# MEASUREMENT OF SEEPAGE LOSSES FROM IRRIGATION CANALS

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A large portion of the water diverted into irrigation channels is lost in transit. This loss is composed of five parts: (a) leakage, (b) waste, (c) evaporation, (d) transpiration, and (e) seepage. By leakage is meant the water lost through poorly maintained gates and structures. Waste represents the amount which is lost through automatic wasteways or merely discharged into wasteways. Although the waste and leakage may be very high in some instances, these losses will not be discussed in this paper.

The rate of evaporation from irrigation canals has been measured in several instances with the floating-type pan, and in nearly all cases the quantity is negligible, hence this source of loss can be ignored in a general discussion. The same may be said relative to transpiration losses. Seldom is this loss appreciable, even where there are large areas of cattails or similar growth.

The other source of loss from irrigation canals is seepage. It has been estimated that, generally speaking, 30 percent of all water diverted for irrigation is lost by seepage. A way of visualizing this quantity of seepage is that the water diverted in 1946 for irrigation of 36 Bureau of Reclamation projects would have irrigated an additional 1 million acres of land if there had been no seepage loss. Another concept of the amount of water lost by seepage may be derived from the fact that a certain company 2 years ago offered to spend $1,500,000 to install concrete lining in 15 miles of canals of the Salt River Valley Water User's Association, in return for one-half the water conserved over a period of 15 years. The total quantity to be conserved was measured to be 10,000 acre feet per year; hence, 5,000 acre feet per year would be gained by each of the two parties involved.

It cannot be said that seepage is always undesirable. In one known instance, the seepage water is required to replace ground water necessary for irrigation by pumping during a portion of the season when surface water is not available. This procedure is more economical than lining the canals and constructing large storage reservoirs to provide surface water for the entire irrigation season. In other cases the water lost by seepage from a particular portion of a system may not be lost for irrigation purposes, but returns to the surface at a lower elevation and is therefore available for use a second time. Observations on the North Platte River between Whalen and Bridgeport revealed that approximately

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65 percent of the water diverted for irrigation returned to the river at a lower elevation. 2/

The only means of preventing seepage from canals is to install a suitable lining. It must be said, however, that linings are not always installed to prevent seepage, since a lining may be necessary to minimize maintenance for a canal that is subjected to the tramping of cattle or the destructive action of gophers. But, except for these special cases, linings are installed to minimize seepage. However, the goal may not be to conserve water but to prevent water-logging of adjacent productive land. For instance, on the Riverton project, a section of the canal was lined with an impervious material, although the quantity of water seeping from this channel was an insignificant factor. But the adjacent area did not have drainage; hence, any quantity of seepage water, no matter how small, would eventually water-log the land.

Broadly speaking, linings are constructed to conserve water, and the cost of the lining must be borne by the value of the water saved. Canal linings are very expensive, and therefore it is essential that linings be installed only in canals or portions thereof which materially contribute to the seepage loss. This procedure requires measurement to determine the sections of a particular canal which are the most pervious. Anyone who has been confronted with this problem realizes the difficulties in measuring seepage from a canal. The quantity usually represents a relatively small amount of the total flow, and therefore great accuracy is required to evaluate the loss.

Of course, the most economical time to install a lining is during the initial construction period. This requires pre-investigations to predict seepage from particular sections of the proposed canal prior to excavation of the channel. The method and equipment for conducting these measurements together with other factors contributing to expected seepage rate, including the silt to be deposited by normal operation, cannot be discussed in this paper, which is limited to seepage from existing canals.

The following methods have been employed to measure the seepage from canals:

(1) Inflow-outflow method

(2) Ponding method

(3) Constant and variable head permeameters

(4) Seepage meter

The inflow-outflow method involves the measuring of the flow into a certain section, and the flow out of the section, the difference

2/ Return Flow, North Platte River, Nebraska, by R. H. Willis, Trans. A.S.C.E., v. 94, pp. 328-332, 1930.

representing the loss by seepage after correction for any flow through turnouts in the reach. Ordinarily, the masurements must be made with current meters, as permanent measuring devices suitable for this purpose are practically nonexistent. Unless the measurements are made for a very long reach of canal, the loss will be of insufficient magnitude to evaluate by this method. Assuming that the loss is detected by this procedure, the engineer still cannot distinguish which particular sections are contributing mostly to the seepage; hence, this method does not meet the requirements for evaluating seepage from canals.

The ponding procedure requires the construction of dikes in the canal to segregate a particular section. The section is then filled with water, usually by pumping, and the measure of the drop in water surface for a certain period combined with the physical dimensions of the area ponded, will permit computation of the rate of seepage. This procedure does give accurate results, and is the only reliable method known for measuring the rate of seepage.

Figure 1 depicts the construction of a dike in the Friant-Kern Canal. The dike in the foreground supporting the four pumps is provided to enable inspection of the primary dike to insure that leakage did not exist. Construction of such structures necessitates the removal of the canal from operation, and furthermore is a very costly procedure. In smaller canals the dikes can be formed cheaply by merely placing earth in the canal with hand shovels or by employing a temporary wood bulkhead.

Constant head permeameters consist of a pipe placed in the bottom or sides of a canal. The head of water is maintained in the pipe equivalent to the depth in the canal. The constant head is maintained with a tank inverted on top of the pipe to form a Mariotte tube, Figure 2. The amount of water escaping from the tank in a unit time represents the seepage from the area enclosed by the pipe. The variable head permeameter differs only in that the head is allowed to drop over a given time interval. The disadvantages of these permeameters are that the seepage is obtained over a very small area, the equipment is awkward to use, and the apparatus must be installed when the canal is dry.

The seepage meter is actually a constant head permeameter developed by the salinity laboratory of the Department of Agriculture. It has been modified by the Bureau and consists of a seepage cup, conical-shaped at the top, with a valve to facilitate the removal of air, Figure 3. This cup is connected to a flexible bag which is submerged in the canal during manipulation to obtain the same head in the cup as exists in the canal. This device has a great advantage in that it may be operated by one or two men without taking the canal out of service.

To determine the accuracy of the seepage meter several field tests have been made by utilizing the meter simultaneously with ponding tests.

Figure 4 shows the results of tests in the Fort Laramie Canal of the North Platte Project. Note that the seepage meter results are quite erratic, but that the seepage rate is low. This plot also shows the results obtained with the seepage meter immediately prior to the formation of the ponds when the canal was flowing normally.

Similar studies were made in the heavily compacted earth lining of the Friant-Kern Canal, Figure 5. It is significant to notice that the seepage rates by the ponding method also varied. This accounts for some of the erratic results obtained with the seepage meter, and is at least partially explained by variations of temperature and barometric pressure. The air in the soil is also a factor. The seepage rate is very low in this case also.

The lower part of this plot reveals loss through a concrete-lined section of the Friant-Kern Canal. These data were obtained by the ponding method only, since the seepage meter cannot be used in a concrete-lined section. It is of interest to relate that the unit seepage rate at the designed depth is greater for the concrete-lined section than for the heavily compacted earth lining. However, in this case, as in most instances, the concrete-lined section is smaller and therefore contributes less total loss than the larger earth-lined section.

Figure 6 shows another comparison of the seepage rate measured by the seepage meter and the ponding method. In this case the seepage rate is rather high, and although the seepage meter does not check the ponding tests as closely as desired, the order of magnitude is the same.

Other methods of determining the quantity of seepage or the location of seepage paths are being studied; for instance, the electrical resistivity procedure utilized in connection with foundation explorations has been applied with a very small degree of success. Further study, however, may yield valuable results. Another method which has received a small amount of study and is programed for additional investigation in the future involves the principle used in locating reinforcing steel in concrete. The equipment consists of an electrically energized coil which is passed over the ground. As it approaches an energized seepage path the change in tone should be noticeable.

Still another proposed method of locating paths of percolation as well as seepage rates involves the use of radioisotopes. Although much investigation remains to be done, there is every reason to believe that this procedure will have an adaptation to the seepage loss measurement problem.



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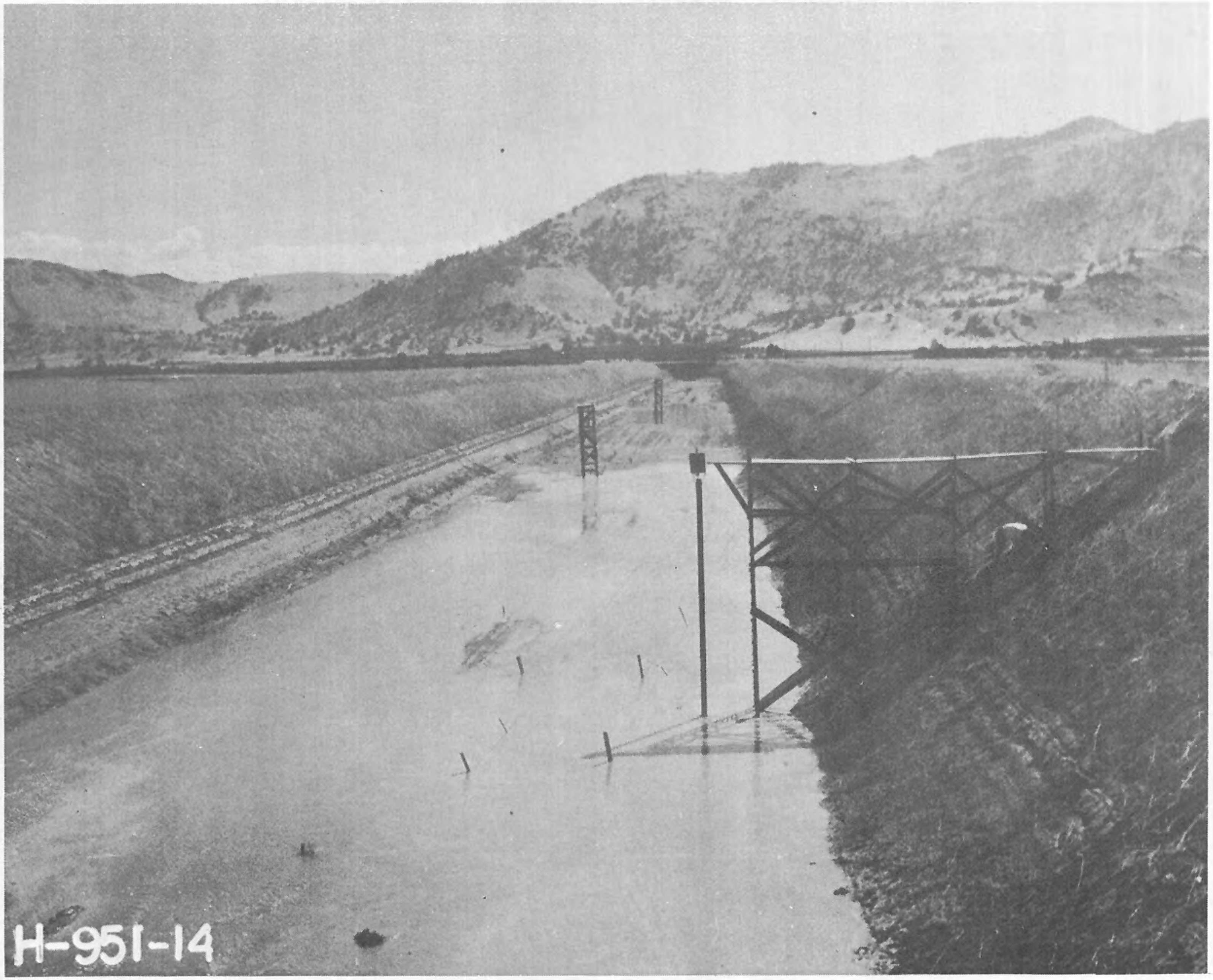
FIGURE 1

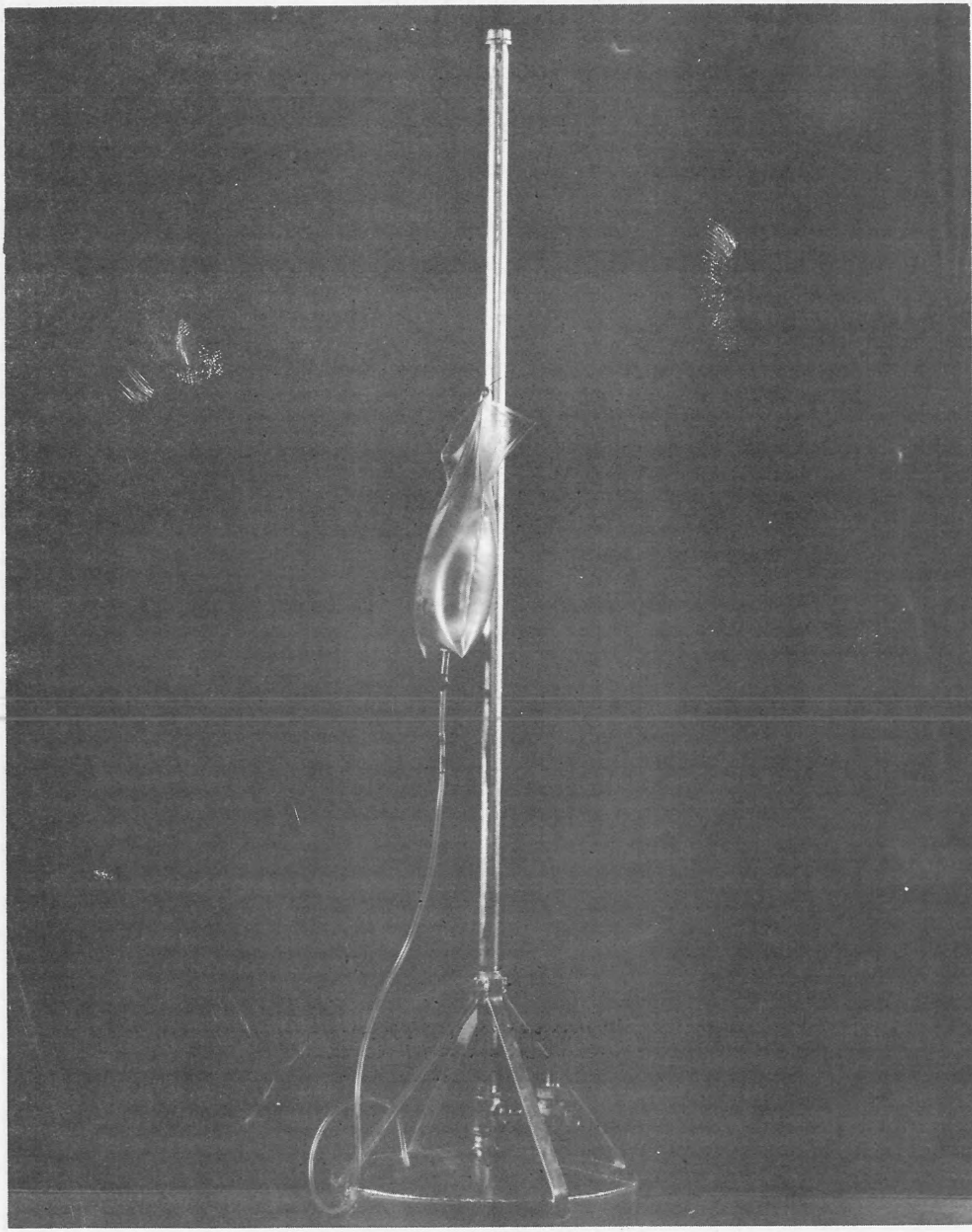
Dikes for ponding test - Friant - Kern Canal

FIGURE 2



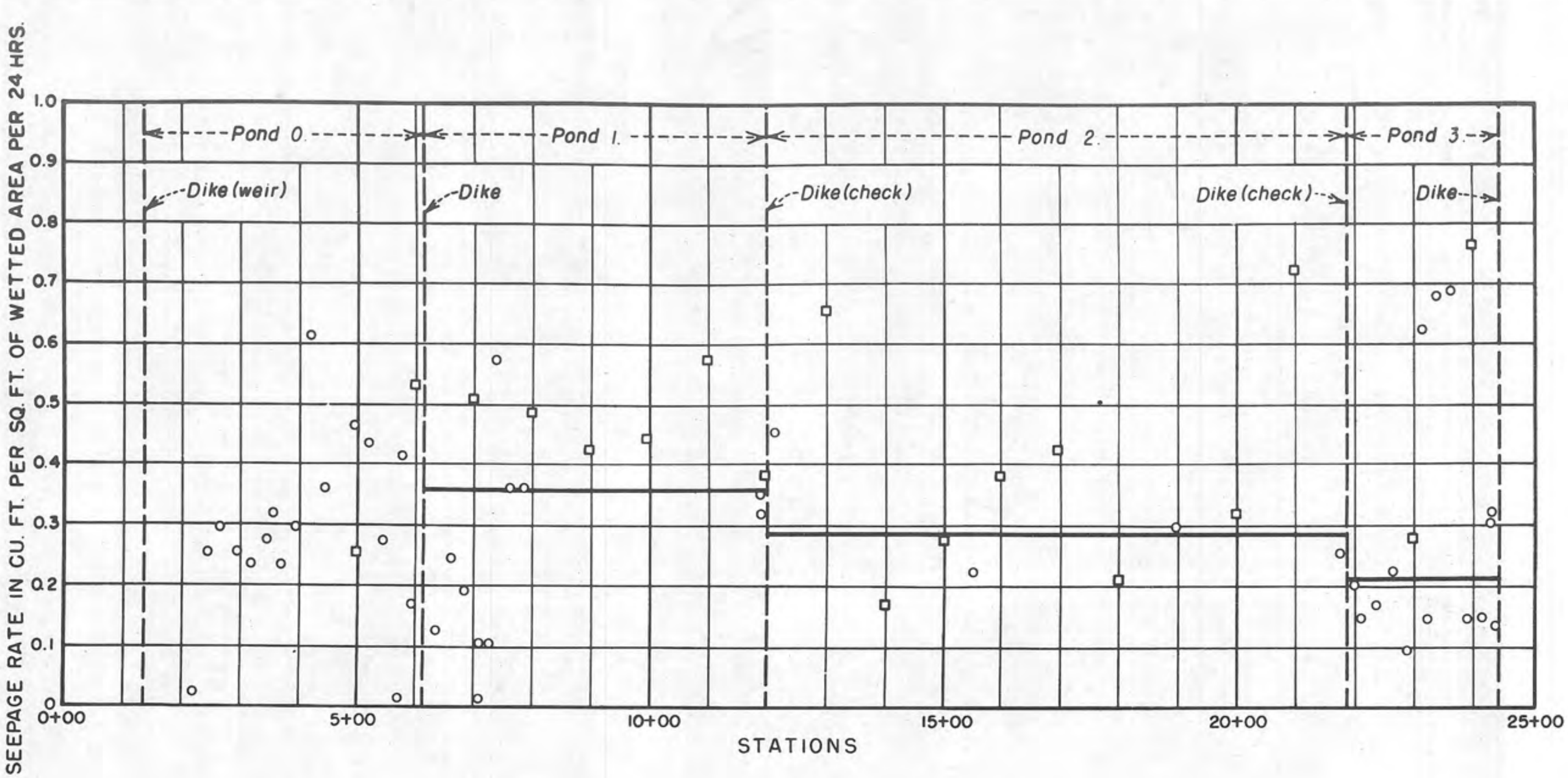

Constant head permeameters for seepage measurements - Friant-Kern Canal.

FIGURE 3



Seepage Meter

FIGURE 4




**EXPLANATION**

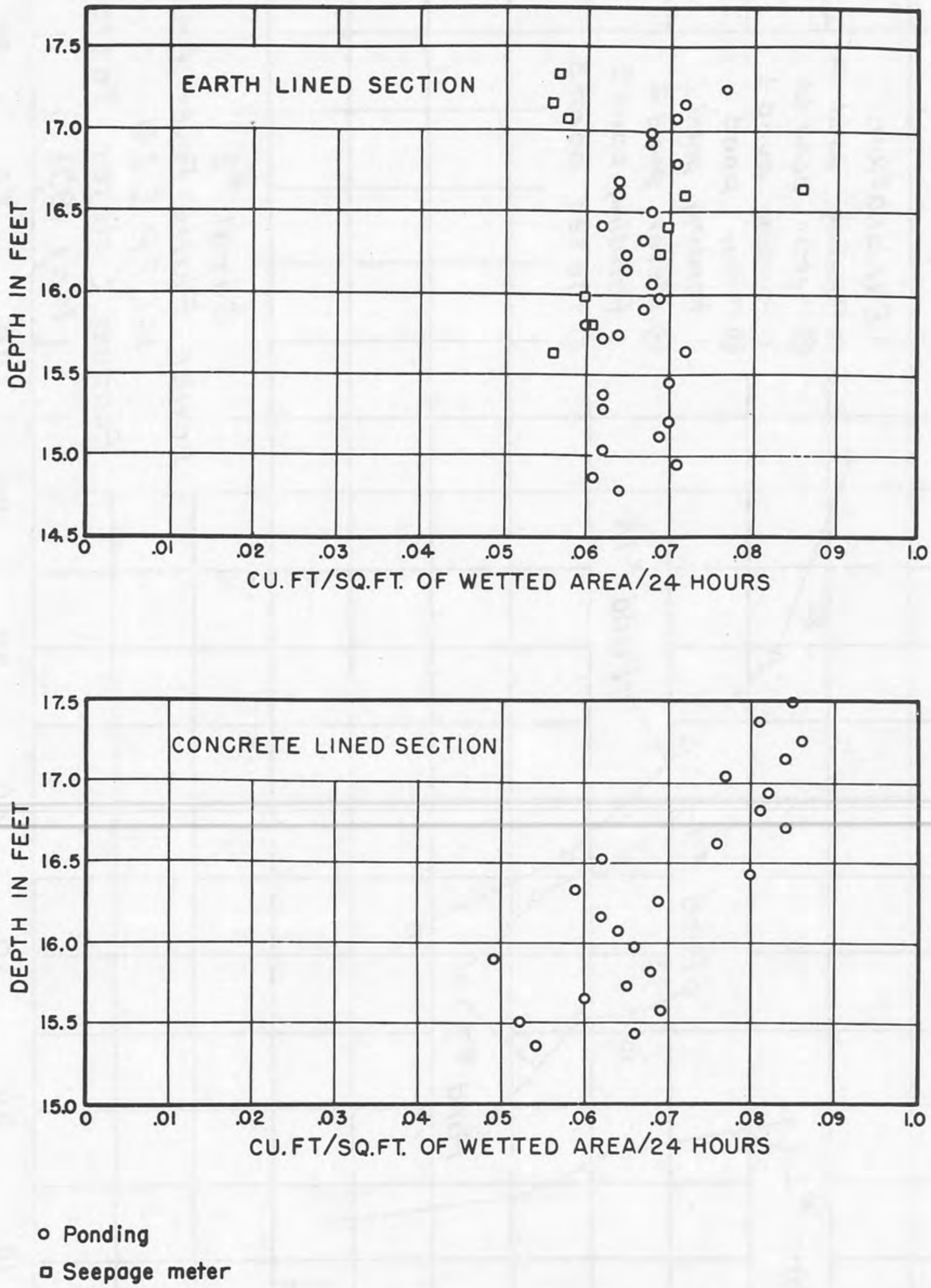
- □ *Seepage meter in flowing water.*
- ○ *Seepage meter in ponds.*
- —— *Seepage rate by ponding tests for the same time interval as the seepage meter tests.*

*NORTH PLATTE PROJECT-WYOMING-NEBRASKA*

*1949 SEEPAGE STUDIES*

*SEEPAGE METER TESTS-FORT LARAMIE LATERAL 29.4*

*D.C.W. 3-8-50*




CENTRAL VALLEY PROJECT — CALIFORNIA

**FRIANT-KERN CANAL**

**1950 SEEPAGE STUDIES**

**PONDING AND SEEPAGE METER RESULTS**

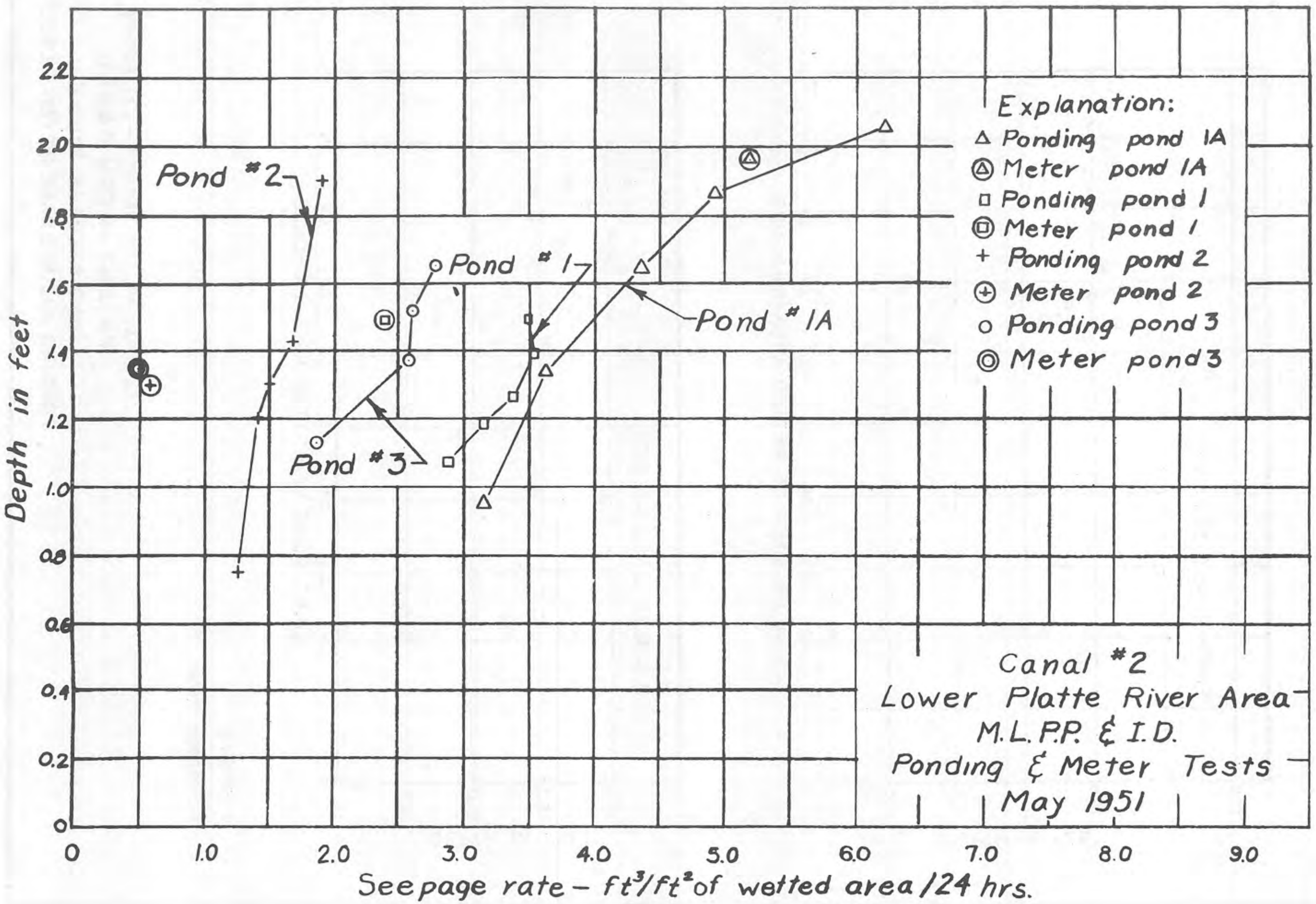

Explanation:
△ Ponding pond 1A
Meter pond 1A
□ Ponding pond 1
Meter pond 1
+ Ponding pond 2
Meter pond 2
○ Ponding pond 3
Meter pond 3
Pond #2
Pond #1
Pond #1A
Pond #3
Canal #2
Lower Platte River Area
M.L.P.P. & I.D.
Ponding & Meter Tests
May 1951
Depth in feet
Seepage rate – ft³/ft² of wetted area /24 hrs.
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0

FIGURE 6