Research Technical Completion Report
Project A-009-Ida

Movement of Water from Canals to Ground Water Table

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RESEARCH TECHNICAL COMPLETION REPORT

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MOVEMENT OF WATER FROM CANALS TO GROUNDWATER TABLE

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ABSTRACT

Investigation of the mechanics of water movement from irrigation canals to the water table has been performed on selected canals in southern Idaho. Field studies of existing seepage measurement techniques including ponding tests, inflow-outflow techniques and seepage meters were made. A new seepage meter which will operate efficiently in large operating canals was developed. An accurate and reliable tensiometer system for monitoring changes in soil moisture pressure beneath operating canals was developed. Measured decreases in soil moisture and pressure beneath an operating canal during the irrigation season indicated decreasing seepage rates caused by natural sealing of a thin soil layer on the canal bottom. A fast response, inexpensive null point tensiometer was laboratory tested and a device for measuring the capillary pressure - saturation curve for soils in situ was investigated. New techniques for obtaining and testing undistrubed soil cores using heat shrinkable tubing allow efficient laboratory determination of hydraulic characteristics.

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KEY WORDS *Seepage, Canals, Irrigation, *Tensiometers, Permeability, Unsaturated flow, Hydraulic Conductivity, *Groundwater

INTRODUCTION

This study was initiated to investigate the mechanics of water movement from irrigation canals, and to develop techniques and equipment for studying the movement in both the saturated and unsaturated phases. The field work was performed near Twin Falls, Idaho on canals operated by local Irrigation Districts and with the cooperation of the Agricultural Research Service. Laboratory experiments were performed at the Snake River Conservation Research Center, ARS, near Kimberly, Idaho and at the University of Idaho.

OBJECTIVES

Specific objectives were:

1. To study the movement of water from canals and natural channels as it affects adjacent lands and local water tables.
2. To text existing methods and develop new techniques for determining the amount and direction of movement of water from canals in both the saturated and unsaturated phases.
3. To develop a field procedure for describing the permeability-capillary pressure relationship for porous material.

PROCEDURES

Investigations under the first objective were directed primarily at evaluation of the mechanics of seepage movement from irrigation canals by extensive field studies as well as laboratory experiments. The U. S. Bureau of Reclamation cooperated on the field studies. This involved the study of various methods of measuring and estimating seepage to include traditional inflow-outflow techniques, ponding tests and an extensive study of the use of seepage meters. Results of this study were reported by Mr. Brockway at the Second Seepage Symposium in Phoenix, Arizona and a copy of that paper is appended to this report.

The seepage flow system beneath the canals selected for study was unsaturated and the measurement of soil water pressure beneath the canals required the use of tensiometers. Several types of tensiometer installation were investigated in an effort to perfect a system for field use that would be sufficiently accurate and reliable to monitor the soil water pressure beneath an operating canal throughout an entire irrigation season. A tensiometer system using a 3/8 inch diameter porous porcelain cup about 2 inches long was found to be quite satisfactory. Two .096 inch diameter nylon tubes attached to the cup with epoxy resin were used as an indicator tube and bleed tube so that air accumulating in the cup could be removed periodically. The readout used was a simple mercury pot-type manometer constructed of 1.5 mm glass tubing. A total of 35 tensiometers were installed in canal cross sections using several types of cup installation. Tensiometer cups installed in the ends of previously driven 1 inch diameter electrical conduit piezometers proved both expedient and reliable. This method allows installation in an operating canal whereas installation in pits requires dewatering of the canal. Some of the tensiometers installed in 1966 have functioned for 3 irrigation seasons without removal during the winter.

This study is one of the first in which an unsaturated flow system beneath an operating canal has been monitored extensively. In addition to water pressure measurement with tensiometers, the soil moisture profiles beneath the instrumented sections were measured regularly during 1967 using neutron moisture meters in access tubes installed in the operating canal.

Pressure and soil moisture beneath the canal gradually decline during the irrigation season. A typical plot of Elevation Potential versus Time, Fig. 1, illustrates this phenomena. The short term fluctuations could not be attributed to any of the usual factors such as barometric pressure, temperature or irrigation adjacent to the canal. The general decline in the pressure throughout the season can be attributed to a gradual sealing of a thin soil layer on the bottom of the canal with a resulting decrease in seepage. Measurement of the change of hydraulic conductivity with depth in soil cores obtained from the bottom of the canal indicate a sealing layer less than 1 inch thick on the surface.

A new OWRR allotment project to study the mechanics of this natural sealing process is now underway.

To expedite the reading of banks of tensiometers in the field, a readout system using a variable reluctance type pressure transducer with a portable battery powered meter was developed. A stepping multi-point valve was used and with the short response time of the pressure transducer it was possible to read up to 10 tensiometers in a short time. Field evaluation of this system was not achieved because of a failure in the tensiometer cups caused by swelling of the nylon tubing making it impossible to bleed the air from the cups.

Methods of installation and results of field tensiometer studies are outlined in detail in the progress reports for the project and summarized in the paper "Estimating Seasonal Changes in Irrigation Canal Seepage" presented at the 1967 Regional meeting of the American Society of Agricultural Engineers in Spokane, Washington. A copy of that paper is appended to this report.

Other work under the second objective was done by Mr. J. R. Busch, a graduate student at the University of Idaho, who developed a null tensiometer and wrote his M.S. thesis on the laboratory evaluation of the device. The tensiometer uses a positive pressure as a measure of the negative pressure in the soil water by means of two connected diaphragms. Some of the advantages of this device over other tensiometers are very small response time, no water filled tubes under tension going below the ground level, and the device is relatively inexpensive when compared to other tensiometers with similar response time. The accuracy is satisfactory for laboratory use and it appears that it would be durable enough for field use although it has not been tested in the field as yet.

Under objective 3, some work was done in the laboratory and a device was built to obtain the capillary pressure saturation curve in situ. However, it is too complicated to be used in the field and the time involved to get one reading is not practical. This device depends on a

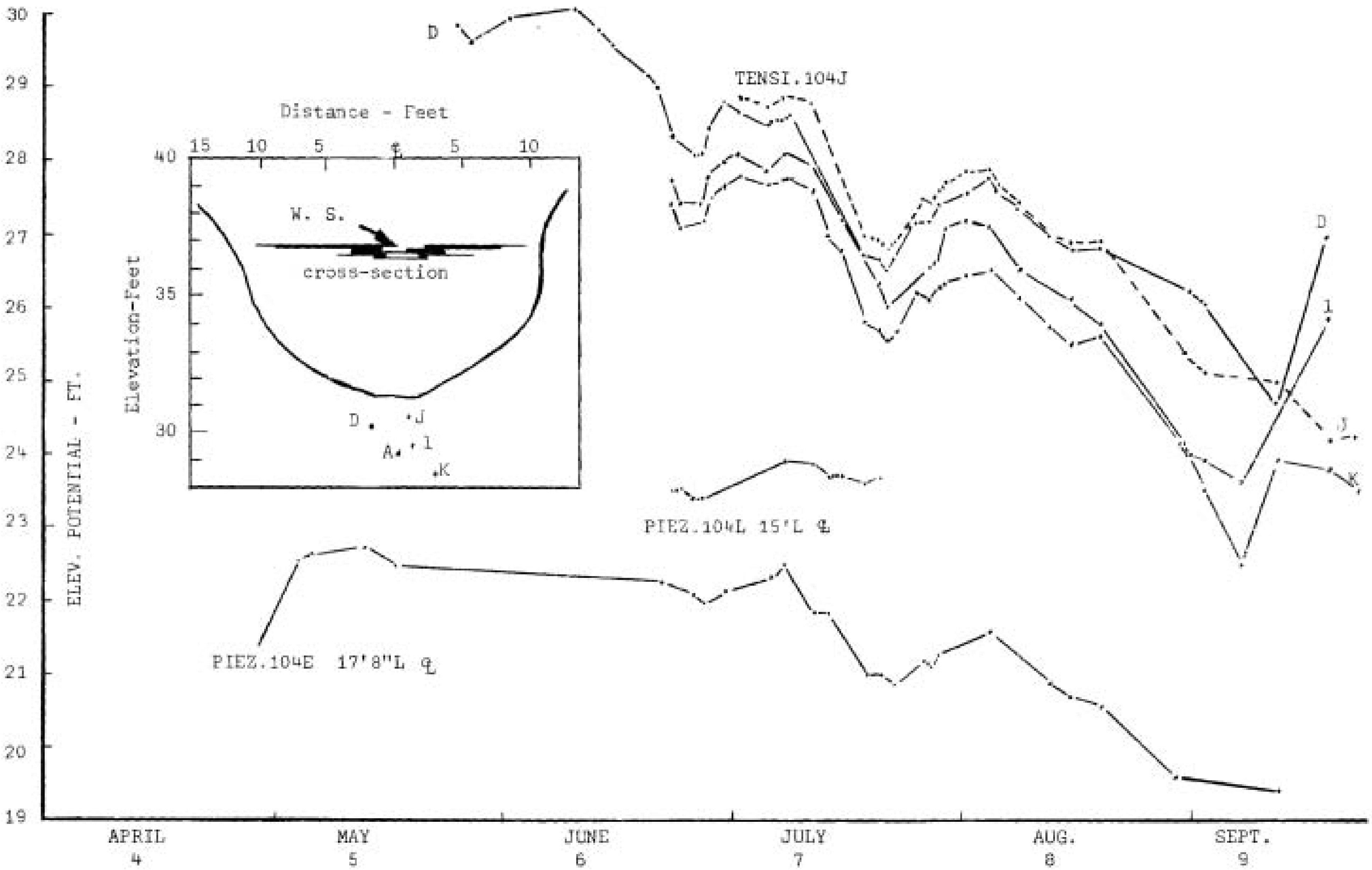

FIGURE 1. TENSIOMETER AND PIEZOMETER POTENTIALS RECORDED AT STATION 104 DURING 1966 IRRIGATION SEASON

steady state flow situation occuring for flow into the soil from a point source. It appears that it will be impossible to develop a practical device for this purpose until the unsteady 3-dimensional equation for flow into a dry soil is solved.

The device developed by Mr. Brockway and others allows field samples to be handled much easier in the laboratory. This sampler is used to remove an undisturbed core which is then encased in heat shrinkable plastic tubing. These samples may then be stored or easily handled without damage until permeability curves may be run in the laboratory. This appears to be a much more feasible procedure than attempting to get measurements of the soil in situ. Details of the laboratory procedure for testing of soil cores in shrinkable tubing are contained in the reference appended to this report.

RESULTS AND CONCLUSIONS

1. A field evaluation of seepage measurement methods showed the ponding method to be the most accurate but the most expensive.
2. The use of seepage meters for obtaining estimates is expedient and economical. A new meter capable of functioning in a canal at operating depth has been developed.
3. A procedure for estimating statistically the number of seepage meter tests required was developed.
4. A reliable tensiometer system and readout for monitoring soil moisture pressure beneath operating canals was constructed.
5. Soil moisture and pressure beneath operating canals may gradually decrease during the irrigation season with a corresponding decrease in seepage flow. This decrease is attributed to gradual sealing by sediment, and microbial activity.
6. A new technique for obtaining and testing undisturbed soil cores using heat shrinkable tubing was developed and used successfully in the laboratory.
7. A null point tensiometer which has a small response time and is relatively inexpensive has been laboratory tested and should be

sufficiently rugged for field use.

8. A device for measuring the capillary pressure saturation curve in situ was constructed but it is too time consuming and complicated for field use.

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