DELTA SALINITY STUDY:
A Brief Summary of the 1979-1980 Progress

BY

Blaine R. Hanson*

AND

Alan B. Carlton

This research was supported in part by a grant from the California State Department of Water Resources, Central District, Contract Number B-53226

*University of California, Davis. Drainage Specialist, Cooperative Extension and Specialist, Agricultural Experiment Station, respectively.

ACKNOWLEDGEMENTS

We wish to acknowledge the financial support provided by the California State Department of Water Resources. Their support is appreciated.

We also wish to express our appreciation to the following Staff Research Associates for their efforts this year: Roberta Welling, Ernest Bullock, Richard Paulsen, Jeff Rubin, Del Christiansen, and Fred LaCaro.

We wish to acknowledge the efforts of Dr. Lynn Whittig, LAWR, University of California, Davis, for his efforts in obtaining laboratory space for this project and in directing the laboratory work.

INTRODUCTION

This is a summary of the 1979-1980 studies of the Delta Salinity Study. Results of the experiments are presented, however, discussions are brief and do not attempt to describe the processes investigated. A detailed report will be released sometime next fall.

DELTA REPORT

<u>Background</u>. A study of subsurface water and salt movement during subsurface irrigation has been conducted the past two years. Reasons for this study are given in the 1978-1979 Progress Report. The 1978-1980 study is a continuation of some of the experiments discussed in that report.

During the 1978-1979 study, conversations with irrigators at the sites studied revealed that the soils at the test plots were considered by the irrigators to be highly permeable. The duration of a normal irrigation was about 24 hours. Thus, sites for the 1979-80 studies, reported herein, were established at locations where the soils were considered to be slowly permeable. The sites were at Rindge Tract, Bouldin Island, and Empire Tract. Irrigations at these sites are about 3-5 days long.

Measurements on subsurface water movement and subsequent salt movement, water content changes and hydraulic properties of organic soils were made this past summer at all three sites. A leaching study was conducted on Bouldin Island during the winter.

The soil profile at Rindge Tract and Empire Tract consisted of organic soil down to a depth of about 38-48 inches. The profile at Bouldin Island consisted of peat down to a depth of eight feet.

<u>Subsurface Water Movement</u>. Subsurface water movement during irrigation was found to be primarily lateral at depths between 2-4 feet at sites on Bouldin Island and Rindge Tract. A system of large cracks between one to 2-1/2 feet below the ground surface is believed to be the cause of this movement. Irrigators at these sites had indicated that water movement in these soils was very slow and an irrigation of four to five days was required. However, our measurements showed that the soil profile was saturated to within six to twelve inches from the surface after 24 hours of irrigation.

On Empire Tract, subsurface water movement during irrigation was not primarily lateral (between two spud ditches). Instead, the flow patterns indicated substantial groundwater (water which existed before the irrigation) displacement was occurring upward into the area between spud ditches during the irrigation. Cracks, although present at the Empire Tract Site, appeared to conduct water much more slowly, apparently due to the fineness (small size) of the cracks. The reason for this apparent lack of large cracks is not known at this time. Figures 1-4 shows subsurface water movement on Empire Tract.

Soil Salinity Changes. As found in the 1978-1979 studies, on Bouldin Island, soil salinity accumulated in the top 6-9 inches of the soil profile during the irrigation season but decreased between 1-3 feet. On Empire Tract, however, the decrease in soil salinity was very small and is probably not significant. On Rindge Tract, the pattern showed little or no salt accumulation above the one foot depth but salt removal below that depth. The reason for this behavior is believed to be due to irrigation water flowing from one spud ditch to another and an extremely high water table. This probably resulted in leaching at the very shallow depths. Figure 5 shows the soil salinity patterns before and after the irrigation season.

Subsurface Water Quality. Examples of subsurface water quality are shown in Table 1. All samples were obtained under saturated conditions. Figure 6 shows salt constituents of a profile of Bouldin Island.

Water Content Changes. Measurements of water content were made with a neutron probe during the irrigation season. Calibration curves are shown in Figure 7. Figure 8 shows water content changes with time and with depth for one profile at Rindge Tract. Between 29 June (end of first irrigation) and 25 July (start of second irrigation), the total water content change was 7.6 inches, or 0.28 inches/day (7.1 mm/day).

The water content data shows that about 80 percent of the change occurs within the top 18 to 20 inches of the soil profile (Table 2). Little change occurs below 18 inches. This indicates that root activity is probably concentrated in the top 18 inches of the profile.

Measurements of water content were also made in a non-irrigated field of sunflowers on Rindge Tract. Table 3 shows the pattern of water content changes for this case. It can be seen that the pattern shows most apparent root activity between 17 to 35 inches. Total change of water content was 7.7 inches between 28 June and 25 July, 1980.

Figure 9 shows moisture retention curves developed from tensiometer and neutron probe data for various depths at Rindge Tract. It is of interest to note that as depth increased, desaturation of the soil with increasing matrix potential decreased, and at 24 inches very little desaturation occurred. A possible explanation for this behavior is that bulk density changes occurred as the matrix potential increased. Evidence for this behavior was found during some laboratory experiments on moisture retention of organic soils.

Figures 10 and 11 show the moisture retention characteristics of the soil between the 6-12 inch depth at Empire Tract. Figure 11 shows that between 1 and 15 bars the water content changes very little. At one bar the water content was 0.51 gm/cm^3, while at 15 bars the water content was about 0.48/gm/cm^3. This indicates that although the total amount of moisture held in these organic soils is high, much of the moisture appears to be unavailable to plants. A similar moisture retention curve was found for soil at the Bouldin Island site.

Properties of Peat Soils. Measurements of properties of the peat soils were made on undisturbed samples from all three sites. These properties were hydraulic conductivity (vertical and horizontal), bulk density, organic matter content, and porosity (Empire Tract only). The data listed in Tables 4, 5 and 6 show the number of samples measured, the mean of the samples, and the coefficient of variation.

Based upon the data contained in Tables 4-6, the following conclusions are made on these properties:

1. Bulk density generally decreases with depth in the organic soil.
2. Organic matter content generally increases with depth in the organic soil. The linear correlation between bulk density and organic matter content is good (correlation coefficients are -0.93, -0.74 and -0.85 for Bouldin Island, Empire Tract, and Ringe Tract, respectively).
3. Variability of the hydraulic conductivity, particularly in the upper part of the profile, is extremely large. Thus, using this property to characterize a soil is probably meaningless. Nevertheless, these data show that the hydraulic conductivity generally decreases with depth and that the vertical hydraulic conductivity is greater than the horizontal (Table 7). Hydraulic conductivity of the "buckskin" is very low.

Leaching. A leaching experiment was conducted this past winter on Bouldin Island. The experiment consisted in installing spud ditches in the field and using them as shallow drains. Three sites were established in the ditched field. Irrigation water was to be applied at two of these sites to see if this would result in a more rapid removal of salts leached from the root zone. The third site was to consist of leaching by rainfall only. However, due to the unusual weather and potential problems with levees, the irrigation experiment was not conducted. A fourth site in an unditched adjacent field was used as a control. Data from this experiment is still being processed.

Measurement of Soil Salinity. Saturation extracts were obtained from soil samples that were prepared by two different methods. The "dry" method was the standard procedure of drying and grinding the soil, then wetting it to saturation and extracting the solution. The "wet" method consists of first wetting the sample to saturation without the drying and grinding process, extracting the solution, and then drying. The saturation percentage and the EC of the extracted solution were determined for each sample prepared each way. Table 8 contains data obtained from one set of samples from Bouldin Island.

If a comparison of total salts is made between the two methods, an interesting pattern can be seen (Figure 12). Above the 2-3 foot depth, the total salts in the dry-prepared samples is greater than that in the wet-prepared sample. Below the 2-3 foot depth, the reverse is found. Reasons for this behavior are being investigated.

Table 1. Electrical conductivity of subsurface water samples (mmhos/cm).

Depth (feet)	Rindge	Bouldin	Empire
1	--	1.90	--
2	2.26	1.88	1.13
3	2.08	2.42	0.95
4	1.87	1.51	1.03
5	1.76	1.26	1.26
6	--	1.33	--
8	--	1.22	--

Table 2. Water content change pattern of subsurface irrigated corn between 28 June and 25 July, 1980, Rindge Tract.

Depth (inches)	Percent of Change of Total Water Content
6	23.6
12	29.1
18	27.6
24	16.5
30	3.1
36	0.0

Table 3. Pattern of water content change of non-irrigated sunflowers between 11 July and 21 August, 1980, Rindge Tract.

Depth (inches)	Percent of Change of Water Content
5	8
11	5
17	10
23	22
29	25
35	16
41	8
47	5
53	0

Not as much lateral flow

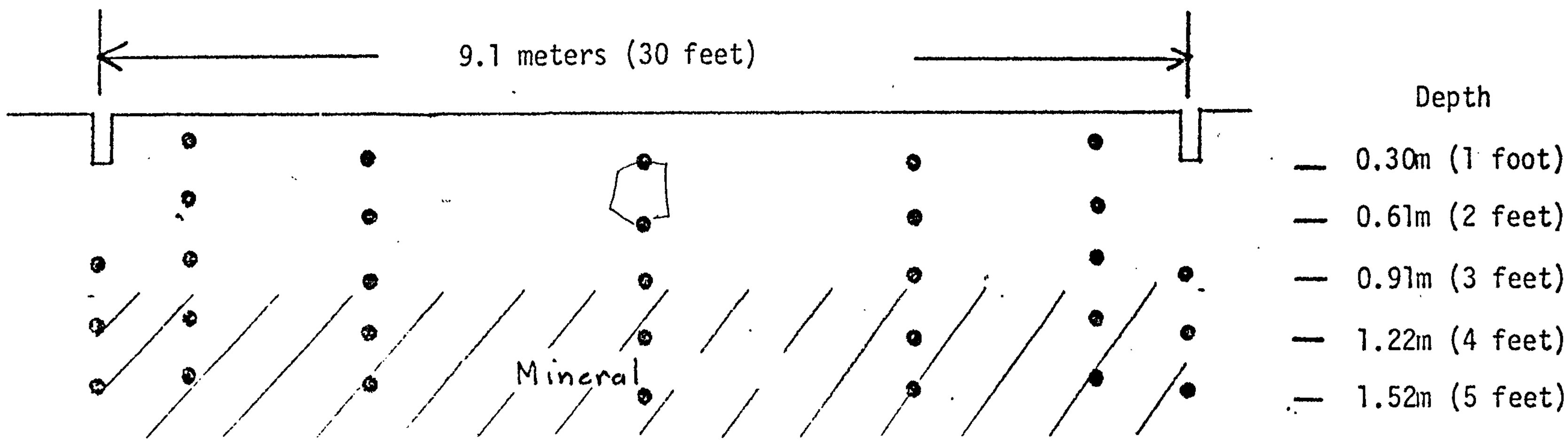

Figure 1. Grid pattern, Empire Tract

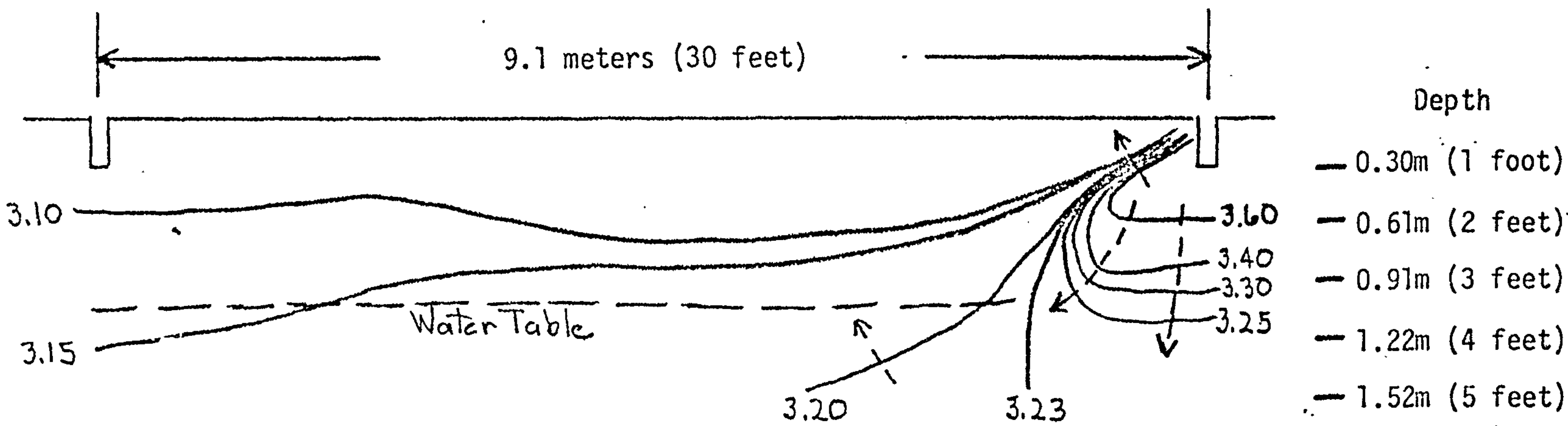

Figure 2. Flow pattern after 75 minutes of irrigation. (Solid lines with assigned numbers are lines of equal hydraulic head, assigned number is the hydraulic head (meters) of that line.)

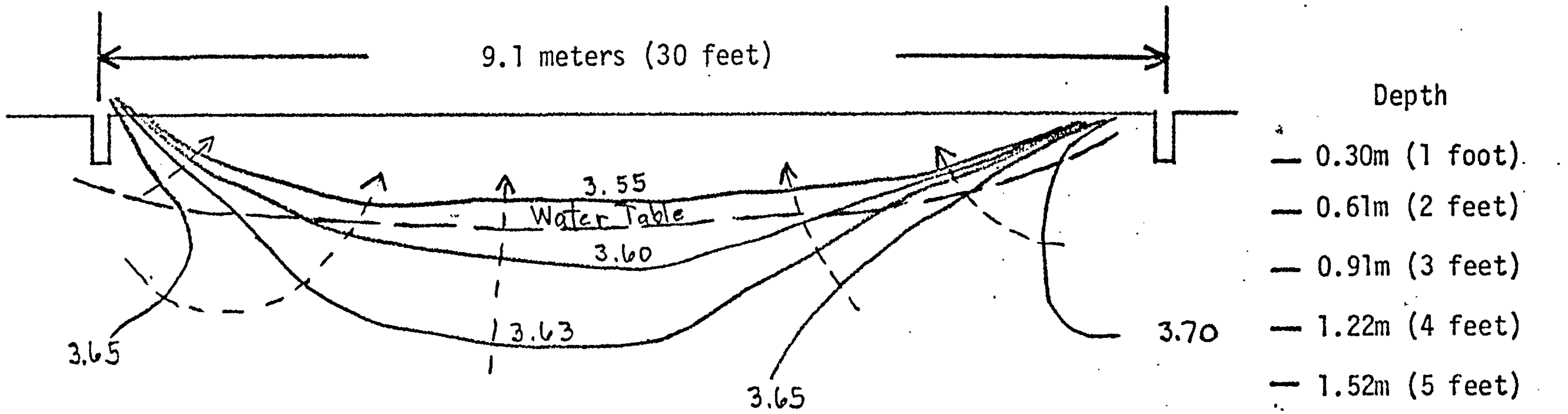

Figure 4. Flow pattern after nearly 28 hours of irrigation

D-030170

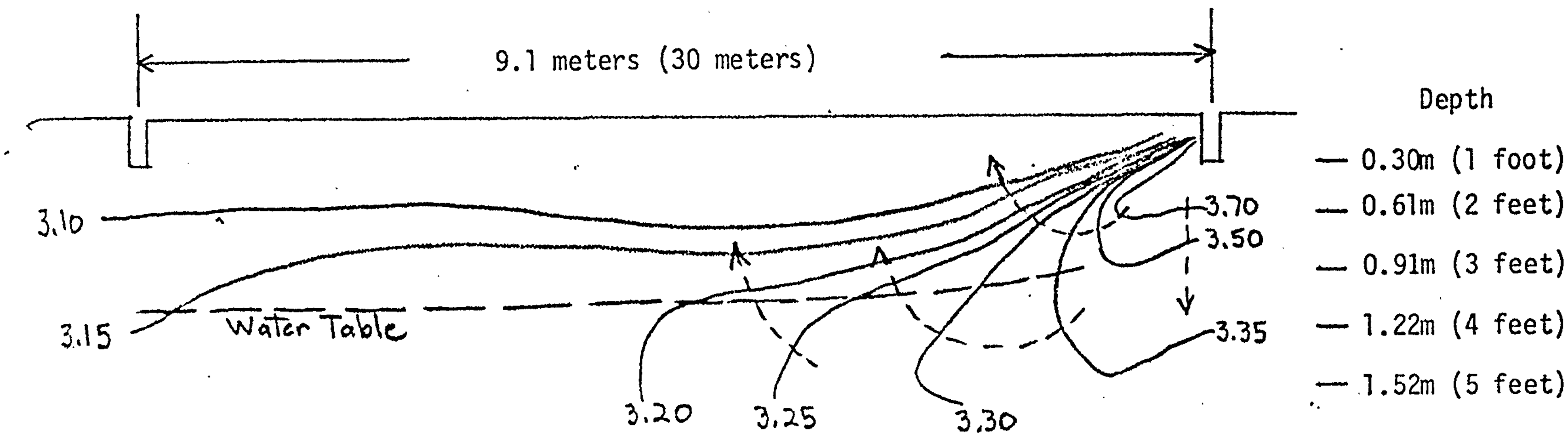

Figure 3. Flow pattern after 135 minutes of irrigation

D-030171

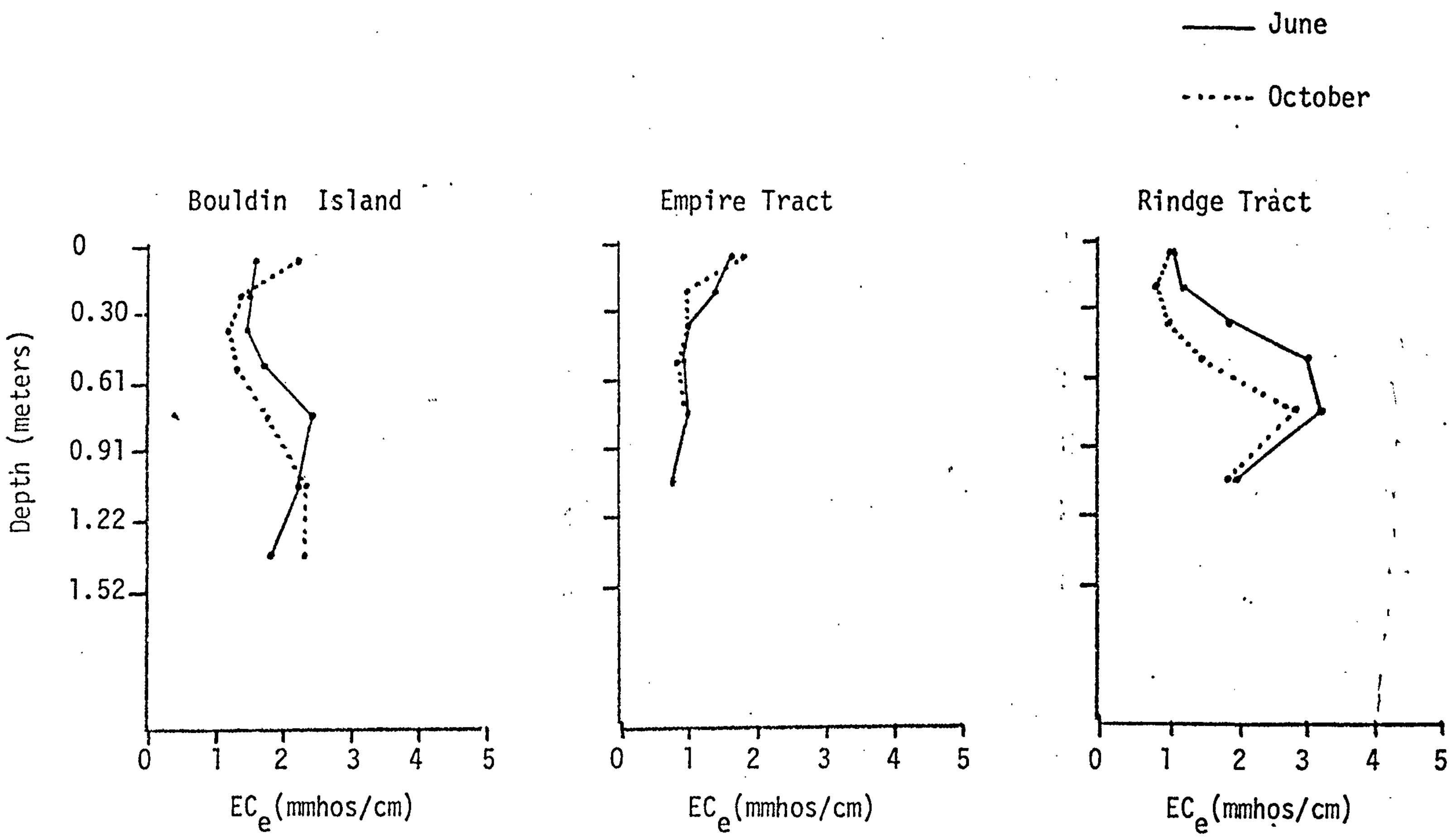

Figure 5. Change in soil salinity during irrigation season.

Table 4. Properties of soils at Rindge Tract site.

Depth (inches)	Number of Samples (n)	Mean	Coefficient of Variation (CV)
(a) Bulk density (gm/cm^3)			
18	4	0.33	3.8
24	4	0.19	6.8
30	6	0.21	12.0
36	6	0.32	17.5
48 (mineral)	3	1.70	0.7
(b) Percent of organic matter content			
18	4	48.2	5.6
24	4	71.1	5.7
30	6	55.0	11.6
36	6	26.4	43.3
48 (mineral)	3	1.3	4.7
(c) Horizontal hydraulic conductivity (cm/sec)			
18	9	0.0034	86.0
24	10	0.0017	68.0
30	4	0.00042	115.0
36	6	0.00018	70.0
48 (mineral)	3	0.000069	14.6
(d) Vertical hydraulic conductivity (cm/sec)			
18	2	0.0219	7.4
24	11	0.0059	67.0
30	8	0.0122	57.0
36	7	0.0044	83.0
48 (mineral)	2	0.00061	3.4