UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

SEEPAGE MEASUREMENTS--
LOWER-COST CANAL LINING PROGRAM--
TUCUMCARI PROJECT, NEW MEXICO

Hydraulic Laboratory Report No. Hyd. 303

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

February 16, 1951

UNITED STATES
DEPARTMENT OF THE INTERIOR
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Branch of Design and Construction
Research and Geology Division
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Laboratory Report No. Hyd-303
Hydraulic Laboratory
Compiled by: B. R. Blackwell
Reviewed by: D. M. Lancaster
C. W. Thomas

Subject: Seepage measurements--Lower-cost Canal Lining Program--
Tucumcari Project, New Mexico

PURPOSE

The purpose of this report is to present the results of the seepage studies, conducted as part of the Lower-cost Canal Lining Program, on the Tucumcari Project, New Mexico at the close of the 1949 irrigation season.

PERSONNEL

The seepage studies described in this report were conducted under the general supervision of R. J. Lyman, Project Engineer. The seepage measurements were made under the immediate supervision of E. E. Cerney, Project Watermaster, who was assisted by R. K. DeWees, Project Hydrographer. Technical assistance was supplied from the Office of the Chief Engineer, Branch of Design and Construction, by Engineers C. W. Thomas, D. M. Lancaster, and B. R. Blackwell.

SYNOPSIS

Seepage rates by ponding were obtained in three reaches of the Conchas Canal. Seepage meter readings were obtained simultaneously with the ponding tests in two of the three reaches. The ponding results are summarized in the following table. Throughout this report the seepage rates are expressed in cubic feet per square foot of wetted area per 24 hours.

Pond number	Type of lining	Depth (in feet)	Seepage rate
2	Unlined	7.0	0.40
1	Clay lined--Specifications No. 1076	7.0	0.13
3	Clay lined on left side and bottom only by Project forces	7.0	0.07

The summary of the averages of the seepage meter settings and a comparison of the results obtained by using the seepage meter and by ponding are shown below.

Pond number	Depth (in feet)	RATE BY SEEPAGE METER				Rate by: ponding	Difference	
		L slope	Centerline	R slope	Avg		Rate	Percent
2	2.3	0.09	0.11	0.10	0.10	0.07	+0.03	+43
3	4.0	0.04	0.06	0.05	0.05	0.03	+0.02	+67

CONCLUSIONS

As a result of the field study, it was concluded that·

1. The quantity of water lost by seepage in the tested reaches containing earth lining was insignificant

2. The loss from the unlined section, although greater than from the earth lined reaches, was less than would normally be expected and hence the installation of a lining would be unwarranted from the standpoint of water conservation

3. The silt blanket deposited in the canal by normal operation was effective in reducing the seepage loss as evidenced by the lowering of the water table adjacent to the canal during the past years

4. The formation of a silt blanket through normal operation will undoubtedly decrease the excessive seepage from the new portion of the canal at the lower end

5. As in other instances where the seepage meter has been utilized, the results were erratic, however, in this particular case, the quantities involved were small

INTRODUCTION

The Tucumcari Project is located in eastern New Mexico adjacent to the City of Tucumcari. The diversion works for the project are located at Conchas Dam on the South Canadian River. About 40 miles of canal are required to transport the water from the diversion works to the project lands under irrigation. These features together with the locations of the test reaches of the canal are shown in Figure 1.

The three reaches of the Conchas Canal selected for seepage measurement studies totaled 9,800 feet in length. Seepage loss measurements were made simultaneously by both the ponding method and by seepage meter measurements thereby obtaining additional data for evaluating the merits of the meter as an instrument for the measurement of seepage losses. The entire program of seepage loss measurements described in this report was conducted as part of the Lower-cost Canal Lining Program in accordance with the recommendations contained in the field trip report from Mr. C. W. Thomas, dated February 27, 1950, subject "Seepage measurement program and inspection of Conchas Canal--Tucumcari Project--Lower-cost Canal Lining Program."

PONDING TESTS

Testing by ponding is the most accurate technique known for the determination of seepage losses from irrigation canals and laterals. Three ponds were formed in the Conchas Canal to obtain data on seepage losses through different types of material. Pond 1 (Stations 2043+60 to 2072+60) was clay lined under Specifications No. 1076 as a part of the original construction program. A report of laboratory tests on samples of this clay lining material is included as Appendix A. Pond 2 (Stations 2518+40 to 2562+00) is an unlined earth section, while Pond 3 (Stations 2562+40 to 2587+00) was clay lined on the left (downhill) bank and bottom by project forces. The right bank was not lined. The Conchas Canal, including the sections ponded, was covered with a silt blanket varying in thickness from 1 to 6 inches. This silt blanket was deposited during the operation of the canal over the past four irrigation seasons. During this time the maximum discharge in the canal was 400 second-feet compared to a design discharge of 700 second-feet. Photographs of the silt blanket are shown as Figures 2 and 3.

Cross-section Survey

In the ponded reaches, the canal was designed with a bottom width of 24 feet, with 1-1/2 to 1 side slopes, a bottom slope of 0.0001, and a depth of 8.65 feet for a discharge of 700 second-feet. A survey of the canal cross section in the reaches ponded was made just prior to the tests to determine the present physical dimensions of the ponds as required in computing the seepage losses. Cross sections were taken at 100-foot stations along the tangents and at 50-foot stations on the curves. Horizontal distances were measured to the nearest 0.1 foot while the elevations were read to the nearest 0.05 foot.

Construction of the Dikes

The construction of four dikes was necessary for the forming of the three seepage ponds. The Jack County Check and Wasteway structure was used as the downstream barrier of Pond 3, eliminating a dike at this point. The first step in the construction of a dike, following the emptying of the canal, was to remove the silt from the sides and bottom of the canal for the full width of the proposed dike. Next, a cut-off trench was dug 1-1/2 to 2 feet deep along the centerline of the proposed dike, using a 1/2 yard dragline bucket. Material for the dike was then dozed into place (some material was placed with the dragline), spread to the proper width in thin layers, wetted with water pumped from pools in the canal, and compacted with the bulldozer. Figure 4 shows this operation on the dike at the upstream extremity of Pond 2, immediately prior to its completion. After the dike was raised to the proper height and width, a select clay material was placed on the faces adjacent to the ponds. Compaction was obtained, after sprinkling, with the dragline bucket. Figure 5 shows the select clay material being placed by dump truck on the upstream dike of Pond 2 while Figure 6 shows the select material being compacted with the dragline bucket on the dike separating Ponds 2 and 3.

In order to reduce, and in one case to completely eliminate, the pumping of water over dikes for the filling of the ponds, 18-inch corrugated metal culverts capped by turnout gates were placed in three of the dikes. The culverts were placed along the centerline of the canal about 4 feet above the bottom. The joints were painted on the inside with pitch to make them watertight. Select clay material was placed around the pipe, sprinkled and carefully compacted using both hand and pneumatic tampers. Figure 7 shows a culvert in place prior to being covered while Figure 5 shows the pipe covered and with the turnout-gate in place. After filling the ponds, the turnout-gate was closed and covered with earth material to make it watertight.

Hook Gage Installations and Water-surface Observations

Hook gages for determining the water-surface elevations in the ponds were installed on specially constructed structures near each end of each pond. Each hook gage was attached to a vertical 6 by 6-inch wooden post while the access platform used in reading the hooks was a separate structure so that the zero elevation of the hook would not be distrubed during the tests. Figure 4 shows one of the access platforms under construction while a completed structure ready for the installation of the hook gage is shown in Figure 5. Hook gage zeros were referenced to adjacent bench marks using an engineers level. The hooks themselves were 6 feet long with graduations at exactly 1-foot intervals. This permitted the lowering of the hooks by intervals of 1 foot without the necessity of rezeroing the hook gage with the engineer's level.

In the early stages of the ponding tests, the hook gages were read twice a day. Due to the great depth of the water in the ponds and to the very slow rate of drop of water surface with time, this procedure was soon changed and the hooks were thereafter read only once a day. The hook gages used for these tests could be read to the nearest 0.001 foot. Portable stilling-wells were used when the water surface was rough to obtain more accurate readings.

Leaks through Dikes and Structures

All dikes and structures within the ponded areas were given careful periodic inspections for leaks during the tests. The only leak observed was through the check and wasteway structure at the downstream end of Pond 3; however, the quantity was insignificant.

Effect of Evaporation

Evaporation data from a Class A pan were available at Conchas Dam. Although the evaporation was small, the seepage rates by ponding were corrected accordingly. The maximum evaporation observed during the tests amounted to 0.248 inch in 24 hours. The following table shows the effect of evaporation on the seepage rate for maximum depth for the three ponds.

Pond	Seepage rate for maximum depth	Maximum evaporation	Corrected seepage rate	Percent change in seepage rate
1	0.17	0.01	0.16	6
2	0.40	0.01	0.39	3
3	0.08	0.01	0.07	12

Results of the Ponding Tests

The seepage rates as obtained from ponding in the three test reaches of the Conchas Canal are shown in Figure 8. The seepage rate is plotted against depth of water in the canal. Comparative seepage rates for a common depth are given in the following table.

Pond number	Type of lining	Depth (in feet)	Seepage rate
2	Unlined	7.0	0.40
1	Clay lined--Specifications No. 1076	7.0	0.13
3	Clay lined on left side and bottom only by Project forces	7.0	0.07

Ground-water Observations

In conjunction with the ponding tests, a study was made of the logs of several ground-water wells located along the section line intersecting the Conchas Canal at Station 2563+00. These ground-water wells have been under observation since the project was opened in 1946. The section line intersects the canal near the dike location between Ponds 2 and 3. All wells except the one adjacent to the canal were dry at all times. This one well, Figure 1, while dry in the winter, indicated ground-water elevation changes during the irrigation season. Observations on this well are shown in Figure 9. During the first 2 years of project operation, the ground-water table came to within 2 feet of the surface of the ground while in 1949 the ground water was over 5 feet below the surface of the ground.

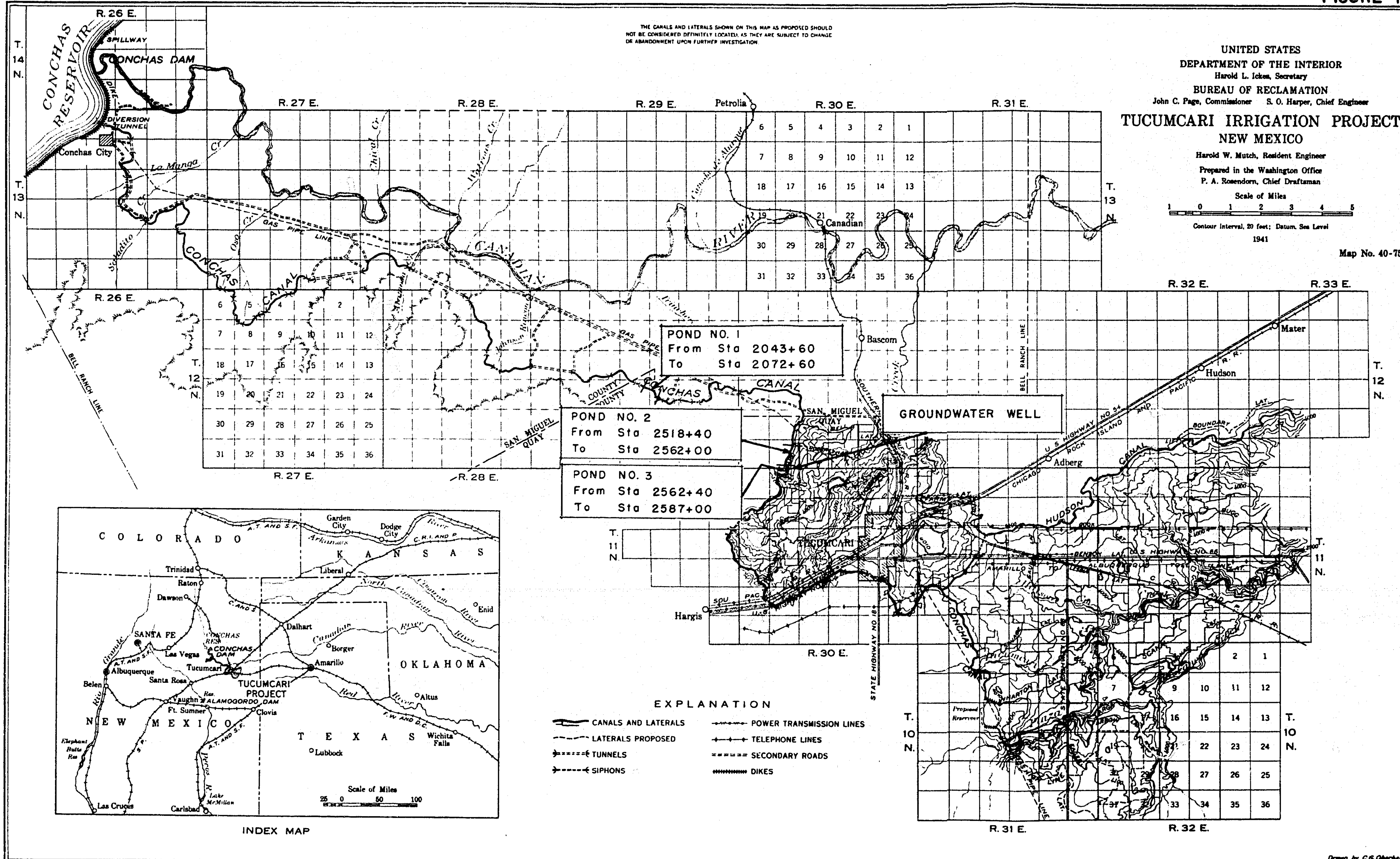
In 1946 and 1947 small seepage areas developed in several of the fields adjacent to the canal but disappeared in 1948 and 1949 when the ground-water table dropped. The lower ground-water table and the disappearance of the small seepage areas were apparently due to reduced seepage rate resulting from the silt blanket, Figures 2 and 3, deposited in the canal.

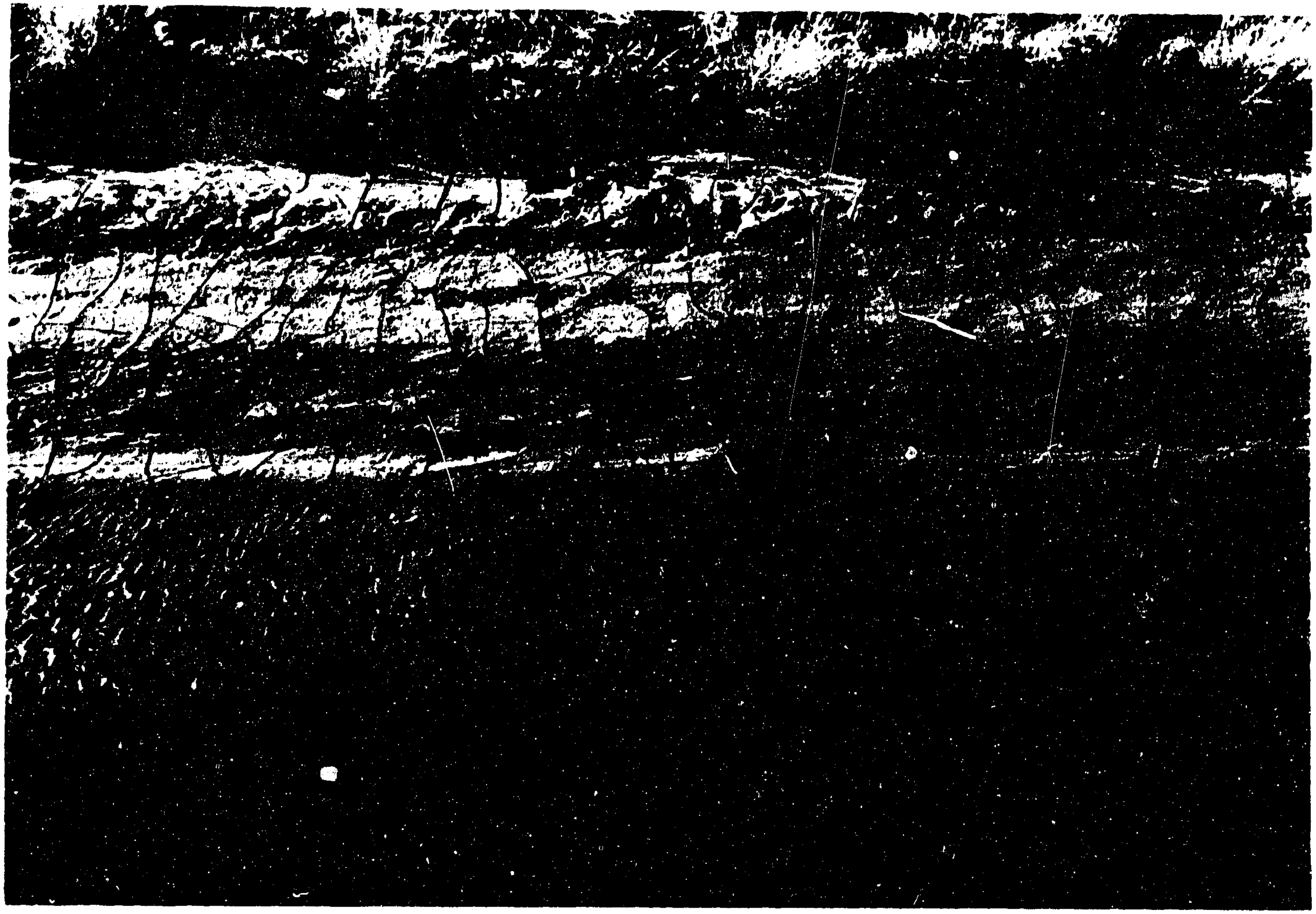
SEEPAGE METER TESTS

Details of the construction of the seepage meter are shown in Figures 10 and 11 while a photograph of the instrument in its present stage of development is shown in Figure 12. This meter is a modified version of the constant head permeameter developed by the Department of Agriculture and consists of a watertight seepage cup connected by a tube to a flexible bag for holding water. The cup isolates a known surface area of canal bottom. The water seeping through this area comes from the flexible bag and may be measured. The flexible bag of water, being submerged, maintains the same head on the test area under the meter as on the surrounding area of canal. Knowing the area under the meter (2 square feet) and the loss of water from the bag for a given period of time, the seepage rate in cubic feet per square foot of wetted area per 24 hours may be easily determined. Form "DCT-27, 11-49, Bureau of Reclamation," Figure 13, was used in recording the data.

Seepage meter studies were made in conjunction with the ponding tests in Ponds 2 and 3. Seepage meter settings were made on the canal centerline and on each side approximately half way up the slope at 400-foot intervals throughout the length of both ponds. An attempt was made to obtain the seepage meter data at maximum depth in the ponds but due to the conditions in the canal resulting from the presence of the silt blanket together with the deep water (7 to 8 feet) it was found necessary to delay the seepage meter tests until the water depth in the ponds decreased to a point where seepage meter operation was practicable. A plot showing the results of the seepage meter studies is shown in Figure 14. The following table summarizes the averages of the seepage meter data and compares them with the ponding test results for the same period of time.

Pond	Depth	RATE BY SEEPAGE METER				Rate by:	Difference	
number	(in feet)	L slope	Centerline	R slope	Avg	ponding	Rate	Percent
2	2.3	0.09	0.11	0.10	0.10	0.07	+0.03	+43
3	4.0	0.04	0.06	0.05	0.05	0.03	+0.02	+67

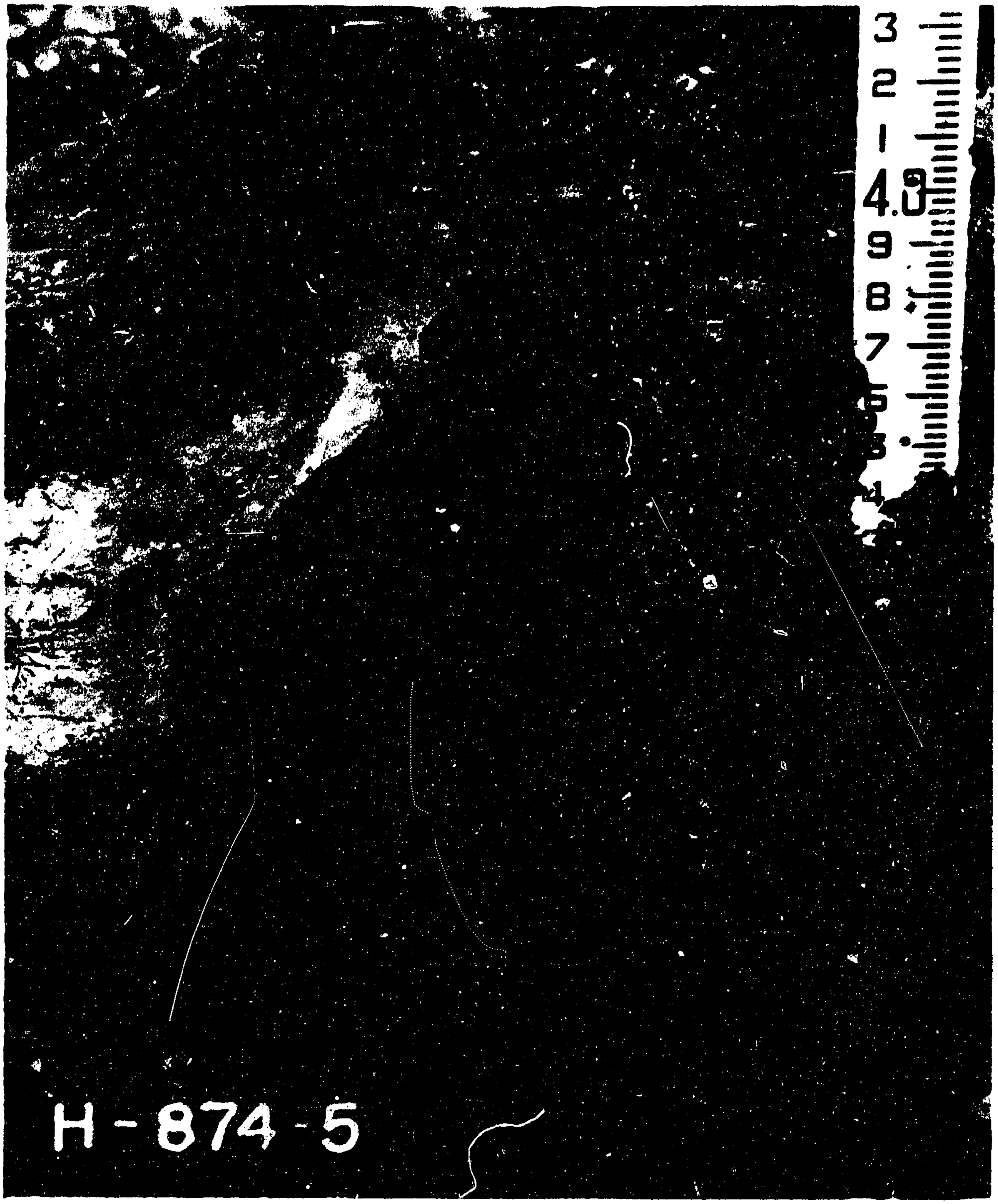

THE CANALS AND LATERALS SHOWN ON THIS MAP AS PROPOSED SHOULD NOT BE CONSIDERED DEFINITELY LOCATED, AS THEY ARE SUBJECT TO CHANGE OR ABANDONMENT UPON FURTHER INVESTIGATION.
UNITED STATES
DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary
BUREAU OF RECLAMATION
John C. Page, Commissioner S. O. Harper, Chief Engineer
TUCUMCARI IRRIGATION PROJECT
NEW MEXICO
Harold W. Mutch, Resident Engineer
Prepared in the Washington Office
P. A. Rosendorn, Chief Draftsman
Scale of Miles
Contour Interval, 20 feet; Datum, Sea Level
1941
Map No. 40-75A
POND NO. 1
From Sta 2043+60
To Sta 2072+60
POND NO. 2
From Sta 2518+40
To Sta 2562+00
POND NO. 3
From Sta 2562+40
To Sta 2587+00
GROUNDWATER WELL
CONCHAS RESERVOIR
SPILLWAY
CONCHAS DAM
DIVERSION TUNNEL
Conchas City
CONCHAS CANAL
CANADIAN RIVER
GAS PIPE LINE
Petrolia
Canadian
Bascom
Mater
Hudson
Adberg
TUCUMCARI
Hargis
HUDSON CANAL
BELL RANCH LINE
SAN MIGUEL QUAY
STATE HIGHWAY NO. 18
U S HIGHWAY NO 54
CHICAGO ROCK ISLAND AND PACIFIC R.R.
R. 26 E.
R. 27 E.
R. 28 E.
R. 29 E.
R. 30 E.
R. 31 E.
R. 32 E.
R. 33 E.
T. 14 N.
T. 13 N.
T. 12 N.
T. 11 N.
T. 10 N.
EXPLANATION
CANALS AND LATERALS
LATERALS PROPOSED
TUNNELS
SIPHONS
POWER TRANSMISSION LINES
TELEPHONE LINES
SECONDARY ROADS
DIKES
COLORADO
KANSAS
OKLAHOMA
TEXAS
NEW MEXICO
Garden City
Dodge City
Liberal
Trinidad
Raton
Dawson
Enid
SANTA FE
Las Vegas
CONCHAS DAM
Dalhart
Borger
Amarillo
Albuquerque
Tucumcari
TUCUMCARI PROJECT
Santa Rosa
Belen
Vaughn
ALAMOGORDO DAM
Ft. Sumner
Clovis
Altus
Wichita Falls
Lubbock
Las Cruces
Carlsbad
Scale of Miles
INDEX MAP
Drawn by C.G. Oberheim



CONCHAS CANAL - TUCUMCARI PROJECT, NEW MEXICO

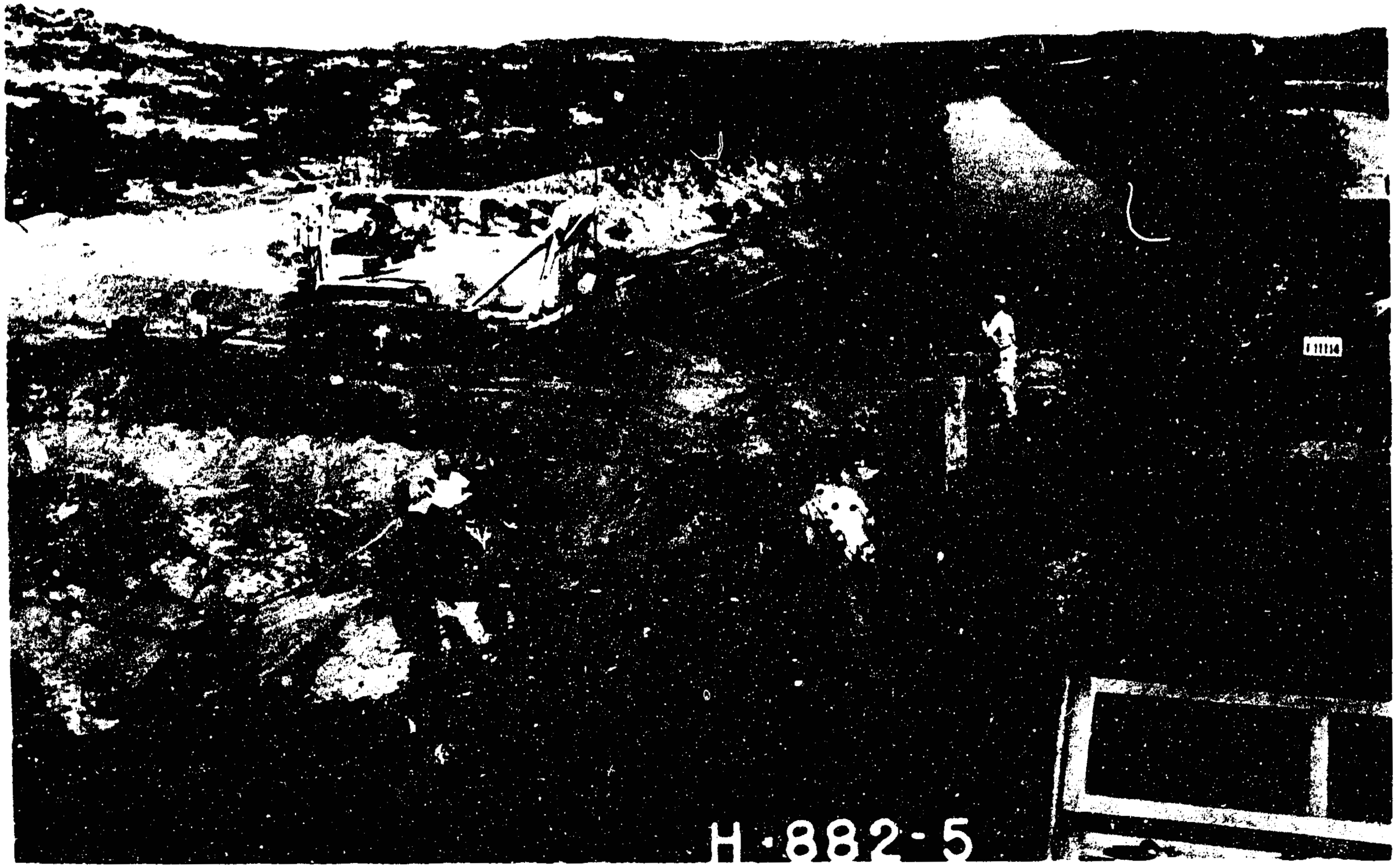
A general view of the silt deposit on the right bank of the Conchas Canal at Station 2550 which is within Pond 2. While the canal was designed for 700 second-feet, the maximum discharge during the four years of operation of the canal was 400 second-feet. (H-874-7)

FIGURE 2



CONCHAS CANAL - TUCUMCARI PROJECT, NEW MEXICO

A closeup view of a section of the silt deposit on the left bank of the Conchas Canal at Station 2550 shows the thickness of the blanket by comparison with a staff gage. (H-874-5)



CONCHAS CANAL - TUCUMCARI PROJECT, NEW MEXICO

This photograph shows the dike at the upstream extremity of Pond 2 (Station 2518+40) nearing completion. The bulldozer is spreading the material in thin layers. Each layer is moistened with water pumped from pools in the canal and compacted with the bulldozer. The walkway for the hook gage is under construction in the right foreground. (H-882-5)

FIGURE 4

CONCHAS CANAL - TUCUMCARI PROJECT, NEW MEXICO

Select clay material is being dumped by truck on the down-stream face of the upper dike of Pond 2 (2518+40). The turnout gate capping the 18-inch corrugated pipe through the dike is shown in the center of the picture. The completed walkway and hook gage post (ready for the installation of the hook gage) is shown in the right foreground. (H-882-6)

FIGURE 5

CONCHAS CANAL - TUCUMCARI PROJECT, NEW MEXICO

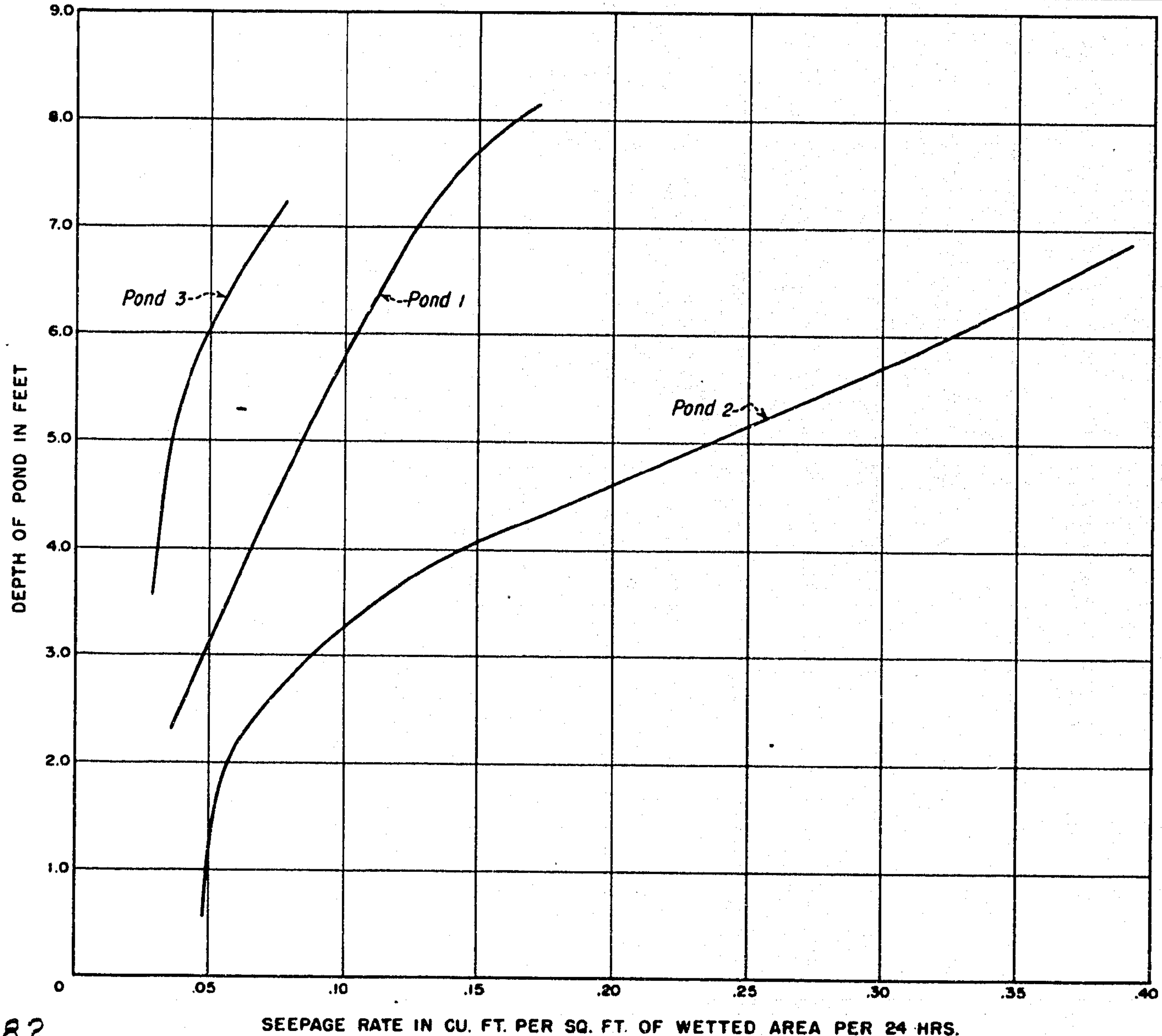
The select clay material is being compacted after moistening, by the dragline bucket, on the downstream face of the common dike between Ponds 2 and 3 (Station 2562+20). The downstream end of the 18-inch culvert is shown. The turnout gate for this culvert is on the upstream side in Pond 2. (H-882-2)

FIGURE 6

CONCHAS CANAL - TUCUMCARI PROJECT, NEW MEXICO

This photograph shows the dike at the upper end of Pond 2 (Station 2518+40) partly completed. Two lengths of 18-inch corrugated culvert are in place with the third length nearby. Water is being sprinkled on the fill for better compaction. Select clay material was placed around the culvert and compacted with hand and pneumatic tampers while the dike proper was compacted with a bulldozer. (H-882-1)

FIGURE 7

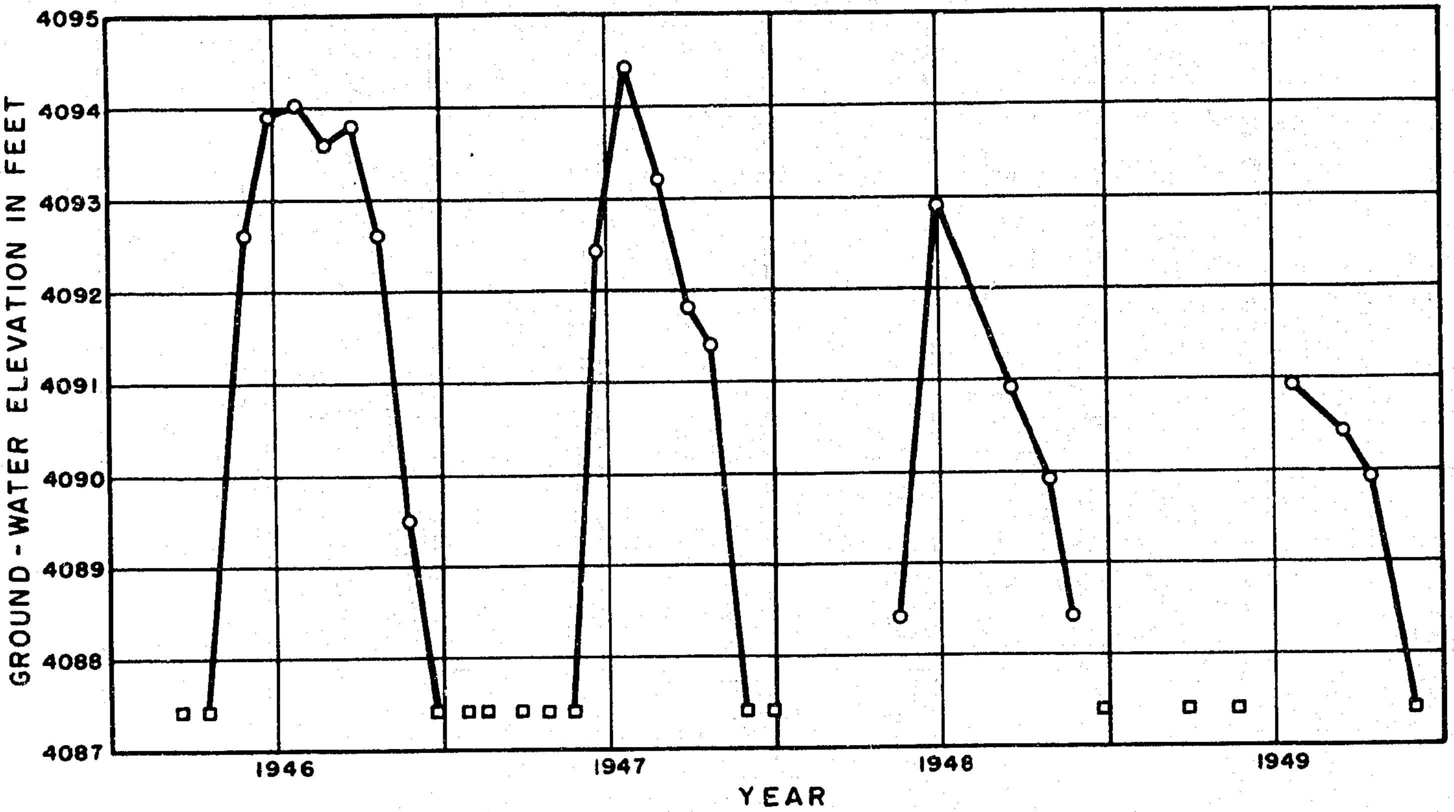


CONCHAS CANAL			
POND NO.	STATION FROM	STATION TO	TYPE OF LINING
1	2043 + 60	2072 + 60	Clay lined
2	2518 + 40	2562 + 00	Unlined
3	2562 + 40	2587 + 00	Clay lined on left side and bottom only.

TUCUMCARI PROJECT–NEW MEXICO
1949 SEEPAGE STUDIES
PONDING TESTS–CONCHAS CANAL

FIGURE 8

HYD. 303



EXPLANATION

□ These points represent observations taken when well was dry and are plotted at elevation of bottom of well. Well was fifty feet from canal.

TUCUMCARI, NEW MEXICO

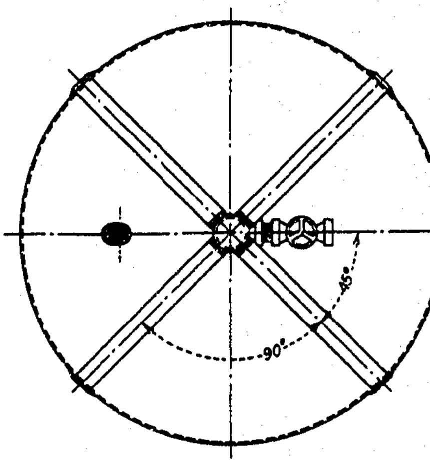
1949 SEEPAGE STUDIES

GROUND WATER WELL-STATION 2563+00

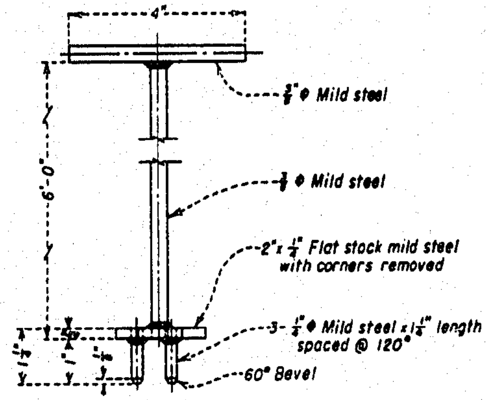
CONCHAS CANAL

FIGURE 9

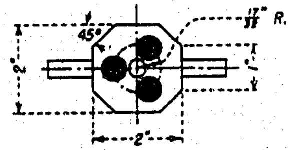
362
[redacted]



PLAN



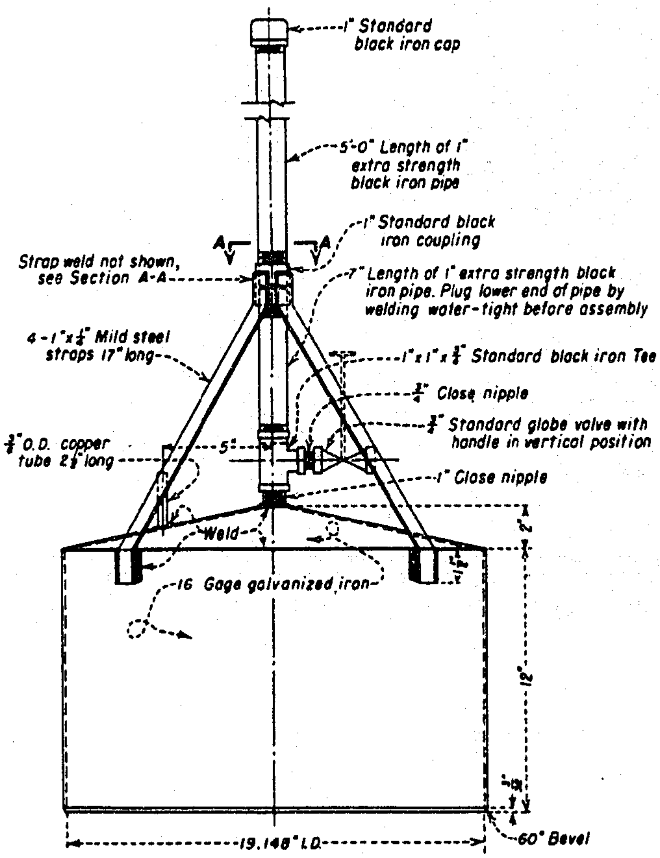
ELEVATION



BOTTOM VIEW

VALVE HANDLE EXTENSION

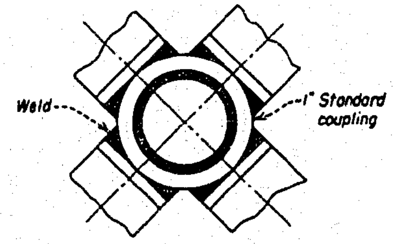
SCALE OF INCHES



ELEVATION

SEEPAGE METER.

SCALE OF INCHES



SECTION A-A

NOTES

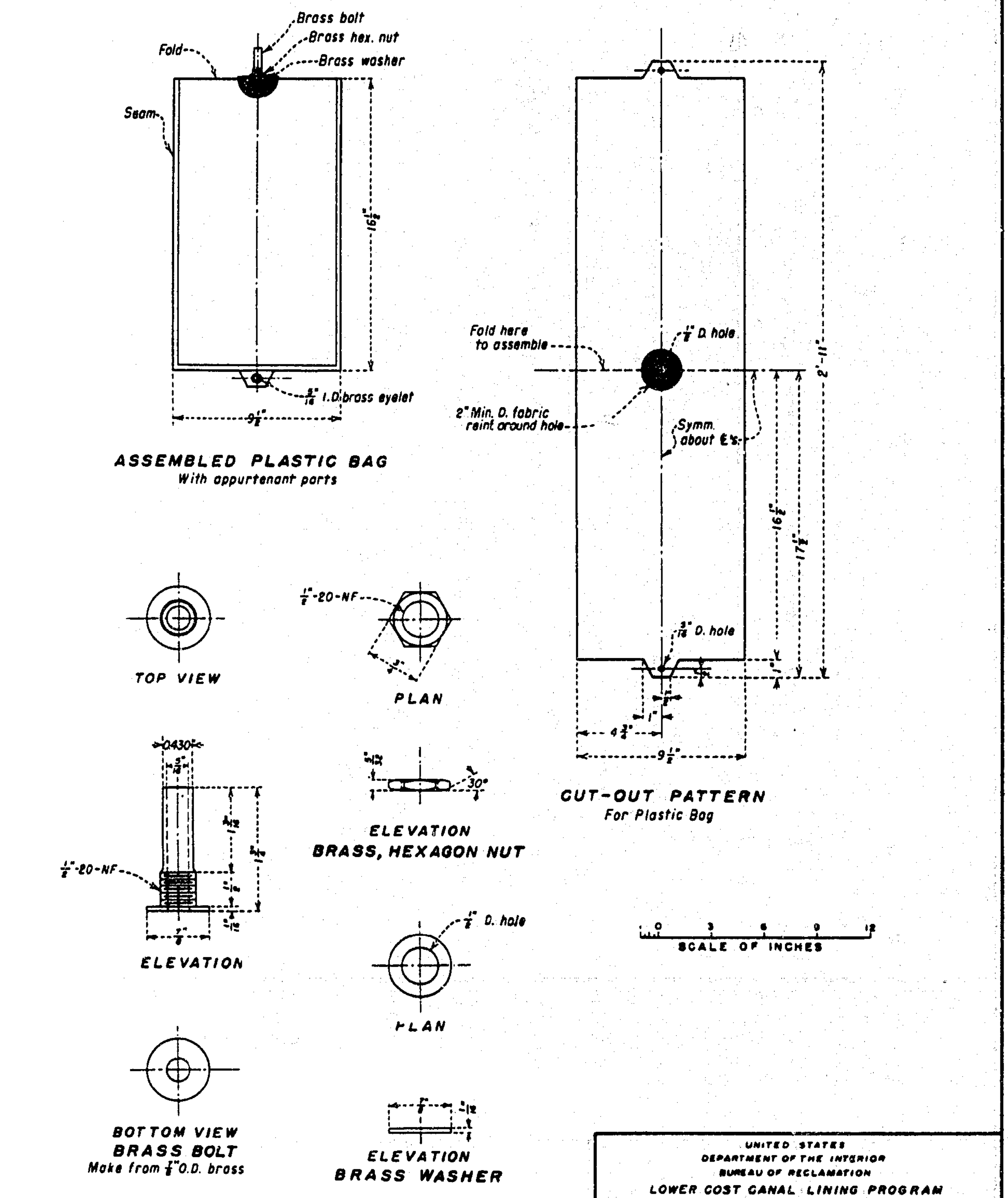
Paint all exposed parts, except brass, with aluminum paint.
All welds on seepage meter, except welds on straps, to be water-tight.
All parts of valve handle extension to be welded together using appropriate size welds.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

LOWER COST CANAL LINING PROGRAM

SEEPAGE METER
AND VALVE HANDLE EXTENSION.

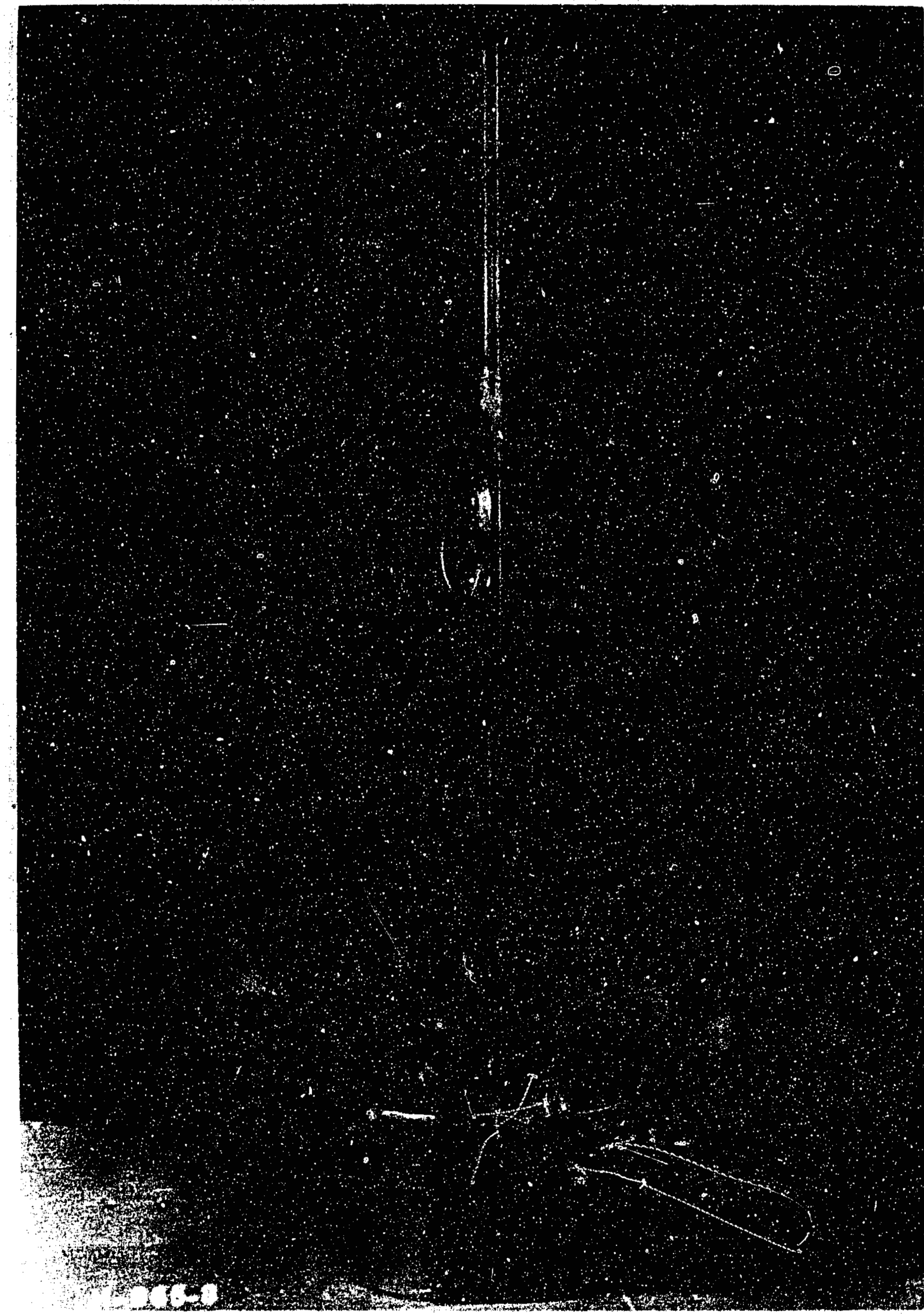
DRAWN A.J.A.	SUBMITTED [signature]
TRACED E.V.M.	RECOMMENDED
CHECKED R.S.-C.O.O.	APPROVED
DENVER, COLORADO — APRIL 25, 1952	8030-RH-1



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
LOWER COST CANAL LINING PROGRAM

PLASTIC BAG WITH BRASS FITTING FOR SEEPAGE METER

DRAWN A.J.A. ..... SUBMITTED Charles W. Thomas
TRACED E.V.M. ..... RECOMMENDED ....
CHECKED RS - G.D.D. ..... APPROVED ....
DENVER, COLORADO—APRIL 21, 1950 | 8030-RH-2



SEEPAGE METER

Form DCT-27
11-49
Bureau of Reclamation

SEEPAGE METER DATA SHEET

Project__________ Canal__________ Sheet ____ of ____

Meter Depth__________ Meter Area__________ Weather__________

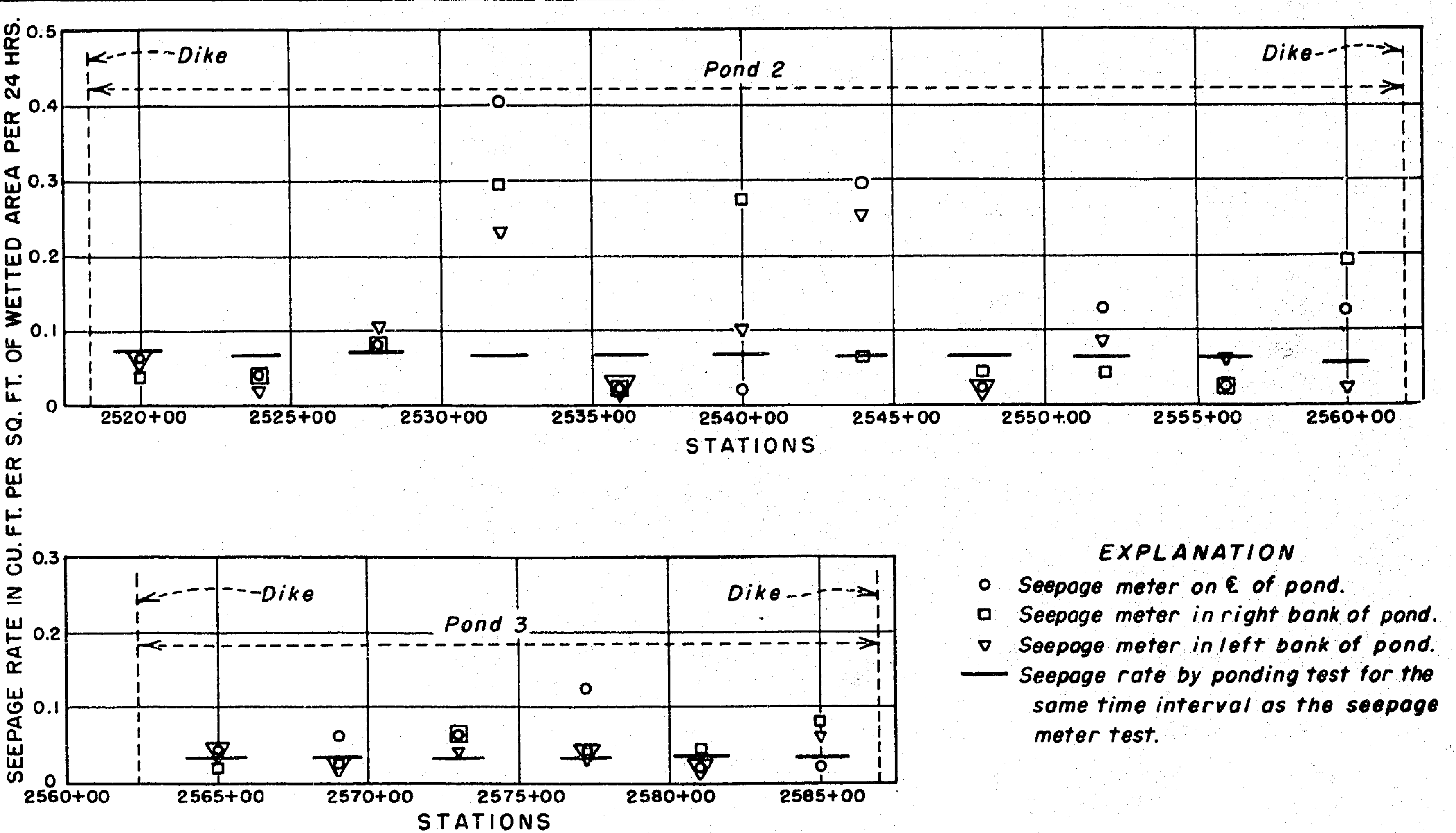
Variation of WS from Normal__________ Design Capacity__________

Percent Cut__________ Fill__________ Soil Type__________

Observer__________ Date__________

Station	Temperature		Water Depth	Water Bag Weights			Time (Min.)			Seepage Loss c.f./s.f./24 hrs.	Remarks
	Air	Water		Initial	Final	Loss	Initial	Final	Net		

FIGURE 13



TUCUMCARI PROJECT-NEW MEXICO

1949 SEEPAGE STUDIES

SEEPAGE METER TESTS-CONCHAS CANAL

FIGURE 14

APPENDIX A

LABORATORY TESTS ON CLAY LINING (Pond 1)

by

V. S. Meissner
Earth Materials Laboratory, Denver

The average dry density of the clay lining at the time of placement (1945) was 99 percent of the maximum density, that is, 115.1 pounds per cubic foot as compared with 116.6 pounds per cubic foot. At the time the seepage tests were made (1949) the dry density of the clay lining had reduced to 111.4 pounds per cubic foot or 96 percent of maximum laboratory density. This reduction in dry density was accompanied by an increase in moisture content of from 10.9 percent (1945) to 15.0 percent (1949). The change in density could have been accomplished either by the swelling of the clay from increased water content or by the successive freezing and thawing of the moisture in the soil. In general, a reduction in soil density causes an increase in permeability. However, since this decrease in density has probably occurred only near the surface of the lining, the deeper soil in this thick lining is probably still impervious. In addition, the fine-grained soils used for this lining are still impervious at much lower densities than the placement densities obtained.

The density of the deeper portions of this lining should be checked for general information and two or three 50-pound samples of lining material taken from density test locations should be submitted to the Denver Laboratories for permeability tests.