MISCELLANEOUS PAPER S-68-22

A STUDY OF THE CONDITION OF PIEZOMETERS IN THE 1949 INSTALLATION AT REID-BEDFORD, LOUISIANA

by

J. L. McCall

November 1968

Sponsored by

Office, Chief of Engineers
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U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

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13. ABSTRACT

Twelve of the piezometers installed at Reid-Bedford, La., in 1949 were cleaned in 1967 by surging with water and air. On the basis of performance observations made for several days, basic time lag tests were performed on eight selected piezometers. Attempts to retrieve all 12 of the piezometers were only partially successful because of severe corrosion on the standpipes of some. Chemical tests showed that the soil was moderately acidic in the vicinity of the corroded piezometers and moderately basic in the vicinity of the noncorroded ones. The lead cable of the one electrical piezometer was short-circuited. The attempt to retrieve this piezometer failed.

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FOREWORD

This study was conducted for the Office, Chief of Engineers (OCE), by the U. S. Army Engineer Waterways Experiment Station (WES) under Engineering Studies ES 531, "Instrumentation of Earth and Rockfill Dams."

The study was performed by Mr. J. L. McCall of the Engineering Studies Section, Soils Division, WES, under the immediate supervision of Mr. W. C. Sherman, Chief, Engineering Studies Section, and under the general supervision of Messrs. W. J. Turnbull and A. A. Maxwell, Chief and Assistant Chief, Soils Division, and J. R. Compton, Chief, Embankment and Foundation Branch. The field work for this study was performed by personnel of the Inspection and Exploration Section, Soils Division, WES, under the immediate supervision of Mr. A. L. Mathews, Chief, Inspection and Exploration Section. This report was prepared by Mr. McCall. The study was performed and the report written during the period March-December 1967.

COL John R. Oswalt, Jr., CE, and COL Levi A. Brown, CE, were Directors of the WES during the study and the preparation of this report. Mr. J. B. Tiffany was Technical Director.

CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
miles	1.609344	kilometers

SUMMARY

Twelve of the piezometers installed at Reid-Bedford, La., in 1949 were cleaned in 1967 by surging with water and air. On the basis of performance observations made for several days, basic time lag tests were performed on eight selected piezometers. Attempts to retrieve all 12 of the piezometers were only partially successful because of severe corrosion on the standpipes of some. Chemical tests showed that the soil was moderately acidic in the vicinity of the corroded piezometers and moderately basic in the vicinity of the noncorroded ones. The lead cable of the one electrical piezometer was short-circuited. The attempt to retrieve this piezometer failed.

A STUDY OF THE CONDITION OF PIEZOMETERS IN THE 1949 INSTALLATION AT REID-BEDFORD, LOUISIANA

INTRODUCTION

1. In order to obtain information on the methods of installation, the behavior, and the relative merits of various types of commercially available piezometers, an experimental piezometer system was installed at Reid-Bedford, La., in 1967. This system was near an older experimental system, installed for essentially the same purpose by the U. S. Army Engineer Waterways Experiment Station (WES) in early 1949.

2. In view of the lack of data on the durability of different types of piezometers available for study at the Reid-Bedford site, it was decided that an attempt should also be made to reactivate the old piezometers to determine whether they still functioned satisfactorily and to retrieve a number of standpipes, including the tips, to determine their condition. This paper describes the results of these efforts. Information on the experimental system installed in 1967 will be presented in a separate report.

3. The 1949 piezometers were located, inspected, reactivated as required, and sounded before and after cleaning. Observations were then made for comparative purposes, after which the old piezometers were retrieved for inspection.

1949 STUDY

4. Originally the Reid-Bedford site was selected for the installation of piezometers to study a system of measuring devices for pore pressures on levee projects. Site requirements were as follows:

- *a.* A homogeneous stratum of fine-grained soil in which excess pore pressures were known to exist.
- *b.* Equal changes in excess pore pressures over the entire test area.
- *c.* Ready accessibility of site regardless of weather conditions.

5. The piezometers installed in early 1949 were located on the land-side toe of the Mississippi River levee about 4 miles* downstream from the Vicksburg Bridge and near Mound, La. (plate 1). The installation was made in a backswamp deposit, approximately 50 ft thick, that had been formed by the overflow from the river and subsequent deposition of fine-grained soils (CH and CL) over a period of many years. Natural water content and Atterberg limits data for the deposit are shown in plate 2.

6. Seven different types of piezometers were installed in duplicate, except for a single WES hydrostatic pressure cell. The installation was made in the pattern shown in plate 1, with a spacing of 15 ft between piezometers. The center of each piezometer tip was placed at el 51.0.** Details of the installation are shown in plate 3. A wellpoint piezometer, 1A, was installed with the center of the tip at el -12.6 to obtain data on the hydrostatic pressure fluctuation in the sand stratum below the backswamp deposit. The installation was completed on 1 February 1949 except for the drive point piezometers, which were installed on 30 June 1949. Piezometers 1 through 6 were operated as closed systems and piezometers 7 through 15, except the WES hydrostatic pressure cell, were operated as open systems.

7. A program of field observations was initiated as soon as each piezometer installation was completed. The observations continued at regular intervals for 11 months and thereafter at irregular intervals for

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* A table of factors for converting British units of measurement to metric units is presented on page vii.

** All elevations (el) cited herein are in feet referred to mean sea level.

several months (plates 4 and 5). During the period of regular observations, special observations were made to determine time lag characteristics and their variation with time. Also studied were the effects of temperature changes and the interaction of closely spaced piezometers when piezometric levels were raised or lowered in one or more piezometers in the group.

8. Results of the study were submitted to Office, Chief of Engineers (OCE) in a series of progress or letter reports and a draft copy of the final report as follows:

a. Letter dated 5 May 1949, subject, "Progress Report–Investigation of Pore Pressure Measuring Devices."

b. Letter dated 23 August 1949, subject, "Additional Data on Performance of Pore Pressure Measuring Devices."

c. Letter dated 22 August 1950, subject, "Report on Investigation of Pore Pressure Measuring Devices," which transmitted a draft copy of the unpublished report on the study.

1967 STUDY

Reactivation and Tests

9. Standpipes or electrical leads were found in the field for all 1949 piezometers shown in plate 3 except 9, 11, and 12. The tops of all located standpipes, including the protective pipes encasing the Saran tubing of piezometers 7 and 8, had been bent. This made it necessary to cut off the top portion of each standpipe before sounding to determine the amount of accumulated sediment. After sounding, the piezometers were flushed by lowering a small-diameter jet pipe into the standpipe and alternately washing with water and surging with air. Then after cleaning, the piezometers were again sounded to determine the effectiveness of the cleaning; rising and falling head tests were then performed. Sounded elevations for each piezometer before and after cleaning are shown in table 1 along with basic time lags computed from the results of the rising and falling head tests. Short circuits occurred in the electrical leads of the WES hydrostatic pressure cell and all attempts to reactivate this cell failed.

Observations

10. A number of daily observations were made after the piezometric level had equalized. Prior to the start of observations, the Mississippi River had been falling for approximately two weeks from a high stage at el 76; it continued to fall until near the end of the observation period. Results of the observations are presented in table 2.

11. For comparative purposes, data from three new piezometers installed in the sand stratum underlying the backswamp deposit are also presented in table 2. These three piezometers had wellpoint tips and were operated as open-system piezometers. Daily observations of these piezometers were started the day following their installation in each case.

Retrieval of Old Piezometers

12. *Methods.* Attempts to retrieve the old piezometers met with varied success. Two methods of recovery were tried. The first method consisted of drilling a hole with a rotating casing fitted with a cutting shoe. The casing was centered over the piezometer standpipe. The teeth of the cutting shoe were flared outward to form an annular space between the casing and the walls of the hole through which soil cuttings were brought to the surface by water forced through the casing. When the casing had been advanced to the installation depth of the piezometer tip, the rotating of the casing and the pumping of water through the casing were discontinued and the casing was pushed approximately 2 ft deeper to form a plug in the bottom. The

casing and contents were then removed from the hole. The second method consisted of simply attaching a cable to the piezometer standpipe and pulling.

13. *Results.* The results of the retrieval attempts and the condition of the piezometers are shown in table 3. Photographs 1-8 show the condition of the recovered piezometer tips and standpipes; the results are discussed in detail in the following paragraphs.

14. The total installed lengths of the standpipes of piezometers 1, 2, 6, 10, 14, and 15 were recovered. The standpipes of piezometers 6 and 10 were badly corroded, while the standpipes of piezometers 1, 2, 14, and 15 showed little or no evidence of corrosion. The lower ends of standpipes of piezometers 14 and 15, which had been in contact with the drive point, showed some brooming as a result of driving during the installation. The standpipes of piezometers 3, 4, 5, and 1A were so badly corroded that only portions of the standpipes were recovered. The total lengths of the protective iron pipes encasing the Saran tubing standpipes for Casagrande piezometers 7 and 8 were recovered and showed evidence of considerable corrosion. The Saran tubing standpipes for the Casagrande piezometers showed no signs of deterioration from age and appeared to be intact; however, mechanical damage occurred during the recovery attempt. The lower 5 ft of the standpipes for piezometers 1 and 2 were seen to be bent in a spiral when recovered; it is presumed that the standpipes were bent during the recovery operation.

15. The tips of piezometers 1, 2, 6, and 10 were the only ones recovered; the driving tips of piezometers 14 and 15 were not recovered. The tips of piezometers 1, 2, and 10 were clogged. The WES hydrostatic pressure cell (diaphragm-strain gage type) was not recovered except for fragments of electrical cable broken off during the recovery attempt.

Corrosion Study

16. In view of the extensive corrosion found on some standpipes and the absence of corrosion on others, soil samples were obtained to determine the pH values and the conductivity of the soil in the vicinity of the corroded and noncorroded standpipes. A sample of the encrusted material on the standpipe of piezometer 4 was also taken. Plate 1 shows that the standpipes for piezometers 1, 2, 14, and 15, which showed no corrosion, were grouped at one end of the installation. All other standpipes showed evidence of corrosion that varied from moderate to nearly complete destruction. Results of tests performed on the soil samples are tabulated below:

Sample No.	Conductivity mhos	pH	Remarks
1	544.5	7.5	Standpipes not corroded
2	544.4	6.7	Standpipes corroded
3	585.0	6.7	Encrusted material on standpipe

DISCUSSION OF RESULTS

1967 Piezometer Observations

17. The observations given in table 2 show that piezometers 3 through 8 gave a maximum spread of 1.8 ft between water surface elevations on any one day during the observation period. If piezometers 10 and 15 are included in the group, the maximum spread for any one day during the observation period was less than 3 ft. The latter spread compares favorably with the average spread of 2.5 ft obtained for open-system piezometers observed during falling stages of the Mississippi River during the first year after installation. The elevation of the water surface observed in the 1967 observation period also compares favorably with that

observed in the 1949 study. The observations made during the 1949 study are shown graphically in plates 4 and 5. The observations made with the deep piezometer, 1A, were within the range of observations for the three new deep piezometers installed during the 1967 observation period. On the basis of these comparisons, it is concluded that piezometers 3 through 8, 10, and 15 were still capable of furnishing as reliable data as had been obtained during the first year after installation.

18. Basic time lags for piezometers 8 and 10 were determined by Hvorslev using equalization diagrams constructed from rising and falling head test data obtained in the 1949 study and were reported in WES Bulletin No. 36, "Time Lag and Soil Permeability," April 1951. Rising and falling head tests were performed on both piezometers in 1967. The basic time lag for piezometer 8 in 1967 was 16 hours compared to 8 hours determined in 1949. Similarly, the basic time lag for piezometer 10 was approximately 36 hours compared to 4.2 hours determined in 1949; however, the latter value may not be too reliable as the testing period was too short. The fact that the basic time lags for piezometers 8 and 10 have increased significantly over the years indicates that some clogging of the filters may have occurred. Basic time lags determined for other piezometers from 1967 rising and falling head tests were also longer than were expected. However, no data on basic time lags soon after installation of the other piezometers are available for comparison because the evaluation of the results of the 1949 study was suspended because of a lack of funds.

19. Unfortunately, in both the 1949 and 1967 studies, most of the rising and falling head tests were not of sufficient continuous duration to accurately define the equalization diagram. The difficulty in performing the tests is attributed to the presence of gas in the backswamp deposit at the site. When hydrostatic conditions in the soil suddenly changed, as is the case in rising or falling head tests, the accumulated gas in the soil would expand or contract in response to pressure changes. This action is reflected by an initial curvature in the equalization diagram. A semilog plot of the head ratio, H/H_0, versus time should be made in the field when a rising or falling head test is performed to ensure that the test has been continued long enough to determine the slope of the straight-line portion of the equalization diagram. In many cases the time required to perform the test properly may be longer than a normal 8-hr workday.

Condition of Piezometers

20. Drive point piezometers 1 and 2 were found to be completely clogged. In the 1949 study these two piezometers were operated as closed systems and consistently showed pressures indicating water elevations at or above the natural ground surface (approximately el 82). At the time, the high readings were attributed to an accumulation of gas in the piezometers. It is probable that these piezometers became clogged during driving and have never functioned properly. The other two drive point piezometers, 14 and 15, were found to be partially clogged, although piezometer 15 gave readings only slightly higher than the piezometers considered to be still giving satisfactory data. It was noted in the 1949 study that piezometers 14 and 15 were very slow in reacting to changes in hydrostatic pressure as compared to the reactions of the other open-system piezometers. It is probable that these piezometers have also been clogged to some extent ever since installation.

21. Tests of the electrical resistance of the leads of the WES hydrostatic pressure cell indicated that a short circuit had occurred. The condition of the cell could not be determined because retrieval efforts failed.

Corrosion Study

22. The results of the chemical tests show that the soil surrounding the corroded standpipes was moderately acidic (pH = 6.7) while that surrounding the noncorroded standpipes was moderately basic (pH = 7.5). The conductivity of the acidic and basic soils was identical and thus would not account for the difference in corrosive action. The slightly higher conductivity of the encrusted material recovered from the standpipe of

piezometer 4 can be attributed to contamination of the soil by products of the corrosion process. The standpipes for all piezometers were made of galvanized iron pipe. Because zinc is anodic with respect to iron, the corrosive attack would first deplete all of the zinc, at least in the zone of attack, before acting on the iron. This was the case with those standpipes found corroded. The zinc coating on noncorroded standpipes was intact. The standpipes for wellpoint piezometers 10 and 15, which had brass parts in the points, were corroded, but not as badly as the four standpipes for the Cherry Creek piezometers which had nonmetallic hemispherical filter tips. In view of the foregoing, it is believed that the basic cause of the extensive corrosion was the acidic condition of the soil surrounding the standpipes.

CONCLUSIONS

23. Based on the findings of this study, it is believed that the following conclusions are warranted:

a. Drive point piezometers are vulnerable to damage and clogging during installation.

b. An increase in basic time lag for open- and closed-system hydraulic piezometers can be expected over an extended period of time due to clogging of the sand filters and porous pickups. In the case of slowly fluctuating subsurface hydrostatic conditions, an increased basic time lag should not seriously impair the usefulness of the piezometer.

c. The pH value of the soil should be determined before selecting the type of piezometer tip and standpipe to be used in an installation. When acidic soils are present, consideration should be given to the use of nonmetallic materials for both the tip and the standpipe.

d. The Cherry Creek, Casagrande, and wellpoint piezometers had a relatively long useful life even though severe corrosion of the standpipes had occurred. No maintenance had been performed on any piezometers for a period of 17 years prior to the study.

e. No conclusions can be drawn with respect to the useful life of the WES hydrostatic pressure cell (electrical). The cover protecting the end of the cable had been destroyed allowing moisture to enter. Normal maintenance might have prevented this condition.

Table 1

Physical Data on 1949 Piezometer Installation

Piez No.	Type	Standpipe Cutoff El, ft	Ground Surface El, ft	Center of Tip El ft	Sounded El, ft: Before Cleaning	Sounded El, ft: After Cleaning: First	Sounded El, ft: After Cleaning: Second	Basic Time Lag T , hr: Falling Head	Basic Time Lag T , hr: Rising Head	Remarks
1	USBR* drive point	82.6	82.4	51.0	82.0	51.3	50.9	Clogged	--	
2	USBR drive point	83.5	81.5	51.0	82.9	53.5	51.9	Clogged	--	
3	Cherry Creek	82.4	82.1	51.0	52.2	51.0	50.7	27.0	32.0	
4	Cherry Creek	80.6	81.5	51.0	51.6	51.8	51.2	15.5	18.5	
5	Cherry Creek	82.4	82.1	51.0	51.5	51.4	50.7	24.5	Inadequate data	
6	Cherry Creek	80.2	81.5	51.0	50.2	49.6	50.9	34.5	39.0	
7	Casagrande	81.3	81.5	51.0	51.3	51.3	--	51.0	14.5	
8	Casagrande	81.5	81.5	51.0	51.5	51.5	--	No test	16.0	
9	Wellpoint							--	--	Not located
10	Wellpoint	79.9	81.8	51.0	48.4	49.1	--	35.7	39.0	
11	Open-end pipe						--	--	--	Not located
12	Open-end pipe						--	--	--	Not located
13	WES hydrostatic pressure cell						--	--	--	Electrical
14	Drive point	82.7	81.3	51.0	65.9	52.3	51.4	Clogged	--	
15	Drive point	81.8	82.6	51.0	56.3	--	--	Clogged	--	Not cleaned
1A	Wellpoint	80.2	81.4	-12.6	79.3	10.6	9.8	Inadequate data	Inadequate data	

* U. S. Bureau of Reclamation.

Table 2

1967 Piezometer Observations

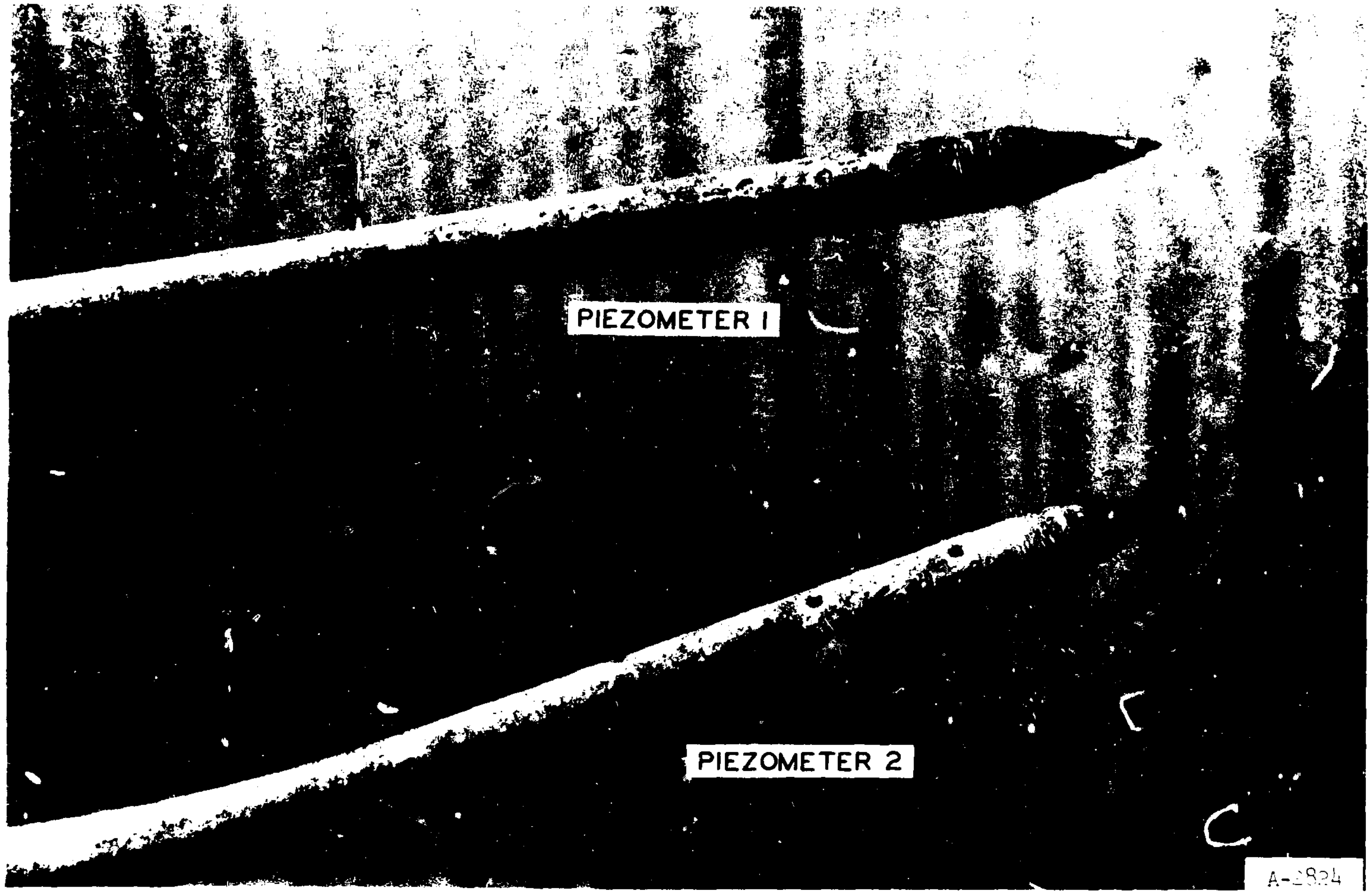
Piez No.	Type	Apr 17	Apr 18	Apr 19	Apr 20	Apr 21	Apr 24	Apr 25	Apr 26	Apr 27
		Elevation of Water Surface, ft msl								
					Piezometers in Backswamp Deposits					
1	USBR drive point	51.30	52.70	51.25	51.24	51.29	Retrieved			
2	USBR drive point	52.20	52.17	51.92	51.94	51.99	Retrieved			
3	Cherry Creek	77.66	77.70	77.60	77.55	77.60	77.55	77.45	77.51	Retrieved
4	Cherry Creek	77.28	76.95	76.57	76.52	76.52	76.41	75.67	76.40	76.30
5	Cherry Creek	77.82	77.95	77.80	77.76	77.66	77.52	77.43	77.53	77.33
6	Cherry Creek	77.57	77.47	77.53	77.38	77.42	77.11	77.10	77.03	76.97
7	Casagrande	77.29	77.16	77.11	77.15	77.09	76.78	76.87	76.86	76.71
8	Casagrande	76.72	76.91	76.95	76.90	76.86	76.78	76.71	76.71	Retrieved
10	Wellpoint	75.50	75.45	75.31	75.23	75.30	75.19	75.13	75.06	75.09
14	Drive point	71.13	71.22	71.20	71.25	71.29	71.41	71.64	Retrieved	
15	Drive point	78.05	78.11	78.04	77.98	77.98	78.03	78.02	77.99	78.03
					Piezometers in Deep Sands					
1A	Wellpoint	67.26	64.10	67.00	67.94	66.89	67.88	67.88	66.92	66.80
1	Wellpoint	Installed	67.97	67.09	67.07	67.00	66.94	66.91	66.94	67.01
2	Wellpoint		Installed	66.91	66.95	66.89	66.83	66.88	66.92	66.87
4	Wellpoint				Installed	66.93	66.80	66.83	66.97	66.77

Table 3

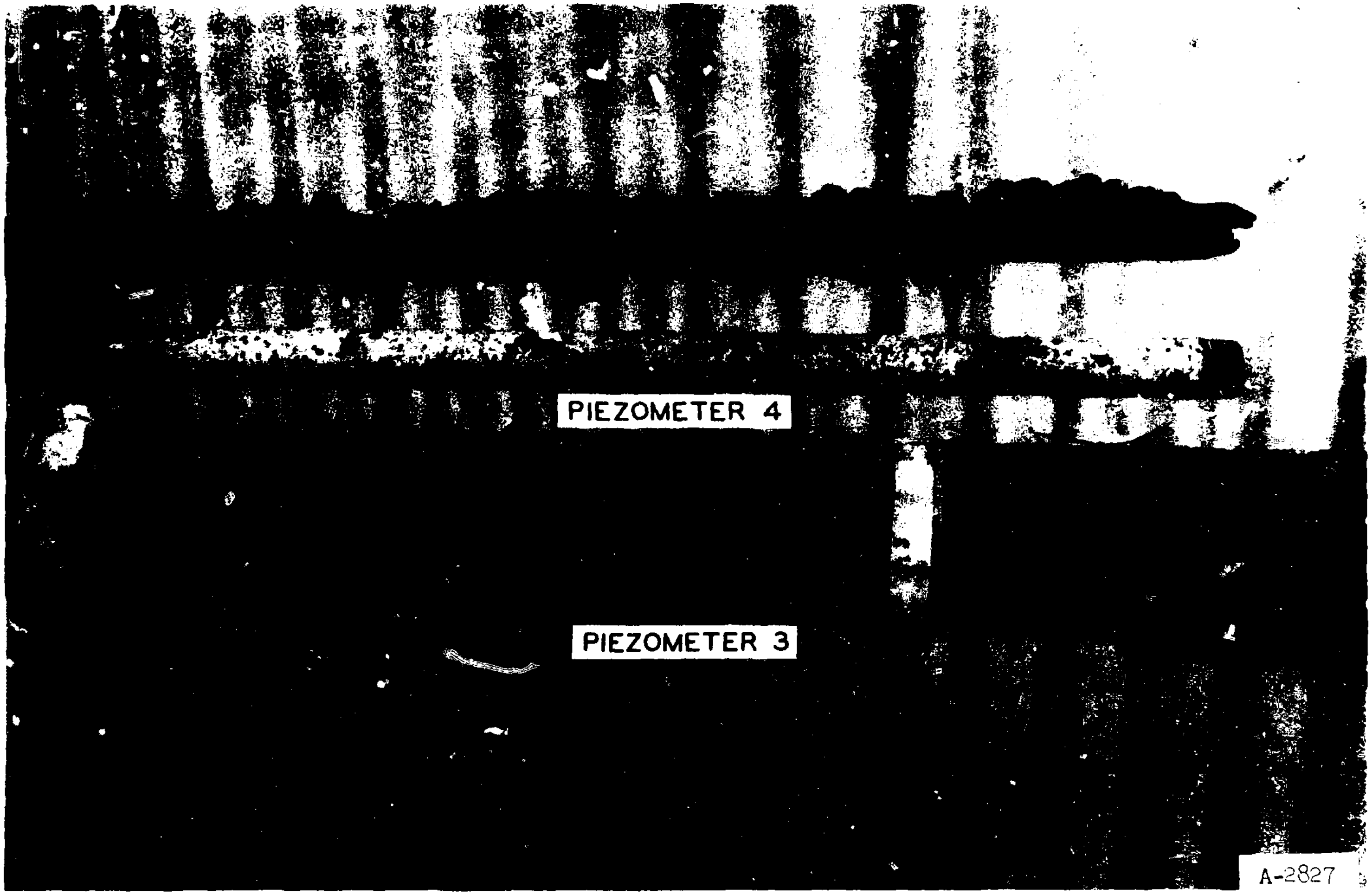
Results of Piezometer Retrieval

Piez No.	Type	Method of Recovery	Recovered Tip	Recovered Standpipe* ft	Condition	Ref Photo No.
1	USBR drive point	Drilled	Yes	31.4 (total)	Tip clogged; standpipe not corroded	1
2	USBR drive point	Drilled	Yes	32.3 (total)	Tip clogged; standpipe not corroded	1
3	Cherry Creek	Pulled	No	12	Standpipe badly corroded	2
4	Cherry Creek	Pulled	No	23.6	Standpipe badly corroded	2
5	Cherry Creek	Pulled	No	8	Standpipe badly corroded	3
6	Cherry Creek	Pulled	Yes	29.2 (total)	Standpipe badly corroded	3 & 4
7	Casagrande	Drilled	No	--	Saran tubing intact; protective iron pipe corroded	5
8	Casagrande	Drilled	No	--	Saran tubing intact; protective iron pipe corroded	5
9	Wellpoint				Not located	
10	Wellpoint	Pulled	Yes	27.4 (total)	Point clogged; standpipe badly corroded	6
11	Open-end pipe				Not located	
12	Open-end pipe				Not located	
13	WES hydrostatic pressure cell	Drilled	No	NA		
14	Drive point	Drilled	No	31.2 (total)	Standpipe not corroded; partially clogged near lower end	7
15	Drive point	Drilled	No	30.3 (total)	Standpipe not corroded; partially clogged near lower end	7
1A	Wellpoint	Drilled	No	26	Standpipe badly corroded	8

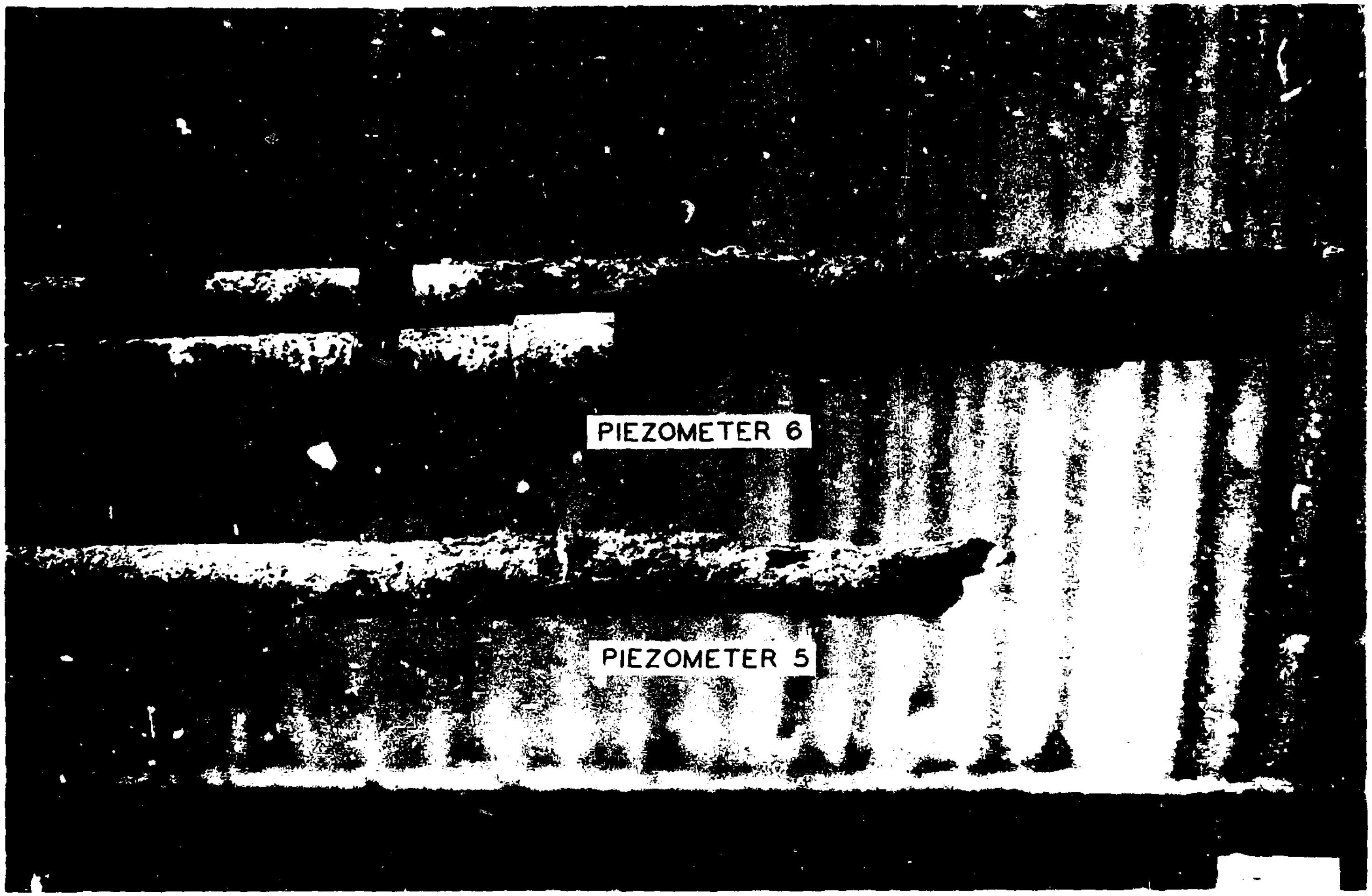
* Does not include portion of standpipe cut off at top during reactivation.



Photograph 1. U. S. Bureau of Reclamation drive point piezometers 1 and 2

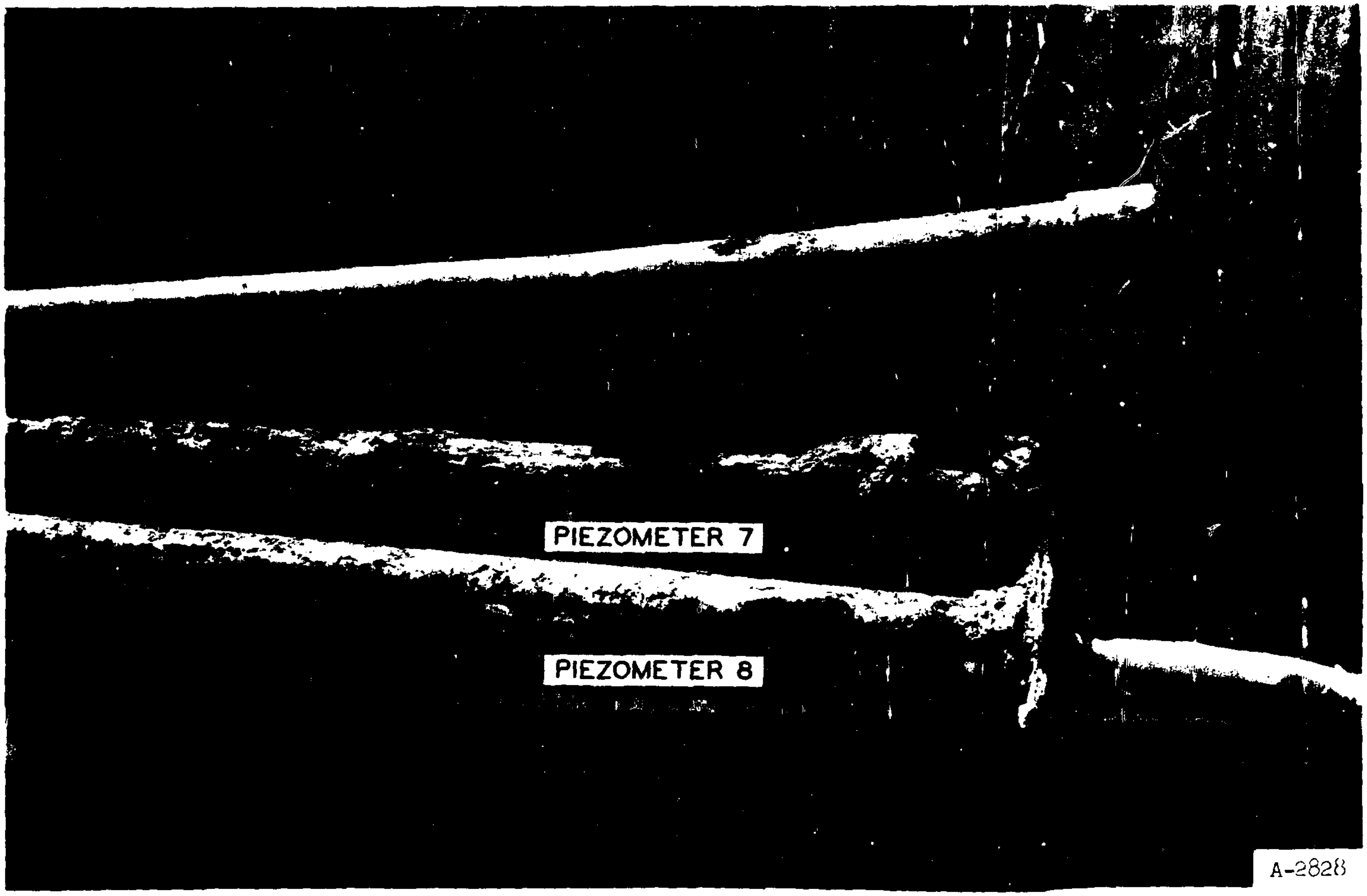


Photograph 2. Standpipes from Cherry Creek piezometers 3 and 4

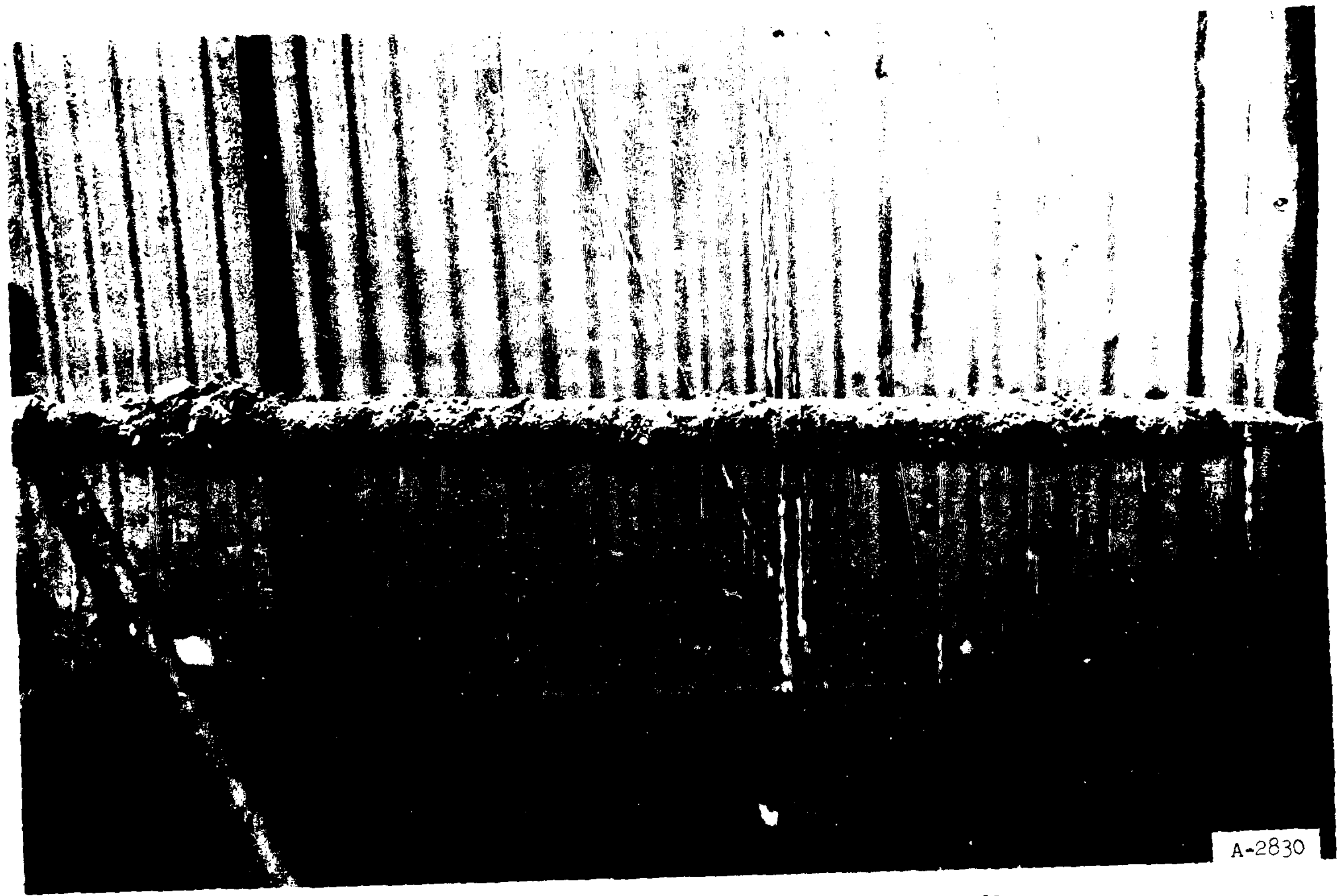


Photograph 3. Standpipes from Cherry Creek piezometers 5 and 6

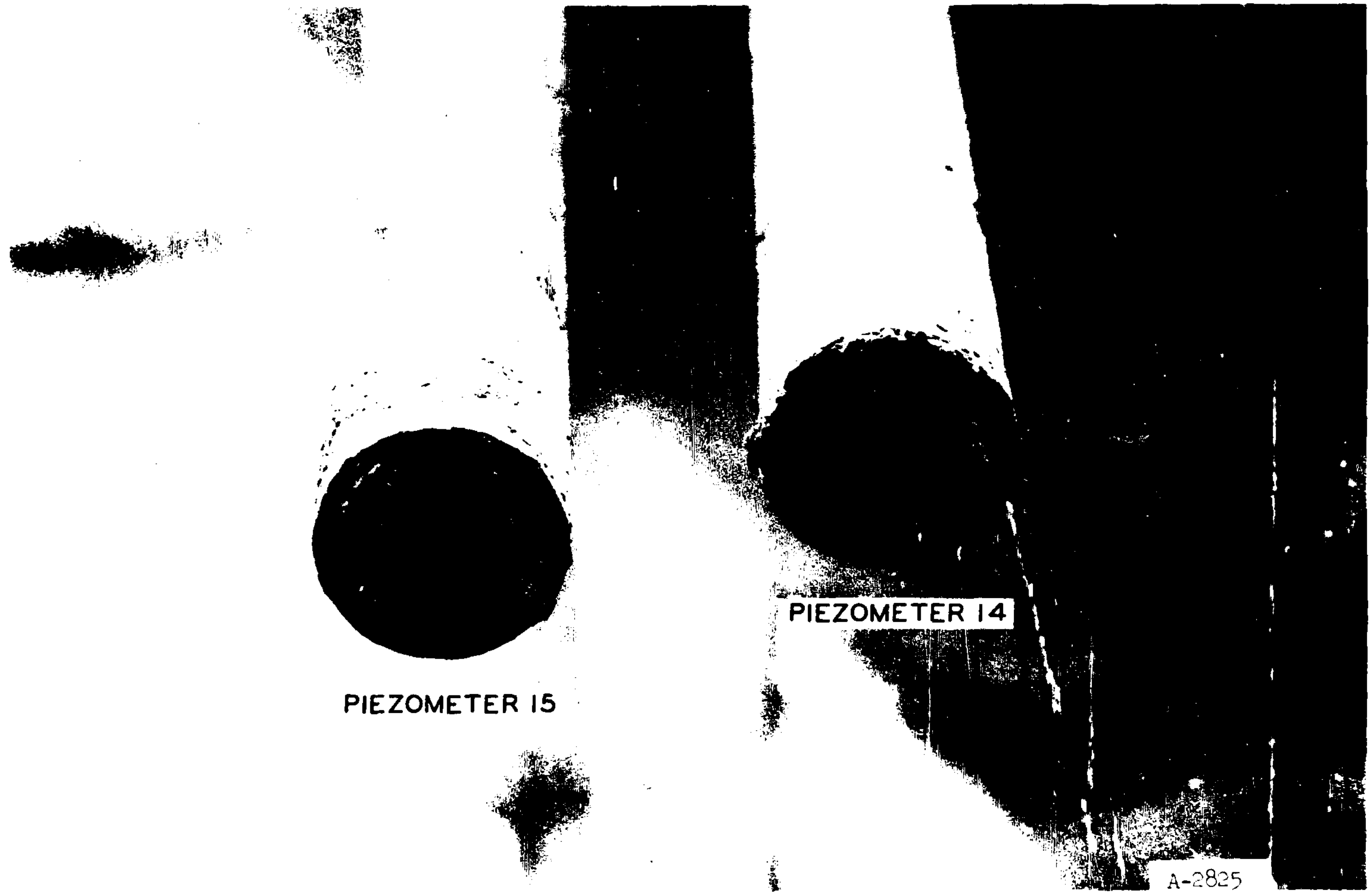
Photograph 4. Hemispherical tip of Cherry Creek piezometer 6



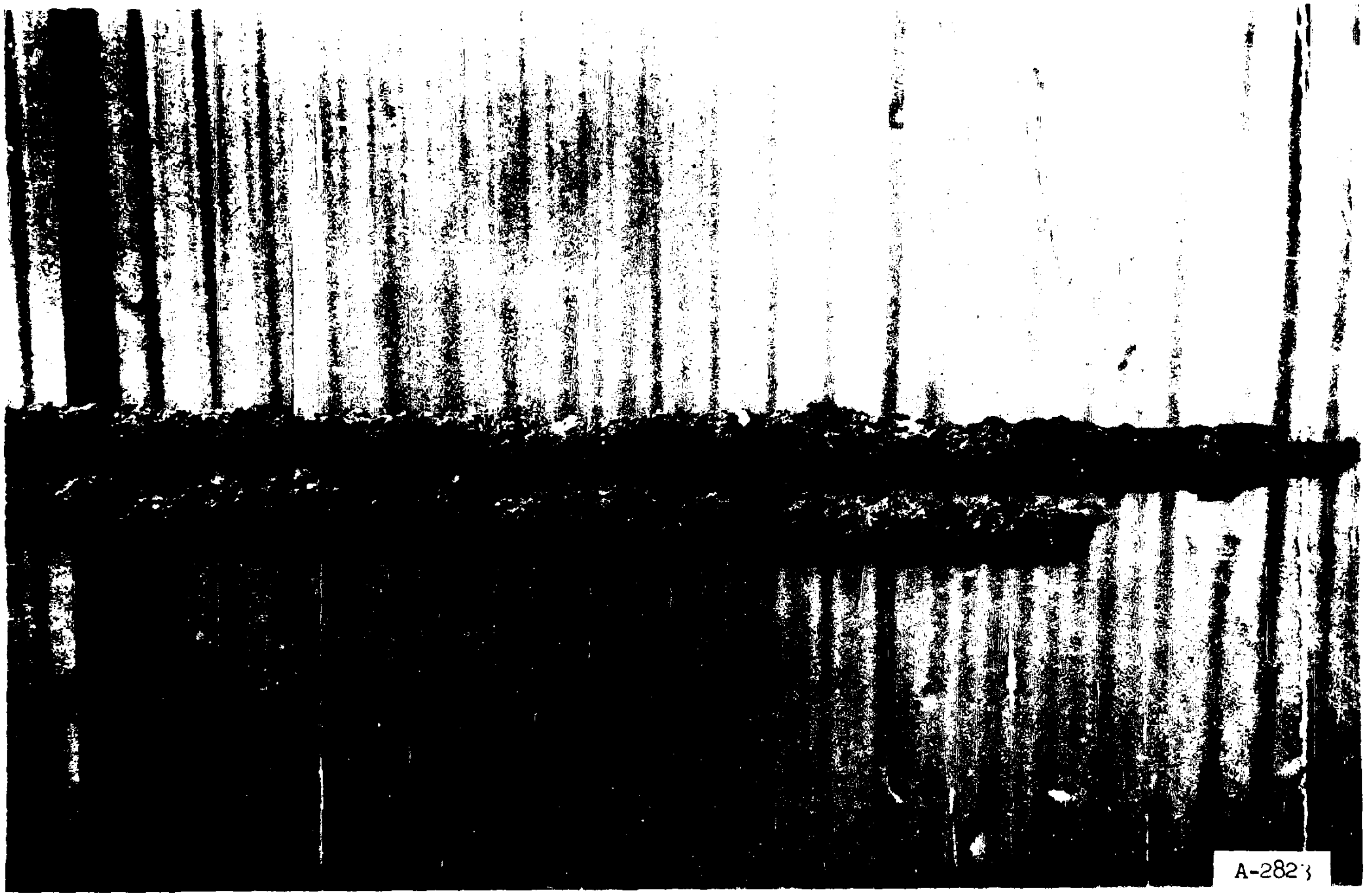
Photograph 5. Standpipes from Casagrande piezometers 7 and 8 with Saran tubing attached to 8



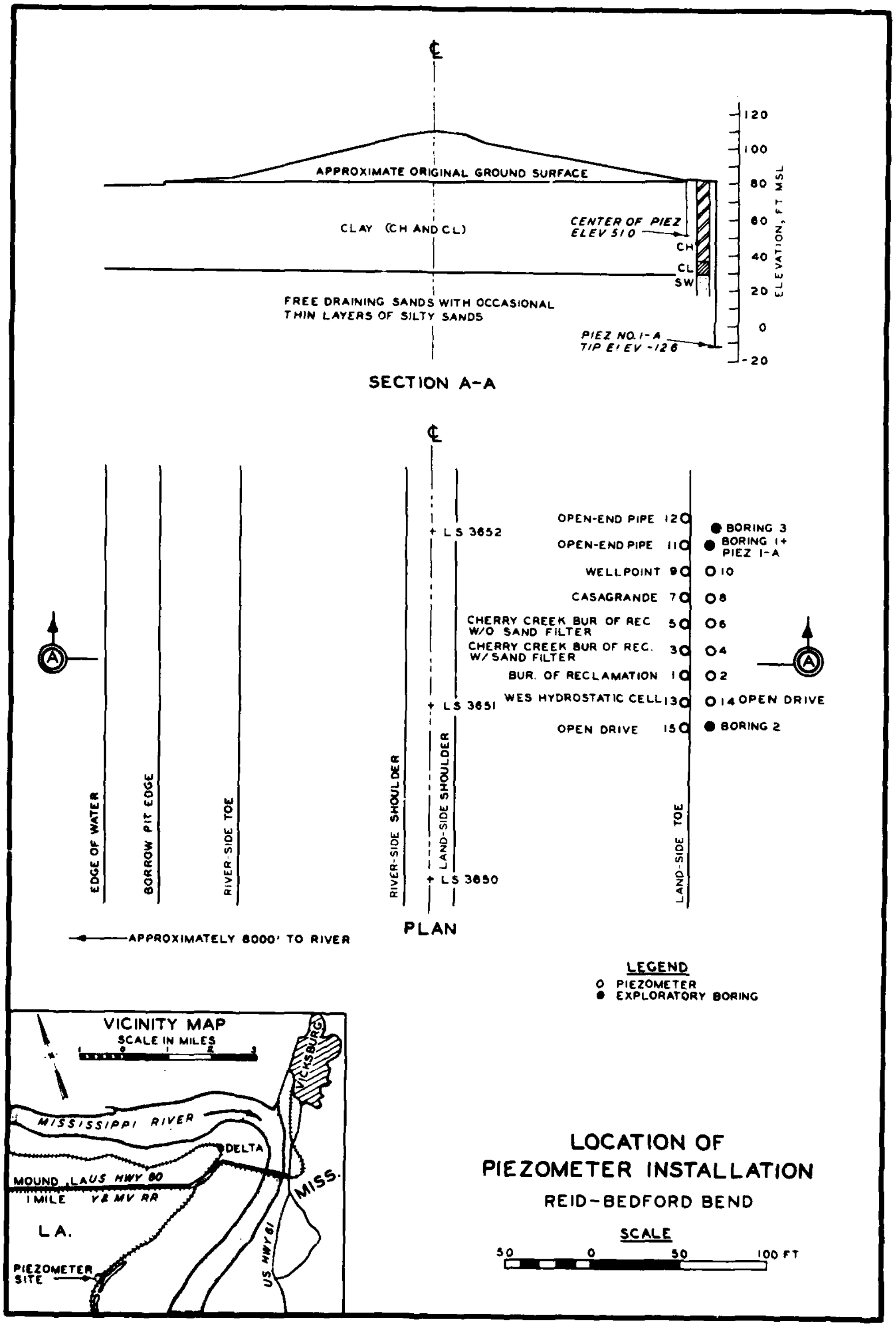
Photograph 6. Encrustation and clogging of screen of wellpoint piezometer 10



Photograph 7. Drive point piezometers 14 and 15



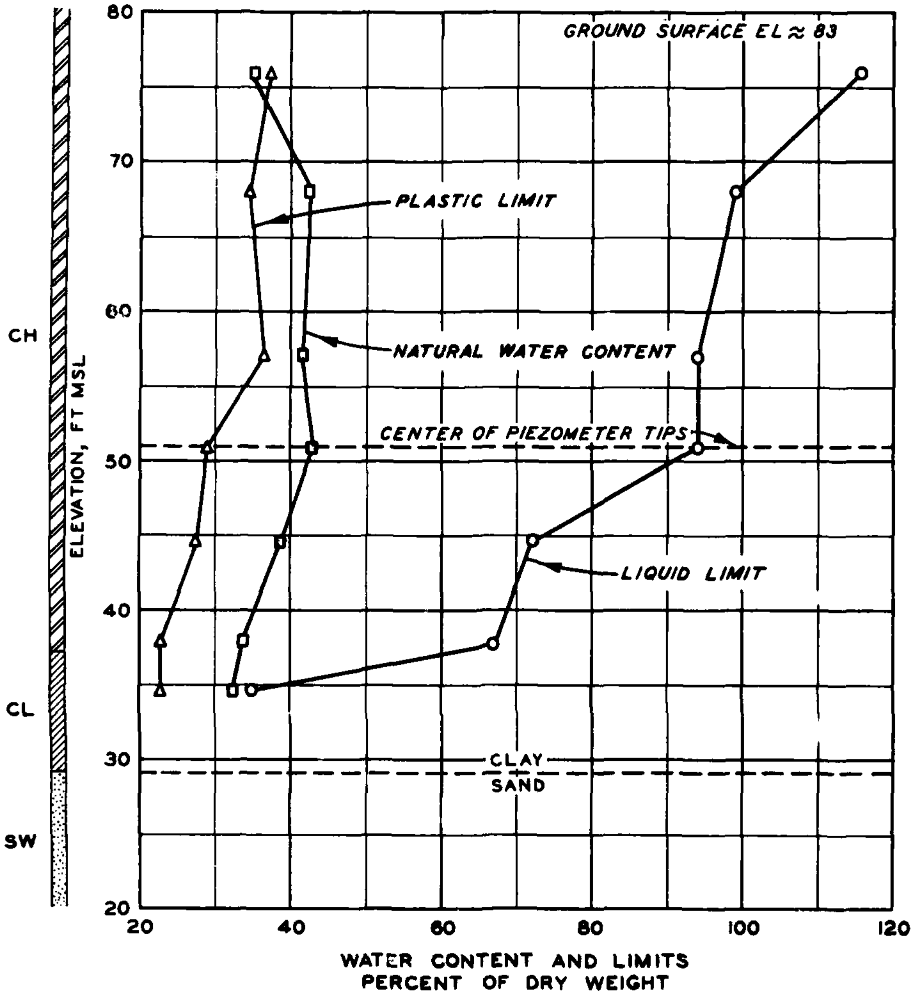
Photograph 8. Encrustation and corrosion of wellpoint piezometer 1A



LOCATION OF PIEZOMETER INSTALLATION

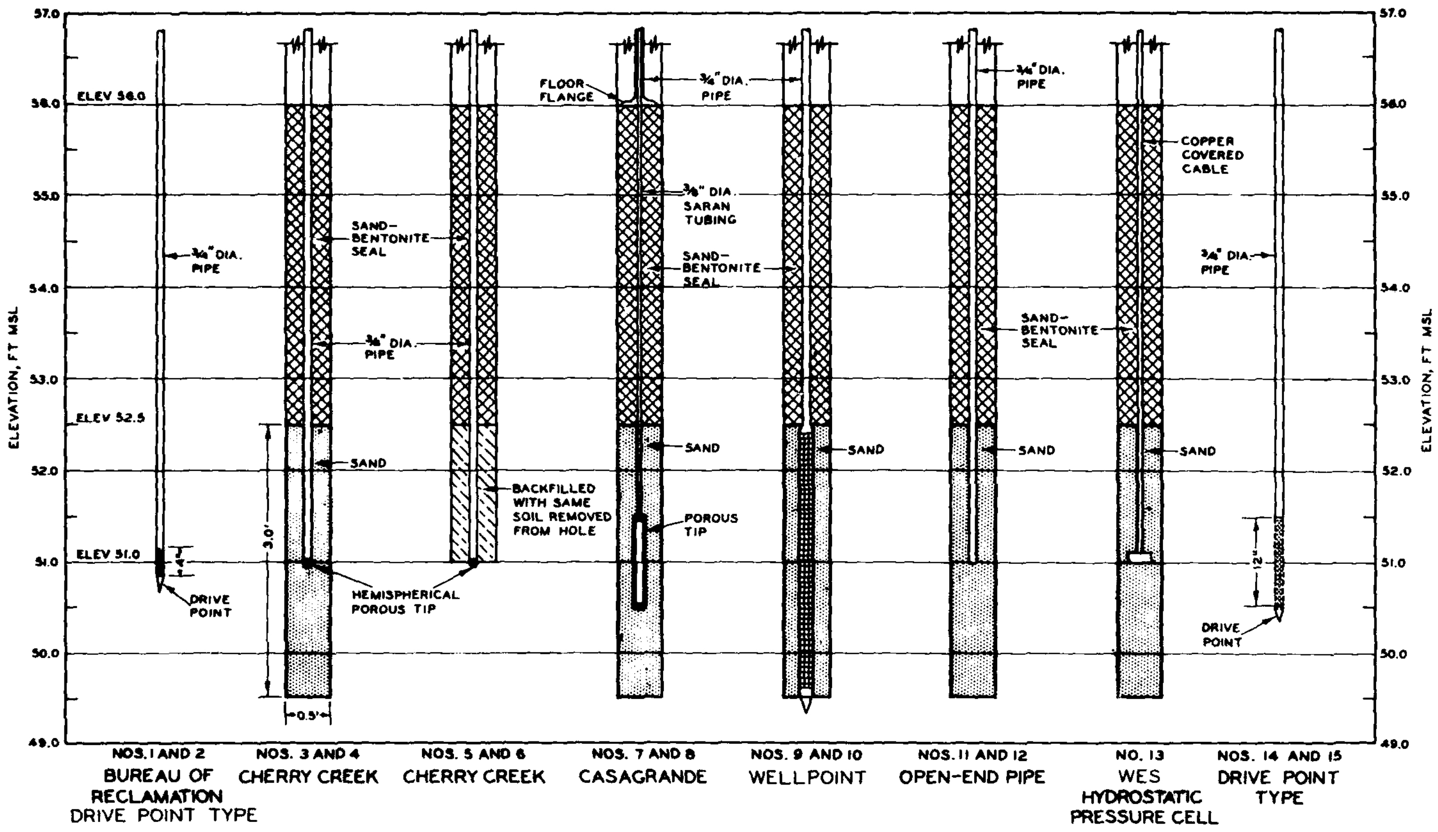
REID-BEDFORD BEND

PLATE 1



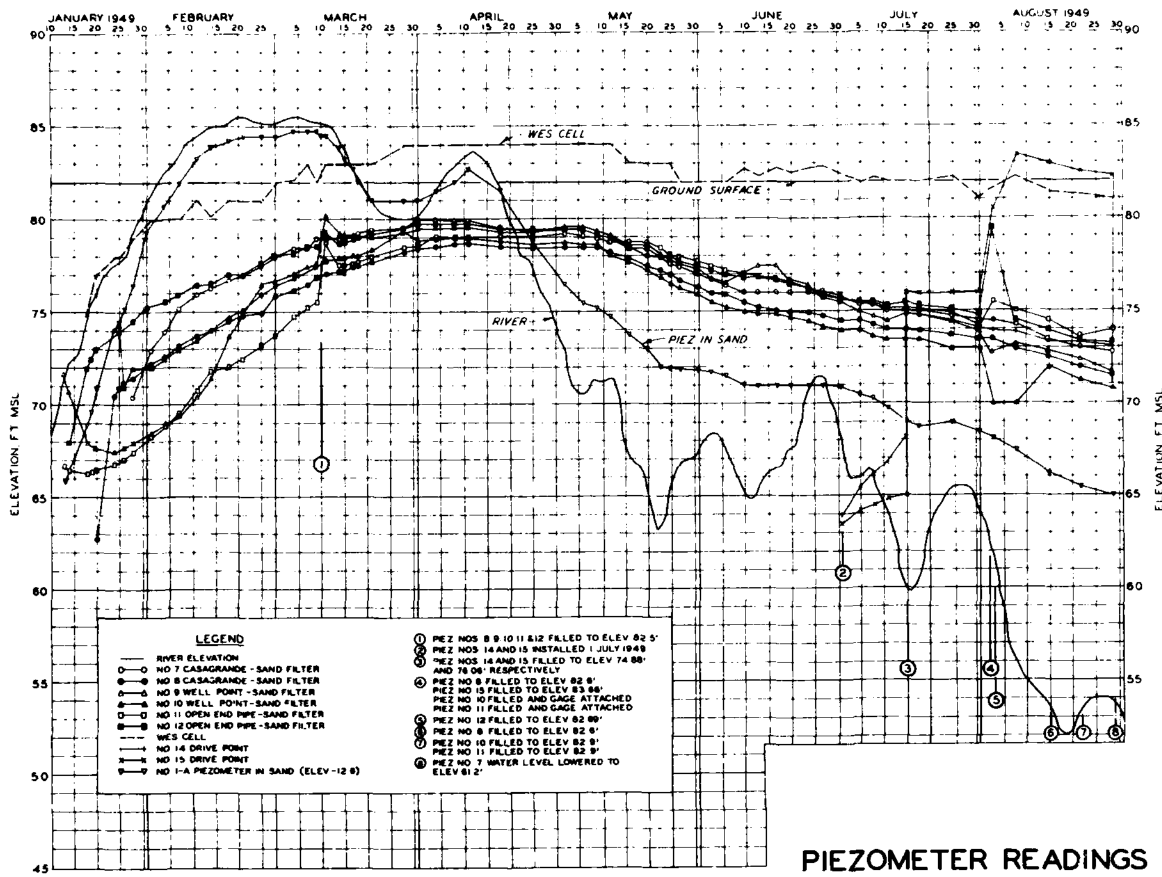
INDEX PROPERTIES OF CLAY STRATUM

PLATE 2



PIEZOMETER TIP
INSTALLATION DETAILS

PLATE 3



PIEZOMETER READINGS VS TIME
OPEN-SYSTEM DEVICES
10 JAN 1949 – 31 AUG 1949

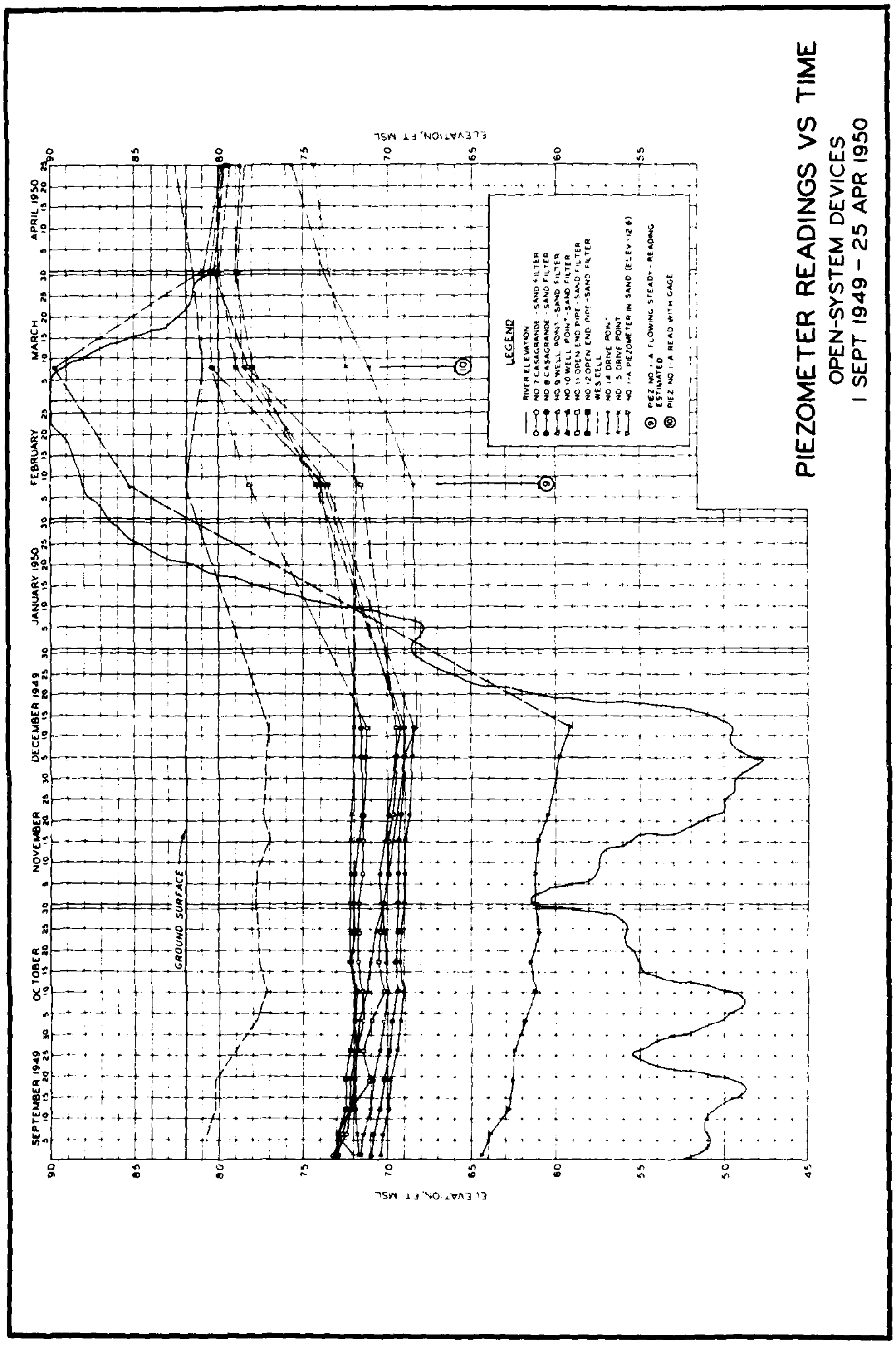

PIEZOMETER READINGS VS TIME
OPEN-SYSTEM DEVICES
1 SEPT 1949 - 25 APR 1950
LEGEND
GROUND SURFACE
ELEVATION, FT MSL

PLATE 5