Administrative Record

FORT WINGATE DEPOT ACTIVITY, GALLUP, NEW MEXICO

Document No. 71-2

Drilling and Testing of Well 69, Fort Wingate Army Depot , McKinley County, New Mexico Open File Report

J. W. Mercer and E. G. Lappala
U.S. Geological Survey
in cooperation with Fort Wingate Army Depot

November 1971

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Albuquerque, New Mexico

Drilling and testing of well 69, Fort Wingate Army Depot, McKinley County, New Mexico

By

Jerry W. Mercer and Eric G. Lappala

Open-file report

Prepared by the U.S. Geological Survey in cooperation with the Fort Wingate Army Depot

November 1971

Contents

Illustrations

Tables

Appendix

Drilling and testing of well 69, Fort Wingate Army Depot, McKinley County, New Mexico

By

Jerry W. Mercer and Eric G. Lappala

Introduction

Fort Wingate Army Depot requested that the U.S. Geological Survey give technical assistance in drilling and testing a new production well. This technical assistance was given in close cooperation with Mr. Don M. Coulter, Engineering Department, Fort Wingate Army Depot, who supervised the engineering aspects of well drilling and construction.

The only aquifer beneath the depot known to yield sufficient water to be considered as a supply source is the Glorieta Sandstone of Permian age. This aquifer has been tapped by several wells on the depot grounds; however, only one well (well 68, fig. 1) yielded an adequate supply of water. The well flowed at the surface.

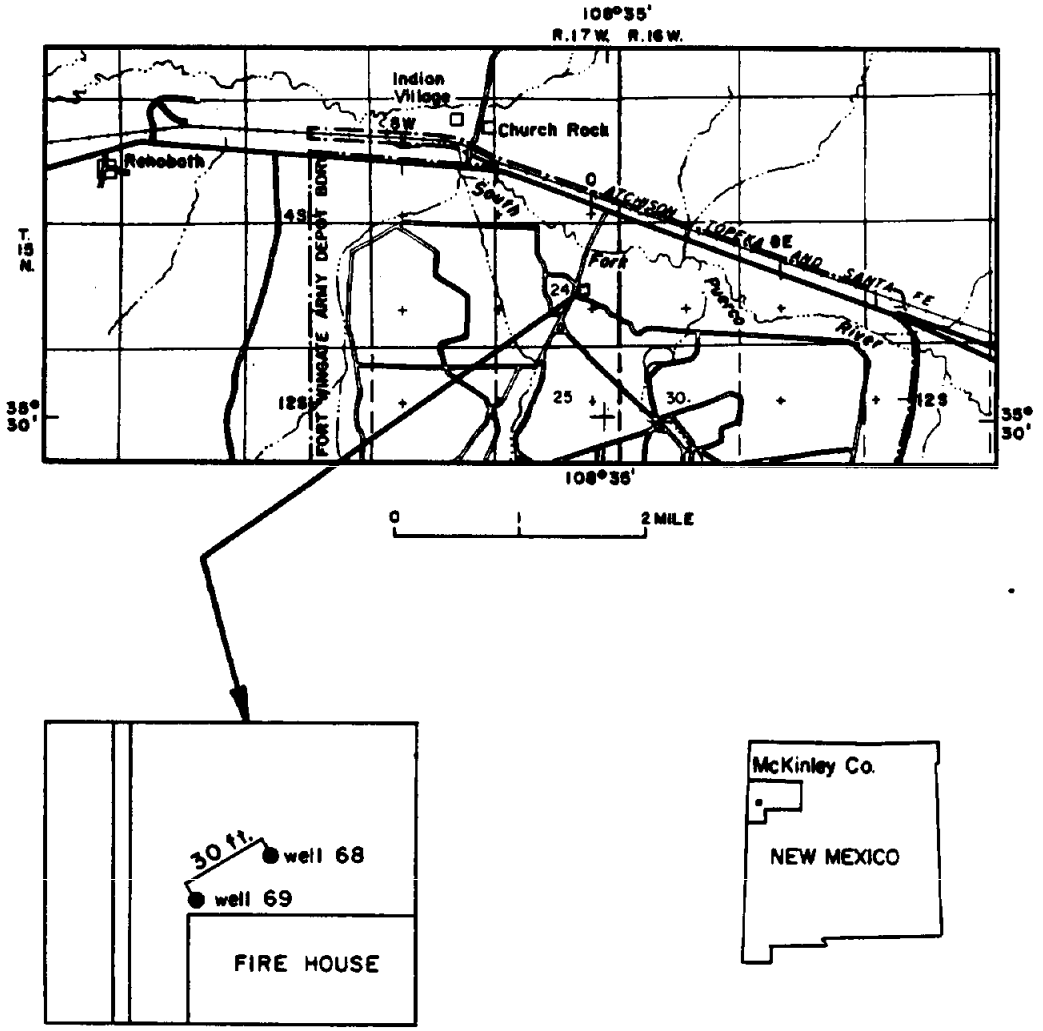


Figure 1.--Location of well 69 on Fort Wingate Army Depot, McKinley County,

Well 68 was drilled in 1942. Examination of the well by the Geological Survey in 1968 (U.S. Geol. Survey, written communication) indicated that the casing had deteriorated and that water under artesian pressure was probably leaking into formations above the aquifer. Army officials decided to drill a new well (well 69) to replace well 68. Well 69 was drilled as close to well 68 as feasible.

Location of the well

Well 69 (fig. 1) was drilled at Fort Wingate Army Depot in the NW¼NE¼NW¼SE¼ sec. 24, T. 15 N., R. 17 W. (projected section) at an altitude of 6,680 feet. It is located 30 feet southwest of well 68.

Well construction

Drilling of well 69 was begun in July 1970 by Coffey Drilling Co. of Ramah, N. Mex. A 12½-inch pilot hole was drilled to a depth of 110 feet using a bentonite-base drilling mud. The pilot hole was then reamed to 20 inches and cased to 100 feet with 16-inch casing and cemented to prevent caving. A 15½-inch hole was then drilled to a depth of 1,050 feet. After gamma-ray and neutron logs were made by the U.S. Geological Survey (figs. 2A and 2B), the hole was cased to 1,037 feet with 12 3/4-inch casing and cemented. An 11½-inch hole was then drilled to 1,350 feet. Acoustic velocity and induction-electric logs (figs. 3A and 3B) were made by Welex Well Service Co. for the interval from 1,028 to 1,350. After logging, the hole was cased with 8 3/4-inch casing; slotted 8 3/4-inch casing was placed opposite the producing interval (1,100 to 1,350 feet). Construction details of the well are shown in figure 4 and a summary record of the well is given in table 1. Samples of drill cuttings were collected at 10-foot intervals and a sample-description log (Appendix A) was made.

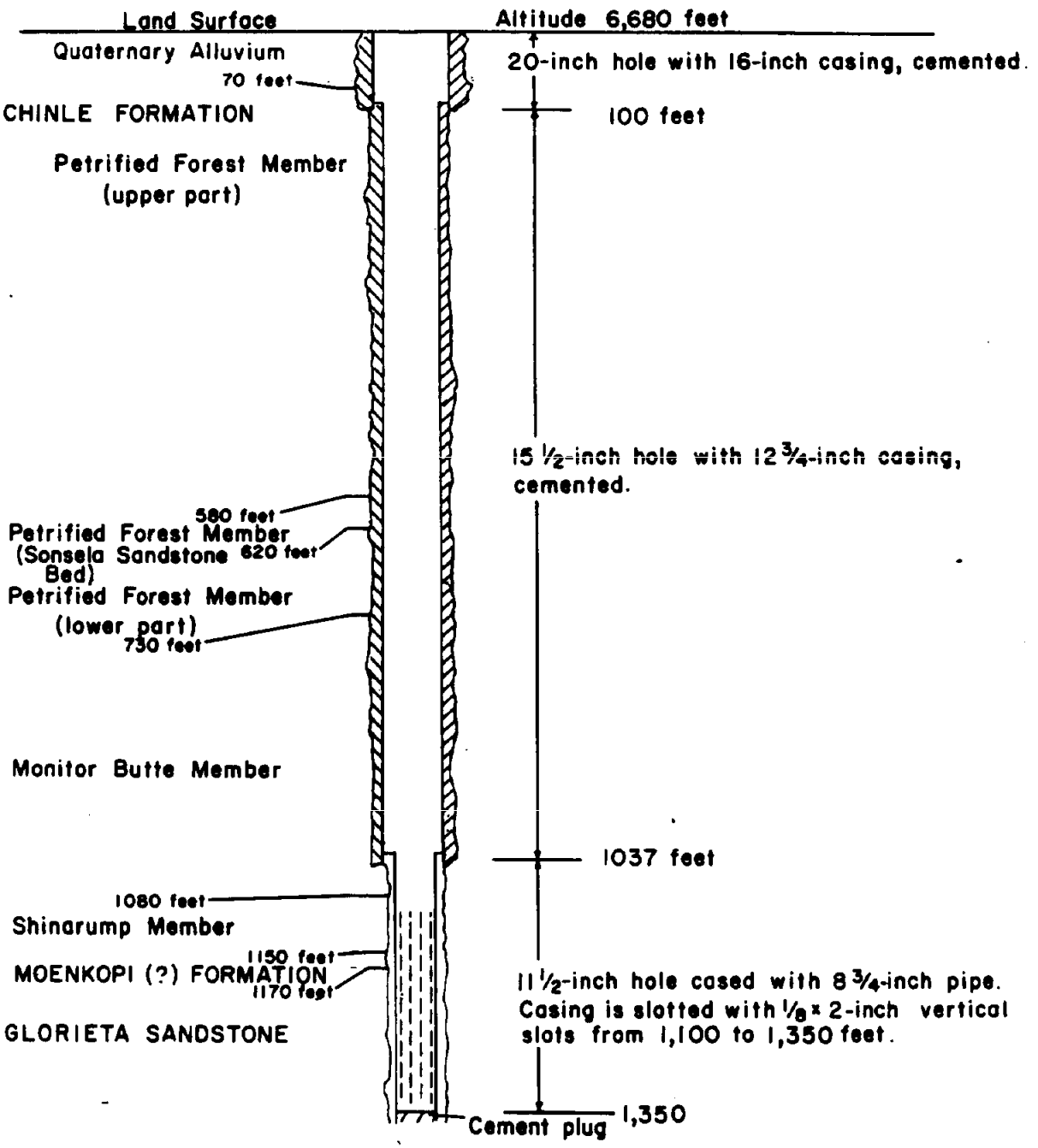


Figure 4.--Construction details of well 69, Fort Wingate Army Depot.

Table 1.--Summary record of well 69, Fort Wingate Army Depot

Location: NW¼NE¼NW¼SE¼ sec. 24, T. 15 N., R. 17 W. (McKinley County, N. Mex.)

Altitude: 6,680 feet (ground level)

Depth drilled: 1,350 feet (driller)

Depth logged: 1,356 feet (Welex)

Date completed: September 10, 1970

Drilling contractor: Coffey Drilling Co., Ramah, N. Mex.

Drilling method: Hydraulic rotary

Casing and well record: From 0-100 feet, 16-inch casing; from 100-1,037 feet, 12 3/4-inch casing; from 1,030 to 1,350 feet, 8 3/4-inch casing.

Slotted casing from 1,100 to 1,350 feet.

Formation logs: Gamma neutron (0-1,050 feet); acoustic velocity and induction-electric log (1,028-1,356 feet)

Water quality: Analyses in table 3

Aquifer testing

After development of well 69 by surging and bailing, a turbine pump was installed in the well and a 72-hour aquifer-performance test was started on October 2, 1970.

Prior to pumping, the well was flowing at a rate of 33 gpm (gallons per minute). Pumping began at an average rate of 310 gpm. Water levels were measured both in the pumped well and in an observation well (well 68) with an electric measuring line and steel tape. The pump discharge was measured with a flow meter installed in the discharge line. At the end of the test the average pumping rate was 300 gpm and the depth to water in the pumped well was 303.40 feet. At no time during the test was sand observed in water pumped from the well.

The well-head pressure in the observation well was 4 psi (pounds per square inch) prior to pumping. This is equivalent to a head of 9.24 feet above land surface. After 72 hours of pumping the water level declined to 59.40 feet below land surface.

During the recovery period the water level was again measured periodically. The pumped well (well 69) began to flow 22½ minutes after the pump was shut off. After 930 minutes of recovery the well was flowing at a rate of 23 gpm.

The observation well (well 68) began to flow 19½ minutes after pumping ceased. After 930 minutes of recovery the well-head pressure was again at 4 psi.

Analysis of aquifer-test data

The Glorieta Sandstone beneath Fort Wingate Army Depot is a confined, extensive aquifer. Formations above and below the Glorieta are not believed to contribute significant amounts of water to the aquifer through leakage. Consequently, the non-equilibrium method and the modified non-equilibrium method (Walton, 1970) were applied to the aquifer-test data.

A logarithmic plot of drawdown in the observation well against the distance, in feet, between the pumped well and the observation well (squared) divided by time since pumping began, in days, is shown in figure 5. Application of the non-equilibrium method to these data yields a transmissivity of 160 ft^2/day and a storage coefficient of 0.0012.

Recovery of water levels in both wells is plotted against the logarithm of time since pumping started divided by time since pumping stopped in figures 6 and 7. Transmissivity determined from recovery in the pumped well is 540 ft^2/day, and from recovery in the observation well is 460 ft^2/day. Table 2 shows a summary of hydraulic properties determined from application of the non-equilibrium or modified non-equilibrium methods to drawdown and recovery data. All solutions yield results of the same order of magnitude but the range in values is appreciable.

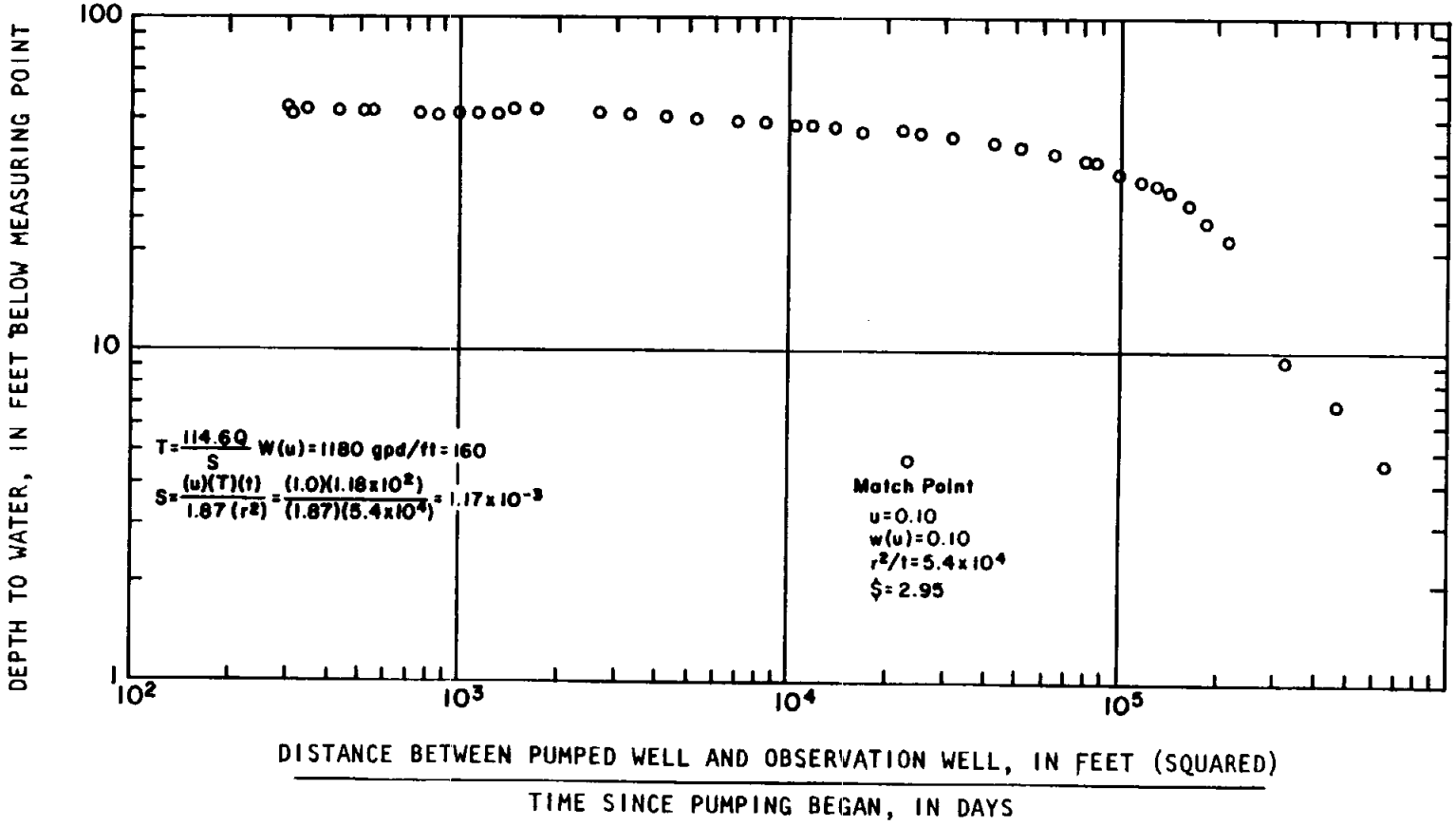


Figure 5.--Drawdown in the observation well (well 68) during pumping of well 69, October 2-5, 1970.

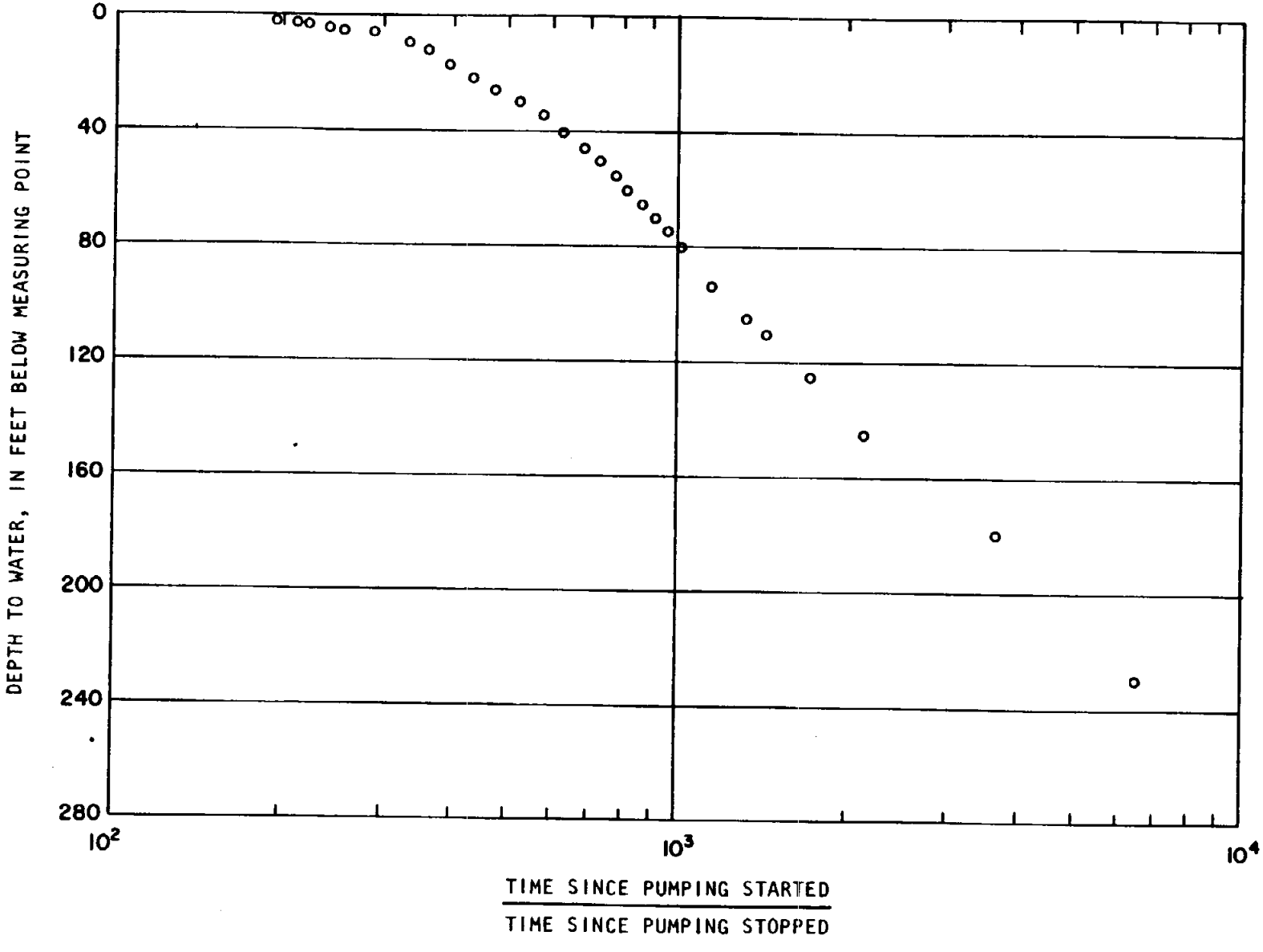


Figure 6.--Depth to water in the pumped well (well 69) during recovery period.

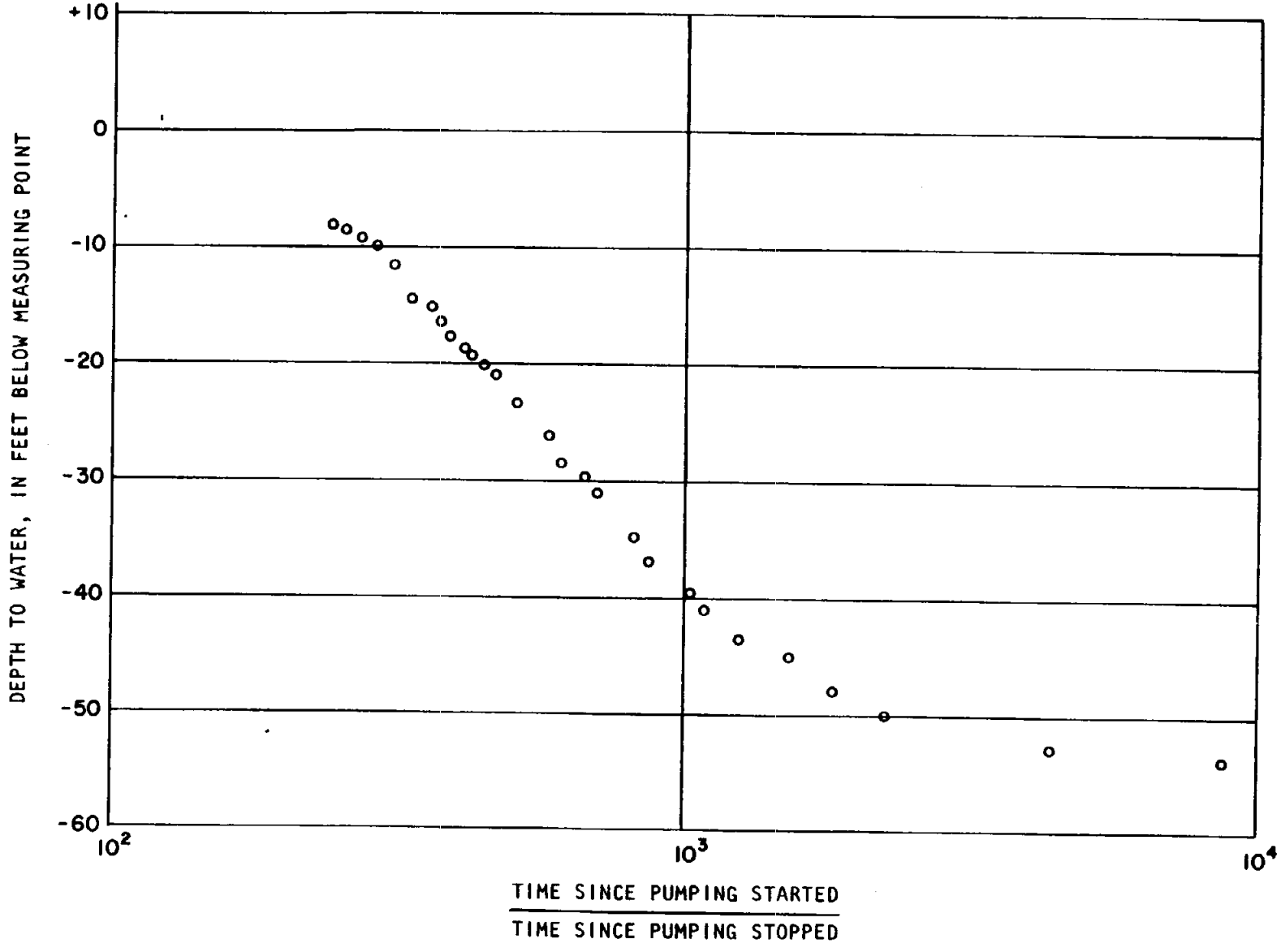


Figure 7.--Depth to water in the observation well (well 68) during recovery period.

Table 2.--Hydraulic properties of the Glorieta Sandstone determined from pumping test, October 2-5, 1970

Method of Analysis	Transmissivity (ft^2/day)	Storage coefficient (dimensionless)
Nonequilibrium, drawdown in observation well	160	0.0012
Modified nonequilibrium, recovery in pumped well	540	--
Modified nonequilibrium, recovery in observation well	460	--

The inferred transmissivity of the Glorieta Sandstone determined from this test is about 400 ft^2/day. The storage coefficient is about 0.001. These values can be used for projecting drawdowns at varying distances from the pumped well, and for different discharge rates and durations of pumping.

Chemical quality of water

Analysis of water from the Glorieta Sandstone (table 3) indicates the water is high in bicarbonate and sulfate ions. The total dissolved solids of 918 mg/l (milligrams per liter) exceeds the maximum of 500 mg/l as recommended by the U.S. Public Health Service. However, in many parts of New Mexico ground-water supplies do not meet these standards and waters of higher salinity are used with no noticeable ill effects.

Table 3.--Chemical analysis of water from well 69

(Analyses by U.S. Geological Survey; chemical constituents in milligrams per liter)

Date of collection - October 5, 1970

Silica as SiO_2	11
Iron as Fe, (Total)	.39
Calcium as Ca	92
Magnesium as Mg	102
Sodium Na+Potassium K (calculated)	53
Bicarbonate as HCO_3	214
Carbonate as CO_3	0
Sulfate as SO_4	564
Chloride as Cl	1.6
Fluoride as F	.2
Nitrate as NO_3	0
Dissolved solids:	
Calculated	929
Residue at 180°C	918
Total hardness as $CaCO_3$	650
Noncarbonate hardness as $CaCO_3$	474
Alkalinity as $CaCO_3$	175
Specific conductance	1,280
pH, standard units	7.7
Color, Hazen units	3
SAR	.9

Summary and conclusions

Well 69, Fort Wingate Army Depot, was completed in 1970 at a depth of 1,350 feet. It is located in the NW¼NE¼NW¼SE¼ sec. 24, T. 15 N., R. 17 W. (projected section) at an altitude of 6,680 feet. The well produces water from the Glorieta Sandstone of Permian age and was test pumped at a rate of 300 gpm. Prior to the test, the well flowed at a rate of 33 gpm; after 72 hours of pumping the water level had declined to a depth of 303.4 feet.

During pumping of well 69 the water level in well 68, 30 feet northeast, was observed. At the end of the test the water level in well 68 had declined from a static level of 9.24 feet above land surface (4 psi well-head pressure) to a depth of 59.40 feet below land surface.

The well was completed approximately 50 feet above the base of the Glorieta Sandstone because of restricted funding. Penetration of the entire thickness of the sandstone might have resulted in a moderately increased yield of the well.

The water pumped from well 69 contained 918 mg/l total dissolved solids. The water is hard and high in sulfate and bicarbonate ions.

References cited

Walton, W. C., 1970, Groundwater resource evaluation: New York, McGraw-Hill, 664 p., 29 figs.

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico

Note: Drill cuttings samples were collected at 10-foot intervals. An effort was made to adjust sample-description log to geophysical logs and to identify cavings and exclude them from the description.

Color symbols in parentheses following the color of the rock are from the "Rock-Color Chart", 1963, distributed by the Geological Society of America, New York, N. Y.

Sample description by J. W. Mercer

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Quaternary System:		
Alluvium:		
Sand, pale-red (5 R 6/2); fine to medium-grained; silty; composed of subangular to subrounded, stained, quartz; minor dark accessory minerals, unconsolidated ----------	50	50
Silt, pale-red (10 R 6/2); sandy; contains subrounded, stained, quartz grains; minor fragments of claystone and sandstone, unconsolidated -----	20	70

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System:		
Chinle Formation:		
Petrified Forest Member (upper part):		
Claystone, pale reddish-brown (10 R 5/4); silty; calcareous; dark-gray limestone fragments common; minor stained quartz grains	60	130
Claystone, grayish-red (5 R 4/2); silty; calcareous; contains light-gray spots; white crystalline calcite and dark gray limestone fragments common	30	160
Claystone, pale-red (5 R 6/2) to grayish-red (5 R 4/2); silty; slightly calcareous	10	170
Claystone, pale-red (5 R 6/2); silty; slightly calcareous; grayish-pink (5 R 8/2) to pale-red (5 R 6/2) fine-grained calcareous sandstone common to abundant	20	190

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (upper part) - Continued:		
Sandstone, pale-red (5 R 6/2); silty; very fine- to fine-grained; poorly sorted; composed of clear to gray, angular, quartz grains; moderately cemented; slightly calcareous; red claystone and gray limestone fragments common	20	210
Siltstone, pale-red (5 R 6/2) to grayish-red (5 R 4/2); very sandy; slightly calcareous; contains minor mica flakes; red sandstone and claystone fragments common	50	260
Sandstone, pale-red (10 R 6/2) to grayish-orange-pink (5 YR 7/2); silty; very fine- to fine-grained; poorly sorted; composed of clear to amber, subangular, quartz grains; moderately cemented; slightly calcareous; contains minor mica and dark accessory minerals; red siltstone and gray limestone fragments common	10	270

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (upper part) - Continued:		
Siltstone, grayish-red (10 R 4/2) to pale-red (5 R 6/2); sandy; slightly calcareous; mica flakes and clear quartz grains common; claystone minor sandstone fragments common	10	280
Sandstone, pale-pink (5 RP 8/2) to pale red-purple (5 RP 6/2); silty; very fine- to fine-grained; poorly sorted; composed of subangular to rounded, clear to amber, quartz grains with dark accessory minerals common; moderately cemented; slightly calcareous; minor white crystalline calcite; red claystone fragments common	10	290

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (upper part) - Continued:		
Siltstone, grayish red-purple (5 RP 4/2); sandy; slightly calcareous; contains mica flakes; abundant pale red-purple (5 RP 6/2) sandstone fragments; red claystone fragments common ------	10	300
Sandstone, pale-red (5 R 6/2) to grayish orange-pink (10 R 8/2); silty; very fine- to fine-grained; moderately sorted; composed of angular to subrounded, clear to frosted, quartz grains; minor dark accessory minerals; moderately cemented, calcarious; abundant grayish-red (5 R 4/2) and light olive-gray (5 Y 5/2) claystone ----------	10	310
Claystone, grayish-red (10 R 4/2); silty; calcareous; gray limestone and red siltstone fragments common ----------	20	330

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (upper part) - Continued:		
Claystone, grayish-red (10 R 4/2) to pale-olive (10 Y 6/2); silty; minor gray limestone and red siltstone fragments ----------	10	340
Claystone, pale-red (5 R 6/2) to grayish-red (10 R 4/2); silty; slightly calcareous; gray limestone and red siltstone minor to common; minor pink sandstone fragments; some of the claystone contains light colored "reduced" zones --	40	380
Claystone, pale-red (5 R 6/2) to grayish-red (10 R 4/2); silty; calcarious; minor red siltstone; minor pale-olive (10 Y 6/2) claystone fragments -------	20	400
Claystone, pale-red (5 R 6/2) to grayish-red (5 R 4/2); silty; very calcareous; common to abundant white to dark-gray, subangular to rounded, limestone fragments; red siltstone fragments common; minor pale-olive claystone fragments -	40	440

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (upper part) - Continued:		
Siltstone, grayish red-purple (5 RP 4/2) to grayish-red (10 R 4/2); clayey; contains rounded gray limestone fragments; very calcareous; red and grayish red-purple (5 RP 4/2) claystone common to abundant	10	450
Claystone, grayish red-purple (5 RP 4/2) to greenish-gray (5 GY 6/1); silty; very calcareous; gray to white limestone fragments common; minor sandstone fragments	10	460
Sandstone, light brownish-gray (5 YR 6/1); silty; very fine- to fine-grained: poorly sorted; composed of subangular to rounded clear to amber, quartz grains; dark accessory minerals common; minor mica flakes; moderately cemented, slightly calcareous; gray limestone and red claystone fragments common	30	490

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (upper part) - Continued:		
Claystone, grayish-red (10 R 4/2) to pale reddish-brown (10 R 5/4); silty; slightly calcareous; abundant light brownish-gray (5 YR 6/1) sandstone; gray limestone fragments common ------	20	510
Sandstone, light brownish-gray (5 YR 6/1); silty; very fine- to fine-grained; poorly sorted; composed of angular to subrounded, clear, quartz grains; dark accessory minerals common; minor mica flakes; moderately cemented; noncalcareous; red claystone common ----------	10	520
Claystone, grayish-red (10 R 4/2) to grayish red-purple (5 RP 4/2); silty; calcareous; white to gray, angular to subrounded limestone common to abundant; brown sandstone common ----------	20	540

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (upper part) - Concluded:		
Claystone, grayish-red (5 R 4/2) to yellowish-gray (5 Y 8/1); silty; slightly calcareous; contains sub-rounded grains of yellowish-gray limestone; minor white crystalline calcite; light-brown sandstone common; pale-red siltstone common ----------	30	570
Claystone, grayish-red-purple (5 RP 4/2) to grayish-red (10 R 4/2); silty; slightly calcareous; contains white limestone fragments; light-brown sandstone and siltstone fragments common ------	10	580

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (Sonsela Sandstone Bed):		
Sandstone, pinkish-gray (5 YR 8/1) to very light-gray (N 8); clayey; very fine- to fine-grained; poorly sorted; composed of angular to subrounded, frosted to clear, quartz grains; moderately cemented; slightly calcareous; rare dark accessory minerals; red siltstone and claystone (cavings?) common -	40	620
Petrified Forest Member (lower part):		
Claystone, grayish red-purple (5 RP 4/2) to grayish-purple (5 P 4/2); silty; contains spots of pale greenish-yellow (10 Y 8/2) clay; calcareous; grayish-red siltstone and dark-gray limestone minor to common ----------	30	650
Claystone, yellowish-gray (5 Y 7/2) with minor grayish-red (10 R 4/2) fragments; silty; contains very fine-grained quartz grains; very slightly calcareous -----	10	660

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (lower part) - Continued:		
Claystone, grayish red-purple (5 RP 4/2) with spots of pale yellowish-gray (10 Y 8/2) clay; silty; calcareous; minor dark-gray clay; minor grayish-red siltstone; clear quartz grains rare ----------	30	690
Sandstone, yellowish-gray (5 Y 8/1) to grayish orange-pink (10 R 8.2); silty; very fine- to medium-grained sand; poorly sorted; composed of angular to subrounded, clear to frosted, quartz grains; well cemented; noncalcareous; common dark accessory minerals; minor grayish-purple claystone fragments --	20	710
Claystone, grayish red-purple (5 RP 4/2) with pale greenish-yellow (10 Y 8/2) reduced zones; silty; slightly calcareous; minor quartz grains; minor red siltstone ----------	10	720

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued:		
Petrified Forest Member (lower part) - Concluded:		
Claystone, pale red-purple (5 RP 6/2) with pale greenish-yellow (10 Y 8/2) reduced zones; silty; slightly calcareous; contains minor, amber, quartz grains --	10	730
Monitor Butte Member:		
Claystone, grayish-red (10 R 4/2) to moderate reddish-brown (10 R 4/6); silty; calcareous; some fragments contain very fine-grained, amber, quartz grains; red siltstone common ----------	60	790
Claystone, grayish red-purple (5 RP 4/2) to grayish-red (10R 4/2); silty; calcareous; contains some fragments of pale greenish-yellow (10 Y 8/2) grayish-red siltstone common; minor mica flakes; minor brown sandstone -------	90	880

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued		
Monitor Butte Member - Continued:		
Siltstone, dark reddish-brown (10 R 3/4) to grayish-red (10 R 4/2); slightly calcareous; abundant grayish-red claystone fragments	20	900
Claystone, moderate reddish-brown (10 R 4/6) to grayish-red (10 R 4/2); silty; very calcareous; reddish-brown siltstone common	20	920
Claystone, grayish-red (5 R 4/2); silty; light-gray (N 7) clay fragments common; very calcareous; minor reddish-brown siltstone	20	940
Claystone, variegated grayish red-purple (5 RP 4/2), grayish-purple (5 P 4/2), grayish-red (10 R 4/2), and light-gray (N 6); silty; calcareous; reddish-brown siltstone fragments common; minor gray limestone fragments	80	1,020

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Continued		
Monitor Butte Member - Concluded		
Claystone, medium light-gray (N 6) to grayish red-purple (5 RP 4/2); silty; calcareous; minor grayish-red siltstone	30	1,050
Claystone, medium light-gray (N 6) to medium gray (N 5); slightly calcareous; minor grayish red-purple siltstone	10	1,060
Claystone, grayish red-purple (5 RP 4/2) to grayish-purple (5 P 4/2); silty; slightly calcareous	20	1,080
Shinarump Member:		
Claystone, grayish-purple (5 P 4/2); silty; slightly calcareous; grayish-pink (4 R 8/2) sandstone common to abundant; silty; very fine-grained, moderately sorted; composed of subangular to subrounded, clear, quartz grains; moderately cemented; noncalcareous	20	1,100

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Continued:		
Chinle Formation - Concluded:		
Shinarump Member - Concluded:		
Sandstone, grayish-pink (5 R 8/2) to white (N 9); medium to very coarse sand; moderately sorted; composed of subangular to rounded, clear to amber, quartz grains; moderately cemented, dark accessory minerals common; grayish-purple claystone minor to common ----------	40	1,140
Conglomerate, pale-red (10 R 6/2) to grayish-pink (5 R 8/2); coarse sand to fine gravel; composed of sub-angular to rounded, clear to amber quartz grains; minor feldspar and dark accessory minerals; greenish-gray (5 GY 6/1) claystone common; sample not consolidated, mostly individual grains ----------	10	1,150

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Triassic System - Concluded		
Moenkopi(?) Formation (may be part of Chinle Formation)		
Siltstone, pale reddish-brown (10 R 5/4); clayey; slightly calcareous; clear to amber quartz grains common; light-gray (N 7) claystone common to abundant; silty; slightly calcareous	20	1,170
Permian System:		
San Andres Limestone: (not present in this hole)(?)		
Glorieta Sandstone:		
Sandstone, light-brown (5 YR 6/4) to moderate orange-pink (5 YR 8/4); very fine- to fine-grained; moderately sorted; composed of subangular to rounded, clear to amber, quartz grains; moderately cemented, slightly calcareous; rare dark accessory minerals; light-gray claystone fragments common to abundant	50	1,220

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Continued

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Permian System - Continued:		
San Andres Limestone - Continued:		
Glorieta Sandstone - Continued:		
Sandstone, moderate orange-pink (5 YR 8/4); very fine- to fine-grained; moderately sorted; composed of subangular to rounded, clear, quartz grains; moderately cemented, very slightly calcareous; rare dark accessory minerals; grayish-purple (5 P 4/2) claystone (cavings?) common to abundant ----------	70	1,290
Sandstone, moderate orange-pink (5 YR 8/4); same as 1,220-1,290 but samples contain no claystone ----------	10	1,300
Sandstone, pale-red (5 R 6/2) to grayish-red (10 R 4/2); silty; very fine- to fine-grained; poorly sorted; composed of angular to subrounded, amber, quartz grains; well cemented; very slightly calcareous; grayish-purple claystone fragments minor to common ----------	10	1,310

Appendix A.--Sample-description log of well 69, Fort Wingate Army Depot, McKinley County, New Mexico - Concluded

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Permian System - Concluded:		
San Andres Limestone - Concluded:		
Glorieta Sandstone - Concluded:		
Sandstone, moderate orange-pink (5 YR 8/4); fairly well sorted; composed of sub-angular to subrounded, clear to amber, quartz grains; well cemented; contains white clay in matrix; minor white clay-stone fragments ----------	40	1,350

Figure 3A.--

ACOUSTIC VELOCITY LOG

WELEX

COMPANY U. S. Army - Fort Wingate
WELL Army Depot # 69
FIELD Fort Wingate
County McKinley State N. M.

COMPANY U. S. ARMY - FORT WINGATE
WELL ARMY DEPOT # 69
FIELD FORT WINGATE
COUNTY McKINLEY STATE NEW MEXICO
Location NE of NW of SE
Other Services: I.E. - E1
Sec. 24 Twp 15-N Rge 17-W

Permanent Datum Ground Level Elev. 6680'
Log Measured From K. B. - 5 Ft. Above Perm. Datum
Drilling Measured From Kelly Bushing
Elev.: K.B. 6685' D.F. G.L. 6680'

Date	9/10/70			
Run No.	- One -			
Depth—Driller	1350			
Depth—Welex	1356			
Btm. Log Inter.	1350			
Top Log Inter.	920			
Casing—Driller	12-3/4" @ 1028	@	@	@
Casing—Welex				
Bit Size	11-3/4"			
Type Fluid in Hole	Mud			
Dens. | Visc.	- | -	- | -	- | -	- | -
pH | Fluid Loss	- | ml	- | ml	- | ml	- | ml
Source of Sample				
R_m @ Meas. Temp.	3.88 @ 70 °F	@ °F	@ °F	@ °F
R_{mf} @ Meas. Temp.	3.55 @ 70 °F	@ °F	@ °F	@ °F
R_{mc} @ Meas. Temp.	3.93 @ 70 °F	@ °F	@ °F	@ °F
Source R_{mf} | R_{mc}	Pndss	-	-	-
R_m @ BHT	@ °F	@ °F	@ °F	@ °F
Time Since Circ.	24 Hours			
Max. Rec. Temp.	°F @	°F @	°F @	°F @
Equip. | Location	7757 | Farmington		-	-
Recorded By	E. Winters			
Witnessed By	Mr. Mercer			

Fold Here

Service Ticket No. W 39338 Remarks:

Change in Mud Type or Additional Samples		
Date | Sample No.	|	|
Depth—Driller		
Type Fluid in Hole		
Dens. | Visc.	|	|
ph | Fluid Loss	| ml	|
Source of Sample		
R_m @ Meas. Temp.	@ °F	@ °F
R_{mf} @ Meas. Temp.	@ °F	@ °F
R_{mc} @ Meas. Temp.	@ °F	@ °F
Source: R_{mf} | R_{mc}	|	|
R_m @ BHT	@ °F	@ °F
R_{mf} BHT	@ °F	@ °F
R_{mc} BHT	@ °F	@ °F

SCALE CHANGES

Type Log	Depth	Scale Up Hole	Scale Down Hole

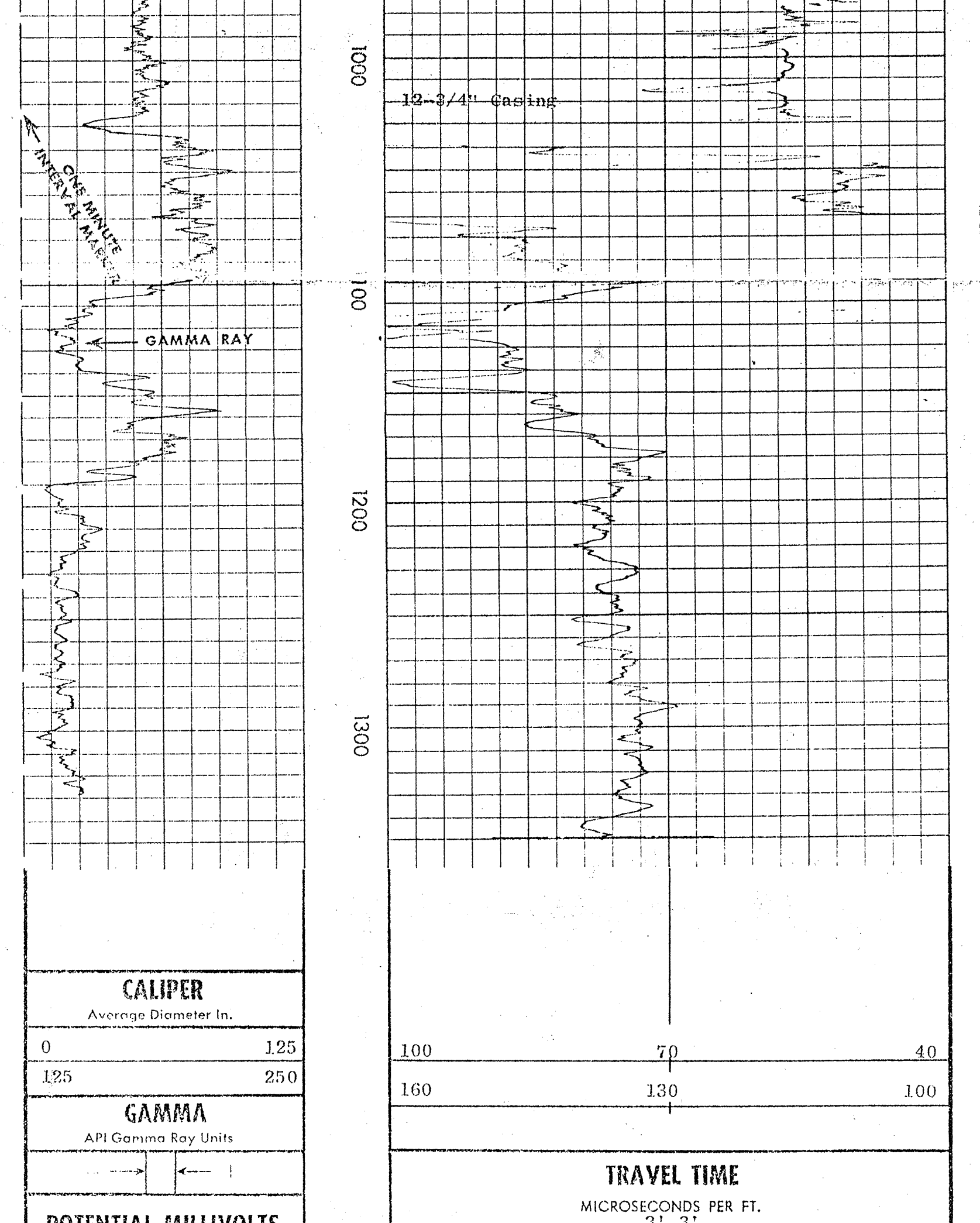
EQUIPMENT DATA

Run No.	Tool Type and No.	Pad Type	Tool Position	Other
-1-	AVL 13823		Centralized	

Welex does not guarantee the accuracy of any interpretation of log data, conversion of log data to physical rock parameters, or recommendations which may be given by Welex personnel or which may appear on the log or in any other form. Any user of such data, interpretations, conversions, or recommendations agrees that Welex is not responsible, except where due to gross negligence or willful misconduct, for any loss, damages, or expenses resulting from the use thereof.

2" = 100'

POTENTIAL MILLIVOLTS	TRAVEL TIME MICROSECONDS PER FT. T 3' R1 3' R2
GAMMA API Gamma Ray Units	100 — 70 — 40
0 — 125	160 — 130 — 100
125 — 250	
CALIPER Average Diameter In.	



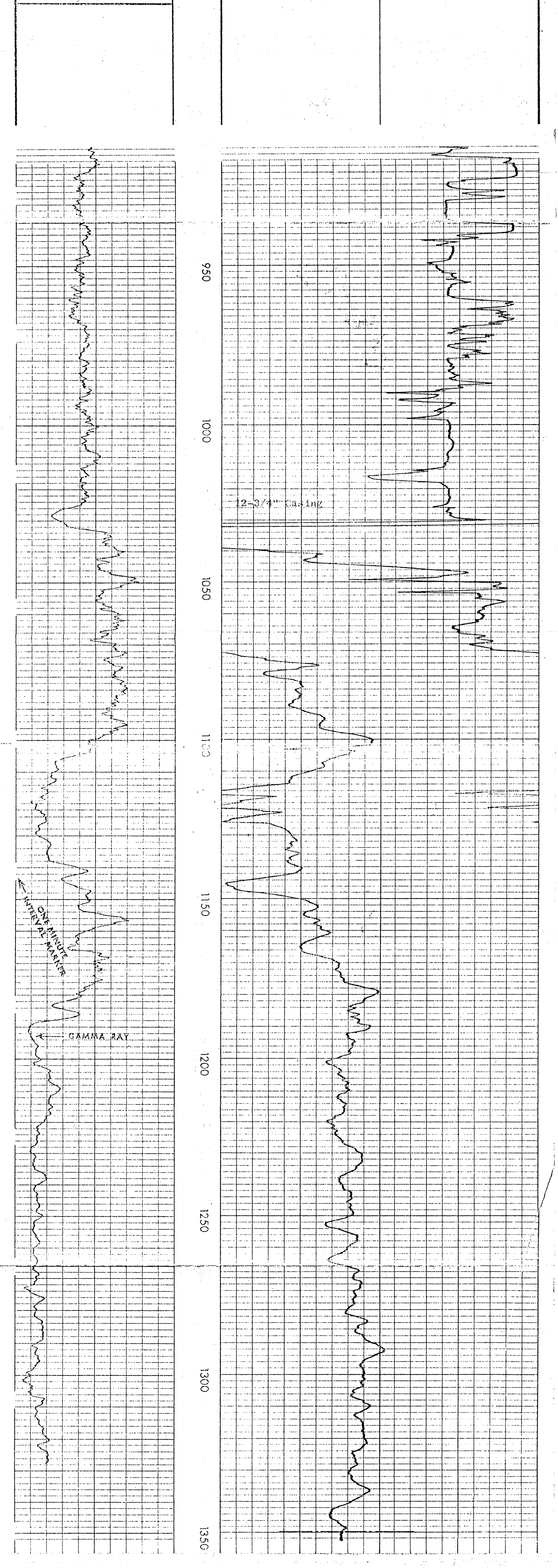
CALIPER Average Diameter In.	
0 — 125	100 — 70 — 40
125 — 250	160 — 130 — 100
GAMMA API Gamma Ray Units	
POTENTIAL MILLIVOLTS	TRAVEL TIME MICROSECONDS PER FT. T 3' R1 3' R2

U. S. Army - Fort Wingate
Army Depot # 69
Fort Wingate Field
McKinley County, New Mexico

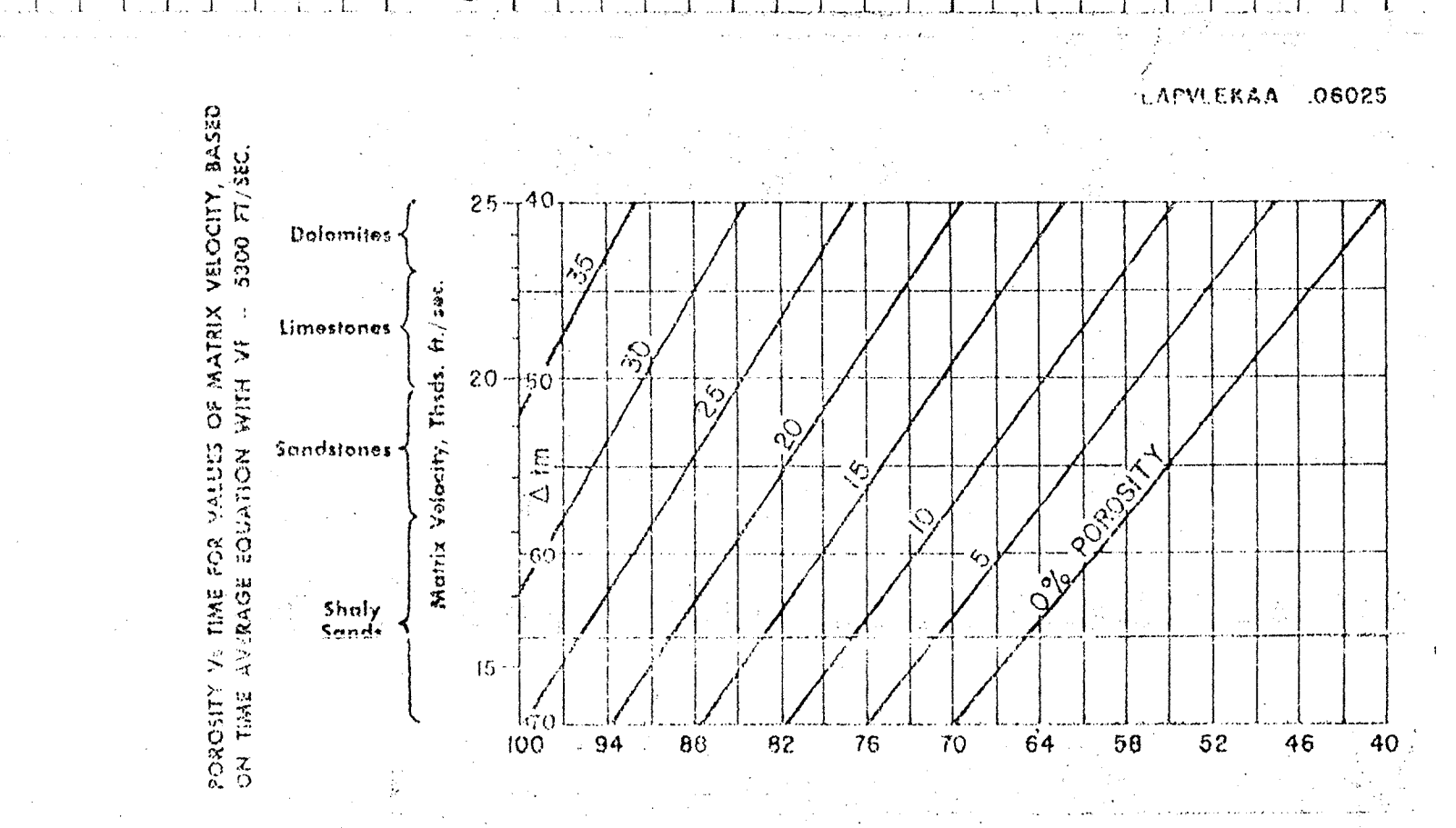
T.D. LOGGED 1350'
T.D. DRILLER 1350'
T.D. WELEX 1356'

5" = 100'

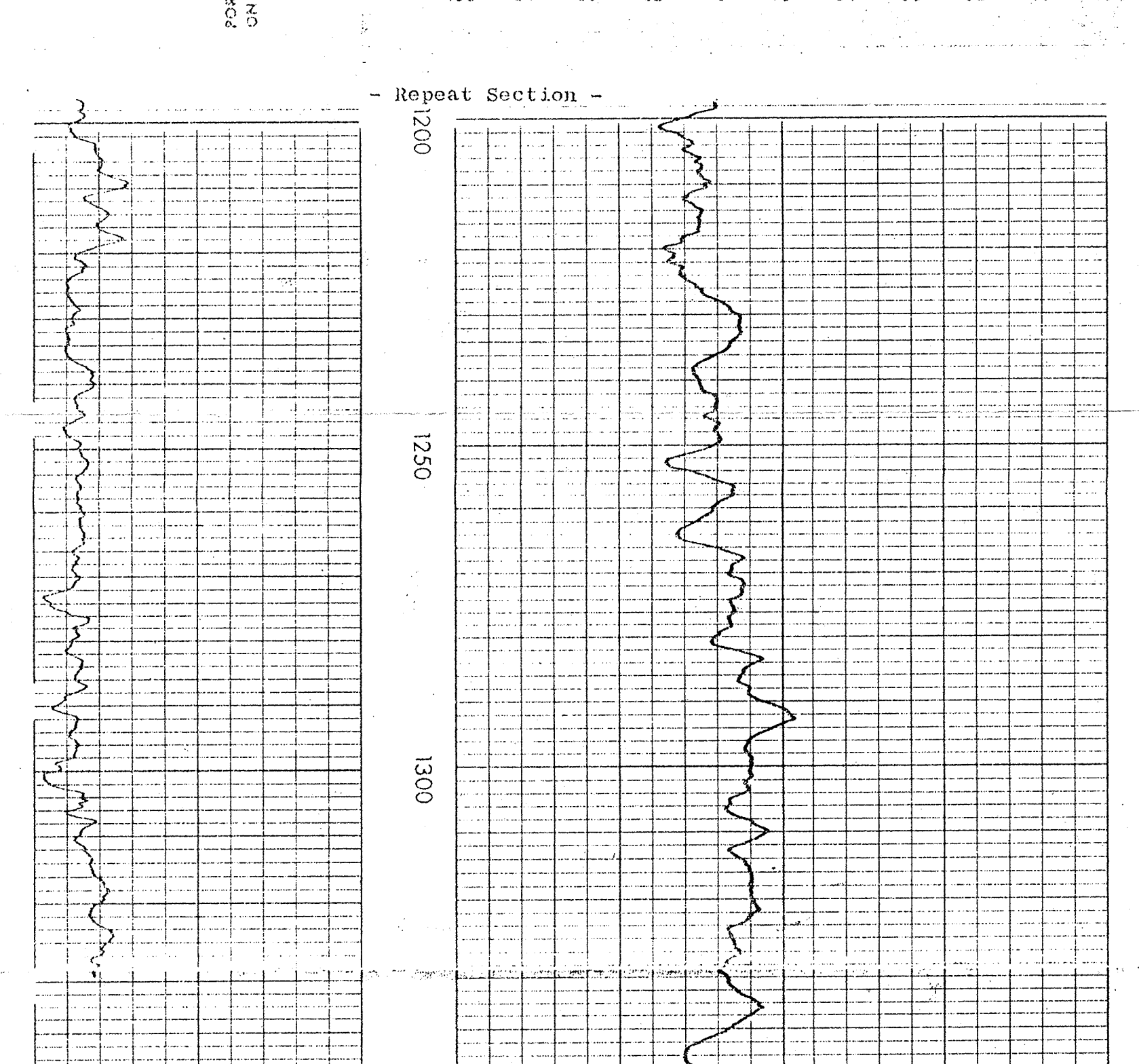
POTENTIAL MILLIVOLTS	TRAVEL TIME MICROSECONDS PER FT. T 3' R1 3' R2
GAMMA API Gamma Ray Units	100 — 70 — 40
0 — 125	160 — 130 — 100
125 — 250	
CALIPER Average Diameter In.	



LAPVLEKAA .06025



- Repeat Section -



CALIPER Average Diameter In.	
0 — 125	100 — 70 — 40
125 — 250	160 — 130 — 100
GAMMA API Gamma Ray Units	
POTENTIAL MILLIVOLTS	TRAVEL TIME MICROSECONDS PER FT. T 3' R1 3' R2

U. S. Army - Fort Wingate
Army Depot # 69
Fort Wingate Field
McKinley County, New Mexico

T.D. LOGGED 1350'
T.D. DRILLER 1350'
T.D. WELEX 1356'

Calibrations

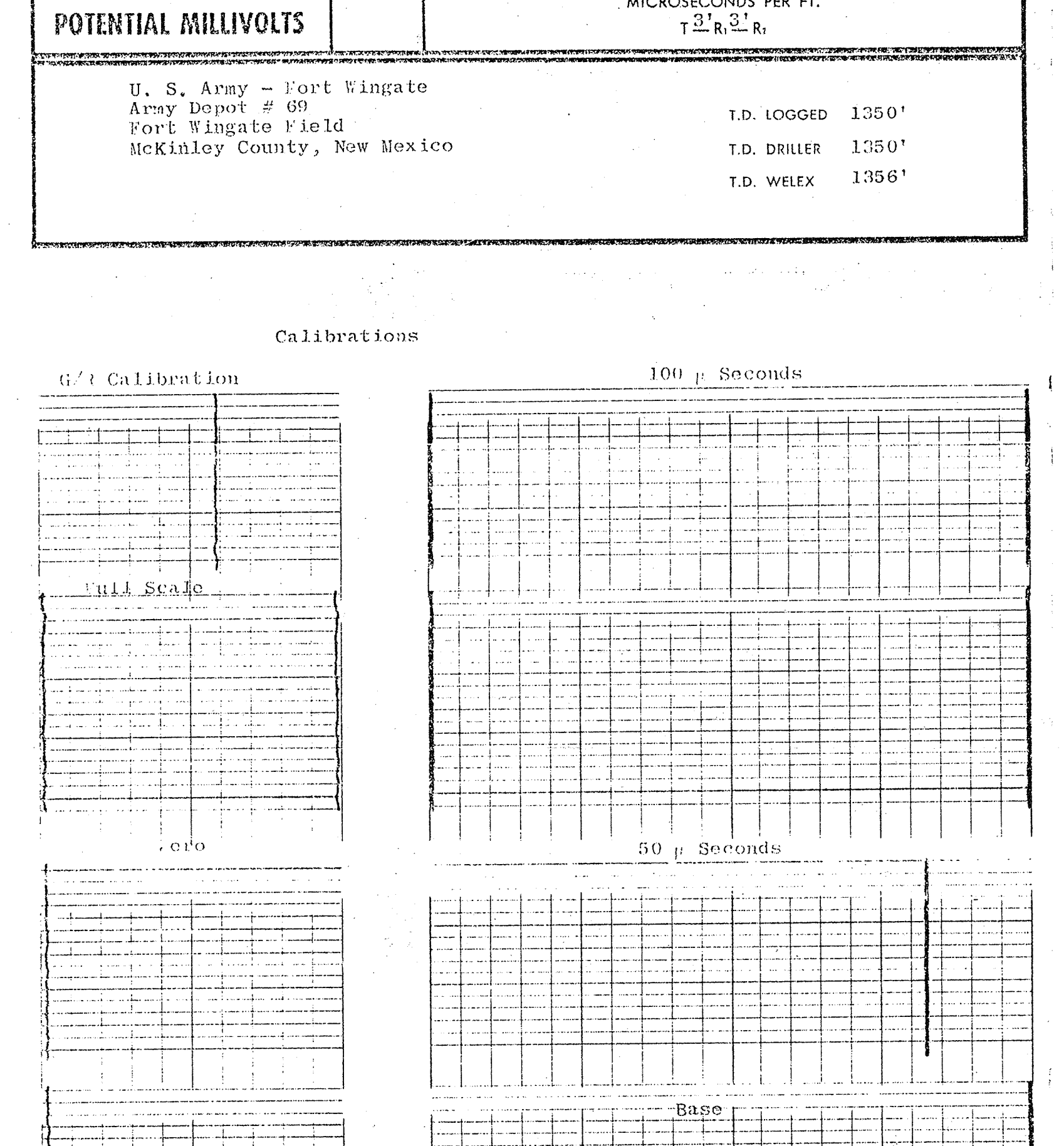


Figure 3B.-- INDUCTION - ELECTRIC LOG

WELEX

COMPANY U. S. Army - Fort Wingate
WELL Army Depot #69
FIELD Fort Wingate
County McKinely State N. M.

COMPANY U. S. ARMY - FORT WINGATE
WELL ARMY DEPOT # 69
FIELD FORT WINGATE
COUNTY McKINLEY STATE NEW MEXICO
Location NE of NW of SE
Sec. 24 Twp 15-N Rge 17-W
Other Services: G/R - AVL

Permanent Datum Ground Level Elev. 6680'
Log Measured From K. B. - 5 Ft. Above Perm. Datum
Drilling Measured From Kelly Bushing
Elev.: K.B. 6685' D.F. G.L. 6680'

Date	9/10/70
Run No.	One
Depth—Driller	1350
Depth—Welex	1356
Btm. Log Inter.	1351
Top Log Inter.	1000
Casing—Driller	12-3/4" @ 1028
Casing—Welex	
Bit Size	11-3/4"
Type Fluid in Hole	Mud
Dens. / Visc.	
pH / Fluid Loss	ml
Source of Sample	
Rm @ Meas. Temp.	3.88 @ 70 °F
Rmf @ Meas. Temp.	3.55 @ 70 °F
Rmc @ Meas. Temp.	3.90 @ 70 °F
Source Rmf / Rmc	Press
Rm @ BHT	@ °F
Time Since Circ.	24 Hours
Max. Rec. Temp.	°F @
Equip. / Location	7757 Farmington
Recorded By	B. Winters
Witnessed By	Mr. Mercer

Fold Here

Service Ticket No. W 39338 Remarks:

Change in Mud Type or Additional Samples		
Date / Sample No.		
Depth—Driller		
Type Fluid in Hole		
Dens. / Visc.		
ph / Fluid Loss	ml	
Source of Sample		
Rm @ Meas. Temp.	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F
Source: Rmf / Rmc		
Rm @ BHT	@ °F	@ °F
Rmf BHT	@ °F	@ °F
Rmc BHT	@ °F	@ °F

SCALE CHANGES

Type Log	Depth	Scale Up Hole	Scale Down Hole

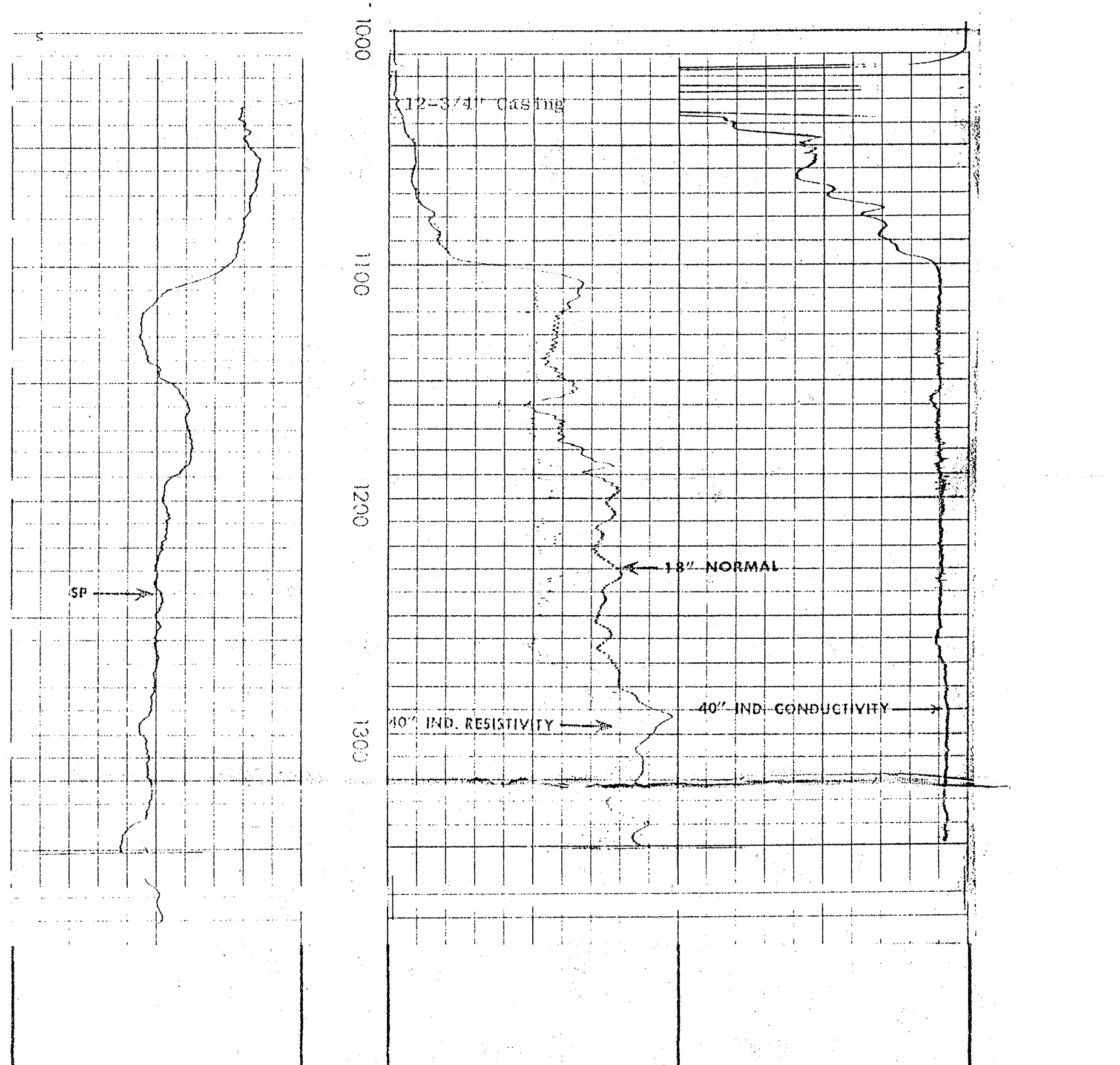
EQUIPMENT DATA

Run No.	Tool Type and No.	Pad Type	Tool Position	Other
-1-	Ind 14128			

Welex does not guarantee the accuracy of any interpretation of log data, conversion of log data to physical rock parameters, or recommendations which may be given by Welex personnel or which may appear on the log or in any other form. Any user of such data, interpretations, conversions, or recommendations agrees that Welex is not responsible, except where due to gross negligence or wilful misconduct, for any loss, damages, or expenses resulting from the use thereof.

2" 100'

POTENTIAL MILLIVOLTS	RESISTIVITY OHMS M²/M	CONDUCTIVITY M MHOS/M
→ 10 ← +	18" Normal 0 — 200	Induction 100 — 0; 500 — 100
Rmf 3.88 at 70 °F.	Induction 0 — 200	RESISTIVITY OHMS M²/M



POTENTIAL MILLIVOLTS	RESISTIVITY OHMS M²/M	CONDUCTIVITY M MHOS/M
Rmf 3.88 at 70 °F.	Induction 0 — 200	
→ 10 ← +	18" Normal 0 — 200	RESISTIVITY OHMS M²/M; Induction 100 — 0; 500 — 100

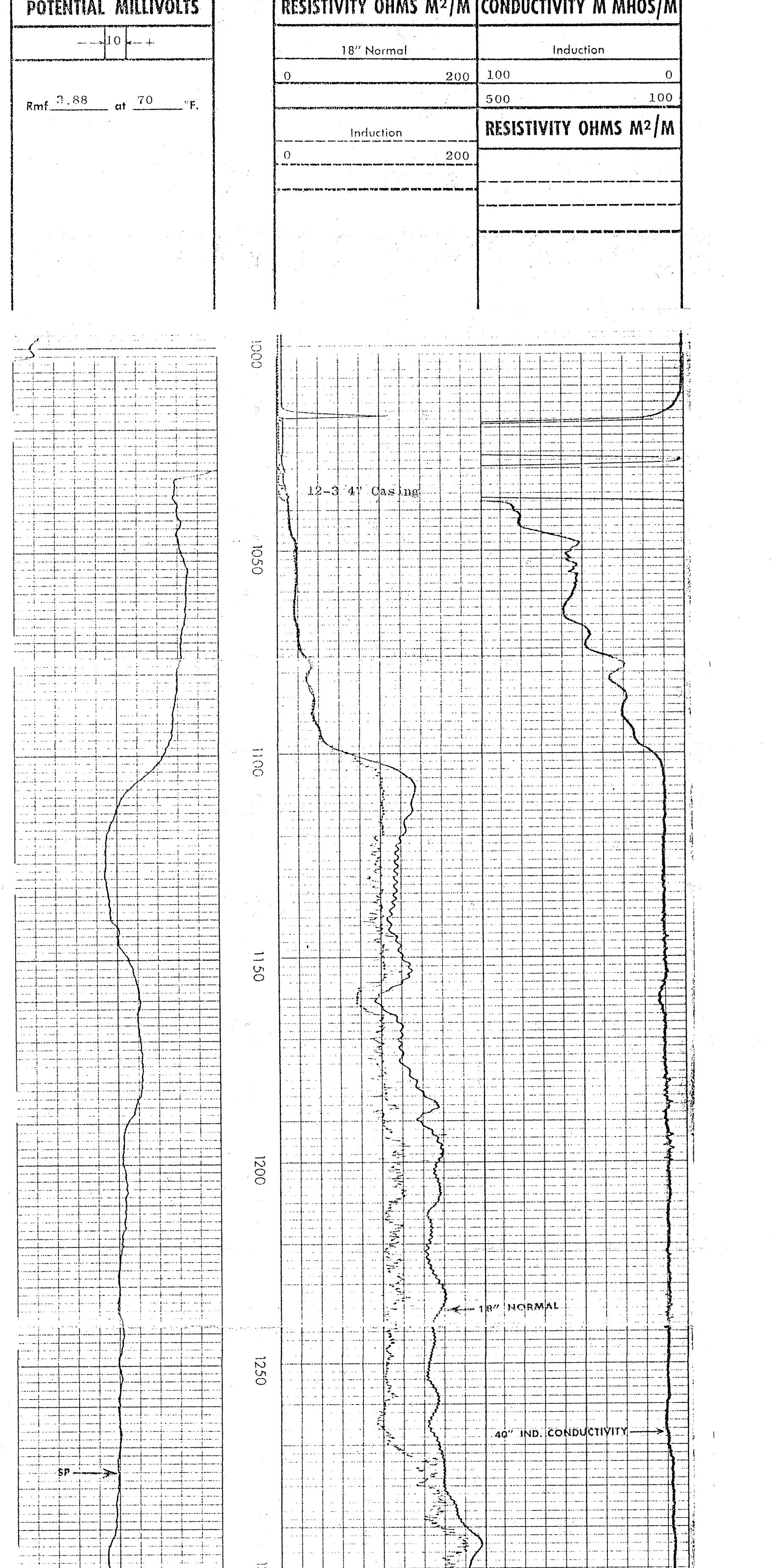
U. S. Army - Fort Wingate
Army Depot # 69
Fort Wingate Field
McKinley County, New Mexico

T.D. LOGGED 1351'
T.D. DRILLER 1350'
T.D. WELEX 1356'

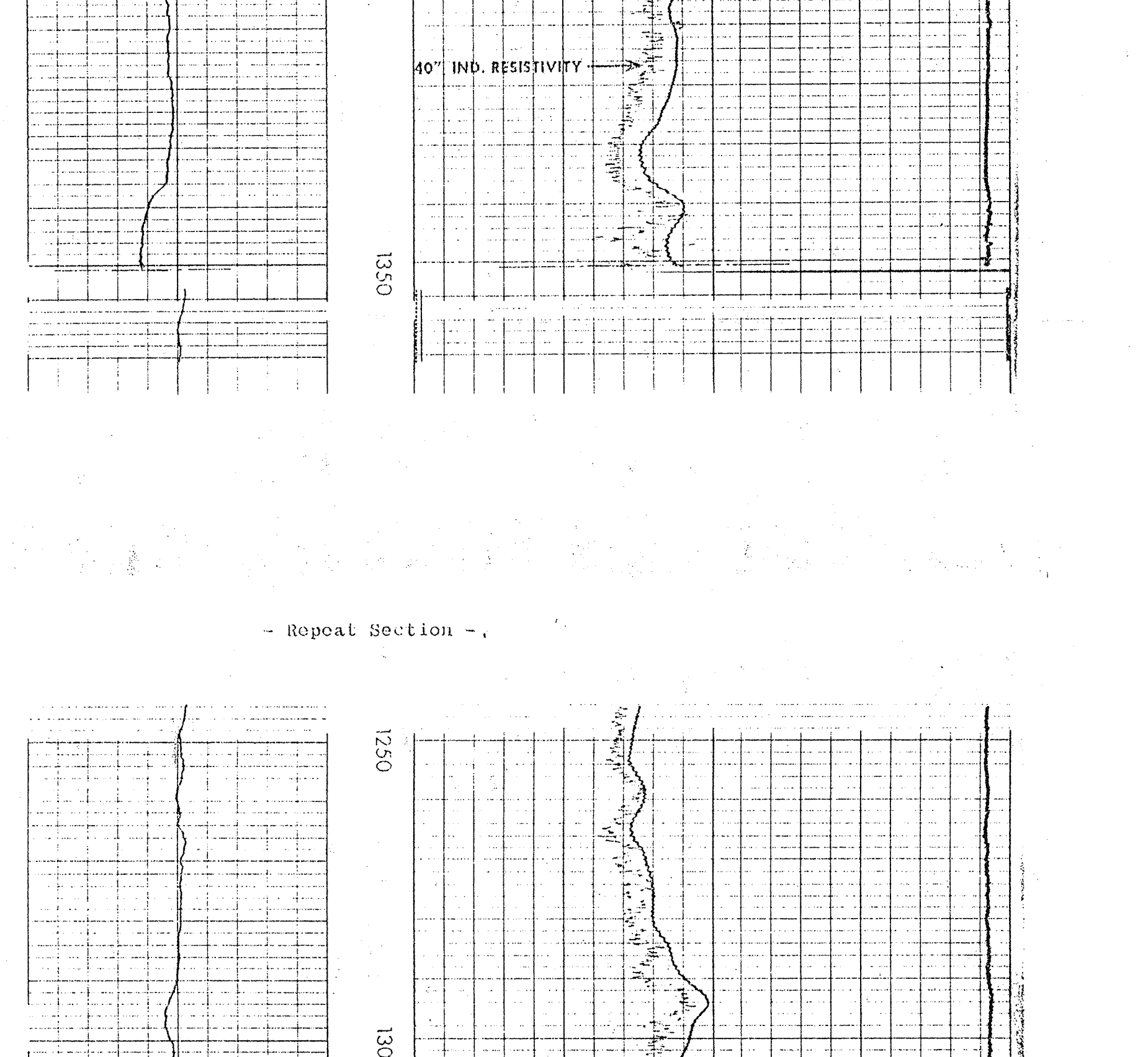
LANLOC-AA.06595

5" 100'

POTENTIAL MILLIVOLTS	RESISTIVITY OHMS M²/M	CONDUCTIVITY M MHOS/M
→ 10 ← +	18" Normal 0 — 200	Induction 100 — 0; 500 — 100
Rmf 3.88 at 70 °F.	Induction 0 — 200	RESISTIVITY OHMS M²/M



Repeat Section

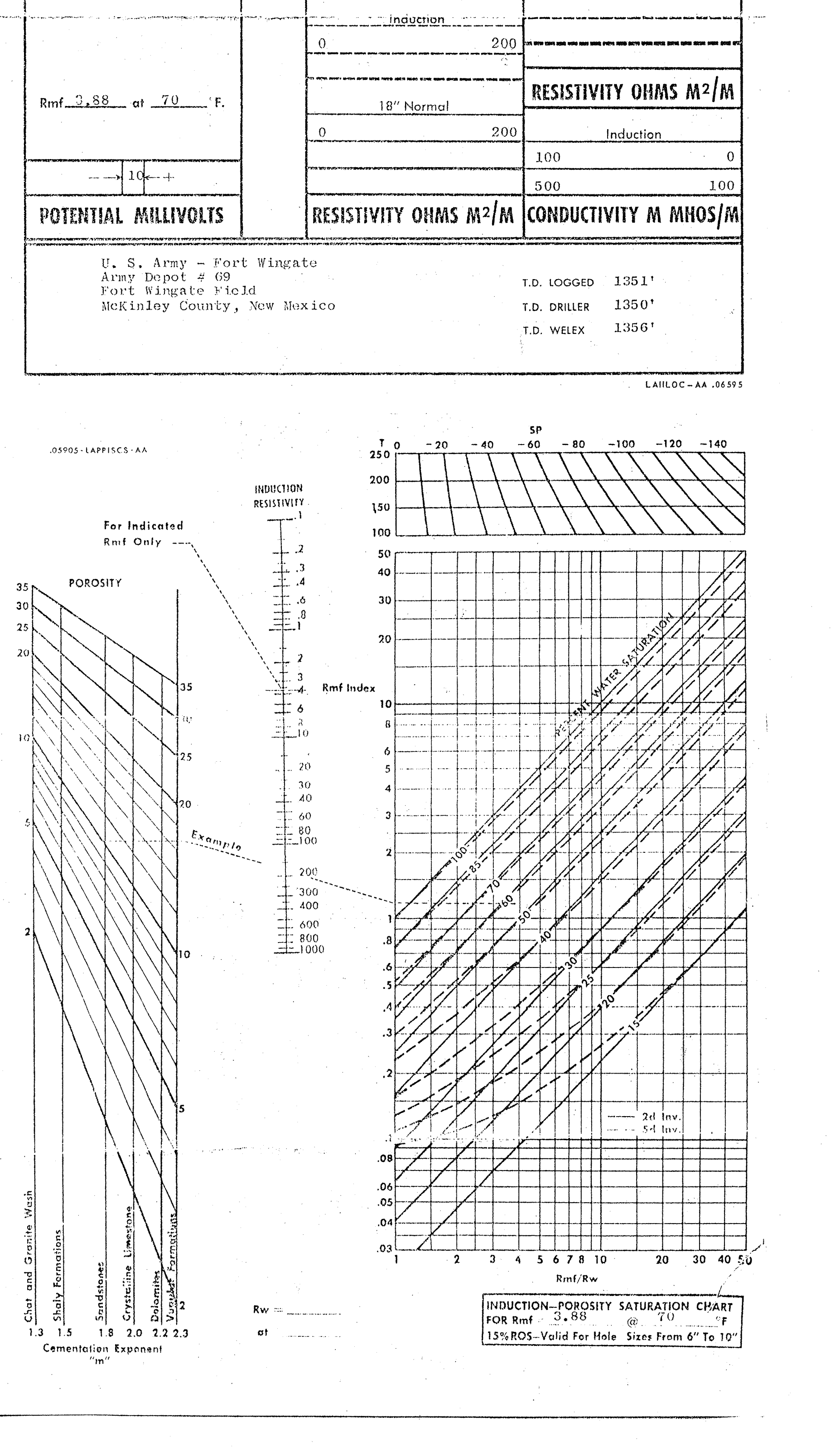


POTENTIAL MILLIVOLTS	RESISTIVITY OHMS M²/M	CONDUCTIVITY M MHOS/M
Rmf 3.88 at 70 °F.	Induction 0 — 200	
→ 10 ← +	18" Normal 0 — 200	RESISTIVITY OHMS M²/M; Induction 100 — 0; 500 — 100

U. S. Army - Fort Wingate
Army Depot # 69
Fort Wingate Field
McKinley County, New Mexico

T.D. LOGGED 1351'
T.D. DRILLER 1350'
T.D. WELEX 1356'

LANLOC-AA.06595



U. S. GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Figure 2A--GAMMA LOG

Owner or Field No. Ft. Wingate
Project Name Replacement Well # 68
Geological Survey No.
State N. Mex. County McKinley
Location
¼ ¼ ¼ ¼ Sec. T N/S R E/W
Depth Datum: Top of Kelly Bushing, which is 4.0 ft. (above, ~~below~~) land surface.

Altitude: MP ft. Land surface ft.
Determined by
Operator(s) Basler / Mercer
Equipment (Vehicle No.) Date Aug. 18, 1970

Casing Data

Casing: Diam. 16 in. 0 ft. to 100 ft. Thickness in.
Diam. in. ft. to ft. Thickness in.
Diam. in. ft. to ft. Thickness in.

Bore: Diam. 18 in. 0 ft. to 100 ft.
Diam. 15½ in. 100 ft. to 1050 ft.
Diam. in. ft. to ft.

Filter: Type Thickness Characteristics,
ft. to
ft. to

Perforations, Screen: Type, size
ft. to
ft. to

Fluid ~~Water~~ Level 37 ft. (~~above~~, below) Kelly Bushing, which is 33 ft. (~~above~~, below) surface. Shut-in head after (hrs., mins.)
Date

Total Depth ft. Interval Logged 5 ft. to 1030 ft.

Fluid in hole: Characteristics
Fluid level ft. Fluid Temperature °F.
Date Date

Water: Temperature °F. at . Field Cond.
Ra(uu c/L Beta-Gamma(uu c/L U(10-3 gr/1

Logging Data

Run No. 1 of 1 runs. Probe Sensitivity (High
Descent: ft./min. Gamma-Ray circuit scale
Potential circuit scale Time constant
Logged out: 40 ft./min. Gamma-Ray circuit scale B
Potential circuit scale 5.0 Time constant 2

Statistical Variation in. at ft. Meter Reading
G-R Scale Time Constant

Calibration in hole: (G-R Scale Pot. circ. scale)
Depth (ft.) Obs. Time (min.) Meter Reading

Remarks

Radiation Intensity Increase ⟶ Depth Scale: 20 ft./in.

U. S. Geological Survey
Water Resources Division

Figure 2B.--NEUTRON LOG

Owner or Field No. Ft. Wingate
Project Name Replacement Well #68
U.S.G.S. No. ______ Town ______
State N. Mex. County or Parish McKinley
Location ______
¼ ___ ¼ ___ ¼ ___ ¼ Sec. ___ T ___ N/S R ___ E/W
Depth Datum: Below Top of Kelly Bushing, which is ______ ft. (above, below) land surface.
Altitude: MP ______ ft. Land surface 6670 ft.
Determined by ______
Operator(s) Basler / Mercer
Equipment ______ Date Aug. 18, 1970
Equipment No.: ______ Vehicle No. I-94081

HOLE LOGGING DATA

Casing: Diam. ______ in. ______ ft. to ______ ft.
Diam. ______ in. ______ ft. to ______ ft.
Diam. ______ in. ______ ft. to ______ ft.
Bore: Diam. ______ in. ______ ft. to ______ ft.
Diam. ______ in. ______ ft. to ______ ft.
Diam. ______ in. ______ ft. to ______ ft.
Fluid ~~Water~~ Level 31 ft. (~~above~~ below) Kelly Bushing
______, which is ______ ft. (above, below) surface. Shut-in head after ______ (hrs., mins.)
Date ______
Depth drilled (feet): ______
Depth Measured (feet): ______
Interval logged: 6 ft. to 1024 ft.

OPERATION DATA

Run No. 1 of 1 runs. Logging Speed: 40 ft./min.
Vertical Scale 20 ft./in.
Source 3 curries AM-BE Spacers 17 in.
Horz. Scale B T.C. 4 sec.
Sens. Scale 2.0 / 5.0 Base Scale 0.0 / 9.5

FLUID DATA

Type: ______
Density, lbs./gal. ______
Viscosity, sec. ______
Resistivity, ohms: ______
Resistivity, B.H.T., ohms: ______ pH: ______
Circ. Temp.: ______ B.H. Temp.: ______
Remarks: ______