DRAINAGE AND WATER PRODUCTION-COVEYANCE

Research

Fort Collins, Colorado
A. R. Robinson
Summary of Research
1956

Introduction

Cooperation:

The research on this project is carried on cooperatively between the Agricultural Research Service, SWC and the Colorado Agricultural Experiment Station. Both the Civil Engineering and Agricultural Engineering Sections of the Experiment Station are involved. The Soil Conservation Services is cooperating in the studies concerned with drainage to the extent of furnishing information and limited assistance.

Personnel:

The employees at the Fort Collins office consist of R. W. Nelson, Agricultural Engineer (Conservation), Gordon Kruse, Agricultural Engineer, who reported for duty on March 4, 1957, and A. R. Robinson, Agricultural Engineer (General) who is employed cooperatively between the Experiment Station and the Agricultural Research Service, SWC. Mr. Carl Rohwer, formerly Senior Irrigation Engineer, now retired, was recently appointed collaborator in the Fort Collins office.

Research Projects

1. Laboratory and Field Investigation of the Vortex Tube Sand Trap.

Objectives:

1. To make an analysis of existing data on the vortex tube which were taken previously but never analyzed.
2. To make a detailed study in the laboratory of the vortex tube sand trap using a sloping flume and a recirculating sediment system. Under laboratory conditions many of the varibles which should affect the operation of the device can be controlled.
3. To conduct a field study of existing installations of sand traps to determine their effectiveness.
4. To check the operation of the field installations with the laboratory findings.
5. To develop generalized criteria for the design of vortex tubes which may be applied with confidence by designing engineers.
6. To publish a general report on the entire study including the previous studies.

Results:

The flume used in this experiment was available in the Hydraulics Laboratory at Colorado A & M College. The slope of the flume is adjustable by jacks to cover a range of slopes normally encountered in canals. The flume has a length of 160 feet, a width of 8 feet and is equipped with a recirculating system so that the suspended sediment can be circulated with the water.

The only major modification of the existing facilities was the construction of a test section (see figure 1). This section was constructed to contain a vortex tube, the shape and size of which was determined from previous data. The total water discharge through the flume was measured through a pipe orifice with the flow from the tube measured by a 6-inch Parshall flume and by weighing. The sediment discharge in the channel was determined using a traversing sampler across the overfall from the flume. A diverter and weighing tank was used to measure the sediment discharge from the tube. The concentrations of sediment were determined in parts per million by weight.

Figure 2 shows the sediment removal efficiency for the tube tested. The efficiency is defined as the ratio in percent of sediment moving in the channel to that removed by the tube. The Froude number is a ratio of velocity to depth of flow. The efficiencies are plotted as an overall efficiency considering the total sediment load and also for four size fractions. Also shown, is the efficiency assuming that the sediment removed is in direct proportion to the amount of water removed. Shown above each set of data is the total load of sediment (ppm by weight) which was flowing in the channel at the time that the test was made.

The amount of water removed by the tube varied from approximately 10 to 19 percent depending on the velocity and depth of flow across the tube. Generally, the efficiency of trapping was very good for the coarser fractions of material. For the range of material sizes greater than 0.295 mm (0.012 inches) an efficiency of trapping of approximately 80 percent is indicated. As would be expected the efficiency in trapping the finer fraction (in this case less than 0.295 mm) is much lower. Even for this material some trapping was accomplished over and above the percentage of water which was removed by the tube.

2. Measuring Devices for Small Canals

Objectives:

The objective of this study is to develop and calibrate water measuring devices and to improve existing devices.

Results:

A standard design for 1 and 2-inch Parshall flumes was developed. Flumes were constructed and calibrations made in the Hydraulics Laboratory utilizing a small flume. Accurate determinations were made of depth of flow and discharge for both free flow and submerged flow conditions. The depths were measured using hook gages and wells and the discharge determined by weighing.

At least two flumes of each size were calibrated. The flumes were found to be accurate devices for measuring small flows provided care was exercised in the construction and installation. Accurate discharge measurements can be made even under submerged flow conditions.

The results of this study are presented in detail in the Colorado Experiment Station Technical Bulletin No. 61.

3. Development of Drainage Design Criteria for Irrigated Lands

Objectives:

The general objective is to provide drainage engineers with dependable criteria upon which to base the design of new drains on irrigated lands in Colorado. The following specific objectives amplify the general objective.

1. To determine if a relationship between measured discharge, farm water supply, physical features of the drain system and drainage characteristics of the soils can be used to predict water yields to be expected from new drains.

2. To check by field data the theoretically derived relationships between soil drainage properties, shape of the water table drawdown and boundary conditions.

3. To determine by field observation the applicability of the findings from the previous interceptor drain model study to actual field conditions.

Results:

Tile drain systems are studied on nine farms in Northeastern Colorado the first season. These nine systems are of the interceptor type and were chosen to best represent the most prevalent drainage problems.

The discharge from the drains were collected by means of automatic recorders attached to small measuring flumes. The physical features and soils data were assembled from Soil Conservation Service records. Ground water levels were collected from cased observation holes installed in lines normal to drain lines. Hydraulic conductivity measurements employing the auger hole method were made.

In order to have some method of classifying the drainage situation for each farm, a classification index was adapted. This index is shown in figure 1.

A summary of data for the farms are given in table 2. Shown are the classification, the hydraulic conductivity, and tile flows.

On the farms studied there seemed to be no relationship between tile flows and measured hydraulic conductivity, disregarding the other variables. There was a considerable fluctuation of flows from the drains for most of the season. The shape of the ground water profile varied depending on irrigation, rainfall and flow in a nearby canal.

Table 1
Farm Classification Scheme
for Characterizing the Drainage Situation

Stratification or uniformity of soil:

No. 1	highly stratified -	> 50% of profile is unlike material
2	moderately stratified -	10 - 50% of profile is unlike material
3	uniform -	< 10% of profile above rock is unlike material

Hydraulic Conductivity - average value by auger hole method:

No. 1	very slow	< 0.06 inches/hr.
2	slow	0.07 - 0.29 inch/ hr.
3	moderate	0.30 - 3.0 inch/hr.
4	rapid	3.1 - 6.0 inch/hr.
5	very rapid	> 6.0 inch/hr.

Thickness of soil material over barrier:

No. 1	< 48 inches
2	48 - 72
3	72 - 120
4	> 120

Slope of land (in vicinity of effective drain line):

A	0 - 1%
B	1 - 3
C	3 - 6
D	> 6

Probable source of ground water:

F	Canal
G	Canal and irrigation
H	Irrigation

Table 2—Summary of Tile Interceptor Drain Study, 1956

Farm No.	Farm	Farm #1 Classification	Length of Pickup Line Feet	Hydraulic #2 Conductivity in./hr.	Maximum Flow date	Maximum Flow cfs	Maximum Flow cfs/1000 ft	July cfs	July cfs/1000 ft	August cfs	August cfs/1000 ft	September cfs	September cfs/1000 ft
1	Aranci	2-3 BG	1539	- -	7-21	1.13	0.74	0.71	0.46	0.57	0.37	0.47	0.31
2	EPH Corp.	343 BF	1045	4.6	7-12	0.042	0.040	0.026	0.025	0.029	0.028	0.015	0.014
3	Foote	353 AG	2645	9.8	8-17	0.60	0.23	0.35	0.13	0.36	0.14	0.30	0.11
4	Kluver	333 BG	1200	1.8	- -	- -	- -	- -	- -	0.22	0.18	0.20	0.17
5	McCormick	242 AH	1436	4.8	7-30	0.51	0.35	0.025	0.017	0.013	0.009	0.035	0.024
6	Ragan	243 CH	600	5.6	8-19	0.28	0.47	0.12	0.20	0.15	0.25	0.10	0.17
7	Spangler	232 AH	1990	2.0	8-21	0.047	0.024	0.022	0.011	0.028	0.014	0.029	0.015
8	Sprenger	353 AF	600	6.4	7-27	0.095	0.158	0.026	0.043	0.030	0.050	dry	--
9	Stewart	333 BG	1570	2.6	8-25	0.068	0.043	0.039	0.025	0.048	0.030	0.037	0.024

#1 See Table 1 for explanation of classification system

#2 Determined by auger hole method.

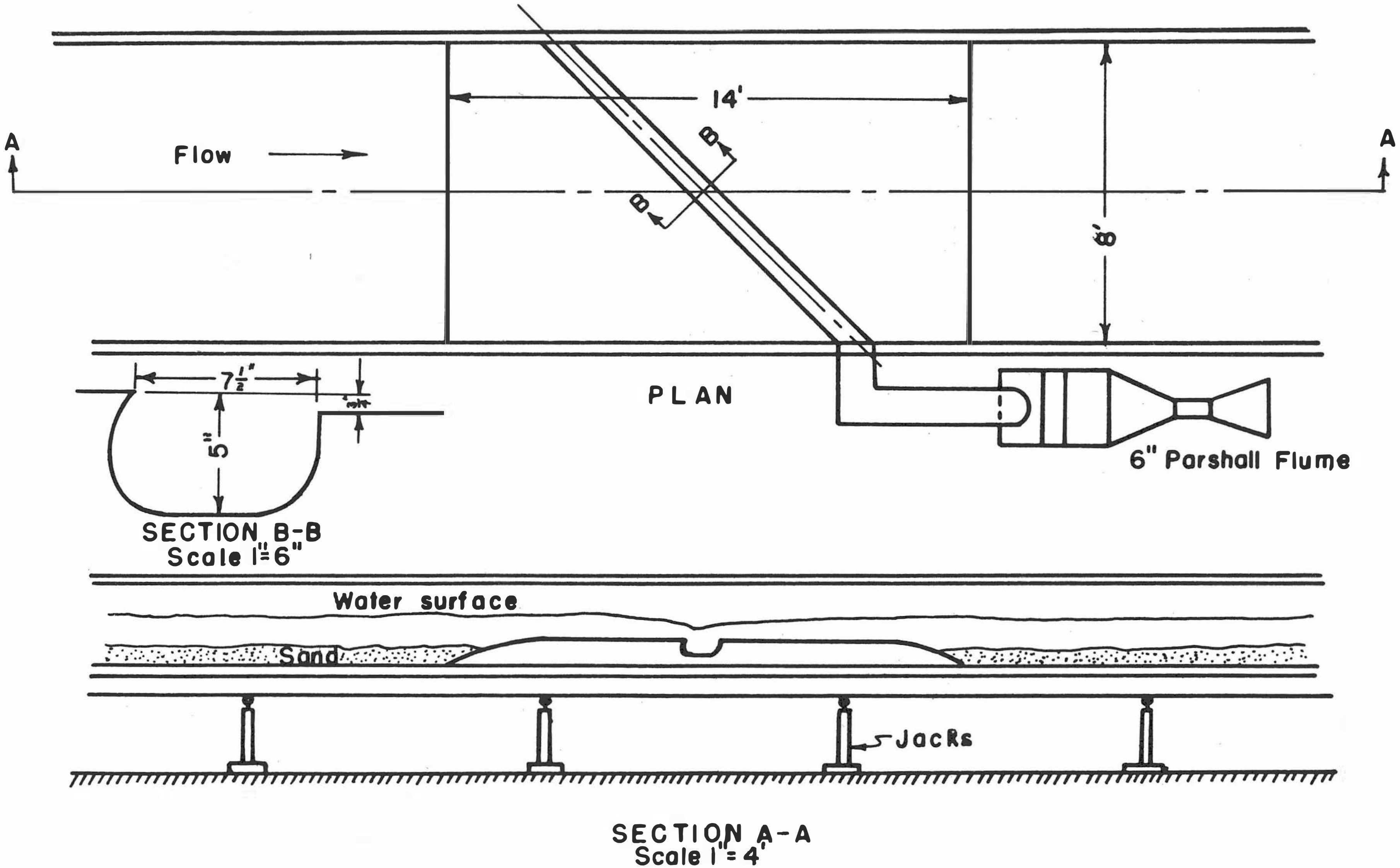
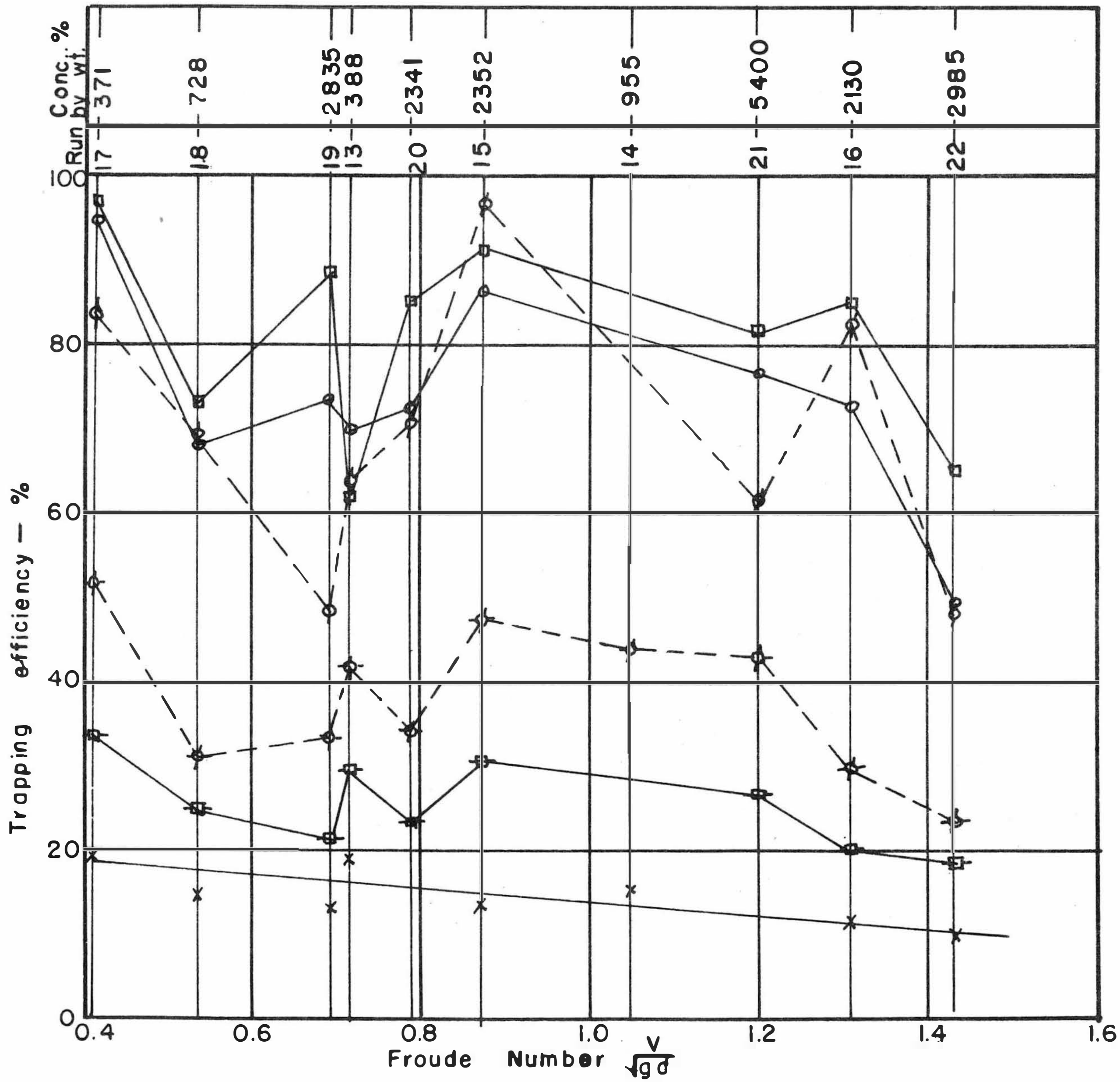


FIGURE I LAYOUT OF VORTEX TUBE SAND TRAP



LEGEND

- Total efficiency
- x Ratio of water removed to total flow
- Greater than 0.833 mm.
- 0.589 – 0.833 mm.
- 0.295 – 0.589 mm.
- Less than 0.295 mm.

Run No	Deposits in Tube
12	Deposits in middle half.
13	Small deposits full length.
14	Tube clean.
15	Small deposits full length Partly full 1/3, 1/2, 2/3 points
16	Tube clean
17	Deposits middle 2/3.
18	Deposits end 2/3. (away from outlet.
19	Deposits middle 2/3.
20	Deposits at 1/3 + 2/3 points.
21	Tube 5/8 full 3/4 of length from closed end.
22	Tube clean.

FIGURE 2 TRAPPING EFFICIENCY OF THE VORTEX TUBE SAND TRAP