
GR Cart.	JC 2559			
Memorizer Panel	—			
Tape Recorder (TTR)	EB 2917			
Depth Encoder (DRE)	C 0958			
Pressure Wheel (CPW)	H 1701			
CALIBRATION DATA				
GR BKG. CPS	—			
GR Source CPS	—			
GR Sens. - Cal	—			
GR T. C. - Cal	—			
FDC P1 — Before Log	107.5			
FDC P2 — Before Log	161.9			
FDC P1 — After Log	107.5			
FDC P2 — After Log	161.9			
LOGGING DATA				
Grain Density	—			
Liquid Density	1.00			
Hole Fluid	LIQ			
Porosity Scale	—			
G.R. T.C. Logged	—			
G.R. Sens. Logged	—			
Zero Div. Left	—			
Scale Per 100 Div.	—			

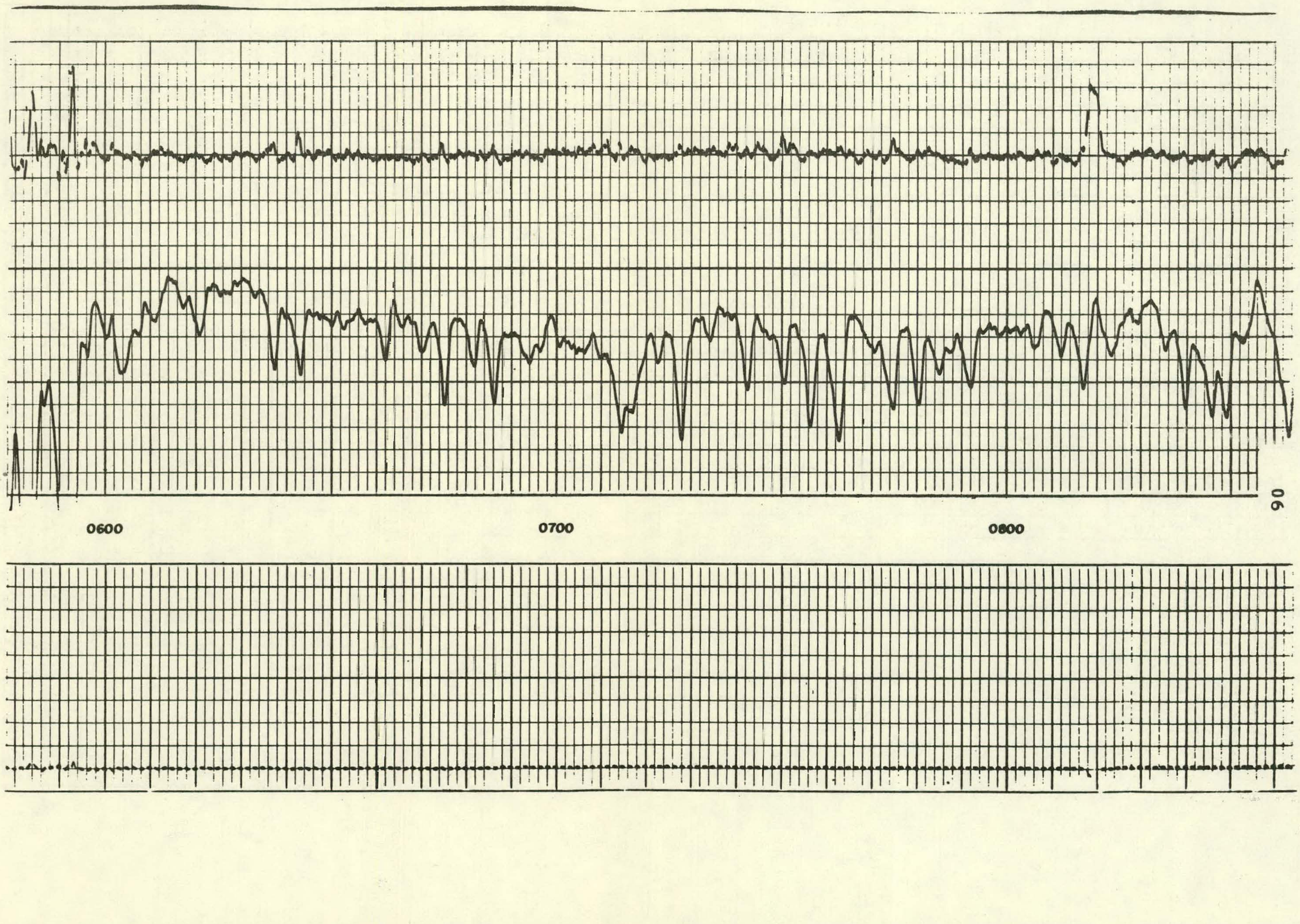
SCALE CHANGE

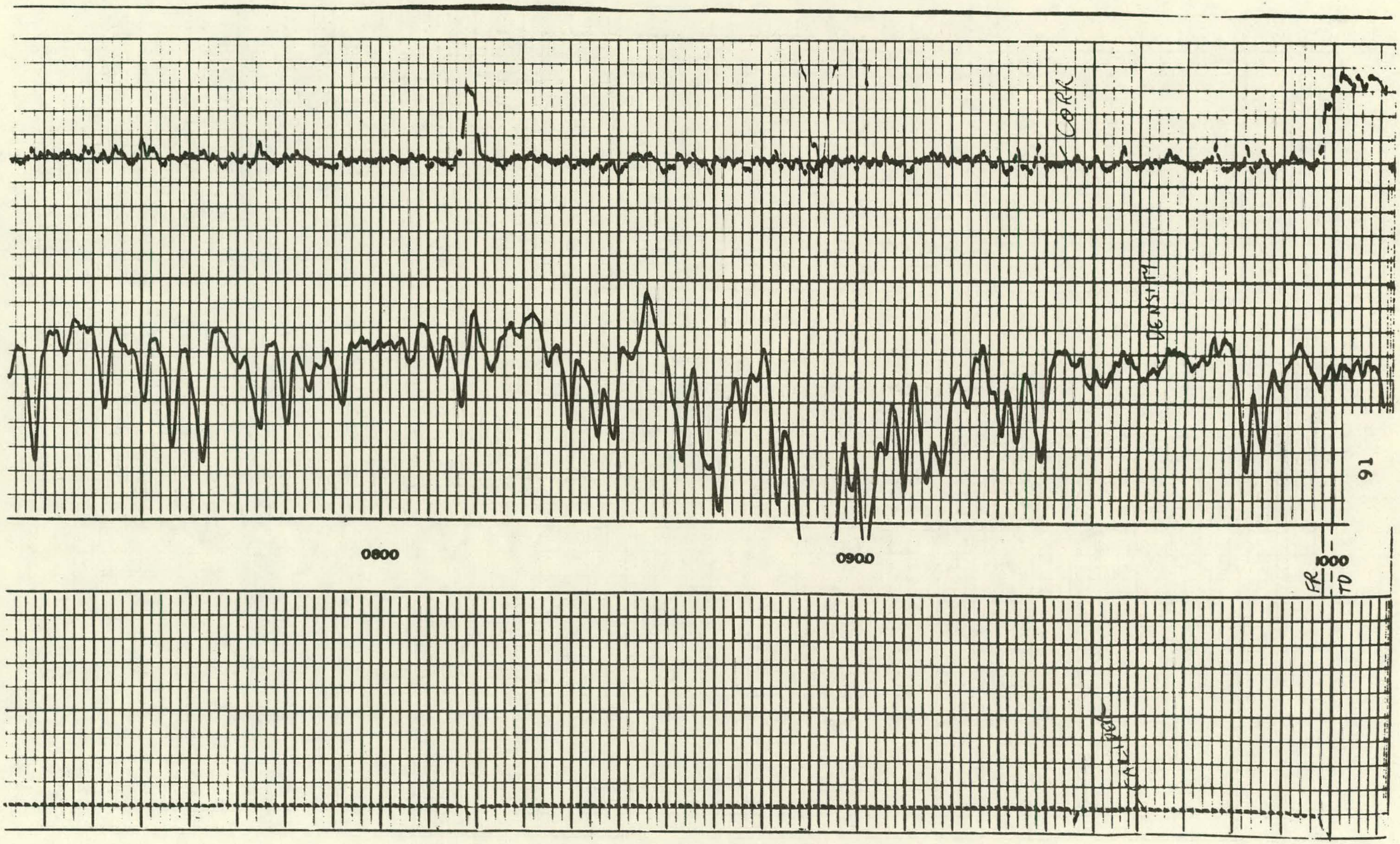
Type Log	Depth	Up Hole	Down Hole

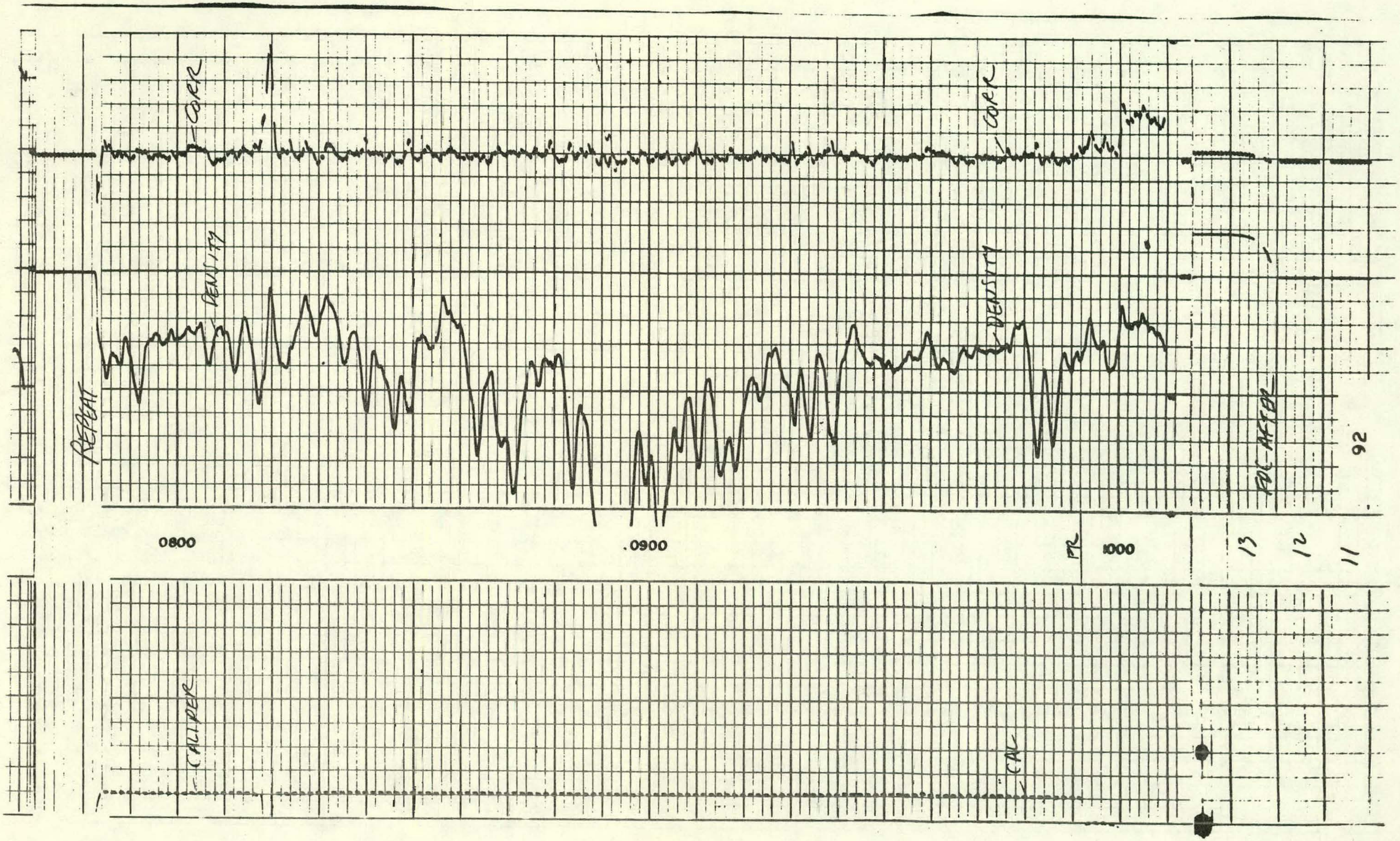
REMARKS:

All interpretations are opinions based on inferences from electrical or other measurements and we cannot, and do not guarantee the accuracy or correctness of any interpretations, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Clause 4 of our General Terms and Conditions as set out in our current Price Schedule.

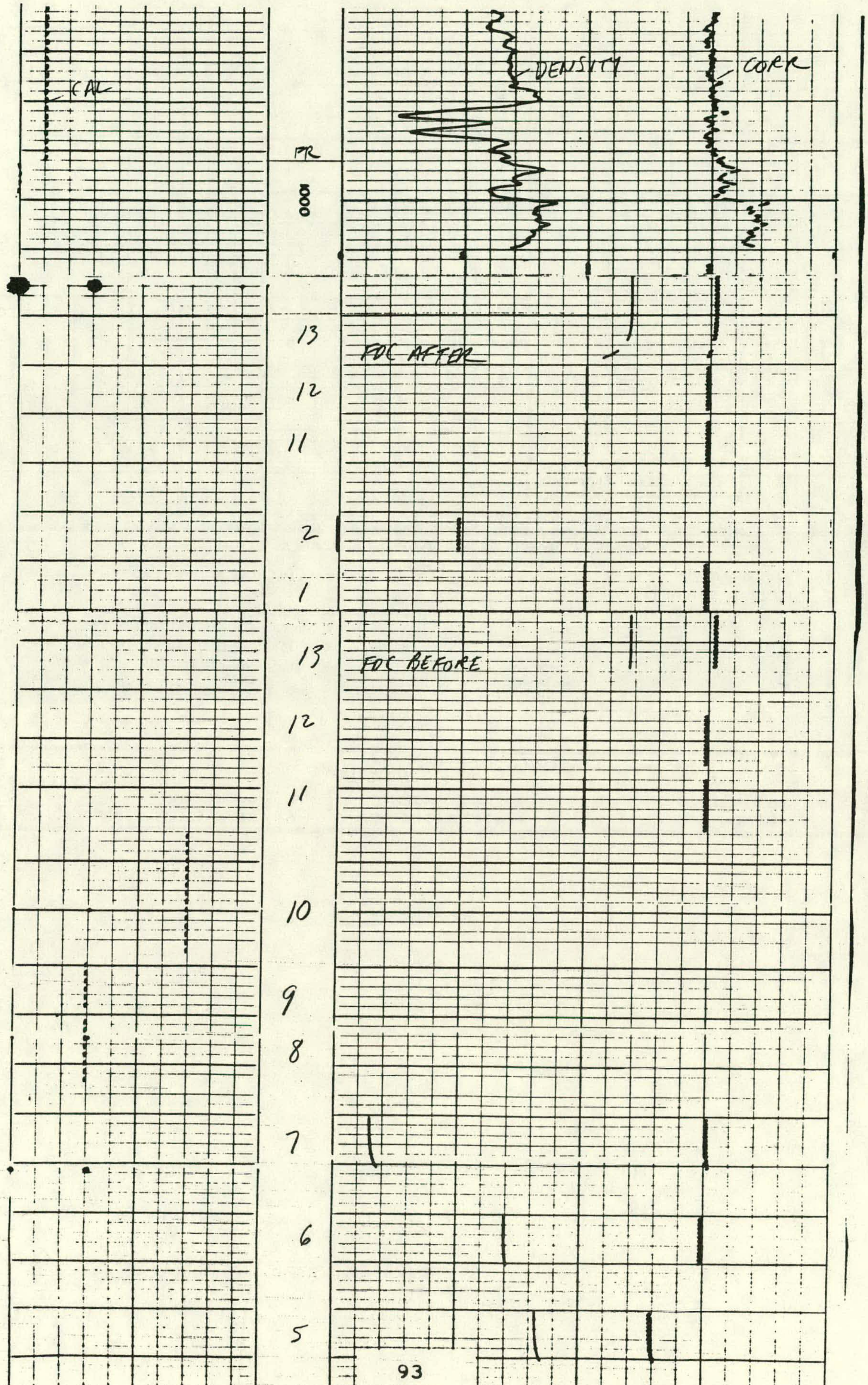



0600
0700
0800


CORR
DENSITY
0800
0900
1000
FR
TD
CALIPER



CORR
DENSITY
REPEAT
0800
.0900
1000
CORR
DENSITY
FDC AFTER
92
13
12
11
CALIPER
CAL


CAL
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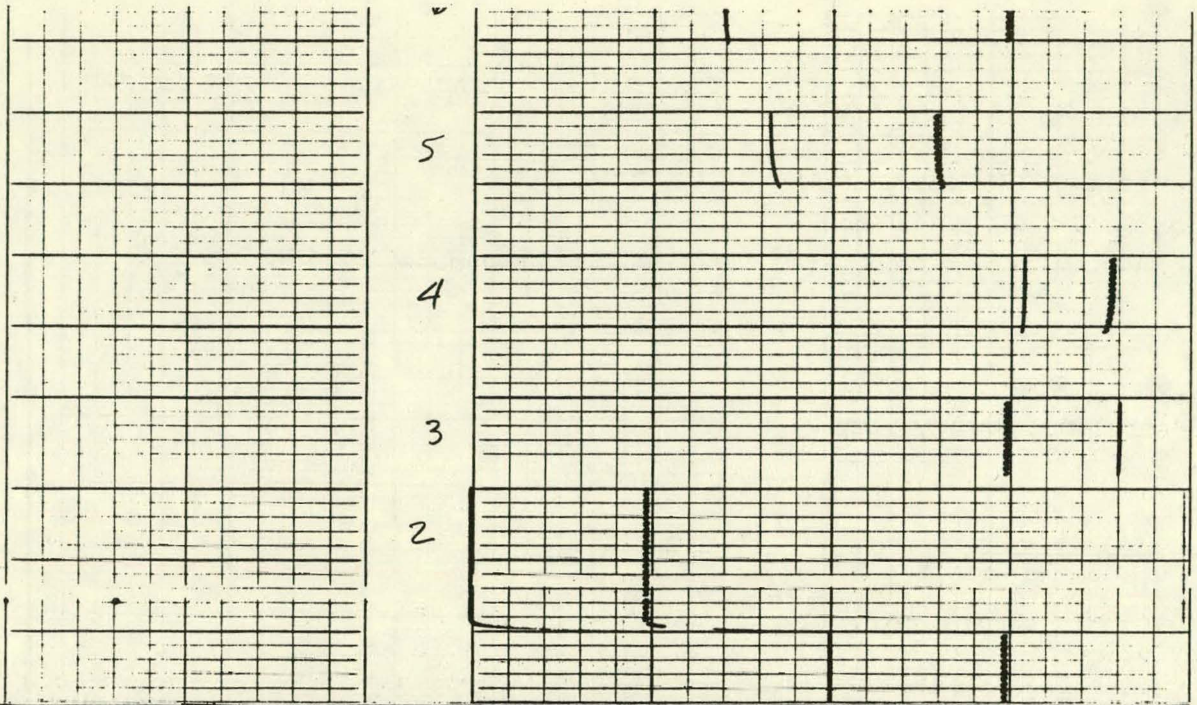

FORMATION DENSITY COMPENSATED CALIBRATION CODING

1. MECHANICAL ZERO
2. RECORDER SENSITIVITY

PANEL TEST

	POS	FDC LIQUID ρ	$\Delta\rho$
3.	# 1	2.92	.00
4.	# 2	2.78	+.14
6.	# 3	2.42	−.10
6.	# 4	2.35	.00
7.	# 5	2.08	.01

8. MECHANICAL ZERO CALIPER
9. 8" RING
10. 12" RING
11. TOOL CALIBRATE #1 SET $\rho = 2.50$
12. TOOL CALIBRATE #2 SET $\Delta\rho = .00$
13. LOG POSITION $\rho = 2.59$, $\Delta\rho = .015$

GAMMA RAY CALIBRATION CODING

1. MECHANICAL ZERO
2. ELECTRICAL ZERO
3. RECORDER SENSITIVITY
4. MEMORIZER ADJUSTMENT
5. BACKGROUND
6. CALIBRATE - SOURCE IN PLACE

U. S. Department of Energy
Laramie Energy Technology Center
P.O. Box 3395, University Station
Laramie, Wyoming 82071

November 26, 1980

Beverly Romig
Occidental Oil Shale, Inc.
P.O. Box 2687
Grand Junction, CO 81501

Dear Beverly:

Enclosed are three copies of our Illustration No. SBR-5083P, the lithologic description of cores from Occidental's LW-156. Also enclosed is one copy of Appendix B from BuMines RI 7357, defining and explaining many of the lithologic terms used in descriptions.

Please note the corrected core sequences at 848.35-867.95 and 888.0-907.5 feet. These corrections have been made in our samples and will appear on our Fischer assay tabulation.

At our current rate of analyses, the assays should be completed in a couple weeks and it will take a few more weeks to have the data typed. I hope we will be able to mail the data by New Year.

Sincerely,

Larry

Laurence G. Trudell
Supervisory Research Geologist

Enclosures

RECEIVED
DEC 1 - 1980
B. A. ROMIG

BuMines RI 7357, APPENDIX B. - LITHOLOGIC DESCRIPTIONS

The detailed lithologic description of cores from Bureau of Mines-AEC Colorado Corehole No. 1 presented in table B-1 is representative of the descriptions placed on open file (tables 1 and A-1). Each sample description is presented in the following pattern: Depth of interval described, followed by

A. Rock classification.

B. Color.

C. Action with acid.

D. Luster.

E. Stratification.

F. Physical properties.

G. Accessory features.

H. Minerals by X-ray diffraction.

To illustrate the application of this pattern the description prepared for the interval 1,025.0 to 1,027.2 feet is divided into these segments: (A) Oil shale: (B) medium to very dark brownish gray and rare brown to tan (10YR 4/2-2/2, rare 5/2 and 5/3-6/3), (C) (no entry); (D) rare satiny luster. (E) Faint to rare distinct, slightly distorted to smooth laminae; rare fine loop structures and displacements. (F) Smooth to slightly irregular, thick to some thin parting; fairly smooth to irregular and conchoidal fracture. (G) Rare thin brown to gray tuff stringers and lenses. Rare tight diagonal fractures with very fine pyrite in upper part. (H) Sample of dark brownish-gray oil shale from 1,026.6 feet: X-ray--quartz, dolomite, analcite, feldspar, illite, pyrite, ferroan.

Given below are explanations of entries in these subject headings and definitions of the terms used:

A. Rock classification.

Sandstone: Composed predominantly of clastic grains between 1/16 mm and 2.0 mm in diameter (textures were determined by comparison with standard samples in a sand gauge folder distributed by Geologic Specialty Company, P.O. Box 8337, Britton Station, Oklahoma City, Okla.). Coarse--1/2-20 mm, medium--1/4-1/2 mm, fine--1/16-1/8 mm.

Siltstone: Composed predominantly of clastic grains discernible under 10X magnification but smaller than 1/16 mm in diameter.

Mudstone: Composed predominantly of poorly sorted microgranular to fine sand size clastic grains.

Claystone: Composed predominantly of microgranular clastic material.

Shale: Claystone displaying tendency to part into thin sheets along bedding planes.

Marlstone: Microgranular to silty-textured rock composed predominantly of chemically precipitated carbonates with moderate amounts of authigenic quartz, feldspar, clay, or other noncarbonate minerals.

Oil shale: Organic marlstone, shale, or mudstone which, by visual examination, is estimated to yield more than 3 gallons of oil per ton by retorting, excluding petroleum or bitumen-impregnated rocks and coal.

Limestone: Composed predominantly of calcite or calcite and dolomite.

Tuff: Composed predominantly of volcanic ash.

B. Color.

Rock colors are indicated by descriptive terms and by symbol notations (in parentheses) according to the Munsell system of color notation (Munsell Book of Colors, Pocket Edition, v. 1, Munsell Color Co., Inc., Baltimore, Md., 1929-42).

C. Action with acid.

Cores were frequently tested with approximately 1.0 normal HCl giving the following results: Calcareous--rapid effervescence producing a white froth; dolomitic--slow evolution of fine bubbles.

D. Luster.

Chalky: Very dull, powdery.

Earthy: Dull, lusterless; like clay.

Satiny: Very slight sheen.

Resinous: Moderate sheen.

Waxy: Very lustrous; like polished leather.

Vitreous: Bright luster, glassy.

E. Stratification.

Massive: No visible stratification.

Bedded: Textural stratification without distinguishable layers.

Variegated: Irregular subtle color variations.

Mottled: Irregular color blotches or spots.

Streaked: Stratification marked by thin to fine flat discontinuous elements.

Laminated: Composed of alternating layers mostly thinner than 1/2 inch.

Banded: Composed of alternating layers mostly thicker than 1/2 inch.

Loop structure: Pinching out of several laminae.

Displacement: Vertical or diagonal offset of laminae, streaks, etc.

F. Physical properties.

Parting: Tendency of rock to break parallel to stratification.

Shaly parting: Commonly breaks into fairly uniform plates 0.1 to 0.5 inch thick

Papery parting: Commonly breaks into plates thinner than 0.1 inch.

"Curly" parting: Breaks into irregular undulating plates.

Fracture: Characteristics of vertical surfaces produced by splitting core.

Conchoidal fracture: Smoothly curved.

Hackly fracture: Jagged with sharp blades or irregular projections roughly parallel to stratification.

Unctuous: Smooth soapy feel indicating abundance of clay minerals.

G. Accessory features.

1. Forms.

Band: Fairly regular and conformable layer thicker than 1/2 inch.

Laminae: Fairly regular and conformable layer thinner than 1/2 inch.

Stringer: Irregular layer or vein.

Streak: Thin to fine flat discontinuous mass.

Lens: Roughly biconvex or oval mass.

Nodule: Large rounded mass.

Blob: Very small irregular or rounded mass.

Patch: Very irregular mass.

Disseminated: Scattered through rock matrix.

Zone: Interval or layer characterized by some particular property, such as color or accessory content.

Interstitial: Occurring as fine partitions between closely spaced crystals.

Vug: Small to large isolated cavity left by solution of minerals (usually nahcolite).

Boxworks: Network of interstitial partitions remaining after mineral solution, usually bordering a vug.

2. Textures.

Sandy: Composed predominantly of grains between 1/16 mm and 2.0 mm in diameter.

Silty: Composed predominantly of grains smaller than 1/16 mm in diameter.

Dense: Compact, microgranular or amorphous.

Sparry: Composed of interlocked crystals which break along cleavage planes.

Oolitic: Containing fine spherical to ellipsoidal concretionary grains.

Porous: Containing common fine cavities.

Spongy: Containing common small to large interconnected cavities.

Collapse breccia: Disoriented angular fragments formed by failure of the rock after mineral removal.

Drusy: Mineral linings composed of well-formed crystals in vugs or on natural fracture surfaces.

3. Distribution.

Quantity terms are used in two distinct senses in the descriptions. As applied to large masses or thick layers they indicate the percentage of accessory material in the core. As applied to small scattered accessory features or thin layers the terms indicate frequency of occurrence. In either case they are only visual estimates and not measured or counted quantities.

Percentage.

Rare: Less than 5 percent.

Some: 5 to 15 percent

Common: More than 15 percent.

Frequency of occurrence.

Rare: Fewer than 50 per square foot of core surface for scattered features or fewer than 3 per foot of core length for layers.

Some: 50 to 150 per square foot for scattered features or 3 to 6 per foot of core for layers.

Common: More than 150 per square foot for scattered features or more than 6 per foot for layers.

4. Sizes.

Large or thick: Greater than 1.0 inch.

Medium: 0.5 to 1.0 inch.

Small or thin: 0.1 to 0.5 inch.

Fine: Smaller than 0.1 inch.

H. Minerals by X-ray diffraction.

Minerals identified by X-ray diffraction analyses of described samples are reported in the descriptions, listed according to estimated amounts in descending order. Samples were selected to represent typical rock and unusual material.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY[1/]

Quarter-core samples from Occidental Oil Shale, Inc.
Corehole LW-156 drilled in 1980 in NE1/4NW1/4NE1/4
(566'FNL, 1,504'FEL) of sec 25, T7S, R97W, Garfield County, Colorado

Surface elevation: 8,613.1 feet
Described interval: 450.8 - 1,003.8 feet
Mahogany marker: 880.4 - 880.9 feet

From	To	Description
450.8	452.7	Siltstone: Light to medium slightly brownish gray and some gray buff; very slightly calcareous. Faint and rare moderately distinct streaked bedding and some irregular thin to medium layering. Irregular thick parting; slightly to moderately irregular fracture. Rare black carbonaceous plant debris. Occasional fine pyritic blebs. Slightly permeable in parts.
452.7	454.7	Siltstone: Light to medium slightly brownish gray; very slightly calcareous. Faint to moderately distinct streaked bedding and thin irregular layers; few 1- to 3-inch massive layers. Irregular thick parting; irregular fracture. Abundant carbonaceous flecks in some parts. Rare pyritic blebs and streaks. Some irregular shredded stringers of buff to brownish-gray very finely streaked to laminated mudstone and marlstone in lower half foot. Slightly permeable in parts. Sample of light to medium gray siltstone from 453.7 feet: X-ray - quartz, analcime, feldspar, pyrite, dolomite, illite, marcasite.
454.7	456.2	Marly mudstone and some siltstone: Buff to light and some medium brownish-gray dolomitic to slightly calcareous mudstone. Faint to moderately distinct very fine laminae with abundant fine to 1/4-inch displacements; few intricately contorted and displaced zones in lower part. Few thin to thick siltstone layers; wavy to truncating contact with marlstone. Moderately to slightly irregular thick parting; slightly conchoidal to irregular fracture.
456.2	456.6	Siltstone: Light to rare medium slightly brownish gray; very slightly calcareous. Faint contorted bedding. Irregular parting and fracture. Some very fine black carbonaceous plant debris. Some fine pyritic blebs and streaks. Slightly permeable.
456.6	457.4	Marly mudstone: Buff to light and rare medium brownish gray; dolomitic to slightly calcareous. Faint to moderate distinct slightly inclined laminae with abundant fine displacements; becoming intricately contorted and displaced in lower 4 inches. Irregular thick parting; slightly conchoidal to irregular fracture.

1/ By L. G. Trudell, completed September 26, 1980

Quarter-core samples from Occidental Oil Shale, Inc.
corehole LW-156 (Con.)

From	To	Description
457.4	460.9	Siltstone and very fine sandstone: Gray buff and light to rare medium slightly brownish gray; very slightly calcareous in parts. Faint to rare distinct contorted to distorted stringers, streaks, and laminae. Irregular thick parting; moderately to slightly irregular fracture; slightly to moderately permeable. Regularly laminated marly mudstone as above at 459.3 - 459.6. Rare carbonaceous flecks.
460.9	462.0	Siltstone: Medium to light brownish gray and gray buff. Noncalcareous. Faintly banded; occasional very thin to fine layers of very finely laminated medium to light brownish-gray marly mudstone. Irregular to regular thick to rare medium parting; irregular to regular fracture. Some carbonaceous plant debris.
462.0	462.5	Silty marlstone: Buff to light brownish gray; dolomitic to slightly calcareous. Faint very fine laminae; slightly distorted near top. Slightly irregular thick parting; conchoidal to slightly irregular fracture.
462.5	463.6	Siltstone and some very fine sandstone: Medium to light slightly brownish gray; very slightly calcareous to noncalcareous. Faintly banded; few thin to 3/4-inch layers of laminated marlstone as above and below. Moderately to slightly irregular thick parting; slightly to moderately conchoidal and irregular fracture. Abundant carbonaceous debris in upper part, becoming sparse in lower part. Slightly permeable.
463.6	465.1	Silty marlstone (oil shale in part) and siltstone: Buff to light and some medium brownish-gray laminated marlstone, banded with siltstone as above. Regular to irregular thick parting; slightly conchoidal to irregular fracture. A very fine dark gray dense crystalline lamina with pyrite blebs at bottom.
465.1	468.7	Silty marlstone: Buff and gray buff to light and rare medium brownish gray; slightly to moderately calcareous. Moderately distinct to faint very fine regular laminae. Regular to some irregular thick to rare medium parting; regular to conchoidal and rare irregular fracture; very slightly permeable in parts. A very fine vitreous black organic streak at 466.85. A small ovate leaf at 466.6. Sample of buff silty marlstone from 466.7 feet: X-ray - dolomite, quartz, analcime, feldspar, calcite, illite, pyrite.

From	To	Description
468.7	469.3	Marlstone grading to oil shale: Buff to light and some medium grayish brown, dolomitic. Moderately distinct to faint very fine laminae. Regular to irregular thick parting; slightly to moderately conchoidal fracture. Sample of buff to grayish-brown oil shale from 469.1 feet: X-ray - dolomite, quartz, analcime, feldspar, calcite, illite, pyrite.
469.3	470.6	Oil shale: Dark brownish gray to black and some medium to rare light grayish brown; common satiny to resinous luster in lower part. Faint to rare distinct streaked bedding and some irregular and discontinuous to regular laminae; interfingered with 1- to 2-inch irregular lenticular grayish-brown tuff (?) stringers in lower 0.2 foot. Fairly regular to irregular thick to rare medium parting; irregular slightly hackly fracture. Sample of finely streaked dark oil shale from 469.6 feet: X-ray - dolomite, quartz, analcime, aragonite, feldspar, illite, calcite, pyrite.
470.6	471.8	Tuff: Very light gray; medium to light brownish gray in upper 2 inches; silty textured. Distinctly streaked with very fine to very thin shreds of black to grayish-brown oil shale. Irregular to slightly irregular thick parting; moderately to slightly irregular fracture. A thin broken and displaced oil shale layer at 471.6. Irregular diagonal contact with oil shale below. Sample of light gray tuff with sparse oil shale shreds from 471.1 feet: X-ray - dolomite, quartz, feldspar, analcime, illite, pyrite.
471.8	473.1	Oil shale: Medium to some dark and light brownish gray; dolomite to slightly calcareous. Faint to some distinct regular to discontinuous laminae; rare fine loop structures. Irregular to rare regular thick parting; irregular and conchoidal fracture. Some very fine gray-buff silty tuff streaks in upper part.
473.1	475.5	Oil shale: Medium to light brownish gray, rare dark in upper part, some buff in lower part; dolomitic to slightly calcareous. Moderately distinct to faint very fine discontinuous to regular laminae; abundant fine loop structures and medium- to low-angle displacements. Irregular to slightly irregular thick to rare medium and thin parting; moderately to slightly irregular and conchoidal fracture. Fine dense cherty pyritic lenses at 474.5 and 474.9.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc. corehole LW-156 (Con.)

From	To	Description
475.5	476.9	Oil shale: Light to medium brownish gray and some buff; dolomitic to slightly calcareous. Moderately distinct to faint very fine regular to discontinuous laminae; some very fine loop structures and displacements. Fairly regular to irregular thick parting; slightly to moderately conchoidal fracture.
476.9	477.9	Oil shale: Medium to light and rare dark grayish brown, dolomitic. Moderately distinct to faint very fine laminae; common very fine loop structures and displacements. Slightly to moderately irregular thick parting; moderately to slightly conchoidal fracture. Rare very fine dull black streaks and lenses.
477.9	478.7	Oil shale: Dark brownish gray to black in upper and lower parts, medium grayish brown in middle, dolomitic. Faint streaked bedding and discontinuous laminae in upper and lower parts; very faintly bedded in middle. Slightly irregular thick parting; irregular and slightly hackly to slightly conchoidal fracture. Some slightly silty grayish-brown streaks and lenses in dark parts.
478.7	483.1	Oil shale: Dark brownish gray to black, dolomitic. Faint streaked bedding and some discontinuous and distorted to rare regular laminae; some massive zones in lower half. Irregular thick parting; irregular to conchoidal fracture; smooth shiny black parting surfaces at 480.0, 480.15, 480.3 and 480.5. Some very fine disseminated crystals in massive shale in lower part. A 1-inch dense brown dolomite band at 482.6. Sample of dark oil shale with fine disseminated crystals from 482.8 feet: X-ray - quartz, dolomite, calcite, analcime, apatite, feldspar, pyrite, illite.
483.1	484.3	Oil shale: Dark to medium grayish brown, very rare black, dolomitic. Faint to moderately distinct very fine to thin regular to slightly distorted laminae. Irregular thick parting; conchoidal to irregular fracture. Some fine dense to silty and porous, black to grayish-brown crystalline streaks and lenses in lower 3 inches.
484.3	485.6	Oil shale: Medium to some light and very rare dark grayish brown, dolomitic. Moderately distinct to faint discontinuous, distorted, and displaced laminae to streaked bedding. Irregular thick parting; irregular to slightly conchoidal fracture. Very thin to 1-inch pinch-and-swell light brownish-gray porous silty to sandy-textured tuff stringers in upper 3 inches. Fine pyrite streaks at 484.6 and 485.5.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc.
corehole LW-156 (Con.)

From	To	Description
485.6	487.3	Oil shale and tuff: Dark and rare medium brownish-gray to black oil shale; some satiny to resinous luster; dolomitic. Faint regular to distorted streaked bedding; abundant fine to 1-inch streaks, stringers and lenses of brownish-gray to buff, silty to very fine sandy-textured tuff. Irregular thick to rare medium parting; irregular to some hackly fracture. Irregular natural (?) high-angle fracture from 485.9 to 486.6. Abundant very fine disseminated crystals below 486.9 (like 482.8). Sample of light brownish-gray tuff with some oil shale from 486.8 feet: X-ray - analcime, quartz, feldspar, calcite, pyrite.
487.3	487.9	Oil shale: Medium to light grayish brown, dolomitic, slightly silty. Faint slightly inclined distorted to regular streaked bedding. Irregular thick parting; irregular to conchoidal fracture. Some interfingered dark oil shale near top and bottom. Some tan silty tuff streaks in upper 3 inches. Natural high-angle fracture at 487.5 - 487.9. Uneven sample split. Sample of grayish-brown oil shale from 487.6 feet: X-ray - dolomite, quartz, feldspar, calcite.
487.9	491.4	Oil shale: Medium to dark grayish brown, dolomitic. Moderately distinct to faint inclined and very distorted laminae and streaked bedding in upper part, becoming slightly distorted in lower part; some massive zones in upper part. Irregular thick parting; irregular to conchoidal fracture. A fine buff silty (biotitic?) tuff stringer at 488.2. Some fine to thin tan dolomite streaks and lenses at 490.2 - 490.7. Few fine dark pyritic streaks and patches at 490.7 - 490.9. Fine partly collapsed cavities with drusy calcite at 491.2.
491.4	492.5	Oil shale: Medium to some dark grayish brown and brownish gray, dolomitic. Faint regular to discontinuous laminae. Irregular thick parting; irregular to slightly conchoidal fracture. Two very fine tight high-angle calcite-filled fractures in upper 3 inches--one with varnish-like coatings and very fine disseminated pyrite. Woody carbonaceous streak on parting surface at 491.95. Rare fine pyrite streaks in lower part.
492.5	494.9	Oil shale: Light to medium and some dark brownish gray, dolomitic. Faint to fairly distinct very fine discontinuous to regular laminae. Moderately to slightly irregular thick to rare medium parting; slightly conchoidal to irregular fracture. Rare fine gray pyritic streaks.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc. corehole LW-156 (Con.)

From	To	Description
494.9	495.2	Oil shale: Tan and buff to medium and some dark grayish brown, dolomitic. Fairly distinct very fine discontinuous and displaced laminae. Irregular parting and fracture. NOTE: Sample depths were remeasured between 495.2 and 498.5 feet.
495.2	496.2	Rubble and broken core: Medium grayish-brown and brownish-gray oil shale. Faint streaked bedding. Abundant very irregular fractured fragments. Few porous earthy patches. Rare fragments of buff dolostone as below.
496.2	496.6	Dolostone: Light brownish gray to tan and buff; dense to fine sandy textured. Irregularly layered; few very fine dark irregular (slightly stylolitic in part) partings in upper part. Irregular parting and fracture. Rare fine partly collapsed cavities near bottom. Sample of tan to buff dense to sandy-textured dolostone from 496.4 feet: X-ray - analcime, quartz, feldspar, dolomite.
496.6	498.0	Oil shale: Medium to rare dark grayish brown and brownish gray, dolomitic. Faintly laminated in upper part to very faintly bedded in lower part. Irregular thick parting; slightly to moderately conchoidal fracture. Few tight high-angle natural fractures at bottom.
498.0	498.5	Rubble: Highly fractured oil shale as below.
498.5	499.8	Missing (see NOTE at 495.2)
499.8	501.3	Oil shale: Medium to rare dark brownish gray and grayish brown, dolomitic. Faint to fairly distinct wavy and inclined to very distorted streaked bedding; some dark streaks have shredded ends. Irregular parting and fracture. Coarse oil shale breccia with some fine cavities and black pyritic blebs at 499.9 - 500.0. A 1/2-inch tan-buff silty dolostone stringer at 500.2. Some very fine crystalline (calcite?) streaks in lower part.
501.3	502.0	Oil shale: Medium to some dark brownish gray and rare black, dolomitic. Faint slightly curved to fairly regular streaked bedding and discontinuous laminae. Moderately to slightly irregular thick parting; irregular fracture. Sparse very fine disseminated crystals and crystalline streaks. A 1-inch stringer of tan-buff silty dolostone at 501.8.
502.0	502.6	Missing

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From	To	Description
502.6	502.9	Dolostone: Tan to buff; silty to very fine sandy textured. Faintly mottled coarse to fine tight breccia; irregular displaced contact with oil shale. Irregular parting and fracture. Abundant fine tight lacy fractures with brownish-black coatings.
502.9	503.7	Oil shale: Medium and some dark brownish gray to grayish brown, dolomitic. Very faint wavy to regular laminae and streaked bedding. Irregular thick parting; irregular to conchoidal fracture. A thin stringer of dolostone breccia near top. Irregular vuggy brecciated core ends at 503.4. Abundant very fine cavities with secondary crystalline fillings in lower 0.2 foot.
503.7	505.4	Oil shale: Very dark to medium brownish gray; calcareous to dolomitic. Thick zones with very faint distorted to disrupted bedding alternating with zones with faint very fine wavy to regular laminae. Irregular thick parting; irregular fracture. Some fine very irregular grayish-brown silty, porous, fracture fillings with calcite and pyrite crystals. Abundant very fine disseminated crystalline blebs in upper 0.2 foot. Sample of dark oil shale with abundant very fine crystalline blebs from 503.7 - 503.8 feet: X-ray - calcite, dolomite, quartz, feldspar, pyrite, Mg-siderite. Sample of faintly laminated medium to dark brownish-gray oil shale from 504.9 feet: X-ray - dolomite, quartz, calcite, feldspar, analcime, pyrite.
505.4	507.1	Oil shale: Medium to some dark and light brownish gray, dolomitic. Faint to rare distinct very fine discontinuous to regular laminae. Irregular to slightly irregular thick parting; irregular to conchoidal fracture. A thin silty and blebby brownish-gray pyritic band at 505.6. A very thin pyritic oil shale streak at 506.1. A 1-inch vug with irregular radial boxworks and abundant pyrite at 506.5. Some very fine pyrite streaks below 506.6.
507.1	507.9	Marlstone: Tan to buff and some medium grayish brown, dolomitic. Distinct to faint very fine laminae; some very fine displacements. Regular to irregular thick parting; irregular fracture. Tight irregular high-angle natural fracture at 507.3 - 507.7. A 1-inch pinch-and-swell layer of grayish-brown dolomitic siltstone at 507.6 - 507.7 and a very thin layer at 507.85. Sharp slightly inclined contact between marlstone and dark oil shale below.

From	To	Description
		Sample of buff marlstone from 507.5 feet: X-ray - dolomite, quartz, feldspar, calcite, analcime.
507.9	510.4	Oil shale: Dark to rare medium brownish gray, dolomitic. Faint streaked bedding; distorted and inclined at 509.0 - 509.5. Irregular thick parting; irregular to slightly conchoidal fracture. Abundant fine crystalline blebs (like 503.7) near top; sparse elsewhere. Abundant thin to fine buff to white marlstone and tuff stringers and streaks at 509.2 - 509.4 (also some medium to dark gray).
510.4	511.5	Oil shale: Medium to very dark brownish gray, dolomitic. Moderately distinct to faint slightly distorted streaked bedding. Irregular parting and fracture. Fine to thin buff silty tuff stringers at 510.6, 510.75 and 511.3. A very irregular vertical stringer of grayish-brown dolostone at 510.8 - 511.0; thickness tapers rapidly from more than an inch at top to very fine at bottom; stringer exhibits swirly flow structure with abundant fine dark oil shale shreds.
511.5	512.2	Oil shale: Very dark brownish gray to medium grayish brown, dolomitic. Faint to moderately distinct distorted streaked bedding. Rare small to fine gray to brownish-gray silty nodules. Rare fine disseminated crystals. Irregular parting and fracture.
512.2	512.6	Oil shale (dolostone): Medium grayish brown, dolomitic. Very faint streaked bedding. Irregular to conchoidal parting and fracture. A slightly irregular vertical fracture with dull dark mottled coatings and rare very fine brownish-gray silty crusts from 512.1 to 512.6. Sample of grayish-brown dolostone from 512.4 feet: X-ray - dolomite, quartz, feldspar, calcite, analcime.
512.6	514.5	Oil shale: Dark brownish gray to black, dolomitic. Very faint distorted to regular streaked bedding; some very faint discontinuous laminae in lower part. Irregular thick parting; moderately to slightly irregular fracture. Some fine to thin brownish-gray to buff silty tuff (?) streaks and stringers above 513.8. Sample of tan to buff silty tuff (?) from 513.7 feet: X-ray - quartz, K-feldspar, Na-feldspar, dolomite.

From	To	Description
514.5	515.8	Oil shale: Dark and some medium brownish gray to black, dolomitic. Faint fairly regular to distorted and disrupted streaked bedding. Irregular thick parting; irregular to slightly conchoidal fracture. Irregular vuggy parting surface at top. Few very fine irregular lacy calcite-filled fractures, becoming abundant below 513.4.
515.8	516.0	Tuff: Tan to buff, silty, slightly dolomitic. Faintly variegated; rare very fine streaks. Rubble with some diagonal fracture surfaces in upper half. Wavy contact with a fine black oil shale layer at bottom.
516.0	516.15	Oil shale: Light to medium brownish gray, dolomitic. Moderately distinct to faint discontinuous laminae (slightly inclined). Few diagonal fractures with patchy brownish-black varnish-like coatings.
516.15	516.8	Oil shale: Medium and some dark brownish gray, dolomitic. Faintly laminated to very faintly streaked. Irregular thick parting; irregular to slightly conchoidal fracture. Few irregular diagonal fractures with sparse very fine drusy patches.
516.8	518.0	Oil shale: Medium and rare dark brownish gray, dolomitic. Faint to some moderately distinct laminae. Irregular to slightly irregular thick parting; conchoidal to irregular fracture. Some very fine pyrite streaks. Some tight diagonal fractures near bottom. Bedding-plane fracture at 517.8. Sample of brownish-gray oil shale from 517.6 feet: X-ray - dolomite, quartz, feldspar, calcite, pyrite, analcime.
518.0	519.0	Oil shale: As above, with numerous irregular discontinuous tight to open fractures.
519.0	522.6	Oil shale: Medium to light brownish gray and some buff, dolomitic. Faint to some fairly distinct very fine regular to discontinuous laminae. Irregular to some regular thick parting; irregular to conchoidal fracture. Abundant medium- to high-angle fractures with slight reddish staining and some with fine dull black mottling; some irregular fractured core pieces and rubble. Partly grab sampled. (UV spectrum of extract from reddish stain indicated presence of nickel porphyrin.)

From	To	Description
522.6	523.3	Oil shale: Black to dark and rare medium grayish brown; most has resinous to waxy luster; dolomitic. Faint regular to distorted streaked bedding. Irregular to regular thick to rare thin parting; slightly conchoidal to irregular and rare coarse hackly fracture. Abundant fine crystalline blebs and streaks in lower part. Sample of very dark resinous oil shale with abundant fine crystalline blebs and streaks from 523.2 feet: X-ray - calcite, dolomite, quartz, feldspar, analcime, pyrite.
523.3	525.4	Oil shale: Medium and some dark brownish gray to grayish brown, dolomitic. Bedding obscured by very abundant tight to partly open fractures and fine partly-collapsed cavities. Some cavities are partly to completely filled with drusy calcite. Irregular parting and fracture. Abrupt change at base from porous oil shale above to tight regularly laminated oil shale below. Good core recovery and good sample representation. Sample of oil shale with drusy calcite from 524.7 feet: X-ray - calcite, domomite, quartz, feldspar, analcime.
525.4	526.4	Oil shale: Medium and rare dark grayish brown to tan and rare buff, dolomitic. Distinct to some faint laminae; some fine loop structures. Regular thick to medium parting; slightly conchoidal fracture. Very slight reddish staining on parting surfaces at 525.8 (Ni-porphyrin?).
526.4	527.4	Oil shale: Medium brownish gray to buff, dolomitic. Distinct to faint laminae; some fine loop structures. Regular thick parting; slightly irregular and conchoidal fracture. Some very fine pyrite (or pyrrhotite?) blebs and streaks; a thin very pyritic layer at 527.2.
527.4	531.7	Silty marlstone (very lean oil shale in part): Buff to light and rare medium grayish brown, dolomitic. Faint to some distinct laminae; rare fine loop structures and displacements. Regular to rare irregular thick parting; slightly irregular fracture. Some high-angle fractures and bedding-plane fractures with dark gray pyritic patches; reddish staining (Ni-porphyrin?) on fracture at 530.7 and on parting surfaces at 530.8. Abundant very fine dark gray pyritic lenses disseminated in marlstone in some zones.

Quarter-core samples from Occidental Oil Shale, Inc.
corehole LW-156 (Con.)

From	To	Description
531.7	533.0	Oil shale: Buff and tan to medium and rare dark grayish brown, dolomitic. Distinct to faint laminae; rare very fine displacements. Regular thick parting; slightly conchoidal to irregular fracture. Some natural fractures with sparse disseminated pyrite and porphyrin stains. Irregular fractured core pieces below 532.1.
533.0	534.0	Missing
534.0	534.6	Oil shale: Grayish brown to tan and rare buff, dolomitic. Faint to moderately distinct laminae. Mostly rubble with natural fracture surfaces. Sparse red stains.
534.6	535.1	Silty marlstone: Buff, earthy, porous, massive. Very abundant fine to small partly collapsed cavities. Sample of buff earthy porous silty marlstone from 534.7 feet: X-ray - dolomite, quartz, feldspar, analcime, illite.
535.1	535.4	Oil shale: Tan to medium and some dark grayish brown, dolomitic. Faint to distinct laminae. Irregular rounded core pieces.
535.4	537.0	Missing
537.0	538.0	Oil shale: Dark to medium grayish brown and rare tan, dolomitic. Faint to moderately distinct laminae. Irregular to regular thick parting; irregular to conchoidal fracture. Rare fine dull black streaks and lenses. High-angle fracture with very fine stellate searlsite (?) crusts at 537.2 - 537.4.
538.0	540.5	Oil shale: Grayish brown to tan and buff; dolomitic to slightly calcareous. Distinct to some faint laminae; abundant fine loop structures and displacements. Regular to some irregular thick to rare medium parting. Fairly abundant high-angle to diagonal fractures--some with red porphyrin staining. Thin massive pyrite streaks at 539.9 and 540.1. A 2-inch vug with fine irregular platy box-works at top. Sample of distinctly laminated grayish-brown to buff oil shale from 539.3 feet: X-ray - dolomite, feldspar, quartz, calcite.
540.5	541.0	Oil shale: Medium grayish brown, dolomitic. Very faintly bedded. Vuggy core and rubble. Some drusy pyrite and calcite.
541.0	542.0	Oil shale: Buff and tan to medium grayish brown, dolomitic. Dinstinct to faint laminae, becoming slightly curved at bottom. Irregular to regular thick to medium parting; conchoidal fracture. Short diagonal fracture with reddish staining at 541.2.

From	To	Description
542.0	543.0	Oil shale: Medium to dark grayish brown and brownish gray, dolomitic. Moderately distinct streaked bedding in upper half; very faint laminae in lower half. Irregular to slightly irregular thick parting; irregular to slightly conchoidal fracture; vuggy and fractured rubble at top. Part of a vug at 542.5.
543.0	544.0	Oil shale: Dark to medium brownish gray, dolomitic. Faint to some moderately distinct laminae. Regular to irregular thick to medium parting; irregular to conchoidal fracture. Rare fine dense dark gray streaks and lenses. Sample of medium-dark brownish-gray oil shale from 543.4 feet: X-ray - dolomite, calcite, feldspar, quartz.
544.0	546.2	Oil shale: Medium to some light and rare dark brownish gray, dolomitic. Moderately distinct to faint laminae. Regular to irregular thick to rare medium parting; slightly irregular and conchoidal fracture. Rare fine dull black streaks and lenses. Some high-angle fractures in lower part. Rubble at 545.5 - 545.7.
546.2	546.7	Missing
546.7	548.0	Oil shale: Dark to medium brownish gray; some light brownish gray to buff in lower part, dolomitic. Faintly laminated; some pieces with faint to distinct streaked bedding in lower part. Irregular to regular thick parting; conchoidal to irregular fracture; irregular discontinuous core pieces and some rubble below 547.5. Rare fine dull black streaks. Some very fine pyrite streaks in upper part. Some natural (?) high-angle fractures. A 2-inch piece of tan to buff marlstone in lower part. Uneven sample split.
548.0	548.8	Missing
548.8	550.0	Oil shale: Medium to dark brownish gray; some tan to buff at 548.8 - 548.9; dolomitic. Faint and rare distinct laminae and streaked bedding. Regular to irregular thick to medium parting; slightly conchoidal to irregular fracture. Natural (?) high-angle fracture at 548.8 - 549.3. Vuggy core with irregular boxworks at 549.6. A thin pinch-and-swell white earthy silty tuff stringer at bottom.
550.0	551.0	Oil shale: Medium to dark brownish gray, dolomitic. Faintly laminated. Regular to irregular thick parting; slightly conchoidal fracture. Irregular fractured core pieces and rubble in lower part.
551.0	553.2	Missing

From	To	Description
553.2	553.6	Oil shale: Dark brownish gray, dolomitic. Faintly laminated. Irregular broken core piece; conchoidal fracture.
553.6	554.0	Oil shale: Dark to some medium brownish gray, dolomitic. Very faint slightly curved bedding. Irregular parting and fracture. Interval cut by a very irregular high-angle fracture with slickensides.
554.0	554.4	Oil shale: Dark to medium grayish brown, dolomitic. Faintly laminated. Regular thick parting; irregular to conchoidal fracture. Rare fine dark gray streaks.
554.4	556.7	Oil shale: Medium to some dark brownish gray; dolomitic to slightly calcareous. Faintly laminated. Irregular to regular thick parting; slightly conchoidal to irregular fracture; fractured rubble at 555.6 - 555.8.
556.7	557.7	Oil shale: Medium to dark brownish gray; dolomitic to slightly calcareous. Very faintly laminated. Irregular thick parting; conchoidal fracture. Some broken core. A thin tan earthy porous stringer near bottom.
557.7	560.9	Oil shale: Medium to some dark brownish gray; dolomitic to calcareous. Very faintly laminated. Irregular to regular thick parting; slightly conchoidal to irregular fracture. Broken core with high-angle fractures at 557.7 - 558.2, 559.7 - 560.0 and 560.7 - 460.9. Rare low-angle fractures. Rare very fine pyrite streaks.
560.9	562.0	Oil shale: Dark to medium brownish gray; slightly calcareous to dolomitic. Faintly laminated. Regular thick to medium parting and slightly conchoidal fracture in upper 0.4 foot; irregular fractured and rare vuggy core pieces in lower 0.7 foot. Tan earthy crushed shale with very abundant fine collapsed cavities at 461.2 - 561.3.
562.0	563.0	Rubble: Oil shale as above and below. Some vuggy pieces. Rare tan marlstone pieces. Grab sampled.
563.0	566.0	Oil shale: Dark to medium brownish gray; slightly to moderately calcareous. Faintly laminated. Regular to irregular thick to some medium parting; slightly conchoidal fracture; mostly irregular fractured core pieces below 564.6. Very rare fine dull black streaks. A very thin tan earthy zone with abundant fine partly collapsed cavities at 564.4. Sample of dark brownish-gray oil shale from 563.8 feet: X-ray - dolomite, calcite, quartz, feldspar, pyrite.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc.
corehole LW-156 (Con.)

From	To	Description
566.0	567.0	Oil shale: Medium to light grayish brown and rare buff; few pieces of dark to medium brownish-gray oil shale as above; slightly to moderately calcareous. Moderately distinct to faint laminae. Regular to irregular thick parting; slightly conchoidal fracture; mostly irregular discontinuous core pieces with high-angle fractures. Rare fine pyrite streaks.
567.0	569.4	Oil shale: Tan and buff to medium grayish brown; slightly to moderately calcareous. Faint to moderately distinct discontinuous laminae. Irregular to regular thick parting; irregular to slightly conchoidal fracture. Some natural(?) high-angle fractures. A fine gray silty tuff layer at 568.7. (Footage remeasured to correct error in location of 568-foot mark.) Sample of tan to grayish-brown oil shale from 568.3 feet: X-ray - dolomite, Na-feldspar, quartz, calcite.
569.4	570.0	Oil shale: Medium to dark grayish brown. Very faint streaked bedding. Irregular high-angle fracture with patches of very fine noncalcareous mineral crust.
570.0	573.0	Oil shale: Dark brownish gray to black, dolomitic. Faint streaked bedding, becoming distorted and inclined in lower half foot. Irregular thick parting; conchoidal to irregular fracture. Slightly irregular natural (?) vertical fracture in upper 1.2 feet. Sparse very fine pyrite blebs and streaks. Few small brown silty dolostone nodules near bottom.
573.0	574.1	Oil shale: Dark to medium grayish brown, dolomitic. Very faint streaked bedding. Irregular thick parting; irregular to slightly conchoidal fracture.
574.1	575.1	Oil shale: Dark brownish gray to some black; dolomitic to calcareous. Faint streaked bedding. Irregular thick parting; irregular to conchoidal fracture. Some very fine calcite and pyrite blebs (these appear to be fillings in partly collapsed solution cavities). A very thin dense brownish-gray limestone lamina at 575.0. Natural high-angle fracture at 574.8 - 575.0.
575.1	575.8	Oil shale: Dark to medium grayish brown and rare tan; dolomitic to calcareous. Faintly laminated. Irregular to regular thick to medium parting; slightly conchoidal to

From	To	Description
		some coarse hackly fracture. A 1-inch tan marlstone nodule with abundant partly collapsed fine platy crystal cavities and some drusy calcite and pyrite at 575.4. A fine black oil shale lamina with abundant very fine pyrite streaks near bottom.
575.8	576.9	Oil shale: Grayish brown to tan and buff; dolomitic to slightly calcareous. Distinct to some faint laminae. Regular to irregular thick parting; slightly irregular to conchoidal fracture. Sparse very fine pyrite streaks and blebs. Few diagonal fractures with slight gray coatings. Bedding-plane fracture with dark gray silty pyritic coatings at 576.4.
576.9	577.9	Oil shale: Grayish brown to tan; slightly calcareous to dolomitic. Fairly distinct to faint laminae; some very fine loop structures and displacements. Regular thick to medium parting; slightly conchoidal fracture. Some very fine pyrite streaks and blebs.
577.9	578.9	Oil shale: Medium to rare dark grayish brown, dolomitic. Moderately distinct to faint laminae. Regular to rare irregular thick to medium parting; irregular to slightly conchoidal fracture. Sparse very fine pyrite streaks. Diagonal fracture with very slight reddish stains at 578.0 - 578.2. Broken core with irregular limonite-stained fracture surfaces at 578.6 - 578.8.
578.9	580.0	Oil shale: Dark to medium brownish gray; calcareous to dolomitic. Faintly laminated. Regular to irregular thick parting; irregular to conchoidal fracture. Irregular vertical fracture with some slight limonite stains in lower 0.4 foot.
580.0	581.0	Oil shale: Dark to medium brownish gray and grayish brown; slightly calcareous to dolomitic. Very faintly laminated. Irregular to regular thick parting; conchoidal fracture. High-angle fracture in upper 0.3 foot. Uneven sample split.
581.0	582.0	Rubble: Oil shale as above and below. Rare vuggy pieces.
582.0	585.0	Oil shale: Dark to medium brownish gray; dolomitic to slightly calcareous. Faint laminae; some faint streaked bedding in lower foot. Irregular thick parting; conchoidal to irregular fracture. A thin white and silty

Quarter-core samples from Occidental Oil Shale, Inc.
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From	To	Description
		to brownish-gray and earthy stringer at 582.1. Abundant fine collapsed cavities at 582.4 - 582.5. A 2-inch vug with fine radiating platy boxworks at 582.5 - 582.6. Occasional high- to low-angle natural fractures. Sample of oil shale with abundant fine collapsed cavities from 582.4 - 582.5 feet: X-ray - dolomite, quartz, calcite, feldspar, pyrite, Mg-siderite.
585.0	586.0	Oil shale: Medium to rare dark grayish brown, dolomitic. Faintly laminated. Slightly irregular to irregular thick parting; slightly conchoidal fracture. Mostly irregular core pieces with medium- to high-angle fractures. Rare calcite crusts on fracture surfaces.
586.0	587.1	Rubble: Medium to some dark grayish-brown oil shale, dolomitic. Some very fractured core pieces with milky white mineral patches. Some pieces with very abundant fine partly collapsed cavities.
587.1	588.6	Oil shale: Medium to dark brownish gray, dolomitic. Faint laminae to very faint streaked bedding. Irregular to some regular thick parting; irregular to conchoidal fracture. Very irregular fractured core pieces in upper half; rare open sections of fractures. Few high- to low-angle fractures in lower part.
588.6	589.6	Oil shale: Medium to some dark brownish gray and grayish brown; calcareous to dolomitic. Very faint bedding. Irregular thick parting; irregular to conchoidal fracture. Very abundant partly collapsed fine cavities in upper half foot. Small vugs with porous milky white mineral fillings at 589.2.
589.6	590.9	Oil shale: Medium to dark brownish gray; calcareous to dolomitic. Very faint streaked bedding and some laminae. Mostly very fractured core pieces with some partly collapsed small vugs and fine cavities with calcite fillings. Reasonably good core continuity and sample split.
590.9	592.2	Oil shale: Medium to rare dark brownish gray and grayish brown; dolomitic to calcareous. Very faint bedding, mostly obscured by very abundant partly collapsed fine cavities. Slightly irregular to irregular thick parting; slightly conchoidal to irregular fracture. Small vugs with coarse boxworks and some pyrite at bottom.
592.2	592.8	Rubble: Oil shale, mostly like below.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc.
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From	To	Description
582.8	594.0	Oil shale: Medium to rare dark brownish gray; dolomitic to calcareous. Very faintly streaked and laminated. Regular to irregular thick to rare medium parting; very irregular and some coarse hackly fracture. Abundant irregular tight discontinuous fractures in upper part. Abundant fine partly collapsed cavities and few small vugs with boxworks in lower half foot.
594.0	594.9	Rubble: Oil shale as above and below.
594.9	599.9	Oil shale: Medium to dark brownish gray; dolomitic to slightly calcareous. Very faintly bedded to faintly laminated. Irregular to rare regular thick parting; slightly to moderately conchoidal and rare irregular fracture. Part of a 1- to 2-inch vug at 595.1 and part of 1-inch vug with coarse platy boxworks at 597.7. Irregular broken core pieces in upper 0.8 foot. A thin tan silty stringer at 598.1. Natural (?) vertical fracture in lower foot. Uneven sample split because of off-center sawing and fractured core.
599.9	600.7	Oil shale: Medium and rare dark grayish brown to some tan; dolomitic. Moderately distinct to faint laminae. Slightly irregular to irregular thick parting; slightly irregular fracture. Two natural high-angle fractures intersecting at about 90° extend thru interval; fine patchy mineral crusts on one fracture.
600.7	601.7	Oil shale: Medium grayish brown and some dark brownish gray, dolomitic. Very faintly bedded to massive; becoming faintly laminated near bottom. Irregular to slightly irregular thick parting; irregular and conchoidal fracture. Some very fine collapsed cavities with pyrite and rarely with vitreous black bitumen specks.
601.7	602.5	Oil shale: Medium and rare dark brownish gray, dolomitic. Very faint very fine laminae and streaked bedding. Irregular thick parting; irregular to conchoidal fracture. Some tight collapse breccia with bitumen-filled fractures. A fine buff silty and earthy tuff stringer at 602.1.
602.5	603.1	Oil shale: Medium to dark brownish gray, dolomitic. Faintly laminated. Regular to irregular thick parting; slightly irregular and conchoidal fracture.

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From	To	Description
603.1	603.6	Oil shale: Like 601.7 - 602.5. Mostly rubble of bitumen-filled collapse breccia.
603.6	604.4	Oil shale: Medium and rare dark brownish gray, dolomitic. Faint very fine regular to discontinuous laminae and some very faint streaked bedding. Irregular thick parting; irregular to slightly conchoidal fracture. A tight natural vertical fracture at 603.7 - 603.9. A fine light brownish-gray to buff silty biotitic tuff at 603.95.
604.4	605.3	Oil shale: Dark to medium brownish gray, dolomitic. Moderately distinct streaked bedding; small Z-shaped fold at 604.7. Irregular to slightly irregular thick parting; slightly conchoidal and irregular fracture. (Break in core continuity at bottom.)
605.3	606.0	Oil shale: Medium grayish brown in upper part to medium-dark brownish gray in lower part. Faint very fine discontinuous to regular laminae. Irregular to regular thick parting; irregular to slightly concoidal fracture. Natural vertical fracture with dark varnish-like coatings in upper half.
606.0	606.8	Oil shale: Medium-dark brownish gray in upper part to dark brownish gray and black in middle to medium and some dark grayish brown in lower part, dolomitic. Faint very fine slightly inclined laminae in upper part; massive in middle; faint to moderately distinct streaked bedding in lower part. Irregular thick parting; irregular to conchoidal fracture. Few very short tight bitumen-coated fractures at 606.2.
606.8	607.4	Oil shale: Medium to rare dark brownish gray and grayish brown, dolomitic. Faint to rare moderately distinct discontinuous laminae and streaked bedding; bedding inclined about 20° - 25°, becoming wavy in lower part. Irregular thick parting; irregular to conchoidal fracture. Few fine gray pyritic streaks at 607.2.
607.4	608.1	Oil shale: Medium to some dark brownish gray, dolomitic. Moderately distinct contorted to fairly regular streaked bedding. Irregular parting and fracture. (Break in core continuity; 605.3 - 608.1 might be upside down.)
608.1	609.5	Lean oil shale and silty marlstone: Light and rare medium brownish gray to buff, dolomitic. Faint very fine regular laminae to very faint streaked bedding. Irregular fractured core pieces in upper half; rubble in lower half; very lean oil shale at top of solid core to base. A small piece of bitumen-filled collapse breccia at 608.6.

From	To	Description
609.5	610.8	Oil shale: Medium and some dark brownish gray to grayish brown; dolomitic to slightly calcareous. Faint fine to thin laminae. Irregular thick parting; slightly to moderately conchoidal and irregular fracture. Regular natural (?) vertical fracture from 609.9 to 610.8. A fine buff-white silty tuff stringer with abundant biotite (and hornblende?) at 610.7. Sample of medium brownish-gray oil shale from 610.0 feet: X-ray - dolomite, calcite, feldspar, quartz, analcime.
610.8	612.5	Oil shale: Dark brownish gray, slightly calcareous. Very faintly laminated. Irregular to slightly irregular thick parting; slightly to moderately conchoidal fracture. Very fine vitreous black organic streaks at 611.2 and 612.1.
612.5	613.1	Oil shale: Medium-dark brownish gray, dolomitic. Very faint bedding obscured by abundant fine buff specks. Slightly to moderately irregular thick parting; irregular fracture. Sample of oil shale with abundant fine buff specks from 612.6 feet: X-ray - dolomite, quartz, calcite, feldspar, analcime.
613.1	613.5	Oil shale: Medium grayish brown; dolomitic to calcareous. Very faintly bedded. A 1 1/2-x 2-inch vug filled with vitreous black bitumen at 613.3 - 613.4; contains abundant broken oil shale boxworks fragments.
613.5	616.5	Oil shale: Dark to medium brownish gray and grayish brown; slightly calcareous to dolomitic. Very faintly laminated. Irregular thick parting; conchoidal to irregular fracture. Some fine lacy bitumen-filled fractures at 614.4. A fine zone of abundant buff-white specks at 614.55.
616.5	617.8	Oil shale: Medium and rare dark grayish brown to some tan, dolomitic. Faint to moderately distinct laminae. Irregular thick to rare medium parting; moderately to slightly irregular fracture. Rare fine dull black lenses and streaks.
617.8	619.0	Oil shale: Medium to dark brownish gray, dolomitic. Faintly laminated. Irregular to some regular thick to rare medium parting; slightly irregular and conchoidal fracture. Rare fine black streaks and lenses.
619.0	620.0	Oil shale: Dark to medium brownish gray and some buff, dolomitic. Faintly laminated; distinctly interbedded with thin to 1-inch layers of buff silty marlstone at 619.05 and 619.4 - 619.7; small loop structures at 619.5. Irregular

From	To	Description
		thick parting; slightly to moderately conchoidal fracture. Few fine to thin black streaks. Sample of oil shale with thin black streak from 619.3 feet: X-ray - dolomite, quartz, feldspar, calcite. Sample of buff silty marlstone from 619.6 feet. X-ray - quartz, dolomite, feldspar, calcite.
620.0	620.8	Oil shale: Medium to rare dark grayish brown and brownish gray; dolomitic to slightly calcareous. Moderately distinct laminae in upper part to very faint bedding in lower part. Irregular to slightly irregular thick parting; slightly to moderately conchoidal fracture. Rare fine black streaks.
620.8	621.0	Oil shale: Dark brownish gray to black, dolomitic. Faint streaked bedding. Natural (?) vertical fracture thru interval.
621.0	622.0	Oil shale: Medium to medium-dark brownish gray; dolomitic to calcareous. Very faintly streaked and laminated to massive. Conchoidal parting; slightly to moderately conchoidal fracture. Sample of massive brownish-gray oil shale from 621.3 feet: X-ray - dolomite, quartz, calcite, feldspar, pyrite, analcime.
622.0	623.3	Oil shale: Massive brownish-gray oil shale as above with irregularly streaked to regularly laminated layers of dark brownish-gray to black oil shale at 622.0-622.07, 622.13-622.24, 622.47-622.59, 622.73-622.79, 622.88-622.90, and 623.0-623.3. Sharp irregular contact between black oil shale and light brownish-gray oil shale at bottom. Conchoidal to irregular thick to rare medium parting; conchoidal to irregular fracture.
623.3	635.0	Oil shale: Medium to some dark and light brownish gray; slightly calcareous to dolomitic. Distinct to some faint laminae; some fine loop structures and displacements. Moderately to slightly irregular thick to rare medium parting; moderately to slightly irregular and conchoidal fracture. Rare fine black streaks and lenses (like 619.3 feet). Rare fine to thin pyrite streaks. Fine buff to white silty and earthy tuff stringers at 628.1, 628.8, and 630.9.

From	To	Description
635.0	636.2	Oil shale: Medium to light and rare dark brownish gray; dolomitic to slightly calcareous. Distinct to faint laminae; some very fine loop structures and displacements. Irregular to regular thick parting; slightly irregular and conchoidal fracture. Rare very fine pyrite streaks. Sample of finely laminated medium to light oil shale from 635.4 feet: X-ray - dolomite, feldspar, quartz, calcite, illite, pyrite.
636.2	638.3	Oil shale: Medium and some light to rare dark brownish gray; slightly calcareous to dolomitic. Moderately distinct to faint regular to discontinuous laminae. Irregular to regular thick parting; slightly to moderately irregular fracture. A small dense brownish-gray lens at 636.6.
638.3	638.8	Oil shale: Medium-dark brownish gray, dolomitic. Very faintly bedded. Conchoidal parting and fracture. A fine vermiform pyrite stringer at 638.4.
638.8	639.8	Oil shale: Dark and some medium brownish gray to black; some satiny to resinous luster in lower part; dolomitic. Faintly laminated. Irregular to slightly irregular thick parting; irregular and rare slight to coarse hackly fracture. A very fine radial platy crystal mass on parting surface at 639.0 (possibly searlesite). Very small brownish-black silty coprolite at 639.1. Irregular parting surface with fine striated vitreous black organic crust near bottom.
639.8	640.3	Oil shale: Dark to medium and rare light brownish gray; slightly calcareous to dolomitic. Faint to some distinct laminae. Irregular to regular thick parting; conchoidal fracture.
640.3	642.3	Oil shale: Medium to some dark and light brownish gray; dolomitic to slightly calcareous. Fairly distinct to some faint laminae; some fine loop structures and displacements. Moderately to slightly irregular thick parting; irregular and conchoidal fracture. Rare very fine pyrite streaks.
642.3	642.9	Oil shale: Medium to light and rare dark brownish gray, dolomitic. Faint to moderately distinct laminae; distinctly laminated with buff silty marlstone (like 619.6 feet) at 642.4-642.6. A fine buff silty tuff lamina at 642.75. Slightly irregular thick to medium parting; slightly conchoidal fracture.

From	To	Description
642.9	643.7	Oil shale: Medium brownish gray; dolomitic to calcareous. Faint very fine laminae; some fine displacements. Moderately to slightly irregular thick parting; slightly conchoidal to irregular fracture.
643.7	644.6	Oil shale: Medium brownish gray in upper part to medium and dark in lower part; dolomitic to calcareous. Faint to fairly distinct laminae. Regular to irregular thick parting; conchoidal fracture. A 1 1/2-inch massive brownish-gray dolomitic mudstone band at 643.9.
644.6	645.6	Oil shale: Dark and rare medium brownish gray to black; some satiny to resinous luster; dolomitic. Faintly laminated to very faintly bedded. Regular to some irregular thick to rare medium parting; irregular to conchoidal fracture. High-angle fractures with very fine calcite crusts and sparse very fine pyrite thru interval.
645.6	646.6	Oil shale: Dark to medium brownish gray; slightly calcareous to dolomitic. Faint streaked bedding to massive. Thick conchoidal parting; conchoidal fracture. Thin to fine irregular buff-white quartz streaks with some bitumen impregnations near bottom.
646.6	649.0	Oil shale: Medium to rare dark brownish gray and grayish brown; moderately to slightly calcareous. Faint to moderately distinct fine to thin laminae. Moderately to slightly irregular thick parting; conchoidal fracture.
649.0	651.0	Oil shale: Medium to light and rare dark brownish gray; slightly calcareous to dolomitic. Faint to moderately distinct discontinuous to regular laminae. Slightly to moderately irregular thick to medium parting; slightly to moderately conchoidal fracture. Thin to fine streaks of fine-grained marcasite at 649.1 and 649.3. (About a half foot of rubble at 649.1 is in excess of a full length of solid core.)
651.0	652.0	Oil shale and marlstone: Medium to light brownish gray and buff; some dark brownish-gray laminae and bands in lower half; slightly calcareous to dolomitic. Faint to distinct laminae and some bands; rare fine loop structures and displacements. Irregular to regular thick and rare thin parting; slightly conchoidal to irregular fracture. A thin light buff silty and earthy tuff lamina with very fine dark specks at 651.3. Commonly silty in lighter parts.

From	To	Description
		Sample of buff marlstone from 651.4 feet: X-ray - dolomite, quartz, feldspar, analcime, calcite.
652.0	654.2	Oil shale: Medium to dark brownish gray in upper part; dark and rare medium in lower part; calcareous to dolomitic. Very faintly laminated; some massive zones in upper part. Irregular to conchoidal thick parting; conchoidal fracture.
		Sample of dark brownish-gray oil shale from 654.0 feet: X-ray - dolomite, calcite, quartz, analcime, feldspar.
654.2	656.3	Oil shale: Medium to dark grayish brown; some tan and rare buff in lower part; moderately to slightly calcareous. Faint to distinct laminae; some fine loop structures in lower part. Irregular to conchoidal thick parting; conchoidal to regular fracture. A very thin tan-buff dolomitic mudstone lamina near top and a fine to thin irregular stringer at 655.05. Very fine gray silty streaks at 656.0.
656.3	659.8	Oil shale: Medium and rare dark brownish gray to light brownish gray and some buff; slightly calcareous to dolomitic. Distinct to rare faint laminae; abundant fine loop structures and displacements in some parts. Irregular to slightly irregular thick parting; slightly to moderately conchoidal fracture. Rare fine to small gray pyritic streaks and lenses. A very thin buff-white silty tuff with very fine dark specks at 656.7; fine streaks and lenses at 656.8 and 656.9.
		Sample of oil shale with fine pyritic streaks and lenses from 658.5 feet: X-ray - pyrite, dolomite, quartz, feldspar, marcasite, calcite.
659.8	662.1	Oil shale: Medium and rare light grayish brown in upper part to medium and rare dark in lower part, dolomitic. Moderately distinct to faint very fine laminae; some fine loop structures. Irregular to regular thick parting; conchoidal to regular fracture. Rare small gray pyritic lenses. Fine buff tuff streaks at 660.4.
662.1	663.1	Oil shale: Medium grayish brown in upper part to dark brownish gray in lower part; dolomitic to calcareous. Faintly laminated. Slightly to moderately irregular thick parting; slightly to moderately conchoidal fracture. A very fine gray tuff layer near top; thin grayish-brown biotitic tuff stringer at 662.4.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc. corehole LW-156 (Con.)

From	To	Description
663.1	664.1	Oil shale: Dark and rare medium brownish gray; some black in lower part; slightly calcareous to dolomitic. Faintly laminated; very faintly bedded in lower 0.4 foot. Irregular to slightly irregular thick parting; irregular and rare hackly fracture. Fine brownish-black bitumen-stained tuff lenses at 663.2 and a 1 1/4-inch brown stringer at 663.9. Abrupt change to leaner oil shale at bottom. Sample of dark brown stringer from 663.9 feet: X-ray - analcime, quartz, feldspar, dolomite, calcite.
664.1	665.3	Oil shale: Medium to some dark grayish brown and brownish gray; slightly to moderately calcareous. Moderately distinct to faint regular to discontinuous laminae. Slightly to moderately irregular thick parting; conchoidal to regular fracture. Rare fine black streaks and lenses (coprolites?).
665.3	666.6	Oil shale: Medium and rare dark brownish gray to tan and rare buff, calcareous. Faint to distinct laminae; some fine loop structures and displacements. Moderately to slightly irregular thick parting; slightly to moderately conchoidal fracture.
666.6	667.6	Oil shale and some marlstone: Medium and rare dark brownish gray to buff; slightly calcareous to dolomitic. Moderately distinct to distinct laminae; some fine loop structures. Regular to irregular thick parting; slightly conchoidal fracture.
667.6	669.6	Oil shale: Dark to medium brownish gray; slightly calcareous to dolomitic. Faintly laminated. Moderately to slightly irregular thick parting; regular to conchoidal fracture. Rare very fine pyrite streaks. A thin pinch-and-swell dark brownish-gray tar-stained silty pyritic stringer at 669.05.
669.6	670.5	Oil shale: Medium to some dark and light brownish gray, dolomitic. Moderately distinct to some faint laminae; some very fine displacements and loop structures. Slightly irregular thick parting; slightly conchoidal fracture. Very fine light gray biotitic tuff streaks at 669.8 and 670.1.

From	To	Description
670.5	670.8	Marlstone: Buff to light and rare medium to dark brownish gray; slightly to moderately calcareous. Moderately distinct to faint laminae. Irregular thick parting; conchoidal fracture.
670.8	672.0	Oil shale: Medium to dark brownish gray; slightly calcareous to dolomitic. Faintly laminated. Irregular to slightly irregular thick to rare medium parting; slightly conchoidal to irregular fracture. Fine buff silty tuff streaks at top.
672.0	672.2	Tuff: Medium to light brownish gray; silty to very fine sandy textured; slightly dolomitic (slightly hydrophobic in upper part). Faintly variegated, grading from medium brownish gray in upper part to light in lower part. Sharp slightly wavy to regular contacts with oil shale above and below. Abundant very fine hornblende and biotite near bottom. Sample of tuff (including some adjacent oil shale from 672.2 feet: X-ray - Na-feldspar, quartz, analcime, dolomite, biotite, calcite.
672.2	675.0	Oil shale: Medium and dark brownish gray in upper part to medium and some light in lower part, dolomitic. Faint laminae, becoming moderately distinct in lower part; rare fine loop structures and displacements. Irregular to slightly irregular thick to rare medium parting; irregular to slightly conchoidal fracture. A very fine light gray biotite tuff lamina at 672.3.
675.0	676.0	Marlstone and oil shale: Buff to medium amd rare dark brownish gray, dolomitic. Distinct to faint laminae; rare fine to 1/8-inch loop structures. Regular to irregular thick parting; slightly conchoidal to some irregular fracture.
676.0	676.7	Oil shale: Very dark brownish gray in upper part to medium in lower part, dolomitic. Very faint streaked bedding to faint discontinuous laminae. Slightly to moderately irregular thick parting; slightly to moderately irregular fracture.
676.7	677.3	Oil shale: Dark brownish gray to black; rare satiny luster; dolomitic. Very faintly laminated. Irregular thick parting; slightly hackly to slightly irregular facture. Some very fine gray tuff streaks in upper half; A 1/4-inch dark grayish-brown pinch-and-swell tuff at 676.9.

From	To	Description
677.3	678.1	Oil shale: Medium and some dark to rare light brownish gray; dolomitic to slightly calcareous. Faint to moderately distinct laminae; some fine loop structures and displacements. Moderately to slightly irregular thick parting; slightly to moderately conchoidal fracture. Sample of oil shale from 677.7 feet: X-ray - dolomite, calcite, quartz, feldspar, analcime.
678.1	681.8	Oil shale: Medium to light and rare dark brownish gray, dolomitic. Moderately distinct to some faint laminae; abundant fine loop structures and displacements. Irregular to slightly irregular thick parting; slightly to moderately conchoidal and irregular fracture. Thin gray pyritic streaks at 680.0 and 680.8.
681.8	682.9	Oil shale: Medium to dark brownish gray, dolomitic. Faintly laminated. Moderately to slightly irregular thick parting; moderately to slightly irregular fracture. A very thin dark brownish-gray tar-stained tuff stringer at 681.85; rare fine tuff streaks elsewhere.
682.9	684.0	Oil shale: Dark to rare medium brownish gray and rare black, dolomitic. Faintly laminated. Irregular thick parting; irregular fracture.
684.0	686.9	Oil shale: Medium to some dark brownish gray, dolomitic. Faint to rare moderately distinct laminae; rare fine loop structures and displacements. Irregular to slightly irregular thick to rare medium parting; irregular to conchoidal fracture.
686.9	688.0	Oil shale: Dark to rare medium brownish gray and rare black; rare satiny to resinous luster in lower part; dolomitic. Faintly laminated. Irregular to fairly regular thick parting; conchoidal to slightly irregular and some slightly hackly fracture. Sample of dark brownish-gray oil shale from 687.6 feet: X-ray - dolomite, quartz, feldspar, calcite, illite, analcime.
688.0	688.8	Missing.
688.8	689.3	Oil shale: Dark to some medium brownish gray, dolomitic. Very faintly streaked to faintly laminated. Fairly regular to irregular thick parting; slightly conchoidal fracture.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc. corehole LW-156 (Con.)

From	To	Description
689.3	692.0	Oil shale: Medium to some light and dark brownish gray, dolomitic. Faint to some distinct laminae; some fine displacements and loop structures. Irregular to slightly irregular thick parting; slightly to moderately conchoidal fracture. Thin gray pyritic streak at 691.4.
692.0	705.0	Oil shale: Medium and dark brownish gray, dolomitic. Faintly laminated. Moderately to slightly irregular thick to rare medium parting; moderately to slightly conchoidal fracture. A 1/2-inch white silty biotitic tuff laced with very fine oil shale stringers at 694.2. A 3/4-inch pinch-and-swell tan silty and earthy tuff at 694.8. A thin pinch-and-swell dark brownish-gray pyritic tuff at 695.6. Sparse very fine pyritic streaks and disseminated crystals from 695 to 697. A 3/4-inch medium to light brownish-gray laminated dolomite band at 703.9. A thin dark brownish-gray silty tar-stained tuff at 704.55. Sample of white tuff from 694.2 feet: X-ray - Na-and K-feldspar; some hornblende, biotite. Sample of tan tuff from 694.8 feet: X-ray - Na-feldspar, quartz, analcime, dolomite, calcite, biotite, hornblende.
705.0	710.0	Oil shale: Medium and some dark brownish gray, dolomitic. Faint to rare moderately distinct laminae. Regular to rare irregular thick to some medium parting; slightly to moderately irregular and conchoidal fracture. Occasional very fine gray to buff silty pyritic streaks and laminae. Abundant very fine disseminated pyrite (or pyrrhotite?) in some parts. A 1/2-inch very light gray biotitic tuff at 707.8; fine dark gray pyritic layer at top. A 1/8-inch dense gray layer with some very fine pyrite at 708.3. A 1/2-inch buff laminated dolomite band at 705.5. Sample of oil shale with very fine disseminated pyrite from 707.4 feet: X-ray - dolomite, calcite, quartz, feldspar, analcime, illite. Sample of very thin gray layer from 708.3 feet: X-ray - dolomite, analcime, feldspar, quartz, marcasite, fluorite, hornblende, biotite.

Quarter-core samples from Occidental Oil Shale, Inc.
corehole LW-156 (Con.)

From	To	Description
710.0	712.0	Oil shale: Dark to medium brownish gray, dolomitic. Faintly laminated. Regular to slightly irregular thick to some medium parting; irregular to slightly irregular fracture.
712.0	713.5	Oil shale: Medium and some dark brownish gray, dolomitic. Faintly laminated. Regular to rare irregular thick to some medium parting; slightly to moderately irregular and rare hackly fracture.
713.5	715.9	Oil shale: Medium and rare dark brownish gray, dolomitic. Faintly laminated. Slightly irregular thick to some medium parting; moderately to slightly irregular and rare slightly hackly fracture. Some very fine pyritic streaks in upper part, becoming sparse in lower part.
715.9	717.0	Oil shale: Dark brownish gray to some black; rare satiny to resinous luster; dolomitic. Faint very fine laminae and some streaked bedding. Slightly irregular to regular thick to rare medium and thin parting; irregular and slightly hackly fractures. Some very fine disseminated pyrite in upper part. A thin grayish-brown silty biotitic tuff at 715.95.
717.0	719.3	Oil shale: Dark to medium brownish gray, dolomitic. Faint to rare moderately distinct laminae. Regular to slightly irregular thick to some medium parting; slightly to moderately irregular and rare hackly fracture. Abundant very fine disseminated pyrrhotite blebs and streaks. Small to 1-inch gray-buff silty tuff lenses at 718.6.
719.3	720.3	Oil shale: Dark and some medium brownish gray to some black, dolomitic. Faint laminae to very faint very fine streaked bedding. Regular to some irregular thick to some medium parting; moderately to slightly laminae and some very faint very fine streaked bedding; very rare fine loop structures. Irregular to regular thick to rare medium parting; slightly to moderately irregular fracture. Abundant very fine pyrrhotite(?) in upper part. A very thin brownish-gray tar-stained silty tuff lamina at 725.15. A fine gray pyritic lamina at 725.2. A fine tight silty brownish-gray lamina with some pyrite at 725.3. Sample of medium brownish-gray oil shale from 725.4 feet: X-ray - dolomite, quartz, calcite, analcime, feldspar, illite.

From	To	Description
720.3	724.5	Oil shale: Medium and some dark to rare light brownish gray, dolomitic. Faint to rare moderately distinct laminae. Regular to some irregular thick to some medium parting; irregular to fairly regular and rare coarse hackly fracture. Abundant very fine pyrrhotite(?) blebs and streaks in upper part, becoming sparse in lower part. Rare fine gray silty pyritic tuff laminae and streaks.
724.5	725.0	Oil shale: Dark and rare medium brownish gray to some black, dolomitic. Faint and rare moderately distinct laminae; rare small loop structures. Regular to irregular thick parting; moderately to slightly irregular fracture. Abundant very fine pyrite and/or pyrrhotite blebs and streaks. A very fine pinched out dense brownish-gray pyritic lamina at 724.95.
725.0	727.1	Oil shale: Medium to some dark and rare light brownish gray; dolomitic to slightly calcareous. Faint to some moderately distinct laminae and some very faint very fine streaked bedding; very rare fine loop structures. Irregular to regular thick to rare medium parting; slightly to moderately irregular fracture. Abundant very fine pyrrhotite(?) in upper part. A very thin dark brownish-gray tar-stained silty tuff lamina at 725.15. A fine gray pyritic lamina at 725.2. A fine tight silty brownish-gray lamina with some pyrite at 725.3. Sample of medium brownish-gray oil shale from 725.4 feet: X-ray - dolomite, quartz, calcite, analcime, feldspar, illite.
727.1	728.1	Oil shale: Medium to light and some dark brownish gray, rare buff; dolomitic to very slightly calcareous. Distinct to some faint laminae; rare fine displacements. Slightly irregular to regular thick to some medium parting; slightly irregular fracture. Abundant very fine disseminated black flecks and pyrrhotite in some parts. A very fine gray siliceous lamina at 727.6. Rare fine gray pyritic streaks near bottom. Sample of very finely laminated dark to light brownish gray oil shale from 727.5 feet: X-ray - dolomite, quartz, calcite, feldspar, illite, analcime.

From	To	Description
728.1	729.1	Oil shale: Medium to some dark brownish gray, dolomitic. Moderately distinct to faint laminae; some fine to small loop structures and displacements. Regular to some irregular thick parting; slightly irregular and conchoidal fracture. Abundant very fine black specks and pyrrhotite(?) in upper part. Rare fine gray pyritic streaks. A fine tight silty brownish-gray laminae with some pyrite at 728.95.
729.1	730.5	Oil shale: Black to dark brownish gray; common satiny to resinous and rare waxy luster; dolomitic. Faintly laminated to very faintly streaked. Irregular to regular thick to rare medium parting; irregular to slightly conchoidal fracture. Thin to fine dark grayish-brown to medium brownish-gray very fine sandy to silty-textured tuff laminae interbedded with oil shale at 729.33-729.45; dark grayish-brown dense to silty tuff irregularly streaked with oil shale at 729.5-729.6. Some very fine pyrrhotite blebs in lower part. Sample of dark to medium grayish-brown tuff with some interbedded waxy black oil shale from 729.34-729.41 feet: X-ray - dolomite, feldspar, quartz, biotite, analcime, hornblende.
730.5	731.5	Oil shale: Dark to some medium brownish gray; dolomitic. Thick faintly streaked dark zones alternating with lighter laminated zones. Regular to irregular thick parting; irregular fracture. Abundant <u>very</u> fine disseminated pyrrhotite(?) blebs and streaks. A fine brownish-gray pyritic tuff overlain by a thin brown dolomite lamina near bottom.
731.5	735.2	Oil shale: Medium to some dark and rare light brownish gray, dolomitic. Faint very fine discontinuous to regular laminae. Regular to rare irregular thick to medium parting; slightly to moderately irregular and conchoidal fracture. Abundant very fine pyrrhotite blebs and streaks down to about 733.5. Two fine light gray siliceous laminae at 734.05. Fine tar-stained black silty tuff lenses at 734.5.
735.2	736.6	Oil shale: Dark brownish gray to rare black, dolomitic. Faint very fine regular to discontinuous laminae. Slightly irregular to regular thick to medium parting; irregular fracture. Abundant very fine disseminated pyrrhotite blebs. Rare fine tight silty brownish gray laminae.

From	To	Description
736.6	737.6	Oil shale: Dark to medium brownish gray, dolomitic. Faint to rare moderately distinct laminae; rare small loop structures and displacements. Regular to rare irregular thick parting; irregular to slightly conchoidal fracture. Rare fine brownish-gray to gray silty laminae. Rare fine pyrite and/or pyrrhotite blebs.
737.6	739.8	Oil shale: Medium and rare dark brownish gray (some slight olive tint), dolomitic. Faint to rare moderately distinct very fine laminae; some fine low-angle displacements. Slightly irregular thick to rare medium parting; slightly to moderately irregular and conchoidal fracture. Fine gray tight silty tuff streaks at 739.2 and 739.4. Sample of slightly olive gray oil shale from 738.6 feet: X-ray - dolomite, quartz, analcime, feldspar, illite, calcite. Sample of oil shale with fine gray silty streaks from 739.2 feet: X-ray - analcime, quartz, Na-feldspar, pyrite, dolomite, smectite, hornblende.
739.8 (NBS #1)	740.3	Oil shale: Medium and rare dark brownish gray (some slight olive tint), dolomitic. Faint very fine discontinuous laminae. Slightly irregular to regular thick to medium parting; regular to slightly irregular fracture. Abundant very fine disseminated pyrrhotite and/or pyrite in some parts. A <u>very</u> fine pyritic lamina at 739.95. Some <u>very</u> fine biotite flakes. Sample of oil shale from 739.9 feet: X-ray - dolomite, quartz, feldspar, analcime, illite, calcite, pyrrhotite.
740.3	742.4	Oil shale: Medium slightly brownish and olive gray, dolomitic. Faint very fine discontinuous to regular laminae. Regular to rare irregular thick parting; slightly to moderately irregular fracture. Abundant <u>very</u> fine disseminated pyrite or pyrrhotite in upper part, becoming sparse in lower part. Rare very fine dark gray silty laminae and streaks. Sample of oil shale from 740.5 feet: X-ray - dolomite, quartz, feldspar, illite, analcime, calcite.
742.4	743.6	Oil shale: Medium to rare light and dark brownish gray; some black laminae in lower 0.2 foot; dolomitic to slightly calcareous. Faint to moderately distinct laminae; some very fine loop structures. Irregular to regular thick parting; slightly to moderately conchoidal fracture.

From	To	Description
743.6	744.6	Oil shale: Dark brownish gray to black; some medium brownish gray in upper and lower parts; some satiny luster in middle; dolomitic. Moderately distinct to very faint laminae. Irregular to regular thick parting; regular to irregular and some slightly hackly fracture. Some very fine silty pyritic streaks and blebs in lower part. Few fine gray to brownish-gray silty tuff laminae in lower 2 inches.
744.6	745.6	Oil shale: Medium to some dark brownish gray and rare black; slightly calcareous to dolomitic. Moderately distinct to very faint laminae. Irregular to regular thick parting; irregular fracture. Some fine buff earthy lenses in upper 0.4 foot, becoming sparse in lower part. A fine brown silty tuff lamina at 744.7.
745.6	752.0	Oil shale: Medium to rare light and dark brownish gray (some slight olive tint); some dark brownish gray at 749.1-749.5 and 750.7-751.2; dolomitic. Faint laminae; rare fine loop structures and displacements. Regular to some irregular thick to rare medium parting; moderately to slightly irregular fracture. Some very fine pyrrhotite blebs. Rare fine buff earthy lenses. A thin gray dense to fine-grained tuff layer at 746.9.
752.0	753.0	Oil shale: Dark brownish gray to black; some medium in upper and lower parts; common satiny to resinous luster in middle; dolomitic. Faintly laminated to very faintly bedded. Regular to some irregular thick to medium parting; moderately to slightly irregular and slightly hackly fracture. Some very fine pyrite blebs and streaks in lower part. Sample of very dark oil shale from 752.7 feet: X-ray - dolomite, calcite, quartz, analcime, feldspar, apatite.
753.0	754.2	Oil shale: Medium to some dark brownish gray and rare black (becoming slightly olive in lower part); dolomitic to calcareous. Faintly laminated. Irregular to regular thick to medium parting; slightly conchoidal to some irregular fracture. Rare fine buff to gray silty streaks in upper part. A very small pyritic bleb at 754.05. Thin buff silty biotitic tuff lenses at bottom.

Quarter-core samples from Occidental Oil Shale, Inc. corehole LW-156 (Con.)

From	To	Description
754.2	755.2	Oil shale: Medium to dark and rare light brownish gray (slightly olive on split surfaces that have been exposed a few hours); dolomitic to slightly calcareous. Faint to some moderately distinct laminae; rare fine displacements. Irregular thick parting; conchoidal fracture. Thin gray-buff marlstone laminae at 754.8, 754.9, and 754.95.
755.2	756.3	Oil shale: Medium to some light and dark brownish gray (slightly olive); dolomitic to very slightly calcareous. Distinct to some faint laminae; rare very fine loop structures. Irregular thick to medium parting; slightly to moderately conchoidal fracture. Small dark brownish-gray to medium gray silty pyritic tuff lenses at 755.6 and 755.9. One-half to 1-inch buff marlstone lenses in wrap-around oil shale laminae at 755.9-756.0. A very thin buff-white biotitic tuff streak at bottom.
756.3	757.5	Oil shale: Medium and rare light to some dark brownish gray, dolomitic. Moderately distinct laminae in upper part to faint in lower part; rare fine loop structures and displacements. Irregular to slightly irregular thick parting; slightly conchoidal fracture.
757.5	757.7	Oil shale: Black, very slight satiny luster, dolomitic. Very faint very fine streaked bedding. Slightly irregular fracture. Sharp regular contacts with leaner oil shale above and below.
757.7	758.3	Oil shale: Medium to dark brownish gray and rare black, dolomitic. Faint and rare moderately distinct laminae to very faint streaked bedding. Slightly irregular to regular thick to medium parting; irregular to slightly conchoidal fracture.
758.3	758.9	Oil shale: Black to very dark brownish gray; common satiny to resinous luster; dolomitic. Very faint very fine laminae and streaked bedding. Slightly irregular to regular thick parting; slightly to moderately irregular and rare slightly hackly fracture. Sample of black oil shale from 758.7 feet: X-ray - dolomite, quartz, calcite, feldspar, illite, analcime, apatite.
758.9	759.5	Oil shale: Very dark to dark and rare medium brownish gray, dolomitic. Faintly laminated. Regular to irregular thick parting; slightly conchoidal to irregular fracture.

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LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc.
corehole LW-156 (Con.)

From	To	Description
759.5	760.5	Oil shale: Dark to medium brownish gray, dolomitic. Faintly laminated; rare very fine loop structures. Irregular to slightly irregular thick to rare medium and thin parting; slightly conchoidal to irregular fracture. Rare fine gray pyritic streaks and laminae.
760.5	764.0	Oil shale: Medium to some dark and rare light brownish gray (common slight olive tint), dolomitic. Faint to moderately distinct laminae; rare fine loop structures. Regular to rare irregular thick to rare medium parting; slightly to moderately conchoidal and irregular fracture. A very fine black silty pyritic lamina at 760.6. Occasional zones with abundant very fine pyrite or pyrrhotite specks. Rare very fine buff earthy lenses and streaks.
764.0	764.9	Oil shale: Medium to dark brownish gray; some black in upper 0.1 and lower 0.3 foot; dolomitic. Faintly laminated to very faintly bedded. Irregular to regular thick to medium parting; irregular fracture. A thin dark grayish-brown silty pyritic tuff lamina at 764.7. A 1-inch brownish-gray silty pyritic tuff with very fine wavy and slightly cross bedded oil shale stringers at bottom. Sample of brownish-gray pyritic tuff from 764.8-764.9 feet: X-ray - analcime, quartz, dolomite, feldspar, calcite.
764.9	765.6	Oil shale: Very dark brownish gray to black; common satiny to resinous luster; dolomitic. Very faint very fine laminae and streaked bedding. Regular to slightly irregular thick to medium and rare thin parting; slightly irregular to slightly hackly fracture.
765.6	769.8	Oil shale: Medium to some dark and rare light brownish gray; slightly calcareous to dolomitic. Faint to moderately distinct laminae. Irregular to slightly irregular thick to rare medium parting; moderately to slightly conchoidal and irregular fracture. A thin to fine dark grayish-brown oil-stained tuff layer at 765.75; a fine pyritic lamina at 766.4. A 1/2-inch irregular light gray silty pyritic tuff at 766.9.
769.8	772.2	Oil shale: Dark to some medium brownish gray, dolomitic. Faintly laminated. Irregular to slightly irregular thick parting; moderately to slightly conchoidal and irregular fracture. Thin to fine black tar-impregnated silty tuff streaks at 769.8, 770.6, and 771.9. A 1-inch medium

From	To	Description
		brownish-gray massive dolomite band at 770.5. (NBS #2, 769.8-770.2) Sample of dark brownish-gray oil shale from 770.0 feet: X-ray - dolomite, quartz, calcite, feldspar, analcime, illite.
772.2	774.2	Oil shale: Dark to medium brownish gray, dolomitic. Faintly laminated. Irregular to regular thick to medium parting; irregular fracture. A 1 1/2-inch light gray to medium brownish-gray silty biotitic tuff at 772.4-772.5; regular upper contact and wavy lower contact; some purplish-black specks. A 1/2-inch tuff (like 772.4) at 773.55; thin streaks and lenses at 773.65. A 1/2-inch band of light gray slightly silty tuff with abundant very fine disseminated pyrite or pyrrhotite at 773.85. Abundant very fine pyrite or pyrrhotite in oil shale at 773.1-773.5. Sample of biotitic tuff from 772.45 feet: X-ray - analcime, quartz, Na-feldspar, dolomite, illite. Sample of pyritic tuff from 773.85 feet: X-ray - analcime, quartz, Na-feldspar, marcasite.
774.2	775.2	Oil shale: Dark to medium brownish gray; some light brownish gray to buff in middle part; dolomitic to slightly calcareous. Faint to some distinct laminae; rare fine loop structures and displacements. Irregular to regular thick parting; irregular to slightly conchoidal fracture. A fine pinch-and-swell very pyritic tuff layer at 774.3. Few very fine dense silty black lenses at 745.1. (Uneven sample split because of off-centered sawing.)
775.2	776.2	Oil shale: Medium to very dark brownish gray; slightly calcareous to dolomitic. Faintly laminated. Irregular to slightly irregular thick to some medium parting; irregular to slightly conchoidal fracture. Fine dense gray lenses and streaks at 776.0.
776.2	777.3	Oil shale: Dark brownish gray to black; some satiny and rare resinous luster; dolomitic. Faintly laminated to very faintly bedded. Regular to some irregular thick parting; slightly irregular and rare slightly hackly fracture. Some very fine disseminated pyrite blebs and streaks. A 1/2-inch brownish-gray silty to very fine sandy-textured tuff band at 777.1; fine layers at 777.05 and 777.15.

From	To	Description
777.3	779.2	Oil shale: Medium to some dark brownish gray; slightly calcareous to dolomitic. Faint to some moderately distinct laminae. Regular to some irregular thick parting; slightly conchoidal to irregular and some hackly fracture. Sample of brownish-gray oil shale from 778.6 feet: X-ray - dolomite, calcite, quartz, feldspar, analcime, illite.
779.2	780.6	Marlstone: Buff to light slightly olive gray; slightly silty; calcareous to dolomitic; some light to medium and rare dark brownish-gray oil shale in upper 0.2 and lower 0.3 foot. Moderately distinct to very faint very fine laminae; rare fine loop structures and displacements. Slightly irregular to irregular thick parting; regular to conchoidal fracture. Sample of olive-buff marlstone from 780.1 feet: X-ray - dolomite, quartz, feldspar, illite, analcime.
780.6	781.6	Oil shale: Medium to dark brownish gray; black satiny shale at 780.85-780.95; dolomitic. Very faint very fine discontinuous to regular laminae. Irregular to slightly irregular thick to rare medium parting; slightly conchoidal to irregular fracture. Thin to fine dark gray pyritic streaks at 781.5.
781.6	782.7	Oil shale: Dark brownish gray to black; some satiny to resinous luster in lower half foot; dolomitic. Faintly laminated. Irregular to rare regular thick to medium parting; slightly conchoidal to irregular and rare hackly fracture. A very thin black silty pyritic steak near top.
782.7	784.7	Oil shale: Dark to some medium brownish gray; rare black in upper part; dolomitic. Faintly laminated. Regular to irregular thick parting; slightly conchoidal to irregular fracture. A thin irregular and wavy dense brownish-gray to buff layer with dark tar-stained silty streaks at 784.6. Sample of buff to brownish-black dense to silty layer from 784.6 feet: X-ray - quartz, analcime, feldspar, dolomite, biotite.
784.7	785.7	Oil shale: Medium to dark brownish gray, dolomitic. Faint very fine regular to slightly wavy laminae. Irregular to

From	To	Description
		slightly irregular thick parting; slightly conchoidal to irregular and rare hackly fracture. Thin brownish-black tar-stained silty pyritic lenses and streaks at 784.9 and 785.2; very fine irregular layer at 785.4.
785.7	786.5	Oil shale: Dark brownish gray; some black in lower 0.1 foot; dolomitic. Faintly laminated. Irregular to regular thick to rare medium parting; slightly conchoidal fracture.
786.5	786.7	Oil shale: Dark brownish gray to buff, dolomitic. Faint to distinct laminae; some fine loop structures and displacements. Slightly conchoidal fracture. A 3/4-inch pinch-and-swell dense blebby biotitic tuff in middle.
786.7	786.9	Oil shale: Medium to dark brownish gray, dolomitic. Faintly laminated. Irregular thick parting; slightly conchoidal fracture.
786.9	787.1	Tuff: Dark to medium grayish brown and rare light gray, silty. Faintly variegated and irregularly streaked. Irregular parting and fracture. Regular upper contact; slightly wavy lower contact. Abundant very fine black specks. Sample of tuff from 787.0 feet: X-ray - analcime, quartz, feldspar, pyrrhotite.
787.1	788.1	Oil shale: Dark to rare medium brownish gray; some black in upper part; dolomitic. Faintly laminated. Slightly irregular to irregular thick parting; slightly to moderately conchoidal and irregular fracture.
788.1	789.2	Oil shale: Dark to medium brownish gray, dolomitic. Faintly laminated. Irregular to slightly irregular thick parting; slightly to moderately conchoidal and some irregular fracture. Fine black drusy tar-impregnated streaks at 788.6.
789.2	789.4	Oil shale: Medium to rare dark and light brownish gray, dolomitic. Faint to moderately distinct laminae. Irregular to slightly conchoidal fracture. Abundant very fine disseminated pyrrhotite(?) in some thin zones.
789.4	789.8	Tuff: Light to medium brownish gray with some white streaks in upper part, becoming dark brownish gray to brownish black in lower part; silty to very fine sandy textured; strongly oil stained in lower part. Distinctly streaked to faintly variegated and mottled. Regular upper contact; slightly wavy lower contact. Abundant very fine biotite. Irregular parting and fracture.

From	To	Description
		Sample of white to brownish-gray tuff from 789.4 feet: X-ray - analcime, quartz, feldspar, dolomite, pyrrhotite.
789.8	792.5	Oil shale: Medium to some dark brownish gray, dolomitic. Faintly laminated. Irregular thick parting; irregular and conchoidal fracture. Sparse very fine disseminated pyrite. A fine dark brownish-gray oil-stained silty tuff streak at 791.7 and a thin pinch-and-swell layer at 729.0. Rare fossil insect larvae.
792.5	793.7	Oil shale: Dark to some medium brownish gray and rare black, dolomitic. Faint to rare moderately distinct laminae. Irregular to slightly irregular thick to some medium parting; slightly conchoidal to irregular fracture. A very fine black silty tuff lamina at 792.9. Rare very fine dark silty pyritic streaks in lower part.
793.7	794.3	Tuff: Buff to dark grayish brown; silty textured. Distinct to faint nonparallel braided stringers and streaks. Irregular thick parting; slightly irregular fracture. Some biotite. Mostly oil stained. Slightly wavy contacts at top and bottom.
794.3	795.6	Oil shale: Medium and some dark brownish gray; some light brownish gray to tan and rare buff in upper half foot; dolomitic. Moderately distinct to faint laminae; rare fine displacements and loop structures in upper half foot. Irregular to slightly irregular thick to rare medium parting; irregular to slightly conchoidal fracture. Rare fine medium to dark brownish-gray oil-stained tuffs in upper part; a 1/2-inch irregular layer at 794.8 with a very thin pinched out layer 1/4-inch lower.
795.6 (NBS #3)	796.4	Oil shale: Medium and rare dark brownish gray, dolomitic. Slightly irregular to irregular thick parting; slightly to moderately conchoidal fracture. Sample of oil shale from 796.0 feet: X-ray - dolomite, quartz, calcite, feldspar, analcime, illite.
796.4	797.3	Oil shale: Medium to some light and dark brownish gray, rare black, dolomitic. Faint to moderately distinct laminae. Irregular thick parting; irregular and conchoidal fracture. Very thin brownish-black oil-stained silty tuff streaks at 796.6; 3/8-inch pinch-and-swell medium grayish-brown layer at 796.8.

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc. corehole LW-156 (Con.)

From	To	Description
797.3	798.2	Oil shale: Medium to rare dark brownish gray, dolomitic. Faint very fine regular to discontinuous laminae. Irregular thick parting; conchoidal and irregular fracture. A thin irregular medium to dark grayish-brown oil-stained silty biotitic tuff near top.
798.2	799.2	Oil shale: Dark to some medium brownish gray and rare black, dolomitic. Faintly laminated. Irregular thick parting; conchoidal and irregular fracture. A fine oil-stained tuff lamina at 799.1.
799.2	801.1	Oil shale: Medium to dark brownish gray, dolomitic. Faintly laminated. Irregular to rare regular thick parting; conchoidal and irregular fracture. Abundant thin black tar-stained silty biotitic tuff lenses and streaks at 799.6-799.7. Fine striated brittle vitreous black organic crust on parting surface at 799.7. A fine lenticular black silty tuff stringer at 801.0.
801.1	803.4	Oil shale: Medium and some dark brownish gray in upper part to medium and rare light in lower part; very slightly calcareous to dolomitic. Faint to some moderately distinct laminae. Slightly irregular to irregular thick parting; moderately to slightly irregular and conchoidal fracture. Some very fine disseminated pyrrhotite from about 801.5 to 802.5. Rare fine tuff streaks. Large dark brownish-gray silty biotitic tuff lenses at 801.2-801.4. A 1-inch light to dark brownish-gray silty tuff at 802.5-802.6; irregular interfingered upper contact; slightly irregular lower contact.
803.4	804.4	Oil shale: Dark to medium brownish gray, dolomitic. Faintly laminated. Irregular thick parting; irregular fracture. A 1/2-inch dark brownish-gray silty tuff lens at 803.9; fine irregular layer at 804.3.
804.4	809.5	Oil shale: Medium to some dark brownish gray; rare light brownish gray to buff in middle part; rare black in upper and lower parts; dolomitic to slightly calcareous. Faint to moderately distinct laminae; occasional zones with moderately abundant loop structures and displacements. Irregular thick parting; moderately to slightly irregular and conchoidal fracture. Thin to 1-inch irregular layers of dark brownish-gray oil-stained silty tuff at 805.4, 805.65, and 805.75. Fine gray and buff silty tuff at 808.4. Fine striated vitreous black organic streak at 806.65. Natural(??) diagonal fracture at 807.3.

Quarter-core samples from Occidental Oil Shale, Inc.
corehole LW-156 (Con.)

From	To	Description
809.5	810.5	Oil shale: Dark to medium grayish brown and some black, dolomitic. Faintly laminated. Moderately to slightly irregular thick parting; slightly conchoidal to irregular fracture. Rare fine gray silty pyritic streaks in lower part.
810.5	811.6	Oil shale: Dark to medium grayish brown and rare black, dolomitic. Faint to rare moderately distinct laminae. Irregular thick parting; slightly conchoidal fracture. A 3/4-inch finely laminated buff marlstone band at 810.95.
811.6	813.8	Oil shale: Medium to some dark grayish brown and rare black; dolomitic to slightly calcareous. Faintly laminated. Irregular to rare regular thick parting; slightly conchoidal to some irregular fracture. Sample of grayish-brown oil shale from 812.4 feet: X-ray - dolomite, calcite, quartz, analcime, feldspar, illite.
813.8	814.8	Oil shale: Medium to rare dark brownish gray; some light brownish gray in lower inch; dolomitic. Faint to moderately distinct laminae. Irregular thick to medium parting; slightly conchoidal to irregular fracture.
814.8	816.0	WAVY BEDDED TUFF: Medium to light gray and brownish gray to buff; silty to very fine sandy textured; dolomitic. Faintly variegated and mottled; abundant fine to rare thin wavy to broken stringers and streaks of lean oil shale as below. Irregular parting and fracture. Abundant very fine biotite. Irregular slightly inclined upper and lower contacts.
816.0	816.5	Oil shale: Light to dark brownish gray and some buff, dolomitic. Distinct to faint slightly wavy and inclined to regular and flat laminae. Irregular thick parting; irregular to slightly conchoidal fracture. Interfingered with tuff as above at 816.2-816.3.
816.5	817.0	Oil shale: Dark to some medium brownish gray, dolomitic. Faintly laminated. Slightly irregular to regular thick to medium parting; slightly irregular and conchoidal fracture. Rare very small pyritic patches. Sample of dark to medium brownish-gray oil shale from 816.6 feet: X-ray - dolomite, calcite, quartz, analcime, feldspar, illite.

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From	To	Description
817.0	818.0	Oil shale: Medium to some dark grayish brown, dolomitic. Very faintly bedded to faintly laminated. Irregular thick parting; slightly to moderately conchoidal fracture. Fine brown silty tuff lenses at 817.9.
818.0	819.0	Oil shale: Dark to medium brownish gray, dolomitic. Faint to rare moderately distinct laminae. Irregular to slightly irregular thick to rare medium parting; slightly to moderately conchoidal and irregular fracture. A thin lamina at 818.25: tan and silty upper part; buff and dense lower part; irregular contact between. Sample of thin tan to buff lamina from 818.25 feet: X-ray - quartz, analcime, Na-feldspar, dolomite, K-feldspar, calcite, biotite.
819.0	820.0	Oil shale: Medium to dark brownish gray, dolomitic. Faintly laminated. Irregular thick parting; moderately to slightly conchoidal fracture.
820.0 (NBS #4)	820.5	Oil shale: Medium to light and some dark brownish gray; thin buff zones at 820.0 and 820.4; dolomitic. Distinct to some faint laminae; abundant fine loop structures and displacements. Irregular to slightly irregular thick to rare thin parting; irregular to slightly conchoidal fracture. A thin buff fine-grained analcime lamina near top. Few very fine dark gray silty pyritic streaks at 820.2. Sample of distinctly laminated light to dark brownish-gray oil shale from 820.1 feet: X-ray - dolomite, quartz, calcite, feldspar.
820.5	821.9	Oil shale: Medium and rare dark brownish gray, dolomitic. Moderately distinct to faint laminae; rare fine loop structures. Regular to irregular thick parting; slightly to moderately conchoidal and irregular fracture. Some very fine pyrite. A very thin pinched out dark brownish-gray oil-stained silty tuff lamina at 821.1.
821.9	823.0	Oil shale: Medium and rare dark brownish to slightly olive gray; thin light zones at 821.95 and 822.8; dolomitic. Very faint very fine discontinuous laminae to faint and rare moderately distinct regular laminae. Irregular thick to rare medium parting; irregular fracture. Some very fine disseminated pyrite and/or pyrrhotite. A 1/2-inch light to medium gray and brownish-gray silty biotitic tuff band at 822.0 (at base of thin light zone). A 3/8-inch light gray silty biotitic tuff lamina at 822.8 (at top of thin light zone).

Quarter-core samples from Occidental Oil Shale, Inc.
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From	To	Description
823.0	824.1	Lean oil shale and marlstone: Buff to some medium and rare dark brownish gray; dolomitic to slightly calcareous; silty in lightest parts. Faint to rare distinct laminae; some fine loop structures. Irregular thick parting; slightly irregular and conchoidal fracture. A fine dense gray cherty dolomite streak at 823.2. Sample of buff silty marlstone from 823.8 feet: X-ray - dolomite, quartz, feldspar, calcite, illite, analcime.
824.1	825.1	Oil shale: Medium and rare dark brownish gray; some light brownish gray to buff at 824.8-824.9; dolomitic. Faint very fine discontinuous to regular laminae; distinct laminae at 824.8-824.9. Regular to some irregular thick parting; moderately to slightly irregular and conchoidal fracture. A fine pinch-and-swell dark grayish-brown oil-stained silty tuff at 824.3.
825.1	826.1	Oil shale: Dark to some medium brownish gray and rare black, dolomitic. Faintly laminated. Slightly irregular to irregular thick parting; moderately to slightly irregular fracture. Rare fine silty pyritic streaks near bottom.
826.1	827.1	Oil shale: Medium to rare dark brownish gray and black, dolomitic. Faintly laminated. Moderately to slightly irregular thick parting; irregular to slightly conchoidal fracture. Rare fine brownish-black silty pyritic streaks in upper part.
827.1	828.1	Oil shale: Medium to dark grayish brown and rare black; thin tan to buff zones at 827.2 and 827.6; dolomitic. Faint to moderately distinct laminae. Slightly irregular thick parting; slightly irregular and conchoidal fracture. A fine brownish-gray silty tuff lamina in tan zone at 827.2; very fine streaks at 527.3; fine pinch-and-swell lamina in tan and buff zone at 827.6. Very irregular artificial(?) vertical fracture in lower 0.3 foot.
828.1	829.2	Oil shale: Medium and some dark brownish gray; some medium to light grayish brown in lower part; dolomitic. Faint to rare moderately distinct laminae. Slightly to moderately irregular thick parting; slightly irregular and conchoidal fracture.

Quarter-core samples from Occidental Oil Shale, Inc.
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From	To	Description
829.2	830.3	Oil shale: Medium to some light and dark brownish gray and grayish brown, dolomitic. Distinct to some faint laminae; some fine loop structures and displacements. Irregular thick parting; moderately to slightly conchoidal and some irregular fracture. A very thin gray silty pyritic lens at 829.3. A thin pinch-and-swell buff silty dolomitic tuff at 830.2.
830.3	832.5	Oil shale: Medium to dark brownish gray and very rare black, dolomitic. Faint to rare moderately distinct laminae. Irregular thick parting; slightly to moderately conchoidal fracture. Few thin lenses and small irregular nodules of dark gray silty tuff at top; rare fine streaks elsewhere.
832.5	833.5	Oil shale: Light to some dark brownish gray and some buff, dolomitic. Distinct to some faint laminae; abundant fine to thin loop structures and displacements. Irregular thick parting; conchoidal fracture. Rare very fine pyritic streaks and laminae.
833.5	834.5	Oil shale: Medium to some dark brownish gray, dolomitic. Faint to some moderately distinct laminae; rare fine loop structures and displacements. Irregular thick parting; slightly conchoidal fracture. A small dark silty very pyritic lens at 833.85. Rubble in lower 0.1 foot.
834.5	834.8	Missing.
834.8	835.5	Oil shale: Dark to light brownish gray and rare buff; very slightly calcareous to dolomitic. Distinct to rare faint laminae; some fine loop structures. Irregular thick parting; conchoidal fracture.
835.5	836.6	Oil shale: Buff to medium and some dark brownish gray; slightly calcareous to dolomitic. Distinct to faint laminae; fairly abundant fine to 1/4-inch displacements and rare fine loop structures. Irregular to regular thick parting; slightly to moderately conchoidal fracture.
836.6	837.6	Oil shale: Dark brownish gray to rare black, dolomitic. Faintly laminated. Irregular thick parting; slightly irregular and conchoidal fracture. Sample of dark brownish-gray oil shale from 836.9 feet: X-ray - dolomite, calcite, quartz, feldspar, analcime, illite.
837.6	839.0	Oil shale: Medium to dark brownish gray and rare black, dolomitic. Faint to some moderately distinct laminae.

From	To	Description
		Irregular to rare regular thick to rare medium parting; slightly conchoidal to irregular fracture. Fine striated brittle black organic crust on parting surface at 838.1.
839.0	841.4	Oil shale: Light to dark brownish gray; some buff and rare black; dolomitic to very slightly calcareous. Distinct to rare faint laminae; fairly abundant fine to thin loop structures. Irregular thick parting; moderately to slightly conchoidal fracture; some rubble at 840.0 and 841.0. Very fine dark brownish-gray silty pyritic streaks at 839.7.
841.4	842.6	Oil shale: Black to dark brownish gray; common satiny to resinous luster; dolomitic. Faint laminmae to very faint streaked bedding. Irregular to regular thick to rare medium parting; slightly to moderately irregular fracture. Rare very fine dark brownish-gray silty laminae and streaks.
842.6	847.5	Oil shale: Dark to light grayish brown; rare black and buff; dolomitic to slightly calcareous. Distinct to some faint laminae; abundant fine to thin loop structures in most parts. Regular to some irregular thick to rare medium parting; slightly conchoidal to some irregular fracture; some rubble at 844.1. Rare fine to thin buff to brownish-gray silty lenses in lower half. (NBS #5, 844.3-844.9) Sample of dark to light grayish-brown laminated oil shale from 844.4-844.5 feet: X-ray - dolomite, calcite, quartz, feldspar, analcime.
847.5	848.5	Oil shale: Dark and rare medium brownish gray to black; dolomitic; some satiny to resinous luster. Faintly laminated. Regular to some irregular thick parting; slightly to moderately irregular and some slightly hackly fracture. Irregular natural(?) low-angle fracture at 848.0; short irregular open high-angle fracture at 848.3. Rare fine to thin dark silty streaks and laminae. Sample of very thin dark silty streak in black oil shale from 848.0 feet: X-ray - analcime, feldspar, dolomite, quartz, illite, hornblende, pyrite.

NOTE: Core No. 24, between 848.35 and 867.95 feet, was upside down and partly mixed up. Numbers in parentheses below are approximate original footages before correction.

From	To	Description
848.5 (862.4	849.5 863.4)	Oil shale: Dark to medium brownish gray, dolomitic. Faint to some moderately distinct laminae. Irregular to regular thick parting; irregular to regular fracture.
849.5 (863.4	850.6 864.5)	Oil shale: Dark brownish gray to tan and buff, dolomitic. Faint to very distinct laminae; rare fine displacements. Regular thick parting; irregular to regular fracture.
850.6	851.4	Oil shale: Black to some medium grayish brown; common satiny and some resinous luster; dolomitic. Very fine grayish-brown to tan blebby to lenticular mineral laminae separated by very dark shiny organic-rich oil shale. Regular to rare irregular thick to medium and rare thin parting; slightly irregular and slightly hackly fracture. Abundant very fine pyrite blebs and streaks. Few very thin to fine grayish-brown to tan silty biotitic tuff laminae at 850.7-850.8 and near bottom. Sample of rich blebby oil shale from 850.9 feet: X-ray - dolomite, quartz, illite, feldspar, analcime, pyrite.
851.4 (865.3	852.4 866.3)	Oil shale: Medium to dark and some light brownish gray, dolomitic. Faint to moderately distinct laminae. Slightly to moderately irregular thick to rare medium parting; regular to slightly irregular and conchoidal fracture. Sample of medium to dark brownish-gray oil shale from 851.8 feet: X-ray - dolomite, aragonite, calcite, quartz, analcime, feldspar, illite.
		TOP OF A-GROOVE
852.4 (866.3	854.1 868.0)	Oil shale: Medium and some dark brownish gray to light brownish gray and gray-buff; dolomitic to slightly calcareous. Distinctly laminated; some fine loop structures. Regular to irregular thick parting; conchoidal to regular fracture. Sample of distinctly laminated lean oil shale from 853.1 feet: X-ray - dolomite, quartz, K-feldspar, calcite, illite, analcime.
854.1 (862.2	857.8 858.5)	Oil shale and some marlstone: Buff and tan to medium and some dark grayish brown; slightly calcareous to dolomitic. Distinct to some faint laminae; some fine loop structures and displacements. Regular to rare

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc.
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From	To	Description
		irregular thick to some medium and thin parting; regular to slightly conchoidal fracture. A very thin dark oil shale lamina with abundant fine white mineral blebs at 855.9; a thick zone at 846.5-856.7; a 1-inch zone with very irregular large chalky white masses at 856.8-856.9. A 2-inch light gray to buff silty tuff band at 857.4-857.6. Sample of buff to tan marlstone from 855.5 feet: X-ray - dolomite, quartz, feldspar, analcime, calcite, illite. Sample of dark to medium grayish-brown oil shale with fine disseminated crystal blebs from 856.6 feet: X-ray - dolomite, calcite, quartz, feldspar, analcime, illite. Sample of chalky white mass from 856.9 feet: X-ray - quartz, trace dolomite, analcime. Sample of light slightly brownish gray silty band from 857.4 feet: X-ray - dolomite, quartz, feldspar, analcime, illite.
857.8 (858.5	859.1 857.2)	Oil shale: Dark to medium and some light brownish gray, dolomitic. Distinct to rare faint laminae; some fine loop structures and displacements. Regular to irregular thick parting; slightly to moderately conchoidal and irregular fracture.
859.1 (857.2	862.5 853.8)	Marlstone and lean oil shale: Light to some medium and very rare dark slightly brownish gray, dolomitic, silty. Moderately distinct to faint laminae; rare fine loop structures and displacements. Regular to slightly irregular thick parting, becoming mostly irregular in lower foot; regular to some conchoidal fracture. Possible raindrop impressions on parting surfaces at 859.2 and 859.6. Sample of light slightly brownish-gray silty marlstone from 860.5 feet: X-ray - dolomite, quartz, K-feldspar, illite.
		BOTTOM OF A-GROOVE TOP OF MAHOGANY ZONE

From	To	Description
862.5 (853.8	864.9 850.4)	Oil shale: Medium to some dark and rare light brownish gray, dolomitic. Faintly laminated. Irregular thick to medium parting; slightly conchoidal to irregular and some coarse hackly fracture.
864.9 (850.4	865.9 851.4)	Oil shale: Medium to dark brownish gray and some black; some satiny to waxy luster; dolomitic. Faint to some moderately distinct laminae; some very faint streaked bedding in richer part. Regular to rare irregular thick to medium parting; slightly irregular and some slightly hackly fracture. Some fine dark gray silty tuff laminae and streaks in upper part.
865.9 (851.4 (868.0	868.6 848.4) 868.6)	Oil shale: Buff to dark brownish gray, dolomitic. Distinctly laminated; some fine loop structures and displacements. Regular to some irregular thick to rare medium and thin parting; regular to slightly irregular and conchoidal and rare coarse hackly fracture. Occasional fine to 1/2-inch stringers, streaks and lenses of buff and white to dark gray silty tuff. Sample of distinctly laminated oil shale from 867.9 feet: X-ray - dolomite, quartz, feldspar, analcime, illite.
868.6 (NBS #6)	869.0	Oil shale: Medium to dark brownish gray and rare black; rare satiny to resinous luster; dolomitic. Moderately distinct to some faint laminae; rare fine displacements and loop structures. Slightly wavy to irregular thick to medium parting; slightly to moderately irregular fracture. Abundant fine to very thin black pyritic streaks and lenses; a fine lamina near bottom. Sample of medium to dark oil shale with fine pyritic streaks from 868.8 feet: X-ray - dolomite, quartz, analcime, feldspar, pyrite, illite.
869.0	869.8	Oil shale and tuff: Dark and rare medium brownish-gray to black oil shale, dolomitic. Faint to some moderately distinct laminae; becoming slightly wavy adjacent to tuffs. Regular to some irregular thick to medium and rare thin parting; moderately to slightly irregular and some slightly hackly fracture. Dark gray to brownish-gray silty to very fine sandy-textured tuff in upper 0.2 foot; streaked with brownish-gray to tan marlstone in lower inch. Faintly

From	To	Description
		variegated and mottled to indistinctly brecciated brownish-gray silty to very fine blebby-textured biotitic tuff at 869.5-869.7. Abundant very fine disseminated pyrite. Short tight bitumen-coated vertical fracture in upper tuff. Sample of brownish-gray silty to blebby biotitic tuff from 869.6 feet: X-ray - analcime, quartz, feldspar, dolomite, pyrite, biotite, hornblende.
869.8	870.4	Oil shale: Dark and rare medium brownish gray to some black, dolomitic. Faintly laminated. Regular to slightly irregular and wavy thick to medium parting; slightly irregular fracture. Some very fine to thin dark gray to black pyritic silty tuff laminae, streaks and lenses. Abundant very fine disseminated pyrite. Sample of dark oil shale with pyritic tuff streaks from 870.0-870.1 feet: X-ray - dolomite, quartz, analcime, feldspar, calcite, illite, pyrite.
870.4	872.1	Oil shale: Medium to some dark brownish gray and rare black; some medium grayish brown and rare tan in upper half; dolomitic. Faint to moderately distinct laminae; rare fine to thin displacements and loop structures. Irregular to regular thick to rare medium parting; slightly irregular fracture. A thin pinch-and-swell brownish-gray silty tuff at top; thin lenses at 870.8; occasional fine streaks and lenses elsewhere.
872.1	873.4	Oil shale: Dark brownish gray to black; some satiny and rare resinous luster; dolomitic. Faint very fine laminae to very faint streaked bedding. Slightly irregular and wavy thick to some medium parting; slightly irregular to some coarse hackly fracture. Abundant very fine disseminated pyrite and pyritic streaks. Some thin dark to medium grayish-brown tuff laminae and lenses at 873.0-873.2.
873.4	874.0	Oil shale: Medium and some dark grayish brown, dolomitic. Faint to moderately distinct laminae. Slightly to moderately irregular thick parting; slightly irregular to regular fracture. A thin brown silty to fine sandy-textured tuff lamina at 873.5.

From	To	Description
874.0	875.8	Oil shale: Medium to rare dark brownish gray, dolomitic. Faint very fine regular to discontinuous laminae. Regular to irregular thick to rare medium parting; moderately to slightly irregular and conchoidal fracture. Two fine tuff laminae at 874.2.
875.8	877.1	Oil shale: Medium to rare dark and light brownish gray; thin buff zone near top; dolomitic. Faint to rare moderately distinct laminae; rare fine loop structures and displacements. Irregular thick parting; moderately to slightly conchoidal fracture.
877.1	878.4	Oil shale: Medium to some dark and rare light brownish gray, dolomitic. Faint regular to discontinuous laminae and streaked bedding. Irregular to slightly irregular thick parting; irregular to some regular fracture. Sample of dark to medium brownish-gray oil shale from 877.8 feet: X-ray - dolomite, quartz, analcime, calcite, feldspar.
878.4	879.4	Oil shale: Medium and some dark brownish gray to light brownish gray and buff, dolomitic. Faint to rare moderately distinct laminae with some thin to 0.1-foot distinct lighter zones; some fine displacements and loop structures in lighter zones. Slightly to moderately irregular thick parting; slightly to moderately conchoidal fracture. Sample of light brownish-gray to buff oil shale from 879.1-879.2 feet: X-ray - colomite, quartz, feldspar, analcime, illite.
879.4	880.4	Oil shale: Medium to some dark and light brownish gray, dolomitic. Faint to rare moderately distinct laminae. Slightly to moderately irregular thick to medium parting; slightly conchoidal to irregular fracture. Some very fine dark gray silty pyritic streaks; very thin to fine black silty pyritic streaks at 880.3. A thin dense medium-light brownish-gray dolomite band at 879.9.
880.4	880.9	MAHOGANY MARKER Tuff: Light to medium and rare dark slightly brownish gray; silty to medium sandy textured. Faintly streaked and variegated. Irregular parting and fracture. Some very fine disseminated pyrite and pyritic streaks. Sample includes a small amount of buff to brownish-gray oil shale at top and bottom.

From	To	Description
		Sample of tuff from 880.8 feet: X-ray - analcime, quartz, feldspar, marcasite, pyrite.
880.9	884.3	Oil shale: Light to dark brownish gray and some buff; some grayish brown to tan in lower half foot; dolomitic. Faint to moderately distinct laminae, becoming very distinct in lower foot; some fine loop structures and displacements. Irregular to regular thick to rare medium parting; irregular and conchoidal to regular fracture. Some very fine dark gray silty streaks in upper part, becoming sparse in lower part. A thin grayish-brown fine granular porous tuff layer at 884.1.
884.3	885.3	Oil shale: Dark grayish brown to black; common satiny to resinous and some waxy luster; dolomitic. Faint very fine blebby laminae (like 850.9) and streaked bedding in upper half, becoming very faintly bedded in lower part. Regular to some irregular thick to medium parting; slightly irregular and hackly to slightly conchoidal fracture. Abundant very fine disseminated pyrite and pyritic streaks. (Top of "rich section")
885.3	886.3	Oil shale: Dark to medium brownish gray, dolomitic. Faintly laminated. Slightly to moderately irregular thick parting; slightly to moderately irregular fracture. Very rare fine gray silty streaks.
886.3	887.3	Oil shale: Medium and some dark brownish gray; thin buff zone at 887.2; dolomitic. Faintly laminated; rare fine displacements and loop structures. Irregular thick to rare medium parting; moderately to slightly irregular fracture. Very rare fine gray silty streaks.
887.3	888.0	Oil shale: Brownish gray to buff. Distinct to faint laminae. Mostly rubble; grab sampled.

NOTE: Core No. 26, between 888.0 and 907.5 feet, was upside down. Core was reversed and renumbered. Numbers in parentheses below are original footages before correction.

From	To	Description
888.0 (907.5	889.2 906.3)	Oil shale: Medium to dark brownish gray; some light brownish gray; some light brownish gray and rare buff in upper 0.3 foot; dolomitic. Faint discontinuous to regular laminae; some moderately distinct laminae near top. Slightly to moderately irregular thick parting; irregular to slightly conchoidal fracture. A 0.2 foot pinch-and-swell brown to brownish-gray dense to silty tuff at 888.6; includes some fine waxy-lustered crystal blebs. A 3/4-inch

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From	To	Description
		light slightly brownish-gray fine to medium sandy-textured tuff at bottom. Fine tuff lenses at 888.8. Sample of dense brownish-gray tuff with fine crystal blebs from 888.6 feet: X-ray - quartz, analcime, feldspar, dolomite, biotite, hornblende.
889.2 (906.3	890.7 904.8)	Oil shale: Dark brownish gray to black; common satiny to resinous and rare waxy luster; dolomitic. Faint discontinuous to regular laminae. Regular to irregular thick to rare medium parting; slightly irregular and hackly to some irregular fracture. Thin dark brownish-gray dense to silty tuff lenses at 890.1.
890.7 (904.8	891.2 904.3)	Oil shale: Dark grayish brown and rare black to tan and buff, dolomitic. Distinct to faint laminae. Regular thick to medium parting; slightly irregular fracture. Sample of distinctly laminated buff to dark grayish-brown oil shale from 890.9 feet: X-ray - dolomite, quartz, calcite, feldspar, analcime.
891.2 (904.3	892.1 903.4)	Oil shale: Dark grayish brown to rare black; almost all has satiny to resinous luster; dolomitic. Faint very fine laminae. Regular to slightly irregular thick to some thin parting; slightly irregular to slight and rare coarse hackly fracture.
892.1 (903.4	892.9 902.6)	Oil shale: Dark to medium brownish gray and rare black; rare satiny luster; dolomitic. Faint to rare moderately distinct laminae. Regular to slightly irregular thick to rare medium parting; slightly irregular to slightly hackly fracture. Abundant very fine pyrite(?) blebs in some layers.
892.9 (902.6	894.5 901.0)	MAHOGANY BED Oil shale: Black to dark and some medium brownish gray; nearly all has waxy to satiny luster; dolomitic. Faintly laminated with occasional very distinct light brownish-gray to buff laminae; some fine to 1/4-inch loop structures and displacements. Regular to slightly irregular and wavy thick to rare medium parting; slightly irregular to hackly fracture. Abundant very fine disseminated mineral blebs (pyrite in part?). Sample of very rich oil shale with very fine disseminated mineral blebs from 893.1 feet: X-ray - quartz, illite, feldspar, dolomite, analcime, pyrite.

From	To	Description
		Sample of buff lamina from 893.2 feet: X-ray - dolomite, quartz, feldspar, pyrite.
894.5 (901.0	895.7 899.8)	MAHOGANY BED Oil shale: Dark to rare medium brownish gray and rare black; most has satiny to resinous luster; dolomitic. Faintly laminated; some fine to 1/4-inch loop structures. Regular to slightly irregular thick to some medium parting; slightly irregular and hackly fracture. Abundant very fine disseminated mineral blebs as above.
895.7 (899.8	896.9 898.6)	Oil shale: Dark and some medium brownish to black-gray in upper and lower parts; dark grayish brown to tan and rare buff at 896.0-896.5; dolomitic. Faint laminae in upper and lower parts to distinct in middle. Regular to slightly irregular thick to rare medium parting; slightly irregular to some irregular and hackly fracture. Unidentified mashed fossil(?) on parting surface at 896.8.
896.9 (898.6	898.0 897.5)	Oil shale: Very dark brownish gray to black; most has satiny to resinous luster; dolomitic. Very faint very fine laminae and streaked bedding. Regular to irregular thick parting; slightly conchoidal to slightly hackly fracture. Possibly natural diagonal fracture at 897.2. A 3/4-inch pinch-and-swell brownish-gray to gray silty to sparry tuff at 897.85. A very fine crystalline streak at 897.45; fine platy and granular crystals; fine vitreous black conchoidal surfaces (bitumen or glass?).
		Sample of very fine crystalline streak in black oil shale from 897.45 feet: X-ray - dolomite, quartz, analcime, feldspar, illite.
		Sample of tuff from 897.85 feet: X-ray - analcime, quartz, pyrite, feldspar.
898.0 (897.5	898.8 896.7)	Oil shale: Dark to medium and some light brownish gray; rare black near top; dolomitic to calcareous. Faint to some distinct laminae; some fine loop structures in distinctly laminated part. Regular to irregular thick parting; irregular to slightly conchoidal fracture. Fine dark gray silty pyritic streaks at 898.25.
898.8 (896.7	899.7 895.8)	Oil shale: Medium and some dark brownish gray to light brownish gray and some buff; calcareous to dolomitic. Distinct to some faint laminae. Slightly irregular to

From	To	Description
		regular thick parting; regular to irregular fracture. Very fine pyritic crystalline streaks at 899.3.
899.7 (895.8	900.0 895.5)	Oil shale: Black to dark and some medium brownish gray; common satiny to resinous luster in upper part; dolomitic. Faint streaked bedding and discontinuous laminae. Irregular thick parting; slightly conchoidal and irregular fracture.
900.0 (895.5 (NBS #7)	900.3 895.2)	Oil shale: Dark and some medium grayish brown in upper part to brownish black in lower part; common satiny to resinous luster in lower part; dolomitic. Faint streaked bedding and discontinuous laminae in upper part to very faint very fine laminae in lower part. Slightly irregular thick parting; irregular to slightly conchoidal fracture. Fine brittle vitreous black organic crust on parting surface at bottom.
900.3 895.2	900.9 894.6)	Oil shale: Black to very dark brownish gray; some medium brownish gray in lower 0.1 foot; almost all has resinous to satiny luster; dolomitic. Very faintly streaked to faintly laminated; rare thin loop structures near bottom. Slightly to moderately irregular thick to rare medium parting; slightly conchoidal to irregular fracture.
900.9 (894.6	902.5 893.0)	Oil shale: Medium to some light and rare dark brownish gray; rare buff in lower part; calcareous. Distinct to some faint laminae; abundant fine displacements and loop structures; thin conglomeratic zones at 902.4 and 902.5. Irregular to regular thick parting; irregular to regular fracture. Sample of medium to dark brownish-gray oil shale from 901.8 feet: X-ray - calcite, dolomite, quartz, feldspar, illite.
902.5 (893.0	903.6 891.9)	Oil shale: Dark brownish gray to black; common satiny to resinous luster; dolomitic. Very faintly streaked to faintly laminated. Regular thick to some medium parting; slightly irregular and hackly fracture.
903.6 (891.9	904.6 890.9)	Oil shale: Medium and some dark brownish gray; dolomitic. Very faint to rare moderately distinct laminae. Regular to some irregular thick to medium parting; regular to slightly irregular fracture. A thin irregular brownish-gray dense and sparry to silty tuff at 904.3.

From	To	Description
904.6 (890.9	905.6 889.9)	Oil shale: Dark and rare medium brownish gray to black; common satiny to rare resinous luster; dolomitic. Very faint very fine laminae. Regular to some irregular thick parting; slightly irregular and hackly fracture. A thin brownish-gray silty tuff lens at 904.85.
905.6 (889.9	906.9 888.6)	Oil shale: Medium and some dark brownish gray to tan and some buff, dolomitic. Distinct to rare faint laminae; some fine low-angle displacements in upper part. Regular to some irregular thick parting; slightly irregular to regular fracture. Fine black silty streak at 905.7.
906.9 (888.6	907.5 888.0)	Oil shale: Dark and some medium grayish brown in upper part to very dark brownish gray and black in lower part; rare satiny luster in lower part; dolomitic. Faintly laminated. Slightly to moderately irregular thick parting; conchoidal to slightly irregular fracture. A thin dark brownish-gray silty tuff lamina at 907.35.
907.5	908.0	Oil shale: Dark brownish gray to black; common satiny to resinous luster; dolomitic. Faintly laminated. Regular thick parting; slightly irregular fracture.
908.0	911.0	Oil shale: Medium and rare dark grayish brown to tan and buff; calcareous in upper half foot to dolomitic in other parts. Very distinct to some faint laminae; abundant fine loop structures and displacements in some parts. Regular to rare irregular thick to some medium parting; conchoidal to regular fracture. Fine slightly wavy light gray silty lamina at 909.2.
911.0	912.1	Oil shale: Very dark brownish gray to black; most has satiny to resinous and rare waxy luster; dolomitic. Very faintly laminated; some fine to thin loop structures. Irregular to regular and slightly wavy thick parting; moderately to slightly irregular and rare hackly fracture. Irregular 1/2- to 1-inch grayish-brown to brownish-gray blebby to silty tuff lenses at 911.6, 911.7 and 911.95 Sample of 1-inch tuff lens from 911.7 feet: X-ray - Na-feldspar, quartz, analcime, pyrite, biotite, hornblende.
912.1	913.1	Oil shale: Dark to light brownish gray and rare buff; calcareous to dolomitic. Distinctly laminated; rare fine

From	To	Description
		to thin loop structures and displacements. Regular to irregular thick parting; slightly to moderately irregular fracture. A thin pinch-and-swell light gray silty biotitic tuff at top. Very thin medium to dark gray silty pyritic lenses at 912.8.
913.1	915.2	Oil shale: Buff to medium and rare dark brownish gray and grayish brown; slightly calcareous to dolomitic. Distinct to some faint laminae; some very fine to thin loop structures and displacements. Regular to rare irregular thick parting; regular to conchoidal fracture. Rubble at 915.0
915.2	916.3	Oil shale: Dark brownish gray; some black in upper part; dolomitic. Very faint streaked bedding in upper part; faint very fine discontinuous to regular laminae in lower part. Irregular to regular thick to rare medium parting; slightly to moderately irregular and rare coarse hackly fracture. A thin dark gray silty tuff lens at 915.6; rare fine streaks elsewhere.
916.3	917.9	Oil shale: Dark to rare medium brownish gray, dolomitic. Very faint to faint discontinuous to regular laminae. Slightly to moderately irregular thick parting; slightly to moderately irregular fracture.
917.0	919.1	Oil shale: Dark to medium and some light brownish gray; rare black and buff; dolomitic to slightly calcareous. Faint to distinct laminae; some fine loop structures and displacements. Regular to rare irregular thick to rare medium and thin parting; slightly irregular and conchoidal fracture; rubble at 918.9. A 1-inch pinch-and-swell medium-light brownish-gray silty to blebby tuff(?) at top. Very fine black silty pyritic streaks at 918.25. Very fine light to dark gray silty streaks at 918.85. Top of core below rubble zone appears slightly leached. Sample of brownish-gray tuff from 917.9 feet: X-ray - Na-feldspar, calcite, analcime, quartz, dolomite.
919.1 (NBS #8)	920.0	Oil shale: Dark and some medium grayish brown to rare black, dolomitic. Faint streaked bedding in upper part; faint to moderately distinct discontinuous to regular laminae below 919.4. Slightly to moderately irregular thick parting; slightly irregular to slightly hackly fracture. Rare very fine dark silty pyritic streaks. Sample of black to dark grayish-brown laminated oil shale from 919.6 feet: X-ray - dolomite, quartz, analcime, calcite, feldspar, illite.

From	To	Description
920.0	921.0	Oil shale: Black to medium brownish gray, dolomitic. Faint to distinct laminae. Regular to rare irregular thick parting; slightly irregular to conchoidal fracture. Sparse very fine disseminated pyrite in lower part. Rare very fine silty streaks.
921.0	922.0	Oil shale: Dark to light brownish gray; rare black and buff; dolomitic. Very distinct laminae in upper part; moderately distinct to faint laminae below 921.4; some fine to thin loop structures. Regular to irregular thick parting; slightly to moderately irregular and conchoidal fracture.
922.0	924.7	Oil shale: Buff to medium and rare dark brownish gray; calcareous to dolomitic. Faint to very distinct laminae; some fine to rare thin loop structures. Regular to rare irregular thick to rare medium parting; regular to some irregular and some slightly conchoidal fracture. Few fine irregular milky white chert specks (very short fracture fillings?) at 923.25.
924.7	925.5	Oil shale: Black to dark and some medium brownish gray; some satiny to resinous luster; dolomitic. Very faint to some moderately distinct laminae. Moderately to slightly irregular thick to rare medium parting; slightly conchoidal to irregular fracture. A 3/4-inch pinch-and-swell medium to dark brownish-gray silty to sandy-textured biotitic tuff at 925.2. Very thin dark silty pyritic streaks at 925.4 and 925.5.
925.5	926.2	Oil shale: Medium to light and some dark grayish brown; dolomitic to slightly calcareous. Distinct to some faint laminae; some fine loop structures and displacements. Slightly to moderately irregular thick parting; slightly conchoidal fracture.
926.2	928.5	Marlstone and some oil shale: Very light buff to some medium and rare dark grayish brown, slightly calcareous. Very distinct to very faint very regular laminae. Regular to rare irregular thick parting; regular to conchoidal fracture. A very regular 1/2-inch light to medium gray silty to fine sandy-textured lamina with rare pyrite at 926.65. Very fine dark gray silty pyritic streaks at 927.05; rare very fine pyritic streaks elsewhere.

From	To	Description
		Sample of thin gray lmaina with some marlstone from 926.65 feet: X-ray - analcime, feldspar, quartz. Sample of very light buff marlstone from 928.2 feet: X-ray - dolomite, quartz, calcite, feldspar, analcime, illite.
928.5	929.3	Oil shale: Medium and rare dark brownish gray to buff, dolomitic. Distinctly laminated. Irregular to regular thick parting; conchoidal to regular fracture. A fine white silty biotitic tuff lamina at 928.8. A thin light brownish-gray silty to very fine sandy-textured tuff band at 929.2.
929.3	929.8	Oil shale: Dark to medium and rare light grayish brown, dolomitic. Distinct to faint laminae. Slightly to moderately irregular thick parting; slightly conchoidal and irregular fracture.
929.8	930.6	Oil shale and tuff: Buff to some medium and rare dark brownish-gray oil shale. Distinct to faint laminae. Irregular to regular thick to rare medium parting; slightly conchoidal and irregular fracture. Tuff at 930.1-930.4: light gray and silty in upper part to dark gray coarse bitumen-coated analcime grains in lower part; some pyrite at upper contact and disseminated among analcime grains in lower part. A fine gray silty pyritic tuff lamina at 929.9. A fine vertical dark gray silty pyritic stringer at 930.4-930.5. Sample of light gray silty tuff from 930.15 feet: X-ray - analcime, quartz, feldspar. Sample of dark gray analcime tuff from 930.35 feet: X-ray - analcime, quartz, pyrite, feldspar, dolomite.
930.6	931.3	Oil shale: Light to some dark brownish gray, dolomitic. Distinctly laminated. Moderately to slightly irregular thick parting; irregular to slightly conchoidal fracture. Abundant very fine black mineral grains in some laminae in upper part. A very thin tan fine-sandy-textured tuff lamina at bottom. Sample of oil shale with some very fine black mineral grains from 930.85 feet: X-ray - dolomite, quartz, feldspar, illite, analcime.

From	To	Description
931.3	932.3	Oil shale: Dark to some medium grayish brown and some black; some satiny to resinous luster; dolomitic. Moderately distinct to faint laminae in upper and lower parts; very fine grayish-brown mineral blebs and blebby laminae in black organic-rich shale at 931.5-931.9 (like 850.6-841.4). Regular to slightly irregular thick to some medium parting; moderately to slightly irregular fracture. Sample of rich blebby oil shale from 931.6 feet: X-ray - dolomite, quartz, feldspar, illite, pyrite, analcime.
932.3	933.4	Oil shale: Dark to some light brownish gray and rare buff, dolomitic. Distinctly laminated rare fine displacements and loop structures. Regular to irregular thick parting; slightly irregular and conchoidal fracture. Fine gray silty tuff lamina at 932.7. Abundant very fine dark specks (biotite?) in lower part.
933.4	934.1	Oil shale: Buff to medium and some dark grayish brown, dolomitic. Very distinct laminae. Irregular to regular thick parting; slightly conchoidal to regular fracture. Very fine gray pyritic laminae at 933.7 and 933.95.
934.1	934.8	Oil shale: Light to dark brownish gray and some buff, dolomitic. Distinctly laminated; abundant fine loop structures. Slightly irregular to regular thick parting; slightly irregular and conchoidal fracture. A very thin gray silty tuff lamina at top.
934.8	935.8	Oil shale: Dark and rare medium brownish gray to black; common satiny to resinous luster; dolomitic. Faint regular laminae in upper and lower parts to blebby laminae and streaked bedding (like 931.5-931.9) in middle; few small loop structues near top. Slightly to moderately irregular thick parting; slightly to moderately irregular fracture.
935.8	936.8	Oil shale: Buff to some medium and dark grayish brown, dolomitic. Distinct to faint laminae; rare small loop structures. Slightly irregular thick parting; regular to conchoidal fracture. A fine white silty biotitic tuff lamina at 936.1.
936.8	937.8	Marlstone: Buff to light and rare medium to dark brownish gray; silty in parts dolomitic to slightly calcareous.

From	To	Description
		Moderately distinct to very faint laminae and rare streaked bedding. Regular to irregular thick parting; conchoidal to regular fracture. A very thin light gray silty to very fine sandy-textured lamina at 937.65. Sample of very light buff silty marlstone from 937.1 feet: X-ray - dolomite, quartz, feldspar, analcime, illite, calcite.
937.8	938.9	Marlstone and oil shale: Buff to some medium and rare dark brownish gray; dolomitic to slightly calcareous. Faint to some distinct laminae; rare fine loop structures and displacements. Irregular to regular thick to rare medium parting; regular to some conchoidal fracture. Very fine disseminated white crystal blebs in some oil shale layers. Sample of brownish-gray oil shale with abundant very fine crystal blebs from 938.45 feet: X-ray - dolomite, calcite, quartz, feldspar, illite.
938.9	939.5	Oil shale: Light to dark brownish gray and some black; rare satiny luster; dolomitic. Distinct to very faint laminae; rare fine loop structures. Irregular to regular thick to rare medium parting; slightly to moderately irregular and conchoidal fracture. Fine brownish-gray to black silty pyritic tuff streaks at 939.05. Irregular half-inch coarse-grained analcime lens at 939.4. Finely interfingered lenticular contact with tuff below. Sample of dark brownish-gray to black oil shale from 939.35 feet: X-ray - dolomite, quartz, calcite, analcime, illite, feldspar.
939.5	940.5	CURLY BEDDED TUFF: Medium to light gray and rare buff to white; silty to coarse sandy textured. Faintly variegated; some indistinct irregular layering. Irregular parting and fracture. Some very fine biotite. Sharp slightly wavy contact with oil shale below. Sample of gray fine-grained tuff from 940.1 feet: X-ray - quartz, analcime, biotite, pyrite, feldspar. Sample of coarse-grained salt-and-pepper tuff from 940.4 feet: X-ray - analcime, quartz, biotite, feldspar, pyrite.
940.5	940.9	Oil shale: Black to some dark brownish gray; almost all has satiny to resinous luster; dolomitic. Very faint very

From	To	Description
		fine laminae; rare fine loop structures. Regular thick to medium parting; slightly conchoidal fracture. Fine grayish-brown dense blebby streaks at 940.8. Sample of black oil shale from 940.55 feet: X-ray - dolomite, quartz, analcime, calcite, feldspar, illite, pyrite.
940.9	941.4	Oil shale: Dark to medium brownish gray; some black in upper half; dolomitic. Faint to moderately distinct laminae; some fine loop structures. Slightly irregular thick parting; irregular to slightly conchoidal fracture. Fine dense dark brownish-gray silty lenses at 941.2. Very fine black pyritic streaks at 941.25.
941.4 (NBS #9)	942.0	Oil shale: Medium to dark brownish gray; thin light zone at 941.8; dolomitic. Moderately distinct laminae; some fine to thin loop structures. Irregular thick parting; irregular fracture. A fine black silty pyritic streak at 941.5. Fine dark gray silty lenses at 941.7. Sample of dark to medium brownish-gray oil shale from 941.6 feet: X-ray - dolomite, quartz, calcite, analcime, feldspar, illite.
942.0	942.8	Oil shale: Dark to medium and some light brownish gray; some black near top; dolomitic to very slightly calcareous. Distinct to rare faint laminae; rare fine loop structures and displacements. Irregular thick parting; irregular to slightly conchoidal fracture. A 3/4-inch moderately coarse grained analcime band at 942.45. A very thin white silty tuff lens at 942.6.
942.8	947.4	Oil shale and marlstone: Medium and rare dark brownish gray to buff; dolomitic to slightly calcareous; commonly slightly silty in lighter layers. Distinct to some faint laminae and rare bands; some fine loop structures and displacements. Irregular to some regular thick to rare medium and thin parting; regular to conchoidal fracture. A very thin light to medium gray biotitic tuff lamina at 943.7. Very fine gray silty streaks at 947.2. (NBS #10, 946.0-946.6)

Quarter-core samples from Occidental Oil Shale, Inc.
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From	To	Description
947.4	947.9	Oil shale: Medium to some dark and light brownish gray, dolomitic. Faint to moderately distinct laminae; some very fine loop structures and displacements. Slightly irregular to regular thick parting; slightly irregular fracture. Rare very fine dark gray silty pyritic streaks.
947.9	948.7	Very lean oil shale grading to silty marlstone: Medium and very rare dark brownish gray to buff and gray-buff, dolomitic. Faint and rare moderately distinct very fine laminae; rare very fine loop structures and displacements. Irregular thick parting; slightly irregular and conchoidal fracture. Some gray silty streaks. Some very fine biotite.
		BOTTOM OF MAHOGANY ZONE TOP OF B-GROOVE
948.7	949.7	Mudstone and siltstone: Gray buff to some light brownish gray and rare gray, dolomitic. Very faint to some moderately distinct laminae; some distinct medium to dark gray pyritic and biotitic streaks. Slightly irregular to regular thick parting; slightly irregular fracture. Sample of mudstone with fine dark streaks from 949.1 feet: X-ray - dolomite, quartz, feldspar, analcime, illite, calcite.
949.7	952.0	Siltstone and mudstone: Gray buff and rare light to medium brownish gray, dolomitic. Faintly laminated and banded; some distinct dark gray streaks as above in middle part. Moderately to slightly irregular thick parting; slightly irregular fracture. Massive to faintly variegated and mottled dark gray to rusty brown silty band at 950.3-950.5. Fine dark brownish-gray silty lamina at 951.7. Slightly permeable in parts. Sample of dark gray and rusty brown silty band from 950.4-950.5 feet: X-ray - analcime, pyrrhotite, feldspar, quartz, calcite.
952.0	959.7	Siltstone and some mudstone: Gray buff and rare light brownish gray; dolomitic to slightly calcareous. Very faintly laminated and banded to massive; rare distinct dark gray streaks. Irregular to some regular thick parting; regular to some irregular fracture; slightly permeable.

From	To	Description
		Abundant fine to 1/4-inch dark gray silty very pyritic streaks at 955.25-955.35. Light to dark gray dense silty and slightly sparry band at 955.5-955.65.
959.7	961.0	Siltstone and some mudstone: Gray buff and light gray to some light and medium grayish brown, slightly calcareous. Very faint to some moderately distinct laminae. Regular to rare irregular thick to some medium parting; regular to slightly irregular fracture; slightly permeable in parts.
961.0	968.0	Siltstone: Gray buff to some light gray and rare buff to light brownish gray, slightly calcareous. Very faintly laminated and banded to massive. Irregular to rare regular thick parting; regular to some irregular fracture; slightly permeable. Sample of massive light gray siltstone from 963.9 feet: X-ray - dolomite, quartz, feldspar, calcite, analcime, illite.
968.0	974.0	Siltstone and marly mudstone: Gray buff to buff and light to some dark gray; slightly calcareous to dolomitic. Faint to some distinct laminae and bands. Irregular to regular thick parting; regular to some irregular fracture; slightly permeable. Sample of gray silty layer from 973.2 feet: X-ray - dolomite, quartz, feldspar, analcime, illite. Sample of buff marly layer from 973.3 feet: X-ray - dolomite, quartz, feldspar, analcime, illite.
974.0	979.2	Mudstone and marlstone: Gray buff and buff to some light and rare medium brownish gray, dolomitic. Very faint to rare moderately distinct laminae; some distinct dark gray silty laminae in upper part; wavy distorted laminae at 974.5-974.6. Irregular to regular thick parting; slightly to moderately conchoidal and some irregular fracture; slightly permeable. Abundant very fine disseminated black specks. Sample of buff marlstone with abundant very fine black specks from 977.7 feet: X-ray - dolomite, analcime, quartz, feldspar, illite, pyrite.

From	To	Description
979.2	980.4	Oil shale and marlstone: Medium and rare dark grayish brown to tan and buff, dolomitic. Distinct to some faint laminae in 1/2- to 2-inch lighter and darker zones; rare fine loop structures and displacements. Irregular thick to medium parting; conchoidal fracture. A thin dark gray silty to very fine sandy-textured very pyritic lamina at 979.4; some very fine dark pyritic specks at 979.5.
980.4	982.4	Marly mudstone and siltstone: Buff; dolomitic to slightly calcareous. Very faint regular to slightly disrupted and irregular laminae and bands. Irregular thick parting; slightly conchoidal to irregular fracture. Two fine irregular wavy oil shale layers in lower 2 inches.
		BOTTOM OF B-GROOVE
982.4	983.4	Oil shale: Buff to medium and some dark brownish gray; very dark to black zones at 982.46-982.67 and 983.12-983.18; dolomitic. Distinct to some faint laminae; rare fine loop structures; faint discontinuous laminae and streaked bedding in dark zone near top. Irregular to slightly irregular thick to medium parting; moderately to slightly conchoidal fracture. A very thin rusty brown silty tuff lamina near bottom.
983.4	984.4	Oil shale: Black to dark and rare medium brownish gray; common satiny to waxy luster; dolomitic. Very faintly streaked to faintly laminated; slightly blebby in middle part (like 850.6-841.4 and 931.5-931.9). Irregular to rare regular thick to some medium parting; moderately to slightly irregular and some slightly hackly fracture. Some very fine pyrite blebs and streaks. Rare fine to small brownish-gray silty lenses. Natural(?) vertical fracture at 984.0-984.2.
984.4	987.0	Oil shale, some marlstone in lower part: Dark to light brownish gray and buff; dolomitic to very slightly calcareous. Distinct to rare faint laminae. Regular to irregular thick to rare medium and thin parting; regular to slightly conchoidal and some irregular fracture. Very abundant very fine disseminated black specks (like 977.7) in upper part, becoming sparse in lower part. (986.4-986.6 missing)

LITHOLOGIC DESCRIPTION OF SAMPLES SUBMITTED FOR ASSAY

Quarter-core samples from Occidental Oil Shale, Inc. corehole LW-156 (Con.)

From	To	Description
NOTE:		Core sequence from 987.0 to 993.0 might not be exactly correct.
987.0	987.4	Oil shale: Dark brownish gray to black; dolomitic; some satiny to resinous luster. Faintly laminated; rare small loop structures. Irregular to slightly irregular thick parting; slightly conchoidal to irregular coarse hackly fracture. Fine to 1-inch dark gray silty to very fine sandy-textured tuff streaks and lenses at 987.1. Abundant very fine disseminated pyrite.
987.4	988.1	Oil shale: Black to medium grayish brown and brownish gray, dolomitic. Moderately distinct to faint laminae. Irregular to regular thick to rare medium parting; conchoidal to regular fracture. A small dark brownish-gray silty tuff lens near bottom. Abundant very fine pyrite in dark layers.
988.1	989.2	Oil shale: Medium to dark brownish gray; rare black in upper part; some light brownish gray in lower part; dolomitic. Moderately distinct to distinct laminae. Irregular to regular thick parting; regular to irregular and some conchoidal fracture. Some very fine disseminated pyrite (or pyrrhotite?) in upper part. Gray silty tuff band at 988.7-988.8. A very fine irregular vertical fracture filled with dark gray silty pyritic material in lower 0.3 foot; a fine lens of similar material at 989.05. Sample of medium to dark brownish-gray oil shale from 988.4 feet: X-ray - dolomite, quartz, aragonite, calcite, feldspar, analcime, illite.
989.2	989.5	Marlstone: Buff to light and some medium brownish gray; very slightly calcareous. Moderately distinct laminae; rare fine displacements. Irregular thick parting; slightly conchoidal to irregular fracture. A 3/4-inch gray silty tuff band at top. A fine gray silty lamina with abundant very fine biotite (and hornblende?) at 989.35.
989.5	990.5	Mudstone: Gray buff to light gray; rare light to medium brownish-gray streaks and laminae; dolomitic to slightly calcareous. Very faint to rare moderately distinct laminae in upper and lower parts to very faintly streaked in middle. Irregular thick to medium parting; conchoidal to irregular fracture. Slightly irregular and displaced dark

From	To	Description
		gray silty band with some fine pyrite streaks and blebs at 990.3-990.4. (Continuity with core above and below is questionable.) Sample of dark gray silty band from 990.3-990.4 feet: X-ray - analcime, pyrite, feldspar, quartz, illite.
990.5	991.9	Oil shale: Very light buff to light and rare medium to dark brownish gray; slightly calcareous to dolomitic. Faint to some distinct laminae. Irregular thick to rare medium parting; slightly to moderately conchoidal fracture.
991.9	993.1	Oil shale: Light to some dark brownish gray, rare buff, dolomitic. Moderately to very distinct laminae. Irregular to rare regular thick parting; slightly to moderately conchoidal and irregular fracture. Abundant very fine disseminated dark gray to black specks. Some very fine pyrite and/or pyrrhotite blebs and streaks in dark layers. Rare fine gray silty laminae and streaks. Sample of medium to light brownish-gray oil shale with very fine dark specks from 992.3 feet: X-ray - dolomite, quartz, calcite, feldspar, illite.
993.1	995.2	Oil shale: Buff and tan to dark brownish gray and rare black; dolomitic to slightly calcareous. Distinctly laminated. Regular to irregular thick parting; conchoidal to regular fracture. A 0.2-foot gray silty tuff band at top; light gray and biotitic in upper 1/4-inch; dark gray and pyritic in lower 1/4 inch. A thin dark gray silty pyritic lamina at 993.8. A very fine gray silty lamina at 994.55.
995.2	996.4	Marlstone and oil shale: Buff to some medium and rare dark brownish gray, dolomitic. Faint to some distinct laminae. Irregular to rare regular thick parting; moderately to slightly conchoidal fracture. Rare very fine pyrite blebs and streaks.
996.4	997.0	Oil shale: Light to medium and rare dark brownish gray, rare buff, dolomitic. Distinct to rare faint laminae. Irregular to regular thick parting; regular to slightly conchoidal and some irregular fracture. A fine gray silty pyritic tuff lamina at 996.55.

Quarter-core samples from Occidental Oil Shale, Inc.
corehole LW-156 (Con.)

From	To	Description
997.0	998.0	Oil shale: Buff to some medium and rare dark brownish gray; dolomitic to very slightly calcareous. Very distinct to faint laminae. Irregular to regular thick parting; slightly conchoidal to regular fracture. A fine pinch-and-swell dark gray silty pyritic lamina at 997.15. A 1/2-inch irregular medium to dark gray silty biotitic tuff at 997.4. Abundant very fine milky white mineral blebs in lower 0.3 foot. Sample of light to medium oil shale with very fine white mineral blebs from 997.9 feet: X-ray - dolomite, calcite, quartz, analcime, feldspar, illite.
998.0	999.8	Marlstone and lean oil shale: Very light buff to light and rare medium to dark brownish gray; slightly calcareous to dolomitic; commonly silty in lighter parts. Faint to rare distinct laminae. Regular to some irregular thick to rare medium parting; regular to conchoidal fracture. A very thin white silty biotitic tuff lamina at 998.85.
999.8	1001.1	Oil shale: Buff and tan to medium and some dark brownish gray, dolomitic. Distinctly laminated. Regular to irregular thick to medium and rare thin parting; slightly to moderately conchoidal and some irregular to coarse hackly fracture. Rare fine pyrite blebs and streaks. A fine gray silty tuff lamina at 1000.7.
1001.1	1001.9	Oil shale: Very light buff to medium and rare dark brownish gray; dolomitic to slightly calcareous. Faint to distinct laminae. Regular to irregular thick to some thin parting; moderately to slightly conchoidal fracture.
1001.9	1002.9	Oil shale: Buff to dark brownish gray, dolomitic. Distinctly laminated. Irregular thick to rare medium parting; slightly to moderately conchoidal and some irregular fracture. A fine dense light brownish-gray lamina with abundant pyrite blebs at 1002.05. A fine dark gray silty pyritic lamina at 1002.3. A 0.1-foot gray to brownish-gray silty to very fine sandy-textured at bottom; slightly irregular upper contact; finely interfingered lower contact.
1002.9	1003.1	Oil shale: Dark brownish gray to black; rare satiny luster; dolomitic. Very faint very fine laminae (slightly curved). Slightly conchoidal fracture. Abundant very fine disseminated pyrite blebs. A 3/8-inch brown silty dolomite lamina near bottom, with a 10 x 1/2-inch brownish-gray

From	To	Description
		silty nodule nested in a depression in the upper part of the layer. Sample of black oil shale with very fine pyrite blebs from 1002.95 feet: X-ray - quartz, dolomite, feldspar, analcime, illite, pyrite, marcasite.
1003.1	1003.8	Oil shale: Medium to dark and rare light grayish brown, dolomitic. Faint to some distinct laminae. Regular to irregular thick to rare medium parting; slightly conchoidal fracture. Occasional layers with abundant very fine pyrite blebs and streaks. Very fine dark brownish-gray oilty streaks at 1003.6. Sample of medium to dark grayish-brown oil shale from 1003.5 feet: X-ray - dolomite, quartz, analcime, calcite, feldspar, illite.
		BOTTOM OF CORE

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APPENDIX B

ENVIRONMENTAL DATA

This appendix includes data not previously reported in prior quarterly reports.

Following table is a list of malfunction codes used for missing air quality and meteorological data.

AIR QUALITY AND METOROLOGICAL

MALFUNCTION COMPUTER CODES

Numerical Entry Code	Letter Code	Description
8000	TR	Trace of Precipitation
9000	CA	Calibration (calibration, system check)
9100	MT	Maintenance (changing paper, tape, charcoal)
9200	FO	Flame Out (on the GC - THC, HC, CH_4, CO)
9300	IM	Instrument Malfunction (instrument failures)
9400	PF	Power Failure (generator failure)
9450	WR	Weather Related Malfunction (instrument freezes, temperature readings below instrumental detection)
9500	RF	Recording System Failure (chart jams, runs out clock stop)
9550	NV	Not Visible (values were not within range of instrument i.e. inversion heights may exist beyond the full scale of the Acoustic Radar)
9600	LI	Local Interference (car nearby)
9650	OE	Operator Error (Field tech leaves switch in wrong position)
9700	OS	Off Scale
9750	IN	Interference (CO_2 interference on sulfur data, SO interference in oxidant readings)
9800	SE	Special Experiment
9850	OR	Out for Repair (instrument removed from site with no replacement)
9870	TS	Temporary Monitoring Shutdown due to Operations Conflict
9900	VA	Variable Wind Direction
9950	CM	Calm (no wind direction when wind speed = 0)
9980	UN	Unlimited Ceiling (reported by NWS Stations)
9999		Blank (causes a space to be printed as in the beginning of a new month before a component starts)

7/31/80

AIR QUALITY

and

METEOROLOGICAL DATA

Coors / SPECTRO-CHEMICAL LABORATORY
DIVISION OF COORS PORCELAIN COMPANY
GOLDEN, COLORADO, U.S.A.
303-278-4000 Ext. 2302

Mailing Address:
P.O. Box 500
Golden, Colorado 80401

Analytical Report

CI-1317-A

TO: Occidental Oil Shale, Inc.
2372 "G" Road
P. O. Box 2687
Grand Junction, CO 81501

Attention: Paul Oliver

LABORATORY NUMBER	94646
DATE	10-7-80
CUSTOMER ORDER NO.	AFE 8779-01

Hi-Vol Filters

METEOROLOGICAL TOWER STATION LW02

Filter No.	Date	Particulates (μg/m³)
1005282	7-22-80	30.9
1005283	7-29-80	78243*
1005284	8-5-80	0.4
1005285	8-19-80	3.2
1005286	8-12-80	0.5
1005287	8-25-80	5.8

* The data record for filter 1005283, dated 7-29-80, indicates a sample time of only 56 minutes, which gives an excessively high particulate count. If time were 23 hours and 56 minutes, the particulates would be 37.3 μg/m³, a much more realistic number.

Coors / SPECTRO-CHEMICAL LABORATORY

BY ____________
LABORATORY MANAGER

DISTRIBUTION: WHITE & PINK - Customer; GREEN - Numerical File; CANARY - Customer File

MONTHLY DIURNAL TABLES

For

STATIONS LW01, LW02, LW03, LW04

WIND DIRECTION @10M
DEGREES

LOGAN WASH
MRI LW01
FEB 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	PREV
1	179	108	155	125	131	122	121	115	132	123	128	269	169	284	290	323	287	141	124	123	121	136	130	127	165
2	126	134	150	132	127	126	128	146	128	175	288	295	277	251	293	278	111	113	128	133	89	145	135	105	167
3	134	140	134	121	122	133	131	105	101	135	58	253	84	303	262	331	91	101	125	118	122	139	96	135	145
4	128	115	132	139	136	137	76	159	125	300	288	285	314	84	87	246	228	135	124	135	132	128	111	106	160
5	128	124	111	116	107	134	110	124	155	138	144	307	283	296	240	264	255	122	134	131	131	135	131	129	165
6	139	122	124	161	118	135	147	105	108	126	273	265	272	277	286	289	252	192	152	91	252	133	300	287	192
7	55	80	180	302	59	38	56	157	66	48	57	61	44	335	237	55	(CM)	(CM)	(CM)	(CM)	110	90	45	61	107
8	62	62	302	169	117	52	200	206	270	280	248	238	292	288	51	105	84	47	53	84	120	189	131	146	158
9	140	152	148	136	136	141	212	141	132	132	146	134	290	290	296	289	284	60	148	130	116	125	125	123	168
10	134	136	128	133	125	139	134	125	126	130	163	173	293	272	291	292	260	236	117	168	120	101	107	133	168
11	123	120	124	124	134	126	139	138	139	137	135	245	304	229	296	295	266	53	105	120	130	115	95	130	159
12	130	131	123	127	144	137	126	155	140	228	320	275	290	293	287	319	273	257	128	185	212	122	139	116	194
13	121	125	131	135	120	129	130	182	273	280	275	300	311	312	315	305	290	292	281	101	335	285	276	237	231
14	325	293	321	150	70	273	317	35	41	78	9	48	298	320	307	309	270	288	299	138	273	290	246	98	212
15	315	231	324	250	285	273	224	252	276	117	214	279	297	285	292	269	246	206	195	87	114	34	285	60	225
16	87	105	94	113	130	134	124	141	116	19	67	306	307	75	123	296	273	135	133	132	121	138	117	133	142
17	136	122	112	31	286	319	24	20	269	301	287	292	284	299	288	297	294	289	264	251	140	201	312	97	217
18	169	307	291	266	289	(VA)	(VA)	(VA)	279	284	282	297	230	302	288	231	151	320	35	233	317	(VA)	(VA)	(VA)	254
19	(VA)	(VA)	(VA)	290	212	261	99	145	168	166	198	340	261	276	284	307	325	323	339	344	133	104	302	95	237
20	258	240	259	270	332	316	282	286	285	280	302	279	273	291	287	294	303	290	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	285
21	(CM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	312	344	308	318	292	286	46	339	27	153	41	33	(CM)	(CM)	208
22	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	282	295	291	281	167	232	276	278	207	162	108	105	115	118	105	201
23	292	96	118	93	252	279	126	169	24	296	322	285	280	284	165	88	157	111	260	114	102	283	92	135	184
24	134	157	149	177	138	118	111	30	148	163	167	268	230	228	145	277	254	162	169	90	76	101	85	88	153
25	104	127	128	122	139	122	117	202	123	134	120	280	272	211	278	266	273	52	129	127	132	118	126	122	159
26	131	123	123	133	115	114	119	109	129	139	234	288	235	247	272	262	248	124	130	127	125	114	115	116	161
27	126	124	114	121	134	132	135	115	139	138	283	287	252	304	257	256	233	59	130	122	124	87	122	123	163
28	135	129	120	137	124	128	130	135	130	137	204	254	245	239	297	266	223	276	102	127	140	83	284	328	182
29	225	121	28	147	93	65	55	(CM)	209	283	290	291	310	275	286	170	195	142	299	264	331	194	108	80	194
PV	155	143	159	156	155	157	137	140	157	180	211	260	262	263	253	260	230	181	159	146	152	138	159	131	185

(11/05/80-RPI)

(11/05/80-RPI)

WIND DIRECTION @10M
DEGREES

LOGAN WASH
MRI LW01
MAR 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	PREV
1	71	64	67	68	55	72	289	79	139	129	294	300	136	271	247	278	260	233	170	116	121	118	117	119	159
2	127	130	121	124	194	139	115	129	276	294	297	297	297	60	293	298	279	26	51	152	109	134	157	146	177
3	125	24	275	296	311	322	296	302	303	101	319	300	302	313	286	292	307	307	312	262	337	258	292	232	270
4	290	290	299	295	294	288	287	272	288	302	302	287	293	290	292	117	297	280	131	99	88	153	134	98	240
5	127	145	133	86	94	115	109	158	276	337	312	281	311	279	279	293	286	201	280	288	220	291	297	285	228
6	312	284	290	287	300	295	247	204	284	270	290	297	293	288	276	157	245	(VA)	(VA)	(VA)	(VA)	(VA)	(VA)	(VA)	272
7	(VA)	(VA)	(VA)	(VA)	(VA)	(VA)	(VA)	(VA)	(VA)	(VA)	316	296	298	296	311	293	284	278	294	248	279	300	291	275	290
8	299	300	304	281	104	278	109	115	133	143	296	256	333	276	340	278	305	296	255	244	112	43	79	117	221
9	133	125	129	113	130	138	101	114	135	165	297	164	282	312	297	292	295	287	222	136	72	113	144	125	180
10	119	134	121	137	124	116	124	114	145	152	276	250	311	246	281	276	275	248	94	97	110	96	106	102	169
11	127	123	130	143	127	132	139	142	290	301	287	258	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	183
12	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )
13	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )
14	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )
15	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )
16	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )
17	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )
18	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )
19	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	289	295	275	278	298	99	89	93	104	100	( )
20	110	110	115	89	93	78	156	202	153	187	246	177	269	287	297	300	308	293	61	122	119	127	146	74	172
21	149	117	129	135	170	281	315	63	287	299	297	287	309	298	303	300	304	303	283	170	179	164	71	299	230
22	167	170	347	157	315	154	194	315	29	61	61	111	295	43	131	63	201	208	145	291	40	114	118	135	161
23	266	116	225	143	175	136	126	66	294	85	328	296	204	196	287	75	301	274	217	136	127	133	114	159	187
24	119	126	90	133	276	113	320	122	232	244	277	314	265	339	307	309	297	300	297	305	303	257	47	290	237
25	273	294	260	228	304	106	120	148	287	301	247	314	287	292	140	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	240
26	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	142	140	164	186	309	295	280	257	252	70	131	134	130	132	125	183
27	163	139	127	198	133	135	122	127	151	299	288	295	221	309	286	278	294	66	103	109	88	77	41	97	173
28	98	113	80	64	54	75	84	65	110	120	137	268	182	157	221	214	231	292	38	75	223	291	281	284	157
29	289	263	203	149	74	286	163	203	179	223	264	164	285	141	182	141	283	111	157	109	103	103	123	126	180
30	127	105	113	107	130	147	209	105	96	205	213	197	324	308	309	301	281	300	94	262	258	279	305	271	210
31	168	155	105	211	126	124	174	323	285	256	301	289	295	174	307	276	78	282	233	87	104	109	96	111	195
PV	174	158	174	164	171	168	181	160	208	210	265	255	272	249	272	246	270	244	181	168	153	161	152	170	205

WIND DIRECTION @10M
DEGREES

LOGAN WASH
MRI LW01
APR 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	PREV
1	113	144	165	82	214	81	67	282	257	87	299	134	279	283	169	304	280	220	177	119	112	55	75	58	169
2	40	45	55	49	85	89	62	312	282	312	99	70	306	306	306	308	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	263	176
3	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	198	294	294	231	291	326	321	303	293	291	213	109	131	128	131	137	231
4	131	125	123	114	130	126	119	151	194	287	298	296	303	257	284	121	311	241	74	116	121	115	144	130	180
5	139	122	128	138	98	118	214	136	189	263	310	309	301	300	303	310	306	303	256	277	293	220	294	190	230
6	288	225	307	131	199	178	107	133	257	303	283	298	305	301	284	300	288	295	310	305	287	303	132	256	253
7	284	287	112	294	115	282	287	254	290	307	293	286	292	297	123	293	272	303	193	125	122	103	112	116	227
8	80	106	110	96	152	169	129	150	134	286	300	286	297	302	274	305	136	130	140	133	132	142	134	116	177
9	179	121	146	175	140	156	290	318	280	329	326	328	331	331	327	331	199	153	150	151	155	162	151	146	224
10	136	152	142	264	222	264	247	198	218	309	313	309	177	327	302	130	168	132	276	108	142	148	142	143	207
11	157	149	143	144	175	219	214	294	200	221	214	211	112	233	232	201	313	204	199	202	210	130	106	111	191
12	113	111	147	150	116	155	122	104	220	66	84	118	155	145	83	102	105	153	116	135	135	160	103	116	126
13	129	64	157	86	144	246	167	257	218	283	207	294	156	181	110	89	73	101	149	106	135	129	146	146	157
14	147	151	151	154	148	148	181	243	300	301	300	302	175	116	87	329	92	118	149	147	149	144	147	149	180
15	162	160	150	145	152	148	268	298	268	267	296	266	292	266	265	269	85	116	113	87	89	85	141	177	190
16	87	91	86	118	57	150	210	146	86	182	176	212	88	150	298	(CM)	59	89	118	119	90	(VA)	(VA)	(VA)	131
17	118	118	120	149	151	120	206	150	120	299	210	272	119	152	273	299	300	64	97	89	93	92	92	122	159
18	119	134	130	126	131	125	129	135	238	296	283	212	292	274	301	299	304	300	211	118	126	96	97	122	192
19	123	125	122	124	124	124	153	124	188	283	277	181	305	302	156	296	282	303	246	211	92	119	124	121	188
20	118	183	126	133	136	134	122	163	290	281	144	323	316	305	311	310	310	299	270	93	122	136	139	164	205
21	131	141	168	146	119	191	180	146	316	299	295	296	327	317	319	296	287	300	250	283	143	134	172	292	231
22	104	167	139	101	129	116	140	124	129	117	80	103	78	132	163	303	212	94	47	116	83	99	83	82	123
23	89	98	301	115	119	136	135	141	285	317	307	302	294	301	301	328	164	303	298	212	118	178	273	145	219
24	139	308	182	307	338	325	172	92	59	316	328	255	77	345	317	299	57	165	31	114	77	203	89	132	197
25	53	59	40	59	75	56	140	82	214	294	237	294	119	294	266	129	147	295	85	120	129	170	148	108	151
26	83	117	117	91	93	84	202	118	308	323	313	212	115	183	181	318	314	205	160	107	129	122	126	74	171
27	63	104	101	114	129	120	133	182	261	279	294	301	304	174	126	117	101	59	51	65	120	89	100	153	148
28	129	126	127	130	110	113	125	143	304	289	300	303	303	305	295	355	288	297	299	139	104	135	109	113	206
29	127	87	92	142	130	122	144	63	81	85	65	290	101	319	57	71	286	76	287	305	103	278	260	31	150
30	114	256	166	68	118	75	149	112	286	301	298	318	284	303	117	296	287	286	217	134	187	274	216	137	208
PV	127	141	140	136	140	151	166	174	222	263	251	254	230	261	232	256	218	203	179	150	135	148	142	140	186

(11/05/80-RPT)

(11/05/80-RPI)

180

WIND DIRECTION @10M
DEGREES

LOGAN WASH
MRI LW01
MAY 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	PREV
1	174	96	286	302	310	162	260	295	307	342	147	307	288	291	164	301	145	127	56	102	146	109	110	121	206
2	125	211	126	138	124	134	159	298	301	307	288	127	313	295	286	295	291	137	233	126	117	125	120	111	199
3	123	119	131	118	128	132	130	136	289	322	301	352	287	292	286	86	223	308	75	96	114	94	111	103	182
4	187	66	100	95	131	117	99	295	301	294	301	295	123	294	122	50	117	118	272	135	155	137	120	136	171
5	129	130	274	130	126	141	109	165	314	300	312	322	120	76	101	77	114	312	307	94	99	105	124	134	171
6	118	108	106	115	137	112	132	280	290	286	302	312	314	309	95	268	276	232	104	262	288	115	132	145	204
7	123	128	138	125	124	130	134	86	306	283	223	297	264	286	291	127	161	274	276	217	120	291	281	246	205
8	132	131	110	103	(VA)	(VA)	(VA)	(VA)	287	289	301	297	279	334	324	310	224	250	257	298	143	182	134	124	227
9	185	182	212	281	170	131	110	254	195	342	242	304	288	193	318	301	293	276	294	281	83	292	169	298	237
10	72	97	186	317	99	67	324	325	306	320	315	339	303	308	334	293	314	326	297	284	302	301	292	273	266
11	278	302	304	280	65	295	257	303	180	292	280	309	295	315	313	281	300	313	260	158	284	80	323	298	265
12	288	297	324	327	249	98	296	305	271	283	287	278	293	299	307	304	279	257	122	255	112	141	88	278	253
13	85	92	93	117	124	109	103	132	125	192	48	148	182	292	301	289	286	300	333	121	110	127	121	103	164
14	176	136	169	33	137	229	261	122	302	308	305	300	330	317	312	290	298	299	146	91	89	75	58	97	203
15	145	111	126	102	194	131	142	130	103	296	289	294	305	301	289	344	94	289	111	144	105	307	120	104	191
16	119	122	137	117	105	112	134	320	276	294	308	300	296	306	308	307	301	303	302	219	289	218	162	143	229
17	157	113	109	84	(VA)	(VA)	(VA)	143	137	118	101	288	62	63	124	307	303	293	295	115	115	133	105	108	156
18	118	124	86	58	118	89	111	124	111	291	197	171	210	285	295	151	137	304	302	93	63	87	87	101	155
19	108	101	106	97	143	127	121	132	269	290	292	292	281	294	286	279	252	118	188	76	79	101	120	108	178
20	90	140	223	118	151	117	130	119	295	296	316	268	292	209	260	312	295	286	50	99	115	116	120	135	190
21	70	321	131	232	132	105	194	118	306	296	299	325	282	314	274	311	33	291	302	103	118	100	103	89	202
22	112	146	138	133	134	139	128	100	87	84	289	297	274	80	286	297	113	294	104	133	108	309	104	71	165
23	56	303	304	307	291	306	277	293	301	313	303	303	300	306	291	309	299	302	276	306	311	311	298	312	291
24	297	297	310	293	282	303	297	306	301	307	315	302	312	297	287	291	300	286	276	297	319	277	297	200	294
25	258	188	316	155	177	312	301	312	311	269	297	298	296	302	302	290	297	295	299	274	160	120	169	165	257
26	219	111	130	105	112	108	123	118	105	295	303	309	321	314	307	307	319	295	304	105	127	115	119	108	199
27	150	123	113	107	120	133	123	126	294	291	298	313	285	313	311	300	308	305	283	292	117	180	152	112	215
28	132	141	136	129	123	130	131	99	293	307	317	296	282	294	309	292	298	295	252	267	145	151	108	103	210
29	138	186	227	280	272	256	242	240	280	298	279	294	293	302	283	289	286	300	298	228	218	104	113	91	242
30	90	119	113	116	128	156	123	117	281	288	307	302	306	292	283	300	307	314	299	282	91	142	134	133	209
31	305	304	276	306	36	307	60	302	289	292	284	303	297	292	299	315	311	286	295	248	136	141	126	126	247
PV	154	163	179	168	153	162	173	203	252	283	272	288	270	273	269	267	244	275	234	187	154	164	149	151	212

WIND DIRECTION @10M
DEGREES

LOGAN WASH
MRI LW01
JUNE 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	PREV
1	107	91	101	99	118	128	139	125	117	288	303	289	279	290	309	302	291	287	282	289	180	134	131	129	200
2	117	131	113	119	131	128	99	67	287	301	306	295	294	293	285	303	311	300	299	288	54	280	297	331	226
3	264	315	316	311	318	296	112	301	303	296	294	286	296	299	313	299	301	308	294	272	276	87	84	317	273
4	303	303	320	323	275	316	309	300	296	302	298	298	300	308	311	296	302	315	305	202	167	135	125	109	272
5	125	125	131	113	117	101	95	274	295	286	304	296	303	312	311	313	300	296	314	242	134	97	133	177	216
6	122	180	92	150	171	136	135	329	320	310	326	325	322	307	310	309	295	308	300	295	171	98	61	83	227
7	117	108	104	299	150	163	130	120	305	297	295	296	314	305	310	306	299	302	296	201	108	127	101	101	215
8	106	83	121	139	153	180	117	131	273	314	293	294	185	291	133	250	285	288	152	123	94	100	94	104	179
9	89	119	135	113	89	92	92	131	280	300	303	309	297	277	303	295	287	308	50	107	85	78	108	84	180
10	121	121	125	105	105	66	132	106	305	296	314	295	294	307	298	297	305	294	308	214	308	83	132	116	210
11	101	90	117	123	126	133	112	125	203	297	313	325	306	305	313	313	315	293	306	233	134	97	107	160	206
12	131	151	130	157	98	138	131	108	297	304	314	293	292	301	307	309	293	309	297	276	148	137	98	78	212
13	133	116	76	110	97	128	130	136	93	292	302	292	306	318	323	307	302	318	311	293	303	174	121	127	213
14	103	131	112	126	137	144	124	144	317	323	309	309	297	289	307	294	301	295	289	290	297	199	96	79	221
15	108	134	77	122	54	167	125	126	69	276	263	301	300	320	285	291	297	297	268	297	104	112	97	85	191
16	97	75	78	75	62	32	131	119	111	295	283	309	284	282	183	314	286	295	297	61	107	86	137	59	169
17	76	122	126	120	119	116	128	125	119	323	235	294	304	242	329	152	290	287	286	70	122	95	86	85	177
18	88	86	102	105	127	121	131	126	110	131	297	285	295	296	284	289	294	287	296	270	140	195	111	97	190
19	95	88	90	88	98	105	126	121	118	137	294	283	299	307	287	286	289	294	276	337	60	91	268	84	188
20	66	69	134	119	132	109	172	124	132	325	304	304	294	292	301	311	290	299	274	309	190	123	121	107	204
21	81	96	111	118	124	113	111	101	92	277	307	296	288	312	302	301	297	289	282	274	164	139	98	91	194
22	85	83	98	96	125	125	121	128	124	236	279	286	276	294	313	304	301	315	291	293	128	100	306	148	202
23	125	57	115	133	132	112	115	128	332	301	315	306	315	314	289	299	324	326	311	310	294	90	136	116	221
24	92	119	135	130	127	126	130	126	275	303	302	291	289	305	291	301	292	315	307	296	167	117	126	128	212
25	96	119	116	129	83	125	144	126	135	296	289	291	285	300	53	41	298	296	305	313	123	112	126	108	180
26	106	90	97	96	150	139	100	141	130	299	293	303	301	307	303	321	316	305	299	301	270	154	299	135	219
27	177	191	200	275	264	158	116	108	95	281	151	181	293	276	290	288	285	297	305	286	137	126	113	102	208
28	150	102	104	96	111	126	99	90	122	290	262	259	293	83	277	288	309	315	31	308	114	97	102	98	172
29	93	109	101	110	118	143	134	137	184	293	288	297	292	298	303	289	297	297	293	284	113	185	87	113	202
30	113	109	119	129	298	153	141	104	54	76	295	94	139	304	273	286	297	292	108	319	89	92	88	221	175
PV	120	124	127	141	140	137	129	144	196	278	291	286	288	291	283	285	298	301	268	255	159	125	133	126	205

(11/05/80-RPI)

WIND DIRECTION @10M
DEGREES

LOGAN WASH
MRI LW01
JULY 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	PREV
1	153	139	107	105	103	94	86	239	296	283	282	300	297	289	293	290	283	133	308	113	192	292	68	104	202
2	293	322	123	123	136	142	165	79	168	296	279	281	295	288	309	297	299	309	299	54	135	82	115	168	211
3	88	303	145	153	130	131	122	127	125	281	283	320	270	311	292	297	302	297	303	313	261	37	193	137	218
4	116	119	118	109	99	95	143	119	133	132	304	306	313	313	317	298	311	298	298	307	143	135	114	105	198
5	101	93	105	132	124	129	129	134	136	315	305	296	306	302	302	297	309	300	290	298	286	147	105	111	211
6	119	97	97	109	90	111	149	138	138	136	122	274	285	296	306	122	297	264	246	144	87	95	98	91	163
7	93	114	111	130	144	132	131	134	138	291	147	291	305	318	308	297	296	62	182	321	102	157	128	214	189
8	128	91	101	135	123	113	128	143	125	143	239	277	299	297	306	301	295	304	295	310	281	125	99	90	198
9	85	119	101	104	101	101	127	140	152	127	293	280	294	293	287	100	85	56	283	300	50	66	113	96	156
10	98	103	97	82	122	118	120	107	122	115	288	292	291	277	293	285	299	294	285	300	262	176	106	130	194
11	291	150	124	124	129	103	104	125	294	299	282	314	310	289	306	306	303	74	72	85	62	98	116	65	184
12	80	90	142	83	124	125	112	75	293	294	285	287	294	294	295	303	332	117	310	115	331	303	124	149	207
13	271	140	116	138	237	141	142	257	311	36	287	97	310	99	66	39	330	270	336	295	280	122	114	138	191
14	131	127	165	130	127	134	147	111	318	312	55	293	300	299	175	308	297	299	298	166	128	117	102	105	194
15	108	112	132	138	121	114	104	116	259	308	288	306	302	295	283	337	319	303	320	109	116	127	129	111	202
16	125	101	96	157	132	131	128	129	274	283	270	313	300	308	307	307	299	307	80	104	102	111	99	94	190
17	103	103	101	118	119	130	126	128	132	298	298	294	296	291	297	306	308	306	310	134	73	138	132	117	194
18	92	108	101	76	81	146	94	90	295	298	303	96	296	307	297	306	310	294	293	117	131	107	141	159	189
19	131	146	137	314	162	87	272	296	297	306	306	306	305	311	293	234	291	299	297	137	106	129	118	114	227
20	129	105	103	107	129	139	152	138	149	272	290	296	289	185	281	38	291	119	71	107	123	78	96	103	160
21	124	111	105	100	101	94	112	132	132	305	281	305	294	293	288	298	168	77	133	105	117	106	126	143	169
22	120	86	136	117	103	141	117	119	197	290	300	292	300	302	304	292	294	305	300	147	139	109	126	94	197
23	136	119	152	142	131	143	129	129	145	305	287	300	311	253	184	98	44	277	97	100	142	114	119	110	165
24	89	106	114	114	135	125	137	123	285	287	299	278	294	265	267	279	285	108	112	267	102	37	121	132	182
25	120	134	122	121	168	130	125	131	30	249	289	310	291	302	295	285	300	295	288	122	111	104	104	126	190
26	116	136	128	131	123	117	121	128	297	182	293	264	261	316	298	275	107	284	275	287	95	85	164	137	193
27	109	96	99	113	121	125	132	127	297	283	294	286	276	299	303	284	294	67	48	112	114	131	104	107	176
28	109	104	130	126	121	120	138	129	249	295	279	302	304	298	290	307	340	341	62	94	96	104	98	105	189
29	107	126	127	114	130	105	132	132	118	284	296	300	280	286	283	288	285	293	269	302	90	98	74	89	192
30	70	96	154	165	124	153	125	137	289	290	292	295	289	31	64	151	82	100	80	95	84	111	103	101	145
31	100	116	119	128	126	102	87	133	123	289	188	287	294	295	293	303	285	246	119	144	135	118	110	121	178
PV	127	126	120	127	126	122	130	137	204	254	268	282	295	277	274	259	269	229	224	181	144	121	115	118	189

WIND SPEED @10M
METERS/SEC

LOGAN WASH
MRI L=01
FEB 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	2
2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	2
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	2
5	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1	2	2
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	2
7	2	3	3	3	4	4	3	3	3	3	3	4	3	3	3	3	3	4	4	5	5	5	5	6	4	6
8	5	4	2	2	3	3	2	2	1	1	1	2	2	2	3	3	2	3	3	2	2	1	1	1	2	5
9	2	2	2	2	2	2	1	1	1	1	1	1	2	2	2	1	1	1	1	2	2	2	2	2	2	2
10	2	2	2	2	1	1	1	1	1	1	1	1	2	2	1	1	1	2	2	2	2	2	2	2	2	2
11	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	1	1	1	1	1	2	2	3	2	2	2	1	1	1	1	1	1	2	3
13	2	2	2	2	2	1	1	1	2	3	3	4	4	0	4	4	3	2	2	2	2	2	2	2	2	4
14	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	3	1	1	1	1	1	1	2	3
15	1	1	1	1	1	1	1	1	1	1	1	1	3	2	2	2	1	1	1	1	1	1	1	4	1	4
16	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	2
17	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	2	1	1	1	1	1	1	1	3
18	2	2	2	2	1	(CM)	(CM)	(CM)	1	1	1	1	2	2	2	2	2	1	1	1	2	(CM)	(CM)	(CM)	2	2
19	(CM)	(CM)	(CM)	1	1	1	1	1	1	1	1	1	2	2	2	3	4	3	3	2	2	2	2	1	2	4
20	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	2	2	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	2	3
21	1	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	2	2	2	2	2	1	1	1	1	1	1	1	2	2	1	2
22	3	2	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
23	1	2	2	2	3	2	1	1	1	1	1	2	3	4	2	2	1	1	1	1	1	1	1	1	2	4
24	1	1	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	2
25	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	3	3	3	2	2	3
26	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	2	2	2	2	2	3
27	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	3	2	3
28	3	3	2	2	2	2	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1	1	3	2	2	3
29	1	1	1	1	1	1	1	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	3	3	2	3
AV	2	2	2	2	2	2	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
PK	5	4	3	3	4	4	3	3	3	3	3	4	4	4	4	4	4	4	4	5	5	5	5	6		6

(11/05/80-RPI)

WIND SPEED @10M
METERS/SEC

LOGAN WASH
MRI LW01
MAR 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	4	4	3	3	3	2	2	2	1	1	2	2	2	1	1	1	1	2	1	2	2	2	2	2	2	4
2	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	2
3	2	2	3	4	4	3	3	3	4	4	4	4	5	2	2	3	4	3	1	1	1	1	2	2	3	5
4	3	3	3	3	2	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	2	3
5	1	1	1	1	1	1	1	1	2	3	3	3	4	4	3	3	3	3	3	2	3	3	4	2	2	4
6	2	4	4	4	4	3	2	2	1	1	2	3	2	2	2	1	1	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	2	4
7	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	(CM)	3	3	3	3	2	2	1	1	1	1	1	1	2	2	2	3
8	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1	2
9	1	1	1	1	1	1	1	1	1	1	1	1	1	2	4	4	4	2	1	1	2	2	2	2	2	4
10	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
11	2	2	2	2	1	1	1	1	1	1	1	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	2
12	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(CE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
13	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(CE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
14	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(CE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
15	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OF)	(OE)	(OE)	(CE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
16	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
17	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
18	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
19	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	4	4	3	2	2	3	4	6	6	5	( )	6
20	6	6	5	3	7	3	2	1	1	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	3	7
21	2	2	2	2	2	2	2	2	3	4	5	6	6	6	7	7	5	3	2	2	2	2	2	1	3	7
22	2	1	1	1	1	1	1	4	3	3	2	2	3	4	3	2	3	4	4	4	2	2	1	0	2	4
23	1	0	1	0	1	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2
24	1	1	1	1	1	1	1	1	1	1	1	2	3	3	3	4	3	3	3	1	1	1	2	1	2	4
25	1	1	1	1	1	1	1	1	1	1	1	2	2	2	4	3	3	2	2	1	1	1	1	1	1	4
26	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	2	2	2	2	2	2	1	2
27	1	2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	4	4	2	4
28	5	5	5	5	5	5	5	4	4	2	2	3	3	4	3	3	3	3	2	2	2	2	2	2	3	5
29	2	2	2	2	2	2	1	1	1	2	2	2	2	3	3	2	2	1	1	1	2	2	2	2	2	3
30	2	2	2	2	1	1	1	1	1	1	1	3	3	4	4	4	3	3	3	1	1	1	1	0	2	4
31	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	2	2	1	1	1	1	2
AV	2	2	2	2	2	2	1	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	
PK	6	6	5	5	7	5	5	4	4	4	5	6	6	6	7	7	5	4	4	4	4	6	6	5		7

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WIND SPEED @10M
METERS/SEC

LOGAN WASH
MRI LW01
APR 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	2	3	3	4	5	4	2	5
2	5	4	4	5	5	3	2	2	1	1	2	3	3	3	2	2	2	2	1	1	1	1	1	2	2	5
3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2	3	3	2	2	2	2	2	2	2	3
4	2	2	2	2	2	2	1	1	1	1	2	2	2	2	2	1	1	1	1	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	1	1	2	3	3	4	5	5	4	4	3	3	2	2	2	2	1	3	5
6	3	2	1	1	1	1	1	1	1	3	4	5	4	5	6	6	5	3	3	4	2	2	2	2	3	6
7	2	2	2	3	5	4	3	3	5	4	5	4	5	4	3	3	4	4	2	2	2	2	2	2	3	5
8	2	2	2	1	1	1	1	1	1	1	2	2	1	1	1	1	2	2	2	2	2	2	2	1	2	2
9	1	1	1	1	1	1	1	2	2	2	3	9	5	9	4	2	2	2	2	2	2	2	2	2	2	9
10	2	2	2	2	2	2	3	3	3	5	4	3	9	3	3	3	3	3	3	4	4	3	2	2	3	9
11	1	2	4	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	4
12	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
13	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
14	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
15	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	1	1	1	2	2	2	2	4	4	3	2	2	3	3	2	2	2	3	2	4
16	4	4	3	2	1	1	1	3	3	2	3	3	2	2	2	2	2	2	2	3	3	(CM)	(CM)	(CM)	2	4
17	2	2	2	2	2	2	2	1	1	1	1	2	2	2	1	1	2	2	2	3	3	3	2	2	2	3
18	2	2	2	2	2	2	2	1	1	1	1	2	2	3	3	4	4	2	2	3	3	2	2	2	2	4
19	2	2	2	2	2	2	2	2	1	1	1	2	2	3	3	3	4	2	1	1	2	3	2	2	2	4
20	2	2	2	2	2	1	1	1	1	2	2	2	3	5	5	5	3	2	2	2	3	3	3	2	2	5
21	2	2	2	2	2	2	2	2	2	2	2	3	4	3	2	3	5	4	3	2	2	2	2	2	2	5
22	2	2	2	2	1	1	1	2	3	4	4	3	3	3	3	3	3	3	4	5	5	4	4	0	3	5
23	1	4	3	3	3	2	2	2	2	2	3	4	4	4	3	3	2	2	2	1	1	1	1	1	2	5
24	1	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	4	3	3	5	5	3	4
25	3	3	4	3	3	3	2	2	2	2	2	2	3	3	2	2	3	2	1	2	2	2	3	3	2	5
26	3	3	3	3	3	3	2	2	2	2	2	2	3	3	3	2	2	2	1	1	1	1	1	1	2	4
27	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
28	2	2	2	2	2	1	1	1	1	2	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2
29	2	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	2	2	2	2	2	1	1	1	2	4
30	2	2	2	2	2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1	2	2	2
AV	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2	2	2	2	
PK	5	4	4	5	5	4	3	3	5	5	5	9	9	9	6	6	5	4	4	5	5	4	5	5		9

(11/05/80-RPT)

WIND SPEED @10M
METERS/SEC

LOGAN WASH
MRI LW01
MAY 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	2	2	2	2	1	1	1	1	1	1	1	3
2	1	1	1	1	1	1	1	1	1	1	1	2	2	5	4	3	2	1	1	1	2	2	2	2	2	5
3	2	2	2	2	2	2	1	1	1	2	2	2	3	3	2	2	1	1	2	2	2	2	2	2	2	3
4	2	4	2	2	2	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	4
5	1	1	1	1	1	1	1	2	2	2	3	2	2	2	2	2	1	1	1	2	2	2	2	2	2	3
6	2	2	1	1	1	1	1	1	2	2	2	2	6	7	2	3	2	2	2	2	2	1	1	2	2	7
7	2	2	1	1	1	0	1	1	1	1	1	3	2	2	1	1	1	2	1	2	2	2	1	1	1	3
8	1	1	1	1	(CM)	(CM)	(CM)	(CM)	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	2	2
9	1	1	1	1	1	2	2	2	2	3	4	5	3	3	3	3	3	3	3	2	2	2	2	1	2	5
10	1	1	1	1	2	2	3	4	4	4	6	8	8	8	7	5	1	6	3	3	2	3	2	2	4	8
11	3	3	3	1	1	1	2	2	2	3	3	3	3	3	3	3	3	4	2	2	2	3	2	2	2	4
12	2	2	2	2	1	2	2	2	1	1	2	3	3	2	1	1	1	1	1	1	1	1	1	1	2	3
13	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1	2
14	1	1	1	1	1	1	1	1	1	2	2	2	3	2	2	2	3	3	3	4	2	2	2	1	2	4
15	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	2	2
16	1	1	1	1	1	1	1	1	1	1	2	2	3	3	4	4	3	3	2	2	2	2	3	3	2	4
17	2	2	1	1	(CM)	(CM)	(CM)	1	1	1	1	1	1	1	1	1	2	1	2	2	2	2	2	1	1	2
18	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	3
19	2	2	2	2	1	1	1	2	2	2	3	3	4	3	3	3	2	2	2	2	2	2	2	1	2	4
20	1	1	1	1	2	2	2	2	1	3	3	1	1	1	2	2	2	2	1	2	2	2	2	2	2	3
21	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	2	2	2	2	2	2	3	2	2	3
22	2	2	2	2	1	1	1	2	2	2	3	3	3	4	1	3	3	3	3	3	4	3	2	1	2	4
23	5	4	3	4	5	3	3	5	5	5	5	5	5	4	5	6	6	4	1	8	6	7	4	4	5	8
24	4	3	3	3	3	4	4	3	7	10	9	7	7	8	7	6	5	3	3	2	1	1	1	1	4	10
25	1	1	1	1	1	2	3	3	5	5	6	4	4	6	6	5	5	5	3	1	1	1	1	1	3	6
26	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4	3	2	2	2	2	3	3	2	4
27	3	3	2	2	2	2	2	2	2	3	4	5	6	6	6	5	5	1	4	2	3	4	2	2	3	6
28	2	3	2	2	2	2	2	4	5	5	5	5	5	7	6	1	5	3	2	2	1	1	1	1	3	7
29	2	2	2	3	1	1	1	2	2	5	6	5	4	4	3	3	4	4	3	2	2	2	2	2	3	6
30	2	2	2	2	2	2	2	2	2	2	3	3	4	5	5	1	6	5	4	1	2	2	2	2	3	6
31	3	3	2	2	2	2	3	3	5	6	5	5	5	5	9	4	4	4	3	1	1	2	2	2	3	9
AV	2	2	2	2	2	2	2	2	2	3	3	3	3	4	3	3	3	3	2	2	2	2	2	2	2	
PK	5	4	3	4	5	4	4	5	7	10	9	8	8	8	9	6	6	6	4	8	6	7	4	4		10

WIND SPEED @10M
METERS/SEC

LOGAN WASH
MRI LW01
JUNE 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	2	2	2	2	2	1	1	2	2	2	3	4	8	4	4	5	6	2	3	2	2	2	2	2	3	8
2	2	2	2	2	2	1	2	2	3	4	5	1	5	5	6	6	6	5	3	3	3	3	3	3	3	6
3	4	5	2	6	4	2	2	4	5	6	3	7	2	7	2	6	6	5	2	2	1	1	3	3	4	7
4	3	3	3	2	2	2	3	3	5	5	5	7	2	7	7	7	6	5	4	1	2	2	2	2	4	7
5	2	2	2	2	2	2	2	2	3	4	5	6	6	7	6	6	1	5	4	2	2	2	2	2	3	7
6	1	1	1	1	1	2	2	4	5	6	5	6	2	5	6	2	7	2	5	2	2	2	3	4	3	7
7	5	4	2	2	2	1	2	1	2	2	3	3	3	3	3	4	4	3	2	2	2	2	2	3	3	5
8	2	2	2	1	1	1	1	1	1	2	2	2	2	2	2	2	3	2	2	2	2	2	2	1	2	3
9	2	2	2	2	2	1	1	1	2	2	2	3	3	3	3	3	3	2	2	3	3	3	2	2	2	3
10	2	2	2	2	2	1	1	1	2	2	2	3	3	3	4	4	5	4	2	2	2	2	2	2	2	5
11	2	2	2	2	2	2	2	2	2	3	3	5	7	7	6	6	1	5	4	1	1	1	2	2	3	7
12	2	1	1	1	2	2	2	2	4	4	5	5	6	5	6	5	5	5	4	2	2	2	2	2	3	6
13	2	2	2	2	2	2	3	2	2	2	4	5	5	5	6	6	6	5	4	3	2	2	2	2	3	6
14	2	2	2	2	2	2	2	3	3	4	5	6	6	7	6	6	6	5	5	4	2	1	2	3	4	7
15	4	9	4	3	2	2	1	1	1	2	2	2	2	3	4	5	4	3	2	2	2	3	2	2	3	9
16	3	3	5	4	3	2	2	1	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	5
17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	3	3	3	2	3
18	3	2	2	2	2	2	1	1	1	2	2	2	2	2	4	5	4	4	2	2	2	2	2	2	2	5
19	2	2	2	2	2	2	2	1	1	1	2	2	3	3	3	4	4	4	3	2	2	2	2	2	2	4
20	2	2	2	2	2	2	2	1	1	1	2	2	3	3	4	4	9	4	9	3	1	2	2	2	3	9
21	3	3	3	2	2	2	2	2	1	1	3	4	5	6	5	5	5	9	4	2	1	2	2	3	3	9
22	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4	4	4	4	2	2	2	2	2	2	2	4
23	2	2	2	2	2	2	2	2	2	4	6	8	3	7	2	7	2	6	5	4	2	2	2	2	3	8
24	2	2	2	2	2	2	2	2	2	3	4	5	0	5	6	5	5	5	4	1	2	2	2	2	3	6
25	3	3	3	2	2	2	1	1	1	3	3	4	4	5	5	0	5	4	3	2	2	2	2	2	3	5
26	3	3	2	2	1	1	1	2	2	2	3	4	6	8	6	7	7	6	5	3	2	1	1	1	3	8
27	1	1	2	3	2	2	2	3	1	2	2	2	3	5	5	4	4	4	4	3	2	2	2	2	3	5
28	2	3	4	3	2	2	2	2	1	1	2	2	2	2	2	3	3	2	2	2	2	3	3	3	2	4
29	2	2	2	2	2	2	2	1	1	1	2	2	2	2	3	4	4	3	2	2	2	3	2	2	2	4
30	2	1	2	1	2	1	2	1	2	2	2	2	2	2	2	3	4	3	2	2	3	3	3	1	2	4
AV	2	3	2	2	2	2	2	2	2	2	3	4	4	4	4	4	4	4	3	2	2	2	2	2	3	
PK	5	9	5	6	4	2	3	4	5	6	6	8	8	8	7	7	9	9	9	4	3	3	3	4		9

(11/05/80-RPI)

WIND SPEED @10M
METERS/SEC

LOGAN WASH
MRI LW01
JULY 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	3	4	4	4	4	3	1	1	1	2	2	2	2	3	2	3	4	3	2	1	1	1	1	1	2	4
2	1	1	1	1	1	1	1	1	1	2	1	2	2	2	4	4	4	3	2	1	1	1	2	3	2	4
3	2	1	1	1	1	1	1	1	1	1	2	3	3	3	4	3	4	3	3	2	1	1	1	2	2	4
4	2	2	2	2	2	2	2	2	1	1	2	2	3	1	5	5	9	4	3	2	2	2	3	3	3	9
5	3	3	2	2	2	2	2	1	1	1	2	2	3	4	6	5	5	4	4	3	1	2	2	2	3	6
6	2	2	2	2	2	1	2	2	1	1	1	1	2	3	3	3	3	3	1	1	2	2	2	2	2	3
7	2	2	1	2	2	2	1	2	1	1	1	2	3	3	5	5	2	2	1	3	2	1	1	2	2	5
8	2	1	1	1	2	2	2	1	2	1	2	2	3	4	4	4	5	4	3	3	1	2	2	2	2	5
9	2	2	2	2	2	2	1	1	1	1	1	1	2	2	2	3	3	2	2	1	1	2	2	2	2	3
10	2	2	2	3	2	2	2	2	2	1	1	1	1	3	4	4	3	3	3	2	1	1	2	2	2	4
11	1	2	2	2	2	2	1	1	1	1	2	2	2	2	3	2	2	1	2	1	2	4	4	3	2	4
12	3	2	2	2	3	3	3	1	1	2	3	3	5	1	4	3	3	2	5	3	2	2	1	2	3	5
13	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	3	3	5	3	1	2	3	1	1	2	5
14	1	1	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	3
15	2	2	2	2	2	2	2	2	1	2	2	3	3	3	2	2	2	2	2	2	3	3	2	2	2	3
16	3	3	1	1	1	2	2	2	1	1	2	2	2	3	3	2	2	2	2	3	3	3	3	2	2	3
17	2	2	2	2	2	2	2	2	0	2	1	3	3	4	5	4	4	4	2	2	2	2	3	4	2	5
18	4	4	4	4	3	2	3	2	1	2	3	2	5	9	4	4	4	2	3	1	2	2	2	2	3	9
19	2	2	2	2	2	2	2	2	3	4	5	0	5	5	5	5	5	4	2	2	2	1	2	2	3	5
20	3	4	3	2	2	2	2	2	2	2	2	2	2	3	2	2	2	1	1	2	2	2	2	2	2	4
21	3	4	4	3	2	2	2	2	1	1	2	2	2	2	2	2	2	2	1	2	2	3	2	2	2	4
22	2	2	2	2	2	2	2	2	1	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	3
23	2	2	1	2	2	2	2	2	2	2	2	2	2	2	3	3	2	4	3	2	2	2	2	2	2	4
24	2	2	2	2	2	2	1	1	1	2	2	2	2	2	3	1	3	4	4	3	3	2	2	2	2	4
25	1	2	2	2	2	2	2	1	1	2	3	3	3	4	2	1	2	2	1	2	2	2	2	2	2	5
26	2	2	2	2	2	2	2	1	1	1	1	2	2	3	5	2	0	2	1	2	2	2	2	2	2	3
27	2	2	2	2	2	3	2	1	1	3	2	2	3	3	2	3	2	2	2	2	2	3	3	2	2	3
28	2	2	2	2	2	2	2	1	1	2	2	2	3	3	3	4	2	2	3	3	3	3	2	2	2	4
29	2	2	2	2	2	2	1	1	1	1	3	3	3	2	3	4	4	4	4	4	4	4	3	3	3	4
30	2	2	1	1	1	1	0	1	1	2	2	2	3	2	4	2	2	3	2	2	1	2	2	2	2	3
31	2	2	2	2	2	2	1	1	1	2	2	3	3	3	3	3	1	1	1	1	2	2	2	5	2	5
AV	2	2	2	2	2	2	2	1	1	2	2	2	3	3	3	3	3	3	2	2	2	2	2	2	2	
PK	4	4	4	4	4	3	3	2	3	4	5	3	5	9	6	5	9	5	5	4	4	4	4	5		9

TEMPERATURE @10M
DEGREE C

LOGAN WASH
MRI LW01
FEB 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	-11	-11	-11	-11	-10	-12	-13	-13	-12	-11	-9	1	6	3	-2	2	1	0	-7	-8	-7	-8	-9	-9	-7	6
2	-9	-9	-9	-9	-9	-10	-10	-11	-10	-9	-5	-1	3	2	2	3	0	-1	-3	-5	-5	-5	-5	-5	-5	3
3	-5	-6	-6	-6	-5	-4	-7	-7	-6	-4	-1	0	2	2	5	3	4	1	-2	-2	-2	-2	-3	-2	-2	5
4	-2	-2	-2	-2	-3	-3	-3	-3	-3	-1	1	6	3	4	5	3	1	0	-3	-4	-5	-6	-6	-7	-1	6
5	-7	-8	-8	-8	-8	-8	-9	-9	-9	-8	-6	-1	3	3	3	5	5	5	-4	-5	-5	-5	-5	-5	-4	5
6	-4	-5	-6	-5	-6	-6	-6	-6	-5	-2	1	1	6	4	4	3	2	1	-1	-2	-2	-3	-4	-6	-2	6
7	-6	-4	-5	-6	-5	-6	-6	-6	-6	-5	-4	-4	-5	-3	-3	-4	-4	-5	-6	-7	-8	-8	-9	-9	-6	-3
8	-9	-9	-10	-12	-14	-12	-16	-16	-16	-16	-14	-6	-7	-4	-6	-2	-7	-7	-10	-11	-12	-13	-14	-14	-11	-2
9	-14	-15	-15	-16	-17	-16	-15	-18	-17	-16	-14	-6	-6	-4	-3	-2	-2	-2	-8	-10	-11	-12	-12	-13	-11	-2
10	-13	-13	-13	-13	-13	-14	-14	-15	-14	-13	-11	-1	-2	-2	-2	0	1	1	-8	-8	-8	-9	-9	-11	-9	1
11	-12	-12	-12	-13	-13	-13	-13	-14	-14	-13	-10	-2	-2	4	0	-1	2	2	-6	-8	-8	-8	-8	-9	-8	4
12	-9	-10	-11	-11	-11	-12	-12	-12	-11	-9	-6	-3	-1	0	-1	0	1	-2	-5	-5	-6	-6	-6	-7	-6	1
13	-6	-6	-7	-7	-7	-6	-4	-4	-2	0	1	1	1	2	2	2	2	0	-2	-1	-1	-2	-1	-1	-2	2
14	-3	-3	-4	-4	-4	-4	-3	-3	-3	-4	-2	-2	-2	-1	-1	-2	-2	-2	-3	-4	-2	-2	-2	-3	-3	-1
15	-2	-2	-2	-3	-3	-3	-4	-3	-3	-2	-1	0	-1	-1	0	2	1	-1	-2	-2	-3	-3	-4	-4	-2	2
16	-3	-4	-4	-4	-5	-5	-6	-6	-4	-2	2	0	1	3	4	1	2	-2	-3	-3	-3	-3	-3	-3	-2	4
17	-4	-3	-3	-2	-2	-2	-2	-3	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-1	-1	-1	-2	-1
18	-1	-1	-1	-2	-2	-2	-3	-3	-2	-2	-1	-1	0	1	1	1	0	-2	-3	-3	-3	-4	-4	-4	-2	1
19	-4	-3	-3	-3	-4	-3	-4	-3	-3	-2	4	2	1	1	2	1	1	1	1	1	0	0	1	-3	-1	4
20	-1	-3	-3	-4	-3	-4	-4	-5	-4	-4	-4	-4	-4	-3	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-1
21	-4	-4	-4	-4	-4	-4	-4	-4	-5	-4	-4	-3	-3	-3	-1	-2	-4	-4	-3	-4	-3	-3	-4	-4	-4	-1
22	-4	-5	-5	-5	-6	-5	-5	-6	-5	-4	-3	-2	1	2	3	-1	-3	-3	-4	-6	-6	-6	-5	-5	-4	3
23	-6	-6	-6	-6	-6	-7	-7	-7	-6	-4	-3	-1	0	-4	2	1	-2	-4	-5	-6	-6	-6	-7	-8	-4	2
24	-8	-9	-9	-10	-12	-11	-12	-11	-12	-10	2	6	7	2	-2	3	5	-1	-7	-8	-8	-8	-8	-10	-5	7
25	-10	-11	-12	-12	-12	-13	-13	-13	-12	-12	-1	4	5	6	5	3	3	6	-4	-6	-7	-7	-8	-8	-5	6
26	-8	-8	-9	-8	-9	-9	-10	-10	-10	-7	3	3	8	7	11	11	9	5	-2	-3	-3	-4	-4	-4	-2	11
27	-4	-5	-5	-6	-6	-6	-7	-7	-6	-4	4	8	11	9	13	9	12	7	1	0	-1	-1	-2	-2	1	13
28	-3	-3	-4	-3	-4	-4	-6	-6	-4	-2	7	7	13	11	8	8	9	8	2	1	2	1	1	-1	2	13
29	-2	-3	-4	-4	-4	-4	-4	-4	-2	-1	-2	-3	1	2	3	0	-2	-3	-4	-4	-4	-4	-4	-4	-3	3
AV	-6	-6	-7	-7	-7	-7	-8	-8	-7	-6	-3	0	1	1	2	1	1	0	-4	-4	-5	-5	-5	-6	-4	
PK	-1	-1	-1	-2	-2	-2	-2	-3	-2	0	7	8	13	11	13	11	12	8	2	1	2	1	1	-1		13
MN	-14	-15	-15	-16	-17	-16	-16	-18	-17	-16	-14	-6	-7	-4	-6	-4	-7	-7	-10	-11	-12	-13	-14	-14		

MONTHLY MINIMUM = -18

(11/05/80-RPI)

(11/05/80-RPI)

TEMPERATURE @10M
DEGREE C

LOGAN WASH
MRI LW01
MAR 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	-5	-5	-6	-6	-7	-7	-7	-8	-9	-7	2	-1	1	3	7	5	6	7	-2	-4	-4	-3	-4	-6	-2	7
2	-7	-7	-7	-7	-7	-7	-7	-7	-6	-2	1	-1	-3	3	5	4	2	1	1	-1	-1	-2	-1	-1	-2	5
3	-1	1	2	2	2	2	2	2	3	3	4	4	2	-3	-3	-2	-1	-1	-2	-2	-2	-3	-3	-4	0	4
4	-3	-4	-4	-5	-5	-5	-5	-5	-3	-3	-2	-2	-3	-1	2	-2	0	-2	-3	-4	-4	-4	-5	-4	-3	2
5	-6	-6	-7	-6	-6	-6	-6	-5	-2	-2	-1	0	1	0	1	1	1	1	-1	-1	-2	-2	-2	-4	-2	1
6	-2	-2	-1	-1	-2	-2	-4	-4	-4	-4	-4	-3	-4	-4	-4	-3	-3	-3	-4	-4	-4	-4	-4	-5	-3	-1
7	-4	-4	-4	-4	-6	-6	-6	-6	-4	-5	-4	-4	-4	-4	-4	-4	-3	-4	-5	-6	-6	-6	-6	-6	-5	-3
8	-6	-6	-7	-7	-8	-7	-8	-8	-6	-3	-3	0	-1	-1	4	1	-1	-1	-3	-4	-6	-6	-6	-6	-4	4
9	-6	-7	-8	-8	-8	-8	-9	-9	-6	-3	-3	2	1	-1	0	0	-2	1	-3	-6	-6	-6	-6	-7	-5	2
10	-7	-8	-7	-8	-8	-8	-8	-8	-7	-2	4	9	1	8	8	7	6	7	1	-4	-4	-4	-4	-6	-2	9
11	-6	-6	-7	-7	-8	-7	-7	-7	-4	-2	0	-1	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	0
12	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
13	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
14	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
15	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OF)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
16	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
17	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
18	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	( )	( )
19	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	5	6	5	6	4	2	1	-2	-3	-4	( )	6
20	-4	-4	-5	-6	-6	-6	-7	-8	-7	-1	3	7	6	4	6	6	6	7	4	-1	-2	-2	-1	-1	-1	7
21	-1	-1	-1	1	0	2	1	1	2	3	4	6	7	8	7	6	5	5	4	3	3	1	-1	-2	3	8
22	-4	-4	-3	-4	-4	-5	-5	-4	-5	1	1	1	4	2	0	2	-2	-2	-3	-3	-3	-3	-5	-5	-2	4
23	-6	-6	-6	-6	-6	-7	-7	-7	-5	-4	-2	1	-1	2	1	1	1	0	-1	-3	-5	-5	-5	-5	-3	2
24	-6	-6	-4	-5	-4	-7	-6	-7	-5	3	2	3	6	2	2	3	2	1	1	-1	-3	-4	-3	-4	-2	6
25	-4	-4	-4	-5	-5	-6	-6	-5	-4	-3	-3	-1	-3	-2	-3	-5	-5	-6	-6	-6	-6	-6	-6	-6	-5	-1
26	-6	-6	-6	-6	-7	-7	-7	-7	-6	-5	-3	-3	-1	-3	2	2	1	2	0	-7	-7	-7	-7	-8	-4	2
27	-7	-8	-9	-9	-10	-10	-11	-10	-7	-2	-2	3	3	3	3	8	2	[illegible]	2	-3	-3	-4	-5	-6	-3	8
28	-6	-5	-6	-6	-7	-7	-7	-7	-6	-3	-2	-1	1	0	-1	-2	-3	-3	-4	-5	-5	-6	-6	-7	-4	1
29	-7	-7	-7	-7	-7	-8	-8	-6	-4	-4	-2	0	2	3	3	0	2	4	5	-4	-5	-5	-6	-7	-3	5
30	-7	-7	-7	-8	-8	-8	-8	-6	-3	-3	0	3	2	0	1	1	-1	-4	-8	-9	-9	-10	-11	-12	-5	3
31	-12	-12	-12	-12	-13	-13	-13	-12	-10	-6	-8	-7	-6	0	-4	-2	-1	-7	-7	-9	-11	-11	-11	-11	-9	0
AV	-5	-5	-5	-6	-6	-6	-6	-6	-5	-2	-1	1	( )	( )	2	1	1	0	-1	-4	-4	-5	-5	-5	( )	
PK	-1	1	2	2	2	2	2	2	3	3	4	9	7	8	8	8	6	7	5	3	3	1	-1	-1		9
MN	-12	-12	-12	-12	-13	-13	-13	-12	-10	-7	-8	-7	-6	-4	-4	-5	-5	-7	-8	-9	-11	-11	-11	-12		

MONTHLY MINIMUM = -13

TEMPERATURE @10M
DEGREE C

LOGAN WASH
MRI LW01
APR 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	-11	-11	-11	-11	-11	-11	-11	-10	-7	-4	-3	-1	-2	2	4	0	3	3	-2	-4	-4	-3	-4	-3	-5	4
2	-4	-5	-5	-6	-6	-6	-6	-7	-3	-3	-2	-2	-3	-3	-3	-3	-3	-4	-4	-4	-4	-4	-5	-5	-4	-2
3	-6	-6	-6	-6	-7	-7	-7	-7	-6	-2	2	0	2	1	1	-1	1	2	3	-3	-4	-4	-3	-3	-3	3
4	-4	-4	-5	-5	-6	-6	-6	-5	-2	6	8	4	7	7	8	11	8	13	8	2	1	1	1	1	2	13
5	1	1	1	1	-1	-1	0	2	4	6	6	6	7	7	8	8	8	8	6	5	4	3	3	1	4	8
6	1	-1	0	-2	-3	-2	-4	-2	2	1	3	3	1	4	6	7	7	5	5	4	3	3	1	2	2	7
7	-1	-1	-1	0	-3	-4	-5	-5	-4	-4	-4	-1	-2	-1	-1	-1	-2	-1	-3	-5	-4	-6	-6	-6	-3	0
8	-8	-8	-8	-9	-9	-9	-11	-10	-6	0	-1	3	2	-5	-4	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	3
9	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
10	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
11	-1	-2	-1	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	-1
12	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
13	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	13	11	(RF)	( )	13
14	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
15	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
16	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	9	(RF)	(RF)	( )	9
17	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
18	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
19	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	18	19	19	19	19	20	23	(RF)	11	9	10	9	( )	23
20	8	8	6	6	5	6	4	6	9	13	15	19	19	21	19	19	19	21	26	12	11	11	11	10	13	26
21	9	9	8	8	10	8	8	12	14	14	16	19	18	19	14	19	19	13	9	7	5	4	6	7	12	19
22	8	6	5	5	5	4	4	5	10	12	13	15	14	13	13	14	16	14	13	10	9	8	8	8	10	16
23	9	9	9	6	7	4	3	3	7	8	12	11	7	8	11	7	7	7	6	3	-1	-1	-1	-1	6	12
24	-1	0	2	2	1	2	2	2	3	4	6	7	7	9	9	9	7	7	7	6	6	6	5	5	5	9
25	4	3	4	3	2	3	-1	2	4	7	9	11	13	12	15	14	14	15	19	8	6	6	6	6	8	19
26	5	4	3	2	2	2	2	2	3	6	7	9	12	12	12	13	13	19	19	7	6	5	4	3	7	19
27	4	2	2	1	1	0	0	2	6	10	11	12	14	15	14	14	15	18	18	9	8	8	7	7	8	18
28	5	4	5	4	4	3	3	4	8	11	13	15	16	16	18	17	18	19	19	13	10	9	9	9	10	19
29	8	9	8	8	7	7	8	11	13	14	15	15	17	13	14	15	11	6	5	3	2	2	2	2	9	17
30	2	2	2	2	1	1	1	2	2	3	4	6	8	8	11	10	8	7	4	3	3	2	2	2	4	11
AV	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
PK	9	9	9	8	10	8	8	12	14	14	16	19	19	21	19	19	19	21	26	13	11	13	11	10		26
MN	-11	-11	-11	-11	-11	-11	-11	-10	-7	-4	-4	-2	-3	-5	-4	-3	-3	-4	-4	-5	-4	-6	-6	-6		

MONTHLY MINIMUM = -11

(11/05/80-RPT)

TEMPERATURE @10M
DEGREE C

LOGAN WASH
MRI LW01
MAY 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	2	2	2	1	1	0	0	1	2	5	7	6	7	6	7	9	9	8	7	5	4	3	2	1	4	9
2	1	2	1	2	2	1	2	2	5	4	5	8	9	7	9	10	9	13	12	6	6	4	3	3	5	13
3	2	3	2	2	1	1	1	1	7	9	11	11	10	9	9	13	13	13	11	8	6	7	6	6	7	13
4	6	7	7	5	4	3	4	6	8	9	11	13	10	8	13	11	10	9	8	7	6	5	6	6	8	13
5	5	6	6	3	4	4	6	5	8	11	12	13	16	12	11	12	15	13	12	9	8	8	7	7	9	16
6	7	6	6	5	6	5	5	7	9	11	11	12	13	12	13	13	14	10	9	6	6	6	6	6	8	14
7	4	4	4	3	4	4	4	4	5	5	9	7	4	5	7	8	9	7	7	5	4	4	4	3	5	9
8	3	2	2	2	2	3	2	3	3	4	6	7	8	7	7	11	13	13	9	8	4	4	4	3	5	13
9	2	3	3	3	2	2	1	4	6	7	8	8	6	6	6	7	6	7	6	6	7	6	5	4	5	8
10	3	3	2	3	3	3	4	4	5	6	6	8	7	9	9	9	9	8	8	6	6	6	3	4	6	9
11	5	6	4	2	2	2	2	-1	0	3	2	5	3	5	4	3	3	2	-2	-3	-3	-3	-2	-3	1	6
12	-3	-3	-4	-4	-4	-4	-4	-4	-4	-3	-3	-3	-4	-3	-3	-3	-2	-1	-2	-2	-2	-3	-3	-3	-3	-1
13	-3	-3	-3	-3	-3	-3	-3	-3	0	2	6	6	6	7	8	9	9	8	11	5	3	3	2	2	3	11
14	2	1	1	2	1	1	1	2	5	6	8	9	9	8	9	11	9	6	4	4	3	3	3	1	4	11
15	0	-1	-1	-1	-1	-1	1	2	6	6	6	8	10	11	12	11	9	8	6	8	4	5	3	2	5	12
16	2	2	1	3	1	0	2	3	4	4	7	8	12	10	11	12	11	11	11	10	6	4	4	2	6	12
17	-2	-2	-3	-3	-3	-3	-3	-3	1	5	1	3	3	4	5	4	5	4	3	3	2	1	1	0	1	5
18	0	-1	0	1	-1	-1	-2	1	5	7	9	11	12	14	12	13	16	14	17	9	7	7	6	6	7	17
19	5	5	4	4	4	3	3	4	10	11	12	13	13	15	16	16	17	15	17	12	9	9	9	8	10	17
20	9	8	7	7	7	5	5	7	12	13	14	14	16	19	20	19	19	21	19	14	12	13	12	10	13	21
21	11	9	8	9	7	9	8	10	14	16	18	19	21	22	24	24	24	24	26	18	16	15	14	14	16	26
22	13	12	11	11	11	9	9	12	18	18	21	22	21	22	22	23	24	18	21	18	16	16	14	13	16	24
23	14	14	12	10	8	7	7	7	8	10	12	12	14	16	16	16	17	16	16	14	14	13	13	12	12	17
24	11	11	9	8	8	7	8	9	12	13	12	13	14	13	11	7	3	1	1	-7	-1	-1	0	-1	7	14
25	-1	-2	-2	-2	-3	-2	-1	-1	2	2	2	3	5	6	7	6	6	7	4	3	1	-1	1	0	2	7
26	1	-1	-2	-3	-3	-3	-2	1	7	7	9	9	10	10	13	14	15	17	15	10	8	7	7	9	7	17
27	12	11	9	10	6	5	6	7	13	14	14	15	17	17	17	15	17	18	18	14	12	11	10	9	12	18
28	7	7	5	4	6	5	5	8	10	11	12	14	16	16	17	17	18	18	15	15	12	10	10	11	11	18
29	9	8	7	7	6	5	4	4	6	7	7	9	11	10	13	12	13	14	15	10	8	6	4	5	8	15
30	6	5	4	3	2	2	2	4	10	12	13	14	16	17	18	18	19	19	18	14	12	13	9	10	11	19
31	12	12	10	7	8	8	8	9	10	11	11	13	13	14	15	16	16	18	17	13	9	8	6	6	11	18
AV	5	4	4	3	3	2	3	4	7	8	9	10	11	11	12	12	12	12	11	8	7	6	5	5	7	
PK	14	14	12	11	11	9	9	12	18	18	21	22	21	22	24	24	24	24	26	18	16	16	14	14		26
MN	-3	-3	-4	-4	-4	-4	-4	-4	-4	-3	-3	-3	-4	-3	-3	-3	-2	-1	-2	-7	-3	-3	-3	-3		

MONTHLY MINIMUM = -7

TEMPERATURE @10M
DEGREE C

LOGAN WASH
MRI LW01
JUNE 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	6	6	6	7	5	5	4	6	12	14	13	15	17	16	16	14	13	9	9	9	8	7	5	4	9	17
2	4	3	3	3	3	3	3	7	9	11	12	14	14	16	17	17	17	19	19	16	15	14	15	14	11	19
3	14	14	14	13	13	12	10	13	14	16	16	18	18	19	20	21	22	21	21	17	15	14	16	16	16	22
4	16	14	13	13	11	11	11	13	14	14	17	17	19	20	21	21	22	22	23	17	13	11	11	10	16	23
5	9	9	10	7	7	8	7	13	15	16	17	19	20	20	21	21	22	22	22	18	14	12	12	14	15	22
6	14	11	11	9	8	8	11	13	14	16	17	18	19	20	21	21	22	22	21	17	15	13	13	11	15	22
7	11	10	10	9	6	6	4	8	15	15	17	18	19	21	21	21	22	23	22	17	14	13	12	12	14	23
8	12	12	10	9	10	9	11	12	17	18	21	23	26	27	26	27	25	27	24	20	17	19	17	14	18	27
9	12	11	11	13	13	13	13	14	17	19	19	24	24	26	26	26	27	30	33	19	17	17	17	16	19	33
10	16	14	12	16	14	12	12	15	18	21	23	24	26	26	27	26	27	28	29	23	21	18	17	16	20	29
11	14	15	14	14	12	12	9	12	18	20	21	22	24	24	24	24	25	26	27	22	18	15	15	15	18	27
12	14	14	13	12	11	11	9	12	18	18	19	22	22	23	24	25	24	26	26	22	18	15	14	13	18	26
13	12	12	12	11	10	9	8	10	17	18	19	19	22	23	24	24	24	26	26	23	21	18	14	14	17	26
14	14	13	14	14	13	11	10	9	16	17	18	19	21	21	21	22	22	23	23	23	19	14	13	12	17	23
15	13	11	11	11	9	7	4	4	7	11	14	16	17	18	18	19	19	19	27	23	13	11	13	13	14	27
16	11	11	9	8	8	7	4	3	8	13	14	16	19	19	22	21	23	23	22	24	16	14	13	14	14	24
17	14	12	11	10	10	9	9	8	13	17	19	21	23	24	24	27	24	26	27	27	19	17	17	17	18	27
18	16	16	13	12	12	11	10	9	14	19	23	23	24	26	27	27	26	28	29	29	23	21	17	17	20	29
19	17	15	15	15	14	13	13	12	15	21	23	23	24	26	25	26	26	27	30	28	18	18	17	16	20	30
20	18	17	15	14	12	12	12	11	14	19	20	23	24	26	26	26	26	26	28	26	22	17	15	16	19	28
21	14	14	13	13	12	13	12	14	18	19	21	23	23	24	24	24	24	25	26	26	21	19	15	16	19	26
22	15	14	14	14	12	11	11	9	15	20	24	24	23	26	26	26	26	27	28	28	21	18	22	18	20	28
23	15	18	16	14	15	17	14	13	19	21	21	23	24	26	27	27	26	28	28	29	23	19	17	16	21	29
24	16	16	15	13	13	12	12	11	16	19	21	22	24	25	27	27	28	28	29	29	23	19	19	16	20	29
25	15	15	16	15	16	13	12	12	17	24	22	23	26	27	29	29	29	30	32	32	23	20	19	19	22	32
26	18	19	18	19	18	16	16	14	19	24	25	26	28	27	29	29	29	30	30	31	25	22	21	21	23	31
27	21	21	19	21	19	16	14	17	18	21	25	26	24	25	25	25	26	27	28	27	23	17	16	16	22	28
28	14	15	16	15	14	11	11	10	12	18	21	22	23	25	26	26	28	29	32	37	21	19	19	18	20	37
29	18	17	16	14	13	12	12	13	18	21	24	26	27	30	30	29	29	31	31	32	24	24	22	22	22	32
30	22	21	20	18	18	18	18	18	18	22	23	26	26	27	30	29	29	29	23	28	19	20	18	17	22	30
AV	14	14	13	13	12	11	10	11	15	18	20	21	22	23	24	24	24	25	26	24	19	17	16	15	18	
PK	22	21	20	21	19	18	18	18	19	24	25	26	28	30	30	29	29	31	33	37	25	24	22	22		37
MN	4	3	3	3	3	3	3	3	7	11	12	14	14	16	16	14	13	9	9	9	8	7	5	4		

MONTHLY MINIMUM = 3

(11/05/80-PPI)

(11/05/80-RPI)

TEMPERATURE @10M
DEGREE C

LOGAN WASH
MRI LW01
JULY 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	16	16	14	14	13	13	14	13	14	18	18	21	23	24	24	25	25	18	14	13	14	13	13	13	17	25
2	12	12	11	9	9	9	9	11	11	14	15	16	17	18	19	20	21	22	21	24	16	16	16	14	15	24
3	14	14	12	11	9	9	8	9	12	18	20	21	22	23	24	23	26	26	23	29	22	21	20	18	18	29
4	15	15	14	14	13	13	11	11	14	20	21	22	24	24	26	27	27	27	29	30	24	18	17	18	20	30
5	18	17	17	16	13	12	12	12	11	19	22	23	24	26	27	28	28	28	31	32	27	21	18	17	21	32
6	17	16	18	17	17	16	14	12	12	18	24	25	29	28	29	30	30	28	28	26	24	22	22	22	22	30
7	19	19	19	17	18	17	17	16	19	20	22	24	24	24	25	23	22	22	24	21	14	14	14	14	20	25
8	12	12	11	10	10	9	9	8	8	11	17	17	17	19	21	22	22	23	24	25	27	21	18	17	16	27
9	15	14	14	13	13	13	12	12	13	14	19	20	22	24	27	28	29	26	29	31	31	23	20	19	20	31
10	19	18	18	18	17	16	14	14	14	17	20	23	26	29	28	27	26	25	24	23	22	19	19	20	21	29
11	20	17	16	16	16	15	17	18	22	23	26	28	28	29	31	31	31	35	36	23	21	23	21	21	23	36
12	19	19	16	18	14	14	18	19	19	26	26	26	26	27	27	27	30	26	21	18	18	18	19	16	21	30
13	13	13	13	14	15	14	15	16	18	17	17	17	21	23	23	24	22	18	13	13	10	11	12	9	16	24
14	9	8	8	8	8	8	8	12	15	17	18	19	20	22	23	23	24	26	27	19	16	15	14	15	16	27
15	13	13	12	12	12	12	12	15	19	21	22	23	25	26	26	27	29	30	37	20	19	17	17	17	20	37
16	17	19	19	15	13	12	12	15	20	22	25	27	28	29	29	29	31	33	32	22	21	20	20	19	22	33
17	19	18	17	14	14	14	13	16	22	26	27	28	29	31	30	30	31	33	33	24	24	21	19	23	23	33
18	22	22	22	19	19	19	19	21	23	27	27	28	29	31	30	30	31	32	34	23	21	22	22	22	25	34
19	20	19	19	21	21	21	20	20	22	23	25	26	27	28	28	29	29	31	31	24	21	21	23	21	24	31
20	21	21	20	17	16	16	14	17	22	24	24	27	29	28	26	31	31	38	31	23	21	22	22	20	23	38
21	22	22	21	20	17	17	15	17	23	23	28	28	31	31	31	31	36	37	43	26	24	23	23	21	25	43
22	19	19	17	17	17	15	14	18	24	24	25	27	29	30	31	32	31	33	34	26	21	23	21	19	24	34
23	18	18	17	16	16	15	15	17	24	25	27	29	29	28	24	25	28	25	22	22	19	17	17	17	21	29
24	17	17	16	14	13	13	13	16	22	24	25	27	28	26	29	28	24	23	25	21	19	19	16	15	20	29
25	13	15	13	13	12	11	11	14	18	22	23	22	25	27	27	24	24	27	29	20	18	18	17	16	19	29
26	16	15	16	13	14	12	12	14	18	23	25	29	30	29	31	31	28	26	24	23	19	19	22	18	21	31
27	16	16	14	13	14	13	13	15	22	26	24	26	30	29	29	31	31	37	35	23	21	21	19	21	22	37
28	20	17	17	15	15	15	14	15	22	23	27	29	31	30	31	32	31	34	33	24	22	22	22	21	23	34
29	21	17	18	17	16	17	15	18	20	25	26	28	29	29	29	27	28	29	23	23	19	19	18	18	22	29
30	18	17	15	15	14	14	15	17	21	23	24	25	25	28	28	27	30	24	25	22	19	18	18	17	21	30
31	17	16	14	14	13	17	17	16	23	25	28	26	28	29	30	29	29	29	26	23	23	24	23	23	22	30
AV	17	16	16	15	14	14	14	15	18	21	23	24	26	27	27	27	28	28	28	23	21	19	19	18	21	
PK	22	22	22	21	21	21	20	21	24	27	28	29	31	31	31	32	36	38	43	32	31	24	23	23		43
MN	9	8	8	8	8	8	8	8	8	11	15	16	17	18	19	20	21	18	13	13	10	11	12	9		

MONTHLY MINIMUM = 8

TEMPERATURE @2M
DEGREE C

LOGAN WASH
STATION LW02
AUG 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	(RF)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
2	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
3	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
4	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
5	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
6	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
7	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
8	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
9	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
10	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
11	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
12	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	21	22	23	24	23	24	20	19	18	14	14	14	14	14	( )	24
13	14	14	14	14	14	14	14	15	16	17	18	19	21	23	(RF)	(RF)	(RF)	(RF)	16	13	12	11	11	11	15	23
14	11	11	11	11	12	12	12	13	14	14	14	14	18	20	22	22	21	20	18	17	13	13	13	13	15	22
15	13	13	12	12	11	11	11	11	11	11	12	12	13	13	13	14	14	14	14	9	8	8	8	8	12	14
16	8	8	8	8	8	8	9	9	9	11	11	13	14	16	17	17	17	16	13	13	13	13	13	12	12	17
17	12	12	12	12	12	12	12	12	12	13	15	17	19	20	20	20	20	19	19	18	18	17	17	16	16	20
18	16	16	16	16	15	15	14	15	18	18	18	18	18	18	17	17	17	16	16	15	14	14	14	13	16	18
19	13	13	12	13	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	13
20	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
21	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
22	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
23	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
24	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
25	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
26	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
27	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
28	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
29	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
30	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
31	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
AV	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
PK	16	16	16	16	15	15	14	15	18	18	21	22	23	24	23	24	21	20	19	18	18	17	17	16		23

TEMPERATURE
DEGREE C

LOGAN WASH
STATION LW03
AUG 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
2	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
3	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
4	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
5	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
6	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
7	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
8	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
9	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
10	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
11	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
12	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	23	24	26	25	27	28	22	20	14	14	14	15	17	21	28
13	16	17	14	14	14	16	16	16	16	17	21	22	23	25	26	27	26	26	22	20	16	16	12	13	19	27
14	13	13	13	14	13	13	12	12	13	15	16	17	19	22	23	24	24	22	21	19	18	16	14	14	17	24
15	14	13	12	12	11	10	10	10	10	11	13	14	16	16	13	16	19	19	20	17	12	10	10	11	13	20
16	11	10	9	9	9	9	9	9	8	11	14	16	16	18	18	19	18	18	17	16	14	14	13	13	13	19
17	13	13	13	11	11	11	10	10	11	15	17	19	22	22	21	22	22	21	19	18	18	17	17	17	16	22
18	17	16	16	16	14	14	14	14	14	14	17	19	20	21	21	21	21	22	21	20	19	19	18	18	18	22
19	18	17	17	16	16	14	13	12	12	13	15	16	18	20	17	17	18	17	14	14	10	10	9	8	15	20
20	7	7	7	6	6	5	4	4	5	9	12	14	16	17	18	18	19	19	16	14	13	13	13	12	11	19
21	12	12	12	11	9	9	9	9	9	14	18	19	20	21	22	22	23	23	19	18	18	17	17	17	16	23
22	17	16	13	14	14	13	16	16	16	19	21	22	24	24	24	24	24	24	22	21	20	19	19	18	19	24
23	18	17	17	16	13	13	13	13	14	16	16	19	19	13	14	17	17	17	17	16	11	11	9	9	15	19
24	9	8	8	8	8	8	8	3	8	9	11	11	12	13	14	14	14	13	12	12	11	11	11	11	11	14
25	11	10	10	9	9	9	9	10	11	13	16	16	17	15	13	13	13	26	16	13	12	12	12	12	12	17
26	11	11	10	11	10	10	10	9	10	12	15	17	18	18	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	12	18
27	(RF)	(RF)	(RF)	9	9	9	9	10	13	18	20	21	21	21	21	21	21	20	19	19	18	18	18	18	17	21
28	18	17	17	16	16	16	14	14	14	18	19	20	21	22	22	23	23	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	18	23
29	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
30	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
31	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
AV	14	13	12	12	11	11	11	11	12	14	16	18	19	20	20	20	21	20	18	17	15	15	14	14	15	
PK	18	17	17	16	16	16	16	16	16	19	21	23	24	26	26	27	28	26	22	21	20	19	19	18		28

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TEMPERATURE
DEGREE C

LOGAN WASH
STATION LW04
AUG 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	25	24	23	22	21	19	19	21	23	27	28	32	33	34	36	34	32	31	29	28	26	26	24	23	27	36
2	22	21	20	19	19	18	18	19	24	27	29	31	33	32	33	32	34	33	32	29	24	23	23	23	26	34
3	21	19	17	17	17	15	15	18	22	24	27	31	32	33	33	34	34	33	31	29	28	26	24	21	25	34
4	20	21	18	16	13	12	13	17	21	24	28	31	32	32	33	34	34	33	33	(RF)	(RF)	(RF)	(RF)	(RF)	25	34
5	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
6	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	24	24	21	21	( )	24
7	19	17	17	15	14	13	13	16	19	22	27	32	33	34	35	36	36	36	36	36	30	28	26	23	25	36
8	22	19	18	17	16	15	13	15	19	22	27	30	34	36	36	36	37	37	36	35	32	29	26	24	26	37
9	23	23	22	20	18	18	18	18	21	27	29	31	33	34	35	36	36	36	36	34	30	26	27	24	27	36
10	23	23	23	22	21	19	18	16	19	23	27	30	32	34	36	36	36	36	35	34	31	29	27	27	27	36
11	27	25	23	21	19	18	16	15	19	22	26	29	31	33	34	35	36	36	36	35	30	27	24	22	27	36
12	23	18	16	12	(OE)	(OE)	(OE)	(OE)	(OE)	24	28	31	33	34	34	35	30	30	24	18	18	17	16	15	24	35
13	14	14	13	13	13	13	13	16	20	23	26	28	30	32	33	33	32	31	27	23	18	18	18	18	22	33
14	18	17	17	16	16	14	16	19	21	21	22	23	27	28	30	29	30	29	27	25	23	22	21	20	22	30
15	20	19	16	16	14	13	13	14	15	18	20	22	23	18	21	24	24	25	23	19	18	16	16	14	18	25
16	13	13	12	11	10	9	10	13	16	18	21	23	24	26	26	26	26	26	24	21	20	17	16	13	18	26
17	12	11	11	9	8	8	9	13	16	18	21	24	26	27	28	29	29	29	28	23	19	19	16	15	19	29
18	13	11	10	9	8	7	9	13	16	19	24	27	28	28	29	29	29	29	29	27	26	21	18	17	20	29
19	16	13	12	11	11	10	12	19	(OE)	(OE)	(OE)	(OE)	26	26	27	27	26	27	27	21	22	19	17	16	19	27
20	14	13	12	12	11	9	8	8	8	11	14	17	20	21	23	24	24	25	25	25	23	20	17	16	17	25
21	13	12	12	9	8	7	6	5	7	11	16	18	22	24	27	28	29	29	29	29	27	19	18	17	18	29
22	15	13	11	9	8	8	7	6	9	12	17	21	24	28	30	31	32	32	32	31	29	24	22	22	20	32
23	21	19	18	16	17	17	16	16	16	17	19	22	23	25	24	20	22	23	24	23	22	21	14	14	20	25
24	13	13	13	13	13	13	12	13	13	13	14	16	17	17	18	19	20	19	20	20	19	18	16	14	16	20
25	14	13	12	12	12	11	11	11	11	12	14	17	20	22	23	19	17	18	20	21	20	18	17	15	16	23
26	13	12	12	11	10	9	(RF)	(RF)	(RF)	(RF)	(RF)	21	24	26	27	26	26	24	22	20	19	17	15	(RF)	19	27
27	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	13	17	20	23	26	28	28	28	28	28	28	21	18	16	16	14	22	28
28	13	12	11	9	8	8	7	11	15	20	22	26	27	28	29	29	29	29	28	24	22	19	17	14	19	29
29	14	13	12	12	11	11	11	12	16	19	22	24	26	26	27	27	27	26	24	20	17	16	14	13	18	27
30	12	10	8	7	6	6	4	10	13	15	17	21	19	19	20	27	27	27	24	23	21	19	19	17	16	27
31	14	13	12	11	9	8	7	11	15	17	18	20	24	24	25	26	25	24	22	21	18	17	16	14	17	26
AV	18	16	15	14	13	12	12	14	16	19	22	25	27	28	29	29	29	29	28	26	23	21	19	18	21	
PK	27	25	23	22	21	19	19	21	24	27	29	32	34	36	36	36	37	37	36	36	32	29	27	27		37

TEMPERATURE #2M
DEGREE C

LOGAN WASH
STATION LW02
SEPT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
2	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	19	19	19	19	19	19	19	19	18	18	17	17	( )	19
3	17	16	16	16	16	15	15	15	15	15	16	(RF)	(RF)	(RF)	21	20	20	20	20	19	18	18	18	18	17	21
4	17	16	16	16	16	16	14	14	14	15	18	19	20	23	23	23	23	23	22	21	19	18	18	18	18	23
5	18	17	17	17	17	16	16	16	16	18	19	22	23	23	24	24	24	23	20	19	19	19	19	18	19	24
6	18	17	17	16	16	16	16	16	16	16	18	19	20	22	22	22	19	18	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	18	22
7	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
8	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
9	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	7	16	15	14	13	12	12	12	12	12	12	( )	16
10	12	12	12	12	12	12	12	13	13	14	16	16	16	17	17	17	17	15	14	14	14	14	13	13	14	17
11	13	13	12	12	12	12	12	13	14	14	14	16	16	15	14	14	14	14	14	14	14	14	14	13	14	16
12	13	13	13	13	12	14	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	14
13	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
14	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
15	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
16	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	16	17	17	17	17	17	17	16	15	14	14	( )	17
17	13	13	13	12	12	11	11	11	11	11	11	13	14	16	18	19	19	19	18	16	16	15	15	14	14	19
18	14	14	14	14	14	14	14	14	14	14	16	17	18	19	20	21	19	20	19	18	17	17	16	16	16	21
19	16	16	15	14	14	14	13	13	13	14	16	18	18	19	19	19	19	19	17	17	16	(IM)	(IM)	(IM)	16	19
20	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
21	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
22	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
23	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	11	13	14	14	15	14	14	13	12	12	11	11	( )	15
24	10	8	7	7	7	7	7	7	7	8	8	9	10	12	14	15	16	16	16	15	13	13	12	12	11	16
25	12	11	11	8	8	7	7	7	7	7	9	10	11	14	15	16	18	18	18	17	17	14	12	12	12	18
26	12	12	12	12	12	12	12	12	(IM)	(IM)	11	12	13	14	16	17	18	18	17	17	16	14	14	14	14	18
27	13	13	13	13	13	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	14	16	17	18	19	19	17	17	17	16	16	16	( )	19
28	16	16	16	16	16	15	14	14	14	14	14	16	18	18	19	20	20	20	20	19	18	17	17	17	17	20
29	17	16	16	16	14	14	13	13	13	13	13	14	15	17	18	18	19	19	19	19	18	17	17	16	16	19
30	16	16	16	16	16	14	13	13	13	13	14	16	17	18	18	20	20	20	19	18	18	17	17	17	16	20
AV	15	14	14	13	13	13	13	13	( )	( )	14	( )	16	17	18	18	18	18	17	17	16	15	15	15	16	
PK	18	17	17	17	17	16	16	16	16	18	19	22	23	23	24	24	24	23	22	21	19	19	19	18		24

TEMPERATURE
DEGREE C

LOGAN WASH
STATION LW03
SEPT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
2	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	22	22	22	23	23	19	19	18	17	17	( )	23
3	16	16	16	15	14	14	13	13	13	14	16	18	20	22	22	23	23	23	23	20	19	19	19	18	18	23
4	17	17	17	16	14	14	14	13	13	13	17	20	21	24	26	24	26	26	26	22	20	19	18	18	19	26
5	18	17	17	17	16	17	16	16	14	14	19	22	23	24	26	27	27	28	26	23	21	21	20	20	20	28
6	19	17	17	17	16	14	14	14	13	14	17	19	20	22	21	24	24	23	21	19	18	17	16	16	18	24
7	15	15	14	14	14	13	13	13	13	14	16	16	16	19	19	21	20	19	16	16	14	15	15	13	16	21
8	14	14	14	13	13	12	11	11	11	12	12	12	13	14	16	17	18	18	16	14	13	13	13	13	14	18
9	12	12	12	12	12	12	12	12	11	12	12	12	12	14	13	15	14	14	13	13	13	13	13	13	13	15
10	12	12	12	12	12	12	12	12	12	12	13	14	13	12	9	9	9	8	8	9	9	8	7	7	11	14
11	7	8	8	8	8	8	7	8	8	9	11	11	12	13	14	14	13	13	12	11	11	10	10	9	10	14
12	9	9	9	8	8	8	7	8	6	9	11	12	16	14	14	14	16	16	15	13	12	11	11	11	11	16
13	12	12	12	12	12	12	12	12	12	13	14	16	18	19	19	21	20	20	18	17	16	16	15	15	15	21
14	14	14	14	14	14	13	13	14	14	15	17	18	19	21	20	20	20	21	18	17	16	15	15	14	16	21
15	14	14	13	13	13	13	12	12	13	14	17	19	19	20	20	20	19	19	18	17	16	16	16	16	16	20
16	15	14	14	14	14	14	13	12	12	12	15	18	19	20	21	21	21	19	18	17	16	16	14	14	16	21
17	13	13	12	12	11	11	11	11	11	15	18	19	21	21	21	22	21	19	17	17	16	16	16	15	16	22
18	14	14	14	14	14	13	12	13	14	20	21	22	23	24	23	24	24	22	21	20	20	19	19	19	19	24
19	19	18	18	17	17	17	16	16	17	19	20	21	22	22	23	23	22	21	20	19	19	17	10	8	18	23
20	7	8	8	7	7	7	7	7	7	11	13	15	16	17	17	18	18	15	13	13	12	12	12	12	12	18
21	12	12	12	11	11	10	10	10	10	13	14	16	17	18	18	18	17	14	10	8	7	6	6	5	12	18
22	4	4	3	3	3	3	3	3	4	6	11	13	14	16	17	17	17	15	13	12	11	10	9	9	9	17
23	9	9	9	8	8	7	6	5	6	10	13	15	15	16	17	18	18	18	15	14	13	13	12	11	12	18
24	11	9	9	8	8	7	7	7	7	7	10	13	15	16	18	18	18	19	16	14	13	13	13	12	12	19
25	12	11	10	9	8	8	8	8	8	8	11	14	17	19	19	21	21	20	18	16	15	14	13	13	13	21
26	13	12	12	11	11	10	9	9	9	12	14	17	17	19	21	21	21	21	18	16	16	16	16	14	15	21
27	14	13	13	13	12	12	12	11	11	12	16	19	19	21	22	22	22	22	18	17	17	17	16	15	16	22
28	14	14	14	13	13	13	12	11	10	11	16	19	21	22	21	22	22	22	19	17	17	17	17	15	16	22
29	14	14	15	13	13	12	12	11	11	12	14	17	19	20	22	22	21	21	19	18	16	16	16	15	16	22
30	15	15	14	14	14	13	12	12	11	11	13	18	21	22	22	23	23	23	22	20	18	18	17	16	17	23
AV	13	13	13	12	12	11	11	11	11	12	15	17	18	19	19	20	20	19	17	16	15	15	14	14	15	
PK	19	18	18	17	17	17	16	16	17	20	21	22	23	24	26	27	27	28	26	23	21	21	20	20		28

TEMPERATURE
DEGREE C

LOGAN WASH
STATION LW04
SEPT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	13	11	10	9	8	6	9	12	15	18	21	23	24	25	26	26	26	26	26	23	17	16	14	13	17	26
2	11	9	8	8	7	6	5	8	12	17	20	22	26	29	29	29	30	29	29	27	20	18	16	16	18	30
3	14	12	11	10	9	8	8	7	8	12	18	21	24	28	31	31	32	31	31	29	23	22	20	19	19	32
4	18	16	14	12	11	9	9	8	9	14	19	23	27	29	32	32	33	33	32	30	24	24	22	21	21	33
5	18	17	15	14	12	11	9	9	10	14	20	23	27	31	32	34	34	33	33	32	29	25	24	22	22	34
6	22	19	18	18	18	16	14	13	13	17	23	26	27	29	30	31	31	31	29	28	24	24	23	23	23	31
7	21	20	19	17	16	14	13	13	14	18	20	23	24	26	27	29	28	29	23	22	21	20	19	18	21	29
8	18	17	16	16	16	16	16	16	16	16	17	17	20	22	23	24	24	24	24	23	22	21	21	20	19	24
9	19	18	17	17	16	16	15	15	16	17	18	19	19	20	20	22	22	22	21	20	19	18	18	18	18	22
10	17	17	16	16	16	16	15	16	16	17	19	20	20	16	15	15	14	14	14	13	13	11	10	9	15	20
11	9	8	7	7	7	6	6	7	8	11	14	18	21	21	22	22	22	22	19	17	17	16	13	12	14	22
12	12	12	11	11	10	8	8	10	13	16	17	21	22	21	23	23	24	24	23	20	16	15	14	12	16	24
13	10	10	10	10	9	8	7	9	12	16	19	21	24	27	27	28	28	27	27	23	20	16	12	13	17	28
14	11	9	9	7	6	5	5	8	12	16	19	22	26	27	28	28	27	28	27	22	19	17	15	14	17	28
15	12	10	9	8	7	7	6	7	10	14	18	22	25	27	28	28	27	27	27	24	22	19	18	17	17	28
16	16	16	16	15	14	13	10	12	17	22	24	27	27	28	29	28	28	26	21	19	18	16	14	13	19	29
17	12	11	10	9	8	7	8	12	16	19	22	24	26	27	28	28	28	27	18	17	16	14	13	11	17	28
18	10	9	7	7	6	6	8	11	17	20	23	27	29	31	31	31	30	26	22	21	18	16	14	16	18	31
19	16	17	19	14	12	11	13	18	26	27	29	29	30	31	31	29	29	27	26	24	22	23	17	15	22	31
20	14	13	12	11	9	9	10	13	16	18	20	22	23	24	24	24	24	22	16	13	12	11	9	9	16	24
21	7	7	6	5	4	3	6	10	14	17	21	24	24	24	26	24	24	19	16	14	13	13	12	12	14	26
22	12	12	10	9	9	8	9	11	13	16	18	19	21	22	22	23	23	22	18	16	13	11	10	8	15	23
23	7	6	4	3	2	1	3	7	12	14	18	19	22	(MT)	23	24	25	25	23	20	15	14	13	12	14	25
24	11	12	8	7	6	5	3	4	7	12	14	17	19	21	23	24	24	24	24	19	16	15	13	12	14	24
25	10	8	7	6	5	4	4	4	8	12	16	19	22	24	26	27	27	27	26	18	17	16	13	13	15	27
26	10	9	7	6	4	3	3	3	7	12	16	19	22	25	27	27	27	27	26	17	17	15	13	11	15	27
27	10	8	7	6	5	4	3	3	8	12	16	19	22	24	27	28	28	28	26	21	19	18	16	14	16	28
28	12	10	9	7	7	6	4	5	8	13	17	19	22	24	27	28	29	29	28	19	17	17	16	13	16	29
29	12	11	10	9	8	7	6	5	8	12	17	20	23	25	27	28	29	28	28	24	21	21	19	17	17	29
30	16	13	11	10	8	6	4	4	7	12	21	23	26	28	30	30	31	29	26	19	17	17	15	12	17	31
AV	13	12	11	10	9	8	8	9	12	16	19	22	24	25	26	27	27	25	24	21	19	17	16	14	17	
PK	22	20	19	18	18	16	16	18	26	27	29	29	30	31	32	34	34	33	33	32	29	25	24	23		34

TEMPERATURE #2M
DEGREE C

LOGAN WASH
STATION LW02
OCT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	(IM)	16	16	16	16	16	16	15	16	16	16	17	18	19	20	21	21	21	21	18	16	14	14	13	17	21
2	12	12	11	10	10	9	8	7	7	7	8	11	12	14	15	16	16	16	15	14	12	11	11	11	11	16
3	11	11	11	11	11	11	11	11	11	11	11	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	18	18	(RF)	(RF)	16	15	14	( )	18
4	14	14	14	13	13	13	13	12	12	12	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	14
5	14	14	12	11	11	10	10	10	10	11	12	14	16	17	17	18	18	16	15	13	12	12	12	12	13	18
6	12	12	12	12	12	12	11	11	11	11	12	14	16	17	18	19	20	20	19	18	17	16	16	16	15	20
7	16	15	15	15	15	15	15	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	22	22	22	22	22	20	19	19	19	18	( )	22
8	18	18	18	18	17	17	17	17	17	17	17	19	19	21	22	22	23	23	22	20	(IM)	(IM)	(IM)	(IM)	19	23
9	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
10	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
11	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
12	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
13	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
14	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
15	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
16	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
17	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
18	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
19	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
20	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
21	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
22	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
23	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
24	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
25	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
26	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
27	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
28	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
29	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
30	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
31	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
AV	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
PK	18	18	18	18	17	17	17	17	17	17	17	19	19	21	22	22	23	23	22	20	19	19	19	18		23

TEMPERATURE
DEGREE C

LOGAN WASH
STATION LW03
OCT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	16	15	14	14	14	14	14	14	14	13	13	17	21	21	23	23	24	23	23	21	18	18	16	16	18	24
2	15	14	13	13	12	11	11	8	9	9	9	13	16	17	19	21	20	19	17	14	13	13	13	13	14	21
3	13	12	12	12	12	12	11	10	8	8	9	13	17	18	19	21	21	22	22	18	17	17	16	16	15	22
4	15	14	13	13	12	12	12	12	12	11	11	16	19	19	21	22	22	22	21	18	17	17	17	16	16	22
5	14	14	14	13	12	12	11	11	11	12	13	17	18	19	21	22	21	21	19	18	16	16	15	14	16	22
6	14	14	13	14	13	12	12	12	10	11	12	16	18	20	21	22	23	23	22	19	18	17	17	17	16	23
7	16	16	14	14	14	14	12	12	12	12	12	14	18	21	22	23	24	24	24	22	19	18	17	17	17	24
8	17	16	16	16	15	14	13	13	13	13	12	14	18	21	22	23	24	25	25	21	19	18	18	18	18	25
9	17	16	16	16	16	13	13	13	13	12	13	16	17	19	20	21	21	21	21	18	16	15	14	14	16	21
10	13	13	13	12	12	12	11	11	10	10	10	12	15	18	19	21	21	22	19	16	14	13	13	13	14	22
11	13	13	13	12	11	11	11	10	10	11	10	13	16	18	19	20	21	21	19	17	16	15	14	14	15	21
12	14	14	14	13	12	12	12	12	12	12	11	12	14	13	12	11	8	7	6	6	6	6	5	4	10	14
13	4	6	6	6	6	5	5	5	4	4	4	6	7	7	8	9	8	10	11	9	8	8	8	8	7	11
14	8	8	8	8	7	8	7	7	7	7	7	7	9	10	6	6	4	3	3	1	1	1	1	1	6	10
15	-1	-1	-1	0	0	0	0	-1	-1	-2	-1	-1	-1	-1	-1	-1	-1	-1	-3	-3	-3	-3	-3	-4	-1	0
16	-4	-3	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-3	-3	-3	-3	-3	-3	-3	-3	-4	-4	-3
17	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-3	-2	-2	-1	-1	-1	-1	-1	-2	-2	-2	-2	-2	-3	-3	-1
18	-3	-3	-3	-3	-3	-3	-3	-3	-2	0	1	1	2	2	2	2	2	2	0	0	0	0	0	-1	0	2
19	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	1	3	6	7	7	8	8	7	6	4	4	4	3	3	3	8
20	3	2	2	2	2	1	0	-1	-1	-1	2	5	7	8	9	11	11	11	8	6	6	6	4	4	4	11
21	3	3	3	3	2	2	2	1	1	1	2	7	8	9	11	11	11	11	8	6	6	5	4	4	5	11
22	4	4	3	3	3	3	3	3	3	3	4	6	8	9	9	11	10	9	7	7	4	2	-1	-2	5	11
23	-3	-3	-4	-4	-6	-6	-6	-6	-6	-6	-2	0	1	3	2	4	4	1	-2	-2	-3	-3	-2	-3	-2	4
24	-3	-3	-3	-4	-4	-4	-6	-6	-5	-5	-1	2	3	4	6	7	7	6	3	2	2	2	1	0	0	7
25	0	1	1	0	-1	-2	-3	-2	-3	-2	2	6	8	10	11	12	12	8	7	7	6	6	6	6	4	12
26	6	6	5	4	4	4	4	4	3	4	3	4	4	4	2	2	2	0	-1	-1	-1	-2	-2	-2	2	6
27	-2	-2	-2	-3	-3	-3	-3	-3	-4	-3	-3	-3	-3	-3	-3	-3	-3	-3	-4	-4	-5	-6	-7	-7	-4	-2
28	-7	-7	-7	-7	-8	-8	-8	-8	-8	-7	-6	-2	-2	-3	-3	-3	-4	-4	-6	-6	-6	-6	-6	-6	-6	-2
29	-6	-6	-7	-7	-7	-7	-7	-7	-7	-3	-1	0	2	3	4	4	4	1	0	0	0	0	0	0	-2	4
30	-1	-2	-2	-2	-2	-2	-2	-2	-1	2	6	7	8	9	10	10	8	6	5	4	4	3	4	4	3	10
31	4	4	3	3	2	1	1	1	2	4	6	9	10	11	11	11	8	7	7	6	6	6	4	4	5	11
AV	6	5	5	5	4	4	4	4	3	4	5	7	9	10	10	11	11	10	9	8	7	6	6	6	7	
PK	17	16	16	16	16	14	14	14	14	13	13	17	21	21	23	23	24	25	25	22	19	18	18	18		25

TEMPERATURE
DEGREE C

LOGAN WASH
STATION LW04
OCT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	11	10	9	7	6	5	5	8	13	17	20	23	26	28	30	30	30	29	22	21	21	19	18	18	18	30
2	17	18	17	16	15	14	13	14	16	18	21	23	24	24	25	26	26	23	21	19	17	14	13	11	19	26
3	9	7	7	4	3	2	2	7	12	15	18	21	24	26	27	28	27	26	18	17	18	15	13	11	15	28
4	9	7	6	4	4	3	2	6	11	16	18	21	23	27	28	28	29	27	20	18	17	14	12	10	15	29
5	9	8	6	4	3	3	3	7	12	16	19	22	24	27	28	27	27	25	22	22	21	21	18	17	16	28
6	12	10	9	8	6	5	5	7	12	16	19	22	24	27	28	28	28	28	24	18	16	17	15	13	17	28
7	11	10	9	8	6	4	3	6	11	15	18	20	21	24	26	28	30	30	29	25	20	21	18	17	17	30
8	14	13	11	9	7	6	6	4	5	9	15	18	21	24	27	29	30	30	28	22	22	19	17	14	17	30
9	12	11	9	7	7	5	4	3	5	10	14	19	21	24	26	27	27	26	24	21	20	18	19	18	16	27
10	17	16	16	12	12	13	11	12	11	14	17	19	21	24	26	26	26	26	24	21	19	17	15	13	18	26
11	12	10	8	7	6	4	3	2	3	8	11	16	18	21	23	25	27	26	24	16	14	13	11	10	13	27
12	10	8	7	6	4	4	4	4	7	8	12	16	18	18	18	13	12	12	11	11	11	11	10	10	10	18
13	10	9	9	9	9	9	9	9	9	9	11	13	16	17	16	17	17	17	17	14	11	11	10	9	12	17
14	9	10	10	9	9	8	(RF)	(RF)	(RF)	(RF)	13	17	14	16	16	14	9	9	7	7	7	7	7	7	10	17
15	6	5	5	5	3	4	3	4	6	6	7	7	8	8	8	9	8	8	5	5	4	4	4	3	6	9
16	2	2	2	2	2	2	2	2	3	4	3	3	4	2	2	3	3	3	3	3	3	3	3	2	3	4
17	2	2	2	2	2	2	2	2	3	4	5	6	7	7	8	7	7	6	4	3	3	2	2	2	4	8
18	1	1	1	1	1	1	1	1	2	4	6	6	9	10	10	10	10	10	7	6	4	3	3	2	5	10
19	1	-1	-1	-1	-2	-2	-3	-2	1	4	7	9	11	13	14	15	15	14	8	7	6	4	3	2	5	15
20	1	0	-1	-2	-2	-2	-3	-2	1	4	8	10	12	14	16	17	17	17	13	8	8	7	4	4	6	17
21	2	2	1	0	-1	-2	-3	-2	1	6	8	10	13	14	(MT)	(MT)	18	18	17	13	9	8	7	6	6	18
22	5	3	2	2	1	1	0	0	0	1	4	7	10	12	14	16	17	17	16	13	11	11	9	6	7	17
23	5	4	3	3	3	2	2	1	1	2	3	6	7	8	8	9	9	9	8	7	4	3	2	1	5	9
24	0	-1	-2	-3	-4	-4	-6	-7	-6	-3	1	4	6	8	10	12	13	13	12	3	2	2	1	-1	2	13
25	-2	-3	-3	-4	-5	-6	-7	-7	-7	-3	1	4	7	9	11	13	14	16	14	8	3	2	2	2	2	16
26	1	0	-1	-2	-2	-3	-3	-2	-2	-1	1	3	6	8	10	9	8	8	7	6	5	4	4	4	3	10
27	3	3	3	3	3	3	3	3	3	4	4	4	4	5	5	5	5	5	4	4	4	3	3	3	4	5
28	2	2	1	0	0	-1	-1	-1	-1	0	1	3	7	8	8	8	7	4	3	3	2	1	-1	-1	2	8
29	-2	-3	-4	-4	-6	-6	-7	-4	0	2	5	7	8	10	11	11	11	4	2	2	1	0	-1	-2	1	11
30	-3	-3	-3	-4	-6	-6	-6	-3	2	5	8	10	12	13	15	15	14	6	4	3	2	1	1	-1	3	15
31	-1	-2	-3	-4	-4	-4	-4	-1	1	3	7	9	12	13	14	14	12	7	6	4	3	3	2	0	4	14
AV	6	5	4	3	3	2	1	2	4	7	10	12	14	16	17	17	17	16	14	11	10	9	8	7	9	
PK	17	18	17	16	15	14	13	14	16	18	21	23	26	28	30	30	30	30	29	25	22	21	19	18		30

RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW02
AUG 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	84	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	84
2	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
3	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
4	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
5	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
6	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
7	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
8	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
9	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
10	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
11	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
12	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	39	37	35	32	29	29	30	30	42	76	84	53	51	45	46	( )	84
13	44	41	40	43	45	47	45	45	46	45	41	35	30	25	28	27	32	40	54	63	83	81	72	66	47	83
14	68	59	56	58	61	60	50	51	53	54	54	46	36	28	31	36	36	45	51	59	83	81	77	82	55	83
15	83	95	91	92	92	91	91	90	87	85	78	76	74	52	48	50	38	39	52	64	70	75	72	72	73	95
16	65	65	50	51	49	48	53	53	55	55	42	32	26	27	26	24	26	29	41	47	49	48	48	51	44	65
17	52	45	47	44	39	38	35	32	31	29	29	23	17	18	16	15	16	16	17	19	20	20	22	22	28	52
18	22	22	21	22	22	23	23	14	13	11	10	8	8	13	16	17	17	18	20	22	25	27	29	31	19	31
19	32	33	31	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	33
20	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
21	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
22	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
23	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
24	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
25	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
26	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
27	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
28	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
29	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
30	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
31	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
AV	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
PK	84	95	91	92	92	91	91	90	87	85	78	76	74	52	48	50	38	45	76	84	83	81	77	82		95

RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW03
AUG 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	34	37	36	37	39	39	40	43	40	37	33	30	29	29	25	27	32	34	40	42	48	56	55	56	38	56
2	57	56	59	62	61	60	62	62	65	51	47	42	39	37	34	30	21	20	30	33	37	40	40	38	45	65
3	37	42	50	50	49	55	57	57	56	49	45	42	39	35	34	31	33	32	32	30	28	28	28	30	40	57
4	32	34	36	38	40	40	40	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	40
5	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	26	26	26	25	24	23	23	22	22	23	( )	26
6	25	26	27	29	30	32	33	35	37	39	40	42	39	35	34	33	31	30	29	27	28	28	29	29	32	42
7	30	31	32	34	34	35	36	37	38	39	39	39	34	32	30	29	29	27	25	24	25	27	27	27	32	39
8	27	27	29	30	32	33	33	34	36	36	37	39	36	34	31	29	26	25	25	24	25	27	32	37	31	39
9	38	40	41	42	45	47	49	52	56	58	59	59	51	45	40	33	23	20	22	22	22	25	27	28	39	59
10	28	30	30	33	34	36	36	37	38	40	41	40	34	33	30	26	24	22	18	16	16	20	22	21	29	41
11	22	24	24	25	24	24	24	24	24	26	27	30	28	25	23	19	15	15	14	10	8	8	10	12	20	30
12	12	13	14	14	15	16	20	30	36	39	4	1	45	45	34	33	33	25	25	30	37	65	82	67	31	82
13	60	54	60	60	63	61	62	57	58	59	57	55	50	45	42	35	31	31	32	33	35	47	61	70	51	70
14	90	77	72	69	69	64	71	72	72	71	70	66	70	58	53	41	38	36	37	39	41	51	55	79	61	90
15	82	78	75	78	84	94	92	99	90	93	91	77	81	67	65	57	48	45	40	33	36	44	55	61	69	99
16	62	52	56	59	61	65	63	63	63	63	67	65	49	42	36	27	26	25	22	21	26	35	40	40	47	67
17	41	41	40	41	41	50	46	46	49	53	49	35	30	24	19	18	19	17	15	16	19	19	21	22	32	53
18	23	24	26	26	25	25	25	25	27	25	27	27	23	20	18	16	15	14	12	10	14	18	19	18	21	27
19	19	21	23	26	27	29	31	33	33	34	35	34	31	26	23	27	25	22	20	32	32	40	56	53	31	56
20	51	57	58	57	58	57	62	68	68	65	64	52	43	35	31	29	26	22	21	23	26	29	31	32	44	68
21	33	34	35	36	35	36	40	41	40	41	41	31	25	21	20	19	17	16	14	15	18	18	18	18	28	41
22	19	20	21	22	24	21	22	21	20	20	17	14	14	14	13	14	15	15	15	17	19	21	23	25	19	25
23	28	28	33	41	43	46	71	66	68	66	65	60	59	53	52	75	70	50	46	50	56	60	80	79	56	80
24	86	90	81	95	95	90	85	89	92	80	96	82	80	80	77	68	64	66	64	70	75	76	76	78	81	96
25	73	79	78	80	81	85	88	80	81	81	75	64	60	55	48	66	60	60	55	45	55	60	60	60	68	88
26	57	60	57	66	69	68	71	68	72	71	72	60	48	39	33	32	29	29	23	30	38	45	48	43	51	72
27	40	41	44	46	49	52	51	54	54	54	42	34	28	25	25	24	21	23	23	23	24	25	27	25	36	54
28	31	32	33	33	33	34	34	35	35	36	36	30	25	22	18	12	16	17	16	17	20	22	23	24	26	36
29	24	24	25	27	30	29	33	28	27	28	30	29	28	25	21	19	18	19	15	14	14	15	17	19	23	33
30	19	19	19	19	20	21	23	24	24	24	24	24	25	28	28	27	26	23	23	21	21	22	24	26	23	28
31	32	33	35	35	36	42	38	39	41	45	45	40	35	34	30	26	25	(RF)	(RF)	(RF)	(RF)	38	39	45	37	45
AV	40	41	42	44	45	46	48	49	50	49	47	43	41	37	33	32	29	28	27	27	30	34	38	40	39	
PK	90	90	81	95	95	94	92	99	92	93	96	82	81	80	77	75	70	66	64	70	75	76	82	79		99

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RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW04
AUG 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
2	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
3	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
4	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
5	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	19	17	16	14	13	12	12	10	10	14	21	26	32	36	( )	36
6	36	40	44	47	49	53	55	40	32	27	22	20	18	12	11	15	14	14	15	20	26	31	31	36	30	55
7	41	44	50	55	57	60	60	46	35	26	25	22	19	19	12	11	15	15	17	22	23	27	29	32	32	60
8	37	40	42	45	49	53	56	54	38	37	26	23	21	17	16	16	16	16	16	21	29	32	35	38	32	56
9	40	42	42	55	61	58	61	55	46	37	32	26	21	13	13	13	13	13	14	20	24	25	29	29	33	61
10	31	32	33	35	41	46	51	45	39	32	29	24	21	17	15	12	11	11	11	13	14	17	16	16	26	51
11	17	18	20	22	24	28	30	29	26	23	20	16	14	12	11	7	6	5	5	7	14	15	17	20	17	30
12	21	27	31	34	36	37	40	36	28	24	22	20	17	16	19	19	19	27	78	80	82	82	80	83	40	83
13	82	83	85	86	83	80	56	39	33	26	21	19	13	12	13	13	17	27	33	82	65	68	62	65	48	86
14	67	70	70	72	77	71	47	44	44	39	32	25	20	19	19	17	20	27	29	44	49	51	57	61	45	77
15	62	89	86	86	89	88	88	82	64	50	49	46	60	35	32	25	26	29	35	42	45	52	62	65	58	89
16	64	69	73	77	82	81	53	42	41	27	15	12	12	13	12	13	12	21	28	35	41	44	51	62	41	82
17	63	67	76	76	81	74	56	39	31	24	15	9	8	5	5	5	5	7	19	26	28	32	35	42	35	81
18	50	56	62	63	68	60	45	32	25	12	8	6	5	5	3	2	4	5	6	11	17	27	30	33	26	68
19	40	47	52	55	56	56	45	36	23	19	17	16	12	14	13	11	9	13	22	23	30	38	44	50	31	56
20	52	52	51	54	58	61	63	64	56	46	35	24	22	18	16	14	13	13	14	18	22	31	32	37	36	64
21	42	44	51	56	60	65	70	70	51	37	27	20	15	12	10	8	8	7	7	13	23	28	30	33	33	70
22	40	45	51	55	57	59	64	60	47	31	22	15	9	7	7	7	7	8	9	12	20	27	25	30	30	64
23	34	38	44	45	58	70	76	80	80	55	42	36	32	44	52	42	36	33	38	42	45	85	86	89	53	89
24	90	91	85	85	90	89	89	90	87	80	68	61	63	58	50	48	49	46	47	52	64	78	79	81	72	91
25	82	88	85	84	87	86	87	87	83	69	53	46	34	40	55	71	58	43	40	47	55	67	74	82	67	88
26	85	87	84	87	90	91	91	91	85	65	52	38	28	22	18	15	16	16	18	23	30	35	41	51	52	91
27	55	61	70	73	77	81	82	82	74	48	36	26	17	15	10	10	10	10	10	12	27	34	43	42	42	82
28	48	51	57	63	67	72	73	77	65	40	30	15	10	5	5	5	5	5	6	9	11	16	20	33	33	77
29	41	47	49	52	51	55	54	57	60	44	32	20	10	9	8	8	6	6	6	8	14	26	35	38	31	60
30	41	42	45	49	58	60	65	68	58	41	31	29	18	15	14	13	12	10	10	10	11	17	19	22	32	68
31	25	32	39	43	46	50	55	64	52	42	36	31	25	15	12	11	11	11	17	21	22	28	32	36	32	64
AV	49	54	57	60	64	65	62	58	50	39	30	25	21	18	17	16	16	17	21	27	32	38	42	46	39	
PK	90	91	86	87	90	91	91	91	87	80	68	61	63	58	55	71	58	46	78	82	82	85	86	89		91

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RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW02
SEPT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
2	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	20	20	19	19	19	20	20	20	21	21	19	20	( )	21
3	22	24	24	24	25	26	27	27	26	26	25	22	19	15	15	15	16	16	18	20	21	21	21	23	22	27
4	26	28	28	27	27	29	31	31	27	26	22	20	17	12	8	8	8	11	12	19	19	19	19	19	21	31
5	19	19	19	22	25	27	27	25	24	21	19	17	13	12	12	13	14	16	17	18	18	18	25	29	20	29
6	30	38	44	50	52	52	52	49	47	40	37	32	27	27	28	35	50	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	52
7	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
8	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
9	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
10	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
11	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
12	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
13	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
14	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
15	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
16	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	20	17	15	14	13	13	13	17	22	24	24	25	( )	25
17	26	26	28	28	30	30	30	30	30	29	28	26	23	20	18	16	16	18	21	23	24	24	24	24	25	30
18	25	26	26	26	26	26	26	26	25	23	20	18	18	18	16	18	17	20	21	22	23	24	25	24	22	26
19	24	25	27	28	29	30	31	31	28	26	25	23	21	20	21	17	18	20	22	25	26	(IM)	(IM)	(IM)	25	31
20	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
21	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
22	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
23	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	19	16	14	12	11	13	15	17	18	19	20	21	( )	21
24	21	35	42	45	46	48	50	50	48	42	40	37	33	27	22	21	20	20	21	23	24	26	27	27	33	50
25	28	29	29	29	28	30	35	36	35	31	26	23	20	17	15	11	11	12	12	12	17	22	23	23	23	36
26	23	23	23	23	23	23	23	24	24	24	28	28	26	19	21	21	19	18	20	21	22	22	22	22	23	28
27	24	25	24	26	26	28	28	30	30	30	27	27	26	24	21	16	15	19	20	20	22	30	31	31	25	31
28	31	31	32	33	33	34	35	35	35	33	30	27	25	23	22	19	18	17	17	18	21	23	23	23	27	35
29	24	25	26	30	34	33	34	34	35	34	32	28	25	19	17	15	12	10	10	11	13	15	16	19	23	35
30	20	21	22	22	22	23	23	23	23	21	18	17	16	16	12	11	12	12	14	16	17	18	18	18	18	23
AV	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
PK	31	38	44	50	52	52	52	50	48	42	40	37	33	27	28	35	50	20	22	25	26	30	31	31		50

RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW03
SEPT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	47	43	42	40	41	44	46	46	50	48	47	45	37	29	30	28	24	22	22	22	26	27	29	30	36	50
2	31	31	31	31	31	31	31	34	36	33	33	28	22	20	21	20	19	19	19	18	19	20	21	22	26	36
3	21	20	21	25	26	26	27	28	28	29	29	29	25	23	21	20	17	15	16	16	19	21	21	21	23	29
4	21	22	25	27	28	30	30	32	32	34	34	35	30	26	21	13	11	10	10	11	14	16	20	22	23	35
5	22	22	21	22	22	24	26	26	26	27	29	29	26	21	20	17	15	14	13	13	14	17	18	18	21	29
6	18	19	22	28	32	35	42	45	50	51	53	53	49	45	40	37	34	31	29	34	43	45	50	58	39	58
7	57	57	59	60	61	64	65	69	72	72	71	67	62	62	57	55	46	37	37	55	63	65	62	59	60	72
8	62	66	62	60	66	70	72	76	85	86	76	84	70	80	70	75	62	59	55	61	67	71	73	72	70	86
9	72	73	73	69	70	72	71	70	75	70	72	72	72	70	71	83	81	84	78	75	76	75	83	83	75	84
10	79	80	87	88	90	91	90	92	83	90	90	93	75	75	75	93	100	88	100	97	90	65	65	73	85	100
11	84	70	78	75	70	75	76	74	76	76	76	73	67	67	55	54	40	41	42	45	50	55	56	63	64	84
12	66	69	70	75	77	81	83	85	84	82	78	74	60	55	43	44	42	40	37	35	41	45	51	59	62	85
13	62	60	56	53	52	51	51	47	41	43	43	41	36	32	27	21	22	15	15	16	16	17	17	17	35	62
14	19	21	22	21	22	22	23	25	26	31	31	30	25	25	23	23	23	24	23	24	27	30	30	30	25	31
15	29	29	29	32	32	33	33	33	36	36	36	34	28	29	27	28	28	23	24	22	28	36	38	40	31	40
16	40	40	40	43	44	45	46	49	53	56	63	63	40	24	20	18	18	16	16	18	21	25	25	26	35	63
17	26	28	30	31	32	33	33	34	36	37	37	30	27	25	21	19	18	19	22	25	27	28	28	28	28	37
18	28	29	29	30	30	30	30	31	35	34	30	23	24	20	19	20	20	19	20	22	24	25	27	27	26	35
19	26	27	28	29	31	31	33	34	33	32	32	27	25	24	23	20	20	21	22	27	29	30	31	37	28	37
20	66	83	85	75	69	73	73	76	75	75	75	56	44	27	26	20	20	19	20	23	25	27	28	29	50	85
21	30	31	30	30	30	30	30	32	33	34	33	27	25	21	19	19	17	16	18	35	54	65	63	73	33	73
22	74	62	60	60	61	62	63	63	62	63	63	51	46	37	31	20	19	20	14	10	16	24	28	29	43	74
23	29	26	25	25	29	31	33	30	29	32	33	28	29	25	23	22	20	19	20	23	25	26	26	27	26	33
24	29	28	33	42	46	48	49	51	52	54	54	53	44	36	32	31	29	27	26	26	29	29	30	30	38	54
25	31	33	34	34	33	34	37	38	37	37	38	39	34	30	25	21	17	17	17	17	18	19	23	25	29	39
26	26	26	28	30	31	31	32	34	35	34	33	39	39	38	35	26	26	27	24	22	25	26	26	27	30	39
27	27	29	31	31	32	34	35	36	38	41	41	41	35	31	32	28	25	22	22	29	28	29	32	33	32	41
28	33	36	37	37	37	38	40	41	44	45	46	46	37	32	28	24	21	20	19	18	21	24	25	25	32	46
29	26	30	31	32	34	38	36	36	36	38	39	37	32	28	19	19	21	16	13	12	14	17	19	21	27	39
30	23	24	26	25	26	27	28	27	28	30	31	31	28	25	23	21	21	20	20	20	23	25	26	27	25	31
AV	40	40	42	42	43	44	45	46	48	48	48	46	40	36	33	31	29	27	27	29	32	34	36	38	39	
PK	84	83	87	88	90	91	90	92	85	90	90	93	75	80	75	93	100	88	100	97	90	75	83	83		100

907

RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW04
SEPT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	39	42	49	52	56	58	63	70	59	47	40	32	22	18	14	13	12	12	13	14	20	33	34	40	36	70
2	41	48	53	55	61	63	66	70	69	43	35	23	16	12	11	11	10	10	10	12	20	30	34	35	35	70
3	39	45	50	52	54	58	60	62	64	46	31	27	18	14	13	12	11	11	12	14	21	27	29	31	33	64
4	33	38	42	47	54	59	61	66	71	53	40	32	24	19	11	10	10	10	10	11	19	22	24	28	33	71
5	33	36	42	43	48	52	58	60	62	56	30	28	23	18	15	13	11	11	11	12	15	21	23	25	31	62
6	26	31	36	41	43	47	60	66	68	67	40	36	35	31	29	27	24	24	29	31	36	39	48	47	40	68
7	55	58	60	66	70	74	80	84	84	63	59	48	44	40	35	29	26	27	48	50	51	58	60	62	55	84
8	62	64	65	68	72	70	81	90	85	88	83	75	66	46	42	36	35	35	33	43	45	49	51	53	60	90
9	60	65	70	72	73	76	74	76	73	67	62	57	55	53	58	51	50	50	56	62	70	70	70	75	64	76
10	77	85	86	87	87	85	83	81	80	75	60	57	55	70	84	86	89	89	89	77	85	90	93	93	81	93
11	93	93	93	93	93	93	93	94	94	90	70	45	37	25	20	22	22	23	37	40	42	47	65	73	62	94
12	70	71	75	75	76	84	87	85	66	49	40	29	28	25	20	18	17	18	22	30	48	49	56	62	50	87
13	70	78	79	80	80	83	86	88	65	47	34	24	15	9	8	5	5	5	5	8	13	17	33	36	41	88
14	46	53	57	63	66	73	74	72	46	30	20	17	12	11	11	12	12	11	17	23	27	34	36	35	36	74
15	40	47	55	62	67	69	70	72	61	36	27	21	16	15	15	12	11	13	15	20	27	34	41	49	37	72
16	52	52	53	54	58	63	70	77	55	32	18	12	11	9	8	9	10	12	17	21	25	32	37	42	35	77
17	46	49	48	55	58	60	61	50	32	27	20	17	13	11	11	11	12	16	27	36	39	39	42	51	35	61
18	50	57	63	67	68	70	70	51	34	25	17	13	11	10	10	10	12	14	20	25	33	42	45	40	36	70
19	38	35	33	40	54	60	57	40	19	15	14	13	11	10	10	11	13	17	19	26	31	33	50	57	29	60
20	63	67	71	75	78	80	78	65	52	44	32	20	14	13	12	12	12	15	23	28	34	39	44	48	42	80
21	51	55	60	62	65	68	70	55	40	34	18	12	11	10	9	9	12	25	37	43	47	50	51	45	39	70
22	42	41	41	43	44	44	43	40	34	31	29	25	19	17	17	8	5	10	15	20	25	29	32	36	29	44
23	39	43	47	51	54	57	61	51	33	27	20	18	(MT)	(MT)	14	13	13	14	14	20	26	28	31	32	32	61
24	33	34	38	47	54	59	65	69	64	46	36	33	25	23	19	18	18	17	17	23	26	28	32	35	36	69
25	41	47	52	55	55	56	58	59	52	42	34	26	19	15	13	11	10	9	11	19	24	27	30	33	33	59
26	38	42	49	52	56	62	64	69	65	45	33	28	26	22	20	16	14	13	14	21	28	33	36	42	37	69
27	45	51	55	58	63	66	68	69	69	46	36	28	25	24	18	17	16	18	19	25	30	34	37	41	40	69
28	46	52	57	61	67	69	72	78	72	55	40	33	26	20	15	13	11	11	12	19	27	31	32	39	40	78
29	40	44	47	51	57	58	63	65	61	50	37	28	23	15	10	8	6	6	6	8	11	13	17	21	31	65
30	24	29	34	38	43	47	56	63	60	42	33	20	17	14	13	12	12	13	19	27	30	30	35	40	31	63
AV	48	52	55	59	62	65	68	68	60	47	36	29	25	21	20	18	17	19	23	27	33	37	42	45	41	
PK	93	93	93	93	93	93	93	94	94	90	83	75	66	70	84	86	89	89	89	77	85	90	93	93		94

602

RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW02
OCT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	(IM)	19	19	21	22	22	22	23	23	21	20	19	18	17	16	15	15	15	15	19	20	16	15	17	19	23
2	20	22	26	27	30	33	40	43	41	39	36	30	23	18	17	16	16	17	18	21	22	20	20	22	26	43
3	24	24	24	24	24	24	25	27	27	25	23	21	19	18	16	16	15	15	17	19	21	22	23	23	22	27
4	22	23	24	25	25	25	25	24	23	21	20	18	18	17	15	14	13	14	17	19	18	16	16	16	20	25
5	17	18	20	22	25	26	28	31	30	28	27	25	23	21	19	18	19	20	21	23	24	24	25	27	23	31
6	28	29	29	30	31	33	36	36	35	34	29	26	25	23	21	18	17	18	18	21	23	22	22	22	26	36
7	22	23	23	23	23	22	23	24	24	23	21	19	18	17	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	24
8	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
9	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
10	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
11	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
12	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
13	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
14	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
15	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
16	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
17	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
18	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
19	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
20	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
21	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
22	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
23	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
24	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
25	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
26	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
27	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
28	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
29	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
30	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
31	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	( )
AV	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
PK	28	29	29	30	31	33	40	43	41	39	36	30	25	23	21	18	19	20	21	23	24	24	25	27		43

RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW03
OCT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	24	25	25	25	26	26	27	29	29	30	30	31	31	26	25	24	22	22	21	21	23	24	25	25	26	31
2	22	22	23	27	28	30	32	34	38	43	42	42	43	37	32	28	22	20	18	19	21	23	25	24	29	43
3	23	24	26	28	27	27	27	28	29	30	34	35	34	28	26	24	22	21	20	20	22	24	25	26	26	35
4	27	27	28	29	30	32	33	32	32	32	33	35	35	29	26	25	22	20	19	18	21	24	25	21	27	35
5	21	22	24	24	26	28	30	33	35	38	40	38	37	34	31	28	26	25	24	24	25	27	28	29	29	40
6	30	31	32	33	33	33	35	36	37	38	41	41	40	33	30	27	25	22	22	22	23	26	27	25	31	41
7	26	25	26	27	29	29	30	30	32	32	33	34	34	30	26	24	23	21	20	19	19	19	21	23	26	34
8	21	22	28	28	28	29	29	31	32	33	33	34	35	32	28	25	22	20	19	18	19	20	22	21	26	35
9	22	23	23	24	25	27	29	31	31	31	32	31	30	28	26	24	23	21	19	19	20	22	25	27	26	32
10	27	28	28	29	28	27	27	27	28	30	31	32	32	31	29	28	24	22	22	22	24	26	26	26	27	32
11	26	28	28	28	29	30	32	32	32	33	33	33	34	33	29	25	24	23	23	23	22	24	26	27	28	34
12	27	28	29	29	29	30	30	30	31	32	34	50	60	56	49	50	59	64	98	88	87	97	84	87	52	98
13	97	90	84	78	79	77	72	70	86	84	88	93	87	81	80	75	65	67	68	64	58	66	69	65	77	97
14	59	58	57	56	64	65	64	64	65	65	65	65	66	63	56	49	60	68	63	75	72	74	66	76	64	76
15	69	81	93	78	76	75	65	50	57	45	53	65	75	47	54	50	50	52	45	47	60	69	79	76	63	93
16	76	86	91	98	100	100	100	100	100	98	100	100	100	99	98	94	95	97	95	98	91	95	89	92	96	100
17	94	100	100	100	100	100	100	91	95	96	90	84	83	83	79	75	73	75	82	79	80	80	80	76	87	100
18	75	75	75	74	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	75
19	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
20	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
21	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	34	33	34	36	42	46	46	48	( )	48
22	48	48	50	54	55	55	56	56	57	58	56	56	50	45	42	42	41	35	38	40	34	28	22	20	45	58
23	33	35	37	39	41	45	47	52	58	61	63	65	57	50	44	38	37	34	34	37	43	45	47	47	45	65
24	46	45	44	44	47	50	52	53	57	58	60	60	53	40	37	30	25	25	24	27	32	32	35	35	42	60
25	38	39	36	36	36	39	39	42	43	42	43	40	37	33	31	15	12	9	11	13	18	15	15	16	29	43
26	16	17	17	19	19	20	20	22	23	26	27	30	32	31	35	45	53	75	79	92	96	94	98	98	45	98
27	99	100	87	90	85	82	86	80	82	83	82	77	78	82	83	76	75	78	81	76	73	73	74	73	81	100
28	72	71	72	70	68	67	67	67	67	67	67	65	59	54	53	50	50	53	50	56	60	62	63	65	62	72
29	64	65	64	64	68	66	69	72	72	71	70	63	56	47	42	37	34	33	37	43	45	45	44	50	55	72
30	53	53	55	59	59	60	61	62	62	61	61	50	44	36	31	28	27	30	35	39	39	40	42	44	47	62
31	43	46	45	45	46	47	51	53	54	56	52	51	48	33	30	27	26	29	34	36	37	38	40	40	42	56
AV	46	47	47	48	47	48	49	48	51	51	52	52	51	45	43	39	38	39	41	42	43	45	45	46	46	
PK	99	100	100	100	100	100	100	100	100	98	100	100	100	99	98	94	95	97	98	98	96	97	98	98		100

RELATIVE HUMIDITY
PERCENT

LOGAN WASH
STATION LW04
OCT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVE	PEAK
1	0	49	51	55	58	63	66	65	49	38	29	22	19	16	15	15	15	15	18	20	21	23	23	23	32	66
2	0	24	28	31	34	36	37	38	35	31	26	22	18	15	15	15	14	15	17	19	22	25	28	31	24	38
3	0	41	43	46	50	55	59	58	44	34	28	24	20	17	16	15	16	17	25	28	28	30	35	39	32	59
4	0	47	52	54	59	63	65	63	51	36	31	26	21	16	14	13	13	15	23	26	25	29	33	39	34	65
5	0	44	47	50	58	60	63	63	46	35	30	27	23	18	17	17	17	19	20	20	21	21	25	27	32	63
6	0	40	47	51	55	60	64	63	50	39	31	29	25	20	17	17	17	18	22	32	35	33	37	41	35	64
7	0	48	52	54	57	59	66	69	57	40	34	33	28	23	20	17	15	15	16	22	24	24	28	32	35	69
8	0	40	44	47	52	57	63	67	68	61	43	34	28	22	18	14	13	13	17	21	22	25	29	32	35	68
9	0	41	45	47	53	56	58	61	63	53	42	31	27	19	17	15	14	15	17	19	20	23	23	23	33	63
10	0	25	25	31	31	32	33	35	36	35	31	29	25	22	18	17	17	18	18	19	19	22	25	28	25	36
11	0	34	38	42	47	51	54	59	63	57	42	35	29	25	22	19	18	17	17	23	29	34	37	41	35	63
12	0	47	51	53	57	61	62	63	62	61	50	39	38	45	48	62	89	87	91	91	91	93	90	87	63	93
13	0	88	90	91	91	92	92	91	89	91	88	74	53	48	47	41	37	36	42	52	69	76	81	82	68	92
14	0	87	86	89	91	91	92	93	94	94	90	52	60	46	35	42	76	84	80	88	87	91	91	94	76	94
15	0	89	92	92	93	94	94	94	91	64	73	56	50	38	39	40	34	36	59	63	73	71	73	78	66	94
16	0	93	93	93	93	87	82	87	84	82	71	80	77	82	89	92	85	87	90	92	90	89	85	84	83	93
17	0	92	92	93	93	93	91	93	93	87	74	60	50	51	45	55	55	60	78	81	86	87	86	83	74	93
18	0	80	83	87	86	89	88	85	82	68	59	52	46	36	35	35	35	37	60	66	78	79	81	78	64	89
19	0	89	93	92	92	93	93	93	93	67	54	42	35	26	25	23	21	22	48	57	64	69	77	80	60	93
20	0	88	90	92	93	93	93	93	93	79	50	43	33	22	18	15	16	20	32	48	49	51	58	60	55	93
21	0	74	77	82	85	87	89	91	90	57	44	33	25	21	18	17	15	14	16	28	47	54	59	64	49	91
22	0	71	78	80	80	83	85	86	88	84	70	47	34	27	20	15	15	17	15	17	13	6	8	13	44	88
23	0	17	20	19	21	27	35	39	44	43	38	31	24	20	18	16	15	15	18	21	24	30	35	39	25	44
24	0	47	56	64	68	72	75	78	80	78	49	33	25	19	14	13	11	10	15	30	41	46	46	52	43	80
25	0	60	61	67	70	75	78	83	85	84	51	36	26	19	15	11	8	7	8	17	32	42	43	43	43	85
26	0	53	57	64	64	68	72	71	75	68	65	48	37	38	27	33	49	55	68	77	81	86	88	88	60	88
27	0	90	89	92	91	81	68	66	51	50	49	48	48	45	43	43	43	44	44	43	45	42	42	40	54	92
28	0	43	45	46	46	47	47	48	48	44	40	33	26	25	25	27	28	33	40	44	46	50	54	60	39	60
29	0	68	71	77	80	84	86	86	64	44	35	27	21	19	18	17	20	34	47	54	60	64	69	73	51	86
30	0	82	83	83	85	87	89	89	69	40	32	26	22	18	16	16	20	36	47	51	60	64	68	69	52	89
31	0	76	80	83	85	86	87	87	71	54	38	32	25	20	16	16	22	37	44	51	55	57	61	64	52	87
AV	0	60	63	66	68	70	72	73	68	58	48	39	33	28	26	26	28	31	37	43	47	50	52	54	47	
PK	0	93	93	93	93	94	94	94	94	94	90	80	77	82	89	92	89	87	91	92	91	93	91	94		94

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SOLAR RADIATION
LANGLEYS

LOGAN WASH
STATION LW02
AUG 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TL	PEAK
1	(OE)	0	0	0	0	8	12	19	39	47	70	74	50	78	58	39	8	8	4	0	0	0	0	0	512	78
2	0	0	0	0	0	8	27	43	58	66	74	78	81	78	78	66	50	39	8	0	0	0	0	0	752	81
3	0	0	0	0	0	8	23	39	54	70	74	78	78	78	27	66	16	8	12	0	0	0	0	0	628	78
4	0	0	0	0	0	4	19	39	54	66	74	78	81	78	78	66	54	39	19	4	0	0	0	0	752	81
5	0	0	0	0	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	(OE)	70	78	66	58	39	23	0	0	0	0	0	333	78
6	0	0	0	0	0	0	8	31	43	58	70	70	74	81	58	66	50	39	23	0	0	0	0	0	671	81
7	0	0	0	0	0	0	8	31	47	62	66	74	74	78	74	66	50	35	16	0	0	0	0	0	678	78
8	0	0	0	0	0	0	12	27	47	58	66	70	74	78	74	62	54	35	16	0	0	0	0	0	670	78
9	0	0	0	0	0	0	12	27	47	58	70	74	78	78	74	66	62	39	19	0	0	0	0	0	701	78
10	0	0	0	0	0	0	8	23	43	58	66	74	74	81	81	70	54	43	23	0	0	0	0	0	698	81
11	0	0	0	0	0	0	4	23	43	58	66	74	78	78	74	66	58	43	23	0	0	0	0	0	686	78
12	0	0	0	0	0	0	8	27	43	58	66	78	78	23	50	43	4	0	0	0	0	0	0	0	477	78
13	0	0	0	0	0	4	19	39	54	66	74	74	74	70	50	50	23	8	0	0	0	0	0	0	605	74
14	0	0	0	0	0	4	31	39	19	27	23	74	74	70	62	43	12	4	0	0	0	0	0	0	481	74
15	0	0	0	0	0	0	4	19	31	54	54	58	4	66	62	43	23	8	0	0	0	0	0	0	426	66
16	0	0	0	0	0	12	31	47	66	74	85	81	85	39	43	43	31	12	0	0	0	0	0	0	647	85
17	0	0	0	0	0	8	27	43	58	70	58	70	58	39	19	4	0	0	0	0	0	0	0	0	453	70
18	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	( )	)
19	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	(IM)	78	81	23	43	35	39	19	4	0	0	0	0	0	322	81
20	0	0	0	0	0	0	12	31	50	66	74	78	78	78	74	62	47	27	4	0	0	0	0	0	678	78
21	0	0	0	0	0	0	12	31	50	66	74	78	78	74	70	58	39	23	4	0	0	0	0	0	655	78
22	0	0	0	0	0	0	12	31	50	62	70	74	74	58	50	58	39	23	4	0	0	0	0	0	605	74
23	0	0	0	0	0	0	4	16	35	66	78	39	16	4	50	47	23	4	0	0	0	0	0	0	380	78
24	0	0	0	0	0	0	4	12	16	23	27	31	35	47	27	27	12	8	0	0	0	0	0	0	267	47
25	0	0	0	0	0	0	8	12	39	66	58	70	31	39	27	12	43	35	4	0	0	0	0	0	442	70
26	0	0	0	0	0	4	12	23	43	62	58	81	27	43	27	12	43	27	4	0	0	0	0	0	465	81
27	0	0	0	0	0	0	12	31	50	66	74	66	74	74	39	62	62	47	23	4	0	0	0	0	682	74
28	0	0	0	0	0	0	0	12	31	50	62	70	74	78	74	70	58	47	23	4	0	0	0	0	651	78
29	0	0	0	0	0	0	0	12	23	35	43	47	62	50	58	50	31	27	16	0	0	0	0	0	453	62
30	0	0	0	0	0	0	0	12	35	39	43	31	39	89	81	31	66	50	27	4	0	0	0	0	546	89
31	0	0	0	0	0	0	0	12	16	58	39	43	43	58	39	50	81	16	12	4	0	0	0	0	469	81
TL	0	0	0	0	0	58	326	748	1182	1608	1752	1957	1821	1872	1697	1496	1190	748	310	19	0	0	0	0	****	
PK	0	0	0	0	0	12	31	47	66	74	85	81	85	89	81	70	81	50	27	4	0	0	0	0		89

SOLAR RADIATION
LANGLEYS

LOGAN WASH
STATION LW02
SEPT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TL	PEAK
1	0	0	0	0	0	0	0	8	31	47	62	70	74	78	78	74	62	50	35	12	0	0	0	0	678	78
2	0	0	0	0	0	0	0	8	31	47	62	70	74	74	70	62	47	31	8	0	0	0	0	0	581	74
3	0	0	0	0	0	0	4	23	43	54	66	74	74	74	70	62	47	31	4	0	0	0	0	0	624	74
4	0	0	0	0	0	0	4	19	43	54	66	70	74	74	70	58	39	27	4	0	0	0	0	0	601	74
5	0	0	0	0	0	0	4	23	39	54	66	70	74	70	66	62	43	27	12	0	0	0	0	0	609	74
6	0	0	0	0	0	0	4	16	47	58	66	47	66	47	70	54	27	8	4	0	0	0	0	0	512	70
7	0	0	0	0	0	0	8	27	19	35	43	50	35	58	58	58	16	16	4	0	0	0	0	0	426	58
8	0	0	0	0	0	0	4	8	23	12	16	43	35	35	58	27	19	27	8	4	0	0	0	0	318	58
9	0	0	0	0	0	0	0	8	8	12	12	27	16	27	70	19	19	12	0	0	0	0	0	0	229	70
10	0	0	0	0	0	0	0	4	4	43	23	8	8	12	12	16	0	4	0	0	0	0	0	0	132	43
11	0	0	0	0	0	0	8	27	50	66	66	66	85	85	74	19	16	8	0	0	0	0	0	0	570	85
12	0	0	0	0	0	0	4	31	54	43	74	78	70	43	19	50	39	15	0	0	0	0	0	0	519	78
13	0	0	0	0	0	0	4	27	47	58	62	74	74	74	66	58	47	27	4	0	0	0	0	0	620	74
14	0	0	0	0	0	0	0	16	35	50	58	35	78	70	74	58	27	39	4	0	0	0	0	0	543	78
15	0	0	0	0	0	0	0	16	31	47	58	62	74	74	(RF)	(RF)	43	31	8	0	0	0	0	0	442	74
16	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
17	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
18	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
19	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	(RF)	( )	( )
20	0	0	0	0	0	0	0	12	35	50	66	70	74	74	74	66	50	39	12	0	0	0	0	0	620	74
21	0	0	0	0	0	0	0	4	23	43	58	66	74	74	74	70	58	43	23	0	0	0	0	0	608	74
22	0	0	0	0	0	0	0	8	31	47	62	70	74	74	74	70	58	43	27	4	0	0	0	0	639	74
23	0	0	0	0	0	0	0	8	(RF)	(RF)	(RF)	58	70	74	70	66	54	43	19	0	0	0	0	0	461	74
24	0	0	0	0	0	0	0	0	12	35	50	62	70	70	70	66	54	39	19	0	0	0	0	0	547	70
25	0	0	0	0	0	0	0	0	16	35	50	62	66	70	70	66	54	39	19	0	0	0	0	0	547	70
26	0	0	0	0	0	0	0	0	19	39	50	62	70	70	70	62	50	39	19	0	0	0	0	0	551	70
27	0	0	0	0	0	0	0	0	12	39	54	62	66	70	70	62	54	39	19	0	0	0	0	0	547	70
28	0	0	0	0	0	0	0	0	12	31	47	58	66	70	70	66	54	43	23	0	0	0	0	0	539	70
29	0	0	0	0	0	0	0	0	12	31	47	58	66	70	70	66	58	47	31	0	0	0	0	0	554	70
30	0	0	0	0	0	0	0	0	16	35	50	62	66	70	66	58	47	31	8	0	0	0	0	0	508	70
TL	0	0	0	0	0	0	43	291	690	1062	1333	1531	1666	1674	1628	1395	1081	795	314	19	0	0	0	0	****	
PK	0	0	0	0	0	0	8	31	54	66	74	78	85	85	78	74	62	50	35	12	0	0	0	0		85

SOLAR RADIATION
LANGLEYS

LOGAN WASH
STATION LW02
OCT 1980
OCCIDENTAL OIL SHALE INC.

HOUR (LOCAL STANDARD TIME)

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TL	PEAK
1	0	0	0	0	0	0	0	4	19	35	50	62	66	66	62	54	39	23	4	0	0	0	0	0	485	66
2	0	0	0	0	0	0	0	4	23	43	58	62	70	66	66	54	43	27	0	0	0	0	0	0	515	70
3	0	0	0	0	0	0	0	4	27	43	58	66	66	66	62	50	35	19	0	0	0	0	0	0	496	66
4	0	0	0	0	0	0	0	4	27	47	58	66	70	66	62	54	39	23	4	0	0	0	0	0	519	70
5	0	0	0	0	0	0	0	4	23	43	54	62	66	70	66	54	31	8	0	0	0	0	0	0	481	70
6	0	0	0	0	0	0	0	4	19	39	50	62	66	70	66	62	47	35	16	0	0	0	0	0	535	70
7	0	0	0	0	0	0	0	4	27	43	54	62	66	62	62	58	50	35	16	0	0	0	0	0	539	66
8	0	0	0	0	0	0	0	0	8	23	43	54	62	66	66	58	47	31	12	0	0	0	0	0	469	66
9	0	0	0	0	0	0	0	0	8	27	47	58	62	66	66	62	50	35	12	0	0	0	0	0	492	66
10	0	0	0	0	0	0	0	0	8	31	47	58	66	66	62	58	47	31	12	0	0	0	0	0	484	66
11	0	0	0	0	0	0	0	0	8	27	47	58	62	66	66	58	19	35	12	0	0	0	0	0	457	66
12	0	0	0	0	0	0	0	0	4	8	31	58	35	16	12	4	8	4	0	0	0	0	0	0	178	58
13	0	0	0	0	0	0	0	0	0	4	12	16	27	47	27	23	19	31	16	0	0	0	0	0	221	47
14	0	0	0	0	0	0	0	0	4	19	27	39	19	43	27	43	4	4	0	0	0	0	0	0	229	43
15	0	0	0	0	0	0	0	0	0	8	19	31	12	8	27	8	23	4	0	0	0	0	0	0	140	31
16	0	0	0	0	0	0	0	0	4	8	19	23	19	16	12	23	4	4	0	0	0	0	0	0	132	23
17	0	0	0	0	0	0	0	0	8	12	16	27	35	27	23	8	16	4	0	0	0	0	0	0	174	35
18	0	0	0	0	0	0	0	0	8	27	35	27	47	31	27	23	12	8	0	0	0	0	0	0	244	47
19	0	0	0	0	0	0	0	12	39	62	54	66	70	70	62	50	39	19	0	0	0	0	0	0	543	70
20	0	0	0	0	0	0	0	0	16	39	54	62	66	66	62	58	43	35	8	0	0	0	0	0	508	66
21	0	0	0	0	0	0	0	0	8	27	47	54	62	66	62	50	35	12	0	0	0	0	0	0	422	66
22	0	0	0	0	0	0	0	4	16	35	43	54	66	66	62	50	35	12	0	0	0	0	0	0	442	66
23	0	0	0	0	0	0	0	4	23	43	54	66	54	66	62	50	31	12	0	0	0	0	0	0	465	66
24	0	0	0	0	0	0	0	4	23	43	58	66	66	66	58	50	31	8	0	0	0	0	0	0	473	66
25	0	0	0	0	0	0	0	4	23	43	58	62	66	66	62	50	31	8	0	0	0	0	0	0	473	66
26	0	0	0	0	0	0	0	4	8	16	27	43	31	27	19	16	19	4	0	0	0	0	0	0	213	43
27	0	0	0	0	0	0	0	4	8	12	16	19	23	19	12	8	4	4	0	0	0	0	0	0	128	23
28	0	0	0	0	0	0	0	4	8	31	43	54	47	39	47	39	8	0	0	0	0	0	0	0	318	54
29	0	0	0	0	0	0	0	16	39	54	58	62	62	58	47	31	8	0	0	0	0	0	0	0	434	62
30	0	0	0	0	0	0	0	12	31	47	58	58	62	58	47	31	8	0	0	0	0	0	0	0	411	62
31	0	0	0	0	0	0	0	23	16	31	43	62	58	50	39	23	4	0	0	0	0	0	0	0	349	62
TL	0	0	0	0	0	0	0	117	481	965	1337	1620	1647	1632	1500	1264	826	473	108	0	0	0	0	0	****	
PK	0	0	0	0	0	0	0	23	39	62	58	66	70	70	66	62	50	35	16	0	0	0	0	0		70

MONTHLY FREQUENCY TABLES

STATION LW01

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL

L-W SHALE OIL PROJECT

STATION LW01 PERIOD(1/01/80 TO 1/31/80)

WIND SPEED (METERS/SEC)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX	0	0	5	5	8	3	3	3	3	3	3	3	3	5	6	2	0	
GT 11. :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 :	0
8. - 11. :	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0 :	1
5. - 8. :	0	0	1	1	2	0	0	0	0	0	0	0	0	3	3	0	0 :	10
3. - 5. :	0	0	4	4	3	2	1	1	1	1	1	1	1	16	11	0	0 :	47
1. - 3. :	0	0	3	13	14	36	62	12	13	12	5	10	18	46	13	5	0 :	262
LT 1. :	0	1	0	3	8	20	13	12	3	2	6	4	16	35	10	0	0 :	133
TOTAL :	0	1	8	21	28	58	76	25	17	15	12	15	35	100	37	5	0	453
PERCENT	0.	0.	2.	5.	6.	13.	17.	6.	4.	3.	3.	3.	8.	22.	8.	1.	0.	100.

0 = NO OBSERVATIONS

(03/07/80-RPI)

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL — L-W SHALE OIL PROJECT

STATION LW01 PERIOD(2/01/80 TO 2/29/80)

WIND SPEED METERS/SEC	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX	2	1	5	5	5	5	2	2	2	2	2	2	3	3	4	2	4	
GT 11.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. - 11.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. - 8.	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	4
3. - 5.	0	0	6	6	0	1	0	0	0	0	0	0	2	2	5	0	4	26
1. - 3.	1	6	13	10	26	80	145	20	12	13	10	21	44	79	26	9	12	527
LT 1.	0	3	1	1	8	13	19	10	2	4	8	9	14	15	4	2	1	114
TOTAL	1	9	21	18	35	95	164	30	14	17	18	30	60	96	35	11	17	671
PERCENT	0.	1.	3.	3.	5.	14.	24.	4.	2.	3.	3.	4.	9.	14.	5.	2.	3.	100.

0 = NO OBSERVATIONS

(11/11/80-RPI)

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL L-W SHALE OIL PROJECT

STATION LW01 PERIOD(3/01/80 TO 3/31/80)

WIND SPEED METERS/SEC	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX	0	2	5	5	6	5	3	3	2	3	3	2	3	6	5	3	3	
GT 11.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. - 11.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. - 8.	0	0	1	2	4	3	0	0	0	0	0	0	0	5	2	0	0	17
3. - 5.	0	0	3	6	7	3	3	1	0	3	1	0	4	27	11	1	1	71
1. - 3.	0	3	4	18	15	47	61	21	12	12	12	17	39	85	21	5	3	375
LT 1.	0	0	1	0	3	10	11	6	2	2	2	2	6	6	3	1	14	69
TOTAL	0	3	9	26	29	63	75	28	14	17	15	19	49	123	37	7	18	532
PERCENT	0.	1.	2.	5.	5.	12.	14.	5.	3.	3.	3.	4.	9.	23.	7.	1.	3.	100.

0 = NO OBSERVATIONS

(11/11/80-RPI)

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL

L-W SHALE OIL PROJECT

STATION LW01 PERIOD(4/01/80 TO 4/30/80)

WIND SPEED (METERS/SEC)	WIND DIRECTION: N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX	2	3	4	4	5	5	4	3	8	3	3	2	4	6	5	8	1	
GT 11.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. - 11.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	3
5. - 8.	0	0	0	0	1	2	0	0	0	0	0	0	0	9	2	0	0	14
3. - 5.	0	1	8	7	14	8	4	2	1	1	1	0	5	24	17	3	0	96
1. - 3.	1	1	2	21	37	73	96	33	22	19	8	14	25	80	35	7	16	490
LT 1.	0	0	0	0	3	0	3	2	3	0	2	0	1	1	0	0	0	15
TOTAL	1	2	10	28	55	83	103	37	27	20	11	14	31	114	54	12	16	618
PERCENT	0.	0.	2.	5.	9.	13.	17.	6.	4.	3.	2.	2.	5.	18.	9.	2.	3.	100.

0 = NO OBSERVATIONS

(11/11/80-RPI)

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL — L-W SHALE OIL PROJECT

STATION LW01 PERIOD(5/01/80 TO 5/31/80)

WIND SPEED (METERS/SEC)		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR		TOTAL
MAX		2	2	4	3	4	3	3	2	3	2	2	3	5	8	9	8	0		
GT 11.	:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	:	0
8. - 11.	:	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	:	5
5. - 8.	:	0	0	0	0	0	0	0	0	0	0	0	0	1	29	17	1	0	:	48
3. - 5.	:	0	0	1	1	3	1	2	0	1	0	0	1	3	50	33	0	0	:	96
1. - 3.	:	1	2	5	16	40	104	85	17	15	11	13	12	39	112	50	7	0	:	529
LT 1.	:	0	0	0	0	6	13	17	4	3	0	1	1	4	8	2	0	0	:	59
TOTAL	:	1	2	6	17	49	118	104	21	19	11	14	14	47	201	104	9	0		737
PERCENT		0.	0.	1.	2.	7.	16.	14.	3.	3.	1.	2.	2.	6.	27.	14.	1.	0.		100.

0 = NO OBSERVATIONS

(11/11/80-RPI)

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL — L-W SHALE OIL PROJECT

STATION LW01 PERIOD(6/01/80 TO 6/30/80)

		WIND DIRECTION																
WIND SPEED METERS/SEC	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX	0	2	4	4	3	4	8	2	2	2	1	2	8	8	8	3	0	
GT 11. :	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 :	0
8. - 11. :	0	0	0	0	0	0	1	0	0	0	0	0	2	2	1	0	0 :	6
5. - 8. :	0	0	0	0	0	0	0	0	0	0	0	0	0	36	39	0	0 :	75
3. - 5. :	0	0	1	4	2	6	0	0	0	0	0	0	2	78	35	2	0 :	130
1. - 3. :	0	2	4	17	81	96	105	20	15	6	4	3	27	82	35	3	0 :	500
LT 1. :	0	0	1	0	1	2	0	1	1	0	1	0	1	1	0	0	0 :	9
TOTAL :	0	2	6	21	84	104	106	21	16	6	5	3	32	199	110	5	0	720
PERCENT	0.	0.	1.	3.	12.	14.	15.	3.	2.	1.	1.	0.	4.	28.	15.	1.	0.	100.

0 = NO OBSERVATIONS

(11/11/80-RPI)

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL

L-W SHALE OIL PROJECT

STATION LW01 PERIOD(7/01/80 TO 7/31/80)

WIND SPEED (METERS/SEC)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX	0	2	2	3	4	5	3	3	2	1	2	2	5	5	8	3	0	
GT 11.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. - 11.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
5. - 8.	0	0	0	0	0	1	0	0	0	0	0	0	1	3	3	0	0	8
3. - 5.	0	0	0	4	11	14	5	1	0	0	0	0	5	50	17	1	0	108
1. - 3.	0	2	10	14	67	126	122	23	7	2	1	5	28	121	44	6	0	578
LT 1.	0	0	0	1	3	5	17	5	0	1	0	4	2	8	2	0	0	48
TOTAL	0	2	10	19	81	146	144	29	7	3	1	9	36	182	68	7	0	744
PERCENT	0.	0.	1.	3.	11.	20.	19.	4.	1.	0.	0.	1.	5.	24.	9.	1.	0.	100.

0 = NO OBSERVATIONS

(11/11/80-RPI)

QUARTERLY FREQUENCY TABLES

STATION LW01

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL L-W SHALE OIL PROJECT

STATION LW01 PERIOD(12/01/79 TO 2/29/80)

WIND SPEED METERS/SEC		WIND DIRECTION																	
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX		2	1	5	8	8	5	3	3	3	3	3	3	3	5	6	2	4	
GT 11.	:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 :	0
8. - 11.	:	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0 :	3
5. - 8.	:	0	0	2	3	3	1	0	0	0	0	0	0	0	3	3	0	0 :	15
3. - 5.	:	0	0	11	22	13	9	1	2	2	1	1	1	3	21	16	0	4 :	107
1. - 3.	:	1	6	20	30	46	152	431	66	41	29	25	41	83	170	52	15	12 :	1220
LT 1.	:	0	4	2	5	22	37	56	35	11	9	20	20	49	74	24	4	1 :	373
TOTAL	:	1	10	35	61	86	199	488	103	54	39	46	62	135	268	95	19	17	1718
PERCENT		0.	1.	2.	4.	5.	12.	28.	6.	3.	2.	3.	4.	8.	16.	6.	1.	1.	100.

0 = NO OBSERVATIONS

(11/12/80-RPI)

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL — L-W SHALE OIL PROJECT

STATION LW01 PERIOD(3/01/80 TO 5/31/80)

WIND SPEED METERS/SEC	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX	2	3	5	5	6	5	4	3	8	3	3	3	5	8	9	8	3	
GT 11.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. - 11.	0	0	0	0	0	0	0	0	1	0	0	0	0	2	2	3	0	8
5. - 8.	0	0	1	2	5	5	0	0	0	0	0	0	1	43	21	1	0	79
3. - 5.	0	1	12	14	24	12	9	3	2	4	2	1	12	101	61	4	1	263
1. - 3.	2	6	11	55	92	224	242	71	49	42	33	43	103	277	106	19	19	1394
LT 1.	0	0	1	0	12	23	31	12	8	2	5	3	11	15	5	1	14	143
TOTAL	2	7	25	71	133	264	282	86	60	48	40	47	127	438	195	28	34	1887
PERCENT	0.	0.	1.	4.	7.	14.	15.	5.	3.	3.	2.	2.	7.	23.	10.	1.	2.	100.

0 = NO OBSERVATIONS

(11/12/80-RPI)

FREQUENCY TABLE OF WIND SPEED BY DIRECTION

10 METER LEVEL — L-W SHALE OIL PROJECT

STATION LW01 PERIOD(6/01/80 TO 8/31/80)

WIND SPEED METERS/SEC		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VAR	TOTAL
MAX		0	5	4	4	8	5	8	4	3	2	2	2	8	8	8	3	0	
GT 11.	:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 :	0
8. - 11.	:	0	0	0	0	1	0	1	0	0	0	0	0	2	7	7	0	0 :	18
5. - 8.	:	0	1	0	0	1	2	0	0	0	0	0	0	2	55	54	0	0 :	115
3. - 5.	:	0	0	2	9	29	27	7	3	2	0	0	0	10	205	73	5	0 :	372
1. - 3.	:	0	8	21	42	206	323	351	83	40	15	10	10	69	299	117	14	0 :	1608
LT 1.	:	1	0	3	1	5	11	22	14	4	1	1	5	5	18	3	1	0 :	95
TOTAL	:	1	9	26	52	242	363	381	100	46	16	11	15	88	584	254	20	0	2208
PERCENT		0.	0.	1.	2.	11.	16.	17.	5.	2.	1.	0.	1.	4.	26.	12.	1.	0.	100.

0 = NO OBSERVATIONS

(11/12/80-RPI)

WATER

QUALITY DATA

GROUNDWATER QUALITY FOR ALLUVIAL WELLS

January-October 1980

LOGAN WASH
WATER QUALITY PARAMETERS
ALLUVIAL WELLS
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	CA (MG/L)	B (MG/L)	V (MG/L)	CU (MG/L)	MOLY (MG/L)	LI (MG/L)	ZN (MG/L)	AL (MG/L)	BA (MG/L)	SR (MG/L)	NH3 (MG/L)
LWA022	80	1	17	270.0	.400	-.050	-.020	.030	.100	-.020	-.100	-.500	9.00	.50
		2	13	180.0	.200	-.050	-.010	.040	.100	.010	-.100	.500	9.30	.05
		3	13	240.0	.300	-.050	.020	.030	.100	-.020	-.100	-.500	6.60	-.04
		4	21	270.0	.300	-.050	.020	.070	.100	.020	-.100	.500	.60	.09
		5	22	190.0	.400	-.050	.040	.100	.100	.030	-.100	.800	3.80	.20
		6	19	240.0	.400	-.050	.060	.100	.100	.020	-.100	-.500	5.60	-.04
		7	24	220.0	.300	-.050	-.020	.100	.100	-.020	-.100	-.500	8.60	-.04
		8	20	210.0	.400	-.050	.020	.100	.200	-.020	-.100	-.500	5.40	.70
		10	22	230.0	.600	-.050	.060	.100	.100	-.020	-.100	-.500	5.20	-.04
LWA101	80	1	17	150.0	2.000	-.050	-.020	.400	.100	-.020	-.100	-.500	9.20	-.04
		2	13	130.0	2.200	-.050	-.010	.400	.100	.020	.200	.500	11.00	-.04
		3	13	160.0	1.500	-.050	.020	.300	.100	.020	-.100	.500	7.60	.20
		4	21	240.0	1.000	-.050	.030	.400	.100	.020	-.100	.500	.70	2.00
		5	22	140.0	.800	-.050	.080	.200	.090	.030	-.100	.500	3.80	.40
		6	19	160.0	1.300	-.050	.040	.600	.100	.010	-.100	-.500	4.70	.20
		7	24	69.0	1.300	-.050	-.020	.600	.100	-.020	-.100	-.500	7.20	1.00
		8	20	150.0	1.500	-.050	.030	.700	.100	-.020	-.100	-.500	5.20	2.60
		10	22	140.0	2.100	-.050	.050	.700	.100	-.020	-.100	-.500	5.40	.10
LWA102	80	1	9	130.0	.400	-.050	-.020	.200	.200	.020	-.100	-.500	6.30	-.04
		2	7	110.0	.300	-.050	-.020	.200	.200	.020	-.100	-.500	6.00	-.04
		3	6	160.0	.500	-.050	.020	.200	.100	-.020	-.100	.500	3.60	-.04
		4	10	190.0	.300	-.050	-.020	.200	.200	.030	-.100	.500	.30	-.04
		5	8	200.0	.100	-.050	.040	.200	.200	.030	-.100	.700	3.50	-.04
		6	3	140.0	.300	-.050	.060	.200	.100	.040	-.100	-.500	4.20	-.04
		7	3	160.0	.500	-.050	-.020	.400	.200	-.010	-.100	-.500	3.50	.05
		8	6	150.0	.400	-.050	-.020	.200	.200	-.020	-.100	-.500	4.80	.08
		9	4	140.0	.400	-.050	-.020	.300	.200	-.020	-.100	-.500	2.40	.05
		10	2	180.0	.400	-.050	.020	.200	.200	.060	-.100	-.500	2.50	.20
LWA103	80	1	16	200.0	.200	-.050	-.020	.090	.100	.020	.400	-.500	5.00	.20
		4	23	270.0	.200	-.050	.020	.070	.090	.020	-.100	-.500	.40	.10
		7	23	230.0	.200	-.050	-.020	.100	.100	-.020	-.100	-.500	6.50	.05
		10	16	270.0	.300	-.050	-.020	.100	.100	-.020	-.100	-.500	6.30	-.04
LWA104	80	1	16	340.0	.900	.010	-.020	-.010	.200	.030	-.100	.500	8.50	-.04
		7	23	74.0	.500	-.050	-.020	-.010	.200	-.020	-.100	-.500	5.40	1.40
		10	16	150.0	.300	-.050	-.020	-.010	.090	-.020	-.100	-.500	3.60	.07
/LWA112	80	5	28	64.0	1.700	-.050	.100	.800	.100	.080	-.100	-.500	1.90	-.04
		6	19	98.0	2.000	-.050	.030	.700	.100	.010	-.100	-.500	3.10	1.10

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
ALLUVIAL WELLS
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	CA (MG/L)	B (MG/L)	V (MG/L)	CU (MG/L)	MOLY (MG/L)	LI (MG/L)	ZN (MG/L)	AL (MG/L)	BA (MG/L)	SR (MG/L)	NH3 (MG/L)
LWA112	80	7	24	120.0	1.700	-.050	-.020	.800	.100	-.020	-.100	-.500	5.30	.40
		8	19	72.0	1.400	-.050	-.020	.600	.200	-.020	-.100	-.500	3.20	5.80
		10	22	59.0	1.800	-.050	.030	.500	.100	-.020	-.100	-.500	3.00	9.00
LWA115	80	1	17	150.0	.100	-.050	-.020	.060	.100	.020	-.100	-.500	6.30	.08
		2	13	120.0	.400	-.050	-.010	.060	.100	.020	.400	-.500	7.20	.05
		3	13	280.0	.400	-.050	.020	.040	.100	.020	-.100	.500	9.40	.20
		7	24	220.0	.400	-.050	-.020	.090	.200	-.020	-.100	-.500	8.90	-.04
		8	20	240.0	.700	-.050	.030	.080	.200	.020	-.100	-.500	6.30	.05
		10	22	160.0	.400	-.050	.050	.100	.100	-.020	-.100	-.500	4.30	.10
LWA121	80	5	8	160.0	.200	-.050	-.010	.030	.100	.030	-.100	.700	3.00	-.04
		7	3	110.0	.300	-.050	.030	.200	.100	.010	-.100	-.500	3.00	.10
		8	6	120.0	.300	-.050	-.020	.100	.100	.020	-.100	-.500	4.50	.20
		9	4	120.0	.200	-.050	.020	.100	.100	-.020	-.100	-.500	2.30	1.50

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
ALLUVIAL WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU
LWA022	80	1	17					1.900	170.0		15.00	2.00				75.0
		2	13			.30		.100	140.0		18.00	21.00	.35	6.50		65.0
		3	13			2.70		-.020	130.0		56.00	19.00	.40	.80		68.0
		4	21			.70		.030	180.0		6.90	14.00		.90		47.0
		5	22			1.30		.020	150.0		24.00	4.70		.60		62.0
		6	19			1.10		.030	160.0							32.0
		7	24			1.00		.020	180.0							38.0
		8	20			1.30		.030	180.0		18.00	9.50		.50		32.0
		10	22			.07		.030	260.0			29.00	.94			49.0
LWA101	80	1	17					.100	190.0		18.00	53.00	.33			58.0
		2	13			2.20		.090	190.0		62.00	168.00	.66	4.70		23.0
		3	13			3.90		-.020	160.0		21.00	8.00				41.0
		4	21			4.20		.030	210.0		8.00	14.00		1.60		96.0
		5	22			2.70		.020	160.0		28.00	10.00	1.20	.50		34.0
		6	19			2.50		.030	140.0							73.0
		7	24			1.10		-.020	120.0							47.0
		8	20			11.00		.020	170.0		13.00	20.00	.19			33.0
		10	22			.30		.030	220.0			8.30				50.0
LWA102	80	1	9	-1.0	-1.00	-1.00		-.020	96.0	5.0	15.00	69.00	.30		-.010	23.0
		2	7			.07		.020	91.0		8.90	12.00				16.0
		3	6			.60		-.020	79.0		9.40	22.00	1.40			58.0
		4	10			.70		.030	95.0		46.00	21.00	4.50	1.80		18.0
		5	8			1.10		-.020	89.0		13.00	22.00	.62	1.20		34.0
		6	3			.40		.020	80.0		14.00	11.00		1.10		1.0
		7	3			.30		.030	92.0		21.00	26.00				390.0
		8	6			.80		-.020	87.0		14.80	22.80	2.10	.60		36.0
		9	4			.10		.030	87.0		15.00	24.00	.45	1.10		53.0
		10	2			.60		.030	89.0			19.00	.36			41.0
LWA103	80	1	16					1.700	120.0		29.00	13.00	.73			140.0
		4	23			.10		.020	130.0		32.00	33.00	1.10	.80		160.0
		7	23			.07		-.020	120.0		36.00	10.90	.80			62.0
		10	16			.30		.020	120.0			16.00				140.0
LWA104	80	1	16					57.000	480.0		23.00	19.00	.49			98.0
		7	23			2.00		.020	250.0		7.20	6.60		.40		58.0

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
ALLUVIAL WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU	
LWA104	80	10	16			.60		-.020	150.0			14.00					130.0
LWA112	80	5	28			1.50		.020	82.0		13.00	9.60		.90			16.0
		6	19			3.20		.020	100.0								48.0
		7	24			6.80		-.020	100.0								160.0
		8	19			6.70		.020	120.0		13.00	21.00	1.00	.40			180.0
		10	22			12.00		.030	160.0			9.90					2,000.0
LWA115	80	1	17			.00		.070	160.0		4.60	11.00					34.0
		2	13			.10		.100	140.0		22.00	7.00		1.30			48.0
		3	13			1.50		-.020	190.0		48.00	11.00	.64				22.0
		7	24			.40		-.020	170.0								88.0
		8	20			1.60		.020	220.0		50.00	11.00	1.00	.10			160.0
		10	22			.10		.030	210.0			17.00					250.0
LWA121	80	5	8			.40		-.020	91.0		12.00	11.00		1.50			56.0
		7	3			.30		.030	96.0		59.00	19.00					78.0
		8	6			1.10		-.020	98.0		12.40	8.90		2.00			83.0
		9	4			1.70		.050	96.0		17.00	15.00	.84	1.50			60.0

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
ALLUVIAL WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWA022	80	1	17				2100.00	56.00	.70	62.00		500.0	13.00	-.020	
		2	13	-1.00			1500.00	42.00	.80	59.00		410.0	7.00	-.020	
		3	13			.010	1400.00	76.00	1.00	120.00		350.0	17.00	-.020	
		4	21			.020	1200.00	78.00	.60	81.00		240.0	7.40	-.020	
		5	22			.090	1100.00	91.00	.80	100.00		220.0	7.70	-.020	
		6	19			-.010	1200.00	32.00	.90	58.00		250.0	7.80	-.020	
		7	24			.010	1500.00	29.00	1.00	66.00		290.0	13.00	-.020	
		8	20			.010	1500.00	23.00	1.40	58.00		280.0	9.20	-.050	
		10	22			.010	1800.00	29.00	.20	51.00		340.0	20.00	-.020	2.20
LWA101	80	1	17				1300.00	110.00	.70	170.00		280.0	11.00	-.020	
		2	13	-1.00			1200.00	72.00	.80	170.00		320.0	10.00	-.020	
		3	13			.040	1200.00	86.00	1.00	190.00		310.0	9.90	-.020	
		4	21			.050	1300.00	100.00	.40	230.00		290.0	9.50	-.020	
		5	22			.040	1100.00	120.00	.70	230.00		230.0	7.50	-.020	
		6	19			.010	940.00	38.00	1.00	140.00		280.0	7.90	-.020	
		7	24			.010	930.00	45.00	1.10	120.00		270.0	7.30	-.020	
		8	20			.020	1200.00	52.00	1.80	170.00		310.0	8.30	-.020	
		10	22			.020	1400.00	70.00	.20	180.00		310.0	8.60	-.020	1.60
LWA102	80	1	9	-1.00	-.020	-.020	890.00	16.00	1.40	3.00	14.0	230.0	18.00	-.020	
		2	7	-1.00		-.002	890.00	21.00	1.50	16.00		220.0	18.00	-.020	
		3	6			-.020	910.00	30.00	1.60	11.00		270.0	17.00	-.020	
		4	10			.020	890.00	78.00	1.50	28.00		200.0	16.00	-.020	
		5	8			.050	900.00	56.00	1.50	13.00		210.0	17.00	-.020	
		6	3			.080	860.00	61.00	1.30	8.00		210.0	16.00	-.020	
		7	3			-.010	900.00	14.00	2.20	8.60		230.0	18.00	-.020	
		8	6			-.010	920.00	16.00	1.30	6.70		220.0	16.00	-.020	
		9	4			-.010	920.00	12.00	2.90	11.00		230.0	17.00	-.020	
		10	2			-.010	920.00	13.00	1.30	8.90		220.0	17.00	-.020	.60
LWA103	80	1	16				1200.00	35.00	1.10	130.00		250.0	7.30	-.020	
		4	23			.040	1100.00	50.00	.90	31.00		220.0	5.50	-.020	
		7	23			.010	1400.00	9.60	1.40	10.00		260.0	4.40	-.020	
		10	16			.010	1300.00	10.00	1.40	6.00		260.0	4.40	.300	1.30
LWA104	80	1	16				6400.00	73.00	.60	330.00		1800.0	8.00	-.020	
		7	23			.050	3700.00	29.00	.80	-.50		1100.0	4.40	-.020	
		10	16			.020	1300.00	18.00	.90	-.50		410.0	2.50	-.020	.70

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
ALLUVIAL WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWA112	80	5	28			.030	670.00	91.00	1.00	98.00		190.0	8.40	-.020	
		6	19			-.010	660.00	43.00	1.20	34.00		240.0	11.00	-.020	
		7	24			-.010	850.00	55.00	1.10	2.40		260.0	11.00	-.020	
		8	19			-.010	910.00	55.00	1.60	1.30		280.0	12.00	-.020	
		10	22			-.010	890.00	64.00	.30	-.50		260.0	11.00	.020	2.40
LWA115	80	1	17				1200.00	23.00	.80	4.00		300.0	6.70	-.020	
		2	13	-1.00		.000	1200.00	25.00	.90	-.10		340.0	5.20	-.020	
		3	13			.020	1800.00	63.00	1.00	61.00		380.0	8.00	-.020	
		7	24			.020	1600.00	17.00	1.00	55.00		340.0	5.20	-.020	
		8	20			.030	1900.00	14.00	.50	66.00		490.0	5.50	-.020	
		10	22			.020	1400.00	15.00	-.10	32.00		340.0	4.90	-.020	1.60
LWA121	80	5	8			.030	640.00	45.00	.90	12.00		160.0	7.00	-.020	
		7	3			-.010	650.00	11.00	2.40	11.00		160.0	7.20	-.020	
		8	6			-.010	700.00	16.00	.80	18.00		170.0	4.40	-.020	
		9	4			-.010	700.00	12.00	2.10	12.00		180.0	5.40	-.020	

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
ALLUVIAL WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	TURBIDITY NTU	CHEM O2 DEMAND (MG/L)	PHEN (MG/L)	BOD5 (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWA022	80	1	17	400.0	400.0	-1.0	3600.0	110.0	75.0	1.0	.002	130.00	-1.00	
		2	13	350.0	350.0	-1.0	2900.0	130.0	65.0	25.0	-.001	-1.00	16.00	7.00
		3	13	490.0	490.0	-1.0	2800.0	270.0	68.0	5.0	.004	12.00	1.00	18.00
		4	21	470.0	470.0	-1.0	2400.0	190.0	47.0	2.0	-.001	2.00	10.00	40.00
		5	22	430.0	390.0	40.0	2300.0	150.0	62.0	2.0	-.001	17.00	1.00	
		6	19	430.0	430.0	-1.0	2400.0	80.0	32.0	40.0	.003	8.00	5.00	
		7	24	480.0	480.0	-1.0	2900.0	160.0	38.0	30.0	-.001	40.00	4.00	
		8	20	450.0	450.0	-1.0	2700.0	43.0	32.0	30.0	.030	32.00	2.00	
		10	22	540.0	540.0	-1.0	3400.0	400.0	49.0	80.0	.009	2.00	3.00	45.00
LWA101	80	1	17	430.0	430.0	-1.0	2700.0	200.0	58.0	38.0	.005	37.00	20.00	
		2	13	400.0	400.0	-1.0	2600.0	39.0	23.0	68.0	-.001	5.00	4.00	10.00
		3	13	440.0	440.0	-1.0	2600.0	32.0	41.0	14.0	-.001	15.00	8.00	22.00
		4	21	430.0	430.0	-1.0	2700.0	160.0	96.0	54.0	-.001	10.00	16.00	60.00
		5	22	420.0	420.0	-1.0	2400.0	34.0	34.0	27.0	-.001	19.00	6.00	
		6	19	390.0	390.0	-1.0	2100.0	240.0	73.0	20.0	.006	1.00	7.00	
		7	24	390.0	390.0	-1.0	2100.0	99.0	47.0	56.0	-.001	5.00	9.00	
		8	20	380.0	380.0	-1.0	2500.0	120.0	33.0	64.0	.040	60.00	2.00	
		10	22	420.0	420.0	-1.0	2700.0	220.0	50.0	60.0	.010	16.00	4.00	56.00
LWA102	80	1	9	340.0	340.0	-1.0	1700.0	38.0	23.0	4.0	-.001	50.00	11.00	2.00
		2	7	360.0	360.0	-1.0	1700.0	5.0	16.0	2.0	.002	5.00	9.00	6.00
		3	6	340.0	340.0	-1.0	1700.0	120.0	58.0	26.0	-.001	5.00	24.00	7.00
		4	10	350.0	300.0	50.0	1700.0	17.0	18.0	13.0	.001	34.00	11.00	10.00
		5	8	350.0	350.0	-1.0	1800.0	140.0	34.0	5.0	.003	10.00	12.00	
		6	3	360.0	360.0	-1.0	1700.0	1.0	1.0	2.0	-.001	17.00	4.00	
		7	3	350.0	350.0	-1.0	1700.0	120.0	390.0	6.0	-.001	55.00	4.00	
		8	6	360.0	360.0	-1.0	1800.0	94.0	36.0	6.0	.001	29.00	3.00	
		9	4	370.0	370.0	-1.0	1800.0	210.0	53.0	5.0	.010	5.00	4.00	
		10	2	350.0	350.0	-1.0	1800.0	97.0	41.0	16.0	-.001	9.00	2.00	42.00
LWA103	80	1	16	350.0	350.0	-1.0	2200.0	210.0	140.0	2.0	.003	19.00	5.00	
		4	23	420.0	420.0	-1.0	2200.0	960.0	160.0	2.0	-.001	1.00	9.00	
		7	23	400.0	400.0	-1.0	2500.0	380.0	62.0	24.0	-.001	26.00	1.00	
		10	16	400.0	400.0	-1.0	2400.0	860.0	140.0	20.0	-.001	57.00	3.00	50.00
LWA104	80	1	16	240.0	240.0	-1.0	10000.0	250.0	98.0	52.0	.013	35.00	4.00	
		7	23	390.0	390.0	-1.0	6200.0	210.0	58.0	34.0	-.001	19.00	-1.00	

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
ALLUVIAL WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	TURBIDITY NTU	CHEM O2 DEMAND (MG/L)	PHEN (MG/L)	BOD5 (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWA104	80	10	16	390.0	390.0	-1.0	2300.0	2.0	130.0	8.0	-.001	51.00	-1.00	45.00
LWA112	80	5	28	310.0	290.0	20.0	1400.0	20.0	16.0	51.0	.015	10.00	1.00	
		6	19	320.0	290.0	28.0	1400.0	76.0	48.0	40.0	.005	40.00	9.00	
		7	24	350.0	300.0	48.0	1700.0	750.0	160.0	160.0	-.001	14.00	14.00	
		8	19	330.0	290.0	44.0	1800.0	1,600.0	180.0	120.0	.040	190.00	-1.00	
		10	22	380.0	380.0	-1.0	1900.0	18,000.0	2,000.0	140.0	.020	290.00	5.00	110.00
LWA115	80	1	17	530.0	530.0	-1.0	2600.0	94.0	34.0	-1.0	-.001	32.00	19.00	
		2	13	540.0	540.0	-1.0	2200.0	140.0	48.0	35.0	-.001	.10	10.00	3.00
		3	13	530.0	530.0	-1.0	3700.0	7.0	22.0	-1.0	.025	20.00	1.00	8.00
		7	24	530.0	530.0	-1.0	3100.0	400.0	88.0	20.0	-.001	10.00	1.00	
		8	20	510.0	510.0	-1.0	3500.0	450.0	160.0	21.0	.040	54.00	3.00	
		10	22	550.0	550.0	-1.0	2800.0	920.0	250.0	24.0	.008	3.00	4.00	44.00
LWA121	80	5	8	490.0	490.0	-1.0	2000.0	260.0	56.0	2.0	-.001	12.00	8.00	
		7	3	450.0	450.0	-1.0	1400.0	430.0	78.0	14.0	-.001	41.00	2.00	
		8	6	450.0	450.0	-1.0	1500.0	490.0	83.0	14.0	-.001	60.00	1.00	
		9	4	470.0	470.0	-1.0	1500.0	2,700.0	60.0	8.0	.020	31.00	14.00	

NOTE: - INDICATES LESS THEN

GROUNDWATER QUALITY FOR DEEP WELLS

January-October 1980

LOGAN WASH
WATER QUALITY PARAMETERS
DEEP WELLS
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	CA (MG/L)	B (MG/L)	V (MG/L)	CU (MG/L)	MOLY (MG/L)	LI (MG/L)	ZN (MG/L)	AL (MG/L)	BA (MG/L)	SR (MG/L)	NH3 (MG/L)
LWD032	80	9	16	48.0	.400	-.050	.020	.020	-.050	-.020	-.100	-.500	3.70	-.04
LWD046	80	9	18	15.0	.100	-.050	-.020	-.010	.090	-.020	-.100	-.500	3.50	-.04
LWD047	80	9	18	63.0	-.100	-.050	-.020	.010	-.050	-.020	-.100	-.500	5.30	-.04
LWD106	80	7	17	46.0	.200	-.050	-.020	.050	.070	-.010	-.100	-.500	13.00	.05
		9	16	66.0	.200	-.050	.020	.080	.080	-.020	-.100	-.500	10.00	.20
LWD108	80	1	10	57.0	2.500	-.050	-.020	.020	.700	-.020	-.100	-.500	7.20	1.70
		2	14	53.0	.300	-.050	-.010	.070	.700	.010	-.100	-.500	9.30	1.60
		3	20	70.0	15.000	-.050	.020	.200	.500	.040	-.100	-.500	3.30	1.70
		4	16	100.0	14.000	-.050	-.020	.600	.500	.030	-.100	-.500	.60	1.70
		6	19	97.0	8.200	-.050	.050	.400	.700	.040	-.100	-.500	6.30	1.90
		7	24	74.0	8.500	-.050	-.020	.090	.700	-.020	-.100	-.500	9.20	1.00
		8	20	71.0	9.200	-.020	.030	.050	.900	-.020	-.100	-.500	5.90	.60
		10	22	65.0	13.000	-.050	.030	.200	.700	-.020	-.100	-.500	4.80	.60
LWD116	80	9	16	70.0	-.100	-.050	.020	.020	-.050	-.020	-.100	-.500	1.20	.04

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
DEEP WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU	
LWD032	80	9	16			.60		.020	15.0								41.0
LWD046	80	9	18			.60		-.020	14.0								42.0
LWD047	80	9	18			-.10		-.020	27.0								57.0
LWD106	80	7	17			6.60		-.020	28.0								22.0
		9	16			.30		-.020	45.0								39.0
LWD108	80	1	10	-1.0	-1.00	3.20		.070	62.0	137.0	6.00	62.00		.00	-.010		34.0
		2	14			3.40		-.020	63.0		5.00	4.00		7.10			16.0
		3	20			3.20		-.020	48.0		22.00			.30			23.0
		4	16			5.10		.020	83.0								14.0
		6	19			1.90		-.020	66.0								25.0
		7	24			1.40		.020	64.0								26.0
		8	20			2.00		.020	69.0								120.0
		10	22			.60		.050	76.0								46.0
LWD116	80	9	16			.80		-.020	21.0	-.5							76.0

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
DEEP WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWD032	80	9	16			-.010	120.00	6.60	.90	-.50		83.0	.70	-.020	
LWD046	80	9	18			-.010	180.00	1.60	1.10	-.50		140.0	.80	-.020	
LWD047	80	9	18			-.010	200.00	2.70	.70	.70		110.0	.80	-.020	
LWD106	80	7	17			-.010	260.00	10.00	.30	6.30		140.0	3.30	-.020	
		9	16			-.010	380.00	4.40	.80	-.50		140.0	.80	-.020	
LWD108	80	1	10	3.90	-.020	-.020	720.00	86.00	7.10	-.10		620.0	4.60	-.020	
		2	14	-1.00	-.020	-.020	890.00	100.00	7.90	-.10		750.0	5.00	.020	
		3	20			-.010	850.00	140.00	8.10	21.00		610.0	6.80	.020	
		4	16			.010	890.00	110.00	8.40	15.00		630.0	5.60	.020	
		6	19			-.010	910.00	50.00	5.60	6.70		620.0	5.00	.020	
		7	24			.010	900.00	51.00	6.20	.90		580.0	3.10	-.020	
		8	20			.030	880.00	47.00	6.20	1.30		610.0	3.60	-.020	
		10	22			.010	920.00	14.00	6.20	2.70		670.0	5.20	-.020	
LWD116	80	9	16			-.010	77.00	9.30	.70	.70		46.0	2.20	-.020	

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
DEEP WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	TURBIDITY NTU	CHEM O2 DEMAND (MG/L)	PHEN (MG/L)	BOD5 (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWD032	80	9	16	280.0	250.0	28.0	420.0	180.0	41.0	36.0	-.001		10.00	
LWD046	80	9	18	280.0	260.0	24.0	500.0	140.0	42.0	12.0	-.001		1.00	
LWD047	80	9	18	380.0	380.0	-1.0	600.0	430.0	57.0	14.0	-.001		3.00	
LWD106	80	7	17	280.0	250.0	30.0	1000.0	49.0	22.0	2.0	-.001		14.00	
		9	16	350.0	350.0	-1.0	910.0	170.0	39.0	-1.0	-.001		1.00	
LWD108	80	1	10	920.0	920.0	-1.0	2300.0	46.0	34.0	300.0	-.001	570.00	5.00	26.00
		2	14	950.0	870.0	30.0	2100.0	8.0	16.0	160.0	.006	16.00	11.00	39.00
		3	20	850.0	800.0	56.0	2500.0	30.0	23.0	48.0	.004	19.00	2.00	
		4	16	820.0	740.0	80.0	2400.0	15.0	14.0	10.0	.005		79.00	46.00
		6	19	810.0	810.0	-1.0	2900.0	35.0	25.0	190.0	.003		11.00	
		7	24	850.0	850.0	-1.0	2200.0	59.0	26.0	60.0	.004		13.00	
		8	20	840.0	840.0	-1.0	2200.0	39.0	120.0	32.0	.030		6.00	
		10	22	880.0	880.0	-1.0	860.0	110.0	46.0	84.0	.020		8.00	52.00
LWD116	80	9	16	320.0	270.0	54.0	490.0	330.0	76.0	4.0	-.001		8.00	

NOTE: - INDICATES LESS THEN

GROUNDWATER QUALITY FOR RETORTS

January-October 1980

LOGAN WASH
WATER QUALITY PARAMETERS
RETORTS
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	CA (MG/L)	B (MG/L)	V (MG/L)	CU (MG/L)	MOLY (MG/L)	LI (MG/L)	ZN (MG/L)	AL (MG/L)	BA (MG/L)	SR (MG/L)	NH3 (MG/L)
LWR001	80	1	3	100.0	2.200	.100	-.020	.300	1.200	-.020	-.100	-.500	6.90	13.00
		4	30											.70
		9	18	220.0	3.800	-.050	.020	.070	.600	-.020	-.100	-.500	2.70	2.50
LWR002	80	1	3	3.3	1.000	.200	.020	4.200	.700	-.020	-.100	-.500	1.00	6.30
		4	30	49.0	2.500	.050	.020	.100	.600	.020	-.100	-.500	.60	6.10
LWR004	80	1	2	5.5	2.100	-.100	-.020	.050	1.000	.030	-.100	.500	1.40	320.00
		7	10	7.2	18.000	-.050	-.020	-.010	.900	.010	-.100	-.500	1.10	300.00
		9	18	4.0	26.000	-.050	-.020	-.010	.600	-.020	-.100	-.500	.70	340.00
LWR005	80	1	2	5.0	1.600	.100	-.020	.040	1.000	-.020	-.100	1.000	.70	400.00
		3	27	3.6	16.000	-.050	-.020	.010	1.100	.020	-.100	-.500	.90	290.00
		7	10	7.6	16.000	-.050	-.020	-.010	.900	-.010	-.100	-.500	.60	170.00
		9	18	1.7	14.000	-.050	-.020	-.010	1.000	-.020	-.100	-.500	-.50	140.00
LWR006	80	1	2	15.0	8.000	.200	-.020	.200	.100	-.020	-.100	.500	5.60	870.00
		3	26	4.1	19.000	-.050	-.020	-.010	.900	.030	-.100	-.500	.90	330.00
				9.8	56.000	-.050	-.020	-.010	.100	.020	-.100	.500	2.40	860.00
		7	10	13.0	23.000	-.050	-.020	1.700	.500	-.010	-.100	-.500	1.50	940.00
		9	18	2.2	9.700	-.050	-.020	-.010	.400	-.020	-.100	-.500	.50	1700.00

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORTS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU
LWR001	80	1	3	-1.0	-1.00	17.00		.600	240.0	37.0	1.50	18.00			-.010	
		4	30			1.00										
		9	18			2.80		.030	130.0	18.0						
LWR002	80	1	3	-1.0	-1.00	7.00		.100	.8	24.0	9.00	191.00	.56		-.010	
		4	30			12.00		.080	8.0							
LWR004	80	1	2	-1.0	-1.00	190.00		.090	2.2	220.0		15.00			-.010	
		7	10			330.00		.030	3.7							
		9	18			380.00		.030	8.3	250.0						
LWR005	80	1	2	-1.0	-1.00	270.00		.080	1.8	473.0	6.00	82.00	.92		-.010	
		3	27			300.00		-.020	3.6							
		7	10			210.00		-.020	3.2							
		9	18			170.00		.040	2.0	300.0						
LWR006	80	1	2	-1.0	-1.00	410.00		.040	25.0	360.0	4.50				-.010	
		3	26			330.00		-.020	1.5							
						860.00		-.020	14.0							
		7	10			1000.00		.020	11.0							
		9	18			1800.00		.040	5.0	490.0						

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORTS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWR001	80	1	3	9.20	-.020	-.020	2400.00	50.00	5.90	42.00	5.0	570.0	260.00	.050	
		4	30				430.00	62.00	1.10	50.00		.0			
		9	18			-.010	1500.00	20.00	8.30	33.00		280.0	140.00	-.020	
LWR002	80	1	3	32.00	-.020	-.020	850.00	44.00	8.20	-.10	12.0	340.0	210.00	.050	
		4	30			-.010	860.00	110.00	8.20	24.00		310.0	250.00	-.020	
LWR004	80	1	2	40.00	-.020	-.020	330.00	100.00	21.00	40.00	26.0	960.0	41.00	-.020	
		7	10	.00		.020	710.00	320.00	18.00	780.00		1100.0	52.00	.040	
		9	18	.00		.020	580.00	350.00	19.00	1200.00		1000.0	59.00	.050	
LWR005	80	1	2	108.00	-.020	-.020	190.00	64.00	38.00	100.00	35.0	1200.0	210.00	.020	
		3	27		.006	-.005	310.00	330.00	30.00	200.00		1200.0	250.00	.060	
		7	10			.010	340.00	240.00	24.00	540.00		1000.0	260.00	.090	
		9	18			-.010	270.00	240.00	33.00	580.00		1000.0	250.00	.090	
LWR006	80	1	2	104.00	-.020	-.020	260.00	75.00	17.00	130.00	28.0	1000.0	42.00	.020	160.00
		3	26		.001	.010	240.00	300.00	23.00	150.00		1100.0	61.00	.020	
					.001	.001 -.010	310.00	490.00	21.00	240.00		1300.0	84.00	.020	
		7	10			.020	470.00	350.00	18.00	640.00		1100.0	73.00	.060	
		9	18			.020	320.00	420.00	28.00	1100.00		1600.0	55.00	.030	

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORTS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	PB (MG/L)	NI (MG/L)	PHEN (MG/L)	CD (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWR001	80	1	3	310.0	310.0	-1.0	3900.0	47.0	.020	.030	.480	-.020	33.00	27.00
		4	30	280.0	280.0	-1.0	1000.0	40.0			.002		2.00	
		9	16	370.0	370.0	-1.0	2800.0	10.0	.020	.030	.050	-.010	11.00	
LWR002	80	1	3	200.0	-1.0	120.0	1600.0	4.0	-.020	.020	.084	-.020	18.00	16.00
		4	30	210.0	10.0	200.0	1600.0	51.0	.020	-.020	.060	-.010	9.00	
LWR004	80	1	2	2100.0	780.0	1300.0	2600.0	4.0	.020	-.020	13.000	-.020	19.00	184.00
		7	10	2600.0	1500.0	1100.0	3300.0	-1.0	.020	-.020	.900	-.010	15.00	
		9	18	2800.0	670.0	2100.0	3100.0	31.0	.020	-.020	.005	-.010	13.00	
LWR005	80	1	2	3500.0	1100.0	2400.0	4000.0	6.0	-.020	.030	15.000	-.020	18.00	445.00
		3	27	3200.0	1400.0	1800.0	3800.0	6.0	-.020	.050	13.000	-.010	25.00	390.00
		7	10	2800.0	1600.0	1200.0	3400.0	-1.0	.020	-.020	12.000	-.010	8.00	
		9	18	2600.0	1400.0	1200.0	3400.0	24.0	.020	-.020	.003	-.010	3.00	
LWR006	80	1	2	4100.0	1500.0	2600.0	3000.0	16.0	.020	.030	22.000	-.020	27.00	310.00
		3	26	2800.0	1000.0	1800.0	3100.0	12.0	-.020	.040	7.000	-.001	10.00	260.00
				4700.0	1700.0	3000.0	3700.0	24.0	-.020	.030	9.000	-.010	12.00	340.00
		7	10	5500.0	1800.0	3700.0	3500.0	8.0	.020	-.020	13.000	-.010	11.00	
		9	18	9100.0	4300.0	4800.0	4100.0	21.0	-.020	.020	.020	-.010	8.00	

NOTE: - INDICATES LESS THEN

GROUNDWATER QUALITY FOR RETORT 6 WELLS

January-October 1980

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	CA (MG/L)	B (MG/L)	V (MG/L)	CU (MG/L)	MOLY (MG/L)	LI (MG/L)	ZN (MG/L)	AL (MG/L)	BA (MG/L)	SR (MG/L)	NH3 (MG/L)
LWD602	80	1	10	2.9	.200	-.050	-.020	.020	.200	-.020	-.100	-.500	.30	.06
			22	2.9	.100	-.050	-.020	.020	.200	-.020	-.100	-.500	.20	.05
		2	26	4.9	.400	-.050	-.020	.010	.200	.040	.100	-.500	.20	-.04
		4	2	5.5	.500	-.050	-.020	.100	.200	.030	-.100	-.500	.40	-.04
		5	1	52.0	.200	-.050	.040	.010	.200	.030	-.100	-.500	-.10	-.04
		7	17	6.0	.300	-.050	-.020	.020	.200	-.010	-.100	-.500	-.50	.10
		8	13	2.3	.300	-.050	-.020	.010	.200	-.020	-.100	-.500	.90	-.04
		9	8	2.9	.400	-.050	-.020	.020	.200	-.020	-.100	-.500	-.50	.10
		10	15	1.3	.200	-.050	-.020	.020	.200	-.020	-.100	-.500	-.50	-.04
LWD603	80	1	22	12.0	3.900	-.050	-.020	.010	1.200	-.020	.100	.500	1.70	3.10
		2	26	16.0	4.200	-.050	-.020	.010	1.200	.020	.200	-.500	1.50	4.00
		3	20	18.0	4.400								.00	3.20
		4	2	15.0	4.400	-.050	-.020	.100	1.300	.030	-.100	-.500	1.20	12.00
			16	19.0	.400					.000				3.80
		5	1	71.0	4.700	-.050	.020	.040	1.400	.030	-.100	-.500	2.80	3.00
		6	26	17.0	4.100									4.10
		7	17	27.0	3.900	-.050	.020	.020	1.200	.010	-.100	-.500	2.80	3.90
		8	13	19.0	4.300	-.050	-.020	.010	1.600	-.020	-.100	-.500	2.10	3.00
		9	8	23.0	4.400	-.050	-.020	.030	1.100	-.020	-.100	-.500	1.20	3.90
		10	15	20.0	4.800	-.050	-.020	.010	1.300	-.020	-.100	-.500	2.20	3.30
LWD604	80	1	22	42.0	17.000	-.050	-.020	2.000	.800	-.020	-.100	1.000	13.00	12.00
		2	26	42.0	13.000	.050	.020	1.500	.900	.040	.100	.500	12.00	12.00
		3	20	32.0	9.100									13.00
		4	2	32.0	11.000	-.050	-.020	1.700	1.000	.040	-.100	-.500	5.90	12.00
			16	59.0	12.000		.000	.000						1.60
		5	1	80.0	9.800	-.050	.030	1.700	.800	.030	-.100	1.200	10.00	11.00
			15											
		6	26	31.0	7.300									8.90
		7	17	37.0	7.400	-.050	.020	1.000	.700	-.010	-.100	-.500	11.00	7.00
			30	30.0	6.600									7.80
		8	13	28.0	7.000	-.050	-.020	.700	.800	-.020	-.100	-.500	6.50	6.00
			26	36.0	6.200									6.10
		9	8	38.0	6.100	-.050	-.020	.500	.700	.030	-.100	-.500	5.70	5.30
		10	15	46.0	6.500	-.050	.030	.080	.800	.020	-.100	-.500	12.00	6.30
LWD605	80	1	30	9.5	35.000	-.050	-.020	.080	2.300	.030	-.100	1.000	6.50	1900.00
		2	26	18.0	37.000	-.050	-.020	-.010	2.100	.060	.100	1.200	5.00	25.00
		3	20	14.0	47.000		.000							280.00
		4	2	13.0	56.000	-.050	-.020	.100	1.900	.030	-.100	1.000	3.00	230.00
			16	14.0	46.000									270.00

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	CA (MG/L)	B (MG/L)	V (MG/L)	CU (MG/L)	MOLY (MG/L)	LI (MG/L)	ZN (MG/L)	AL (MG/L)	BA (MG/L)	SR (MG/L)	NH3 (MG/L)
LWD605	80	5	1	62.0	47.000	-.050	.020	-.010	1.600	.030	-.100	1.300	4.70	240.00
		6	26	8.2	69.000									200.00
		7	17	15.0	69.000	-.050	-.020	.020	1.100	-.010	-.100	-.500	4.40	160.00
			30	6.9	71.000									170.00
		8	13	6.4	68.000	-.050	-.020	.030	1.300	-.020	-.100	-.500	2.50	50.00
			26	12.0	67.000									150.00
		9	8	10.0	64.000	-.050	-.020	.200	1.100	-.020	-.100	-.500	2.10	100.00
		10	15	9.3	40.000	-.050	-.020	.300	1.200	-.020	-.100	-.500	3.00	50.00
LWD606	80	8	13	170.0	26.000	-.050	.020	3.100	1.700	.020	-.100	-.500	5.60	6.30
		9	8	800.0	27.000	-.050	.040	1.500	1.000	-.020	-.100	-.500	5.50	9.00
		10	15	210.0	29.000	-.050	.060	1.000	1.400	.030	-.100	-.500	10.00	3.60
LWD607	80	1	3	3.0	.700	-.100	-.020	.300	.300	-.020	-.100	-.500	.40	1.50
			22	5.3	.900	-.050	-.020	.050	.300	-.020	.100	-.500	.40	1.00
		8	13	27.0	14.000	-.050	-.020	2.700	.700	-.020	-.100	-.500	2.30	4.80
LWD608	80	4	2	41.0	9.900	-.050	-.020	1.200	.400	.020	-.100	-.500	4.30	50.00
		9	18											
				67.0	5.800	-.050	.020	1.200	.600	-.020	-.100	-.500	3.00	9.60
LWD610	80	2	26	35.0	40.000	-.050	-.020	.300	.400	.050	.100	1.600	.80	3.50
		3	20	11.0	40.000									.05
		4	2	8.2	43.000	-.050	-.020	.200	.600	.060	-.100	.500	1.10	1.40
			16	11.0	39.000									3.30
		5	1	61.0	48.000	-.050	.040	.100	.500	.070	-.100	1.800	.30	4.00
			15	8.7	37.000									-.04
		6	12	11.0	46.000	-.050	.090	.500	.600	.070	.100	-.500	-.50	5.80
		7	17	14.0	41.000	-.050	.030	.500	.500	.020	-.100	-.500	.50	4.60
		8	13	4.8	45.000	-.050	-.020	.200	.600	.030	-.100	-.500	1.20	4.60
		9	8	6.8	50.000	-.050	-.020	.400	.600	-.020	-.100	-.500	-.50	3.00
		10	15	5.3	51.000	-.050	.030	.400	.800	.030	-.100	-.500	.50	9.20
LWD611	80	2	5											
			26	17.0	39.000	-.050	-.020	.200	.500	.070	-.100	1.000	.40	6.00
		6	12	13.0	26.000	-.050	.200	1.700	.700	.060	-.100	-.500	.40	2.10
		7	17	16.0	28.000	-.050	.030	1.000	.600	.020	-.100	-.500	.50	3.70
				16.0	28.000	-.050	.030	1.000	.600	.020	-.100	-.500	.50	3.70

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU
LWD602	80	1	10	-1.0	-1.00	-1.00		.400	.9	11.0		23.00	.82		-.010	26.0
			22			.00		.080	1.0			10.00				14.0
		2	26			1.10		.030	1.4		13.00	26.00	2.90	1.60		14.0
		4	2			.80		.030	1.2							41.0
		5	1			.50		.020	8.0							38.0
		7	17			.60		-.020	1.5							15.0
		8	13			.10		-.020	.8							14.0
		9	8			.60		.050	1.3							16.0
		10	15			-.10		-.020	.5							20.0
LWD603	80	1	22			.00		.200	100.0		1.50					17.0
		2	26			6.10		.100	13.0		5.00	11.00		3.70		42.0
		3	20			3.90		.000	10.0							
		4	2			12.00		.080	12.0							140.0
			16			5.10		.000	13.0							
		5	1			5.30		-.020	28.0							33.0
		6	26			5.10		.000	19.0							
		7	17			4.10		-.020	21.0							170.0
		8	13			4.20		-.020	20.0							120.0
		9	8			5.30		.050	21.0	-.5						96.0
		10	15			4.50		.020	19.0							150.0
LWD604	80	1	22			.00		1.500	63.0		24.00	28.00	.75			40.0
		2	26			26.00		.400	71.0			6.00		.40		23.0
		3	20			13.00		.000	41.0							
		4	2			22.00		.080	49.0							50.0
			16			18.00		.000	70.0							
		5	1			28.00		.100	53.0							33.0
			15			.00		.000	.0							
		6	26			10.00		.000	54.0							
		7	17			9.80		.020	47.0							45.0
			30			10.00		.000	51.0							
		8	13			7.00		-.020	50.0							32.0
			26			12.00		.000	54.0							
		9	8			8.10		.050	57.0	-.5						23.0
		10	15			17.00		.020	65.0							14.0
LWD605	80	1	30			2600.00		.070	56.0		11.00	29.00	1.80			

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU
LWD605	80	2	26			310.00		.100	48.0	220.0						.0
		3	20			280.00			33.0							.0
		4	2			280.00		.200	37.0							22.0
			16			280.00			51.0							.0
		5	1			270.00		.020	44.0							24.0
		6	26			200.00			32.0							.0
		7	17			200.00		.090	30.0							32.0
			30			180.00			25.0							.0
		8	13			90.00		.020	23.0							18.0
			26			190.00			33.0							.0
		9	8			120.00		.300	30.0							17.0
		10	15			62.00		.050	23.0							17.0
LWD606	80	8	13			9.20		.040	160.0							98.0
		9	8			16.00		.080	240.0							37.0
		10	15			15.00		.040	240.0							92.0
LWD607	80	1	3	-1.0	-1.00	1.60		.030	2.0	9.0	27.00	38.00	.26		-.010	15.0
			22			.00		.400	3.1		45.00	83.00	.50			36.0
		8	13			7.80		.020	50.0							300.0
LWD608	80	4	2			65.00		.070	49.0							76.0 76.0
		9	18													
						15.00		.020	51.0	29.0						
LWD610	80	2	26			17.00		.600	12.0		8.30	23.00	1.30	6.10	.000	150.0
		3	20			7.00			3.6						.000	.0
		4	2			2.80		.500	3.5						.000	23.0
			16			20.00			8.5						.000	.0
		5	1			17.00		.300	14.0						.000	71.0
			15			13.00			4.5						.000	.0
		6	12			20.00		.300	4.2						.000	40.0
		7	17			20.00		.300	4.7						.000	15.0
		8	13			16.00		.300	3.9						.000	100.0
		9	8			20.00		.600	4.6						.000	14.0
		10	15			21.00		.030	4.0						.000	12.0

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU	
LWU611	80	2	5														
			26			46.00		.500	5.3		12.00	36.00	.56	2.30			40.0
		6	12			10.00		.100	3.3								86.0
		7	17			4.60		.800	4.6								77.0
						4.60		.800	4.6								77.0

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWD602	80	1	10	-1.00	-.020	-.020	910.00	52.00	1.40	8.00	9.3	430.0	3.10	-.020	
			22				120.00	52.00	1.00	-.10		370.0	4.20	-.020	
		2	26	-1.00	-.020	-.020	400.00	42.00	1.10	-.10		400.0	4.10	-.020	
		4	2			-.010	410.00	69.00	1.40	74.00		410.0	3.60	-.020	
		5	1			-.010	400.00	69.00	1.00	12.00		370.0	3.20	-.020	
		7	17			-.010	400.00	30.00	.70	14.00		370.0	3.20	-.020	
		8	13			.000	390.00	43.00	1.20	12.00		380.0	2.20	-.020	
		9	8			.010	400.00	41.00	2.00	17.00		360.0	2.10	-.020	
		10	15			.010	380.00	51.00	1.10	14.00		400.0	1.00	.020	
LWD603	80	1	22				470.00	80.00	3.40	-.10		600.0	9.20	-.020	
		2	26	-1.00	-.020	-.020	450.00	76.00	3.70	-.10		650.0	8.50	.030	
		3	20					110.00	3.50	30.00		670.0	7.90	-.020	
		4	2			-.010	460.00	110.00	3.50	40.00		670.0	6.70	-.020	
			16					130.00	3.50	7.50		590.0	6.00	-.020	
		5	1			-.010	540.00	160.00	5.00	14.00		660.0	7.30	.040	
		6	26					64.00	4.20	8.70		610.0	7.50	-.020	
		7	17			-.010	610.00	66.00	2.90	14.00		640.0	8.10	-.020	
		8	13				620.00	72.00	3.10	8.00		610.0	5.80	-.020	
		9	8			.020	620.00	70.00	4.00	1.40		600.0	5.40	-.020	
		10	15			.020	560.00	73.00	5.10	12.00		690.0	3.60	.030	
LWD604	80	1	22				940.00	93.00	9.80	170.00		1100.0	12.00	.080	
		2	26	1.10	-.020	-.020	890.00	120.00	7.00	170.00		1100.0	11.00	.020	
		3	20					110.00	5.30	30.00		890.0	7.90	.080	
		4	2			-.010	800.00	100.00	5.90	28.00		840.0	9.50	.050	
			16					120.00	6.50	34.00		900.0	8.50	.040	
		5	1			-.010	890.00	120.00	6.50	39.00		770.0	8.00	.020	
			15												
		6	26					52.00	5.60	11.00		640.0	8.20	-.020	
		7	17			-.010	770.00	51.00	3.40	12.00		620.0	8.10	-.020	
			30					49.00	3.20	9.60		620.0	5.60	.020	
		8	13				750.00	53.00	4.10	9.20		600.0	6.20	-.020	
			26					43.00	2.70	8.70		590.0	7.10	-.020	
		9	8			.020	690.00	41.00	4.00	12.00		530.0	5.40	-.020	
		10	15			.020	690.00	40.00	3.80	8.70		580.0	4.00	.020	
LWD605	80	1	30				420.00	350.00	12.00	180.00	19.0	1800.0	120.00	.020	
		2	26		-.020		420.00	350.00	13.00	62.00		1500.0	9.30	.020	

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWD605	80	3	20					470.00	18.00	180.00		1400.0	70.00	.020	
		4	2			-.010	230.00	500.00	20.00	140.00		1500.0	86.00	.020	
			16					410.00	17.00	98.00		1300.0	68.00	.020	
		5	1			.020	350.00	440.00	17.00	120.00		1200.0	60.00	.020	
		6	26					350.00	27.00	32.00		1400.0	75.00	.020	
		7	17			-.010	340.00	370.00	34.00	300.00		1400.0	73.00	.020	
			30					350.00	38.00	21.00		1300.0	43.00	.030	
		8	13				420.00	360.00	31.00	32.00		1200.0	41.00	.030	
			26					310.00	18.00	28.00		1300.0	49.00	.030	
		9	8			.020	490.00	330.00	24.00	28.00		1300.0	37.00	.030	
		10	15			.030	580.00	250.00	19.00	16.00		980.0	17.00	.200	
LWD606	80	8	13				6000.00	1300.00	3.00	31.00		2800.0	83.00	.020	
		9	8			.060	5900.00	1300.00	4.00	36.00		3100.0	83.00	.020	
		10	15			.080	6000.00	1200.00	4.40	24.00		3400.0	64.00	.040	
LWD607	80	1	3	-1.00	-.020	-.020	520.00	57.00	1.10	-.10	10.0	460.0	4.60	-.020	
			22				420.00	64.00	1.10	-.10		420.0	6.50	.020	
		8	13				2400.00	700.00	2.90	-.50		1500.0	28.00	-.020	
LWD608	80	4	2			-.010	810.00	140.00	6.70	350.00		660.0	48.00	.080	
		9	18												
						.020	1200.00	58.00	7.60	330.00		460.0	170.00	-.020	
LWD610	80	2	26	47.00	-.020	-.020	31.00	390.00	35.00	260.00		4200.0	24.00	.080	
		3	20					390.00	36.00	370.00		3200.0	15.00	.150	
		4	2			.030	-5.00	380.00	41.00	340.00		3600.0	44.00	.200	
			16					440.00	39.00	400.00		3200.0	14.00	.200	
		5	1			-.010	-5.00	490.00	43.00	370.00		3300.0	16.00	.100	
			15					130.00	.50	400.00		2800.0	20.00	.100	
		6	12			.040	-5.00	290.00	48.00	480.00		4100.0	18.00	.100	
		7	17			-.010	-5.00	350.00	54.00	540.00		3500.0	22.00	.100	
		8	13				-5.00	390.00	46.00	640.00		3400.0	17.00	.100	
		9	8			-.010	-5.00	380.00	37.00	520.00		3900.0	18.00	.100	
		10	15			-.010	-5.00	400.00	36.00	680.00		2900.0	13.00	.100	
LWD611	80	2	5												
			26	21.00	-.020	-.020	20.00	290.00	36.00	600.00		3400.0	16.00	.200	

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWD511	80	6	12			.040	840.00	170.00	26.00	24.00		1900.0	9.70	.030	
		7	17			-.010	690.00	250.00	30.00	280.00		2100.0	14.00	.070	
						-.010	690.00	250.00	30.00	280.00		2100.0	14.00	.070	

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	TURBIDITY NTU	CHEM O2 DEMAND (MG/L)	PHEN (MG/L)	BOD5 (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWD602	80	1	10	420.0	260.0	160.0	1200.0	6.0	26.0	2.0	-.001	25.00	23.00	3.00
			22	400.0	250.0	150.0	1100.0	30.0	14.0	13.0	-.001	21.00	1.00	
		2	26	390.0	210.0	180.0	1100.0	5.0	14.0	18.0	-.001	19.00	2.00	12.00
		4	2	420.0	230.0	190.0	1100.0	42.0	41.0	19.0	-.001		10.00	18.00
		5	1	430.0	260.0	170.0	1000.0	51.0	38.0	54.0	.008		4.00	
		7	17	400.0	240.0	160.0	1100.0	22.0	15.0	4.0	-.001		6.00	6.00
		8	13	440.0	260.0	180.0	1100.0	6.0	14.0	20.0	.030		9.00	
		9	8	420.0	250.0	170.0	1100.0	30.0	16.0	12.0	-.001		11.00	
		10	15	400.0	200.0	200.0	1100.0	17.0	20.0	-1.0	.001		3.00	44.00
LWD603	80	1	22	810.0	730.0	80.0	1800.0	5.0	17.0	92.0	.009	1.00	3.00	
		2	26	900.0	790.0	110.0	1900.0	37.0	42.0	100.0	.004	1.00	1.00	36.00
		3	20	970.0	850.0	120.0					-.001			46.00
		4	2	950.0	850.0	100.0	1900.0	140.0	140.0	120.0	-.001		7.00	36.00
			16	990.0	850.0	140.0					.005			46.00
		5	1	1100.0	990.0	94.0	2100.0	90.0	33.0	92.0	.010		14.00	
		6	26	990.0	890.0	100.0					.004			110.00
		7	17	940.0	860.0	80.0	2000.0	350.0	170.0	88.0	.004		-1.00	23.00
		8	13	950.0	890.0	60.0	1900.0	630.0	120.0	80.0	.009		15.00	
		9	8	950.0	880.0	66.0	2000.0	360.0	96.0	96.0	.009		10.00	
		10	15	890.0	870.0	22.0	1900.0	610.0	150.0	180.0	.010		2.00	49.00
LWD604	80	1	22	1700.0	1600.0	100.0	3700.0	12.0	40.0	280.0	.007	1.00	13.00	
		2	26	1400.0	1300.0	100.0	3100.0	18.0	23.0	250.0	.004	650.00	16.00	76.00
		3	20	1300.0	1100.0	150.0					-.001			84.00
		4	2	1400.0	1200.0	170.0	2900.0	59.0	50.0	100.0	-.001		10.00	87.00
			16	1500.0	1400.0	100.0					.007			93.00
		5	1	1400.0	1200.0	200.0	2800.0	100.0	33.0	250.0	.010		6.00	
			15								.000			
		6	26	900.0	810.0	92.0					.001			110.00
		7	17	910.0	830.0	76.0	2100.0	62.0	45.0	100.0	-.001		98.00	28.00
			30	880.0	820.0	56.0					-.001			32.00
		8	13	960.0	890.0	68.0	2100.0	120.0	32.0	120.0	-.001		14.00	
			26	910.0	840.0	74.0					-.001			29.00
		9	8	900.0	870.0	32.0	2000.0	31.0	23.0	79.0	.004		8.00	
		10	15	840.0	810.0	28.0	1900.0	7.0	14.0	74.0	.004		2.00	48.00
LWD605	80	1	30	5500.0	2300.0	3200.0	5200.0	120.0			3.400		110.00	330.00

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO.	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	TURBIDITY NTU	CHEM O2 DEMAND (MG/L)	PHEN (MG/L)	BOD5 (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWD605	80	2	26	3500.0	2400.0	1100.0	4400.0	100.0			5.800		8.00	220.00
		3	20	3900.0	2700.0	1200.0					3.400			230.00
		4	2	4000.0	2800.0	1200.0	4600.0	48.0	22.0	240.0	5.000		6.00	74.00
			16	3700.0	2900.0	800.0					2.500			190.00
		5	1	3600.0	2300.0	1300.0	4200.0	24.0	24.0	750.0	2.300		2.00	
		6	26	3100.0	1900.0	1200.0					1.600			260.00
		7	17	3100.0	1500.0	1600.0	4300.0	58.0	32.0	880.0			19.00	
			30	3000.0	1400.0	1600.0					.080			190.00
		8	13	3100.0	2200.0	940.0	4100.0	47.0	18.0	640.0	.900		32.00	
			26	2600.0	2000.0	590.0					.470			150.00
		9	8	2600.0	1100.0	1500.0	4000.0	39.0	17.0	480.0	.400		13.00	
		10	15	1500.0	1000.0	490.0	2900.0	34.0	17.0	360.0	.070		2.00	190.00
LWD606	80	8	13	330.0	-1.0	330.0	11000.0	460.0	98.0	360.0	.030		20.00	
		9	8	300.0	43.0	260.0	11000.0	85.0	37.0	400.0	.020		4.00	
		10	15	270.0	130.0	140.0	11000.0	320.0	92.0	300.0	.020		5.00	140.00
LWD607	80	1	3	390.0	210.0	180.0	1300.0	75.0	15.0	21.0	.290	37.00	3.00	8.00
			22	370.0	230.0	140.0	1300.0	56.0	36.0	20.0	.009	3.00	10.00	.00
		8	13	320.0	140.0	180.0	4700.0	1,100.0	300.0	250.0	.010		5.00	
LWD608	80	4	2	780.0	580.0	200.0	2500.0	75.0	76.0	240.0	-.001		2.00	220.00
		9	18											
				340.0	240.0	96.0	2300.0	120.0			-.001		1.00	
LWD610	80	2	26	6800.0	5800.0	1000.0	11000.0	500.0	150.0	3300.0	.005	370.00	21.00	1200.00
		3	20	6600.0	5900.0	580.0					-.001			1100.00
		4	2	6800.0	5800.0	1300.0	10000.0	78.0	23.0	410.0	-.001		33.00	1100.00
			16	7800.0	7100.0	700.0					.009			1000.00
		5	1	6900.0	6800.0	110.0	11000.0	200.0	71.0	11000.0	.020		18.00	
			15	7900.0	7000.0	920.0					.012		.00	840.00
		6	12	7700.0	6400.0	1300.0	11000.0	31.0	40.0	3200.0	.012		10.00	
		7	17	7800.0	6600.0	1200.0	11000.0	38.0	15.0	3700.0	-.001		16.00	810.00
		8	13	8100.0	7200.0	920.0	11000.0	52.0	100.0	3500.0	.006		12.00	
		9	8	810.0	710.0	96.0	11000.0	44.0	14.0	3000.0	-.001		15.00	
		10	15	7900.0	7000.0	860.0	10000.0	37.0	12.0	3400.0	.005		3.00	910.00

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
RETORT 6 WELLS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	TURBIDITY NTU	CHEM O2 DEMAND (MG/L)	PHEN. (MG/L)	BOD5 (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWD611	80	2	5											
			26	10000.0	9000.0	1000.0	9200.0	1,900.0	40.0	3300.0	.010	1300.00	8.00	1600.00
		6	12	2200.0	1600.0	600.0	5000.0	220.0	86.0	250.0	.008		19.00	
		7	17	3800.0	3200.0	680.0	6400.0	160.0	77.0	2200.0	-.001		1.00	420.00
				3900.0	3200.0	680.0	6400.0	150.0	77.0	2200.0	-.001		1.00	420.00

NOTE: - INDICATES LESS THEN

SURFACEWATER QUALITY FOR STREAMS

January-October 1980

LOGAN WASH
WATER QUALITY PARAMETERS
STREAMS
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	CA (MG/L)	B (MG/L)	V (MG/L)	CU (MG/L)	MOLY (MG/L)	LI (MG/L)	ZN (MG/L)	AL (MG/L)	BA (MG/L)	SR (MG/L)	NH3 (MG/L)
LWS001	80	5	8	91.0	-.100	-.050	.050	.030	.050	.010	-.100	-.500	1.30	-.04
		6	19	350.0	.200								6.10	-.04
LWS002	80	2	20	47.0	.200	-.050	-.020	.010	-.050	.020	2.400	.500	.80	.10
		3	27	200.0	.200	-.050	-.010	.050	.200	.020	-.100	1.000	3.00	.60
		5	8	130.0	.200	-.050	.020	.050	-.050	-.010	-.100	.900	3.50	.50
		6	3	120.0	.400	-.050	.090	.100	.060	.060	-.100	-.500	6.20	.08
		8	6	170.0	.400	-.050	-.020	.100	.100	-.020	-.100	-.500	7.20	.50
		9	4	180.0	.400	-.050	.020	.100	.100	-.020	-.100	-.500	3.90	-.04
		10	2	220.0	.400	-.050	.030	.070	.100	-.020	-.100	-.500	4.10	.06
LWS003	80	1	9	67.0	.400	-.050	-.020	.030	.050	-.020	-.100	-.500	3.60	.08
		2	7	66.0	.200	-.050	-.020	.030	.050	-.020	-.100	.500	3.50	-.04
		3	6	78.0	.200	-.050	.020	.030	.050	-.020	-.100	.500	2.20	-.04
		4	10	110.0	.200	-.050	-.020	.030	.050	.030	-.100	.500	.20	.05
		5	8	99.0	.100	-.050	-.020	.030	-.050	.030	-.100	-.500	1.10	-.04
		6	3	55.0	-.100	-.050	.060	.050	-.050	.030	-.100	-.500	1.40	.05
		7	3	65.0	.200	-.050	-.020	.100	.050	-.010	-.100	-.500	1.60	.05
		8	6	74.0	.200	-.050	-.020	.040	.060	-.020	-.100	-.500	2.90	.20
		9	4	79.0	.200	-.050	.020	.070	.070	-.020	-.100	-.500	1.40	-.04
		10	2	88.0	.300	-.050	.030	.040	.050	-.020	-.100	-.500	1.40	.10
LWS004	80	3	6	140.0	.400	-.050	-.020	.100	.100	-.020	-.100	.500	3.20	.04
		4	10	170.0	.300	-.050	-.010	.090	.200	.030	-.100	.500	.30	-.04
		5	8	150.0	.400	-.050	.020	.200	.200	.010	-.100	.500	3.10	-.04
		6	3	120.0	.400	-.050	.060	.200	.100	.020	-.100	.500	4.40	-.04
		7	3	110.0	.500	-.050	-.020	.400	.200	-.010	-.100	-.500	3.40	.05
		8	6	130.0	.400	-.050	-.020	.200	.200	-.020	-.100	-.500	5.30	.80
		9	4	58.0	.500	-.050	-.020	.300	.200	-.020	-.100	-.500	1.70	-.04
		10	2	88.0	.500	-.050	-.020	.200	.200	-.020	-.100	-.500	1.70	-.04
LWS005	80	4	23	130.0	.200	-.050	.020	.070	.070	.020	-.100	-.500	.20	-.04
		10	16	240.0	-.100	-.050	-.020	.020	-.050	-.020	-.100	-.500	3.80	.60
LWS006	80	7	23	69.0	.100	-.050	-.020	.060	.060	-.020	-.100	-.500	3.60	-.04
				69.0	.100	-.050	-.020	.060	.060	-.020	-.100	-.500	6.00	-.04
		10	16	84.0	-.100	-.050	-.020	.040	-.050	-.020	-.100	-.500	2.50	-.04
LWS007	80	1	16	65.0	.200	-.050	-.020	.030	-.050	-.020	-.100	-.500	3.20	1.20
		4	23	110.0	-.100	-.050	-.020	.010	-.050	.020	-.100	-.500	.10	.30
		7	23	81.0	.200	-.050	-.020	.050	-.050	-.020	-.100	-.500	2.70	.07
		10	16	110.0	.200	-.050	-.020	.040	-.050	-.020	-.100	-.500	2.80	.30

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
STREAMS
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	CA (MG/L)	B (MG/L)	V (MG/L)	CU (MG/L)	MOLY (MG/L)	LI (MG/L)	ZN (MG/L)	AL (MG/L)	BA (MG/L)	SR (MG/L)	NH3 (MG/L)
LWS013	80	1	9	72.0	.200	-.050	-.020	.030	.050	-.020	-.100	-.500	3.70	-.04
		2	7	68.0	.200	-.050	-.020	.030	.050	-.020	.200	-.500	3.60	-.04
		3	6	78.0	.400	-.050	.020	.030	.060	-.020	-.100	.500	2.20	.10
		4	10	100.0	.200	-.050	-.020	.030	.050	.020	-.100	.500	.20	-.04
		5	8	96.0	-.100	-.050	.040	.030	-.050	.020	-.100	.500	1.00	.40
		6	3	55.0	-.100	-.050	.040	.050	-.050	.030	-.100	-.500	1.40	.10
		7	3	63.0	.200	-.050	-.020	.100	.050	-.010	-.100	-.500	1.60	.30
		8	6	74.0	.200	-.050	-.020	.040	.060	-.020	-.100	-.500	2.90	-.04
		9	4	78.0	.200	-.050	-.020	.060	.070	-.020	-.100	-.500	1.40	-.04
		10	2	91.0	.300	-.050	.020	.040	.050	-.020	-.100	-.500	1.40	.08
LWS017	80	1	16	67.0	-.100	-.050	-.020	.030	-.050	-.020	-.100	-.500	3.10	-.04
		4	23	100.0	-.100	-.050	.030	.010	-.050	.020	-.100	-.500	.10	.10
		7	23	88.0	.200	-.050	-.020	.060	-.050	-.020	-.100	-.500	2.70	-.04
		10	15	100.0	.200	-.050	-.020	.040	-.050	-.020	-.100	-.500	2.80	-.04

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
STREAMS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU
LWS001	80	5	8			.60		.020	48.0		5.30	35.00	2.50	.80		210.0
		6	19			.70		.000	180.0							
LWS002	80	2	20			2.20		1.800	26.0		123.00	463.00	.39	.40		220.0
		3	27			.60		-.020	120.0		58.00	34.00	.35	.50		44.0
		5	8			1.30		-.020	63.0		12.00	15.00		1.40		130.0
		6	3			1.40		.020	130.0		6.00	19.00		.40		320.0
		8	6			1.10		-.020	150.0		5.90	13.00		.40		10.0
		9	4			.80		.050	160.0	-1.5	5.90	14.00		.90		10.0
		10	2			.07		.020	190.0			9.10				1.0
LWS003	80	1	9	-1.0	-1.00	-1.00		-.020	76.0	6.0	1.60	19.00			-.010	23.0
		2	7			.60		-.020	80.0		.10	1.00				59.0
		3	6			.10		-.020	77.0		11.00	2.50		.20		250.0
		4	10			.30		-.020	86.0		20.00	7.00		1.00		240.0
		5	8			.10		-.020	38.0		19.00	9.50		1.60		180.0
		6	3			.40		-.020	35.0		8.10	7.30		.10		360.0
		7	3			.07		.020	61.0		17.00	16.00				170.0
		8	6			.40		-.020	76.0		13.40	4.60		1.50		78.0
		9	4			.10		.030	71.0		14.00	12.00		.90		160.0
		10	2			.10		.030	80.0			9.60				28.0
LWS004	80	3	6			.80		.020	76.0		29.00	32.00	2.40	1.10		46.0
		4	10			.50		.040	110.0		40.00	14.00	.22	12.70		230.0
		5	8			.20		-.020	81.0		1.30	14.00		1.40		66.0
		6	3			.70		.030	94.0		19.00	24.00	.86	1.20		20.0
		7	3			.40		.020	98.0		22.00	26.00				1.5
		8	6			.80		-.020	98.0		21.00	29.00	.46	1.10		8.0
		9	4			.40		.030	57.0		15.00	31.00	1.03	1.00		2.0
		10	2			.80		-.020	69.0			34.00	.23			10.0
LWS005	80	4	23			.40		-.020	81.0		27.00	65.00	.67	.60		350.0
		10	16			1.10		.020	40.0			23.00	2.80			2,600.0
LWS006	80	7	23			.10		-.020	85.0		6.20	3.30		.30		12.0
						.10		-.020	85.0							12.0
		10	16			.60		-.020	59.0			13.00	3.40			120.0

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
STREAMS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	FECAL COLIF. COLONY /100 ML	TOTAL COLIF. COLONY /100 ML	N KJELD. (MG/L)	SO3 (MG/L)	FE (MG/L)	MG (MG/L)	TOC (MG/L)	ALPHA (PCI/1)	BETA (PCI/1)	RADIUM 226 (PCI/1)	SR90 (PCI/1)	AG (MG/L)	TURB NTU
LWS007	80	1	16					.070	55.0		1.50	11.00				14.0
		4	23			.50		.080	43.0		26.00	35.00	1.80	1.60		240.0
		7	23			.30		-.020	51.0		1.70	6.60		.90		12.0
		10	16			.40		-.020	49.0			8.10				16.0
LWS013	80	1	9	-1.0	-1.00	-1.00		.070	81.0	6.0	18.00	30.00	.04		-.010	26.0
		2	7			.07		.100	82.0		3.00	5.00				54.0
		3	6			.30		-.020	78.0		15.00	13.00		1.00		250.0
		4	10			.07		-.020	89.0		11.00	3.00		.30		200.0
		5	8			3.90		-.020	36.0		4.00	9.10		.90		200.0
		6	3			.80		.020	35.0		9.30	3.20		1.20		350.0
		7	3			.40		-.020	60.0		35.00	17.00				180.0
		8	6			.30		-.020	76.0		11.10	4.20		1.70		82.0
		9	4			.10		.030	70.0	-.5	4.10	11.00		3.10		170.0
		10	2			.10		-.020	80.0			9.40				26.0
LWS017	80	1	16					.050	54.0		3.00	35.00	.65			12.0
		4	23			.20		-.020	47.0		24.00	27.00	1.60	.90		230.0
		7	23			.40		-.020	52.0					1.80		14.0
		10	15			.60		-.020	45.0			3.60				57.0

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
STREAMS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWS001	80	5	8			-.010	180.00	39.00	.70	7.80		90.0	4.80	-.020	
		6	19				1800.00	49.00	.90	40.00		260.0	7.40	-.020	
LWS002	80	2	20	-1.00	-.020	-.020	210.00	250.00	.50	5.00		54.0	7.20	-.020	
		3	27			.040	1500.00	48.00	.90	14.00		280.0	10.00	-.020	
		5	8			-.010	500.00	59.00	.50	40.00		120.0	6.50	-.020	
		6	3			.060	980.00	84.00	.70	75.00		190.0	6.80	-.020	
		8	6			-.010	1400.00	30.00	.60	59.00		260.0	7.90	-.020	
		9	4			-.010	1400.00	29.00	1.80	49.00		270.0	8.40	-.020	
		10	2			.010	1500.00	29.00	.60	54.00		300.0	10.00	-.020	1.00
LWS003	80	1	9	-1.00	-.020	-.020	480.00	16.00	.80	2.00	15.0	140.0	4.30	-.020	
		2	7	-1.00		-.002	440.00	29.00	.80	-.10		150.0	3.50	-.020	
		3	6			.100	460.00	29.00	1.00	25.00		150.0	6.80	-.020	
		4	10			-.010	360.00	50.00	.90	24.00		140.0	4.10	-.020	
		5	8			-.010	110.00	38.00	.50	6.70		50.0	3.70	-.020	
		6	3			-.010	170.00	49.00	.60	4.40		61.0	2.20	-.020	
		7	3			-.010	310.00	11.00	1.20	3.10		110.0	5.40	-.020	
		8	6			-.010	440.00	13.00	.80	3.00		150.0	4.00	-.020	
		9	4			-.010	480.00	13.00	2.10	3.50		160.0	5.10	-.020	
		10	2			-.010	490.00	12.00	.80	2.20		160.0	5.40	-.020	2.00
LWS004	80	3	6			.100	920.00	34.00	1.50	38.00		200.0	14.00	-.020	
		4	10			.020	920.00	63.00	1.40	38.00		230.0	14.00	-.020	
		5	8			.040	780.00	54.00	1.50	22.00		180.0	19.00	-.020	
		6	3			.020	920.00	64.00	1.20	19.00		220.0	17.00	-.020	
		7	3			-.010	960.00	16.00	1.80	16.00		250.0	21.00	-.020	
		8	6			-.010	1100.00	17.00	1.10	6.20		260.0	18.00	-.020	
		9	4			-.010	560.00	12.00	3.60	19.00		150.0	25.00	-.020	
		10	2			-.010	580.00	11.00	1.50	19.00		150.0	25.00	-.020	1.20
LWS005	80	4	23			-.010	470.00	47.00	.70	15.00		120.0	5.40	-.020	
		10	16			.020	1300.00	9.50	1.00	5.10		240.0	8.40	-.020	6.00
LWS006	80	7	23			-.010	530.00	11.00	.60	.90		150.0	3.30	-.020	
						-.010	530.00	11.00	.60	.90		1503.0	3.30	-.020	
		10	16			-.010	400.00	9.70	.70	3.20		140.0	4.20	-.020	4.20
LWS007	80	1	16				260.00	18.00	.90	-.10		110.0	5.60	-.020	

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
STREAMS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	S2O3 (MG/L)	HG (MG/L)	SE (MG/L)	SO4 (MG/L)	CL (MG/L)	F (MG/L)	NO3 (MG/L)	SI (MG/L)	NA (MG/L)	K (MG/L)	AS (MG/L)	TOTAL SULFUR (MG/L)
LWS007	80	4	23			-.010	100.00	57.00	.40	24.00		46.0	3.60	-.020	
		7	23			-.010	240.00	17.00	1.10	2.20		100.0	4.10	-.020	
		10	16			-.010	300.00	23.00	1.20	3.50		110.0	4.20	-.020	1.20
LWS013	80	1	9	-1.00	-.020	-.020	470.00	16.00	.80	2.00	14.0	150.0	4.60	-.020	
		2	7	-1.00		-.002	430.00	20.00	.80	-.10		150.0	4.50	-.020	
		3	6			-.020	460.00	24.00	1.00	21.00		160.0	7.70	-.020	
		4	10			-.010	410.00	42.00	.80	27.00		140.0	4.10	-.020	
		5	8			-.010	110.00	41.00	.50	6.90		60.0	4.10	-.020	
		6	3			.020	180.00	53.00	.60	5.30		62.0	2.40	-.020	
		7	3			-.010	310.00	11.00	1.30	3.80		110.0	5.40	-.020	
		8	6			-.010	440.00	13.00	.70	2.90		150.0	4.10	-.020	
		9	4			-.010	480.00	13.00	1.90	3.30		160.0	5.40	-.020	
		10	2			-.010	480.00	12.00	.70	2.80		160.0	5.60	-.020	.80
LWS017	80	1	16			.000	250.00	20.00	.90	-.10		100.0	5.50	-.020	
		4	23			-.010	100.00	81.00	.40	22.00		46.0	3.40	-.020	
		7	23			-.010	250.00	19.00	1.10	2.00		100.0	4.00	-.020	.00
		10	15			-.010	310.00	27.00	1.20	3.50		100.0	4.10	-.020	.70

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
STREAMS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	TURBIDITY NTU	CHEM O2 DEMAND (MG/L)	PHEN (MG/L)	BOD5 (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWS001	80	5	8	300.0	190.0	110.0	630.0	300.0	210.0	22.0	-.001	4.00	2.00	
		6	19	350.0	250.0	96.0					-.001			
LWS002	80	2	20	130.0	90.0	40.0	500.0	250.0	220.0	68.0	.003	22.00	4.00	36.00
		3	27	150.0	92.0	60.0	2500.0	57.0	44.0	34.0	-.001	2.00	-1.00	
		5	8	240.0	140.0	98.0	1000.0	5,800.0	130.0	4.0	-.001	4.00	9.00	
		6	3	440.0	220.0	220.0	2000.0	820.0	320.0	22.0	-.001	15.00	16.00	
		8	6	340.0	190.0	150.0	2500.0	13.0	10.0	26.0	-.001	48.00	10.00	
		9	4	450.0	310.0	140.0	2600.0	-1.0	10.0	66.0	.010	6.00	7.00	
		10	2	450.0	350.0	100.0	2900.0	8.0	1.0	38.0	-.001	1.00	-1.00	55.00
LWS003	80	1	9	400.0	320.0	80.0	1100.0	58.0	23.0	2.0	-.001	46.00	5.00	5.00
		2	7	450.0	380.0	70.0	1100.0	110.0	59.0	2.0	.020	7.00	8.00	-1.00
		3	6	400.0	300.0	100.0	1100.0	280.0	250.0	26.0	-.001	12.00	4.00	6.00
		4	10	400.0	300.0	100.0	940.0	450.0	240.0	29.0	.001	25.00	-1.00	11.00
		5	8	270.0	190.0	76.0	530.0	3,800.0	180.0	4.0	-.001	20.00	22.00	
		6	3	320.0	220.0	100.0	570.0	1,400.0	360.0	140.0	-.001	92.00	12.00	
		7	3	390.0	320.0	70.0	820.0	360.0	170.0	14.0	-.001	39.00	4.00	
		8	6	440.0	380.0	58.0	1100.0	300.0	78.0	14.0	-.001	10.00	4.00	
		9	4	440.0	320.0	120.0	1200.0	270.0	160.0	46.0	.010	10.00	6.00	
		10	2	440.0	350.0	94.0	1100.0	56.0	28.0	12.0	-.001	9.00	1.00	10.00
LWS004	80	3	6	240.0	170.0	70.0	1200.0	4,100.0	46.0	9.0	.004	24.00	8.00	13.00
		4	10	250.0	160.0	90.0	1700.0	410.0	230.0	53.0	.001	20.00	4.00	14.00
		5	8	250.0	190.0	60.0	1500.0	150.0	66.0	5.0	.003	4.00	12.00	
		6	3	290.0	190.0	100.0	1800.0	33.0	20.0	2.0	-.001	-1.00	4.00	
		7	3	260.0	140.0	120.0	1700.0	-1.0	1.5	18.0	-.001	45.00	-1.00	
		8	6	290.0	170.0	120.0	2000.0	-1.0	8.0	14.0	-.001	60.00	10.00	
		9	4	230.0	110.0	120.0	1100.0	17.0	2.0	4.0	.009	5.00	16.00	
		10	2	240.0	110.0	130.0	1200.0	-1.0	10.0	19.0	-.001	9.00	1.00	58.00
LWS005	80	4	23	220.0	120.0	100.0	940.0	3,200.0	350.0	4.0	-.001	-1.00	6.00	
		10	16	78.0	78.0	-1.0	2100.0	11,000.0	2,600.0	24.0	.002	53.00	-1.00	47.00
LWS006	80	7	23	380.0	230.0	160.0	1100.0	8.0	12.0	30.0	.005	33.00	2.00	
				390.0	230.0	160.0	1100.0	8.0	12.0	30.0	.005	33.00	2.00	
		10	16	300.0	200.0	100.0	890.0	1,500.0	120.0	16.0	.001	49.00	-1.00	80.00

NOTE: - INDICATES LESS THEN

LOGAN WASH
WATER QUALITY PARAMETERS
STREAMS
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	TOT ALK (MG/L CACO3)	HCO3 (MG/L CACO3)	CO3 (MG/L CACO3)	TDS (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	TURBIDITY NTU	CHEM O2 DEMAND (MG/L)	PHEN (MG/L)	BOD5 (MG/L)	OIL AND GREASE (MG/L)	DOC (MG/L)
LWS007	80	1	16	330.0	240.0	90.0	770.0	-1.0	14.0	-1.0	.018	11.00	2.00	
		4	23	250.0	130.0	120.0	460.0	900.0	240.0	25.0	-.001	1.00	3.00	
		7	23	390.0	290.0	96.0	750.0	4.0	12.0	6.0	-.001	25.00	-1.00	
		10	16	400.0	310.0	92.0	740.0	6.0	16.0	4.0	.003	53.00	-1.00	45.00
LWS013	80	1	9	410.0	320.0	90.0	1000.0	52.0	26.0	4.0	-.001	42.00	10.00	3.00
		2	7	430.0	380.0	50.0	1400.0	68.0	54.0	4.0	.010	2.00	6.00	12.00
		3	6	390.0	290.0	100.0	1100.0	340.0	250.0	4.0	-.001	14.00	8.00	14.00
		4	10	410.0	300.0	110.0	960.0	410.0	200.0	18.0	.002	29.00	2.00	17.00
		5	8	280.0	220.0	60.0	510.0	2,100.0	200.0	6.0	-.001	16.00	11.00	
		6	3	330.0	210.0	120.0	600.0	1,600.0	350.0	9.0	-.001	24.00	2.00	
		7	3	390.0	290.0	100.0	820.0	360.0	180.0	14.0	-.001	39.00	1.00	
		8	6	450.0	370.0	76.0	1100.0	300.0	82.0	22.0	-.001	70.00	6.00	
		9	4	450.0	320.0	130.0	1100.0	380.0	170.0	58.0	.020	21.00	5.00	
		10	2	450.0	360.0	86.0	1100.0	50.0	26.0	19.0	-.001	19.00	1.00	8.00
LWS017	80	1	16	360.0	240.0	120.0	770.0	-1.0	12.0	-1.0	.002	21.00	2.00	
		4	23	250.0	180.0	70.0	470.0	1,300.0	230.0	-1.0	-.001	-1.00	4.00	
		7	23	390.0	280.0	110.0	810.0	16.0	14.0	12.0	-.001	14.00	7.00	
		10	15	400.0	320.0	82.0	830.0	72.0	57.0	4.0	.001	48.00	-1.00	45.00

NOTE: - INDICATES LESS THEN

WATER QUALITY

FOR

NPDES DISCHARGE

February - October 1980

LOGAN WASH
WATER QUALITY PARAMETERS
NPDES DISCHARGE
FOR SAMPLE DATA SHOWN

LOC	YR	MO	DY	AS (MG/L)	B (MG/L)	CR (MG/L)	CU (MG/L)	FE (MG/L)	TOTAL SUSPEND SOLIDS (MG/L)	MO (MG/L)	ZN (MG/L)	F (MG/L)
LWM001	80	8	15	.070	24.000	.060	.040	4.100	3,100.0	1.700	.400	5.20
			18	.070	14.000	.060	.060	30.000	2,300.0	2.100	.200	7.50
		9	9	.070	16.000	.080	.090	44.000	2,400.0	4.600	.400	9.70
			23	.000		.000	.000		900.0			18.00
		10	1	.030	58.000	-.020	.050	1.200	270.0	30.000	.100	14.00
			10	.100	57.000	-.020	.030	.900	5,100.0	.300	.500	17.00
LWM002	80	2	15									
		4	30	.030	1.700	.020	.020	9.800	420.0	.300	.080	2.10
		5	21	.080	7.100	.060	.020	150.000	15,000.0	.060	.500	1.10
		7	31	.020	1.300	-.020	-.020	.090	280.0	.300	-.020	1.40

NOTE: - INDICATES LESS THAN

LOGAN WASH
WATER QUALITY PARAMETERS
NPDES DISCHARGE
FOR SAMPLE DATA SHOWN

WELL	YR	MO	DY	BOD (MG/L)	COD (MG/L)	OIL AND GREASE (MG/L)	PHEN (MG/L)	TOTAL DISSOLVED SOLIDS (M/L)	SCN (MG/L)	NH3 (MG/L)	S (MG/L)
LWM001	80	8	15	31.00	110.0	17.00	.400	5200.0		7.40	
			18	35.00	110.0	7.00	.010	4300.0		12.00	
		9	9	70.00	190.0	8.00	.020	4500.0		11.00	
			23		72.0	11.00	.006	7900.0		2.50	
		10	1	140.00	160.0		-.001	520.0		3.50	
			10	56.00	300.0	10.00	.007	9500.0		140.00	
LWM002	80	2	15								
		4	30	60.00	50.0	5.00	.010	1400.0		14.00	
		5	21	100.00	250.0	14.00	.280	960.0		.40	
		7	31	40.00	30.0	6.00	.005	1100.0		1.60	

NOTE: - INDICATES LESS THAN

HYDROLOGY

FOR

NPDES DISCHARGE

October - November 1980

Daily Averages (CFS)

Flume Dry Gulch

Date	Flow (CFS)	Remarks
October 1–13		Installed instrumentation October 14th
14	0.000	
15	*	
16–22	*	Mud in flume
23	0.14	
24	0.05	
25	*	Mud in flume
26–29	*	Mud in flume
30	0.13	
31	0.08	
November 1	0.04	
2	*	Mud in flume
3	0.01	
4	*	Mud in flume, instru. reset
5	0.000	
6	0.08	
7	*	Mud in flume
8–15	NO FLOW	Mud cleaned out. No flow recorded.
16		
17		
18		
19		
20		

* Value below instrument detection for flow.

THIOCYANATE DATA

FOR

VARIOUS LOCATIONS AT

LOGAN WASH MINE SITE

LOCATION	YEAR	MONTH	DAY	THIOCYANATE
LWA022	80	10	22	-.100
LWA101	80	10	22	-.100
LWA102	80	9	4	-.500
		10	2	-.500
		11	6	-.100
LWA103	80	10	16	-.100
LWA104	80	10	16	-.100
LWA112	80	10	22	-.100
LWA115	80	10	22	-.100
LWA121	80	9	4	-.500
LWD032	80	9	16	-.500
LWD046	80	9	18	-.500
LWD047	80	9	18	-.500
LWD106	80	9	16	-.500
LWD108	80	10	22	-.100
LWD116	80	9	16	-.500
LWD602	80	9	8	-.500
		10	15	.500
		11	13	-.100
LWD603	80	9	8	-.500
		10	15	-.500
LWD604	80	9	8	-.500
		10	15	-.500
		11	13	-.100
LWD605	80	9	8	2.400
		10	15	1.200
			30	.800
		11	13	.300
LWD606	80	10	15	-.500
LWD610	80	9	8	-.500
		10	15	-.500
		11	13	-.100
LWM001	80	9	9	-.500
			23	-.500
		10	1	-.500
			10	-.500
LWR001	80	9	18	-.500
LWS002	80	9	4	-.500
		10	2	-.500
LWS003	80	9	4	-.500
		10	2	-.500
		11	6	-.100
LWS004	80	9	4	-.500
		10	2	-.500
		11	6	-.100
LWS005	80	10	16	-.100
LWS006	80	10	16	-.100
LWS007	80	10	16	-.100
LWS013	80	9	4	-.500
		10	2	-.500
		11	6	-.100
LWS017	80	10	15	-.100

APPENDIX C

VEGETATION DATA AND ANALYSIS FOR SEPTEMBER 1980

APPENDIX I

to

AN ECOLOGICAL BASELINE STUDY OF FLORA, VEGETATION, AND SOILS ON THE OCCIDENTAL OIL SHALE, INC. LOGAN WASH SITE NEAR DEBEQUE, COLORADO

VEGETATION DATA AND ANALYSIS FOR SEPTEMBER, 1980

by

Neil E. West

and

James R. Irvine

for
OCCIDENTAL OIL SHALE, INC.
Grand Junction
Colorado

November, 1980

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ABSTRACT

Twenty one of 54 macroplots, located during 1974 and 1975 were resurveyed in July 1980 for plant cover, density, and frequency. Methods were consistent with previous data collection.

Summary tables were calculated for each of the nine community types occurring on Occidental Oil Shale, Inc. lands. An increase in the number of new individuals and total vegetal cover was observed in both the overstory and understory vegetation. These changes were attributed to two consecutive years of high winter precipitation.

Recommendations include continued road oiling, especially the new road to the top of the plateau, revegetation of cut-fill slopes, location of topsoil barrow areas, and establishment of revegetation test plots.

INTRODUCTION

As part of Occidental's environmental program, a resurvey of vegetation on Occidental Oil Sahle, Inc., Logan Wash site was conducted during July, 1980.

Continual monitoring of the vegetation, based on plots established in 1974 and 1975, was done to inform the company of natural fluctuations and man-induced perturbations to the vegetation.

METHODS

During the 1974-1975 field season 54 macroplots were located throughout Occidental Oil Shale, Inc. property and adjacent Bureau of Land Management (BLM) lands (Fig. 1). These macroplots were combined into nine plant community types. Three macroplots were chosen from each community type for the 1977-1980 resurvey. The selection of macroplots was based on comparative floristic diversity and the relative abundance of vegetal cover in the macroplot: one macroplot had the fewest species and lowest apparent vegetal cover, one had a nearly average number of species and near average vegetal cover, and the third macroplot had the greatest floristic diversity and vegetal cover available from the set of 1975 macroplots taken in a given vegetation type. In the cases where only two or three macroplots existed in a community type, all were surveyed. The same subset of macroplots were again resurveyed in July except two macroplots (#1 and #20), which could not be located due to the removal of the macroplot marker stake. This resulted in 21 macroplots being resurveyed (Table 1).

RESULTS

Tables 2 through 10 summarize vegetation characteristics observed in each of the nine community types occurring on Occidental Oil Shale Inc.

land as of July 1980.

Two consecutive years of above normal winter precipitation has yielded extremely high soil moisture recharge. This is evidenced by above normal stream discharge, moist soil less than 10 cm below the surface, and increased seepage at the sandstone-shale contact zone.

Increased soil moisture has contributed to increased vegetal cover and density. Community types occurring on the most mesic (moist) sites showed the greatest increases in cover and density.

In the shadscale community type, slight cover increases were found for Sarcobatus vermiculatus, mostly as new shoot growth. Increases in both cover and density were found for the grasses (Bromus tectorum and Oryzopsis hymenoides) and the forb, Lepidium perfoliatum.

Slight cover increases were recorded in the pinyon-juniper community type. Notably, the shrubs Artemisia tridentata and Symphoricarpos oreophilus and the grasses, Oryzopsis hymenoides and Elymus salinas, showed slight cover increases. The forbs, Cryptantha bakerii, Hymenoxys acaulis, Physaria australis, Penstemon ousterhoutii, and Stanleya pinnata, also showed slight cover and density increases.

In the closed-brush community type, the shrub Symphoricarpos oreophilus showed a 4 percent increase in cover. Other shrubs showed slight increases in cover or remained unchanged. Grass species exhibited essentially no change. The forbs Galium coloradoense, Penstemon ousterhoutii, Pachistima myrsinites, and Berberis repens all increased in cover and density.

A slight general increase in both cover and density were observed for most species on the open-brush community type. In particular the shrub Symphoricarpos oreophilus increased 1 percent in cover or approximately

20 cm in horizontal diameter per individual. The brown day moth (Pseudohazis egalanteria nuttallii Sth) has reappeared on this shrub; its reappearance possibly triggered by increased shrub growth. At any rate, increased mortality of new growth can be expected as the brown day moth numbers increase. The greatest increases in cover and density were observed in the grasses and forbs. Grass-like Carex rossii and forbs Lupinus adimcus, Lathyrus sp., Eriogonum umbellatum, Achillea lanulosa, and Erigeron speciosus all increased in cover and/or density.

In the Douglas-fir community type, new individuals of Douglas-fir, Pseudotuga menzesii, were observed. A 2 percent cover increase for the shrub Symphoricarpus oreophilus and cover and/or density increases for the forbs Berberis repens, Galium boreale and Pachistima myrsinites were also observed.

The moist understory environment of the aspen woodland community allowed for the establishment of new individuals, and increased vegetal cover. New aspen Populus tremuloides sprouts were observed and are likely to survive and rejuvenate some clones. The most notable cover increase was again the shrub Symphoricarpus oreophilus, with grasses, grass-likes and forbs changing only slightly.

The grassland community type exhibited the least change. Utilization of soil moisture by grasses requires less of a substratum moisture recharge than deep rooted shrubs since grasses primarily utilize near surface soil moisture.

Similarly the grasses on the scree community type exhibited little change. There was an increase in the forbs Galium colorodoense, Leptodactylon watsonii, and Penstemon cyanocaulis, however.

The greatest cover increases in the alluvial community type were the shrubs Artemisia tridentata (2 percent) and Symphoricarpos oreophilus (3 percent). The forbs Penstemon ousterhoutii and Physaria australis both increased 3 percent in cover.

The shrub Symphoricarpos oreophilus has shown the greatest general increase in cover and density with increased soil moisture. Important increases of Douglas-fir seedlings, and new sprouts of aspen occurred, helping to maintain these community types. Forbs have also been growing under favorable seed germination conditions, since they have generally increased in density. Grasses and grass-likes exhibited the least change since they are less dependent on the type of soil moisture recharge that has occurred over the past two years.

RECOMMENDATIONS

Revegetation of cut and fill slopes should occur concurrently with new road building activity. Road development from the mine road to the top of the plateau has produced sizable colluvial slopes from road cuts. Some colluvial material extends from one road level to the next lower level. These areas are susceptible to erosion such as occurred on natural scree slopes in the spring of 1979. Such movement on steep terrain could cause considerable road damage and destruction of natural vegetation downslope. Under typical conditions, erosional movement is minimal, but unseasonably high moisture could trigger massive movement. Particular attention should be made to revegetate fill areas where minor road cuts occur, i.e., road turns and steep mountain side gullies. Revegetating these areas with densely-rooted grasses would help mitigate the possibility of earth slumping. Little would be gained trying to revegetate the cut side of new roads as these are largely rock.

Oiling of the lower road to the mine, as recommended in the past, has reduced dust considerably, and little dust was visible on the vegetation. Similar action should be taken to oil the new road leading to the top of the plateau, thereby reducing the risk of plant mortality and accelerating erosion.

The new smoke stack appears to have little effect on surrounding vegetation. Any new smoke stacks planned fur future construction should be of similar type. The design should afford uninterrupted plume dispersal.

Raw oil shale mine tailings are becoming sizable with new mining activity. Although new mine waste is continually being added to the tailings pile, and revegetation is unfeasible at this time, revegetation test plots should be established on stable sites. As with mineral exploration and development, time is needed to identify and make economical selections of plant materials and planting methods before large scale revegetation can successfully occur. Macroplot #84 is of special interest as it allows the study of natural plant succession on an amalgam of shale material in particle sizes nearly simulating shale mine tailings.

It may also be desirable to undertake a more detailed soil inventory than that done in connection with our 1975 phyto-edaphic studies. Such an inventory would locate sources of gravel and fill for road building and topsoil for revegetation. Source areas for ponds, embankments, and levees would be located. Natural hazards such as excessively wet areas, areas subject to flooding, and areas with low revegetation potential could be identified.

Lastly, a continued resurvey of the vegetation is recommended. Long term subtle changes can only be observed by continual monitoring of the vegetation. Visual on site inspection also allows time to address environmental concerns and recommend natural resource protection concurrent with mining activities.

CONCLUSIONS

Twenty-one macroplots were resurveyed during July, 1980. Comparisons were made between present vegetation data and previous years' data.

In general, floristic diversity has shown little change, but the number of indivuals has increased within the particular community. Similarly, vegetal cover has increased in most overstory and understory vegetation. Changes of this nature are most likely attributable to the previous two years of above normal winter precipitation. Natural fluctuation is attributable to climatic variation. Change induced by man is principally associated with surface distribution caused by mining and road building activity.

Table 1. Macroplots sampled during the July, 1980, field season, by community type.

Community type Diversity and Productivity Rating	Macroplot number High	 Average	 Low
Shadscale		54	
Pinyon-Juniper	9	53	45
Closed Brushland	25	24	43
Open Brushland	19	32	38
Douglas-Fir		42	52
Aspen		26	22
Grassland		50	41
Scree		51	2
Alluvial		48	

Table 2. Summary of 1980 vegetation data for the shadscale community type by cover (C), density (D, number of plants per 50 m^2), and frequency (F).

Species[1/]	Macroplot Numbers					
	54			Average		
	C[2/]	D	F[3/]	C	D	F
Trees and Shrubs						
Sarcobatus vermiculatus	7	9	70	7	9	70
Atriplex confertifolia	5	4	40	5	4	40
Artemisia tridentata	4	11	50	4	11	50
dead *Artemisia tridentata*	T	2	20	T	2	20
Juniperus osteosperma	1	0	0	1	0	0
Grasses						
Bromus tectorum	7	176	50	7	176	50
Oryzopsis hymenoides	1	7	30	1	7	30
Agropyron spicatum	T	1	10	T	1	10
Forbs						
Lepidium perfoliatum	1	34	30	1	34	30
Hymenoxys acaulis	T	8	10	T	8	10
Astragulus spp.	T	4	30	T	4	30
Amsonia tomentosa	T	1	10	T	1	10
Cryptantha bakerii	T	0	0	T	0	0
Chenopodium album	0	3	10	0	3	10
Physaria australis	0	1	10	0	1	10
Salsola kali	0	1	10	0	1	10
Lappula redowskii	0	1	10	0	1	10

1/ For authorities, listing of associated common names, life forms, longevities, season of growth and origin see Table 3 of 1976 report.

2/ Cover is line intercept vertical projection of percentage of line which has vegetation canopy above it.

3/ Frequency is the percentage of the ten 1x5 meter macroplots which has at least one individual of a given species occurring in it.

Table 3. Summary of the 1980 vegetation data for the pinyon-juniper woodland community type by cover (C), density (D, number of plants per 50 m^2), and frequency (F).

Species	Macroplot Number 9			45			53			Average		
	C	D	F	C	D	F	C	D	F	C	D	F
Trees and Shrubs												
Juniperus osteosperma	8	3	30	4	0	0	10	1	10	7	3	13
dead *Juniperus osteosperma*	2	0	0							1	0	0
Cercocarpus montanus	10	6	50	4	14	80	4	6	30	6	9	53
dead *Cercocarpus montanus*	0	1	10							0	1	3
Artemisia tridentata				15	13	50				5	4	17
dead *Artemisia tridentata*				2	3	10				1	1	3
Symphoricarpos oreophilus				2	15	70				1	5	23
dead *Symphoricarpos oreophilus*				0	1	10				0	1	3
Amelanchier alnifolia				3	14	60				1	5	20
dead *Amelanchier alnifolia*				T	0	0				T	0	0
Ephedra viridis	1	0	0	3	11	50	0	1	10	1	4	20
dead *Ephedra viridis*				T	0	0				T	0	0
Pinus edulis							3	0	0	1	0	0
Xanthocephalum sarothrae	T	2	10							T	1	3
Chrysothamnus visidiflorus	0	1	10							0	1	3
Grasses												
Elymus salina	6	29	70	14	135	100	T	7	40	7	57	63
Oryzopsis hymenoides	T	1	10	2	15	30	0	1	10	1	6	17
Bromus tectorum				1	0	0	T	0	0	T	0	0
Poa pratensis							T	0	0	T	0	0
Sitanion hystrix				1	0	0				T	0	0
Hilaria jamesii							0	2	10	0	1	3
Stipa comata				0	1	10				0	1	3
Forbs												
Cryptanthus bakerii	T	8	20	2	35	70	1	22	60	1	25	50
Physaria australis				T	0	0	1	34	60	T	11	20
Hymenoxys acaulis	T	15	10	1	30	50				T	15	20
Penstemon ousterhootii	0	1	10	T	2	20	T	5	30	T	3	20
Stanlyea pinnata				1	1	10	T	8	20	T	3	10
Arenaria fendlerii				T	5	20	T	0	0	T	2	7
Leptodactylon watsonii				T	6	20				T	2	7
Euphorbia robusta	T	3	20				T	4	10	T	2	10
Astraglus spp.	1	4	30							T	1	10
Cheopodium album							T	2	20	T	1	7

Table 3. continued.

Species	Macroplot Number											
	9			45			53			Average		
	C	D	F	C	D	F	C	D	F	C	D	F
Forbs (cont.)												
Erigeron eatoni				T	2	10				T	1	3
Allium cernuum				T	2	10				T	1	3
Erysimum inconspicuum							T	0	0	T	0	0
Senecio multilobatus							T	0	0	T	0	0
Lepidium perfoliatum				T	0	0				T	0	0
Castellija linearifolia				T	0	0				T	0	0
Galium coloradoense	T	0	0							T	0	0
Succulents												
Opuntia rodantha				T	1	10				T	1	3

Table 4. Summary of the 1980 vegetation data for the closed brushland community type by cover (C), density (D, number of plants per 50 m^2), and frequency (F).

Species	Macroplot Number 24			25			43			Average		
	C	D	F	C	D	F	C	D	F	C	D	F
Trees and Shrubs												
Amelanchier alnifolia	33	36	80	11	23	60	20	39	80	21	32	73
dead *Amelanchier alnifolia*	8	2	20	T	3	30	2	1	10	2	2	20
Quercus gambelii	18	32	80	12	46	90	14	86	80	15	55	83
dead *Quercus gambelii*	2	6	40	1	0	0	1	6	30	1	4	23
Symphorcarpus oreophilus	18	24	80	T	2	20	5	10	40	8	12	46
Cercocarpus montanus	2	0	0	1	1	10	10	3	20	4	1	10
Purshia tridentata				8	9	40				3	3	13
Artemisia tridentata	T	1	10	2	3	20	1	2	10	1	2	13
Eriogonum effusum				T	2	10	1	5	20	T	2	10
Tetradymia canescens							1	1	10	T	1	3
Ceanothus martinii	T	0	0	0	1	10				T	1	3
Chrysothamnus visidiflorus				T	0	0				T	0	0
Holodiscus dumosus	T	0	0							T	0	0
Pseudotsuga menziesii	T	0	0									
Ribes wolfii				1	0	0				T	0	0
Grasses												
Elymus salinus	T	2	10	1	9	30	3	20	40	1	10	27
Oryzopsis hymenoides	1	2	20	1	9	40	2	6	40	1	6	33
Carex rossii	1	7	30	2	9	50				1	5	27
Stipa lettermanii	T	0	0	1	5	40				T	2	13
Hilaria jamesii				0	1	10				0	1	3
Forbs												
Galium coloradoense	T	9	20	2	23	50	4	44	100	2	25	57
Penstemon ousterhoutii	1	9	20	2	55	70	1	26	90	1	30	60
Pachystima myrsinites	2	25	70	T	0	0	T	6	30	1	10	33
Berberis repens	4	29	80							1	10	27
Eriogonum umbellata	1	3	10	1	5	30				1	6	13
Senecio multilobatus				1	16	40				T	5	13
Physaria australis	T	0	0	0	4	30	1	7	30	T	4	20
Achillea lanulosa	T	7	10							T	2	3
Chaenactis douglasii				T	2	20				T	1	7
Leptodactylon watsonii				0	3	20				T	1	7
Circium undulatum				T	2	20				T	1	7
Castilleja linearifolia							T	2	10	T	1	3
Penstemon strictus	T	1	10							T	1	3
Stephanomeria tenuifolia				T	0	0				T	0	0
Artemisia biennis							T	0	0	T	0	0
Erigeron inconspicuum							T	0	0	T	0	0
Lupinus aduncys	T	0	0							T	0	0

Table 5. Summary of the 1980 vegetation data for the open brush-grassland community type by cover (C), density (D, number of plants per 50 m^2), and frequency (F).

Species	Macroplot Numbers											
	19			32			38			Average		
	C	D	F	C	D	F	C	D	F	C	D	F
Trees and Shrubs												
Symphoricarpos oreophilus	5	22	70	23	62	100	7	15	50	12	33	73
dead *Symphoricarpos oreophilus*	T	6	10	T	0	0				T	2	3
Quercus gambelii	1	11	20	16	77	60	16	33	70	11	40	50
dead *Quercus gambelii*				0	2	10	2	5	20	1	2	10
Amelanchier alnifolia	3	17	30	15	44	80	14	21	50	11	27	53
dead *Amelanchier alnifolia*							1	1	10	1	1	3
Artemisia tridentata	13	28	90	2	9	30	7	22	60			
dead *Artemisia tridentata*	7	9	50	T	1	10	T	5	40	2	5	33
Prunus virginiana	T	0	0	8	20	30				3	7	10
Chrysothamnus visidiflorus	4	35	70	1	5	50	2	9	40	2	17	54
Rosa nutkana				1	13	60				T	4	20
Purshia tridentata	T	0	0				2	1	10	1	1	3
Cercocarpus montanus							T	0	0	T	0	0
Tetradymia canescens				0	1	10				0	1	3
Grasses and Grass-Likes												
Carex rossii	11	92	100	11	62	70	2	24	100	8	60	90
Stipa letermanii	5	42	60	1	6	30				2	16	30
Poa pratensis	4	38	80	1	0	0				2	13	27
Stianion hystrix	5	5	40	T	0	0				2	2	13
Elymus salina	T	4	10	1	41	70	T	0	0	T	15	27
Bromus polyanthus				T	6	50				T	2	17
Stipa comata	1	1	10	T	1	10				T	1	7
Hilaria jamesii	1	3	10							T	1	3
Bromus marginatus	1	0	0				T	0	10	T	1	3
Oryzopsis hymenoides							T	0	10	T	1	3
Agropyron smithii	0	2	10							0	1	3
Agropyron spicatum				0	1	10				0	1	3
Forbs												
Lupinus aduncus	6	50	80	8	40	60	3	34	80	6	41	73
Lathyrus spp.	8	90	90	3	75	100	T	5	10	4	57	67
Erigonum umbellatum	3	76	60	1	23	40	1	29	60	2	43	53
Lithosperma ruderale	T	3	20	6	2	20	T	0	0	2	2	13
Achillea lanulosa	2	57	80	T	23	40	1	23	30	1	34	50
Agastache urticifolia	T	3	10	2	50	40				1	18	17
Erigeron speciosus	1	8	30	3	25	70				1	11	33
Ligusticum porterii				3	14	40				1	5	13
Gayophytum ramosissimum	T	39	40	T	22	30	T	0	0	T	20	23

Table 5. Continued.

Species	Macroplot Numbers											
	19			32			28			Average		
	C	D	F	C	D	F	C	D	F	C	D	F
Forbs (cont.)												
Galium boreale	T	0	0	1	33	60				T	11	20
Viguera multiflora	T	20	10	T	2	20				T	7	10
Arenaria fendleri	1	16	40							T	5	13
Comandra umbellata	T	7	20	1	8	10				T	5	10
Senecio multilobatus	1	12	50				T	1	10	T	4	20
Penstemon ousterhoutii				0	1	10	1	11	50	T	4	20
Unknown mustard	0	5	50	0	4	20	T	1	10	T	3	27
Calochortus gunnisonii	T	7	40	0	2	20				T	3	20
Castellija linaerifolia	T	0	0	0	5	10	T	0	0	T	2	3
Linum lewsii	0	3	10	T	1	10				T	1	7
Chrysopsis villosa				T	3	20				T	1	7
Tragopogon dubius	T	2	10	T	0	0				T	1	3
Circium undulatum	T	2	10							T	1	3
Penstemon watsonii	T	3	10	T	0	0				T	1	3
Chaenactis douglasii	T	0	0	T	0	0	T	0	0	T	0	0
Phacelia hastata	T	0	0				T	0	0	T	0	0
Taraxacum laevigatum	T	0	0	T	0	0				T	0	0
Galium colorodoense							T	0	0	T	0	0
Pachistima myrsinites							T	0	0	T	0	0
Succulents												
Opuntia rhodantha							T	0	0	T	0	0

Table 6. Summary of the 1980 vegetation data for the Douglas-fir forest community type by cover (C), density (D, number of plots per 50 m^2), and frequency (F).

Species	Macroplot Numbers								
	42			52			Average		
	C	D	F	C	D	F	C	D	F
Trees and Shrubs									
Pseudotsuga menziesii	33	7	40	25	5	40	29	6	40
dead *Pseudotsuga menziesii*	T	1	10				T	1	5
Quercus gambelii	8	37	90	11	56	100	10	47	95
dead *Quercus gambelii*	T	4	30	1	2	20	1	3	25
Amelanchier alnifolia	12	11	60	8	10	40	10	11	50
dead *Amelanchier alnifolia*	1	2	20	2	0	0	2	1	10
Symphoricarpos oreophilus	12	21	80	2	4	30	7	13	55
Rosa nutkana	4	27	90				2	14	45
Betula occidentalis	1	6	40				1	3	20
Acer glabrum	2	6	40				1	3	20
Ribes wolfii	T	2	20	1	2	20	1	2	20
Cercocarpus montanus	T	2	10	T	1	10	T	2	10
dead *Cercocarpus montanus*	T	0	0				T	0	0
Ceanothus martinii				T	1	10	T	1	5
Grasses and Grass-Likes									
Carex rossii	2	85	50	1	16	70	2	50	60
Elymus salina				1	41	40	1	22	20
Stipa columbiana				T	1	10	T	1	5
Forbs									
Berberis repens	6	104	100	1	12	20	6	58	60
Penstemon ousterhoutii				2	66	70	1	33	35
Pachystima myrsinities	1	23	90	T	0	0	1	12	45
Galium boreale	2	23	70				1	12	35
Smilacina stellata	1	24	30				1	12	15
Clematis linguisticafolia	2	22	50				1	11	25
Smilacina racemosa	1	10	50				1	5	25
Lathyrus spp.	1	2	10				1	1	5
Senecio multilobatus				T	50	20	T	25	10
Allium cernuum	T	3	10				T	2	5
Galium coloradoense				T	0	0	T	0	0

Table 7. Summary of 1980 vegetation for the aspen woodland community type by cover (C), density (D, number of plants per 50 m^2) and frequency (F).

Species	Macroplot Numbers											
	21			22			26			Average		
	C	D	F	C	D	F	C	D	F	C	D	F
Trees and Shrubs												
Populus tremuloides	62	19	40	30	16	50	40	18	70	44	18	53
dead *Populus tremuloides*	0	5	20							0	2	7
Symphoricarpos oreophilus	14	31	80	9	55	80	8	29	70	10	38	77
Acer glabrum	12	18	60	1	23	70	0	1	10	4	14	47
Rosa nutkana	T	7	40	1	13	50	1	7	40	1	9	43
Amelanchier alnifolia	4	0	0	0	1	10				1	1	3
Artemisia tridentata	T	1	10				T	1	10	T	1	7
Chrysothamnus visidiflorus	T	1	10							T	1	3
Grasses and Grass-Likes												
Carex rossii	9	120	90	7	75	90	4	66	70	7	87	83
Poa pratensis	6	49	30	2	15	10	13	27	40	7	30	27
Stipa lettermanii	2	27	50				0	2	20	1	10	23
Bromus marginatus	T	16	30	0	2	10	T	13	40	T	10	27
Stipa comata				0	1	10				0	1	3
Forbs												
Galium boreale	21	455	100	4	217	100	2	39	70	9	237	90
Lathyrus spp.	13	88	90	5	99	80	9	97	80	9	94	83
Senecio serra	1	23	40	9	174	80	5	102	100	5	100	73
Thalictrum fendleri	T	19	50	5	133	80	4	45	60	3	66	63
Osmorhiza occidentalis				4	145	90	2	83	60	2	76	50
Ligusticum porterii	T	3	30	1	6	40	4	17	50	2	9	40
Taraxacum officinale	1	30	30	0	67	70	1	73	80	1	57	60
Gayophytum ramosissimum	1	0	0				1	100	30	1	33	10
Achillea lanulosa	1	23	70	T	43	40	1	30	80	1	32	63
Chenopodium album	0	33	20	0	2	10	1	53	30	T	29	30
Agastache urticifolia	T	8	30	T	12	50	T	2	20	T	7	33
Smilacina stellata	0	1	10	T	16	10				T	6	7
Frageria ovalis				0	7	20	T	8	20	T	5	13
Valeriana occidentalis				T	0	0	1	13	20	T	4	13
Geranium fremontii	T	0	0	T	4	30	T	0	0	T	4	10
Clematis hirsutissimus							1	8	50	T	3	17
Aquilegia caerulea				T	3	20	1	7	20	T	3	13
Viola canadensis							T	10	10	T	3	3
Streptopus amplexifolius	T	4	10	0	1	10				T	2	7
Phacelia sericea	T	3	20							T	1	7

Table 7. Continued.

Species	Macroplot Numbers											
	21			22			26			Average		
	C	D	F	C	D	F	C	D	F	C	D	F
Forbs (cont.)												
Erigeron speciosus	T	4	20									
Potentilla gracilis				T	0	0	T	4	20	T	1	7
Lupinus aduncus							T	1	10	T	1	3
Circium undulatum							T	2	10	T	1	3
Chenopodium botrys	T	0	0							T	0	0
Unknown mustard	0	3	20							0	1	7

Table 8. Summary of the 1980 vegetation data for the grassland community type by cover (C), density (D, number of plants per 50 m^2), and frequency (F).

Species	Macroplot Numbers								
	41			50			Average		
	C	D	F	C	D	F	C	D	F
Trees and Shrubs									
Atriplex canescens	9	11	60				5	6	30
Artemisia frigida	4	35	90				2	18	45
Erigonum effusum	4	11	60	T	1	10	2	6	35
Chrysothamnus viscidiflorus				2	30	90	1	15	45
Ephedra viridus	2	3	20				1	2	10
Amelanchier alnifolia	2	2	20				1	1	5
Symphoricarpus oreophilus	1	4	20				1	2	10
Tetradymia canescens				T	3	10	T	2	5
Chrysothamnus nauseosus	1	0	0				T	0	0
Artemisia tridentata				0	5	10	0	3	5
Grasses									
Elymus salina	7	27	90	18	235	100	13	131	95
Bromus tectorum	14	231	100				7	116	50
Oryzopsis hymenoides	6	36	100	3	12	50	5	52	75
Hilaria jamesii				4	52	90	2	26	45
Stipa comata				2	26	60	2	13	30
Forbs									
Artemisia biennis	10	11	20				5	6	10
Astragulus amphioxys				5	38	90	3	19	45
Erigeron eatoni				4	124	100	2	62	50
Hymenoxys acaulis				3	81	100	2	41	50
Rorripa islandica	3	7	40				2	4	20
Castellija rhexifolia				2	60	90	1	30	45
Arenaria fendlerii				2	28	60	1	14	30
Trifolium gymnocarpon				1	74	100	T	37	50
Unknown mustard				T	20	70	T	10	35
Senecio multilobatus				1	17	70	T	9	35
Crypanthus bakerii				T	9	30	T	5	15
Galium coloradoense	1	10	20				T	5	10
Linum lewisii				T	7	30	T	4	15
Abrosia artemisifolia	1	5	20				T	3	10
Achillea lanulosa				1	5	10	T	3	5
Tragopogon dubious	T	0	0				T	0	0
Penstemon ousterhoutii	0	6	50				0	3	25
Penstemon crandellii				0	3	10	0	2	5
Leptodactylon watsonii				0	2	10	0	1	5
Eriogonum umbellatum	1	0	0				T	0	0
Succulents									
Yucca harrimaniae	1	0	0				T	0	0

Table 9. Summary of 1980 vegetation data for the scree slope community type by cover (C), density (D, number of plants per 50 m^2), and frequency (F).

Species	2			51			Average		
	C	D	F	C	D	F	C	D	F
Trees and Shrubs									
Holodiscus dumosus	1	1	10	2	6	30	2	4	20
Symphoricarpus oreophilus				1	3	20	1	1	10
Chrysothamnus visicidiforus	T	0	0	1	2	20	1	2	10
Qucrcus gambelii				1	0	0	1	0	0
Grasses									
Agropyron spicatum				T	1	10	T	1	5
Oryzopsis hymenoides	T	1	10				T	1	5
Forbs									
Galium coloradoense	2	71	80	T	3	30	1	37	55
Pteryxia hendersonii	1	19	70				1	10	35
Penstemon cyanocaulis	0	1	10	1	16	60	1	9	35
Leptcdactylon watsonii	1	14	80				1	7	40
Circium undulatum	T	7	40				T	4	20
Euphorbia robusta	T	3	30				T	2	15
Mentzelia albicaulis	T	3	30				T	2	15
Astragalus lutosus	T	3	20	T	0	0	T	2	10
Physaria australis	T	0	0				T	0	0
Stephanomaria tenufolia	0	1	10				0	1	5

(Column groups 2, 51 and Average are Macroplot Numbers.)

Table 10. Summary of the 1980 vegetation data for the alluval community type by cover (C), density (D, number of plants per 50 m^2), and frequency (F).

Species	46 C	46 D	46 F	48 C	48 D	48 F	Average C	Average D	Average F
Trees and Shrubs									
Artemisia tridentata	22	35	100	21	30	90	22	33	95
dead *Artemisia tridentata*	6	10	70	6	6	40	6	8	65
Symphoricarpos oreophilus	1	4	20	25	40	100	13	22	60
Quercus gambelii	4	0	0	15	90	70	10	45	35
dead *Quercus gambelii*	T	0	0	T	0	0	T	0	0
Chrysothmanus nauseosus	8	16	50	3	9	60	6	13	55
Amelanchier alnifolia	6	2	20	1	0	0	4	1	10
Rhus trilobata	2	1	10				1	1	5
Rosa nutkana				1	1	10	1	1	5
Cercocarpus montanus	T	0	0				T	0	0
Ephedra viridis				T	0	0	T	0	0
Forbs									
Penstemon ousterhoutii	5	6	40	4	73	80	5	40	60
Physaria australis	4	117	100	1	50	30	3	84	65
Erigeron inconspicuum	1	60	20				1	30	10
Cryptantha bakerii	1	40	80	0	3	20	1	22	50
Stanlyea pinnata	1	5	20	T	1	10	1	3	10
Galium colorodoense	T	1	10				T	1	5
Senecio multilobatus	T	2	10				T	1	5
Euphorbia robusta	T	0	0				T	0	0
Penstemon strictus				0	3	10	0	2	5
Chenopodium album	0	2	10				0	1	5

FIGURE I MAP OF OCCIDENTAL OIL SHALE CORP. PROPERTY WITH VEG. SAMPLE LOCATIONS

APPENDIX D

VERTEBRATE POPULATION, SUMMER 1980

VERTEBRATE POPULATIONS AT THE
OCCIDENTAL OIL SHALE, INC.
LOGAN WASH SITE
SUMMER 1980

Prepared by

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for

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November 1980

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ABSTRACT

Vertebrate populations at the Occidental Oil Shale, Inc. Logan Wash site were studied in May/June and August 1980. Data were collected on experimental and control plots in pinyon-juniper, mountain shrub, and aspen in order to test the null hypothesis that mining activities are not affecting small mammals, birds, or deer. Small mammals were studied by the mark and release technique. Birds and deer were censused visually.

Most mule deer are at higher elevations in summer. Populations on study plots were: Upper Fall, 18; Upper Riley, 22; Upper Mine, 21, east end of mesa, 12; 8605, 2; Lower Fall, 1; Lower Mine, 10; total, 86. The 1980 estimated population is 29 per cent lower than the 1978 population, probably due to severe winter conditions in 1978-79. The censused population consisted of 30 per cent bucks, 42 per cent does, and 28 per cent fawns. The percentage of bucks decreased and the percentage of fawns increased, from 1978 to 1980. The buck to doe ratio was 1:1.38, considerably higher than a literature average of 1:3.34. Productivity was 66.7 per cent, up from 1978, but lower than 1977 and the Colorado average of 90 per cent. Fetal rate was 1.35, slightly lower than 1977 and 1978 and a literature average of 1.67 for does 2 to 7 years old in Utah. Deer are found in mountain shrub in summer, though a greater proportion was found in aspen in 1980 than in previous summers.

Small mammal abundance declined at the site between 1978 and 1980, on both experimental and control plots. Deer mice are the most abundant rodent at the site. At lower elevations they contribute 13 to 100 per cent of biomass on control and 11 to 48 per cent on experimental sites. At higher elevations they contribute 40 to 85 per cent on control and 29 to 95 per cent on experimental sites. Rock and pinyon mice, which occur only at lower

elevations, decreased sharply in abundance from 1978 to 1980. Their contribution to biomass has been 6 to 34 per cent on control sites and 0.5 to 6 per cent on experimental. There are no published records of rock mice from this part of Colorado, and the existence of this species at Logan Wash should be verified by experts. Chipmunk and golden-mantled ground squirrel populations have remained relatively constant during the study, comprising 8 to 15 per cent of captures at lower elevations and 5 to 28 per cent of captures at higher elevations. Ground squirrels are rare on higher elevation sites. At lower elevations they contribute 38 to 83 per cent of biomass per hectare on experimental sites and are absent from control sites. Chipmunks (least and/or Colorado) contribute 3 to 24 per cent biomass on lower elevation control sites and 4 to 17 per cent on experimental sites. Only least chipmunks are present on higher elevation sites, contributing 14 to 60 per cent biomass on control sites and 2 to 33 per cent on experimental sites. Long-tailed voles, taken only at higher elevations, were not trapped in 1977. Since then they have contributed 1 to 8 per cent biomass on control sites and 2 to 13 per cent on experimental sites. Bushy-tailed woodrats, captured irregularly only at lower elevations, contribute 40 to 58 per cent of biomass on control sites and 9 to 14 per cent on experimental sites. These data tend to support the null hypothesis that mining activities are not affecting small mammal populations at the Logan Wash site. Curves for higher elevations lend strong support for the hypothesis, suggesting that fluctuations are governed by some extrinsic factor such as weather. Lower curves on the lower elevation experimental plot may be due to reduced habitat variety in this canyon, or to the proximity of mining activities.

Total rodent biomass per hectare on all plots increases during summer due to reproduction and decreases during winter due to mortality. An increase in total biomass on the lower elevation experimental site is due primarily to an increase in numbers of deer mice, which may be an effect of mining activity. Total rodent biomass per hectare data tend to support the null hypothesis.

Diversity indices provide a measure of both number of species and distribution of individuals among species. Diversity is greater on lower elevation sites due to the presence of more species. Diversity indices tend to support the null hypothesis of no effect of mining activity on small mammal populations at the Logan Wash site.

Mining activities may be creating habitat more favorable to deer mice and golden-mantled ground squirrels on the lower elevation experimental site. An increase in populations of these two species may also be due to intrinsic differences in habitat between lower elevation control and experimental sites.

In 1980, only 23 species of birds accounted for a major percentage of sightings at the Logan Wash site, but field data indicate that as many as 35 species could have bred there. Twenty species are deemed of special importance at the site, three species (white-throated swift, broad-tailed hummingbird, MacGillivray's warbler) common at both higher and lower elevations, six (violet-green swallow, scrub jay, blue-gray gnatcatcher, Virginia's warbler, black-throated gray warbler, rufous-sided towhee) common only at lower elevations, and eleven (American kestrel, common flicker, dusky flycatcher, black-capped chickadee, house wren, robin, mountain bluebird, warbling vireo, Audubon's warbler, green-tailed towhee, gray-headed junco) common only at higher elevations. The nine species common at lower elevations contribute 40 to 78 per cent of all sightings on the control, and 61 to 91 per cent on the experimental, plot. The fourteen species common at higher elevations contribute 47 to 93 per cent of all sightings on control, and 59 to 93 per cent of all sightings on the experimental, sites.

Patterns of abundance for common species are similar for control and experimental sites at both higher and lower elevations. These data suggest that abundance is a function of some extrinsic factor such as weather, and lend support to the null hypothesis that mining activities are not having an adverse effect on avian populations.

Avian diversity indices are quite similar on both control and experimental sites at higher elevations. At lower elevations, diversity is lower on the experimental site. This may be a reflection of the impact of mining activities, or it may reflect habitat differences between experimental and control sites. Diversity indices tend to support the null hypothesis.

Eastern fence lizards are present in low densities, and plateau whiptail lizards are rare, in pinyon-juniper. Other mammals found occasionally at lower elevations are desert cottontail rabbit, rock squirrel, and porcupine. Those occasionally observed at higher elevations are white-tailed jackrabbit, yellow-bellied marmot, porcupine, coyote, short-tailed weasel, and long-tailed weasel. Miners observed a mountain lion adult with kitten in Logan Wash in 1980. Four bull elk were utilizing West Riley in August 1980. Cattle were abundant at higher elevations in August, and had a significant impact on vegetation around water sources in Upper Fall, West Riley, and Northwest Riley.

Comparisons between experimental and control sites, to test the null hypothesis that mining activities are not affecting wildlife, tend to support the null hypothesis after three years of field work. June and August are deemed the best times to collect these data. Such collection should continue for another 3 to 5 years.

I. INTRODUCTION

Ecological surveys of the Occidental Oil Shale, Inc. Logan Wash site were begun in the summer of 1974 and continued through August 1976. The purpose of these surveys was to determine the major plant communities found on the site, the major vertebrate species found in each community, and their relative abundance in these communities. Data collected during June and July 1974 were reported by Wirtz, Redmond and Whaley (1974). Wirtz and Whaley (1974) reported on data collected at the site in November 1974 on deer utilization, avian species and numbers, large mammal species and numbers, and availability of water for wildlife. Similar information is reported for February 1975 by Wirtz and Wirtz (1975a) and for June 1975 by Wirtz and Wirtz (1975b). A report summarizing all previous findings and recommendations was prepared by Wirtz (1975) in September 1975. The site was visited again in August 1976, primarily to census deer, but also to collect information on other wildlife (Wirtz and Orr, 1976). During early 1977 study plans were formulated for establishing experimental and control plots in three major habitats at the Logan Wash site in order to determine whether oil shale mining operations were having any effects on resident vertebrate populations. Data collected on these plots during June and August 1977 were reported by Wirtz *et al.* (1978). The plots were again studied during June, July, and August 1978, and the report for that year (Wirtz *et al.*, 1979) compared current findings with those of summer 1977 and summer 1974. The plots were not studied in 1979. This report presents findings from field work conducted from 21 May to 3 June, and from 2 to 14 August 1980, and compares these data with that from earlier work.

II. METHODS AND PROCEDURES

Location of Study Areas

The Logan Wash site is located in parts of Sections 23, 24, 25, and 26, Township 7 South, Range 97 West of the Red Pinnacle Quadrangle and parts of Sections 9, 10, 15, 16, 17, 18, 19, 20, and 30, Township 7 South, Range 96 West of the Red Pinnacle and Grand Valley quadrangles, southern Garfield County, Colorado. Elevations on the site range from 6400 feet in Logan Wash to 8900 feet on top of the mesa to the north. Plant communities on the site are described in detail by West, *et al.* (1976).

Three plant communities were deemed of special importance in establishing control and experimental plots in 1977: pinyon-juniper, mountain shrub, and aspen. Experimental sites were selected in Lower and Upper Mine Gulch, within a half mile of the mine site (Figure 1). Control plots were established 1.5 to 2 miles from the mine site in 8605 Gulch, Upper Fall Gulch, and Northwest Riley Gulch (Figure 1). Each site has parallel rows of stations for live-trapping studies of small mammals. Detailed information is collected on birds on the trapping plots and adjacent areas of the canyon, and deer are carefully censused in the canyons where plots are located.

Plot A. Plot A is located at 6500 feet in 8605 Gulch and serves as a lower elevation control site in pinyon-juniper and mountain shrub communities. Four rows of 25 stations each, with 50-foot intervals

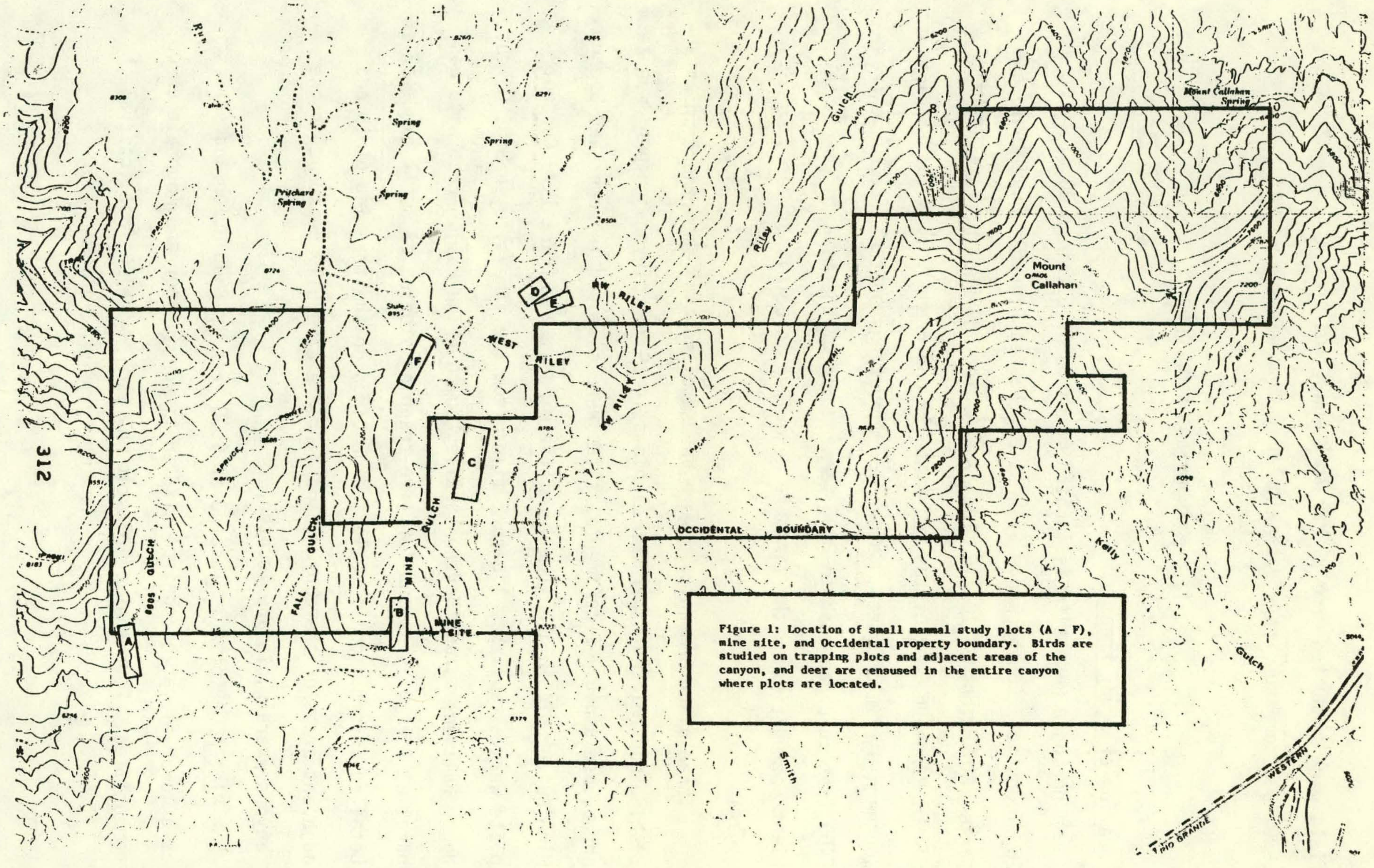

Figure 1: Location of small mammal study plots (A - F), mine site, and Occidental property boundary. Birds are studied on trapping plots and adjacent areas of the canyon, and deer are censused in the entire canyon where plots are located.

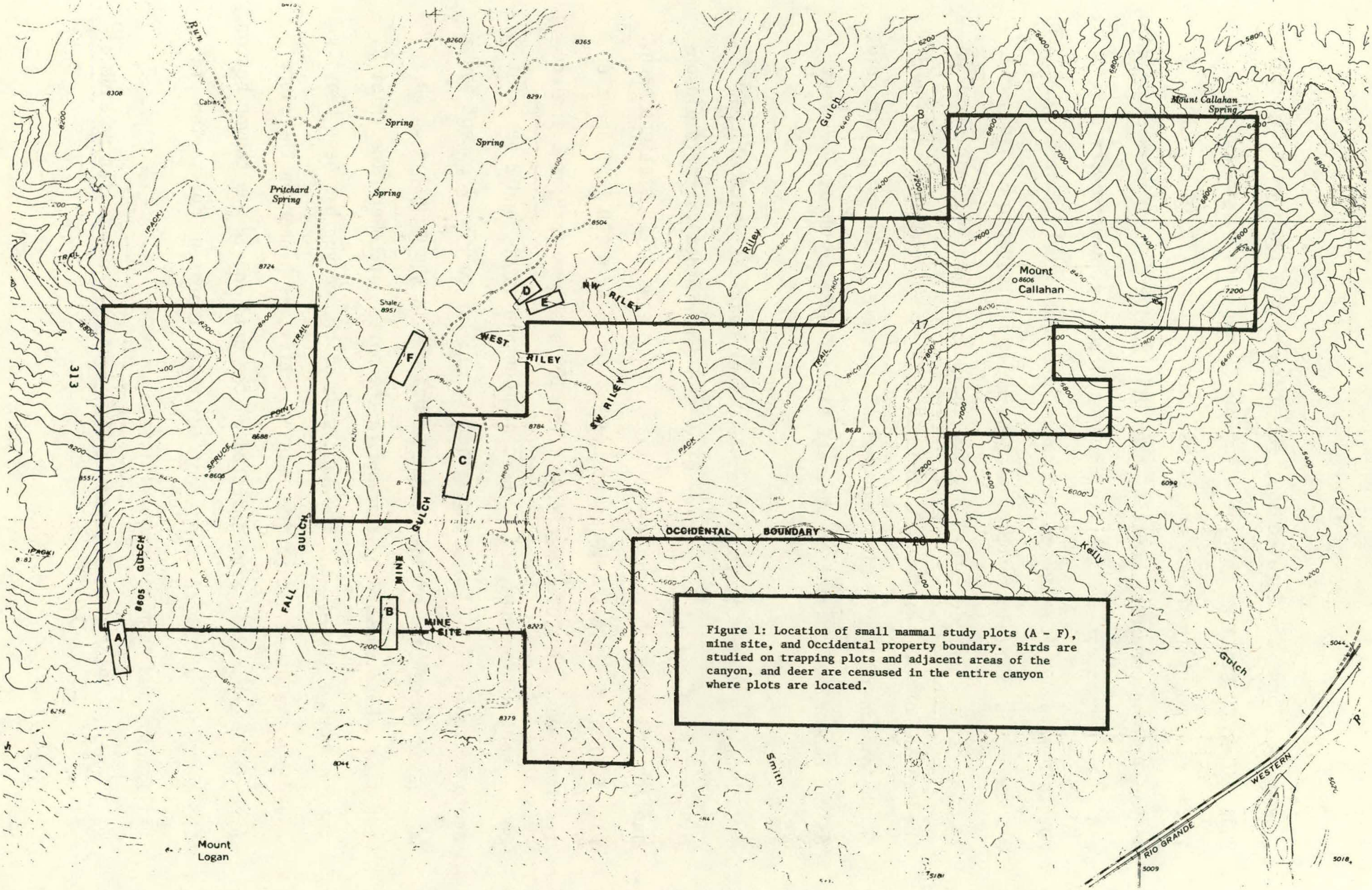

Figure 1: Location of small mammal study plots (A - F), mine site, and Occidental property boundary. Birds are studied on trapping plots and adjacent areas of the canyon, and deer are censused in the entire canyon where plots are located.

between stations, are located 100 feet apart on the lower west side of 8605. The 100 stations in Plot A include 39 per cent pinyon-juniper, 47 per cent mountain shrub, and 14 per cent ecotone (Table 1). The pinyon-juniper community contains many Utah juniper, *Juniperus osteosperma*, and a few pinyon pine, *Pinus edulis*. Serviceberry, *Amelanchier alnifolia*, mountain mahogany, *Cercocarpus montanus*, and Gambel oak, *Quercus gambelii*, are common in mountain shrub on slopes, while big sagebrush, *Artemesia tridentata*, and larger Gambel oak are included in the mountain shrub on the canyon bottom. Elements of the mountain shrub community are found in the pinyon-juniper. Bird and deer studies are conducted on the grid, in the canyon bottom, and on the east side of 8605 to about 6600 feet as well.

Plot B. Plot B is located at 7200 feet near the mouth of Lower Mine Gulch and serves as a lower elevation experimental site in pinyon-juniper and mountain shrub communities. Four rows of 25 stations each, with 50 foot intervals between stations, are located 100 feet apart on the lower west side of Lower Mine. The 100 stations in Plot B include 38 per cent pinyon-juniper, 60 percent mountain shrub, and 2 per cent ecotone (Table 1). Plant composition is similar to Plot A except for a greater percentage of low, dense Gambel oak in the mountain shrub component. Less sagebrush is found in the bottom of Lower Mine (Plot B) than in 8605 (Plot A), and the east side of the canyon has been heavily covered by talus resulting from mining activities higher on the slope. Bird and deer studies are conducted on the grid and in the canyon bottom. The east side of the canyon is not suitable at present for vertebrate utilization due to mining activities.

Plot C. Plot C is located at 8600 feet on the west-facing side of

Table 1. Percent of stations per habitat type in each study area.

Plot	Location	Elevation	No. Stations	Pinyon Juniper	Shrub	Aspen	Ecotone	Type
A	8605	6500 ft.	100	39	47	0	14	control
B	Lower Mine	7200 ft.	100	38	60	0	2	experimental
C	Upper Mine	8600 ft.	200	0	65.5	24.5	10	experimental
D & E	NW Riley	8600 ft.	100	0	64	32	4	control
F	Upper Fall	8600 ft.	100	0	46	43	11	control

Upper Mine Gulch and serves as a large higher elevation experimental area. Due to canyon configuration, this plot contains four rows of 35 stations each and two of 30 stations, for a total of 200. Stations are 50 feet apart; rows are 100 feet apart. These stations include 65.5 per cent mountain shrub, 24.5 per cent aspen, and 10 per cent ecotone (Table 1). Aspen and mountain shrub intermingle in this canyon, and it was not possible to establish separate grids for each habitat. Aspen, *Populus tremuloides*, groves are fairly open, with snowberry, *Symphoricarpos oreophilus*, growing beneath. Serviceberry, snowberry, Gambel oak, and big sagebrush compose most of the mountain shrub community, with the former two species more prevalent on cooler, more moist slopes and the latter two on dryer slopes. Bird studies are conducted on the plot and the entire canyon is used for deer studies.

Plots D and E. Plots D and E are located at 8600 feet in Northwest Riley and form one 100-station control area. Plot D is entirely in mountain shrub and E is chiefly aspen and ecotone. Slopes in Northwest Riley are south-facing, whereas the grid in Upper Mine is west-facing, so control and experimental plots are not identical. And this canyon is smaller than Upper Mine, so the rows here are shorter. Plot D consists of 3 rows of 12 stations and one of 14, with 50 feet between stations and 100 feet between rows. Plot E includes 2 rows of 17 stations and one of 16 stations, with 50 feet between stations and 100 feet between rows. Plots D and E comprise 65 per cent mountain shrub, 32 per cent aspen, and 4 per cent ecotone (Table 1). The single aspen grove in Northwest Riley is denser than those in Upper Mine, with only a sparse ground cover of low herbs and scattered snowberry. Mountain shrub in Northwest Riley is essentially identical to that of Upper Mine. Bird studies are conducted on the plots and the entire canyon is used for deer studies.

Plot F. Plot F is located at 8600 feet on a west-facing slope in the east fork of Upper Fall and provides a second 100-station control area for Upper Mine. This area was added in August 1977 in order to provide a control plot for Upper Mine that has the proper orientation. Four rows of 25 stations each, placed 50 feet apart with rows 100 feet apart, embrace mixed mountain shrub and aspen similar to Upper Mine. However, this control plot is closer to the mine site than are the other two controls, so there is still some compromise involved. The 100 stations of Plot F includes 46 per cent mountain shrub, 43 per cent aspen, and 11 per cent ecotone (Table 1). The composition of both mountain shrub and aspen components is very similar to that of Upper Mine. Bird studies are conducted on the grid, and the entire canyon is used for deer studies.

Study Procedures

Deer are censused at dawn and dusk, and records have been kept of all deer observed at the site. Spotting scopes are used to determine age and sex of as many animals as possible. Tallies of the same canyon by different observers and the same canyon for different days are carefully analyzed to arrive at the maximum number of different individuals on a given study plot, which is considerably lower than the total number of sightings over a several day period.

Large aluminum Sherman traps are used to sample small mammals. Bait is a mixture of hen scratch, sunflower seed, raisins, and oat flakes. Mammals are toe-clipped for identification, weighed and sexed, and reproductive data are noted for all adults. At least 200 trap-nights are accumulated for each plot for each census period. Comparisons are possible between study plots on the basis of number of different individuals per species per 100 trap-nights and total number of different individuals handled per species. Mathematical population estimates would require considerably more field time and are not deemed worthwhile for a study plan involving only two census periods per year.

A running tally is kept of all birds seen on each pass through a study plot. Attempts are made to census in early morning, when bird activity is greatest, and also during the day and in the evening. Mist-netting was conducted in 1980 with very low success. Efforts have been made to locate nests on all plots during visits in May, June and July, and to determine state of nesting cycle at this time. Comparisons are possible between study plots on the basis of individuals per species per man-hour of observation.

Included in the field data are records of all other vertebrates seen at the site.

Joel S. Brown provided field assistance during the summer of 1980, and contributed significantly to data analysis. Helen Wirtz provided figures, and the text is by the principal investigator.

III. RESULTS

Mule Deer

Only 35 deer were seen at the site in May-June 1980 (hereafter referred to as May), while 252 were seen in August 1980 (Table 2). These figures include repeat sightings.

No deer were observed in 8605 Gulch in May, while two does and a fawn were seen in August. Two different bucks were present in Lower Fall Gulch in May, but only one was seen in August. Nine does were seen in Lower Mine Gulch in May. In August eight does and six fawns were observed, and four different bucks were present. Sightings in Lower Mine were concentrated around the heater-treater plant or to the east at the head of Logan Wash, rather than up canyon in Lower Mine itself. Fifteen does were observed in Upper Mine Gulch in May, while 66 deer (20 bucks, 30 does, and 16 fawns) were seen there in August. Sightings were low in May in Upper Riley, Upper Fall, and on the east end of the mesa (listed as Other in Table 2) in May. In August, 79 deer were observed in Upper Riley (13 bucks, 46 does, and 20 fawns), 43 in Upper Fall (5 bucks, 23 does, and 15 fawns), and 42 on the east end of the mesa (one buck, 23 does, and 18 fawns).

In May, 80 per cent of all deer sightings were in the mountain shrub community (Table 3). In August 58 per cent were in mountain shrub and 42 per cent were in aspen. There was heavy utilization of aspen in Upper Riley, Upper Fall, and on the east end of the mesa in August (Table 3).

Table 2: Demographic data on deer population, summer 1980. Per cent of all deer sightings by sex and age and total number seen.

	May-June				August			
	% Male	% Female	% Yg.	Total No.	% Male	% Female	% Yg.	Total No.
8605				0		67	33	3
Lower Fall	100			2	100			1
Lower Mine		100		9	23	44	33	18
Upper Mine		100		15	30	45	25	66
Upper Riley		100		3	17	58	25	79
Upper Fall		100		3	11	54	35	43
Other		100		3	2	55	43	42
Total Sightings	2	33	0	35	44	132	76	252

Table 3: Habitat association of censused deer population, summer 1980. Per cent of deer sightings by habitat.

	May-June			August		
	Pinyon-Juniper	Mountain Shrub	Aspen	Pinyon-Juniper	Mountain Shrub	Aspen
8605					100	
Lower Fall	50	50			100	
Lower Mine		100			100	
Upper Mine		80	20		92	8
Upper Riley		100			42	58
Upper Fall			100		37	63
Other		100			38	62
Total Sightings	1	28	6	0	148	104

Small Mammals

In May-June and August 1980 the survey team captured 282 small mammals in 1000 trap-nights in the lower elevation pinyon-juniper/mountain shrub community of 8605 and Lower Mine gulches, for an overall trapping success rate of 28 per cent (Table 4). Deer mice* accounted for 84 per cent of the captures, while rock and pinyon mice comprised only 1.8 per cent. Least and Colorado chipmunks and golden-mantled ground squirrels accounted for 13 per cent of captures and bushy-tailed woodrats the remaining 0.7 per cent.

In May the sex ratio of deer mice was essentially even on both lower elevation study sites, but in August it was slightly biased in favor of males at both sites (Table 4). Golden-mantled ground squirrels were not trapped in 8605 in 1980, though two were observed on the study plot there in August. Twelve squirrels were seen in one day in Lower Fall in August, and 21 squirrels were trapped in Lower Mine in 1980 (see Figure 1 for the relationship of these three canyons). The sex ratio of squirrels trapped in Lower Mine was essentially equal (Table 4).

Colorado chipmunks were uncommon in 8605 in May, and none were trapped in August. Least chipmunks were trapped in Lower Mine in May and August, but none were taken in 8605. Rock mice and bushy-tailed woodrats were trapped only in Lower Mine, and pinyon mice only in 8605, in 1980.

Pregnant or lactating deer mice and immatures of this species were

*The appendix provides a list of common and scientific names for all vertebrates treated in this report.

Table 4. Demographic data on small mammals live-trapped in lower elevation pinyon-juniper/mountain shrub community, summer 1980: (1) number of individuals trapped, (2) number trapped per 100 trap nights, (3) per cent catch female, (4) per cent adult female pregnant or lactating and (5) per cent immature. Per cent of captures in: (6) pinyon-juniper, (7) mountain shrub, and (8) ecotone. WT means mean weight in grams of sexually mature adults.

8605

	May-June					August				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
S. lateralis										
E. minimus										
E. quadrivittatus	6	2.0	33							
P. maniculatus	46	15.3	48	40	33	41	20.5	37	33	20
P. difficilis										
P. truei	3	1.0	100	33						
N. cinerea										
Total Individuals	55					41				
	(6)	(7)	(8)	WT		(6)	(7)	(8)	WT	
S. lateralis										
E. minimus										
E. quadrivittatus	56	33	11	53.1						
P. maniculatus	26	55	19	20.3		24	59	17	20.0	
P. difficilis										
P. truei	43	57		26.3						
N. cinerea										

Lower Mine

	May-June					August				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
S. latoralis	10	3.3	50	20	10	11	5.5	54		
E. minimus	4	1.3	50	50		7	3.5	86		
E. quadrivittatus										
P. maniculatus	79	26.3	47	54	28	71	35.5	41	5	22
P. difficilis	1	0.3	100	100		1	0.5	100	100	
P. truei										
N. cinerea						2	1.0			
Total Individuals	94					92				
	(6)	(7)	(8)	WT		(6)	(7)	(8)	WT	
S. lateralis	19	81		207.2		18	82		161.2	
E. minimus		100		34.5		11	78	11	32.2	
E. quadrivittatus										
P. maniculatus	30	69	1	20.5		38	59	3	18.8	
P. difficilis	50		50	20.0			100		22.0	
P. truei										
N. cinerea						50	50		157.5	

taken in May and August on both lower elevation grids (Table 4). A higher percentage of breeding females was found in Lower Mine in May than in 8605, but the reverse was true in August. Juveniles constituted a similar percentage of the trapped sample on both sites in both months. A single reproductive female pinyon mouse was found in 8605 in May, and single reproductive female rock mice were taken in Lower Mine in both May and August. No juveniles of either species were trapped in 1980. Reproduction was noted in golden-mantled ground squirrels and least chipmunks in Lower Mine in May.

Golden-mantled ground squirrels and least chipmunks, trapped only in Lower Mine in 1980, were taken chiefly in the mountain shrub community (Table 4). Colorado chipmunks, trapped only in 8605 in 1980, exhibited no habitat preference. Deer mice were more frequently trapped in mountain shrub on both study areas.

May to August comparisons of mean weight of sexually mature adults are available for only three species in 1980 (Table 4); all show a slight decrease for the interval.

In May-June and August 1980 the survey team captured 489 small mammals in 1600 trap-nights in the higher elevation mountain shrub/aspen community of Upper Mine, Upper Fall, and Northwest Riley gulches, for an overall trapping success rate of 30.6 per cent (Table 5). Deer mice accounted for 74 per cent of the captures, least chipmunks and golden-mantled ground squirrels for 20 per cent, and long-tailed voles for the remaining 6 percent (Table 5).

Sex ratios of deer mice are essentially equal for both periods and all three grids, though males were favored on all grids in May (Table 5). Female least chipmunks were taken more frequently than

Table 5: Demographic data on small mammals live-trapped in higher elevation mountain shrub/aspen community, summer 1980: (1) number of individuals trapped, (2) number per 100 trap-nights, (3) per cent catch female, (4) per cent adult female pregnant or lactating, (5) per cent immature. Per cent of captures in: (6) mountain shrub, (7) aspen, (8) ecotone, WT means mean weight in grams of sexually mature adults.

UPPER MINE

	May-June					August				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
S. lateralis	1	0.3				1	0.3			
E. minimus	13	4.3	62			18	6.0	50		6
P. maniculatus	53	17.7	45	39	2	117	39.0	53	28	26
M. longicaudus	8	2.7	62	20		7	2.3	100	14	
Total Individuals	75					143				

	May-June				August			
	(6)	(7)	(8)	WT	(6)	(7)	(8)	WT
S. lateralis	100			156.0	100			150.0
E. minimus	64	29	7	31.7	68	21	11	31.5
P. maniculatus	75	19	6	18.9	62	28	10	18.9
M. longicaudus	20	80		29.2	50	50		33.9

NORTHWEST RILEY

	May-June					August				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
S. lateralis						1	0.5			
E. minimus	28	9.3	43	8		12	6.0	25		17
P. maniculatus	29	9.7	41	25		57	28.5	47	30	26
M. longicaudus						1	0.5			
Total Individuals	57					71				

	May-June				August			
	(6)	(7)	(8)	WT	(6)	(7)	(8)	WT
S. lateralis					100			140.0
E. minimus	63	30	7	34.4	31	46	23	33.0
P. maniculatus	77	21	2	20.6	68	29	3	20.9
M. longicaudus					100			27.5

Table 5: Cont.

UPPER FALL

	May-June					August				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
S. lateralis										
E. minimus	19	6.3	68	15		5	2.5	40		20
P. maniculatus	42	14.0	43	44	5	63	31.5	51	28	46
M. longicaudus	6	2.0	67	75		8	4.0	62		12
Total Individuals	67					76				

	May-June				August			
	(6)	(7)	(8)	WT	(6)	(7)	(8)	WT
S. lateralis								
E. minimus	18	71	11	34.2		100		30.4
P. maniculatus	67	21	12	19.5	51	39	10	19.1
M. longicaudus		89	11	28.7	11	67	22	30.6

males in Upper Fall and Upper Mine in May, but males were more frequently taken in both periods in Northwest Riley. Female voles were more frequent on all grids in both periods, but sample size is small.

Only three golden-mantled ground squirrels were trapped at higher elevations in 1980 (Table 5), though they are occasionally observed in both Upper Mine and Upper Fall and along roads on top of the mesa (15 sight records in August).

Pregnant or lactating deer mice were taken on all higher elevation grids in both May and August, as were juveniles of this species, with the exception that none were taken in Northwest Riley in May (Table 5). Pregnant or lactating least chipmunks were trapped in Upper Fall in May, and juvenile chipmunks were present on all three grids in August (Table 5). Reproductively active voles were found in Upper Mine and Upper Fall in May and in Upper Mine in August, while juveniles were taken in Upper Fall in August (Table 5).

Least chipmunks were most frequently captured in the mountain shrub community in Upper Mine and Northwest Riley in 1980, but more frequently in aspen in Upper Fall (Table 5). Deer mice were most frequently trapped in mountain shrub on all higher elevation grids in 1980, while voles were more frequently taken in aspen, especially in Upper Fall.

May to August comparisons of mean weight of sexually mature adults are available for three species at higher elevations in 1980 (Table 5); there are no significant weight changes.

Birds

Thirty-nine species of birds were noted at lower elevation study sites in 1980 (Table 6), and 46 species were observed at higher elevation sites (Table 8).

In the lower elevation pinyon-juniper/mountain shrub community, white-throated swift* (seen only overhead), Virginia's warbler, black-headed grosbeak, rufous-sided towhee, scrub jay, white-breasted nuthatch, and blue-gray gnatcatcher accounted for 59 per cent of all sightings in 8605 in May. Virginia's warbler, white-throated swift (seen only overhead), black-headed grosbeak, rufous-sided towhee, green-tailed towhee, black-throated gray warbler, and MacGillivray's warbler accounted for 76.5 per cent of all sightings in Lower Mine in May. In August, broadtailed hummingbird, scrub jay, blue-gray gnatcatcher, warbling vireo, and rufous-sided towhee accounted for 63.2 per cent of sightings in 8605, while broad-tailed hummingbird, scrub jay, rufous-sided towhee, and violet-green swallow (seen only overhead) accounted for 60.7 per cent of sightings in Lower Mine.

Of the ten most commonly observed species at lower elevations, six (Virginia's warbler, black-headed grosbeak, rufous-sided towhee, green-tailed towhee, MacGillivray's warbler, broad-tailed hummingbird, and warbling vireo) seem to prefer the shrub community (Table 7). Scrub jays were more frequently observed in pinyon-juniper in 8605, and more frequently in mountain shrub in Lower Mine. Both gnatcatcher and black-throated gray warbler were seen with about equal frequency in either community. The remaining 29 species were distributed as follows: 10 chiefly in pinyon-juniper, 9 chiefly in mountain shrub, 7 in either, and 3 only overhead (Table 7).

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*The appendix provides a list of common and scientific names for all vertebrates treated in this report.

Table 6. Relative density of bird species in the lower elevation pinyon-juniper/mountain shrub community, summer 1980. (1) number per man-hour of observation, (2) per cent of total sightings in habitat. An asterisk (*) indicates that the species was seen only overhead.

	8605				Lower Mine			
	May		August		May		August	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
A. striatus							.13	3.6
A. cooperi			.06	.8	.15	1.5		
*B. jamaicensis**	.15	.7						
*Aquila**	.07	.3	.29	3.9			.13	3.6
F. sparverius	.15	.7	.06	.8				
Zenaidura			.29	3.9				
*Aeronautes**	3.70	16.7	.17	2.3	1.18	11.8	.26	7.1
Selasphorus	.07	.3	.97	13.3	.22	2.2	.39	10.7
Colaptes	.44	2.0	.11	1.6				
E. hammondii	.59	2.7	.29	3.9	.37	3.7		
Contopus	.07	.3						
Nuttallornis	.07	.3						
*Tachycineta**	.07	.3	.06	.8	.15	1.5	.52	14.3
C. stelleri					.07	.7		
Aphelocoma	1.18	5.4	1.20	16.4	.37	3.7	.90	25.0
P. pica			.06	.8				
*C. corax**	.15	.7						
P. atricapillus	.82	3.7	.29	3.9			.26	7.1
P. gambeli	.59	2.7						
Psaltriparus	.82	3.7			.15	1.5	.13	3.6
Sitta carolinensis			.06	.8				
Sitta canadensis	1.18	5.4						
Turdus	.96	4.3						
H. fuscescens			.11	1.6				
Sialia	.52	2.3			.07	.7		
Polioptila	1.18	5.4	1.14	15.6	.44	4.4	.26	7.1
V. gilvus	.67	3.0	.51	7.0	.07	.7		
V. virginiae	1.85	8.4	.17	2.3	2.15	21.3		
D. coronata	.15	.7						
D. nigrescens	.30	1.3	.34	4.7	.67	6.6	.26	7.1
Oporornis	.07	.3			.74	7.4		
Wilsonia	.37	1.7						
Piranga	.96	4.3			.15	1.5		
Pheucticus	1.33	6.0			1.11	11.0		
P. amoena	.30	1.3						
C. purpureus	.15	.7						
Chlorura	.22	1.0	.34	4.7	1.04	10.3		
Pipilo	2.59	11.7	.80	10.9	.82	8.1	.39	10.7
S. passerina	.37	1.7			.15	1.5		
Total Individuals	299		128		136		28	
Man-hours	13.5		17.5		13.5		7.75	

Table 7. Habitat association of bird species in the lower elevation pinyon-juniper/mountain shrub community, summer 1980, by per cent individuals of each species per habitat: (1) pinyon-juniper, (2) sagebrush oak, (3) mountain shrub. An asterisk (*) indicates that the species was seen only overhead.

	8605						Lower Mine					
	May			August			May			August		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
A. striatus												100
A. cooperi				100					100			
*B. jamaicensis**												
*Aquila**												
F. sparverius	100			100								
Zenaidura				60	40							
*Aeronautes**												
Selasporus		100		29		71		100				100
Colaptes	100			100								
E. hammondii			100		80	20			100			
Contopus		100										
Nuttallornis		100										
*Tachycineta**												
C. stelleri							100					
Aphelocoma	62	38		76		24		20	80	29		71
P. pica				100								
*C. corax**												
P. atricapillus	73		27	100								100
P. gambeli	100											
Psaltriparus	100							100				
Sitta carolinensis				100								
Sitta canadensis	100											
Turdus	100											100
H. fuscescens					100							
Sialia			100									
Polioptila	44	31	25	50		50	50	33	17			100
V. gilvus			100	11	22	67			100			

V. virginiae	8	72	20			100	10	28	62			
D. coronata		100										
D. nigrescens	50	50		33		67	56	44				100
Oporornis		100						80	20			
Wilsonia			100									
Piranga	38	62					100					
Pheucticus	22	17	61				40	33	27			
P. amoena	100											
C. purpureus			100									
Chlorura		33	67			100	7	57	36			
Pipilo	11	26	63			100	9	64	27			100
S. passerina	20	40	40					100				
Total Individuals	299			128			136			28		

In the higher elevation mountain shrub/aspen habitat ten species were commonly observed in summer 1980 (Table 8). Five species (house wren, robin, mountain bluebird, warbling vireo, and green-tailed towhee) accounted for 71.5 per cent of sightings in Upper Mine in May, while four species (blue grouse, broad-tailed hummingbird, house wren, and green-tailed towhee) accounted for 60.3 per cent of sightings in August. Six species (house wren, robin, warbling vireo, Audubon's warbler, green-tailed towhee, and gray-headed junco) accounted for 61 per cent of sightings in Northwest Riley in May, while five species (blue grouse, white-throated swift, house wren, green-tailed towhee, and gray-headed junco) accounted for 57.2 per cent of sightings in August. In Upper Fall, seven species (house wren, robin, mountain bluebird, warbling vireo, Audubon's warbler, green-tailed towhee, and gray-headed junco) accounted for 70.0 per cent of sightings in May, and four species (white-throated swift, broad-tailed hummingbird, house wren, and green-tailed towhee) accounted for 50.7 per cent of sightings in August.

Of the ten most commonly observed species at higher elevations, three (broad-tailed hummingbird, mountain bluebird, and green-tailed towhee) were found chiefly in the mountain shrub community, five (house wren, robin, warbling vireo, Audubon's warbler, and gray-headed junco) were found chiefly in aspen, blue grouse fed more frequently in mountain shrub but rested in aspen, and white-throated swifts were seen only overhead (Table 9). The remaining 36 species were distributed as follows: 12 chiefly in mountain shrub, 12 chiefly in aspen, 5 using both communities, and 7 normally seen only overhead (Table 9).

The spring 1980 survey (21 May-3 June) was purposely conducted earlier than those of 1978 (28 June-10 July) and 1977 (7-17 June) in

Table 8. Relative density of bird species in the higher elevation mountain shrub/aspen community, summer 1980: (1) number per man-hour of observation, (2) per cent of total sightings in habitat. An asterisk (*) indicates that the species was seen only overhead.

	Upper Mine				Northwest Riley				Upper Fall			
	May		August		May		August		May		August	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
*Cathartes**	.20	1.3			.03	.3			.17	1.2	.19	1.5
A. striatus							.07	1.0			.10	.8
*A. cooperi**	.14	.8	.14	1.3			.07	1.0				
*B. jamaicensis**	.07	.4			.20	1.8	.50	6.8	.41	2.7	.10	.8
*Aquila**					.10	.9			.06	.4		
F. sparverius			.28	2.6			.14	1.9				
Dendragapus	.07	.4	1.10	10.3	.17	1.5	.50	6.8	.17	1.2	.19	1.5
Bubo			.07	.6			.14	1.9				
Phalaenoptilus							.29	3.9	.11	.8		
*Aeronautes**	.20	1.3	.21	1.9	.41	3.6	.64	8.7	.29	1.9	1.24	9.8
Selasphorus	.20	1.3	.97	9.0			.29	3.9			.67	5.3
Colaptes	.34	2.1			.30	2.7	.14	1.9	.63	4.2	.10	.8
Sphyrapicus	.20	1.3	.07	.6	.07	.6			.23	1.5		
D. villosus					.17	1.5			.29	1.9		
D. pubescens			.14	1.3	.14	1.2	.07	1.0	.06	.4	.19	1.5
Tyrannus					.03	.3						
E. hammondii	.34	2.1	.34	3.2	.27	2.4	.14	1.9	.41	2.7	.29	2.3
E. oberholseri	.61	3.8			.14	1.2			.34	2.3	.19	1.5
E. wrightii	.41	2.6			.14	1.2			.29	1.9		
Contopus					.07	.6	.07	1.0			.48	3.8
Nuttallornis											.10	.8
*Tachycineta**	.07	.4	.14	1.3	.10	.9			.51	3.5	.38	3.0
*C. corax**			.21	1.9							.38	3.0
Nucifraga							.14	1.9			.10	.8
P. atricapillus	.34	2.1			.20	1.8						
P. gambeli					.03	.3					.10	.8
S. canadensis					.10	.9						

Troglodytes	1.63	10.2	1.72	16.0	.64	5.7	1.00	13.6	1.71	11.5	1.33	10.6
Turdus	2.30	14.5			2.00	17.8			.86	5.8	.10	.8
H. ustulata					.03	.3						
H. fuscescens									.34	2.3		
Sialia	1.83	11.5							1.49	10.0	.38	3.0
Myadestes			.07	.6								
V. gilvus	1.90	11.9	.21	1.9	1.02	9.0			1.83	12.3		
V. celata	.07	.4										
V. virginiae									.06	.4		
D. coronata	.27	1.7			1.36	12.0			1.14	7.7	.10	.8
O. tolmiei	.34	2.1	.21	1.9	.03	.3					.38	3.0
P. amoena											.48	3.8
C. purpureus	.07	.4					.07	1.0				
S. pinus	.34	2.1			.24	2.1						
Chlorura	3.73	23.4	2.69	25.0	1.05	9.3	1.21	16.5	2.51	16.9	3.14	25.0
Chondestes			.14	1.3							.19	1.5
J. caniceps	.27	1.7			.81	7.2	.86	11.6	.86	5.8	.29	2.3
S. passerina			1.10	10.3					.11	.8	.19	1.5
S. breweri											1.24	9.8
Total Individuals	235		156		332		103		260		132	
Man-Hours	14.75		14.5		29.5		14.0		17.5		10.5	

Table 9. Habitat association of bird species in the higher elevation mountain shrub/aspen community, summer 1980, by per cent individuals of each species per habitat: (3) mountain shrub, (4) aspen. An asterisk (*) indicates that the species was seen only overhead.

	Upper Mine				Northwest Riley				Upper Fall			
	May		August		May		August		May		August	
	(3)	(4)	(3)	(4)	(3)	(4)	(3)	(4)	(3)	(4)	(3)	(4)
*Cathartes**												
A. striatus								100			100	
A. cooperi			100					100				
*B. jamaicensis**						50	29	71				
*Aquila**												
F. sparverius			100				100					
Dendragapus		100	100		100			100	100		100	
Bubo			100				50	50				
Phalaenoptilus							100		100			
*Aeronautes**												
Selasphorus	100		100				100				100	
Colaptes		100				100	50	50		100		100
Sphyrapicus		100		100		100				100		
D. villosus						100				100		
D. pubescens				100		100		100		100		100
Tyrannus					100							
E. hammondii	100		100		88	12	50	50	71	29	100	
E. oberholseri	56	44			100				50	50	100	
E. wrightii	100				100				100			
Contopus						100	100					100
Nuttallornis												100
*Tachycineta**												
*C. corax**												
*Nucifraga**								100				
P. atricapillus		100				100						
P. gambeli						100						100

S. canadensis						100						
Troglodytes	29	71		100	5	95	43	57		100		100
Turdus	18	82			2	98			27	73	100	
H. ustulata						100						
H. fuscescens						100		100		100		
Sialia	85	15			100		100		100			100
Myadestes				100		100						
V. gilvus	18	82		100		100				100		
V. celata		100										
V. virginiae									100			
D. coronata	25	75			30	70				100		100
O. tolmiei	60	40	100		100						100	
P. amoena											100	
C. purpureus	100							100				
S. pinus		100		100		100	9	91				
Chlorura	89	11	100		100		100		87	13	100	
Chondestes			100								100	
J. caniceps		100			12	88		100	53	47		100
S. passerina				100					100		100	
S. breweri											100	
Total Individuals	235		156		332		103		260		132	

order to broaden the time period over which data on avian breeding phenology were available for the Logan Wash site. Nesting had not yet begun in spring 1980 when the site was visited, but many species had begun courtship, and the absence of leaves on aspen and most shrubs provided an unsurpassed opportunity for identification.

Observations on behavior in May, and the presence of immatures in August, suggest that 35 species bred at the Logan Wash site in 1980 (Table 10). Immature Cooper's hawks were observed hunting at both lower and higher elevations in August. An active red-tailed hawk nest, with either eggs or very young chicks, was found in the aspen of Southwest Riley in May, and immatures were noted over Riley in August. At least two different immature eagles were present in Logan Wash in August; the behavior of one suggested that it was a bird of the year. An American kestrel nest with young was found in the pinyon-juniper of 8605 in August. Blue grouse courtship was observed in Upper Mine in May and numerous young were seen at higher elevations in August. A mourning dove nest with eggs was found in the pinyon-juniper of 8605 in August. White-throated swift aerial courtship was observed at the site in May. Copulation was observed in hairy woodpeckers in May, while immature sapsuckers were present in aspen in August. Courtship and nest-building was observed in dusky and gray flycatchers in May, while immature Hammond's and dusky flycatchers were present at higher elevations in August. Copulating violet-green swallows were observed at higher elevations in May. House wrens were courting at higher elevations in May, and immatures were present there in August. Courtship and singing were observed in robin, veery, and mountain bluebird in May, and immature veery and bluebird were noted in August. Courtship and singing were also observed for blue-gray gnatcatcher, warbling vireo, and all warblers in May. Immature Virginia's and Audubon's warblers were noted in August. Among the sparrows, seven species were singing in May. Immature lazuli bunting, green-tailed towhee, rufous-sided towhee, lark sparrow, chipping sparrow, and Brewer's sparrow were noted at the site in August.

Other Vertebrates

In addition to the species for which quantitative data are presented above, three lizard species and nine additional species of mammals were noted at the site in 1980.

Eastern fence lizards were observed in the pinyon-juniper/mountain shrub habitat of both 8605 and Lower Mine in both May and August at an average rate of 2.38 lizards per man-hour of observation. Single short-horned lizards were noted in higher elevation mountain shrub, all in August. Hatchlings were seen in Northwest Riley and Upper Fall. Adults were seen in Upper Mine and on the mesa north of Riley Gulch. A single plateau whiptail lizard was seen in 8605 in August.

Desert cottontail rabbits were noted in Logan Wash in both May and August. Young were present in May. There are 12 records of adults in 8605 Gulch. Three white-tailed jackrabbits were observed at higher elevations; two in mountain shrub of Northwest Riley in May and one in mountain shrub in Upper Fall in August. No rock squirrels were trapped in Logan Wash in 1980, but there are 12 sight records from 8605, and one each from Lower Fall and Lower Mine. Rock squirrels were resident in 8605 in the rocky outcroppings at both sides of the mouth of the canyon in August 1980. Yellow-bellied marmots were present in West Riley near the cattle tank in May, but none were seen elsewhere on the

Table 10. Evidence for avian reproduction at the Logan Wash site, summer 1980.

	May	August
A. cooperi		immatures
B. jamaicensis	nesting	
Aquila		immatures
F. sparverius		nesting, young
Dendragapus	courtship	immatures
Zenaidura		nesting, eggs
Aeronautes	courtship	
Sphyrapicus		immatures
D. villosus	copulation	
E. hammondii		immatures
E. oberholseri	nesting	immatures
E. wrightii	courtship	
Contopus	singing	
Tachycineta	copulation	
S. canadensis	courtship	
Troylodytes	courtship	immatures
Turdus	singing	
H. fuscescens	singing	
H. ustelata		immatures
Sialia	courtship	immatures
Polioptila	courtship	
V. gilvus	singing	
V. celata	singing	
V. virginiae	singing	immatures
D. coronata	singing	immatures
D. nigrescens	singing	
O. tolmiei	singing	
Pheucticus	singing	
P. amoena	singing	immatures
C. purpureus	singing	
Chlorura	singing	immatures
Pipilo	singing	immatures
Chondestes		immatures
J. caniceps	singing	
S. passerina	singing	immatures
S. breweri		immatures

site, and none were seen at all in August. A porcupine was found in Lower Fall in May, and another was found in Upper Fall in August. These are the first summer records of this species at the site.

Coyote vocalizations were heard in Riley Gulch on 6 August and tracks were found in West Riley in May, but no animals were observed at the site in 1980. Three ermine were trapped at higher elevations in August, two in Upper Fall and one in Upper Mine. An ermine was observed in the mountain shrub of West Riley, and long-tailed weasels were seen several times in Upper Mine, in August. The principal investigator was informed by mining personnel of mountain lion sightings in Logan Wash, including Lower Mine Gulch, by mining personnel in the past year, but was not able to personally verify these records. An adult and a kitten are reported from Lower Mine near the base of the cliffs.

Four bull elk were found in West Riley during August. These are the first sight records on the site by the survey team in seven summers of field work. Elk tracks were found in West Riley in May and on the road north of Northwest Riley in August. Recent pellet groups and tracks were also present in Northwest Riley in August.

Domestic cattle were present on the site in August, especially around the water tank in Upper Fall. A high count of 96 animals in Upper Fall was made and lesser numbers were observed in Northwest and West Riley. Trampling of vegetation was severe around the water tanks in Upper Fall and West Riley, and in the aspen of Northwest Riley. At this latter site virtually all the herbaceous vegetation beneath the aspen was destroyed by 14 August.

IV. DISCUSSION

Mule Deer

The 252 deer observed at the site in August 1980 (Table 2) are believed to represent 86 different individuals, distributed as indicated in Table 11. As not all of the site was censused, this does not represent a population estimate for the entire site. The estimated resident population in August 1980 consisted of 30 per cent adult males, 42 per cent adult females, and 28 per cent fawns. The buck to doe ratio of this population was 1:1.38. Productivity was 66.7 per cent, and the calculated fetal rate for breeding does was 1.35.

A comparison of census data for 1977, 1978, and 1980 (Figure 2) suggests a decrease in the size of the resident herd since 1978 (2a, 2b). There has not been a change in the female proportion of the population since 1977 (2d), but the male proportion has increased slightly (2c) and the fawn proportion has decreased slightly (2e). The buck to doe ratio at the site has remained below 1:2 since 1978; this is considerably better than the average of 1:3.34 given by Taylor (1956). Productivity at the site decreased between 1977 and 1978, but increased between 1978 and 1980 (2f) in spite of a decrease in population size. Productivity at the site has always been lower than the Colorado average of 90 per cent reported by Taylor (1956). At least six sets of twins and two sets of triplets were noted at the site in 1980, and two more sets of twins were noted north of the site. The calculated fetal rate for breeding does at the site in 1980 is slightly lower than the 1.38 determined in 1978 and the 1.42 determined in 1977. These rates are all lower than the 1.67 average reported for does 2 to 7 years old in Utah by Taylor (1956).

Table 11. Distribution of the estimated deer population on study plots at the Logan Wash site in August 1980.

	Male	Female	Fawn	Total
8605	0	1	1	2
Lower Fall	1	0	0	1
Lower Mine	4	3	3	10
Upper Mine	10	7	4	21
Upper Riley	6	11	5	22
Upper Fall	4	9	5	18
Other	1	5	6	12
Total	26	36	24	86

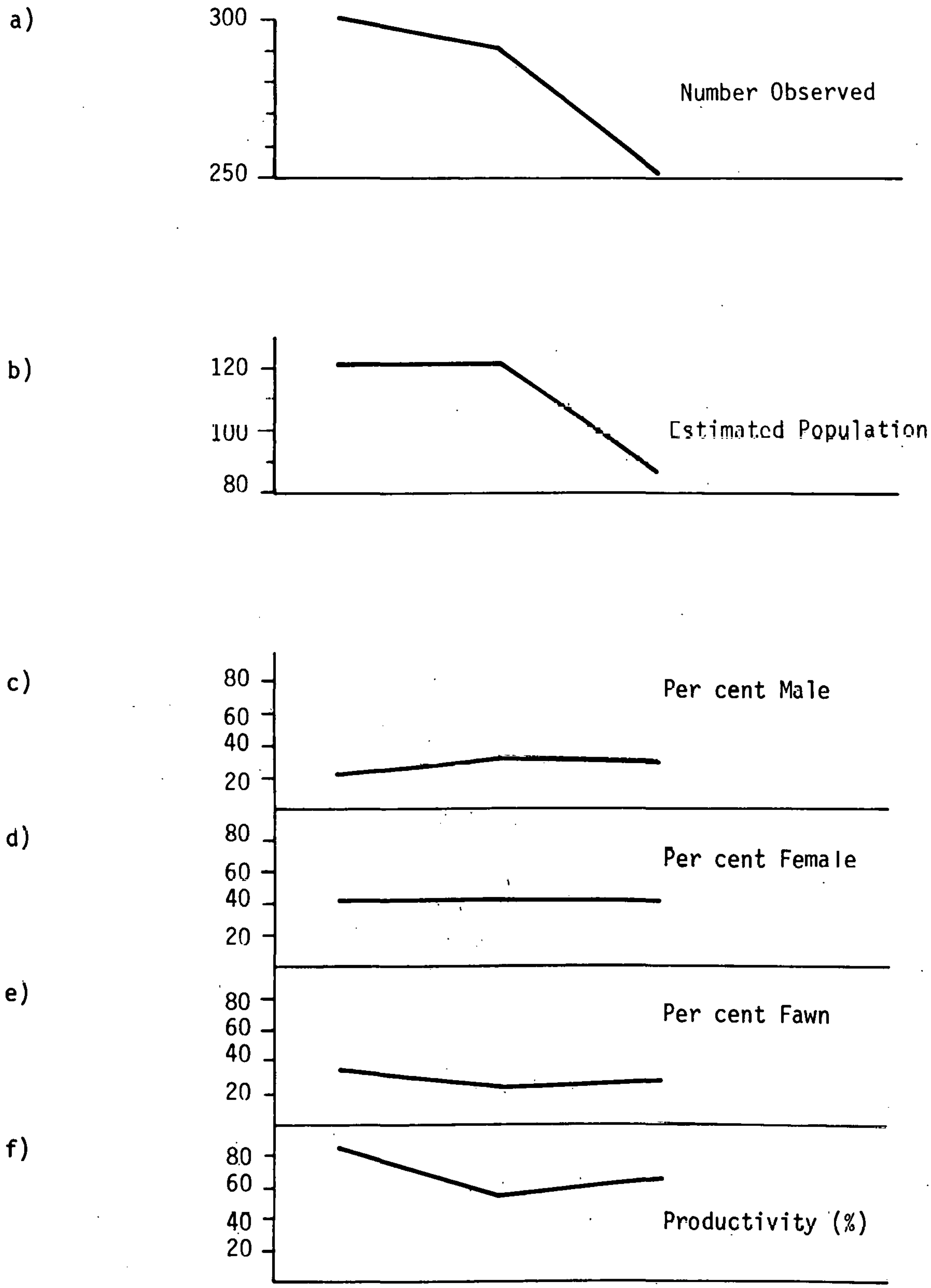

Figure 2: Mule deer demography at the Logan Wash site.

The decrease in number of deer observed at the site and number estimated to be resident on study areas between 1978 and 1980 is most likely attributable to the severe winter that occurred in 1978-79, and not to mining activity or other human perturbation. A 74 per cent increase in natural deer mortality was noted at the C-b tract, 28 miles north of the Logan Wash site, between 1978 and 1979 (1979 C-b Annual Report, Vol. 2, Environmental Analysis, April, 1980). The very low number of deer seen at the site in late May and early June 1980 is attributed to the fact that most deer had not yet moved to higher elevations. Aspen and most shrubs were just beginning to leaf out in late May, and thus neither food nor shelter was available for mule deer at this time.

In May 1980, 80 per cent of all deer sightings were in mountain shrub, while in August only 58 per cent of sightings were in this community. Data from previous years (Wirtz *et al.*, 1979) have shown a clear preference by mule deer for the mountain shrub community at higher elevations in summer. In August 1980 there was heavy utilization of aspen by deer in Upper Riley, Upper Fall, and on the east end of the mesa. There is no obvious explanation for this apparent shift, and no special significance is attributed to it at this time. Should the shift persist in future years, studies on diet and forage nutrient levels might be useful in the search for an explanation. The apparent shift in habitat preference in August 1980 might also explain the reduced number of deer noted during censusing, for more may have been hidden from observers by foliage.

Small Mammals

The author knows of no published demographic studies of small mammamals in north-western Colorado, so it is not possible to compare data for the Logan Wash site with studies elsewhere in the area. Long-term changes between control and experimental plots established in 1977 are the most likely avenue for obtaining information as to whether mining activities are affecting small mammal populations.

Trapping success decreased between 1978 and 1980 at both lower and higher elevations (Fig. 3a), but did not reach the lows observed in 1977. Fluctuations in trapping success are unlikely to be related to mining activities, but rather to be due to changes in available food or some other ecological parameter related to the biology of small mammals at the site. Composition of the rodent population at both higher and lower elevations has fluctuated during the years demographic data have been collected (Fig. 3b). Populations at both higher and lower elevations are dominated numerically by the deer mouse. This was particularly true at higher elevations in 1978. At lower elevations there appears to be an inverse relationship between numbers of deer mice and the abundance of rock and pinyon mice (Fig. 3b). In 1977, when deer mice comprised 42 per cent of captures, rock and pinyon mice constituted 34 per cent of the sample, while in 1980 when deer mice comprised 84 per cent of captures rock and pinyon mice contributed only 1.8 per cent. While these data suggest interspecific competition as a mechanism affecting density of these species, the work of Douglas (1969) does not support the hypothesis for deer and pinyon mice. Douglas notes that, in Mesa Verde National Park in southwestern Colorado, pinyon mice are restricted to pinyon-juniper woodlands because of dependence on hollow juniper branches for nest sites and juniper berries as preferred winter food. Deer mice are found in more open grassy and brushy areas in Mesa Verde, moving into the pinyon-juniper woodland only when population densities are high (Douglas, 1969).

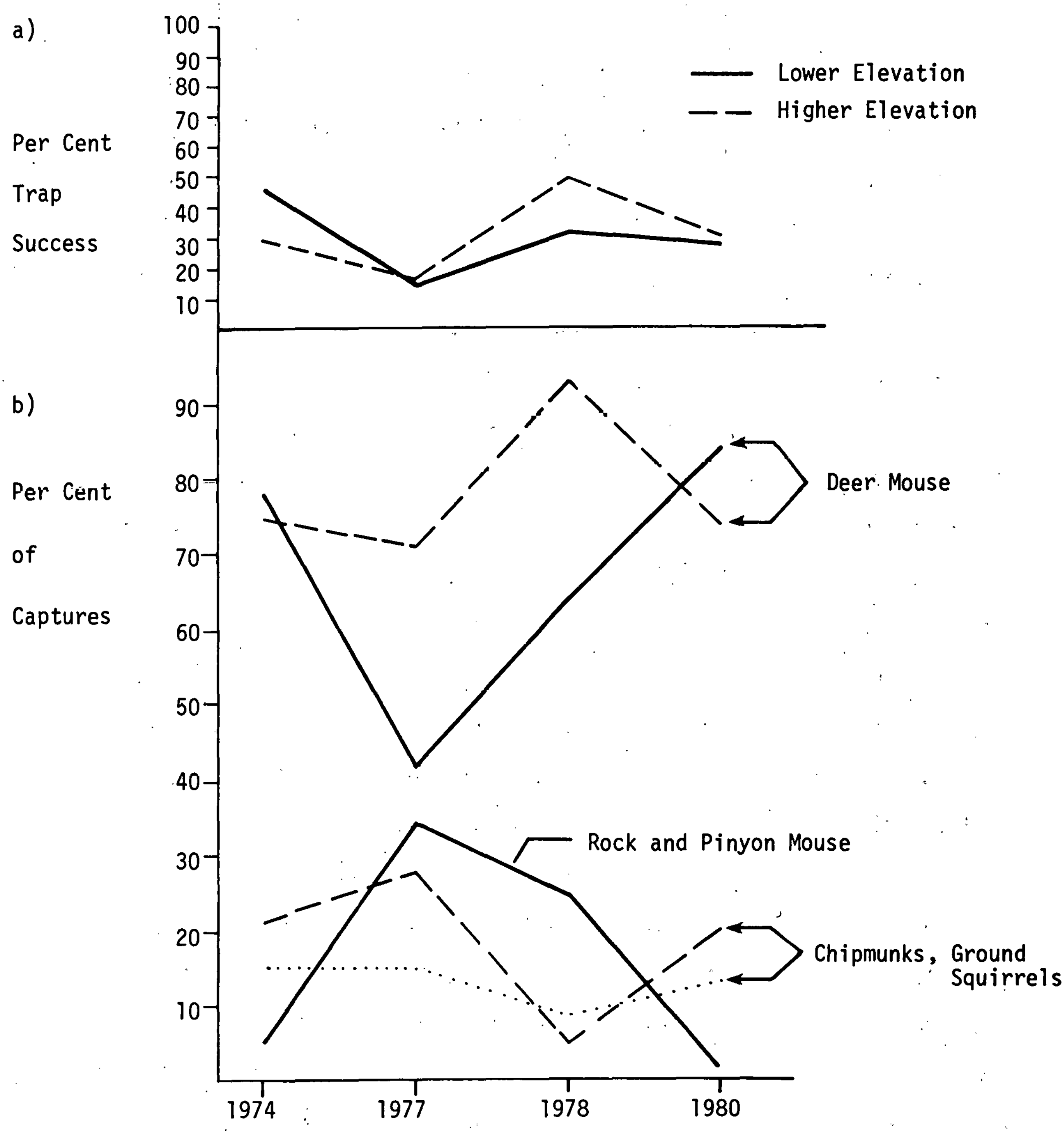

Figure 3: Rodent demography at the Logan Wash site.

At lower elevations, populations of chipmunks and golden-mantled ground squirrels have remained relatively constant at 8 to 15 per cent of captures throughout the study (Fig. 3b). At higher elevations an inverse relationship is noted between their numbers and density of deer mice. Because only a single trap is placed at each station, trap availability may be partly responsible for both these fluctuations and that discussed above for deer mice versus rock and pinyon mice. That is, at high deer mouse densities, traps may be rapidly filled by this species each night, thereby precluding capture of less abundant species and biasing an estimate of density based on per cent of captures.

The occurrence of the rock mouse (*Peromyscus difficilis*) at the Logan Wash site is of particular biological interest. Little is known of the biology of the rock mouse in Colorado (Lechleitner, 1969). Cinq-Mars and Brown (1969) have studied reproduction and ecological distribution of the species in Colorado. They found it most abundant in mountain mahogany, pinyon-juniper, and yellow pine-juniper communities with numerous rocky outcroppings along the eastern flank of the Front Range of the Rocky Mountains. Within the mountain mahogany zone, rock mice occurred with greater frequency on granite and limestone outcroppings. Cinq-Mars and Brown (1969) note the presence of deer mice (*Peromyscus maniculatus*) in all sites occupied by rock mice, suggesting that the two species coexist readily with minimal interspecific competition. Anderson (1961) reports the presence of the rock mouse in Mesa Verde National Park, based on a single immature specimen, but Armstrong (1972) believes this individual to be a brush mouse (*Peromyscus boylii*), and notes that, in his judgement, there are no valid records of rock mice "west of the San Juan Mountains in Colorado, despite an abundance of seemingly suitable habitat." The

Logan Wash site is approximately 200 miles north-northwest of the San Juan Mountains. Vegetation at the Logan Wash site is appropriate for the rock mouse, but the geological formation type present would suggest that only low populations of the rock mouse would be present, according to the work of Cinq-Mars and Brown (1969). Rodents identified as rock mice have been captured at the Logan Wash site in July 1974 (4 individuals), June and August 1977 (18 individuals), June and August 1978 (14 individuals), and May and August 1980 (2 individuals). Most have been taken in 8605 Gulch, where the presence of rocky outcroppings and pinyon-juniper habitat would suggest suitable habitat. The study area in Lower Mine Gulch lacks rocky outcroppings and contains a lower percentage of pinyon-juniper habitat than does the study area in 8605. A single immature animal was trapped, off the study area, in 8605 in August 1980, and will be sent out for expert identification. Additional specimens should be collected in 1981 to verify identification of this species.

Ecological comparisons between study sites may also be made on the basis of the biomass contributed per hectare by each species of rodent. Data are presented separately for control and experimental plots at lower (Fig. 4) and higher (Fig. 5) elevations.

Both golden-mantled ground squirrels and bushy-tailed woodrats are irregular in occurrence on lower elevation plots (Fig. 4), suggesting that habitat and/or conditions are marginal for these species in Logan Wash. An alternative hypothesis is that densities of these rodents are so low that they are only irregularly trapped. Golden-mantled ground squirrels have not been trapped on the control site in 8605 Gulch, though they are occasionally observed there. They have been regularly trapped on the experimental plot in Lower Mine Gulch, contributing between 38 and

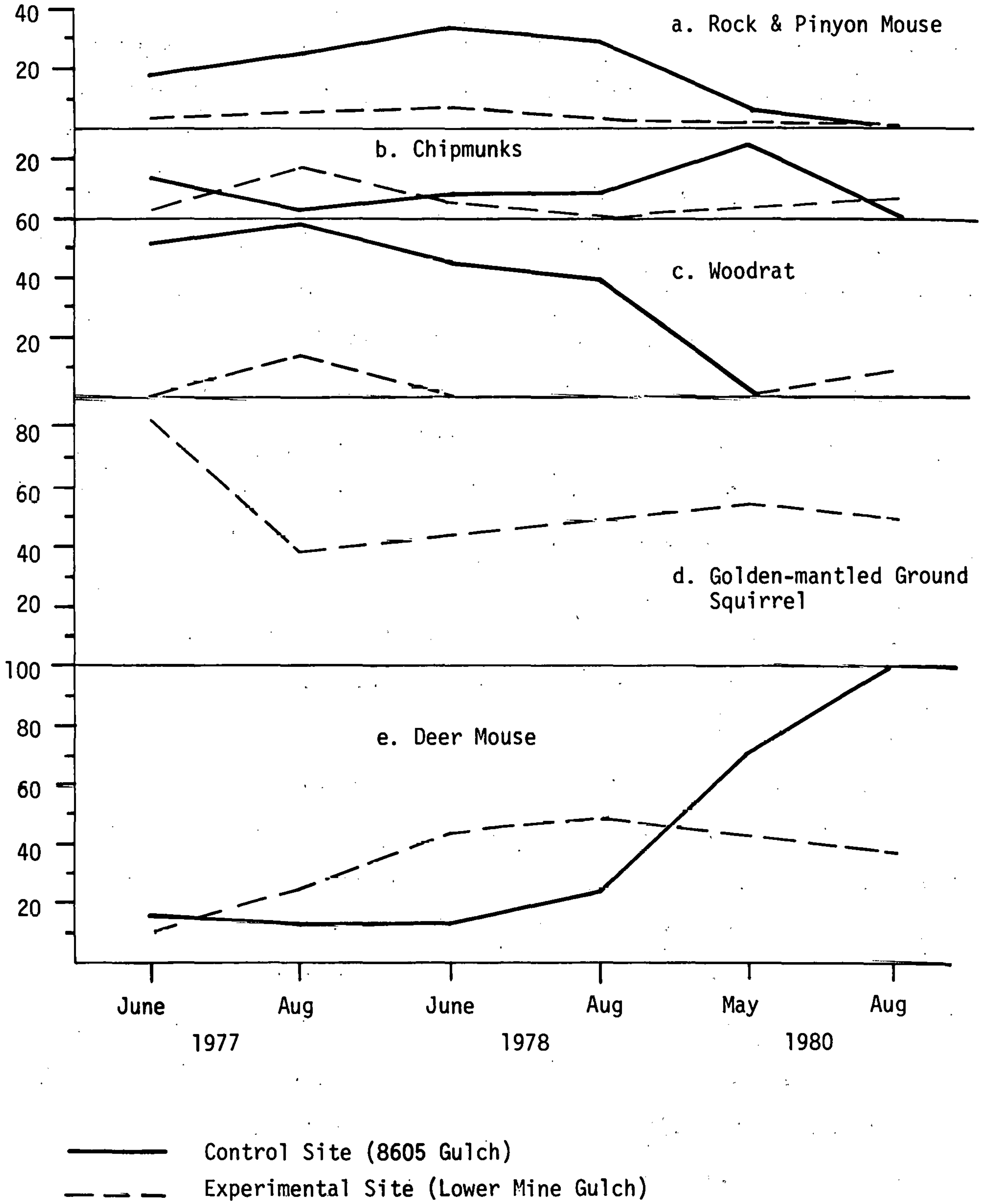

Figure 4: Biomass of rodents on control and experimental sites at lower elevations, per cent of total grams per hectare.

83 per cent of the biomass per hectare (Fig. 4d). Bushy-tailed woodrats are taken irregularly on both experimental and control sites. They were absent from the control in 1980 and from the experimental in 1978. Their contribution to biomass has varied from 40 to 58 per cent on the control and from 9 to 14 per cent on the experimental site (Fig. 4c).

Chipmunks (least and/or Colorado) are normally present on both experimental and control sites at lower elevations, contributing 3 to 24 per cent biomass per hectare on the control and 4 to 17 per cent biomass on the experimental site (Fig. 4b). Both rock and pinyon mice are also normally present on both sites, contributing 6 to 34 per cent of biomass on the control and 0.5 to 6 per cent of biomass on the experimental site (Fig. 4a). Deer mice are the numerically superior species on both sites at lower elevations, contributing 13 to 100 per cent of biomass on the control and 11 to 48 per cent on the experimental site (Fig. 4e).

Biomass data on deer mice, rock and pinyon mice, and chipmunks provide a useful vehicle for testing our null hypothesis that mining activities are not affecting small mammal populations at lower elevations. Biomass curves are similar for these species on both control and experimental plots, and have fluctuated in similar fashion during the period studied. Lower curves for all three on the experimental plot may be due to 1) less suitable habitat in Lower Mine than in 8605; and 2) the presence of golden-mantled ground squirrels in Lower Mine, which make a significant contribution to biomass per hectare. It is concluded that these data tend to support the null hypothesis.

Only three species of rodents are trapped regularly on both control and experimental plots at higher elevations (Fig. 5). Long-tailed voles were not taken at all in 1977. Since then they have contributed 1 to 8

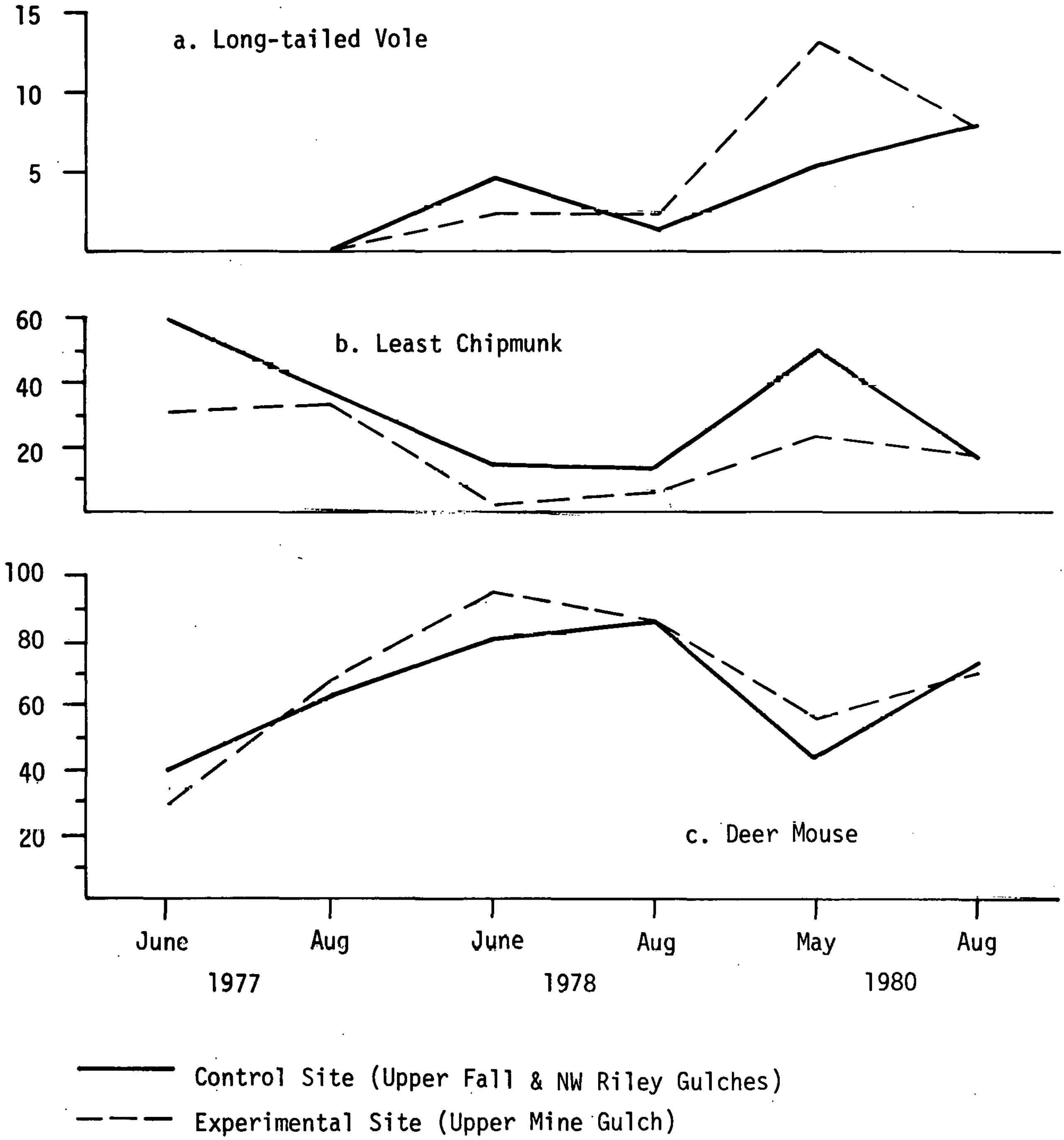

Figure 5: Biomass of rodents on control and experimental sites at higher elevations, per cent of total grams per hectare.

per cent of biomass on control sites and 2 to 13 per cent on experimental sites (Fig. 5a). Least chipmunks have contributed 14 to 60 per cent of biomass on control sites and 2 to 33 per cent on experimental sites (Fig. 5b). Deer mice, which are also numerically superior at higher elevations, have contributed 40 to 85 per cent of biomass on control sites and 29 to 95 per cent on experimental sites (Fig. 5c).

An inspection of biomass curves for higher elevation sites (Fig. 5) lends strong support for the null hypothesis. Though there are minor differences between control and experimental sites, the curves for each species are very similar in form for both control and experimental sites, lending strong support not only for the null hypothesis, but also for the hypothesis that fluctuations in population numbers, and therefore biomass, are governed by some extrinsic factor, such as weather, rather than by proximity to mining activity.

Pregnant or lactating deer mice, and juveniles, have been taken at the Logan Wash site from May through August. The species is known to breed in Colorado from April through September (Warren, 1942), with records as early as January (Reed, 1955) and as late as October (Beidleman, 1954) in Larimer County. Pregnant or lactating rock and pinyon mice have been taken from May through August at the site, and juvenile pinyon mice have been captured there in June and August. Breeding activity in rock mice is known to occur from April to August, with peak activity in May and June, in Colorado (Cinq-Mars and Brown, 1969). Pinyon mice reproduce from June through September in Mesa Verde, with a few females lactating as late as October (Douglas, 1969). Reproductively active female least chipmunks have been captured at the Logan Wash site in May and June, and young have been taken in August. Least chipmunks breed in Colorado in late spring and early summer, and the young may be as large as the parents by the end of the summer (Lechleitner, 1969). Wadsworth (1969) reports that the related Colorado chipmunk breeds in late February or early March in southeastern Utah, with young born in early April and emerging from the nest in May. Pregnant or lactating Colorado chipmunk females were taken at the site in July 1974, but no evidence of reproduction has been noted since.

Biomass of rodents on study plots may be compared by summing the contribution of each species in grams per hectare (Fig. 6). Biomass on all plots tends to increase from June to August due to reproduction, and may decrease over winter due to mortality. At lower elevations (Fig. 6b), biomass on the control site has remained similar throughout the study, exhibiting spring to fall increases, except in 1980. The decline in August 1980 is presumed to be due to both a decrease in total catch (Fig. 3a) and the absence from the trapped population of larger species, such as woodrats, ground squirrels, and chipmunks (Table 4). The large increase in biomass on the lower elevation experimental site (Fig. 6b) is due principally to an increase in numbers of deer mice (Fig. 3b). This increase may be due to the fact that mining operations are making the area more suited for deer mice and perhaps less suited for other species. Williams (1955) found that deer mice appeared in greater numbers in relatively early successional stages after fire, lumbering, or mining in Colorado. The increase in biomass per hectare observed on the lower elevation experimental site may also be attributed to the numbers of golden-mantled ground squirrels trapped there (Fig. 3b, Fig. 4d), and their apparent absence on the lower elevation control site (Table 4).

Biomass of rodents per hectare has remained similar for control and

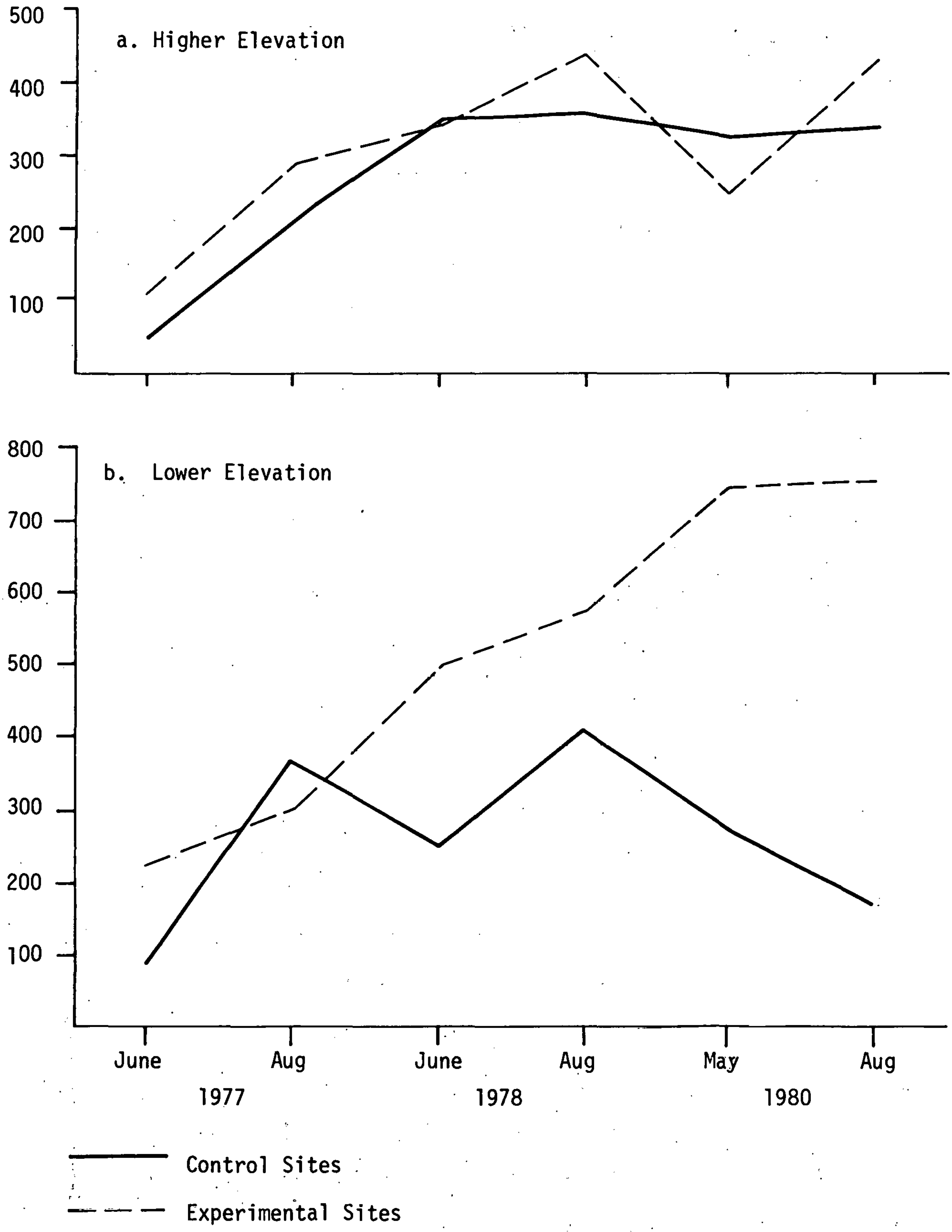

Figure 6: Biomass of rodents, grams per hectare, at higher and lower elevations, control and experimental plots.

experimental plots at higher elevations during the study (Fig. 6a); though there was a dip in biomass on the experimental plot in spring 1980. These data lend support to the null hypothesis that mining activities are not affecting rodent populations at the Logan Wash site.

The Brillouin (1956) information-theoretical measure of mean diversity per individual was used to examine small mammal diversity at the site (Fig. 7). Greater diversity is found at lower elevation sites during 1977 and 1978, due both to the presence of more species and to more equitable distribution of individuals among species, than at higher elevations. Diversity is greater at lower elevations on the control than on the experimental plot in 1977 and 1978 due to the absence of woodrats and rock mice on the experimental plots and the irregular occurrence of chipmunks there. The situation changes significantly in 1980, due to a reduction in the number of species on the control plot, ultimately to a single species population in August 1980, resulting in a diversity index of zero (Table 4, Fig. 7b). Diversity indices are similar for control and experimental plots at higher elevations throughout the study (Fig. 7a). The system is simpler at higher elevations, consisting primarily of deer mice and least chipmunks, with lower numbers of long-tailed voles and golden-mantled ground squirrels (Table 5), but it has remained stable throughout the study to date. These data support the null hypothesis of no effect of mining activities on small mammal populations at higher elevations.

With three years' data, it is possible to examine several parameters of rodent demography for possible affects of mining activity at the Logan Wash site. Per cent trap success (Fig. 3a) has been similar at lower and higher elevations during these years. Fluctuations from year to year at both lower and higher elevations have been similar, suggesting extrinsic

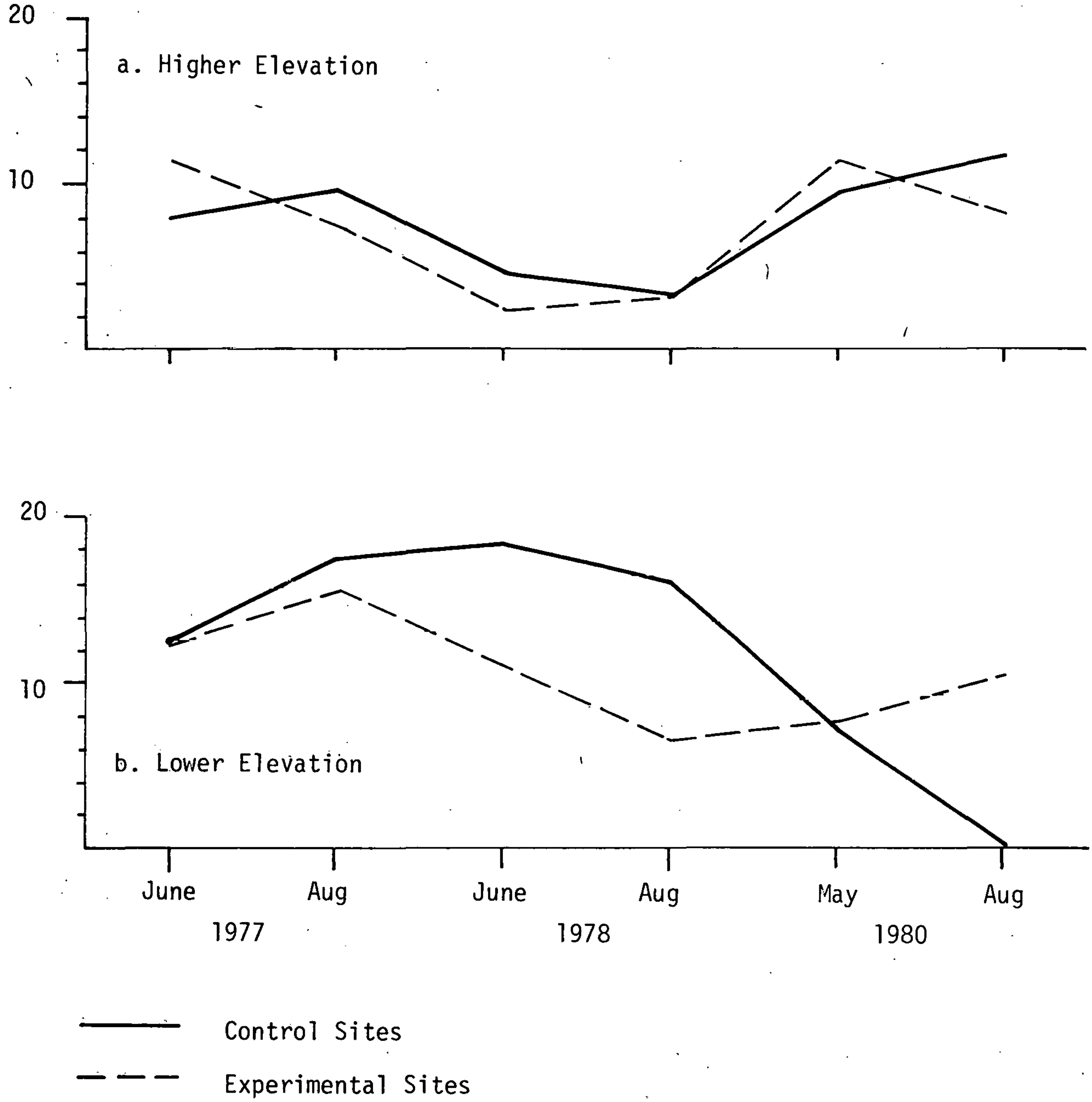

Figure 7: Rodent diversity at higher and lower elevations, control and experimental plots.

factors, such as weather, as the cause of rodent density fluctuations rather than mining activities. Data on biomass contribution of rodent species at lower elevations (Fig. 4) presents a more confusing picture. Rock and pinyon mice make a more substantial contribution to biomass on control than on experimental site, probably due to habitat differences between the sites. Chipmunks have provided a variable contribution to biomass on experimental and control sites. Woodrat populations have decreased on the control area, golden-mantled ground squirrels have only been taken on the experimental area, and deer mouse contribution to biomass has increased to the exclusion of all other species on the control area. These data do not present information on the affect of mining activity. The contribution of three rodent species to biomass at higher elevations has remained similar for both control and experimental sites (Fig. 5). Seasonal fluctuations suggest weather as a factor affecting this parameter, rather than proximity to mining activities. Total biomass per hectare of rodents reflects seasonal changes on the lower elevation control plot (Fig. 6b). Mining activities may be creating habitat more favorable to deer mice and golden-mantled ground squirrels at the experimental site. The noted differences may also be due to habitat differences, unrelated to mining activities, between the two sites. Rodent biomass per hectare at higher elevations has remained similar between control and experimental sites throughout the study (Fig. 6a). No effect of mining activities is perceived in these data. Rodent diversity has remained similar between control and experimental plots at higher elevations throughout the course of the study (Fig. 7a). These data do not suggest an effect of mining activities on rodent diversity. At lower elevations, diversity has decreased on the control site, and exhibited minor fluctuations on the experimental site (Fig. 7b). A decrease in the presence of rare species culminated in a single species rodent population on the control site in August 1980, resulting in a diversity index of zero (Fig. 7b). Small numbers of individuals of these rare species persist on the lower elevation experimental site in 1980, increasing its diversity index over that of the control. These data neither support, nor refute, the null hypothesis. Population densities and diversity indices have fluctuated from year to year, within year from season to season, and between control and experimental plots, suggesting that populations are responding to natural environmental variation, and leading to the conclusion that, at present, there is no eviden ce that proximity to mining activities is having a negative impact on small mammal populations.

Birds

Analysis of bird data for 1974 and 1977 suggested that 33 species were of particular importance at the Logan Wash site, as they accounted for a major percentage of sightings and/or were known to breed at the site (Wirtz *et al.*, 1978). Only 27 species accounted for a major percentage of sightings and/or were known to breed at the site in 1978 (Wirtz *et al.*, 1979). In 1980, only 23 species accounted for a major percentage of sightings (Tables 6 and 8), but field data indicate that as many as 35 species could have bred there (Table 10).

Inspection of all bird data for the Logan Wash site indicates that 20 species are of major importance (Table 12). Three species are found at both higher and lower elevation sites, 6 are found only at lower elevations, and 11 only at higher elevations. The nine common species at lower elevations make up 40 to 78 per cent of all sightings on the control site and

Table 12: Common bird species at the Logan Wash site, per cent of total sightings per period. (control/experimental)

	1974	1977		1978		1980	
	July*	June	Aug.	June	Aug.	May	Aug.
Lower Elevation							
Aeronautes	8/	13/44	8/0	0/27	0/0	17/12	2/7
Selasphorus	13/	1/0	10/0	6/0	5/0	0/2	13/11
Tachycineta	0/	0/0	3/0	0/9	0/28	0/2	1/14
Aphelocoma	6/	4/2	11/31	5/3	23/35	5/4	16/25
Polioptila	19/	12/0	10/6	16/8	0/21	5/4	16/7
V. virginiae	12/	19/28	6/3	12/6	5/0	8/21	2/0
D. nigrescens	1/	10/2	6/9	12/3	5/7	1/7	5/7
Oporornis	0/	0/0	0/9	0/16	0/0	1/7	0/0
Pipilo	18/	19/13	17/3	16/13	2/0	12/8	11/11
Total Per Cent of Sightings	77/	78/89	71/61	67/85	40/91	49/67	66/82
Higher Elevation							
F. sparverius	3/	0/0	2/5	0/2	13/4	0/0	2/3
Aeronautes	10/	1/21	0/0	0/1	5/1	4/1	9/2
Selasphorus	2/	0/1	0/2	1/0	10/12	0/1	4/9
Colaptes	4/	1/4	5/1	5/3	0/2	3/2	2/0
E. oberholseri	1/	3/7	0/0	7/4	0/0	1/4	0/0
P. atricapillus	2/	0/0	12/1	5/0	0/6	2/2	0/0
Tro glodytes	21/	13/6	3/7	8/17	10/18	6/10	14/16
Turdus	4/	16/2	0/0	6/3	0/0	18/14	0/0
Sialia	1/	0/4	0/0	6/7	0/0	0/12	0/0
V. gilvus	4/	25/13	1/3	10/1	0/0	9/12	0/2
D. coronata	3/	7/2	0/5	5/0	0/0	12/2	0/0
Oporornis	5/	12/7	2/2	1/10	0/2	1/2	0/2
Chlorura	10/	13/26	16/31	14/32	15/42	9/23	16/25
J. caniceps	1/	2/0	6/5	11/0	10/2	7/2	12/0
Total Per Cent of Sightings	71/	93/93	47/62	79/80	63/89	72/87	59/59

*no experimental plots in 1974.

61 to 91 per cent of all sightings on the experimental site. At higher elevations, the 14 common species comprise 47 to 98 per cent of all sightings on the control site and 59 to 93 per cent of all sightings on the experimental site.

Per cent of total sightings for five species common at lower elevations is presented graphically in Figure 8, and for seven species common at higher elevations in Figure 9. Data were not plotted for other common species because of the number of census periods in which they were not seen at all on some sites, thereby preventing a comparison of control and experimental plots. Patterns of abundance are very similar for scrub jay (Fig. 8a) and Virginia's warbler (Fig. 8c) on both control and experimental sites at lower elevations. They are less similar for the remaining three species (Fig. 8b, 8d, 8e), but in no instance is there a striking difference between control and experimenal site data. At higher elevations, patterns are very similar between control and experimental sites for dusky flycatcher (Fig. 9b), house wren (Fig. 9c), robin (Fig. 9d), and warbling vireo (Fig. 9e). The flycatcher, robin, and vireo are strictly seasonal breeding species, being essentially gone from the Logan Wash site by August. Common flicker patterns are irregular, but the species occurs in very low numbers (Table 8, Fig. 9a). Green-tailed towhees are much more prevalent on the higher elevation experimental site than on controls, though abundance patterns are similar (Fig. 9f). This may be due to the presence of a larger expanse of mountain shrub community in Upper Mine, where this site is located. Gray-headed juncos are less common on the experimental site than on controls at higher elevations (Fig. 9g). They seem to prefer the aspen community, which is more prevalent near control sites at higher elevations.

Patterns of abundance for most of these species are similar between

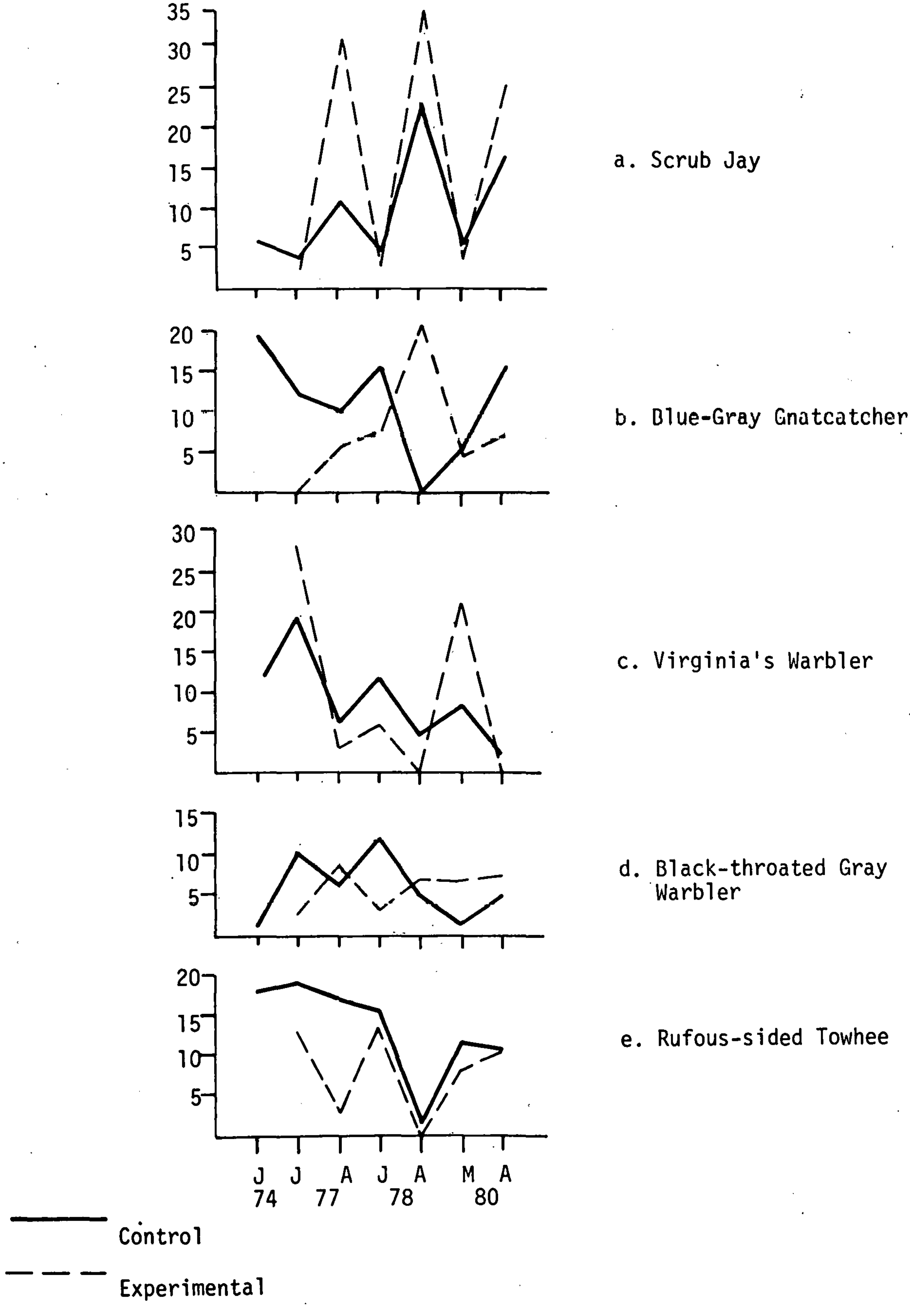

Figure 8: Bird demography at lower elevations; per cent of total sightings for five common species.

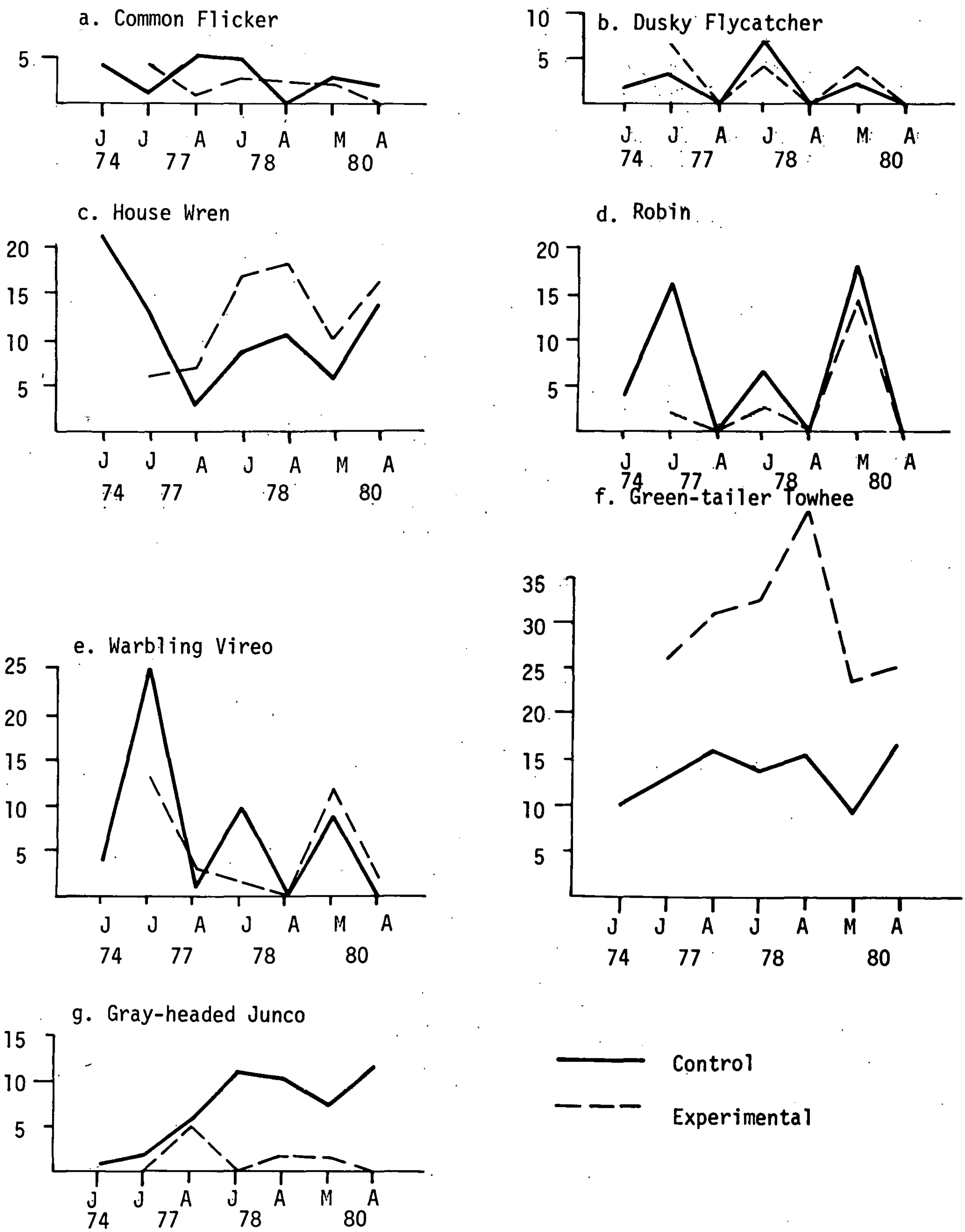

Figure 9: Bird demography at higher elevations; per cent of sightings for seven common species.

experimental and control sites, suggesting that abundance is a function of some extrinsic factor, such as weather. These data tend to support the null hypothesis that mining activities are not having an adverse affect on avian populations.

Brillouin (1956) diversity indices were also calculated for avian populations at the Logan Wash site, and values for three years are plotted in Figure 10. Curves for both experimental and control sites at higher elevations are quite similar in form (Fig. 10a), suggesting that extrinsic factors, such as weather, have acted on avian populations at higher elevations to produce the changes observed. In 1978 diversity was lower on the experimental site, but there is essentially no difference in 1980. Curves for both experimental and control sites at lower elevations are also quite similar in shape, but diversity is always less on the experimental site (Fig. 10b). This may reflect loss of habitat on the east side of the gulch due to mining activities, but it may also reflect rather limited habitat diversity in this canyon.

With three years of data it is possible to examine demographic data on common bird species and diversity indices for differences between experimental and control sites. Demographic data on five common species at lower elevation sites (Fig. 8) do not show any striking differences between control and experimental sites. Per cent contribution of scrub jay and Virginia's warbler to total population at lower elevation sites has varied in similar fashion on both control and experimental sites. Variation in contribution of three other common species has been irregular, but none of the five species show striking differences between control and experimental sites. At higher elevation sites (Fig. 9), immigrant populations of dusky flycatcher, robin, and warbling vireo have varied in similar fashion

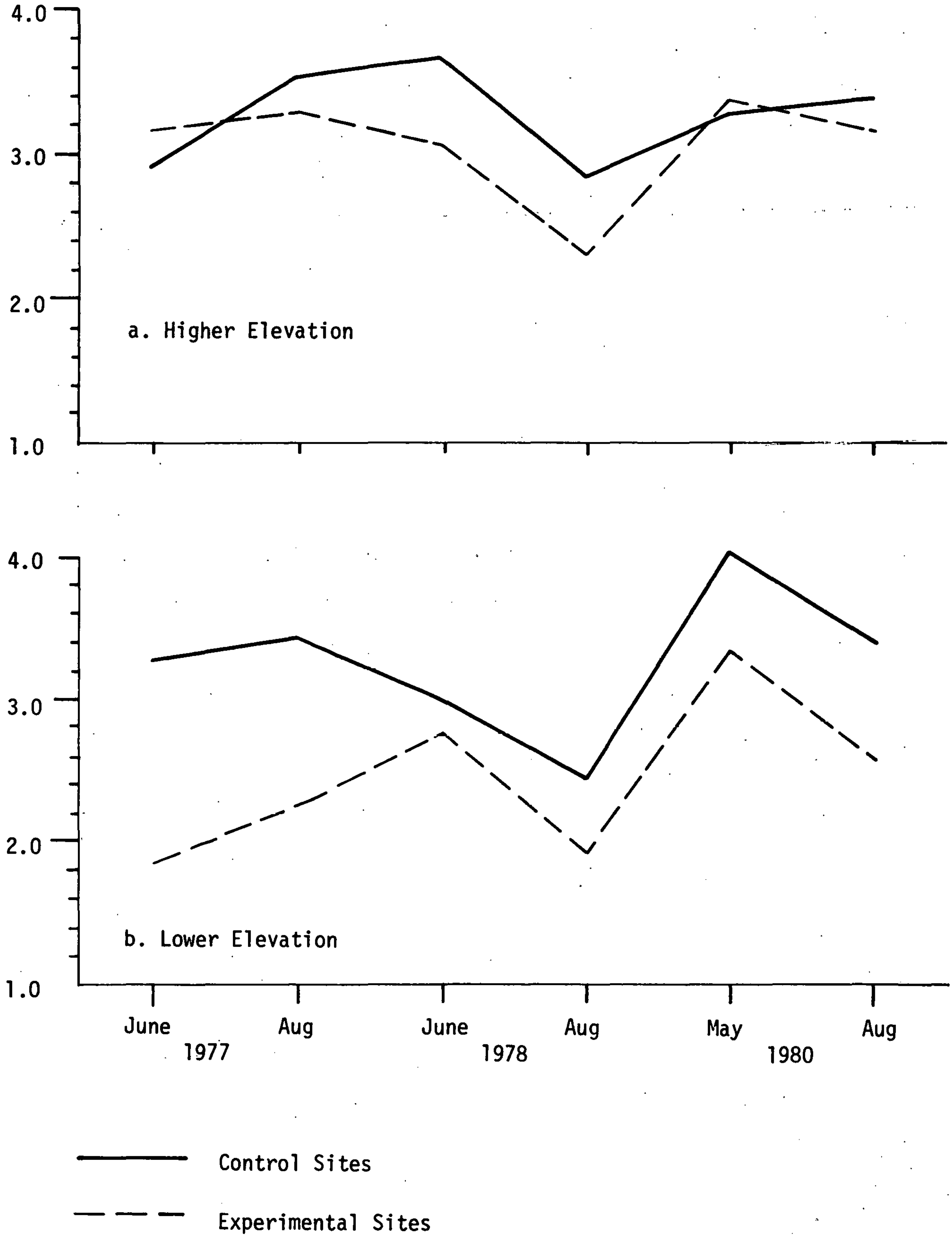

Figure 10: Avian diversity at higher and lower elevations, control and experimental plots.

on both control and experimental sites. Four other common species show somewhat greater variability in per cent contribution to total population on both control and experimental sites, but none of the seven species show striking differences between control and experimental. Diversity at higher elevations is quite similar on both control and experimental sites, and has exhibited similar fluctuations on both areas, though experimental site diversity was lower than control in 1978 (Fig. 10a). At lower elevations, diversity is lower on the experimental site (Fig. 10b). This may be a reflection of the impact of mining activities on the experimental site, or it may reflect habitat differences between experimental and control. Both experimental and control sites have exhibited similar fluctuations in diversity.

These data support the null hypothesis that mining activities are not having an affect on avian populations at the Logan Wash site.

V. CONCLUSIONS

Mule Deer

1. Mule deer populations on study plots in 1980 were: 8605, 2; Lower Fall, 1; Lower Mine, 10; Upper Mine, 21; Upper Riley, 22; Upper Fall, 18; east end of mesa, 12; total, 86. This is not an estimate for the entire mine site. The 1980 estimate is 29 per cent lower than the 1978 estimate for the same study plots. The decrease is probably due to severe winter conditions in 1978-79, which resulted in a 74 per cent increase in natural mortality on the C-b tract, 28 miles north of the Logan Wash site.

2. The estimated population in August 1980 consisted of 30 per cent adult males, 42 per cent adult females, and 28 per cent fawns. Compared with 1978 data, this indicates a slight decrease in the percentage of bucks and a slight increase in the parentage of fawns, while the percentage of does remained essentially the same.

3. The buck to doe ratio of the estimated population was 1:1.38 in 1980, considerably higher than the average of 1:3.34 given by Taylor (1956), and higher than most previous estimates for the site.

4. Productivity in the estimated population was 66.7 per cent, down from the 84.6 per cent reported for 1977 but higher than other previous estimates of 46 to 56 per cent. Taylor (1956) reports an average productivity of 90 per cent for Colorado; this rate has not been reached on the Logan Wash site since the inception of present studies in 1974. The calculated fetal rate for adult does was 1.35 in 1980, as compared to 1.42 in 1977, 1.38 in 1978, and an average of 1.67 for does 2 to 7 years old in Utah (Taylor, 1956).

5. Mule deer prefer the mountain shrub community at the site in summer

months, percentage of sightings in this community ranging from 58 to 94. In August 1980 there was heavy utilization of aspen by deer at higher elevations, resulting in the low of 58 per cent of sightings in mountain shrub. There is no obvious explanation for this apparent shift, and no special significance is attributed to it at this time. Should the shift persist in future years, studies on diet and forage nutrient levels might be useful in the search for an explanation.

Small Mammals

1. Small mammal abundance, as measured by trapping success, decreased at both higher and lower elevations between 1978 and 1980. Trapping success had increased dramatically at the site between 1977 and 1978, due to a nearly four-fold increase in deer mouse numbers at both lower and higher elevations and a three-fold increase in pinyon mouse numbers at lower elevations. Fluctuations in trapping success are unlikely to be related to mining activities, but rather due to changes in available food or some other parameter related to the biology of small mammals at the site.

2. Deer mice are the most abundant rodent at the site, contributing 13 to 100 per cent of biomass per hectare on lower elevation sites and 28 to 95 per cent of biomass per hectare on higher elevation sites. The species breeds from April to September in Colorado (Lechleitner, 1969), and seems to fit this pattern at the Logan Wash site. Deer mice prefer the mountain shrub community at the site.

3. Rock mice show no clear habitat preference at the site, increased in numbers from 1974 to 1977, and decreased from 1978 to 1980. Breeding of rock mice in Colorado is known to occur from April to August, with peak activity in May and June (Cinq-Mars and Brown, 1969). The species fits this pattern at the Logan Wash site. Armstrong (1972) believes that

there are no valid records of rock mice in Colorado west of the San Juan Mountains. The Logan Wash site is approximately 200 miles north-northwest of the San Juan Mountains. Specimens should be collected in 1981 to verify identification of the species at the site.

4. Pinyon mice, found chiefly in pinyon-juniper habitat, and apparently limited to this habitat by nest site and winter food requirements (Douglas, 1969), increased in numbers at the site from 1974 to 1977, increased three-fold in abundance in 8605 between August 1977 and August 1978, and decreased sharply in abundance between 1978 and 1980. The species breeds from June through September in southwestern Colorado (Douglas, 1969), and appears to follow this pattern at the Logan Wash site.

5. Chipmunk and golden-mantled ground squirrel populations have remained relatively constant during the present study, comprising 8 to 15 per cent of captures at lower elevations and 5 to 28 per cent of captures at higher elevations. Breeding of the least chipmunk at the site fits the pattern reported in the literature (Lechleitner, 1969). No evidence of reproduction in the Colorado chipmunk has been noted at the site since 1974. Golden-mantled ground squirrels produce a single litter in early spring in Colorado (Lechleitner, 1969). Young have been taken at the Logan Wash site in May.

6. Ecological comparisons may be made between study sites on the basis of the biomass contributed per hectare by each species of rodent. At lower elevations, golden-mantled ground squirrels contribute 38 to 83 per cent of biomass on the experimental site and are absent from the control site. Woodrats are taken irregularly on both control and experimental sites at lower elevations. Their contribution to biomass is 40 to 58 per cent on control and 9 to 14 per cent on experimental. Chipmunks

(least and/or Colorado) contribute 3 to 24 per cent biomass on lower elevation control, 4 to 17 per cent on experimental. Rock and pinyon mice contribute 6 to 34 per cent biomass on lower elevation control and 0.5 to 6 per cent on experimental. Deer mice contribute 13 to 100 per cent biomass on lower elevation control sites and 11 to 48 per cent on experimental. At higher elevations, long-tailed voles were not trapped in 1977. Since then they have contributed 1 to 8 per cent of biomass on control sites and 2 to 13 per cent on experimental sites. Least chipmunks contribute 14 to 60 per cent biomass on higher elevation control sites, 2 to 33 per cent on experimental sites. Deer mice contribute 40 to 85 per cent of biomass on control, and 29 to 95 per cent biomass on experimental sites at higher elevations. Data on biomass contribution per hectare tend to support the null hypothesis that mining activities are not affecting small mammal populations at the Logan Wash site. Curves are similar on both experimental and control plots. Lower curves on the lower elevation experimental plot may be due to reduced habitat variety, the presence of golden-mantled ground squirrels there and not on the control, or to mining activity. Biomass curves at higher elevations lend strong support for the null hypothesis, and also for the hypothesis that fluctuations in population numbers and therefore biomass, are governed by some extrinsic factor such as weather, rather than by proximity to mining activity.

7. Total rodent biomass per hectare on all plots tends to increase from June to August due to reproduction and decrease over winter due to mortality. An increase in biomass on the lower elevation experimental site is due principally to an increase in numbers of deer mice. Mining activity may be responsible for this increase, as deer mice are known to

increase in early successional stages after disturbance of habitat in Colorado (Williams, 1955). Data on total rodent biomass per hectare tend to support the null hypothesis that mining activities are not having a negative effect on small mammal populations at the Logan Wash site.

8. Diversity indices provide a measure of both number of species and distribution of individuals among species. Greater diversity is is found at lower elevation sites due both to presence of more species and to more equitable distribution of individuals among species. A reduction in number of species on the lower elevation control site in 1980, ultimately to a single species, destroys this relationship. Diversity indices support the null hypothesis of no effect of mining activity on small mammal populations at the Logan Wash site.

9. Mining activities may be creating habitat more favorable to deer mice and golden-mantled ground squirrels at the lower elevation experimental site. An increase in populations of these two species may also be due to intrinsic differences in habitat between lower elevation control and experimental sites.

Birds

1. In 1980, only 23 species accounted for a major percentage of sightings at the Logan Wash site, but field data indicate that as many as 35 species could have bred there. Data for 1974 and 1977 suggested that 33 species were of particular importance at the site, as they accounted for a major percentage of sightings and/or were known to breed there. In 1978, only 27 species accounted for a major percentage of sightings and/or were known to breed there.

2. Inspection of all bird data for the Logan Wash site indicates

that 20 species are of major importance. Three species (white-throated swift, broad-tailed hummingbird, MacGillivray's warbler) are common at both higher and lower elevation sites. Six species are common only at lower elevations (violet-green swallow, scrub jay, blue-gray gnatcatcher, Virginia's warbler, black-throated gray warbler, rufous-sided towhee). Eleven species are common only at higher elevations (American kestrel, common flicker, dusky flycatcher, black-capped chickadee, house wren, robin, mountain bluebird, warbling vireo, Audubon's warbler, green-tailed towhee, gray-headed junco). The nine species common at lower elevation sites contribute 40 to 78 per cent of all sightings on the control, and 61 to 91 per cent of all sightings on the experimental, plot. The 14 species common at higher elevation sites contribute 47 to 93 per cent of all sightings on control, and 59 to 93 per cent of all sightings on the experimental, sites.

3. Patterns of abundance for common species are similar for control and experimental sites at both higher and lower elevations. These data suggest that abundance is a function of some extrinsic factor such as weather, and tend to support the null hypothesis that mining activities are not having an adverse effect on avian populations.

4. Avian diversity indices are quite similar on both control and experimental sites at higher elevations. At lower elevations, diversity is lower on the experimental site. This may be a reflection of the impact of mining activities, or it may reflect habitat differences between experimental and control sites. Data on avian diversity at both higher and lower elevations tend to support the null hypothesis that mining activities are not having an effect on avian populations at the Logan Wash site.

Other Vertebrates

1. Reptiles are not abundant at the Logan Wash site. Eastern fence lizards occur in low densities in pinyon-juniper, horned lizards occur in very low densities on top of the mesa, and plateau whiptail lizards are extremely rare in pinyon-juniper.

2. Desert cottontail rabbits occur at low densities at lower elevations, and white-tailed jackrabbits are rare at higher elevations. Rock squirrels also occur at low densities at lower elevations. Yellow-bellied marmots are rare in aspen groves at higher elevations. Single porcupines were observed in Lower Fall and Upper Fall in 1980. These are the first summer records for the site by this project. Coyotes were very rare at the site in 1980; none were seen, and only vocalizations and a few tracks provided record of presence. Both short-tailed and long-tailed weasels were observed at higher elevations in 1980. Miners reportedly observed a female mountain lion and her kitten in Logan Wash in 1980; this report has not been verified by the principal investigator.

3. Four bull elk were utilizing West Riley in August 1980. These are the first sight records by this project for the Logan Wash site, though tracks have been found on top of the mesa in other years.

4. Cattle were more abundant on the site in August 1980 than ever before observed by this project. There was heavy impact on vegetation around water sources in Upper Fall, West Riley, and Northwest Riley.

VI. RECOMMENDATIONS

1. Comparisons between experimental and control sites, to test the null hypothesis that mining activities are not affecting wildlife, support the null hypothesis after three years of field work. Collection of these data should continue for another 3 to 5 years to verify this conclusion.

2. June is the best time of year to collect data on avian populations, August is the best time to census deer. Small mammals may be censused at both times, and birds may also be censused in August. Data to test the null hypothesis should be collected during these periods.

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APPENDIX

SCIENTIFIC AND COMMON NAMES OF VERTEBRATES OBSERVED AT THE LOGAN WASH SITE

Reptilia

Iguanidae - lizards	
Collared Lizard	*Crotaphytus collaris*
Eastern Fence Lizard	*Sceloporus undulatus*
Short-horned Lizard	*Phrynosoma douglassi*
Teidae - whiptails	
Plateau Whiptail	*Cnemidophorus velox*
Colubridae - snakes	
Desert Striped Whipsnake	*Masticophis taeniatus*
Gopher Snake	*Pituophis melanoleucus*
Western Garter Snake	*Thamnophis elegans*

Aves

Cathartidae - vultures	
Turkey Vulture	*Cathartes aura*
Accipitridae - hawks, eagles	
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperi*
Red-tailed Hawk	*Buteo jamaicensis*
Golden Eagle	*Aquila chrysaetos*
Falconidae - falcons	
Prairie Falcon	*Falco mexicanus*
Peregrine Falcon	*Falco peregrinus*
American Kestrel	*Falco sparverius*
Tetraonidae - grouse	
Blue Grouse	*Dendragapus obscurus*
Sage Grouse	*Centrocercus urophasianus*
Phasianidae - quail, pheasant	
Chukar	*Alectoris graeca*
Columbidae - pige ons, doves	
Band-tailed Pigeon	*Columba fasciata*
Mourning Dove	*Zenaidura macroura*
Strigidae - owls	
Great Horned Owl	*Bubo virginianus*

Caprimulgidae - goatsuckers	
Poor-will	*Phalaenoptilus nuttallii*
Common Nighthawk	*Chordeiles minor*
Apodidae - swifts	
White-throated Swift	*Aeronautes saxatalis*
Trochilidae - hummingbirds	
Black-chinned Hummingbird	*Archilochus alexandri*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Picidae - woodpeckers	
Common Flicker	*Colaptes auratus*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Hairy Woodpecker	*Dendrocopos villosus*
Downy Woodpecker	*Dendrocopos pubescens*
Tyrannidae - flycatchers	
Western Kingbird	*Tyrannus verticalis*
Cassin's Kingbird	*Tyrannus vociferans*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Say's Phoebe	*Sayornis saya*
Hammond's Flycatcher	*Empidonax hammondii*
Dusky Flycatcher	*Empidonax oberholseri*
Gray Flycatcher	*Empidonax wrightii*
Western Flycatcher	*Empidonax difficilis*
Western Wood Pewee	*Contopus sordidulus*
Olive-sided Flycatcher	*Nuttallornis borealis*
Hirundinidae - swallows	
Violet-green Swallow	*Tachycineta thalassina*
Tree Swallow	*Iridoprocne bicolor*
Corvidae - ravens, jays	
Steller's Jay	*Cyanocitta stelleri*
Scrub Jay	*Aphelocoma coerulescens*
Black-billed Magpie	*Pica pica*
Common Raven	*Corvus corax*
Pinyon Jay	*Gymnorhinus cyanocephalus*
Clark's Nutcracker	*Nucifraga columbiana*
Paridae - chickadees	
Black-capped Chickadee	*Parus atricapillus*
Mountain Chickadee	*Parus gambeli*
Plain Titmouse	*Parus inornatus*
Common Bushtit	*Psaltriparus minimus*
Sittidae - nuthatches	
White-breasted Nuthatch	*Sitta carolinensis*
Red-breasted Nuthatch	*Sitta canadensis*
Certhiidae - creepers	
Brown Creeper	*Certhia familiaris*

Cinclidae - dipper	
Dipper	*Cinclus mexicanus*
Troglodytidae - wrens	
House Wren	*Troglodytes aedon*
Rock Wren	*Salpinctes obsoletus*
Turdidae - thrushes, bluebirds	
Robin	*Turdus migratorius*
Swainson's Thrush	*Hylocichla ustulata*
Veery	*Hylocichla fuscescens*
Mountain Bluebird	*Sialia currucoides*
Townsend's Solitaire	*Myadestes townsendi*
Sylviidae - gnatcatchers, kinglets	
Blue-gray Gnatcatcher	*Polioptila caerulea*
Ruby-crowned Kinglet	*Regulus calendula*
Vireonidae - vireos	
Solitary Vireo	*Vireo solitarius*
Warbling Vireo	*Vireo gilvus*
Laniidae - shrikes	
Northern Shrike	*Lanius excubitor*
Parulidae - wood warblers	
Orange-crowned Warbler	*Vermivora celata*
Virginia's Warbler	*Vermivora virginiae*
Audubon's Warbler	*Dendroica coronata auduboni*
Black-throated Gray Warbler	*Dendroica nigrescens*
Townsend's Warbler	*Dendroica townsendi*
MacGillivray's Warbler	*Oporornis tolmiei*
Wilson's Warbler	*Wilsonia pusilla*
Icteridae - blackbirds, orioles	
Western Meadowlark	*Sturnella neglecta*
Brewer's Blackbird	*Euphagus cyanocephalus*
Brown-headed Cowbird	*Molothrus ater*
Thraupidae - tanagers	
Western Tanager	*Piranga ludoviciana*
Fringillidae - grosbeaks, finches, sparrows	
Black-headed Grosbeak	*Pheucticus melanocephalus*
Lazuli Bunting	*Passerina amoena*
Purple Finch	*Carpodacus purpureus*
Cassin's Finch	*Carpodacus cassinii*
House Finch	*Carpodacus mexicanus*
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*
Black Rosy Finch	*Leucosticte atrata*
Pine Siskin	*Spinus pinus*
Lesser Goldfinch	*Spinus psaltria*

Green-tailed Towhee	*Chlorura chlorura*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Lark Sparrow	*Chondestes grammacus*
Slate-colored Junco	*Junco hyemalis*
Gray-headed Junco	*Junco caniceps*
Chipping Sparrow	*Spizella passerina*
Brewer's Sparrow	*Spizella breweri*
White-crowned Sparrow	*Zonotrichia leucophrys*

Mammalia

Leporidae - hares, rabbits	
White-tailed Jackrabbit	*Lepus townsendi*
Desert Cottontail	*Sylvilagus auduboni*
Sciuridae - squirrels, chipmunks	
Yellow-bellied Marmot	*Marmota flaviventris*
Rock Squirrel	*Spermophilus variegatus*
Golden-mantled Ground Squirrel	*Spermophilus lateralis*
Least Chipmunk	*Eutamias minimus*
Colorado Chipmunk	*Eutamias quadrivittatus*
Red Squirrel	*Tamiasciurus hudsonicus*
Geomyidae - pocket gophers	
Northern Pocket Gopher	*Thomomys talpoides*
Cricetidae - native mice and rats	
Deer Mouse	*Peromyscus maniculatus*
Rock Mouse	*Peromyscus difficilis*
Pinyon Mouse	*Peromyscus truei*
Bushy-tailed Woodrat	*Neotoma cinerea*
Montane Vole	*Microtus montanus*
Long-tailed Vole	*Microtus longicaudus*
Erethizontidae - New World porcupines	
Porcupine	*Erethizon dorsatum*
Canidae - coyote, foxes	
Coyote	*Canis latrans*
Ursidae - bears	
Black Bear	*Ursus americanus*
Mustelidae - weasels, skunks	
Short-tailed Weasel	*Mustela erminea*
Long-tailed Weasel	*Mustela frenata*
American Badger	*Taxidea taxus*
Striped Skunk	*Mephitis mephitis*
Felidae - cats	
Mountain Lion	*Felis concolor*
Bobcat	*Lynx rufus*

Cervidae - deer	
Elk	*Cervus canadensis*
Mule Deer	*Odocoileus hemionus*
Bovidae - cattle, sheep	
Cattle	*Bos taurus*
Sheep	*Ovis aries*

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APPENDIX E

SHALE OIL TRANSPORTION LITERATURE SEARCH

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PRELIMINARY INVESTIGATION

FOR

TRANSPORTATION OF

SHALE OIL BY PIPELINE

PHASE I:

STATE-OF-THE-ART

LITERATURE SEARCH

Prepared for

OCCIDENTAL OIL SHALE INC.

by

WILLIAMS BROTHERS ENGINEERING COMPANY

TABLE OF CONTENTS

DEFINITIONS OF TERMS

Bingham Fluid	-	A fluid that exhibits a shear strength at a zero shear rate
Newtonian Fluid	-	A fluid whose viscosity is not a function of shear rate or shear time.
Rheological	-	Dealing with the deformation and flow of matter.
Rheopectic	-	A fluid whose viscosity increases with increased shear rate and shear time.
Thixotropic	-	A fluid whose viscosity decreases with increased shear rate and shear time.

Section 1
INTRODUCTION

As the first step in the shale oil pipeline transportation study, literature and industry experience was assembled to be used as a data base for both the laboratory testing program and the feasibility study of transporting shale oil from the Piceance Basin area to some undefined location.

Transporting shale oil by pipeline is a relatively new field with no operating experience to draw from; however, considerable literature is available on waxy crude oils with high pour points and viscosities such as shale oils appear to exhibit.

This report gives a general overview of the state-of-the-art in transporting waxy crudes by pipelines. Appendix A is a listing of the articles and papers compiled for this study.

Section 2
RHEOLOGICAL PROPERTIES

The rheological properties of shale oil that are of most interest are the pour point, viscosity, and gelled yield strength. These properties are a function of temperature, shear rate, and the past treatment of the specific liquid. The assumption that waxy crudes and shale oils exhibit similar properties and react to stimulus (temperature and shear rate) in the same manner is valid only to about 10°C (50°F) or above. According to work by Lovell and Seitzer, the behavior of Utah shale oils deviate from that of a waxy crude below that temperature.[53,55]

In general, the flow character of waxy crudes and shale oils is Newtonian at temperatures at least 11°C (20°F) above their pour points. With decreasing temperature the waxy crudes and shale oils change to Bingham and then to thixotropic-Bingham fluids. However, below 14°C (57°F), at low flow rates, the Utah shale oils become rheopectic (Antithixotropic). At flow rates in the turbulent range (shear rate of 150 $sec.^{-1}$) the shale oil and waxy crudes revert back to Bingham plastic fluids.

Caution should be exercised in using these general flow characteristics. Two Utah shales that were tested, Union "B" and Paraho DH, had different pour points and the transition to rheopectic occurred at different temperatures.[53,57]

The pour point in waxy crude oils and shale oil is greatly affected by their wax crystalline structure. At temperatures near the pour point the wax crystals start to grow.[9] As the temperature continues to decrease the wax crystalline structure increases in size until the oil gels.[76] Factors that affect the wax structure are the rate at which the oil was cooled, the shear rate at any given time, and the chemical content of the crude.[41]

At constant temperature and steady flow rate the viscosity of waxy crudes decreases with time to some constant value. This is because of a physical breaking of the wax structure in the crude. If the shear rate is taken to zero (flow stopped) the wax crystalline structure rebuilds and when flow resumes, the pumping viscosity reverts to the initial value.[28] When a waxy crude is allowed to gel in a pipeline, a large shear stress is required to overcome the wax structure in the crude. This stress is called the yield stress of the oil. When the wax structure starts to break down and flow begins in a waxy crude, the viscosity starts to decrease to a constant value, as defined by the temperature and shear rate.[28] The time required for viscosity breakdown is the least repeatable rheological measurement. In many cases, it is virtually impossible to obtain repeatable rates of breakdown even with the same test apparatus.[24] These factors must all be considered when designing and operating pipelines for waxy crudes and shale oils.

Section 3
RELATIONSHIPS BETWEEN OIL PROPERTIES NEAR THEIR POUR POINTS AND PIPELINE DESIGN

Before a pipeline can be designed, the rheological properties of the crude oil must be determined in the laboratory. The testing should be done over the whole range of pipeline conditions expected due to the high degree of sensitivity to temperature and shear rate. Because rotational viscometers do not simulate the flow characteristics of non-Newtonian waxy crude oils, pipeline viscometers are recommended.[6] An energy balance is used to generate the temperature of the pipeline at any given point. This balance will account for the loss of internal energy of the oil and the heat flux through the wall of the pipe. The soil conductivity, assuming a buried system, must be determined as well as the soil temperature profile. If the pipe is insulated, the soil conductivity becomes less important because of a smaller thermal driving force at the insulation-soil interface.[41]

Temperature profiles should be made for both operating and standby conditions. The maximum standby time would be based on the allowable gel yield strength of the oil.[43] The pressure required to break down the gel cannot exceed the rating of the system. As the oil cools and gels, contraction in line fill volume takes place. To restart a gelled line the oil must be compressed in order for the pressure wave to propagate down the line and overcome the gel yield strength. Flow in the line can begin only after the high pressure gradient has reached the outlet of the pipeline.[93]

Once the gel structure starts to break down and flow begins, the shale oil exhibits some unusual properties. The Union "B" shale oil, produced by in-situ retorting, appears to be rheopectic at low temperatures and shear rates, i.e., the viscosity increases with shear rate and time. According to Seitzer and Lovell,[53,55] this was observed at a shear rate of 23.4 $sec.^{-1}$ and increased in effect as the temperature decreased below 14°C (57°F). Between 14°C (57°F) and 28°C (82°F) the shale oil behaved as a thixotropic Bingham fluid, i.e., the viscosity decreased with time and shear rate. Above 28°C (82°F) the shale oil became Newtonian. The characteristics of shale oils at their gel points can be of great importance because of difficulties in restarting flow after extended standby time.

The use of pipeline insulation would reduce the heat loss during operating and standby conditions; thereby decreasing pumping viscosities and pumping horsepower requirements. Insulation will increase the allowable standby time and effectively extend the permissible distance between heating locations along the pipeline. The accompanying reduction in viscosity and horsepower also extends the distance between pump stations.

Section 4
PIPELINE INSTALLATIONS

As stated in the Introduction, there are no shale oil pipelines in operation; however, there are numerous waxy crude pipelines. These pipelines were designed with varying philosophies depending on environmental and performance criteria.

Methods which have been used to handle waxy crudes with ambient temperatures below the crude's pour point are:[28,45,87]

- o Mixing the crude with water to form a stable oil-in-water emulsion
- o Cutting the crude with a hydrocarbon diluent to improve viscosity and lower the pour point
- o Preheating the crude oil and heat tracing the pipeline to maintain the elevated temperature
- o Subjecting the crude oil to a special heating and cooling cycle to change the wax crystaline structure, reducing the pour point and effective pumping viscosity
- o Injecting water to lubricate the pipe wall/crude interface, thus reducing the frictional drag
- o Preheating the crude and pumping through a buried insulated pipeline

- o Injecting of flow modifiers to change the wax structure of the crude to reduce viscosity and gel strength.

There are advantages and disadvantages to each of the methods listed above. Some of the methods for transporting a waxy crude can be eliminated due to operating environment of the pipeline. The length and throughput requirements of system will eliminate other methods. The method finally selected for any given system should be the most economical.

A. TRANSPORT AS A STABLE OIL-IN-WATER EMULSION

One of the most publicized systems of this nature is the 238-km, 20-inch line which runs from the Tandjung field to Balik Papan on the Island of Sumatra.[112] The crude is highly paraffinic (33 wt.% wax) with a pour point of 41°C (105°F). The line, placed in operation in 1962 by P.T. Shell Indonesia, transports 40,000 b/d of crude oil. The average ground temperature at burial depths along the route is 28° to 29°C.

Before the oil-in-water method was selected, various methods for viscosity reduction were studied. A heated pipeline system was considered. As long as the temperature could be maintained over 40°C this method would be satisfactory. In case of flow stoppage, resulting in the oil cooling to ambient soil temperatures, the yield stress generated would require a pressure drop of about 15,000 psi/mile. This was excessive so this method was eliminated. Other methods considered were:

1. Pour point depressors - none found to be sufficiently effective

2. Diluents - would require large amounts because of the high wax content and would require a return line

3. Visbreaking - found feasible, but for various reasons was not generally attractive for the project.

Finally, mixing with water was attempted and the results in laboratory and pilot tests proved promising. A 30% water - 70% oil by volume was found to be stable and dehydration could be accomplished by standard heat and chemical treatments. The oil-water suspension produces a substantial velocity gradient in the external water layer (slip) which results in a great decrease in effective viscosity compared with the crude at temperatures below the pour point.

Crude and water are kept separate at the main pump station, and are mixed at high pressure on the discharge side of the station through a simple mixing device to form the oil-in-water suspension. In a one mile loop of 18" pipe it was determined that the suspension pipeline could be shut down as long as five days and restarted with reasonable pressure drop. The pipeline has one initial pump station and two intermediate booster stations with dehydration facilities at the intermediate stations to remove water from enough crude to use it as fuel for the engine driven pumps.

B. ADDITION OF A HYDROCARBON DILUENT

The rheological properties of a waxy crude can be improved by blending with another crude oil or a light distillate having a lower pour point. The ratio of blending can be as high as 1:1 to achieve an effective reduction in the waxy crude viscosity and gel yield strength.[11] This presents two major problems: first, the net throughput capacity of the waxy crude is greatly reduced; and second, large amounts of diluent are required.

This has been an effective method for transporting waxy crudes in existing pipelines in Europe. No modification to the pipeline has been required and it simply becomes a scheduling problem of the pipeline dispatcher.

C. HEAT TRACING AND INSULATION

At Continental Oil Company's Dickson Heath Sand Unit located near Dickson, North Dakota, a gathering system was installed to service 37 wells with 70°F to 90°F pour point crude.[66] Several methods of piping the crude to the gathering center were investigated and a heat traced, insulated system was selected as the most feasible and cost effective. However, nothing was stated in the article as to how the oil was handled after it left the gathering center.

The line sizes in the system are 3 inch and 6 inch diameter insulated with 1-1/2 inch of 2.7 lb/ft^3 density urethane foam. This maintains the temperature in the pipeline at between 80°F and 110°F. The total cost for 26,400 feet of 6 inch pipeline, including heat tracing and insulation, was $16.63 per foot (1978 dollars). With 30,000 feet or more the cost would reduce by about 20%.

D. SPECIAL HEAT TREATMENT OF THE OIL[14,81]

The Nahorkatiya and Moran oil fields in India produce waxy crude oil with a pour point of 85°F to 90°F. The design ambient pipeline conditions were 65°F. Three methods of solving the problem of pumping the crude below its pour point were investigated.

1. Mixing a low pour point crude with the high pour point crude during the cooler months to improve the viscosity.

2. Heating the crude and maintaining the flowing temperature above the pour point.

3. Pretreating the crude thermally before pumping to change the wax structure and reduce the pumping viscosity.

The first method did not prove feasible because of insufficient quantities of low pour point crudes to affect the viscosities during the months when the ambient temperature is below 85°F. Heating the crude oil to 175°F at 40 mile intervals to maintain the flowing temperature above the pour point was considered too costly.

In the special heat treating process, the oil is heated to 200°F and rapidly cooled to 150°F. From 150°F to 65°F the rate of cooling is controlled at one degree per minute with a cool water bath. When the oil temperature reaches 65°F it is held there for five minutes before pumping begins. This is a batch process that requires multiple cooling tanks in parallel to allow for continuous operation.

The reduction in viscosity is attributed to modification of the wax crystal structure by absorption of small amounts of asphaltenes and resins on the surface of the growing crystals.[81]

E. WATER JACKET INJECTION

This method involves injecting water, with a special nozzle, into a pipeline to form a core of crude oil with an annulus of water at the pipe wall. This greatly reduces the frictional drag because of the low viscosity of the water in contact with the pipe wall.

There are two major problems with this system. Once the water-oil cross section has been established, it cannot flow through a pump. Flow cannot drop below 3 feet per second or the water annulus will break.

Shell Oil Company has a 24-mile, 6-inch pipeline operating using this system.[110] The pipeline is located in California and transports heavy crude, 11° API, from its Midway-Sunset production area to its Ten Section dehydration plant. The pipeline has a capacity of 27,000 b/d of which 70 percent is oil and 30 percent is water. After the oil leaves the dehydration plant it is blended with other crudes and piped in a normal manner.

F. PREHEATING OIL AND INSULATED PIPELINE

Heating the crude oil and pumping it through insulated, buried pipelines is an effective method of transporting waxy crudes when the operating ambient temperature is below the pour point.[3] If the flowing temperature of the waxy crude is maintained about 20°F above its pour point, the oil behaves as a Newtonian fluid and the pipeline design is straightforward.[6,87] However, if the flow through the line is stopped and the oil cools, restarting the line can be a problem. Once a line is shut down, then the time element becomes important. The maximum shutdown time will be a function of:[45]

- o Pipe surface area per foot of length
- o Insulation type and thickness
- o Soil conductivity and heat capacity
- o Heater spacing and size
- o Pipeline operating temperature
- o Number and size of pump stations
- o Storage capacity for pipeline fill
- o Pipeline pressure rating for restart of gelled oil

Optimization of the independent factors will determine whether this method will be feasible.

G. WAX MODIFIERS

Waxy crude additives have been developed that modify the crystalline growth behavior, size, and crystal-to-crystal adhesion. The concentrations of these additives can range from 0.0002 to 0.5 percent and give reductions in viscosity of 10 to 20 times that of the untreated waxy crude.

In the PIPELINE DE L'ILE DE FRANCE, a test was performed using a wax modifier at 0.12 percent concentration in a high pour point African crude.[11] This reduced the pour point from 24°C (75°F) to approximately 0°C (32°F) and imparted Newtonian characteristics to a typically non-Newtonian fluid. After a 25-day storage period, the treated crude's improved flow properties were unchanged.[11]

Tests on British Petroleum's Finnart to Grangemouth 12-inch pipeline indicates the same kind of results.[11]

R. C. Price reports that the yield strength of a treated crude is greatly reduced and exhibits a rapid reduction in viscosity after yielding.[76]

Wax modifiers also reduce the residual wax buildup in a pipeline.[9] This would mean less restriction to flow and less frequent pigging of the pipeline.

Section 5
OPERATING AND SHUTDOWN PROBLEMS

The transporting of waxy crudes by pipelines presents a number of problems which have already been discussed. The difficult problem to solve is that of restarting a line after the line fill has gelled. After a line has gelled, the yield strength of the crude must be overcome to initiate flow through the line again. This means high pressure and low flow rates.[74] Care should also be taken that the maximum oil temperature is not exceeded during startup. Due to poor pumping efficiency at low flow rates, the oil through the pumps will be heated and the maximum allowable temperature could be exceeded. This can be overcome by looping at the pump station. To maintain the high pressure requiring to break down the gel and also provide sufficient flow through the pump to prevent excessive heat buildup.[93]

If the gel strength is so large that the pumps and/or pressure rating capacity of the pipe are exceeded, then intermediate, temporary pumps may be required to supply the yield stress to start flow.

Three important factors in evaluating design of restart after an extended shutdown are:[93]

1. Yielding of the gelled crude
2. Breakdown from initial to equilibrium viscosity
3. Cleaning of the line to restore design capacity.

The use of insulation on the line pipe can increase the allowable time before the line temperature becomes critical. If the line is allowed to flow at a low rate while cooling, the yield strength of the gel will be reduced and thus the pressure required to restart the line would be reduced. However, during an emergency situation this procedure may not be possible. A maximum critical time for shutdown should be calculated for the system with an appropriate safety margin to account for variable factors that may be hard to define. Initial oil temperature, thickness and conductivity of insulation on the pipe, heat content of the line fill, soil conductivity, depth of pipe burial and ambient temperature are all factors that determine the rate of cooling of the system.[87]

In the shale oils mentioned earlier, the behavior around the gel point differed from that of a waxy crude. They were rheopectic and the viscosity increased with shear rate and time until the oil temperature reached 14°C (57°F). Because this property may be peculiar to all shale oils, and no operating experience is reported in the literature, this will be an area that will require special attention in the design of a shale oil pipeline.

Section 6

PIPELINE FROM PICEANCE BASIN

As shown in the literature search, there are several methods that could be utilized in the proposed shale oil pipeline from the Piceance Basin area to a distant location. Consideration for the cold temperatures and rough, sometimes inaccessible, terrain in the area of the proposed pipeline will be a large factor in selection of the method to be used.

The oil-water emulsion system provides excellent pumping characteristics. The requirement for heaters and insulation is minimized and the size and number of pump stations are reduced. Facilities for mixing at the inlet and separation of the oil-water mixture at the terminus are required. Also, the pipeline size has to be increased to accommodate the same amount of shale oil throughput because a portion of the line capacity is used to transport water. An adequate water supply is required for this system and this could be a problem in the Piceance Basin Area.

Cutting the shale oil with a hydrocarbon diluent, such as a low pour point crude or a light distillate, can render the combined linefill flow properties Newtonian. This reduces the number of pump stations, minimizes the need for heaters and pipeline insulation, and solves the problem of restarting the line after an extended shutdown. Sufficient hydrocarbon diluent must be available to produce the desired rheological properties to make this scheme feasible. Line size is larger than a heated and insulated system because the capacity left for the shale oil is reduced.

Insulating and heat tracing the pipeline has the advantages of maintaining the shale oil temperature well above its pour

Insulating and heat tracing the pipeline has the advantages of maintaining the shale oil temperature well above its pour point, in the range where the crude acts like a Newtonian fluid and has low viscosities. This reduces the pumping requirements and solves the problems of extended shutdown times because the elevated oil temperature is maintained with the heat tracing. Gelling of the shale oil does not occur. The size of the pipeline can be optimized because nothing other than shale oil is being pumped through the line.

This system has the additional capital costs of the heat tracing system and greater operating costs due to electrical power requirements to heat the pipeline. This could be a problem due to limited availability of electrical service along portions of the proposed pipeline corridor.

Preconditioning by special heating and cooling of the shale oil before it is introduced into the pipeline reduces the pour point and viscosity. This reduces the pumping requirements and extends the allowed standby time if flow in the pipeline is stopped. However, large capital costs are required for the preconditioning facilities and the operating and maintenance costs are also high.

A water injection system to lubricate pipe wall/crude interface is a method to decrease frictional drag and thus reduce the pumping horsepower required to operate the pipeline. This system has the same disadvantages as the oil-water emulsion scheme. An adequate water source is necessary and injection and separation facilities are required. Pipeline capacity is reduced, but not to the same extent as with the emulsion systems.

Preheating the shale oil and pumping it through an insulated buried pipeline is a method that should be considered. This method allows for optimization of pipeline size and minimizes the number of pump stations. By maintaining the shale oil temperature in the range where it acts as a Newtonian fluid, viscosity is decreased and thus a reduction in pumping horsepower is obtained.

Preheating facilities may be required if the delivery temperature is not high enough. Intermediate heating facilities may not be required if a sufficient amount of pipeline insulation is used. The trade-off of extra insulation vs. additional cost of fuel for heating and shale oil is an increase in operating expense. Standby time to gelling and emergency measures to insure the line can be restarted should be established. The costs of such emergency measures, if the maximum shutin time is exceeded, should be evaluated and included in the total economic investigation.

The use of flow modifiers or pour point depressants to change the wax crystalline structure of the shale oil may be the simplest solution to the problem of transporting a waxy crude or shale oil by pipeline. This scheme reduces viscosity and gel yield strength, but does not reduce pipeline capacity. The use of additives does not require special separation facilities at the terminus and no special heating facilities or insulation are required. This system would have the lowest capital cost. The additional operating cost of the pipeline could be significant due to the quantity and cost of the additive.

A general economic analysis should be performed on each of the methods discussed. Then a more detailed economic investigation should be given to the cases that look most promising. Points covered in such an investigation should include:

1. Any reduction in pipeline flow capacity due to the use of the particular method

2. The procurement and subsequent separation of materials added to improve flow (emulsions and water injection)

3. Equipment needed for heating, injection, or other treatment

4. Operating costs

5. Capital costs.

APPENDIX A
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