SPEER CANAL SEEPAGE STUDY

by

Gale A. Lutz

Prepared
for
Farmer's Reservoir and Irrigation Company
of
Denver, Colorado

Colorado State University
Civil Engineering Section
Fort Collins, Colorado

February 1963

CER63GAL10

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INTRODUCTION

During the summer of 1962, the Sediment-Sealing Project at Colorado State University conducted a study of the seepage losses in about 20 miles of the Speer Canal of the Farmer's Reservoir and Irrigation Company. The study section started at the Barr Lake outlet and extended downstream (north) to the bifurcation. Barr Lake is about 15 miles northeast of Denver.

On July 30, 1962, a clay-sealing trial was completed in a 3.5 mile section of the Speer Canal. This test section is toward the lower end of the 20-mile section used in the seepage study mentioned above.

This report summarizes the results of the seepage study on the 20-mile section of the Speer Canal. It also summarizes the results of the clay-sealing trial.

PROCEDURE

The seepage study consisted of the development of water depth (stage) - discharge ratings for the following locations: (1) Barr Lake outlet; (2) Ft. Lupton road, (3) Kone road, (4) Speer canal at the bifurcation, and (5) Platteville lateral at the bifurcation. At each of these sites a water-stage recorder was installed to provide a continuous record of the water depth. The development of the water depth (stage) - discharge rating was done by current meter measurements of various water depths at each of the sites. These curves are shown in Figs. 1 through 5. Through the use of the above gaging stations and the diversion records, the water losses were determined by inflow - outflow measurements.

The clay-sealing trial was held in the reach between the Kone Road and the bifurcation gaging stations. Eleven clay dams (built with a Quickway dragline) were spaced at about 1/4 mile intervals throughout the reach. The dams contained about 30 yards of minus 1/4" diameter clay[1],

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[1] Marshall Lake clay deposit (SJ7) located south of Boulder, Colorado.

except for Dam No. 7 which contained about 50 yards of clay and Dam No. 8 which contained about 20 yards of clay. The dams were broken in various ways using the Quickway dragline and all methods were successful in causing the clay to go into suspension. The ponding time behind each dam was about 30 minutes.

ANALYSIS OF RESULTS

An examination of Fig. 1 through 5 show that a fairly good water depth (stage) - discharge relationship was obtained for all the gaging station except for the Barr Lake outlet station. To improve the rating curve for the outlet station, frequent current meter measurements should be made at various water depths during the summer of 1963. Since the Speer Canal carries considerable bed load sand, frequent current meter measurements should be made at all of the gaging stations so that the rating curves are kept up to date.

CONCLUSIONS

The conclusions of this study are divided into two parts; (1) the seepage study, and (2) clay-sealing results.

A. Seepage Study

Figures 6 through 10 show the flow hydrographs for the gaging stations located at the Barr Lake outlet, Ft. Lupton road, and the Ione road. In these figures, all the diversions between any two of the gaging stations are included in the flow hydrographs and therefore, the difference between any two lines is the water losses. In Fig. 11 and 12 are the flow hydrographs for the reach between the Ione road and the bifurcation. The losses that are indicated on all of these figures were obtained by planimetering the curves.

Fig. 13 is a plot of the average daily discharge and again the difference between any two lines is the water losses.

From the flow hydrographs, it can be concluded that the highest water loss occurs in the reach between the Barr Lake outlet and the Ft. Lupton road gaging stations.

B. Clay-sealing Results

As shown in Fig. 11, the before sedimenting losses was about 4%. Since the estimated accuracy of the current metering and the diversions is ± 10%, an accurate evaluation of the clay-sealing cannot be obtained. In an attempt to evaluate the effects of the clay-sealing, the efficiency of this reach was calculated for the runs before sealing and after the sealing (see tables 1a - 1b and Fig. 13). The efficiencies shown for the run of June 22 - 29 are only an estimate since the flow at the bifurcation was estimated for this run. The before clay-sealing run of July 10 - 17 indicates an average efficiency of 97%. The after clay-sealing run of August 10 - 17 indicates an average efficiency of only 95%, but at the beginning and at the end of this run very low efficiencies are indicated. By omitting these two low values of efficiencies from the average value, an average efficiency of 98% is obtained. This 1% increase in the efficiency seems to indicate some sealing, but since the flow measurements and the diversion measurements are only accurate to about ± 10%, no definite conclusion can be made about the clay-sealing in this reach.

Discharge checks were also made on a reach of the Platteville Lateral between the bifurcation and a point about 1-1/2 miles west of the bifurcation. About 30 yards of clay were dumped into this reach during the run immediately preceding the clay-sealing trial. All of the excess clay-sealing water from the Speer Canal clay-sealing trial was also run into this reach. The results of the discharge measurements are tabulated below:

Date	Q(cfs) Bifurcation	Q(cfs) 1-1/2 Miles West	Loss (cfs)	% Loss
		Before Clay-Sealing Trial		
May 30, 1963	15.8	12.2	3.6	22.8
June 22, 1963	12.9	11.3	1.6	12.4
		After Clay-Sealing Trial		
Aug. 16, 1963	15.1	15.6	0.5 - gained	
Aug. 28, 1963	6.8	7.6	0.8 - gained	

The above table indicates that the clay-sealing was effective in the reduction of the seepage losses with in this reach.

RECOMMENDATIONS

1. Frequent current meter checks at all of the gaging stations.

2. Make the following correction on the two weirs at the bifurcation:[1]

   a. Sharpen the weir blades
   b. Air vents should be installed on the underside of the nappe.
   c. The staff gages should be moved from the present locations to a point that is 4 to 6 times the maximum stage upstream from the crest. Between 4 to 6 ft for these weirs.
   d. The distance of the crest from the bottom of the approach channel (weir pond) should preferably be not less than twice the depth of water above the crest, or about a two foot depth for these weirs.

3. Set up a clay-sealing trial for the reach of canal between the outlet and the Ft. Lupton Road gaging stations. The reasons for the selection of this reach are:

   a. A low efficiency reach (high losses).
   b. Few diversions.
   c. The flow of water can be easily controlled during the trial.
   d. Excess clay will be put to use in the lower part of the canal.

In preparation for the clay-sealing, this reach of canal should be cleaned as thoroughly as possible. The reason for the removal of the sand is that the clay seal seems to form in the sand and as the sand is washed downstream the clay-seal is destroyed.

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[1] Water Measurement Manual, Bureau of Reclamation, pp. 9-10, 1953.

TABLE 1 a - BEFORE CLAY SEALING

Day of Month	Daily Discharge in Acre-feet				Efficiency in %			Daily losses in Acre-feet				
	Spear Outlet	Ft.Lupton Road	Ione Road	Bifurcation	Outlet to Ft.Lupton R	Ft.Lupton to Ione R	Ione to Bifurcation	Outlet to Bifurcation	Outlet to Ft.Lupton	Ft.Lupton to Ione	Ione to Bifurcation	Outlet to Bifurcation
June												
22	214	154	148	144	72	96	98	67	60	6	4	70
23	214	156	152	146	73	97	96	68	58	4	6	68
24	220	156	150	142	71	96	95	65	64	6	8	78
25	225	168	160	150	75	95	94	67	57	8	10	75
26	230	166	158	152	72	95	96	66	64	8	6	78
27	234	168	158	154	71	94	97	66	66	10	4	80
28	238	166	154	146	70	95	95	61	72	12	8	92
29	238	158	158	150	66	100	95	63	80	0	8	88
Total	1813	1252	1258	1184					521	54	54	629
Average*	227 A-ft day	162 A-ft day	155 A-ft day	148 A-ft day	71	95	95	65	65 A-ft day	6.7 A-ft day	6.7 A-ft day	78.6 A-ft day
July												
11	182	123	103		68	84			59	20		
12	256	154	119		65	77			82	35		
13	252	174	144	150	69	85	104	59	78	30	(+ 6)	102
14	264	186	158	154	70	85	97	58	78	28	4	111
15	258	186	158	150	72	85	95	58	72	28	8	108
16	256	176	156	148	73	89	95	63	60	20	8	88
17	214	137	114	137	64	105	95	64	77	(+ 7)	7	77
Total	1642	1136	982	739					506	161	27	436
Average*	235 A-ft day	162 A-ft day	140 A-ft day	148 A-ft day	69	84	97	60	72.3	26.7	6.7	97.4

Estimated Flow

Estimated Values

*) Averages were calculated by omitting figures in parenthesis

TABLE 1 a - AFTER CLAY SEALING

Day of Month	Daily Discharge in Acre-feet				Efficiency in %				Daily losses in Acre-feet			
	Speer Outlet	Ft.Lupton Road	Ione Road	Bifurcation	Outlet - Ft.Lupton	Ft.Lupton - Ione	Ione - Bifurcation	Outlet - Bifurcation	Outlet - Ft.Lupton	Ft.Lupton - Ione	Ione - Bifurcation	Outlet - Bifurcation
August												
10	168	107	123	101	64	115	(82)	60	61	(+ 16)	(22)	67
11	178	134	125	119	75	93	95	67	44	(9)	6	59
12	208	152	132	132	73	87	100	63	56	20	0	76
13	220	166	144	142	74	87	99	65	54	22	2	78
14	232	164	142	142	71	86	100	61	68	22	0	90
15	222	176	154	146	79	88	95	66	46	22	8	76
16	214	172	152	148	80	88	97	69	42	20	4	66
17	176	134	133	99	76	99	(75)	56	42	(1)	(34)	77
Total	1618	1205	1105	1029					413	105	20	569
Average*	202	151	138	129	74	90	98	63	52	21.2	3.3	74
August												
24	182	154	150	117	85	97	(78)	64	28	4	(33)	65
25	184	146	137	131	79	94	96	71	38	9	6	53
26	164	142	142	131	86	100	92	80	22	0	11	33
27	137	124	124	121	91	100	98	88	13	0	3	16
28	125	113	108	101	90	96	94	81	12	5	7	24
29	97	95	93	79	98		(84)	81	2	2	14	18
Total	889	774	754	680					115	20	41	209
Average*	148	129	126	113	86	97	95	78	19.2	3.3	8.2	35

* Averages were calculated by omitting figures in parenthesis

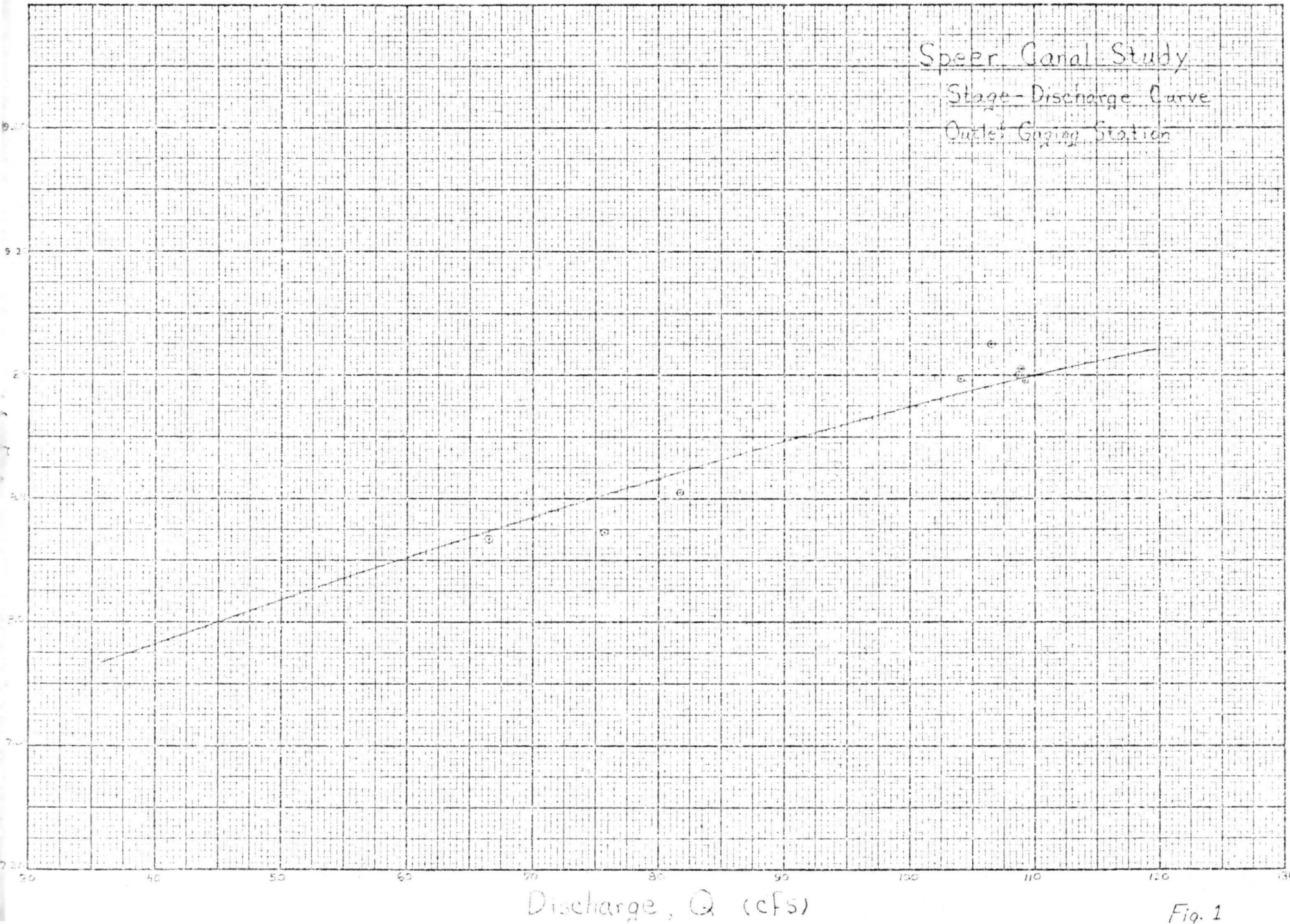

Speer Canal Study
Stage - Discharge Curve
Outlet Gaging Station
9.2
30
40
50
60
70
80
90
100
110
120
130
Discharge, Q (cfs)

Fig. 1

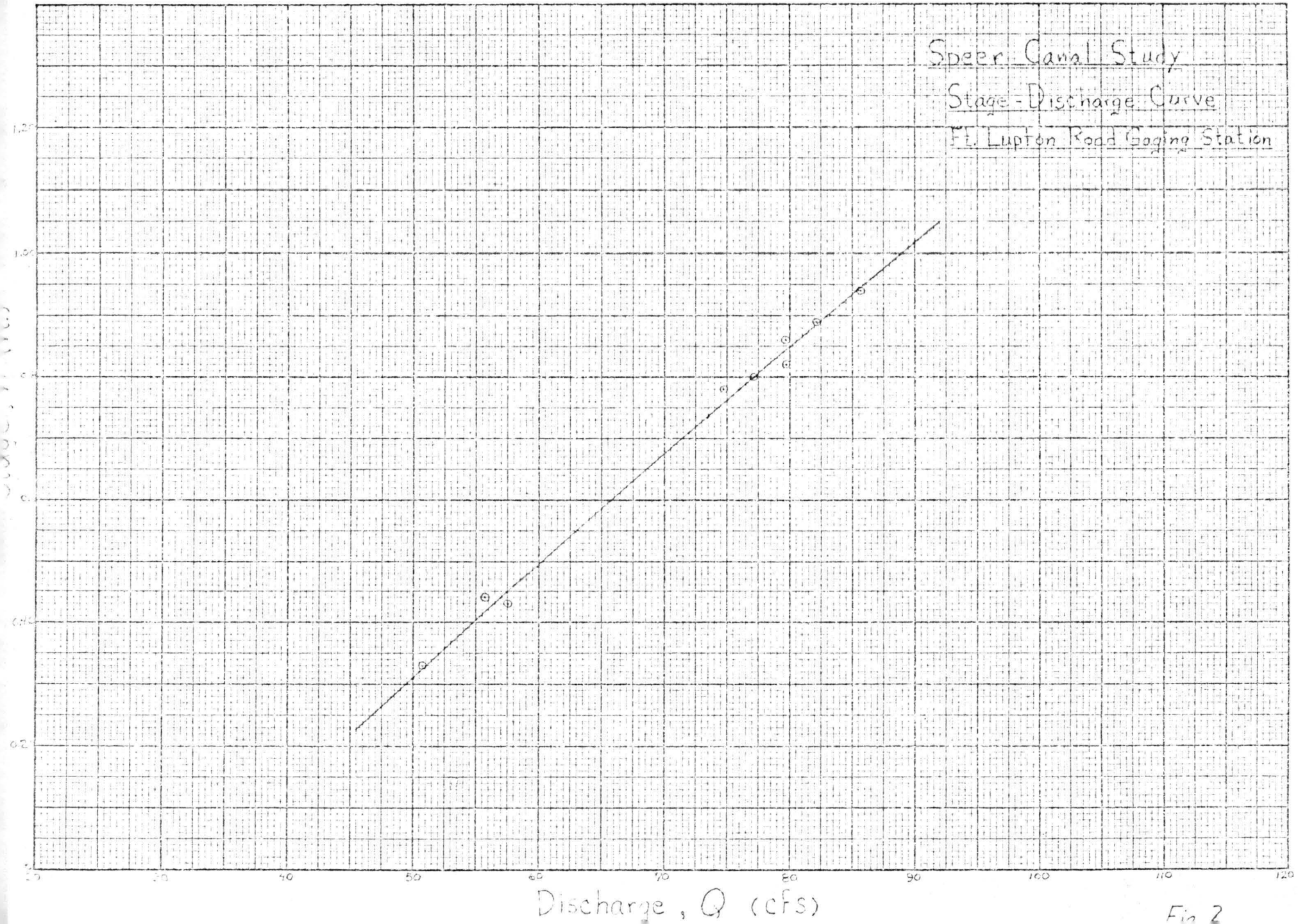

Speer Canal Study
Stage - Discharge Curve
Ft. Lupton Road Gaging Station
1.20
1.00
0.8
0.6
0.4
0.2
40
50
60
70
80
90
100
110
120
Discharge, Q (cfs)

Fig 2

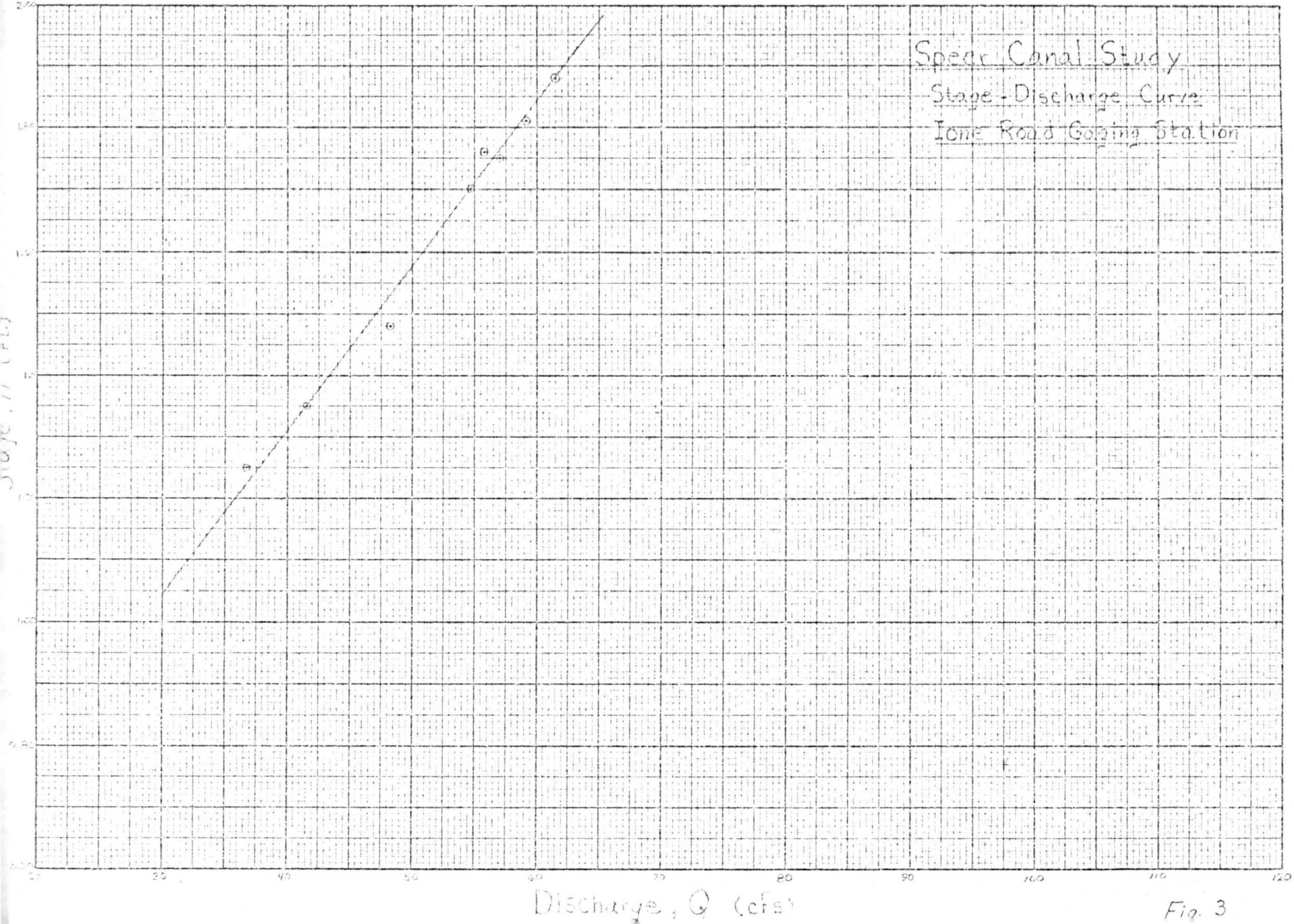

Spear Canal Study
Stage - Discharge Curve
Ione Road Gaging Station
Stage, H (ft)
Discharge, Q (cfs)
30
40
50
60
70
80
90
100
110
120

Fig. 3

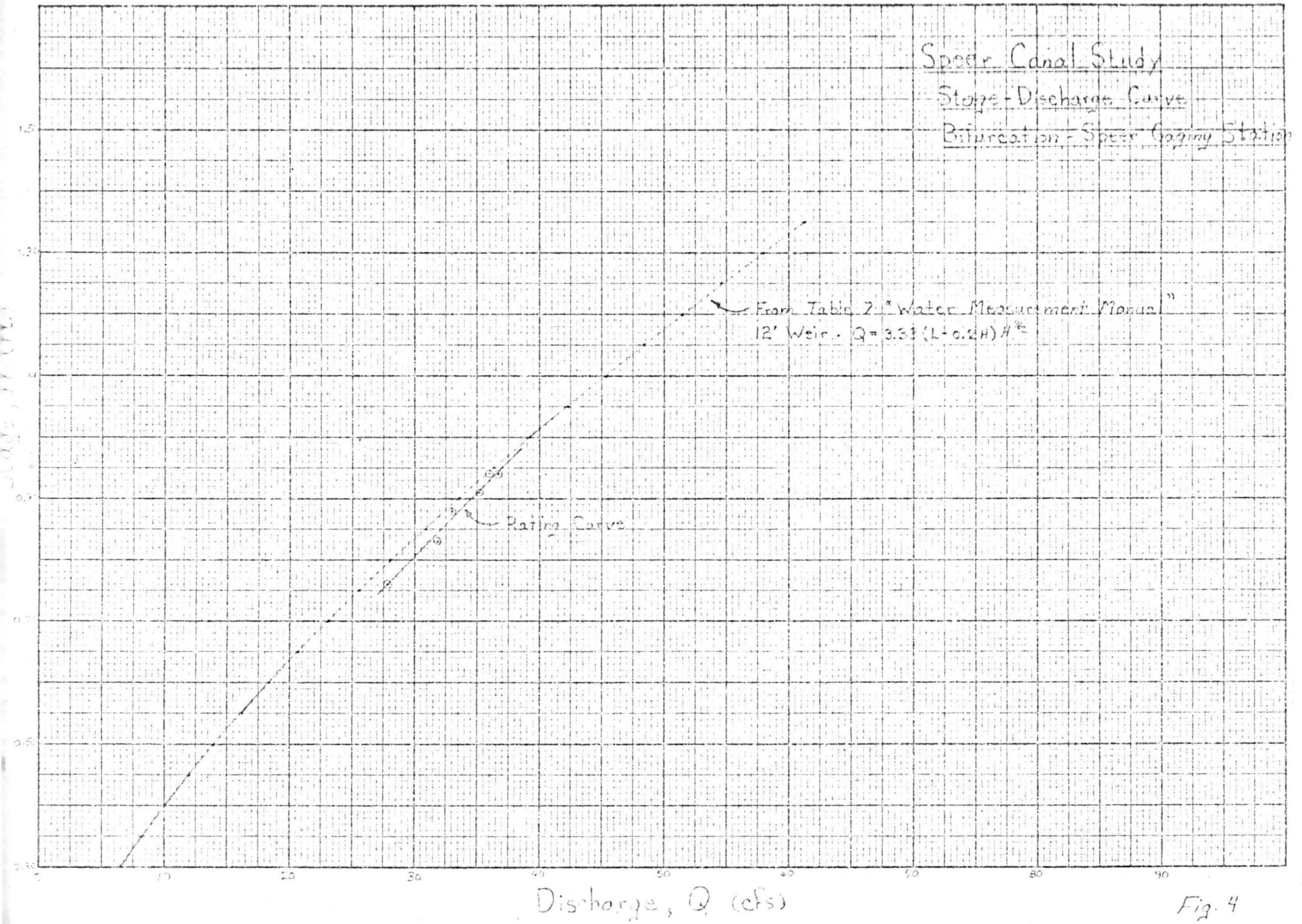

Speer Canal Study
Stage-Discharge Curve
Bifurcation - Speer Gaging Station
From Table 7 "Water Measurement Manual"
12' Weir. Q = 3.33 (L - 0.2H) H^3/2
Rating Curve
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
80
90
Discharge, Q (cfs)

Fig. 4

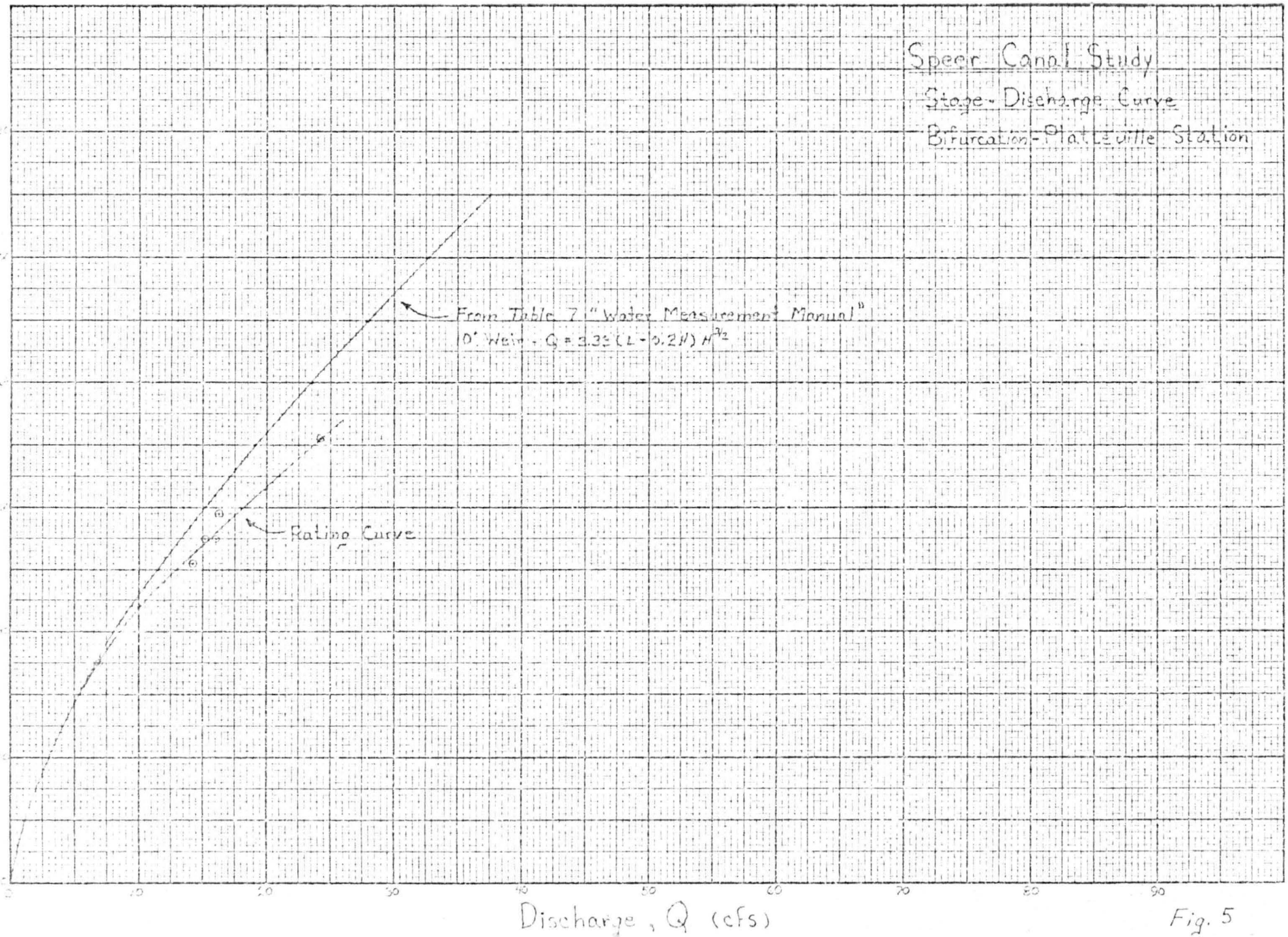

Speer Canal Study
Stage - Discharge Curve
Bifurcation - Platteville Station
From Table 7 "Water Measurement Manual"
10' Weir - $Q = 3.33 (L - 0.2H) H^{3/2}$
Rating Curve
0
10
20
30
40
50
60
70
80
90
Discharge, Q (cfs)

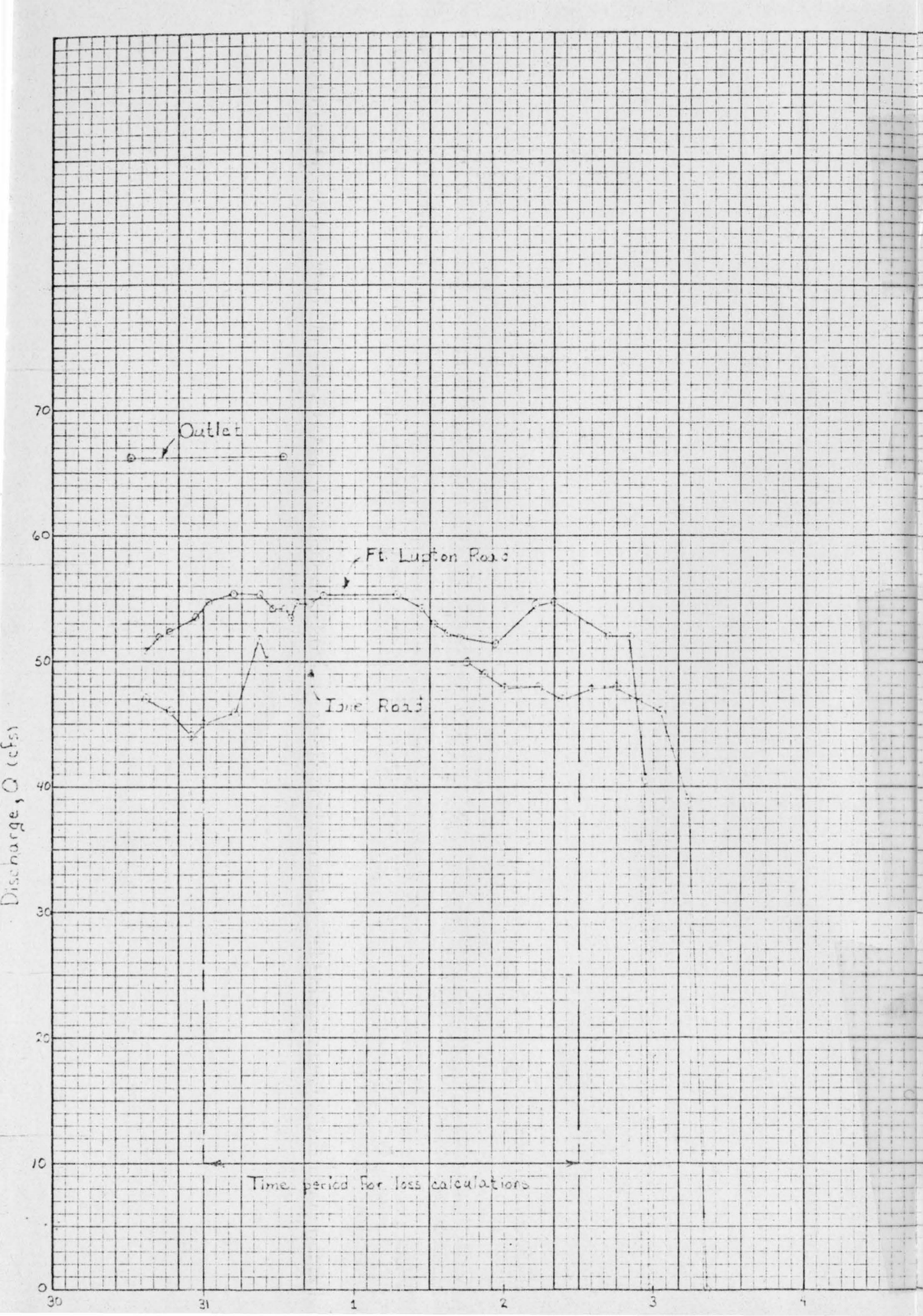
Fig. 5

Spear Canal Seepage Study

May 30 to June 4

Accuracy ± 10 %

Note: Indicated discharges include diversions



Avg. Q @ Ft. Lupton Road = 46.5 cfs

Losses:

Outlet to Ft. Lupton = ~

Ft. Lupton to Ione = 4.6 cfs avg.

% loss:

Outlet to Ft. Lupton = ~

Ft. Lupton to Ione = 10%

Total losses:

Outlet to Ft. Lupton = ~

Ft. Lupton to Ione = 27 Ac-Ft.

Distance between Gaging Stations:

Outlet to Ft. Lupton ≈ 10.5 miles

Ft. Lupton to Ione ≈ 6.2 miles

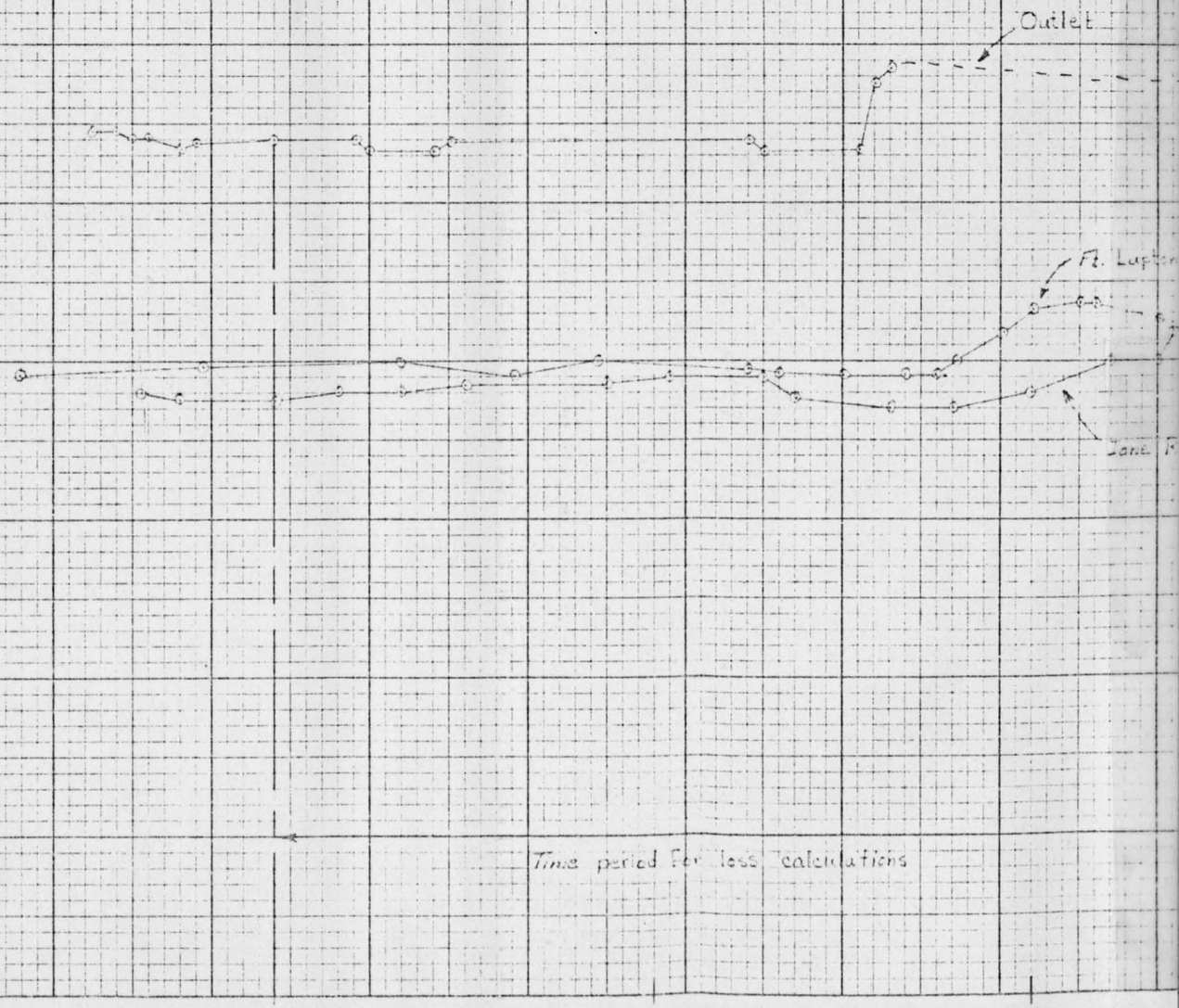
Ione to Bifurcation ≈ 3.7 miles

Speer Canal Seepage Study

June 22 to July 1

Accuracy ± 10%

Note: Indicated discharges include diversions



Avg. Q @ Outlet = 116 cfs

Losses:

Outlet to Ft. Lupton = 31 cfs avg.
Ft. Lupton to Ione = 3.6 cfs avg.
Outlet to Ione = 34.6 cfs avg.

% loss:

Outlet to Ft Lupton = 27 %
Ft. Lupton to Ione = 3 %
Outlet to Ione = 30 %

Total losses:

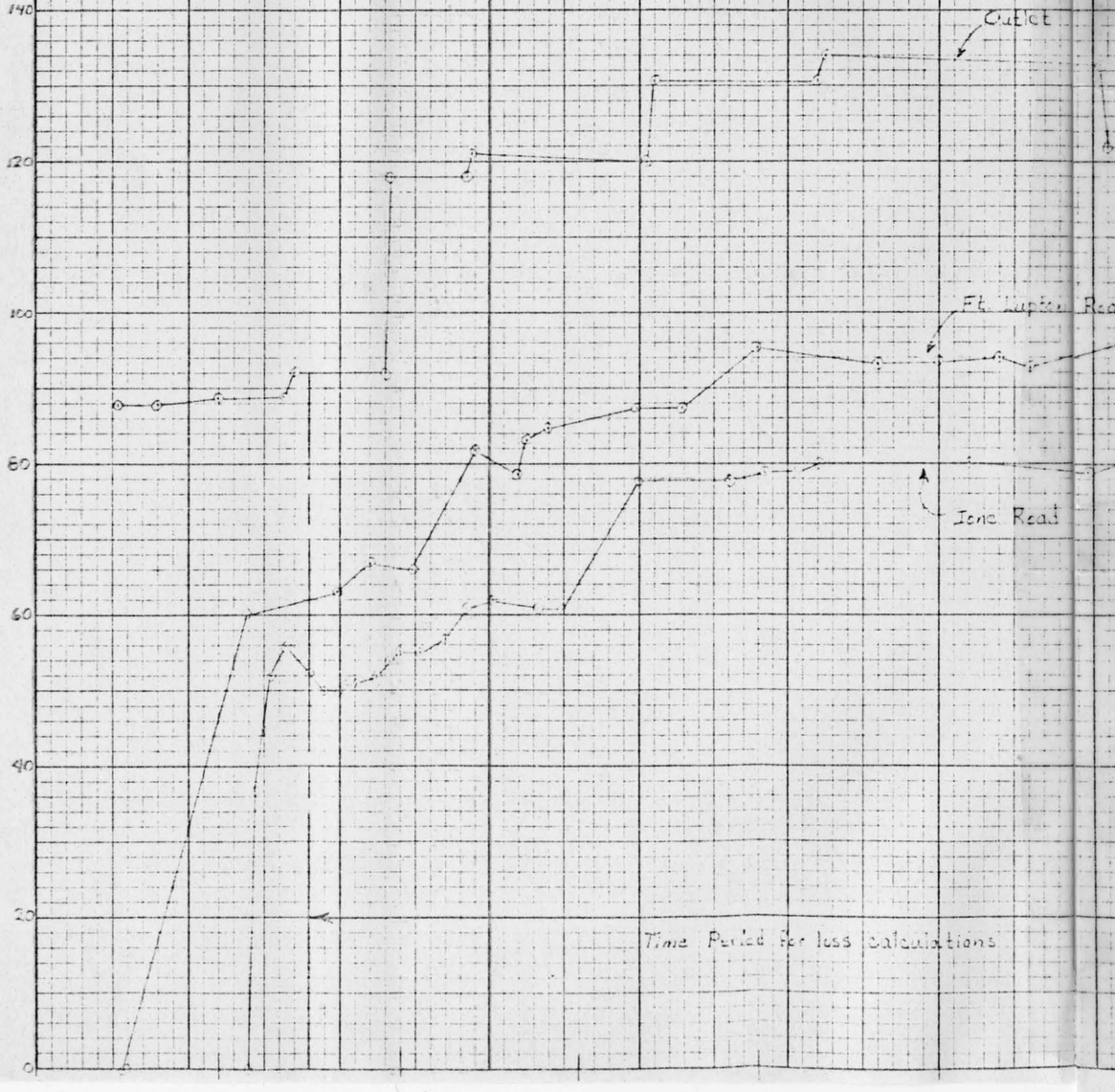
Outlet to Ft Lupton = 154 Ac-Ft.
Ft. Lupton to Ione = 18 Ac-Ft.
Outlet to Ione = 172 Ac-Ft.

Speer Canal Seepage Study

July 10 to July 20

Accuracy ± 10%

Note: Indicated discharges include diversions



Avg. Q @ Outlet = 126 cfs

Losses:

Outlet to Ft Lupton = 37 cfs avg.

Ft Lupton to Ione = 13 cfs avg.

Outlet to Ione = 50 cfs avg.

% loss:

Outlet to Ft Lupton = 29%

Ft Lupton to Ione = 10%

Outlet to Ione = 39%

Total loss:

Outlet to Ft Lupton = 442 Ac-Ft.

Ft Lupton to Ione = 156 Ac-Ft.

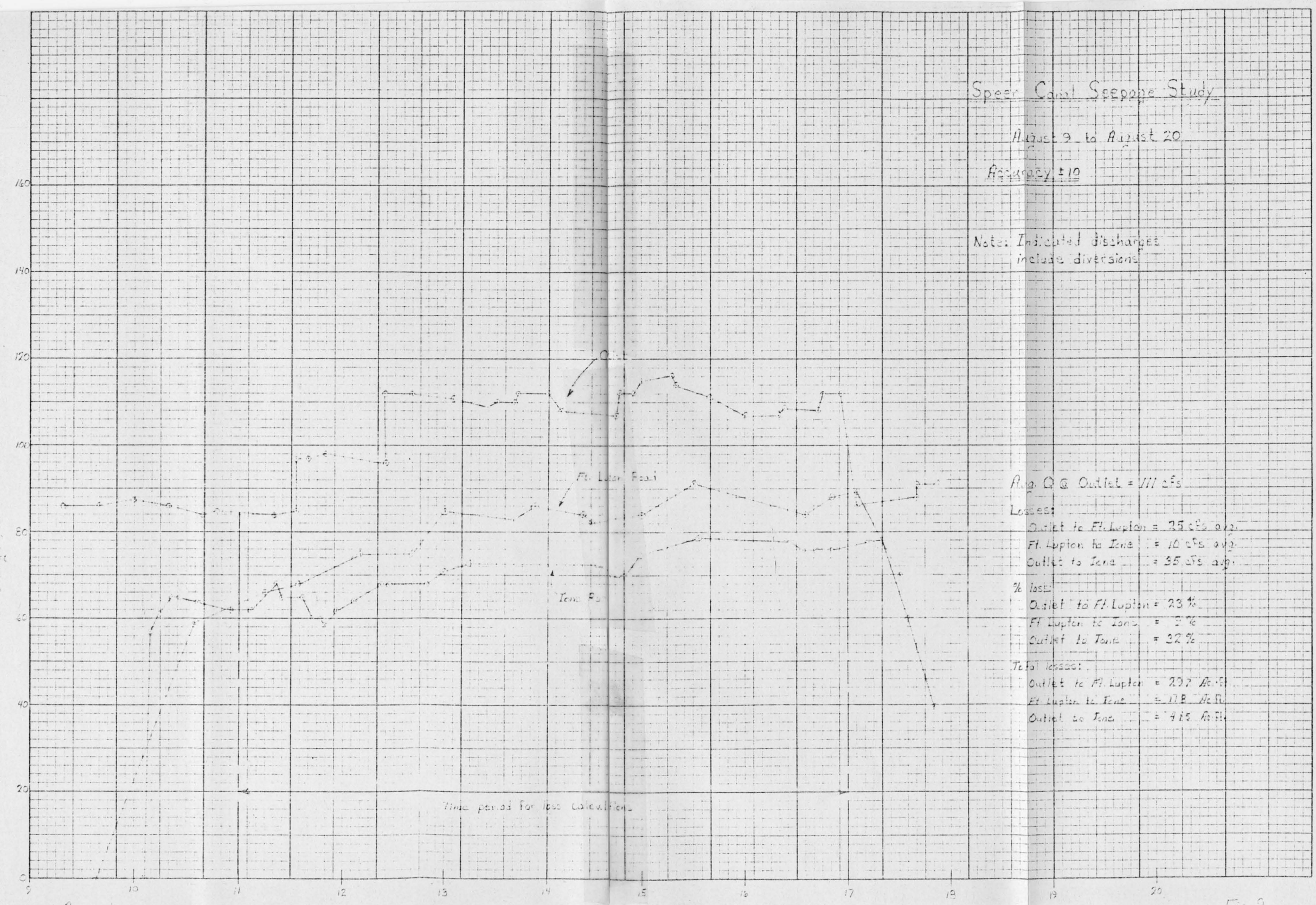
Outlet to Ione = 600 Ac-Ft.

Speer Canal Seepage Study

August 9 to August 20

Accuracy ± 10

Note: Indicated discharges include diversions



Avg. Q @ Outlet = 111 cfs

Losses:

Outlet to Ft. Lupton = 25 cfs avg.

Ft. Lupton to Ione = 10 cfs avg.

Outlet to Ione = 35 cfs avg.

% loss:

Outlet to Ft. Lupton = 23 %

Ft. Lupton to Ione = 9 %

Outlet to Ione = 32 %

Total losses:

Outlet to Ft. Lupton = 237 Ac-Ft

Ft. Lupton to Ione = 118 Ac-Ft

Outlet to Ione = 415 Ac-Ft

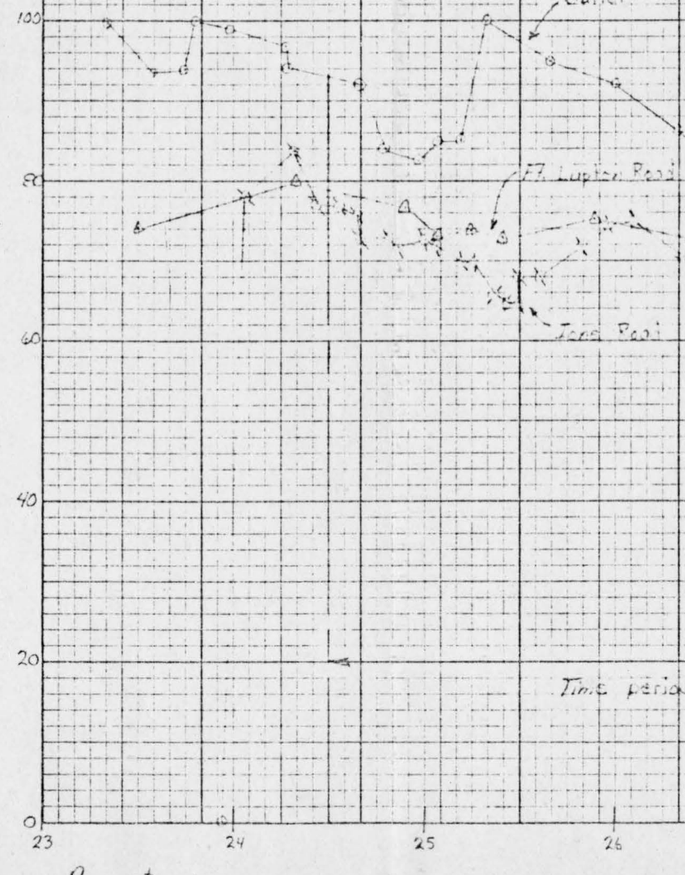
Fig. 9

Spear Canal Seepage Study

August 23 to September 4

Accuracy ± 10%

Note: Indicated discharges include diversions



Avg. Q @ Outlet = 81 cfs

Losses:

Outlet to Ft. Lupton	= 10.7 cfs avg.
Ft. Lupton to Ione	= 2.7 cfs avg.
Outlet to Ione	= 13.4 cfs avg.

% loss:

Outlet to Ft. Lupton	= 14%
Ft. Lupton to Ione	= 3%
Outlet to Ione	= 17%

Total losses:

Outlet to Ft. Lupton	= 95 Ac-ft.
Ft. Lupton to Ione	= 24 Ac-ft.
Outlet to Ione	= 119 Ac-ft.

Fig 10

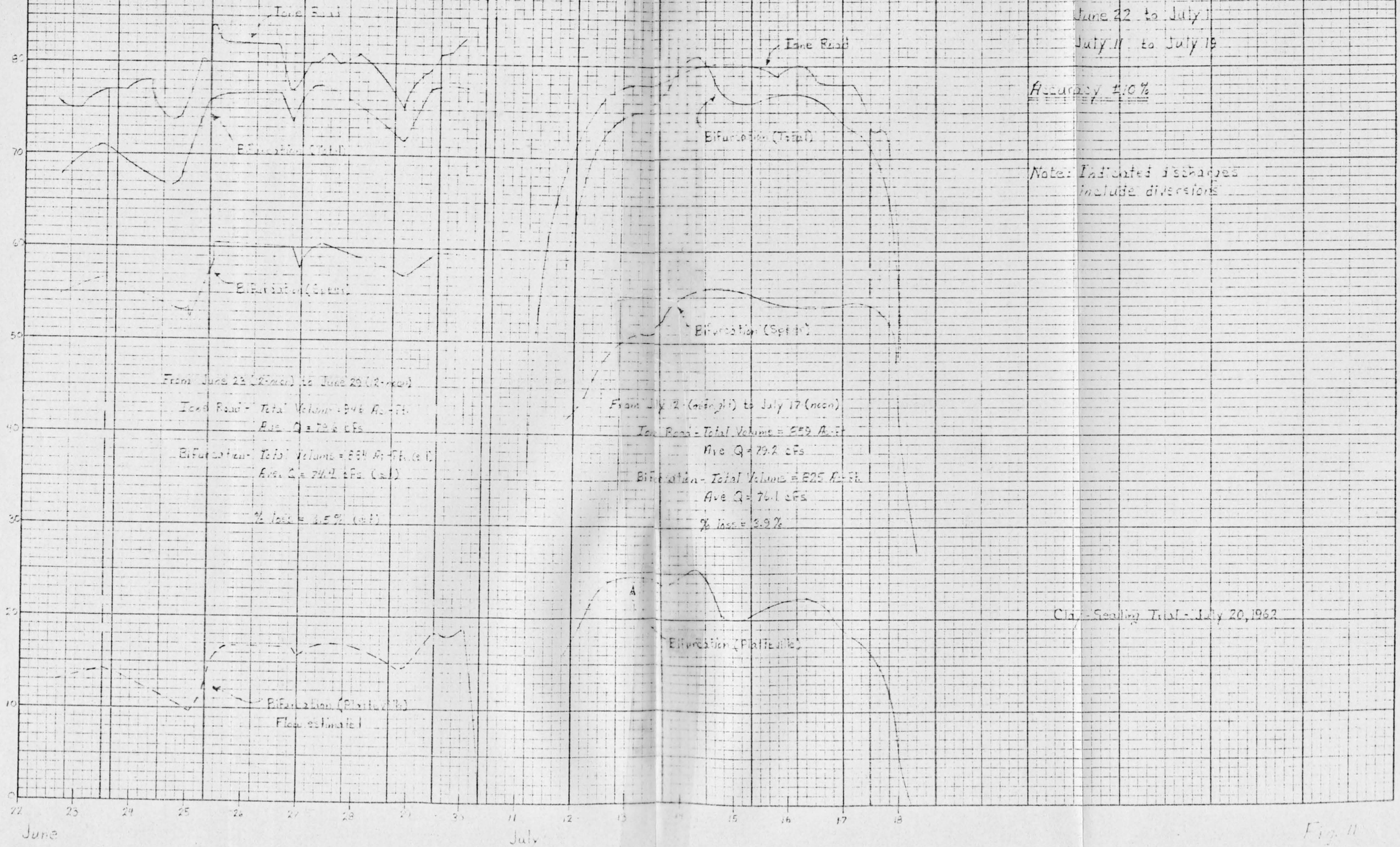
Spare Canal Seepage Study

June 22 to July 1

July 11 to July 19

Accuracy ±10%

Note: Indicated discharges include diversions



Clay - Sealing Trial - July 20, 1962

Fig. 11

Speer Canal Seepage Study

August 10 to August 17

August 23 to September 2

Accuracy ± 10

Note: Indicated discharges include diversions

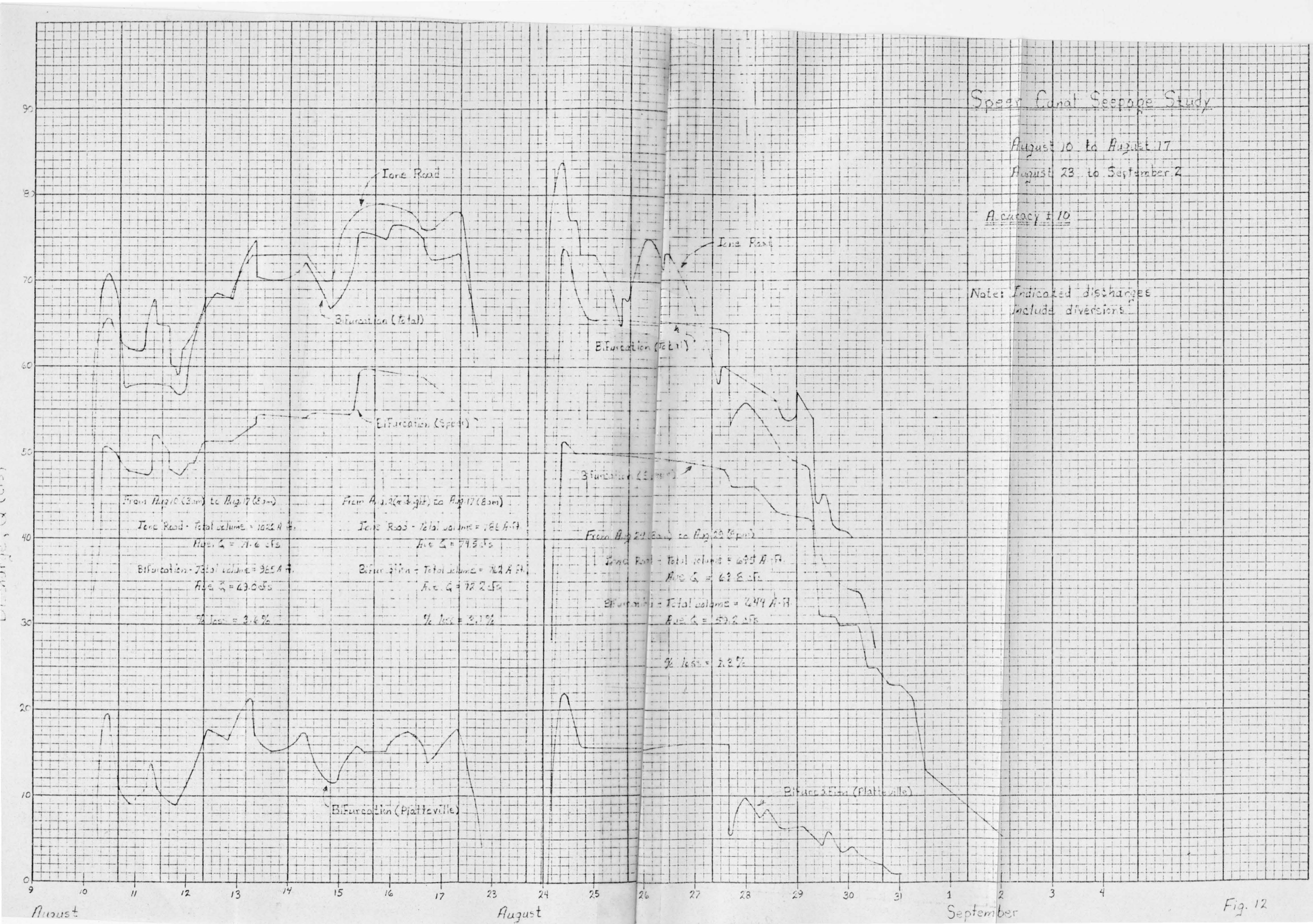


Fig. 12

Spear Canal Seepage Study

Average Daily Discharge

Accuracy ± 10 %

Note: Indicated discharges include diversions

Efficiency, %

Discharge, Q (cfs)

Inlet to Bifurcation

Ft Lupton to Inlet

Ft Lupton to Bifurcation

Outlet to Ft Lupton

Outlet to Bifurcation

Outlet (at I)

Ft Lupton Rd

Inlet Rd

Bifurcation Rd

Outlet Rd

Clay-Bedding Trial - July 20, 1942

June

July

August

August

Fig. 13