20

DEPARTMENT OF AGRICULTURE, SOUTH AUSTRALIA

Agronomy Branch Report

INVESTIGATIONS ON DRAINAGE AND IRRIGATION AT LONG FLAT, 1960-1968

Compiled by P.J. Cole

Report No. 20 May, 1971.

FOREWARD

Research at Long Flat, near Murray Bridge, South Australia from 1961 to 1967 was supported by the Australian Dairy Produce Board. Dr. C.L. Watson, formerly Research Officer, Department of Agriculture, and later of the Department of Soils and Plant Nutrition, Riverside, California, U.S.A., and Research Fellow (Soil Physics), University of the West Indies, carried out the bulk of the investigations.*

Other former officers of the Department of Agriculture who were involved in the project included Mr. P. Judd, Mr. R.C. Shearer, Mr. J.A. Edwards and Mr. L. Wallace.

Professor J.W. Holmes, Department of Earth Sciences, Flinders University (formerly Principal Research Officer, Division of Soils, C.S.I.R.O.), assisted in a number of projects. Mr. R. Culver, Reader in Civil Engineering, University of Adelaide, assisted in design of equipment. Statistical analysis of some of the data was carried out by Mr. J.V. Ellis (Biometrician, Department of Agriculture). After the termination of the projects at Long Flat, Mr. P.J. Cole (Department of Agriculture) examined unpublished reports and data collected during the course of the projects, to present in this report. The Department of Agriculture is indebted to Mr. R.L. Eves, on whose property many of the projects were carried out, the South Australian Department of Lands, in particular officers at Murray Bridge and Mr. E. Taylor, pump master at Long Flat.

Examination of some of the data is incomplete. This is presented in full in this report to provide a basis for further investigations.

(P.M. Barrow)

CHIEF AGRONOMIST.

* Since this material was prepared Dr. C.L. Watson has taken up a new position with C.S.I.R.O., Division of Soils in Canberra.

INDEX

INVESTIGATIONS ON DRAINAGE AND IRRIGATION ON THE LOWER MURRAY SWAMPS: - EXPERIMENTS AT LONG FLAT (1960 - 1968)

1. INTRODUCTION

The Lower Murray Swamps, in South Australia, have now been irrigated for over 50 years. These areas carry dairy cattle supplying city milk markets. The permanent grass-legume pastures are flood irrigated from the adjacent river at three weekly intervals during the dry season from September to May, and are drained by a system of ditches 60 cm deep.

Long Flat, Hd. of Burdett, situated on the eastern side of the river 2 miles south of Murray Bridge, is one of the reclaimed swamps on the lower River Murray, and was the site of a number of experimental projects carried out by the Department of Agriculture and C.S.I.R.O. Division of Soils during the period 1960-68. Both these organisations considered that drainage was the most important factor in pasture management on the swamps, although no accurate measurements had been taken (see Wells, C.B. (1955) and Williams, S.G. (1961)).

In 1960 experiments were initiated by the South Australian Department of Agriculture to measure precisely soil water tables, soil water tension and pasture growth, to determine the precise relationship between irrigation, drainage and pasture production on the swamps, with the view to improving pasture production. It had been suggested that excessive irrigation inputs and poor drainage had led to decreasing pasture growth. This report presents the relevant data collected during the course of these experiments.

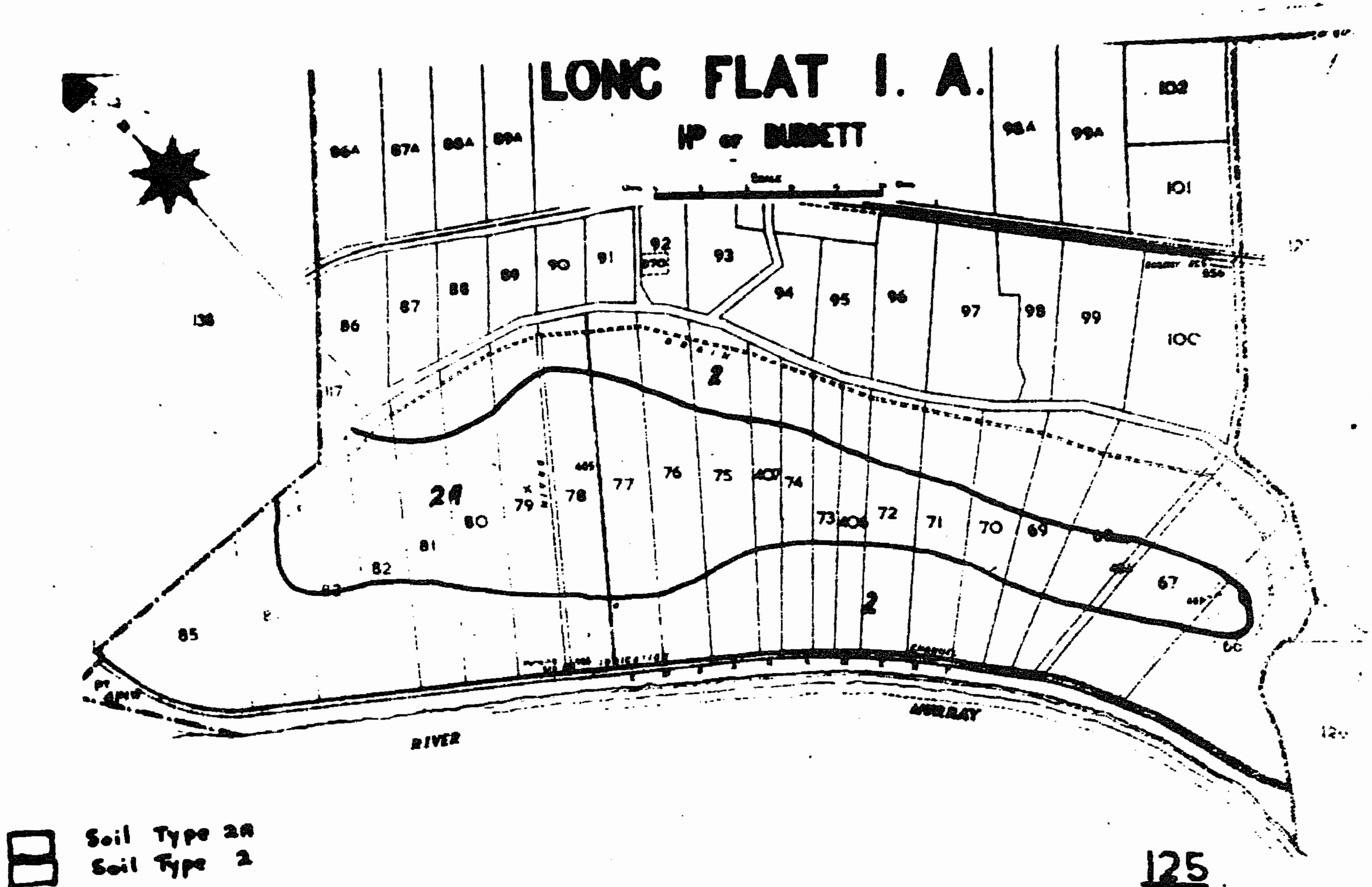
2. PAPERS PUBLISHED ON EXPERIMENTS AT LONG FLAT

1. Watson, C.L.(1967) S.A. Journal of Agriculture 70 270-279 "Improving Pasture Production on the Lower Murray Swamps".

2. Holmes, J.W. and Watson, C.L. (1967) Agricultural Meteorology 4 177-188. "The Water Budget of Irrigated Pasture Land near Murray Bridge, South Australia".

3. Edwards, J.A. and Culver, R. (1967) Agricultural Engineering 48 90-91. "An Integrating Flowmeter"

4. Cole, P.J. and Watson, C.L. Experimental Record (in press) "Drainage Investigations on the Lower Murray Swamps. (1) Water tensions and water levels on an irrigated pasture at Long Flat. (2) Effect of a Drainage Scheme on soil water tensions and water tables".


LONG FLAT I. A.
H[D] OF BURDETT
Scale
86A
87A
88A
89A
98A
99A
102
101
100
86
87
88
89
90
91
92
93
94
95
96
97
98
99
2
2A
2
77
76
75
74
73
72
71
70
69
67
78
79
80
81
82
83
85
138
RIVER
MURRAY
Soil Type 2A
Soil Type 2

125
37

3. SOIL TYPE OF LONG FLAT EXPERIMENTAL AREA

The soils of Long Flat were surveyed in 1931, by Taylor and Poole. At Long Flat, the principal soils are:

(1) Type 2A, covering 2/3 of Long Flat

0-58 cm - Black clay
58-66 cm - Brown clay
66-81 cm - Grey brown clay
81 cm - Grey clay

(2) Type 2, covering 1/3rd of area, mainly located in a strip bordering the river bank

0-76 cm - Black clay
76-91 cm - Brown clay
91-99 cm - Grey brown clay
99 cm - Grey clay

4. HYDRAULIC PERMEABILITY OF THE SOILS OF LONG FLAT

In the design of experiments at Long Flat, it was envisaged that a drainage system would be constructed to observe the effects of deeper drainage on pasture production. As estimate of optimum drain depth and spacing can be made from a knowledge of the permeability of the various soil horizons. The C.S.I.R.O. Division of Soil Physics, had field apparatus available to measure hydraulic permeability, and a project was initiated with the Department of Agriculture to survey the permeability of the Soils of the Long Flat I.A. to a depth of 1.8 meters.

Design of experiment

Measurements of permeability were made at 3-4 sites selected along four representative transects, 300 to 600 meters in length. Two methods, viz. the Two-well method (after Childs) and the Single-tube (after Kirkman) were used at each site. Both methods measure the soil permeability below a water table. The two well method measures horizontal permeability while the single-tube primarily measures the vertical component. Details and theory of the techniques are given in Jnl. Soil Sci, 8:27 (1957)

(1) Two-well method The method utilises one pair of wells, between which a steady water flow is induced by establishing a difference in water head.

Two wells, 1 meter between centres, were excavated to a depth of 100 cm. On one transect the wells were then deepened to 180 cm. With the aid of a small centrifugal impeller pump, water was pumped out of one well into the other, until the water levels in both wells were steady. The rate of flow was then determined by using a measuring cylinder and stop-watch. At the same time, water from another container was poured at a similar rate into the receiving well to prevent disturbance of equilibrim. Replication was obtained by reversing the flow, i.e. by transferring the pump to the other well. At each site, readings were taken from two sets of wells, 9 m apart. During the measurements the water-table averaged 41 cm (ranging from 30 cm to 61 cm) below the ground surface. Results refer either to the 100 cm or to the 41cm - 180 cm soil horizon.

(2) Single-tube method Measurements are taken of the rate of rise of water in an encased well into which water can only enter through the base. Wells dug to depths of 100 cm or 180cm, were lined with a steel tube. Water was pumped out of this tube and the rate of rise was noted at regular intervals. At each site two replicate tubes were installed some 9 m apart.

Results The hydraulic permeability values have been analysed with respect to:

(a) Method of measurement, viz. Two-well or Single-tube.

(b) Soil type, viz. Alluvial clay Type 2 or 2A

(c) Depth of horizon measured, viz 41-100 cm or 40-180 cm

The following table (Table 1) shows the effect of technique and horizon on permeability.

Table 1 - Effect of Method and Depth of Measurement on Hydraulic Permeability at Long Flat Irrigation Area

Site	Depth of measurement (cm. below surface)	Method: Two-well	Method: Single-tube	Significance
		Geometric Means cm/sec		
Sect. 70, 77, 79 & 84 (15 sites)	41-100 cm	1.0×10^{-2}	0.9×10^{-2}	No Sig. Diff.
Sect. 77 (4 sites)	41-180 cm	4.4×10^{-2}	2.0×10^{-2}	No Sig. Diff.

For the purposes of this analysis the readings obtained from both soil types 2 and 2A, have been combined.

The two measuring techniques have given similar values. This indicates that horizontal and vertical permeabilities are the same. The single-tube method values were more variable.

There is a slight increase in permeability with depth but this increase does not appear to be significant.

The permeability values were then grouped into soil types for statistical analysis (Table 2)

Table 2 - Effect of Soil Type and Method of Measurement on Hydraulic Permeability at Long Flat Irrigation Area

Soil Type	Method		Significance
	Two-well	Single-tube	
	Geometric Means cm/sec		
2 (8 sites)	0.63×10^{-2}	0.50×10^{-2}	No. sig. diff.
2A (7 sites)	2.9×10^{-2}	2.8×10^{-2}	No. sig. diff.
Significance	Sig. diff. ($P < 0.001$)	Sig. diff. ($P < 0.05$)	

The two measuring techniques have again given similar values. Soil Type 2 with its greater depth of black clay has a significantly lower permeability.

Discussion

Permeability values are discussed in Comm. Bureau of Soils Tech. Comm. No. 50, 1959. Values greater than 0.7×10^{-2} cm/sec are classed as very rapid. As these figures are of this order, it appears that the Long Flat alluvial clays are very permeable for the top 1.8 m at least. Gravelly sands and silts commonly have permeabilities similar to this, while clays are often less than 0.003×10^{-2} cm/sec. However, as cracks and fissures were observed at Long Flat during well excavations, high hydraulic permeability values could be expected. J. Holmes of C.S.I.R.O. Soils Division used these values to estimate desirable drain depth and spacing. One appropriate system could have drains 1.2 - 1.8 m deep and 61 m apart.

5. SEASONAL PASTURE PRODUCTION ON THE LOWER MURRAY SWAMPS

From 21/6/61 to 2/7/63 pasture production measurements were taken on Section 77, Long Flat. Sites were chosen on perennial pastures typical of the Murray Swamps. The areas were flood irrigated every three weeks from September to May, and were drained by a system of open ditches 60 cm deep. An annual application of 210 Kg superphosphate per hectare was applied prior to 1961. In 1962 the soils were topdressed with 224Kg superphosphate in both January and August. There was no top dressing in the first 6 months of 1963. Preliminary observations had shown that the depth of the water table on Section 77 rose not only during irrigation of the section, but also during irrigation of adjacent sections due to lack of boundary drains between sections.

Seasonal trends in production and botanical composition of the existing pastures were measured at two sites. Site 1 the pasture was primarily N.Z. white clover (Trifolium repens), with N.Z. perennial ryegrass (Lolium perenne), paspalum, (Paspalum dilatatum) and dock (Rumex spp.) This pasture had been sown in 1958 with tyegrass and white clover. Site 2 was Paspalum dominant. Ryegrass and white clover had been sown in 1956.

At each site 16 grazing quadrats, 1.2 x 1.2 meters were placed in a square grid system on an area of 1,600 sq. meters.

Following harvesting, each quadrat was moved to one of four random positions. Harvests were taken when pasture growth in the quadrats reached 15 cm. An area of 1.0 sq. meters was cut from each quadrat. These cuts were made at a height of 2.5 - 5.0 cm to simulate grazing. The new position to which the quadrat was moved was also cut to the same height. Following harvesting the experimental area was topped if necessary. Fourteen harvests were taken, dry weights determined and botanical composition determined (botanical composition determined by hand sorting for 8 harvests and by visual estimation for 6 harvests).

Results

Table 3 gives seasonal growth rate of pasture and components. The figures are averages of the two year period 21/6/61 to 2/7/63.

Figure 1

SEASONAL PASTURE PRODUCTION. SECT. 77, LONG FLAT I.A. 2 YEAR AV. 1961-3.

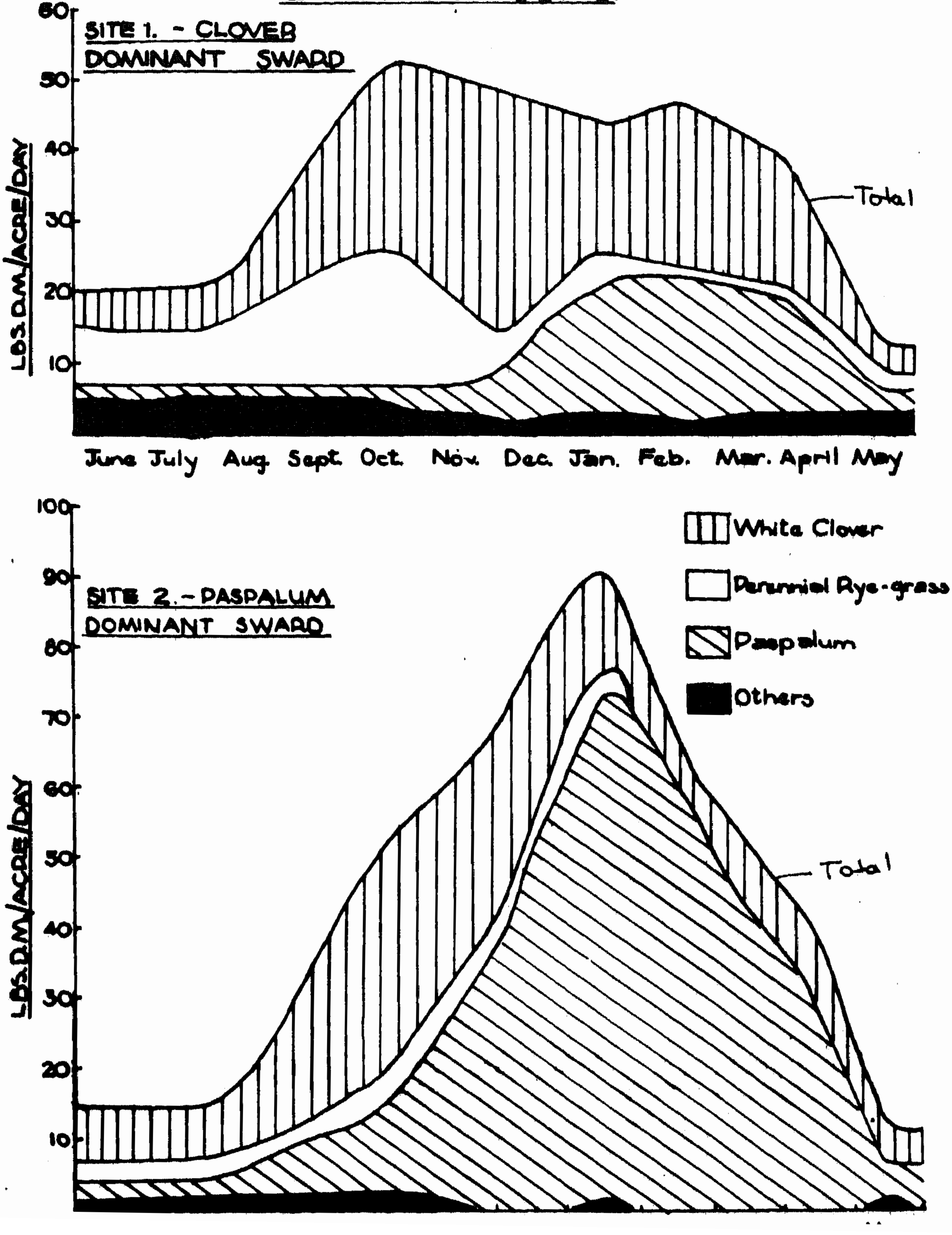


Table 3 - Seasonal Growth Rate at Long Flat Irrigation Area Section 77

Site	Period	Growth Rate (Dry Matter - Kg/ha/day)				
		Total	Perennial Ryegrass	Paspalum	White Clover	Others
1. Clover Dominant Sward	June-Sept.	21	10	2	6	4
	October	57	24	2	28	3
	Nov.-Dec.	54	8	7	38	1
	January	47	6	20	20	2
	February	50	2	22	26	1
	March-April	37	2	19	20	2
	May	12	2	2	4	2
2. Paspalum Dominant Sward	June-Sept.	15	3	3	8	1
	October	57	8	13	35	2
	Nov.-Dec.	75	1	45	30	-
	January	100	2	83	15	1
	February	72	-	69	3	-
	March-April	49	-	41	9	-
	May	11	-	4	6	1

See also figure 1

The annual dry matter production (two year average) is given in Table 4.

Table 4 - Annual Pasture Yield Section 77 Long Flat IA

Site	Yield (Dry Matter Kg/ha/annum)				
	Total	Perennial Ryegrass	Paspalum	White Clover	Others
1. Clover dominant sward	12,700	3,000	2,700	6,200	900
2. Paspalum dominant sward	15,800	700	1,000	4,700	300

Discussion

Winter production at both sites was similar (13-16 Kg D.M./ha/day). Differences in summer production are due to the vigorous growth of paspalum over the summer months while the other pasture grasses tend to grow most rapidly in spring. High yields are obtainable from the paspalum swards, but management problems arise since these swards tend to become sod bound with suppression of clover and winter growing grasses. This may lead to feed shortage in winter even though summer growth is adequate.

Seasonal pasture component composition showed marked fluctuation following the growth pattern of each species - the proportion of paspalum increasing in summer and the proportion of ryegrass in spring. It appears that summer growth of clover may be suppressed by vigorous paspalum growth in this season.

Richardson and Gallus (1932), measured pasture growth at Wood's Point, another irrigated swamp on the Lower Murray, at 27,000 Kg D.M./ha/annum, which is considerably greater than any yield obtained at Long Flat.

The species composition of the pastures at Wood's Point was predominantly white clover - perennial ryegrass, suggesting that either the predominance of paspalum at Long Flat may be restricting optimal pasture growth or soil condition may be unsatisfactory. Examination of water level data and soil water tension data (see part 7) suggests that soil conditions may be limiting pasture growth of the species not adapted to very wet soil. Poor growth is most marked during winter months when paspalum is dormant, and the other pasture species are most likely to be affected by water logging or low soil temperatures.

6. WATER TABLE LEVEL

It has been noted on numerous occasions (e.g. Roe (1937)) that high soil water tables and consequently water logged soil conditions will restrict plant growth. Soil water table levels were measured at Long Flat to observe the proportion of any irrigation period when soil horizons may be excessively wet due to high soil water tables.

Design of Experiment

Soil water tables were recorded by automatic water level recorders, measurements commencing in 1960.

There were 6 well positions on the experimental area.

Well No.	Distance from river bank (metres)			
1	4.5	)		
2	156	)	Site 1	Soil type 2
3	274	)		
4	475	)		
5	590	)	Site 2	Soil type 2A
6	680	)		

Results

Actual water table levels at wells 2, 3, 4 and 5 from 13/10/60 to 26/9/61 are presented in Appendix 1. In table 5 the data from wells 2 and 4 from 20/9/61 to 5/1/63 has been presented as the number of days during any irrigation period that the water table is at any particular level. These results are averaged in figure 2.

Discussion

The data indicates water table levels are close to the surface (above 60 cms) for considerable periods of all irrigation cycles. Consequently plant roots will either be restricted to the surface soil or have to grow in soil that is waterlogged for long periods, both of which are likely to inhibit optimum root growth.

7. SOIL WATER TENSION

Tensiometers were used to measure soil water tension at two sites on Section 77, Long Flat. One site was adjacent to well 2, 155 metres from the river bank (Site 1). The other site was adjacent to well 4, 490 metres from the river bank (Site 2). Duplicate tensiometers were installed at depths of 5 cm, 10 cm, 20cm, 40cm and at 60 or 80 cm. No deeper installations were made since water tables were usually above 80 cm.

The tension range of the tensiometers was up to 700 cm suction. The instruments were constructed locally according to C.S.I.R.O. Division of Soils Tech. Memo. 8/59.

Results

Results are presented in Appendices, I I and III and table 6, as number of days water tensions are in any particular range. In figure 3 the data has been averaged and presented graphically.

Table 6.5

WATER TABLE LEVELS 1961-63

Soil Water Table Level Range (cm below surface)

Irrigation Period	Days	Site 1 (Well 2) Days 0-15	15-30	30-45	45-60	60-75	75-90	>90	Site 2 (Well 4) Days 0-15	15-30	30-45	45-60	60-75	75-90	>90
Summer (Nov-Feb) Incl.															
9-11-61 to 30-11-61	21	1	1	2	6	0	11	0	2	1	6	4	6	4	0
30-11-61 to 21-12-61	21	2	0	3	1	6	4	6	0	1	2	3	4	6	6
21-12-61 to 11-1-62	21	1	1	2	5	0	9	4	0	1	2	2	2	4	4
11-1-62 to 1-2-62	21	1.5	0	1.5	1	10	7	0	0	1	1	2	6	11	0
1-6-62 to 21-2-62	20	1.5	1	1.5	1	4.5	12	0	1	1	1	3	12	4	0
5-11-62 to 25-11-62	20	1	1	3.5	1	6	2	6	1	1	1	3	3	5	6
25-11-62 to 16-12-62	21	1	1	5	4	6	5	0	0	1	5	10	5	6	0
16-12-62 to 5-1-63	20	1	0	3	0	3	11	2	1	0	1	2	6	10	0
Mean No. days	20.6	1.1	0.6	2.7	2.4	4.4	7.7	2.2	0.6	0.9	2.4	3.6	6.0	6.3	2.0
% period		5	3	13	12	21	37	11	3	4	12	17	29	30	10
Autumn and Spring															
20-9-61 to 19-10-61	29	2	1	4	15	5	3	0	1	1	8	11	7	0	0
19-10-61 to 9-11-61	21	1.5	1	2	2	8	7	0	1	1	1	3	4	3	0
21-2-62 to 15-3-62	22	1	2	8	3	5	3	0	1	1	6	5	6	3	0
15-3-62 to 11-4-62	27	1	3	5	7	5.5	5	0	1	5	6	8	6	4	0
11-4-62 to 18-5-62	37	1.5	0.	3	1	13	7	12	0	1	1	3	6	14	11
1-10-62 to 5-11-62	35	1	0	9	2	8	15	0	0	1	3	12	11	8	0
Mean No. days	28.5	1.3	1.1	5.1	5.0	7.4	6.6	2.0	0.7	1.7	4.2	7.0	6.6	5.3	1.9
% period		4	4	18	18	26	23	7	2	6	15	25	23	19	7
Non-irrigation period Winter															
17-5-61 to 20-9-61	122	0	1	2	44	34	16	27	0	0	31	54	40	4	0
5-7-62 to 10-9-62	67	0	0	11	26	30	0	0	2	7	13	36	9	0	0
Mean No. days	94.5	0	1	7	35	32	8	14	1	4	22	45	25	2	0
% period		0	1	7	37	34	8	15	1	4	23	47	26	2	0

Figure 2.

WATER TABLE LEVELS FOLLOWING IRRIGATION

1961 - 63

SECT. 77 LONG FLAT IA AV. SITE 1 & 2

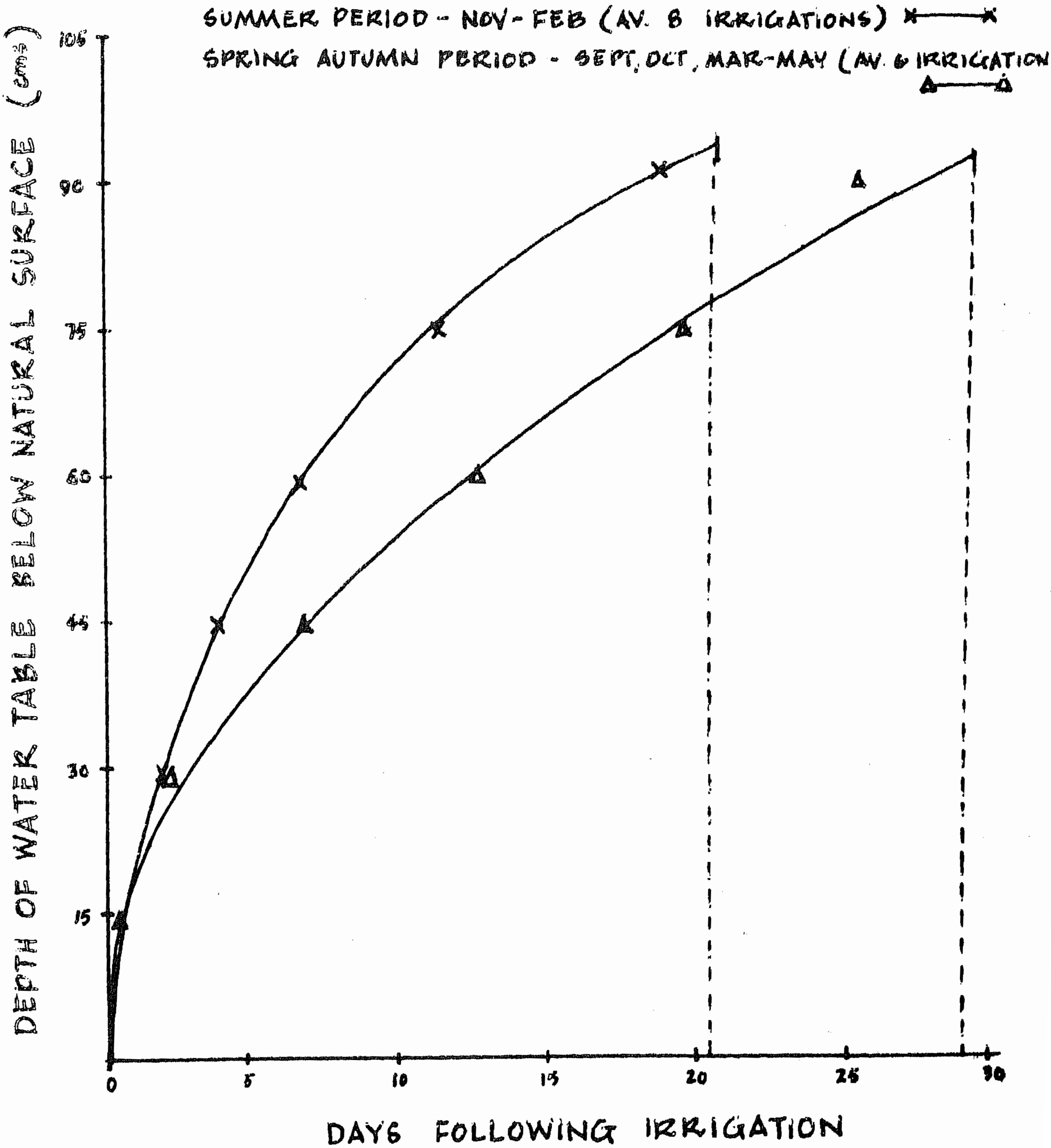


TABLE 6

SOIL WATER TENSION

Number of days water tension is in given range

Average of sites 1 and 2
Sect. 77 Long Flat

Tensio-meter depth in cm.	Period*	Average days per Irriga-tion	<100 cm Water	1-200	2-300	3-400	4-500	5-600	>600
10	Summer	20.6	5.0	1.5	2.0	3.3	3.1	3.3	2.2
	Autumn-Spring	28.5	11.6	3.6	1.3	1.5	5.0	2.4	3.3
	Winter	114	37	29.3	10.3	11.3	8.8	10.0	7.0
20	Summer	20.6	8.6	3.8	2.3	2.5	1.7	1.3	0.3
	Autumn-Spring	28.5	16.3	2.1	3.1	2.8	2.7	1.5	0.1
	Winter	114	65.3	21.8	7.3	4.3	4.8	6.3	4.3
40	Summer	20.6	14.4	2.6	1.4	1.1	0.6	0.5	-
	Autumn-Spring	28.5	22.5	4.9	1.0	0.4	-	-	-
	Winter	114	106.0	5.3	2.8	-	-	-	-

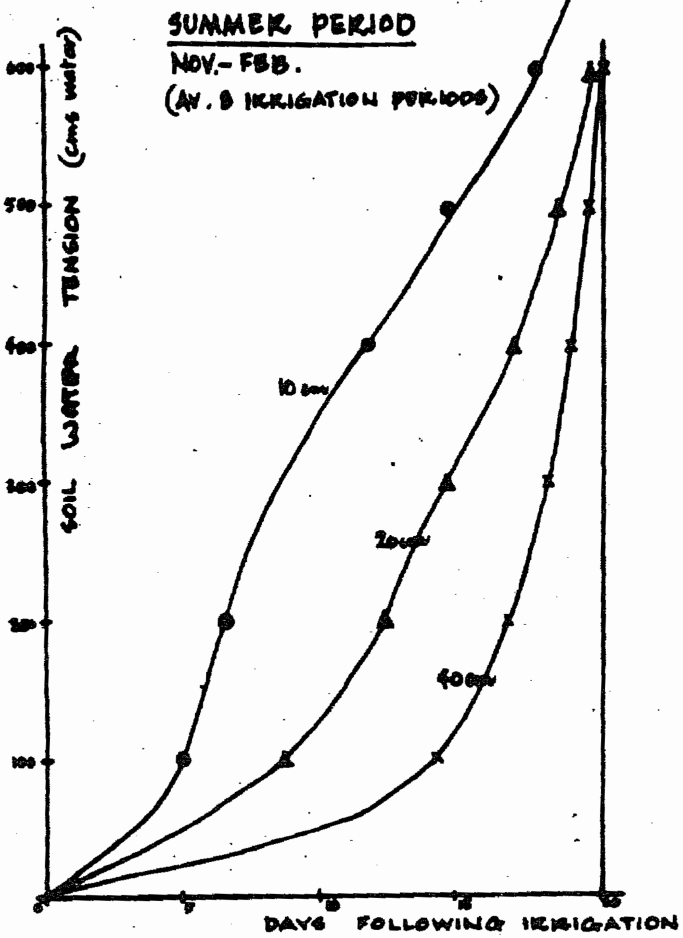
* Summer period from November to February (inclusive) - 8 irrigation period

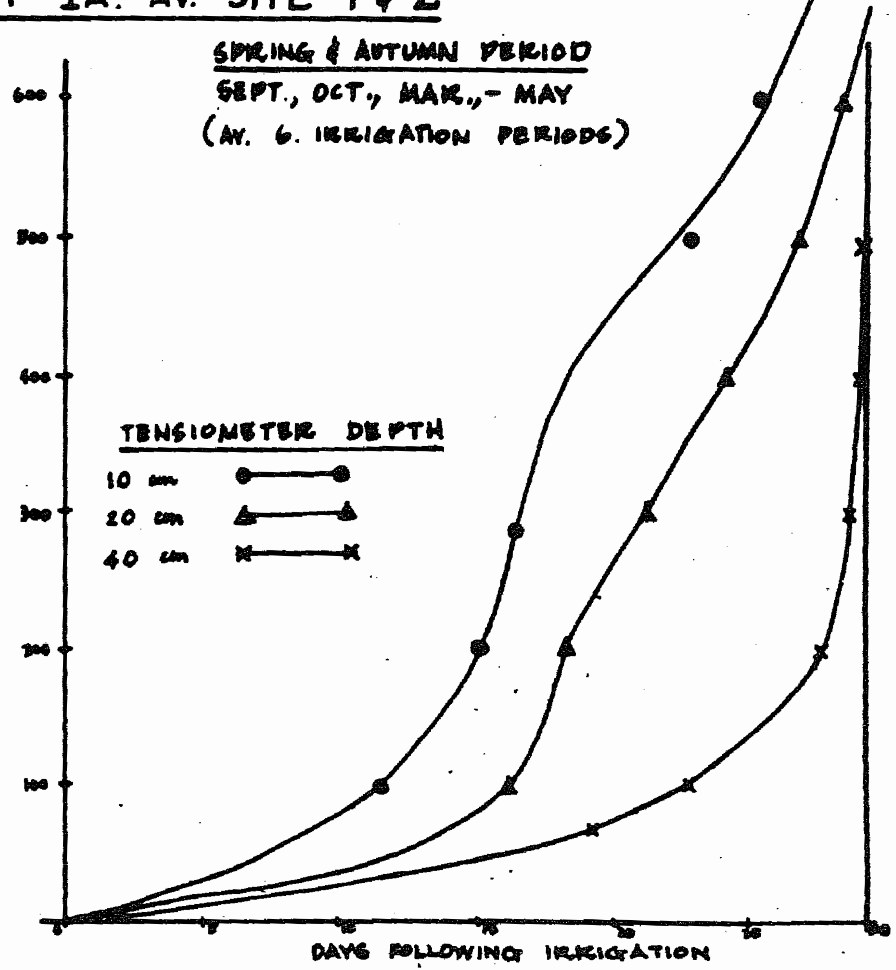
Autumn-Spring periods September, October, March to May - 6 irrigation periods

Winter period (2 winter periods) - Non irrigation.

SOIL WATER TENSION FOLLOWING IRRIGATION 1961-63

SECT. 77. LONG FLAT IA. AV. SITE 1 & 2





(1) Water tensions are less than 100 cms suction, and probably unsatisfactory for normal plant root growth, for long periods. This is particularly noticeable at 40 cm depth at site 2, where tensions rarely exceed 100 cm suction.

(2) Soil water tensions greater than 400 cm suction are likely to be excessive for normal root growth. Again, tensions lie in this range for long periods.

Discussion

Soil water tensions lie in range unsatisfactory for normal plant growth for long periods. It is likely that growth would be restricted by these unsatisfactory soil conditions.

Soil horizons below 40 cm appear to be nearly continuously saturated. The surface 30 cm of soil take over one week after an irrigation to rise to a tension considered satisfactory for plant growth. The results suggest that improved drainage is necessary to rapidly remove excess water after irrigation.

The existing drainage system on the Swamps consisted of a system of lateral ditches connecting with a main drainage channel. The depth of this channel limited the depth of lateral drains, and the depth of the main drain was determined by pumping installations. The pumps were set at a level which would allow removal of water to a depth of about 90 cm below the surface at the furthermost point of the swamp. It was considered that by lowering pumps, deepening drains, and decreasing spacing between drains, more efficient drainage could be effected.

However, more frequent irrigation may then be necessary. If the area was irrigated when soil moisture tensions reached critical values, and more efficiently drained, it was considered that improved soil conditions would result.

Testing of these ideas led to the design of a drainage trial on which it was attempted to improve pasture growth by improved management.

8. WATER BALANCE (Section 77 Long Flat) (Joint Project - Department of Agriculture and C.S.I.R.O., Division of Soil Physics) See Holmes and Watson (1967)

From 1962 to 1965 detailed records were kept of rainfall, surface irrigation and drainage into the river of this area.

The aim was to measure rainfall, evaporation losses, volume of water applied, volume of drainage water pumped out and seepage water flowing in beneath the levee banks. (See table 7). These measurements supplied the following information.

(i) The efficiency of water use. It was suspected that excess water usage through poor application mentods was aggravating drainage problems.

(ii) The information of seepage into the irrigation area and the practicability of lowering water levels on the swamps economically without increasing seepage.

(iii) The establishment of pasture water requirement based on rainfall and evaporation loss records. This was to provide a sound basis for establishing a suitable roster system for irrigation.

A rain gauge was installed and rainfall records kept. A net radiometer was also installed to assess evaporation. Special piezometer tubes were designed and installed on a transect from the river to the back of the swamp to investigate seepage and the general hydrology of the area.

Special water meters to measure the flow and quantity of water passing through the sluice gate were designed and installed, operating an automatic recorder. Drainage pumps were accurately calibrated. Seepage from the River Murray was small and is not included in the data of table 7.

To summarise:

(1) Drainage (SD) is approximately half of irrigation water supplied (I) Allowing for an annual leaching requirement (e.g. 150 mm) it appears that irrigation volumes are far in excess of requirements.

(2) Comparison in input (P + I) and output (E + SD) indicates a good correlation of data.

(3) Water input from rainfall is minor when compared with input from irrigation.

9. DRAINAGE SYSTEM

Experimental measurements on the Long Flat IA indicated soil water tensions and water tables were unsatisfactory for normal plant growth over most of the year. In an attempt to overcome these problems, a drainage system was installed on Sect. 80 to lower the water table and increase soil water tensions. Soil water tension, water table level, tile line flow and pasture production were measured after the installation of the system to observe changes brought about by drainage. These measurements were taken during the 1964-65 and 1965-66 irrigation season and the 1965 non-irrigation season.

Table [redacted] 7

The water budget of irrigated pasture land at Long Flat 1A

All components in m.m.

	Rainfall (P)	Irrigation (I)	P + I	Evaporation (E)	Drainage (SD)	E + SD
1962						
Oct.	73	103	176	93	104	197
Nov.	14	254	268	133	99	232
Dec.	40	201	241	166	85	251
1963						
Jan.	42	240	282	176	105	281
Feb.	2	197	199	130	84	214
Mar.	1	211	212	115	103	218
Total for 6 Months	172	1206	1378	813	580	1393
April	54	135	189	64	104	168
May	84	0	84	28	69	97
June	63	0	63	31	56	87
July	56	0	56	31	20	51
Aug.	43	0	43	57	18	75
Sept.	23	128	151	112	50	162
Total for 6 Months	323	263	586	323	317	640
Oct.	49	186	235	139	89	228
Nov.	4	214	218	157	111	268
Dec.	1	314	315	163	113	276
1964						
Jan.	8	264	272	184	94	278
Feb.	16	277	293	135	97	232
Mar.	5	240	245	108	108	216
Total for 6 months	83	1495	1578	886	612	1498
April	41	86	127	50	53	103
May	19	156	175	38	77	115
June	38	0	38	22	17	39
July	51	0	51	27	17	44
Aug.	33	115	148	56	73	129
Sept.	50	95	145	82	68	150
Total for 6 Months	232	452	684	275	305	580
Oct	37	128	165	123	71	194
Nov	67	183	250	129	97	226
Dec	22	234	256	152	137	289
1965						
Jan	1	244	245	161	96	257
Feb.	0	294	294	147	108	255
Mar.	2	235	237	120	121	241
Total for 6 months	129	1318	1447	832	630	1462

10. DESIGN OF DRAINAGE SYSTEM

The design of the drainage system can be seen from diagram 1. Three tile lines, each 107 m long and constructed of 10 cm slotted PVC pipe, were installed at a minimum depth of 1.5 m on a grade of 0.25%. Coarse sand was placed around the pipe to act as a filter for silt. The tile lines emptied into concrete sumps from which the drainage water was removed by an automatic pumping unit.

From the design of the drainage system a site 3.1 metres from the drainage line could be expected to be well drained and a site 48.8 metres from the drainage line poorly drained. A comparison of results from a well drained site and a poorly drained site should give some indication of the functioning of the drainage scheme.

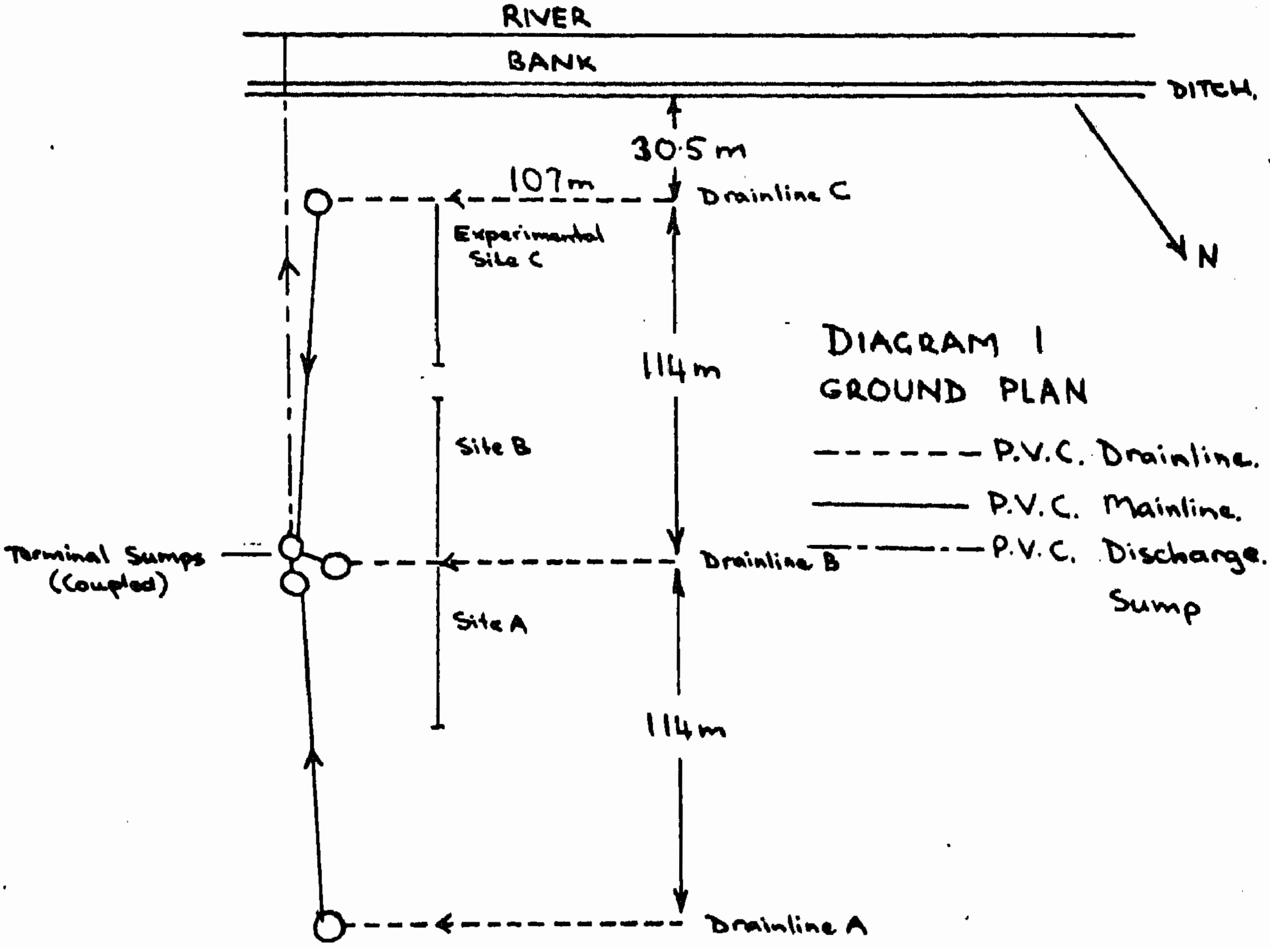
11. SOIL MOISTURE TENSION MEASUREMENTS

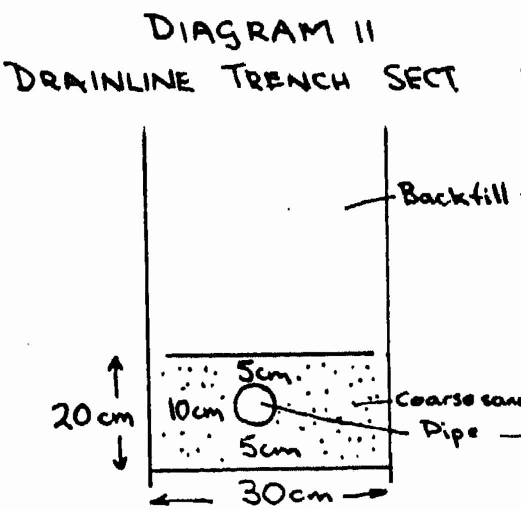
Three sets of tensiometers were installed on the trial area 3.1, 6.1, 12.2, 24.4 and 48.8 metres from drainage lines and were at depths of 10, 20, 40, and 60 cm. The installations were 40 m from the eastern PVC mainlines, site C being closest to the river bank and site A furthest from the bank (diagram 1). Commencing on 4/1/65, soil water tension values were recorded. Measurements were usually taken just after irrigation and then about 14 days later, except for two irrigation cycles (18/3/65 to 15/4/65 and 22/2/66 to 10/3/66) where six or seven measurements were taken during the irrigation cycle (Appendices IV and V). Readings were taken at regular intervals during the 1965 non-irrigation cycle (Appendix VI). Approximately equal volumes of water were applied to the irrigation bay during each irrigation.

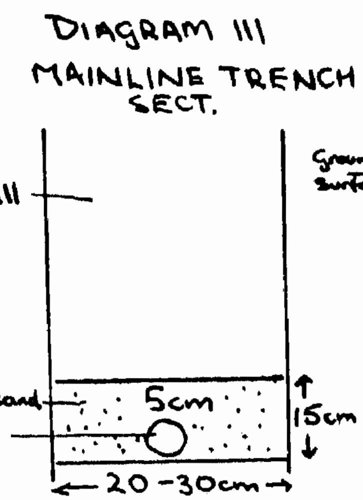
Discussion

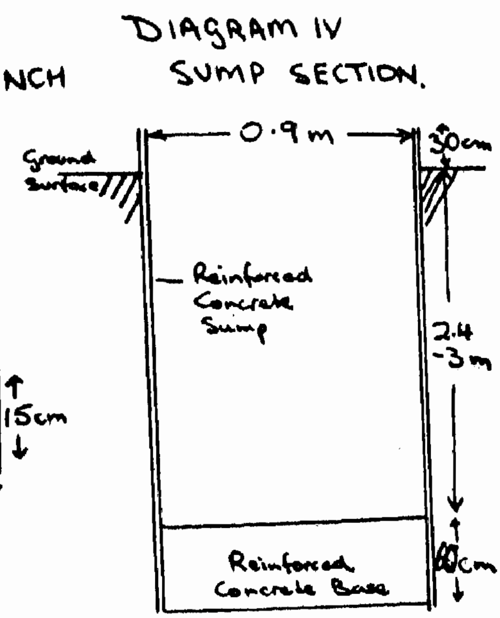
Soil water tensions at depths of 10 cm and 40 cm were representative of the results obtained, and show the change in water tension with increased soil depth. These results, measured 3.1 and 48.8 m from the drainage line, for the two irrigation periods 18/3/65 to 15/4/65 and 22/2/66 to 10/3/66 are plotted in figures 4 and 5. The tension readings are averages from the three sets of tensiometers. Figure 4 suggests drainage had some effect on soil water tension during the first season of operation. At a soil depth of 10 cm, soil water tensions exceeded 100 cms by day 6 for a drained site as compared with 9 days for a non-drained site. Also, on the drained site soil water tensions rapidly increased after 20 days, while this was not as marked on the non-drained site. With measurements taken at a depth of 40 cm soil water tension exceeded 100 cm in 13 days on a drained site as compared with 22 days on a non-drained site.

Drainage Design Sect 80 Long Flat I.A.

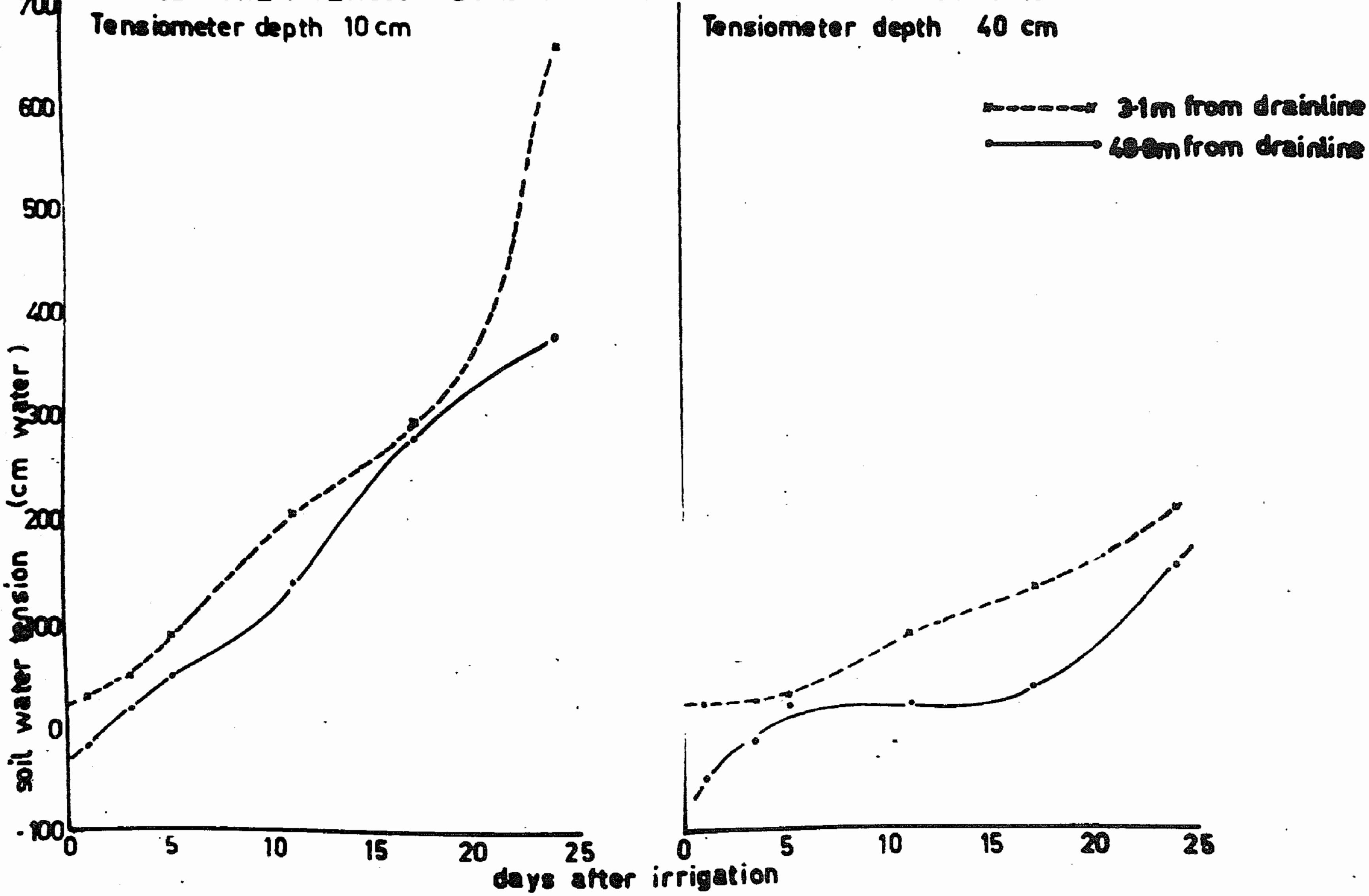




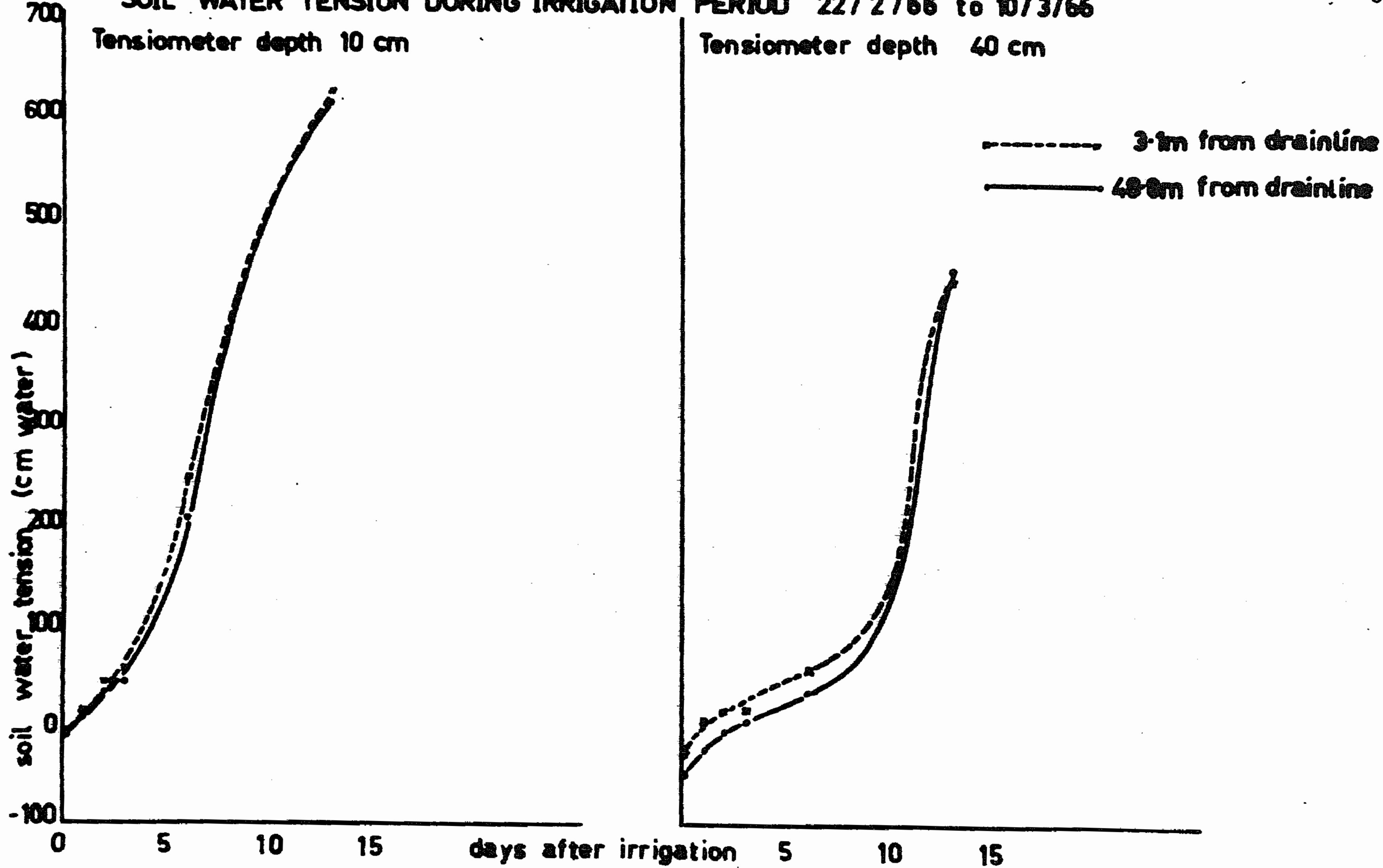




SOIL WATER TENSION DURING IRRIGATION PERIOD 18/3/65 to 15/4/65



SOIL WATER TENSION DURING IRRIGATION PERIOD 22/2/66 to 10/3/66



In the 1965 non-irrigation season, differences in soil water tension between the drained and non-drained sites, as indicated by measurements at a depth of 10 cm, were not marked (Figure 6). However, tensions rarely fell below 100 cm, indicating that, at 10 cm the soil rarely became excessively wet for normal plant growth during this season.

During the irrigation period in 1966 (Figure 5), differences in soil water tension between the two sites and at both 10 cm and 40 cm were minimal, and apparently drainage was not occuring.

12. TILE LINE FLOW following irrigation

Tile line flows along drainline B were measured at intervals after irrigations on 18/3/65 and 22/2/66 using a bucket and stopwatch at the sump (See Figure 7).

Tile line flows were high immediately after irrigation, and fell rapidly in the first 40 to 60 hours to become almost constant by 80 hours. Tile line flows were lower in the second year of measurement than in the first. This may have been due to silting of the drainlines and surrounding soil by iron oxides, as samples of iron oxides were collected from the drainlines.

13. WATER TABLE LEVELS

Self recording water level recorders were located a few metres west of the tensiometers on the trial area, 6.1, 12.2, 24.4 and 48.8 metres south of drainline B. Levels during one irrigation cycle in the 1964/65 irrigation season and for three cycles in the 1965/66 season, and during the 1965 non-irrigation season are presented in appendices VII, VIII, IX, X and XII. The difference in water levels between sites 6.1 and 48.8 m from drainlines is also presented in appendices XI and XII.

Discussion

Water levels fell most rapidly close to the drainline, and at 48.8m from the drainline may have been little influenced by drainage. During the non-irrigation cycle, the water table became closer to the surface with increasing distance from the drainline. However, during the 1965/66 irrigation season water levels near the drainline did not fall as rapidly as during the 1964/65 season, possibly due to reduced drainage occurring since reduced tile line flows were observed.

Water levels tended to be lower on the drainage trial area both during irrigation and non-irrigation seasons than in 1962 on section 77. Winter rainfall in 1965 was 175 mm, in 1961 151 mm and 1962 58mm so that differences in winter rainfall will not explain these differences.

SOIL WATER TENSION DURING NONIRRIGATION PERIOD 1965

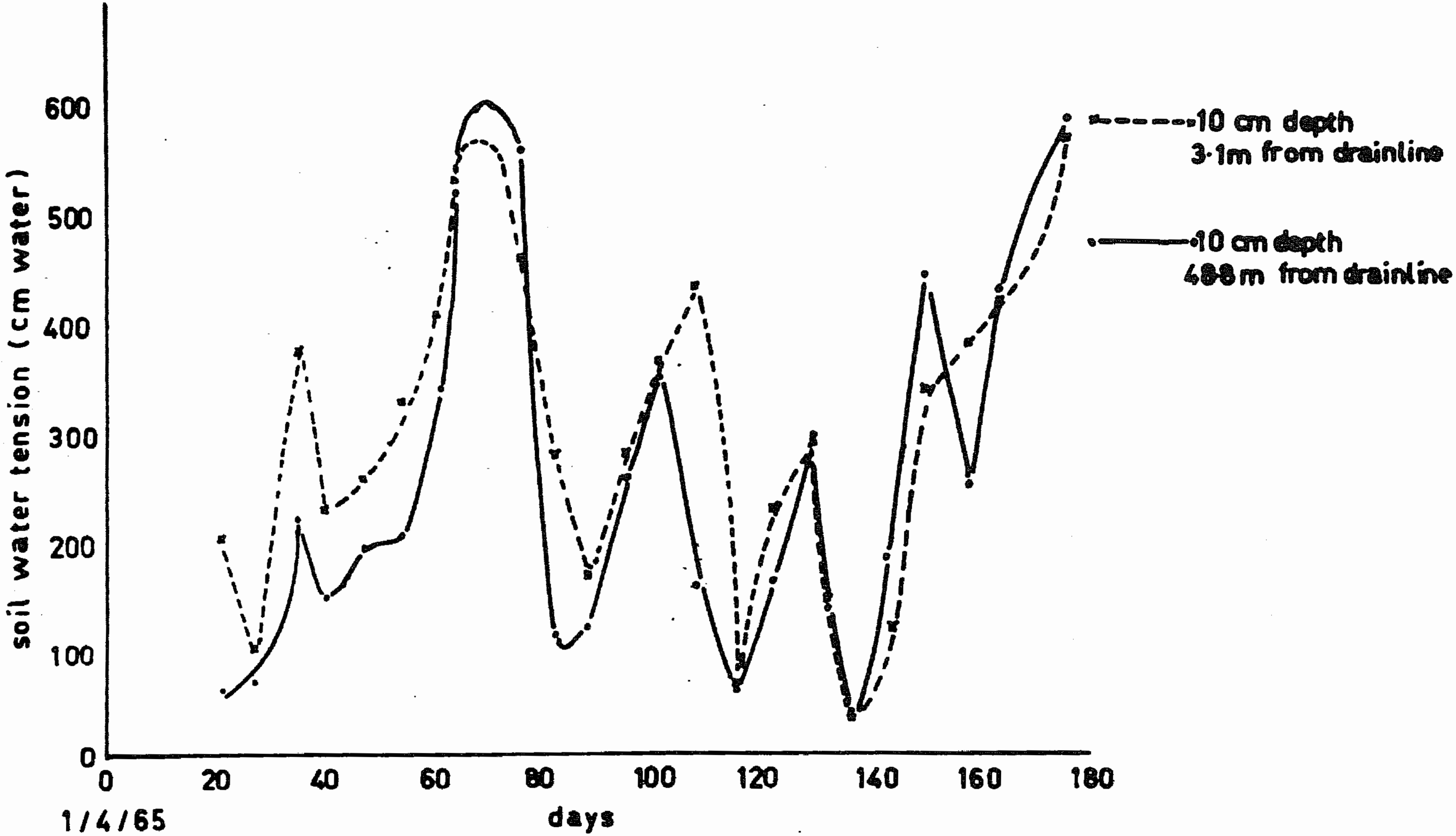
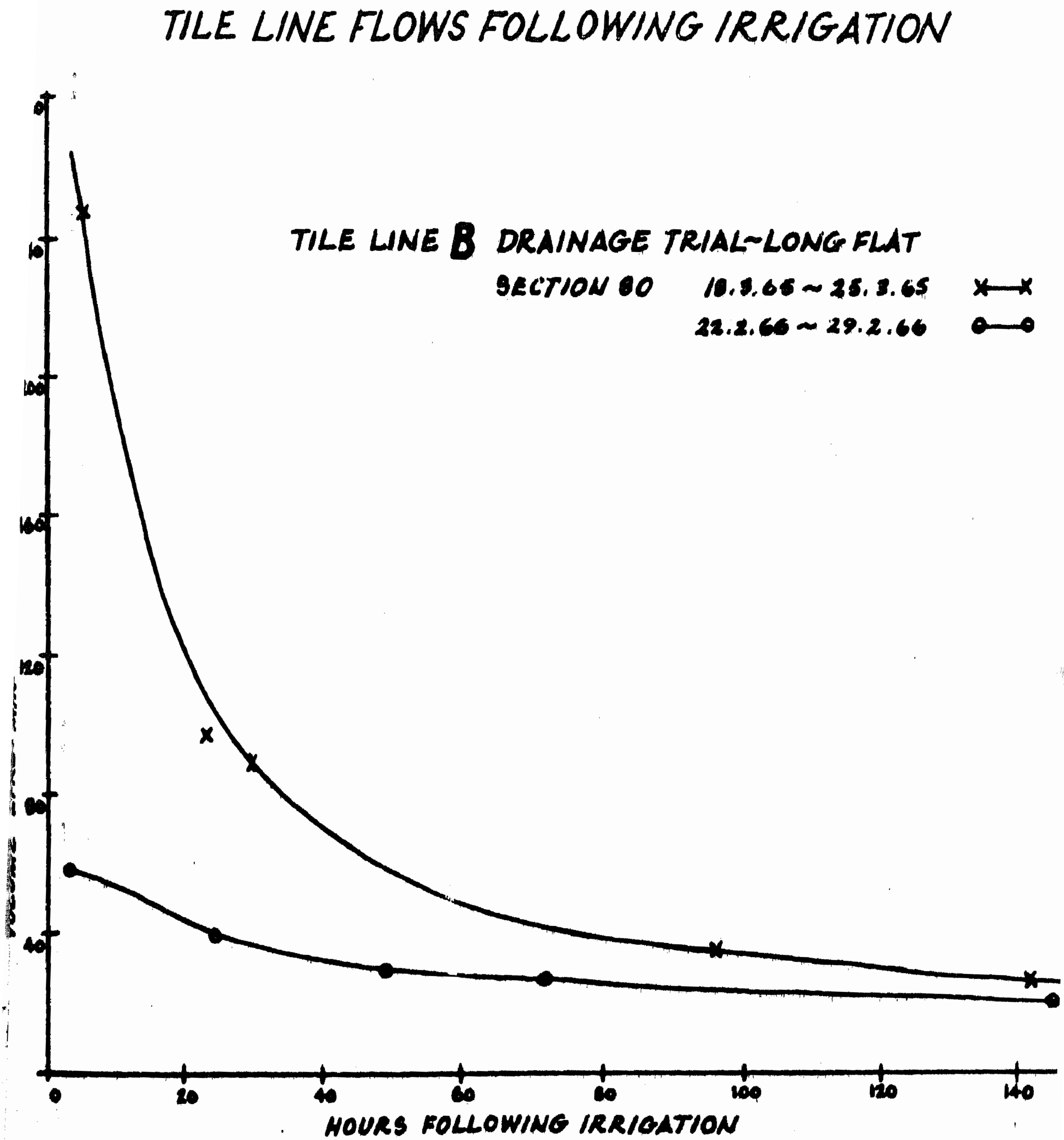


Figure 7


TILE LINE FLOWS FOLLOWING IRRIGATION
TILE LINE B DRAINAGE TRIAL~LONG FLAT
SECTION 80
18.3.66 ~ 25.3.65
22.2.66 ~ 29.2.66
40
80
120
160
0
20
40
60
80
100
120
140
HOURS FOLLOWING IRRIGATION

Drainage or the change in site (1961-3 Sect. 77; 1965 Sect. 80) may account for lower water tables in 1965.

14. ANALYSIS OF TILE DRAIN EFFLUENT

Tile drains were installed in October, 1964. These were below the water table until the beginning of February, 1965, when the pumping unit commenced operation. Before this the water table on the experimental area would not have dropped more than 0.6 - 1.0 metres from the surface.

Previously the area had been drained by a grid of shallow ditches 46 cm - 76 cm. deep. The central ditch on the trial area was refilled in September, 1964. Consequently on the trial area, water tables following irrigation would have been higher than hitherto. Moreover a build up of salts would be expected near the soil surface since the area was in a fallow condition in October, and much of November 1964. The area was rotary hoed at the beginning of October and sown to pasture on 9/10/65. It was not until mid-November that there was good vegetative cover.

Objective

To measure

(1) the salt content of the water table
(2) changes in salt content following irrigation

Method

Water samples were collected from two tile drain outlets, (B and C) shortly after the pasture area was irrigated on two occasions, 18/3/65 and 22/2/66. Samples were also taken on the 31/8/65 at the end of winter period before irrigations had recommenced. Tile flows at this stage were small - approximately 2 l/min.. By comparison tile line flows during the two irrigation cycles ranged from 90-270 l/min. immediately after irrigation to 9-23 l/min. some 160 hours later.

Apart from the samples of River Murray water, all samples were analysed in April, 1966 by the South Australian Department of Chemistry for Total Sol. Salts, (T.S.S.), Sodium (Na), Potassium (K), Magnesium (Mg), Chloride (Cl), Phosphorus (P), Carbonate (CO_3), Sulphate (SO_4), Nitrate (NO_3) Iron (Fe) and Silica (SiO_2) and expressed as parts per million (ppm) soluble salts.

Samples of River Murray water were taken monthly by the Engineering and Water Supply Department at Murray Bridge. The analyses are given in appendices XIII and XIV.

Results:

Changes in salt content following irrigation are illustrated in the following analyses taken from tile line B. Table 8 also shows the reduction in salt that has occurred following 12 months of drainage.

Table 8 - Water Analyses Following Irrigation(ppm) March, 1965, (Tile line B) February, 1966

Hours following irrigation	T.S.S.		Na		Cl		SO_4	
	Mar. 1965	Feb. 1966	Mar. 1965	Feb. 1966	Mar. 1965	Feb. 1966	Mar. 1965	Feb. 1966
5	1,530	1,420	442	390	640	580	256	280
30	2,200	1,750	589	450	990	730	359	335
96	2,400	1,870	622	450	1090	780	382	350

The T.S.S., Na, and Cl values are higher in March, 1965 than February, 1966. The SO_4 values however are of the same order.

Immediately following irrigation T.S., Na, and Cl are at their minimum levels, the most rapid rise is in the 30 hours following irrigation; for the remainder of the irrigation interval the rise in T.S.S. is more gradual.

Discussion

The T.S.S. Values, which range from 1400 to 2400 ppm., show that the water table is much more saline than the irrigation water (300 p.p.m. average). The effect of this water table salt on pasture growth may be serious unless drainage rapidly lowers the water table to a point where capillary rise of salts to the root zone is small.

It was anticipated that salt levels would be high on this trial section. Drainage had been previously poor, and moreover the tiles were not functioning until the end of the summer, by which time a concentration of salts at the surface would be expected. A fall in salt content was observed by February, 1966, so it was expected that salt content would continue to fall provided the quality of the irrigation water from the River Murray did not deteriorate.

15. PASTURE PRODUCTION ON TRIAL AREA

The trial area was rotary hoed in October, 1964, and sown to pasture (white clover and perennial rye) on 9/10/65. The pasture established well although Paspalum was still present.

Diagram 1 shows the general drainage trial design. On each of the three replicates (sites A, B, C) pasture cuts were made 3.1, 6.1, 12.2, 24.4 and 48.8 m from drainlines.

At each of these distances on each site, four positions were marked, between 30 and 50 m from the eastern mainlines. Closed cages were placed at each of these positions since pasture yields were measured under grazing. At each harvest, the pasture was sampled (pasture cuts made to 5 cm) from within the closed cages. Each cage was then resited at an adjacent position with the pasture trimmed to 5 cm. Half the pasture samples were subsampled for botanical composition determinations.

Results and Discussions

Pasture production data and botanical composition data was analysed by computer. There were no significant differences in pasture yields with varying distances from the drainlines, and only one significant difference in botanical composition changes with varying distances from the drainline. Table 9 presents mean yield results; appendix XV includes results at each distance from the drainline.

Although there are no obvious differences in pasture growth with varying distances from the drainline, pasture yields are greater than those observed in section 77 (see earlier). There is no indication that yields increased through improved drainage; water tension data suggests that drainage was ineffective. The higher yields may be due to better pasture or naturally better soil conditions - ground water levels appear to have been lower on section 80 at nondrained sites, than on section 77.

16. GROWTH OF OATS AND SUDAX ON TRIAL AREA

During 1966 the drainage trial area was sown to oats and sudax to determine if these fodder crops would show a yield response to the lower water tables on the drained sites. This planting was part of a renovation cycle prior to the sowing of new pasture species on the area.

Establishment (sudax only), yield under g4azing, and % N in plant tops were determined in relation to distance from drainage line.

Results

(1) Early Kherson Oats

TABLE 9

PASTURE PRODUCTION — DRAINAGE TRIAL

2/12/64 - 5/4/66 — Section 80 Long Flat

Date of Harvest	No. days since pervious harvest	Dry Matter Kg/ha/day						Total dry matter per harvest Kg/ha
		Per. Rye	Pas-palum	White Clover	Other Grasses	Others	Total	
11/1/65	39	7.1	23.0	6.4	1.1	16.6	56.4	2,200
16/2/65	36	4.4	33.5	8.1	1.8	7.6	57.7	2,078
23/3/65	35	2.2	36.7	6.7	1.3	6.4	58.2	2,042
1/6/65	70	6.5	5.3	9.0	0.2	1.1	22.4	1,572
* Missing Harvest cut on 13/8/65 Data Lost								
22/9/65	40	9.7	0.4	17.3	2.9	1.6	31.4	1,252
18/10/65	26	17.9	5.4	35.3	7.4	2.4	71.3	1,854
9/11/65	22	24.6	14.9	54.2	7.1	5.0	105.6	2,323
7/12/65	28	10.6	28.9	30.8	6.5	3.2	77.3	2,267
4/1/66	28	0.2	54.4	28.6	3.6	2.9	93.4	2.616
25/1/66	21	0.7	63.8	19.0	1.0	1.1	81.5	1,712
15/2/66	21	0.8	65.0	13.4	4.4	1.3	85.1	1,788
7/3/66	20	0.3	66.1	4.8	1.0	1.3	71.9	1,438
5/4/66	29	0.6	39.2	5.4	1.5	1.6	46.5	1,348

* Assume 18 Kg/ha/day for 73 days to 13/8/65 then total dry matter in harvest = 1308 Kg.

Total annual Dry Matter Production from 16/2/65 to 15/2/66 is 18,736 Kg/ha

Results from three experimental sites have been averaged (Table 10). The area was sown on 11/5/66.

Table 10

Distance from drainline (m)	6.1	12.2	24.4	48.8
Yield (Kg dry matter/ha)				
Harvest 1 (14/7/66)	1,173	1,200	1,101	973
Harvest 2 (15/11/66)	7,073	7,347	6,647	6,513
% Nitrogen				
Harvest 1 (14/7/66)	4.44	4.60	4.48	4.84
Harvest 2 (15/11/66)	1.21	1.24	1.16	1.14

There appeared to be some yield decrease at 48.8m from drainline. Nitrogen levels show no consistent change with distances from drainlines, but appear to be low at harvest 2.

(2) Sudax

Results from three experimental sites have been averaged. (Table 11). The same sites as for the oat fodder crop were sown on 16/12/66.

Establishment (plants per 0.04 sq. m; mean of 10 samples from each of 3 replicates).

Distance from drain	3.1m	6.1m	12.2m	24.4m	48.8m
Establishment	1.97	1.61	1.57	1.47	0.92

With increasing distance from the drainline, establishment decreased.

Table 11

Distance from drain (m)	3.1	6.1	12.2	24.4	48.8
Yield (cut at 15 cm) Kg dry matter/ha					
Harvest 1 (7/ 2/67)	948	886	748	843	504
Harvest 2 (15/ 3/67)	385	373	338	357	268
Harvest 3 (5/ 4/67)	801	790	806	766	619
% Nitrogen - harvest 2 and 3 only					
Harvest 2 (15/ 3/67)	1.69	1.66	1.59	1.58	1.53
Harvest 3 (5/ 4/67)	2.43	2.33	2.28	2.25	2.14

Yields decrease with increasing distance from drainline. % N may also have decreased with increasing distance from drainlines.

In general, the yield of the fodder crops was greatest closest to the drainlines, indicating that there may have been some response in terms of plant yield to the fall in water tables observed, although water tensions had apparently been little influenced by the drainage system.

Yield of resown pastures

The trial area was sown with N.Z. ryegrass, H.I. ryegrass, Demeter fescue and Ladino White clover on 14/4/67, and the area irrigated on 18/4/67. The pasture was to be cut at regular intervals during the following season, but technical difficulties led to the trial being concluded before yield data was satisfactorily collected.

17. SUMMARY OF RESULTS

1. Seasonal pasture production during 1961-3 was apparently below that which had been recorded on similar soils in 1932.

2. Water tables 1961-3 were observed to be close to the surface for long periods of the year.

3. Soil moisture tension ranges 1961-3 appeared to be unsatisfactory for much of the year.

4. The water budget determined for Long Flat indicated that water applications were in excess of evapotranspiration and leaching requirements.

5. Hydraulic permeability of soils of Long Flat high.

6. Results from a drainage trial suggest :

   (1) Soil water tensions were little influenced by the drainage system after one year.

   (2) Ground water tables fell much less in the second season of operation than the first.

   (3) Tileline flows were reduced in the second year of operation.

   (4) The salinity of ground water indicated the necessity for good drainage.

   (5) Pasture yields were not increased on trial area.

   (6) Yields and %N of oats and sudax show no marked increase on trial area.

Soil water conditions are far from ideal for optimum plant growth on the Long Flat Irrigation Area. The type of drainage system constructed on a trial basis would not appear to be satisfactory for improving these conditions.

18. REFERENCES

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APPENDIX I

Section 77 LONG FLAT 1A WATER TABLE LEVELS (cm below natural surface)

13/10/60-26/9/61

WELL

Date	1	2	3	4
13/10/60	62	66	55	54
14/10/60	65	62	57	57
17/10/70	76	80	68	74
20/10/60	26	37	31	25
22/10/60	40	42	32	45
24/10/60	63	58	53	57
26/10/60	71	66	58	63
31/10/60	41	62	63	64
2/11/60	59	73	63	68
4/11/60	62	77	64	69
7/11/60	72	74	64	68
9/11/60	76	86	71	74
11/11/60	81	90	74	78
14/11/60	56	66	53	57
16/11/60	70	83	68	70
18/11/60	71	83	70	71
21/11/60	84	94	77	82
23/11/60	91	97	81	82
28/11/60	105	98	79	71
2/12/60	16	25	8	6
5/12/60	40	42	42	47
7/12/60	58	55	47	49
9/12/60	64	61	54	56
12/12/60	82	77	68	67
14/12/60	89	83	73	73
19/12/60	98	94	81	77
21/12/60	31	55	46	53
23/12/60	58	69	58	62
29/12/60	19	8	3	0
2/ 1/61	62	54	47	48
6/ 1/61	75	66	58	60
9/ 1/61	63	83	72	72
11/ 1/61	25	40	40	50
12/ 1/61	49	52	48	53
16/ 1/61	78	76	69	71
20/ 1/61	82	87	76	80
23/ 1/61	93	93	83	87

APPENDIX I (Cont.)

Date	2	3	4	5
27/ 1/61	46	45	44	47
29/ 1/61	72	66	64	63
2/ 2/61	17	37	35	47
6/ 2/61	53	58	52	61
9/ 2/61	49	57	46	48
12/ 2/61	72	72	66	72
15/ 2/61	79	82	64	61
17/ 2/61	64	87	74	75
22/ 2/61	27	25	21	23
24/ 2/61	16	0	0	26
1/ 3/61	55	49	42	44
3/ 3/61	59	55	49	52
6/ 3/61	68	62	57	60
10/ 3/61	75	70	57	56
13/ 3/61	83	71	60	56
17/ 3/61	93	87	70	61
20/ 3/61	98	92	75	74
27/ 3/61	28	35	37	42
29/ 3/61	53	47	43	46
31/ 3/61	58	48	47	48
5/ 4/61	71	66	54	53
7/ 4/61	50	49	26	26
10/ 4/61	56	51	33	33
12/ 4/61	64	58	46	51
17/ 4/61	56	56	44	46
19/ 4/61	61	56	45	49
24/ 4/61	66	59	52	56
26/ 4/61	68	63	52	56
28/ 4/61	70	63	56	58
1/ 5/61	72	65	57	58
3/ 5/61	67	65	51	54
5/ 5/61	68	63	49	52
8/ 5/61	70	66	53	55
10/ 5/61	78	69	55	57
15/ 5/61	77	73	59	62
19/ 5/61	81	75	63	64
22/ 5/61	85	80	66	68
8/ 8/61	65	62	50	53
15/ 8/61	71	67	57	58
28/ 8/61	77	77	63	65
13/ 9/61	54	59	48	53
26/ 9/61	65	56	53	55

~~Table 7~~ Appendix II

SOIL MOISTURE TENSION SITE 1 LONG FLAT SECT. 77 1961-63

	Irrigation Period	Days	Tensiometers Depth (cm.) 10 cm							20 cm							40 cm						
			* <100	1-200	2-300	3-400	4-500	5-600	>600	<100	1-200	2-300	3-400	4-500	5-600	>600	<100	1-200	2-300	3-400	4-500	5-600	>600
	9/11/61 -30/11/61	21	3	1	5	7	3	2	-	14	3	4	-	-	-	-	15	4	2	-	-	-	-
	30/11/61 -21/12/61	21	3	1	2	2	1	3	9	8	3	2	4	4	-	-	8	3	3	2	3	2	-
Nov.	21/12/61 -11/1/62	20	4	1	1	2	2	6	4	7	2	2	1	1	7	-	9	2	1	2	3	3	-
to	11/ 1/62 - 1/2/62	20	3	2	3	3	4	5	-	6	5	2	3	4	-	-	9	7	4	-	-	-	-
Feb.	1/2/62 -21/2/62	20	5	2	1	4	8	-	-	10	3	1	4	2	-	-	15	2	2	1	-	-	-
(incl.	5/11/62 -25/11/62	20	2	1	1	1	2	2	11	4	3	4	1	1	3	4	10	2	1	2	3	2	-
	25/11/62 -16/12/62	21	4	1	1	2	2	3	8	4	2	4	6	5	-	-	8	4	3	6	-	-	-
(Summer)	16/12/62- 5/1/63	19	3	2	3	3	4	4	-	4	3	5	4	3	-	-	8	7	4	-	-	-6	-
	Av.	20.6	3.4	1.4	2.1	3	3.3	3.1	4	7.1	3	3	2.9	2.5	1.3	0.5	10.3	3.9	2.4	1.8	1.1	0.9	-
Sept.	20/ 9/61 -19/10/61	29	7	1	1	1	1	3	15	7	2	2	2	16	-	-	14	6	5	4	-	-	-
Oct.,	19/10/61 - 9/11/61	20	5	1	-	2	2	2	18	7	3	3	7	-	-	-	10	10	-	-	-	-	-
March	21/ 2/62 -15/3 /62	24	4	2	4	1	2	9	2	7	4	3	3	2	5	-	20	4	-	-	-	-	-
to may	15/ 3/62 -11/ 4/62	26	14	3	1	2	2	1	3	18	2	2	4	-	-	-	26	-	-	-	-	-	-
(Spring-	11/ 4/62 -18/ 5/62	37	6	1	1	1	11	10	7	7	3	12	9	6	-	-	21	12	4	-	-	-	-
Autumn)	1/10/62 - 5/11/62		19	7	1	-	1	2	4	25	2	-	1	1	5	-	28	3	3	-	-	-	-
	Av.	28.5	9.2	2.5	1.3	1.2	3.2	4.5	6.5	11.8	2.7	3.7	4.3	4.2	1.7	-	19.8	5.8	2	0.7	-	-	-
Nonirrigation Winter	7/ 5/61 -20/ 9/61	122	29	10	10	18	24	25	6	5	44	19	6	13	18	17	100	11	11	-	-	-	-
Period	15/ 6/62 - 1/10/62	106	27	22	6	10	4	15	22	40	36	6	11	6	7	-	96	10	-	-	-	-	-
	Av.	114	23	16	8	14	14	20	14	22.5	40	12.5	8.5	9.5	12.5	8.5	98	10.5	5.5	-	-	-	-

* cms. water tension

~~Table 8~~ Appendix III

SOIL MOISTURE TENSION SITE 2 LONG FLAT SECT. 77 1961-63

Irrigation Period		Days	Tensiometers Depth (cm) 10 cm							20 cm							40 cm						
			<100	1-200	2-300	3-400	4-500	5-600	>600	<100	1-200	2-300	3-400	4-500	5-600	>600	<100	1-200	2-300	3-400	4-500	5-600	>600
	9/11/61 -30/11/61	21	11	2	1	2	2	3	-	16	1	1	3	-	-	-	21	-	-	-	-	-	-
	30/11/61 -21/12/61	21	6	2	4	8	1	-	-	10	3	4	4	-	-	-	21	-	-	-	-	-	-
Nov.	21/12/61 -11/1/62	20	6	2	1	1	1	6	3	7	3	2	1	2	5	-	13	2	2	3	-	-	-
to	11/1/62 -1/2/62	20	4	2	2	2	5	5	-	8	3	2	4	3	-	-	20	-	-	-	-	-	-
Feb.	1/2/62 -21/2/62	20	7	-	1	2	5	5	-	13	2	2	3	-	-	-	20	-	-	-	-	-	-
(Inc)	5/11/62 -25/11/62	20	6	2	3	1	3	4	-	10	2	1	1	1	5	-	20	-	-	-	-	-	-
	25/11/62 -16/12/62	21	6	2	2	10	6	4	-	8	13	-	-	-	-	-	13	8	-	-	-	-	-
	16/12/62 -5/1/63	19	6	1	2	-	-	-	-	9	10	-	-	-	-	-	19	-	-	-	-	-	-
Av.		20.6	6.5	1.6	2	3.5	2.9	3.4	0.4	10.1	4.6	1.5	2	0.8	1.3	-	18.4	1.3	0.3	0.4	-	-	-
Sept.	20/9/61 -19/10/61	29	6	2	2	3	16	-	-	9	2	3	3	4	7	1	27	2	-	-	-	-	-
Oct.	19/10/61 -9/11/61	20	7	1	3	3	4	2	-	10	3	2	2	3	-	-	20	-	-	-	-	-	-
Mar.	21/2/62 -15/3/62	24	9	1	1	1	12	-	-	13	4	5	2	-	-	-	24	-	-	-	-	-	-
to	15/3/62 -11/4/62	26	17	3	1	2	3	-	-	26	-	-	-	-	-	-	26	-	-	-	-	-	-
May	11/4/62 -18/5/62	37	24	13	-	-	-	-	-	37	-	-	-	-	-	-	37	-	-	-	-	-	-
	1/10/62 -5/11/62	34	20	8	-	1	5	-	-	29	-	5	-	-	-	-	34	-	-	-	-	-	-
Av.		28.5	13.9	4.7	1.2	1.7	6.7	0.3	-	20.7	1.5	2.5	1.2	1.2	1.2	0.2	28	0.3	-	-	-	-	-
~~Sub-irrigation~~ Winter	17/5/61 -20/9/61	122	41	49	14	16	2	-	-	118	4	-	-	-	-	-	122	-	-	-	-	-	-
Period	15/6/62 -1/10/62	106	57	32	11	1	5	-	-	99	3	4	-	-	-	-	106	-	-	-	-	-	-
		114	49	40.5	12.5	8.5	3.5	-	-	106	3.5	2	-	-	-	-	114	-	-	-	-	-	-

Appendix IV

SOIL MOISTURE TENSION DRAINAGE TRIAL SECTION 80

18.3.65 to 15.4.65 following irrigation on 18.3.65

Days after Irrigation	Distance of tensiometer from drain (metres)	Tensiometer Depth / Tensiometer Site: 10 cm A	10 cm B	10 cm C	10 cm Av.	20 cm A	20 cm B	20 cm C	20 cm Av.	40 cm A	40 cm B	40 cm C	40 cm Av.	60 cm A	60 cm B	60 cm C	60 cm Av.
0	3.1	24	62	13	32	-	13	28	21	-19	-20	-30	-23	-7	-7	-60	-25
	6.1	0	79	-25	18	22	-6	10	9	-13	14	-37	-12	-50	-17	-41	-36
	12.2	2	7	-22	-5	-5	54	-5	18	39	7	-38	3	-20	-47	-96	-31
	24.4	13	9	-33	3	11	4	-13	1	-18	-12	-10	-13				
	48.8	-14	-21	-13	-16	4	-2	-21	-6	-45	-60	-34	-46				
0.25	3.1	-28	63	25	38	8	12	33	17	-17	-18	-21	-19	-4	-13	-55	-24
	6.1	10	-83	-15	26	-12	13	14	1	10	19	-37	-3	1	-2	-34	-15
	12.2	1	7	-22	-5	-5	54	-5	15	39	7	-38	3	20	-47	-22	-29
	24.4	13	9	-33	-3	11	4	-13	1	18	-12	-10	-1				
	48.8	-14	-21	-13	-16	4	-2	-21	-6	-45	-60	-34	-46				
3	3.1	79	56	38	57	6	112	44	54	14	15	44	24	48	56	-33	30
	6.1	35	40	58	44	-10	30	86	35	16	-1	-27	-4	-24	34	-23	-4
	12.2	-5	-5	27	6	-	-9	9	0	71	5	-23	-10	-10	-34	-10	-18
	24.4	11	-2	-4	-1	48	16	41	35	10	-12	-23	-8				
	48.8	15	13	36	21	20	25	-43	0	40	-3	-2	-12				
5	3.1	89	93	100	94	28	111	73	70	19	19	57	31	67	55	-8	38
	6.1	85	85	88	86	30	29	100	53	33	7	3	14	-	48	-9	20
	12.2	52	40	67	53	-	36	20	28	2	13	0	7	7	4	11	7
	24.4	60	32	41	44	70	36	72	59	35	8	-12	10				
	48.8	45	44	72	54	49	12	76	45	54	-1	10	21				
11	3.1	85	256	298	213	114	81	120	105	58	150	81	96	60	36	11	36
	6.1	204	233	61	166	119	178	90	129	41	177	33	84	78	55	0	44
	12.2	192	212	180	95	107	372	25	168	455	170	15	213	26	131	9	16
	24.4	230	129	175	178	72	178	118	123	57	5	24	28				
	48.8	75	181	164	140	84	134	78	99	80	-6	5	26				
17	3.1	126	377	375	293	275	121	152	183	160	144	119	141	123	-29	81	58
	6.1	129	325	235	230	274	158	64	165	106	137	123	122	116	83	84	94
	12.2	82	365	262	236	80	27	156	88	154	48	74	92	74	4	90	56
	24.4	358	193	340	297	77	302	230	203	122	20	59	66				
	48.8	196	312	340	283	221	307	220	249	123	-62	59	40				

Contd./....

Appendix IV (cont)

24	3.1	99	510	572	670	453	142	232	276	224	250	182	219	223	-48	148	[illegible]
	6.1	166	429	358	317	482	236	101	273	305	325	203	278	138	125	157	[illegible]
	12.2	225	522	392	380	187	469	266	307	326	-	148	237	149	-	211	[illegible]
	24.4	522	326	471	439	230	477	63	257	225	138	12	125				
	48.8	230	417	480	376	391	460	368	406	227	77	171	158				

Appendix VI (cont)

14.9.65	3.1	192	662	-	427	117	440	110	222	60	103	46	70	41	0	11	26
	6.1	296	377	553	442	413	181	180	258	302	61	152	172	188	51	85	108
	12.2	342	394	508	415	88	105	354	182	31	50	155	79	25	-6	88	36
	24.4	540	751	478	589	179	627	337	381	66	492	148	235				
	48.8	283	530	500	438	147	349	318	271	105	32	159	99				

Appendix V

SOIL MOISTURE TENSION DRAINAGE TRIAL SECTION 80

22.2.66 to 10.3.66 following irrigation on 22.2.66

Days after irrigation	Distance of tensiometer from drain (metres)	Tensiometer Depth: 10 cm — Tensiometer Site A	10 cm B	10 cm C	10 cm Av.	20 cm A	20 cm B	20 cm C	20 cm Av.	40 cm A	40 cm B	40 cm C	40 cm Av.	60 cm A	60 cm B	60 cm C	60 cm Av.
0	3.1	-13	-13	-4	-10	-26	-23	-12	-20	-	-9	-44	-27	-63	-23	-63	-50
	6.1	-13	-11	-15	-13	-21	-22	-25	-23	-45	-20	-38	-34	-66	-36	-62	-55
	12.2	-11	-10	-4	-8	-23	-13	-21	-19	-42	-23	-41	-35		-43	-60	-52
	24.4	-9	-7	26	3	-20	-17	-14	-17	-43	-17	-45	-35				
	48.8	-14	-9	-9	-11	-25	80	-18	12	-42	-	-45	-44				
1	3.1	19	16	5	13	1	6	4	4	57	-9	-19	10	-27	-23	-38	-29
	6.1	-	23	11	17	12	5	-11	2	-11	-20	-15	-15	-24	-36	-38	-33
	12.2	15	13	30	19	5	-2	6	3	-13	-23	-32	-23	-29	-43	-32	-35
	24.4	12	17	2	10	-	4	6	5	-19	-17	-19	-18				
	48.8	-9	19	17	9	-14	7	5	-1	-33	-13	-21	-22				
2	3.1	43	47	29	40	9	30	18	19	55	-2	-1	17	-5	0	-19	-8
	6.1	132	48	33	71	27	19	8	18	-5	-6	-1	-4	-16	-11	-22	-16
	12.2	35	35	47	39	17	13	15	15	7	-3	-22	-6	-8	-25	-23	-19
	24.4	38	37	36	37	10	12	67	30	-6	0	-3	-3				
	48.8	19	42	36	32	14	24	21	20	-	3	-5	-1				
3	3.1	49	63	60	57	1	31	28	20	55	-3	-1	17	4	-1	-13	3
	6.1	131	56	54	80	29	20	18	22	0	0	2	2	-12	-7	-11	-10
	12.2	29	57	57	48	23	23	12	19	2	6	-	4	-2			-2
	24.4	56	52	82	63	12	18	47	26	-6	3	-	1.5				
	48.8	17	59	45	40	18	34	26	26	4	12	-	8				
6	3.1	170	268	300	246	-	143	179	161	53	19	97	56	19	6	24	16
	6.1	131	243	263	212	110	61	56	76	34	29	44	36	1	8	3	4
	12.2	190	257	210	219	34	93	106	78	44	20	16	27	17	5	21	14
	24.4	212	256	440	303	56	56	183	98	-2	16	52	22				
	48.8	115	317	180	204	78	112	103	98	30	56	26	37				
13	3.1	569	672	645	628	363	588	558	503	469	294	561	441	292	-	440	366
	6.1	499	458	-	479	335	338	-	337	371	402	473	415	345	-	138	242
	12.2	204	510	631	448	427	612	572	537	520	358	316	398	204	104	263	190
	24.4	513	656	648	607	500	608	522	543	371	190	419	327				
	48.8	-	613	623	618	541	607	556	568	389	508	-	449				

Appendix VI

SOIL MOISTURE TENSION DRAINAGE TRIAL SECTION 80

During Non-irrigation Season

Date	Distance of tensiometer from drain (metres)	Tensiometer Depth 10 cm				20 cm				40 cm				60 cm			
		Tensiometer Site A	B	C	Av.	A	B	C	Av.	A	B	C	Av.	A	B	C	Av.
21.4.65	3.1	51	40	65	51	36	135	77	83	13	11	13	12	-9	10	-3	-1
	6.1	41	31	121	64	35	-13	104	42	26	-9	39	19	-13	-7	-4	8
	12.2	44	25	107	59	35	28	125	63	17	11	38	22	2	-33	-4	-12
	24.4	42	33	82	52	41	33	32	35	5	6	1	4				
	48.8	69	44	77	63	29	15	-22	7	7	11	45	21				
27.4.65	3.1	85	137	98	106	45	15	55	38	17	14	19	16	19	2	13	11
	6.1	126	40	128	98	62	20	99	60	4	-36	30	0	4	16	4	6
	12.2	73	63	141	92	19	45	56	40	21	18	4	14	17	14	6	12
	24.4	113	79	126	106	30	58	26	38	17	20	14	17				
	48.8	37	84	83	68	48	34	53	45	28	7	24	23				
5.5.65	3.1	375	494	255	375	106	97	133	112	29	44	74	49	36	11	31	26
	6.1	261	246	272	260	157	82	111	116	50	39	83	57	21	21	45	29
	12.2	272	272	341	295	85	78	70	78	48	47	69	55	38	14	38	30
	24.4	427	428	360	405	123	116	121	120	51	40	64	52				
	48.8	144	264	246	218	90	149	163	134	47	6	24	26				
10.5.65	3.1	189	307	192	229	168	140	169	159	29	56	89	58	46	-35	49	20
	6.1	248	303	282	278	227	150	110	162	73	45	127	82	6	32	64	34
	12.2	56	153	40	37	182	102	133	139	176	55	98	110	44	29	30	34
	24.4	86	395	419	300	167	184	195	182	60	45	95	66				
	48.8	27	115	308	150	116	225	158	166	58	-4	42	32				
17.5.65	3.1	230	340	209	259	231	199	231	330	51	88	126	88	65	250	93	61
	6.1	296	315	332	314	318	225	206	256	113	90	194	132	49	57	105	70
	12.2	106	219	327	217	179	126	266	190	85	81	133	100	72	34	78	61
	24.4	428	194	450	357	194	258	190	214	102	66	158	109				
	48.8	89	259	227	192	187	309	289	262	96	9	89	65				

SOIL MOISTURE TENSION (CM WATER)

DRAINAGE TRIAL SECTION 80

During Non-irrigation season

Date	Distance of tensiometer from drain (metres)	10 cm A	10 cm B	10 cm C	10 cm Av.	20 cm A	20 cm B	20 cm C	20 cm Av.	40 cm A	40 cm B	40 cm C	40 cm Av.	60 cm A	60 cm B	60 cm C	60 cm Av.
24/5/65	3.1	290	442	247	326	281	263	301	282	152	104	208	155	82	11	108	67
	6.1	261	376	408	348	356	270	202	276	136	140	246	175	158	83	121	121
	12.2	162	391	397	317	201	169	307	226	121	91	242	151	79	83	101	88
	24.4	504	335	—	420	249	304	233	262	138	96	197	144				
	48.8	199	135	279	204	211	366	317	298	131	243	122	92				
31/5/65	3.1	322	563	334	406	333	338	322	331	166	172	170	169	85	—	111	98
	6.1	259	659	453	457	387	325	203	305	128	164	295	196	147	87	122	119
	12.2	292	569	463	441	225	237	353	272	136	78	116	110	91	72	98	87
	24.4	627	389	—	508	239	350	299	296	184	115	223	174				
	48.8	236	426	364	342	262	409	354	342	139	4	129	91				
3/6/65	3.1	397	675	507	526	422	323	167	304	194	207	170	190	953	—	171	133
	6.1	497	337	460	431	466	362	228	352	224	249	276	250	208	71	162	147
	12.2	432	621	616	556	269	414	398	361	204	200	191	198	126	143	141	137
	24.4	700	598	705	668	148	529	517	398	253	197	67	172				
	48.8	328	616	603	516	360	526	467	451	115	37	216	123				
15/6/65	3.1	438	727	219	461	405	370	[illegible]	361	199	224	174	199	101	—	295	132
	6.1	564	421	555	513	507	391	[illegible]	387	205	301	335	280	228	78	172	159
	12.2	526	689	654	623	306	550	[illegible]	453	223	221	226	223	140	157	172	156
	24.4	737	669	732	713	329	586	[illegible]	456	317	274	985	148				
	48.8	367	644	668	560	431	116	518	355	122	17	253	131				
23/6/65	3.1	50	742	39	277	40	422	−4	152	217	199	—	208	117	−2	2	39
	6.1	24	423	540	329	51	243	282	192	58	329	280	222	202	117	201	173
	12.2	30	62	444	179	35	73	522	210	38	280	205	168	46	45	45	45
	24.4	58	263	360	227	52	126	32	70	773	—	129	103				
	48.8	148	129	67	115	16	—	56	36	−27	4	69	15				
29/6/65	3.1	356	105	44	168	60	135	28	74	121	107	92	107	90	—	151	120
	6.1	154	232	127	171	69	6	116	90	80	109	259	149	140	122	186	149
	12.2	49	66	251	122	59	74	79	71	44	28	206	93	73	323	108	167
	24.4	134	263	127	175	88	126	50	88	33	—	183	108				
	48.8	55	129	181	122	34	—	78	56	33	4	91	43				

SOIL MOISTURE TENSION (CM WATER)

DRAINAGE TRIAL SECTION 80

During Non Irrigation Season

Date	Distance of tensiometer from drain (metres)	10 cm				20 cm				40 cm				60 cm			
		Tensiometer Depth / Tensiometer Site															
		A	B	C	Av.	A	B	C	Av.	A	B	C	Av.	A	B	C	Av.
6/7/65	3.1	326	415	101	281	111	172	40	108	129	92	123	115	83	—	158	120
	6.1	336	261	212	270	124	89	125	113	101	92	264	152	135	94	287	172
	12.2	87	147	353	196	43	101	131	92	52	23	192	89	73	49	117	80
	24.4	453	330	275	353	137	186	110	144	65	42	93	67				
	48.8	127	289	358	258	127	109	123	120	67	6	91	54				
13/7/65	3.1	415	509	175	366	—	249	72	161	129	114	21	88	83	—	151	117
	6.1	464	310	301	358	203	138	151	164	132	106	196	145	147	93	189	143
	12.2	152	280	456	296	78	130	232	147	71	45	198	104	73	61	122	85
	24.4	453	404	387	415	137	268	184	196	65	112	158	112				
	48.8	127	441	485	351	127	200	190	172	67	4	—	35				
20/7/65	3.1	460	427	—	443	50	298	—	174	124	124	139	129	90	—	146	118
	6.1	117	337	220	225	289	182	161	211		120	322	221	120	97	179	132
	12.2	—	33	406	220	111	126	289	175	79	—	196	138	76	55	232	121
	24.4	83	12	150	82	154	341	252	249	97	—	194	146				
	48.8	42	93	344	160	48	209	—	128	68	—	96	82				
27/7/65	3.1	107	23	—	65	39	163	19	73	127	222	114	154	83	—	148	115
	6.1	100	330	261	230	301	173	185	208	160	132	305	199	131	104	171	135
	12.2	29	34	332	132	69	93	323	162	101	75	203	126	86	71	135	98
	24.4	57	514	78	216	142	380	294	272	187	132	212	177				
	48.8	29	68	95	64	30	225	93	116	34	36	122	64				
3/8/65	3.1	387	300	—	229	403	340	39	261	266	188	196	217	181	3	134	106
	6.1	228	307	332	289	58	182	285	175	513	144	314	324	74	101	187	121
	12.2	9	149	304	154	83	114	353	183	88	159	280	176	69	59	142	90
	24.4	182	559	230	324	185	499	385	356	134	215	319	223				
	48.8	109	199	182	163	25	209	135	156	71	134	161	122				

SOIL MOISTURE TENSION (CM WATER) DRAINAGE TRIAL SECTION 80

Non-Irrigation Season

Date	Distance of tensiometer from drain (metres)	Tensiometer Depth 10 cm				20 cm				40 cm				60 cm			
		Tensiometer Site A	B	C	Av.	A	B	C	Av.	A	B	C	Av.	A	B	C	Av.
10/8/65	3.1	252	332	—	292	91	250	60	134	512	256	136	301	75	−7	—	34
	6.1	456	—	—	—	498	212	241	317	310	160	335	268	205	111	—	158
	12.2	180	141	423	248	110	128	—	162	128	—	—	—	89	—	−14	38
	24.4	369	—	262	316	248	—	417	333	158	—	311	235				
	48.8	167	382	344	298	—	260	213	237	99	—	158	129				
13/8/65	3.1	22	280	—	151	23	330	14	122	504	—	36	270	72	—	33	53
	6.1	207	—	63	135	485	144	190	273	321	151	18	163	190	100	65	118
	12.2	25	25	359	136	84	102	221	136	118	69	—	94	74	61	33	56
	24.4	37	—	—	—	249	180	399	276	160	37	408	202				
	48.8	29	311	80	140	32	169	213	138	23	35	156	71				
17/8/65	3.1	43	24	—	33	22	193	18	77	29	15	11	18	15	0	77	46
	6.1	—	35	45	27	200	17	321	179	174	21	23	73	172	20	−3	63
	12.2	64	32	59	52	17	17	31	21	10	155	—	82	7	−8	1	0
	24.4	43	37	38	39	155	357	41	184	115	139	5	86				
	48.8	39	31	47	39	35	29	28	31	19	77	7	34				
24/8/65	3.1	93	274	—	122	45	156	45	82	19	54	23	32	25	4	64	31
	6.1	218	133	167	173	157	58	200	138	198	26	54	93	157	24	26	69
	12.2	136	118	272	175	45	38	157	80	23	25	96	48	23	14	42	26
	24.4	205	555	220	327	169	389	122	227	90	264	51	135				
	48.8	129	239	187	185	48	147	82	92	52	115	114	94				
31/8/65	3.1	202	487	—	345	122	468	102	231	40	87	29	52	29	0	66	48
	6.1	411	341	382	378	311	111	123	182	261	46	83	130	202	32	47	94
	12.2	354	432	509	432	81	96	236	138	44	30	140	71	35	17	96	49
	24.4	—	669	585	627	—	524	237	381	—	374	112	162				
	48.8	270	549	517	445	113	324	192	210	69	93	128	97				
8/9/65	3.1	60	705	—	383	53	407	27	162	27	105	23	52	28	18	−4	14
	6.1	222	157	207	195	327	70	185	194	228	44	97	123	110	37	61	69
	12.2	82	82	199	121	36	32	172	80	24	23	158	68	15	17	15	16
	24.4	142	470	173	262	75	544	197	272	31	29	109	56				
	48.8	76	197	477	250	131	111	153	132	44	29	109	61				

APPENDIX VII

Water table level (cm below surface) following irrigation on 18/3/65

Date	Hours following irrigation	Distance of water level recorder from drain (metres)			
		6,1	12.2	24.4	48.8
18/3/65	2	11	11	8	1
	8	14	12	9	2
19/3/65	20	56	26	11	4
20/3/65	44	101	64	40	31
21/3/65	68	114	82	55	45
22/3/65	92	131	93	68	59
23/3/65	116	126	100	78	71
24/3/65	140	130	107	87	79
25/3/65	164	133	111	92	83
26/3/65	188	135	116	97	87

Tile line depth 165 cm.

APPENDIX VIII

Water table level (cm below surface) following irrigation on 23/9/65

Date	Hours following irrigation	Distance of water level recorder from drain (metres)			
		6.1	12.2	24.4	48.8
23/9/65	2	11	11	8	3
	8	17	14	11	6
24/9/65	20	44	31	23	17
25/9/65	44	68	57	49	46
26/9/65	68	79	68	59	57
27/9/65	92	89	78	68	67
28/9/65	116	96	85	75	74
29/9/65	140	101	91	80	80
30/9/65	164	106	96	85	83
1/10/65	188	109	100	88	86
2/10/65	212	113	104	92	90
3/10/65	236	116	107	95	92
4/10/65	260	119	110	99	-
5/10/65	284	122	114	102	-

Tile line depth 165 cm.

APPENDIX IX

Water Table Level (cm below surface) following irrigation on 17/12/65

Date	Hours following irrigation	Distance of water level recorder from drain (metres)			
		6.1	12.2	24.4	48.8
17/12/65	2	11	10	8	3
	8	16	14	10	5
18/12/65	20	32	20	16	13
19/12/65	44	63	53	46	42
20/12/65	68	79	68	59	55
21/12/65	92	91	80	70	67
22/12/65	116	100	89	80	76
24/12/65	164	107	98	90	85
25/12/65	188	110	102	94	88

Tile line depth 165 cm.

APPENDIX X

Water table level (cm below surface) following irrigation on 22/2/66

Date	Hours following irrigation	Distance of water level recorder from drain (metres)			
		6.1	12.2	24.4	48.8
22/2/66	2	14	14	9	4
	8	21	17	12	8
23/2/66	20	43	35	28	24
24/2/66	44	68	58	50	46
25/2/66	68	-	72	-	58
26/2/66	92	91	82	73	68
27/2/66	116	98	90	81	76
28/2/66	140	104	96	87	82
1/3/66	164	110	102	93	88
2/3/66	188	114	107	99	91
3/3/66	212	118	112	103	95
4/3/66	236	122	116	106	98
5/3/66	260	126	120	111	101
6/3/66	284	129	124	114	104

Tile line depth 165 cm.

APPENDIX XI

Water table level (cm below surface) during non-irrigated season

Date	Distance of water level recorder from Drainline B (metres)				X*
	6.1	12.2	24.4	48.8	
16/4/65	43	43	11	6	37
20/4/65	67	60	50	54	13
25/4/65	73	97	-	66	7
30/4/65	137	120	99	90	47
5/5/65	144	137	125	98	46
10/5/65	148	141	122	105	43
15/5/65	146	142	122	107	39
20/5/65	150	143	119	109	41
25/5/65	146	144	118	111	35
30/5/65	143	136	117	-	-
4/6/65	150	147	-	-	-
9/6/65	154	-	136	118	36
14/6/65	155	-	139	121	34
19/6/65	142	-	138	122	20
24/6/65	142	-	132	116	26
29/6/65	115	138	133	114	1
4/7/65	132	130	134	116	16
9/7/65	147	145	134	118	29
14/7/65	151	148	138	119	32
19/7/65	145	-	139	122	23
24/7/65	144	140	139	123	21
29/7/65	140	138	137	124	16
3/8/65	134	133	-	126	8
8/8/65	132	132	134	126	6
13/8/65	132	131	132	126	6
18/8/65	142	137	138	122	20
23/8/65	150	146	141	124	26
28/8/65	151	150	142	126	25
2/9/65	154	150	143	118	36
7/9/65	151	148	140	117	34
12/9/65	150	147	139	122	28
17/9/65	152	149	-	117	35
22/9/65	153	152	-	-	-

Tile line depth 165 cm.

X* = difference in water table 48.8 m from drainline and 6.1 m from drainline.

APPENDIX XII

Difference in water table level between recorder 48.8 m from drain and recorder 6.1 m from drain (cm) following irrigation on:-

Hours after irrigation	1 18/3/65	2 23/9/65	3 17/12/65	4 22/2/65
2	10	8	8	10
8	12	11	11	17
20	52	27	19	19
44	70	22	21	22
68	69	22	24	-
92	62	22	24	23
116	55	22	24	22
140	51	21	22	22
164	50	23	22	22
188	48	23		23
212		23		
236		23		

APPENDIX XIII

WATER ANALYSIS FROM RIVER MURRAY BRIDGE (ppm)

E & W.S. Figures

Date	T.S.S.	Cl	SO_4	HCO_3	Na	Ca	Mg	SiO_2	Fe
12/10/64	145	48	13	55	32	11	7	7	0.74
9/11/64	123	37	10	61	25	12	7	2	0.94
14/12/64	151	45	10	79	31	14	8	4	0.70
11/ 1/65	157	47	15	73	34	14	8	3	0.56
8/ 2/65	272	102	29	79	66	18	13	5	0.24
8/ 3/65	542	230	67	98	147	26	21	3	<0.1
12/ 4/65	602	264	72	98	169	24	24	1	<0.1
10/ 5/65	590	260	67	98	166	24	23	2	<0.1
14/ 6/65	609	256	67	122	166	30	23	7	<0.1
13/ 7/65	669	280	77	134	179	32	28	7	<0.1
9/ 8/65	699	292	77	146	189	34	28	7	0.1
13/ 9/65	580	268	67	67	167	22	21	2	0.1
11/10/65	210	92	15	43	54	10	10	8	0.54
8/11/65	231	108	17	37	56	13	11	8	0.54
13/12/65	290	130	21	55	77	14	12	9	0.5
10/ 1/66	426	198	37	61	120	17	16	7	0.24
14/ 2/66	453	216	38	67	126	18	19	3	0.12
14/ 3/66	486	240	34	67	137	16	22	4	0.12

Appendix XIV
~~TABLE~~ 22

WATER ANALYSIS IN P.P.M. Sect. 80 Drainage Trial
Long Flat

TILE LINE B

Date	Time	Hours Following Irrigation	Sample Code No.	T.S.S.	Sodium (Na)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Chloride (Calc. as Cl.)	Phosphate (Calc. as P.)	Carbonic (CO_3)	Sulphuric (SO_4)	Nitric (NO_3)	Iron (Fe)	Silica (SiO_2)
18/3/65	1730	5½	11	1529	442	10.0	42.9	47.9	640.2	0.86	38.6	255.8	-	20.0	47.0
19/3/65	1715	30	12	2201	589	11.4	68.6	71.5	990.3	0.57	38.6	358.7	-	6.6	58.6
22/3/65	1200	96	13	2401	622	15.7	74.3	80.0	1090.3	2.14	51.4	381.5	-	3.0	67.0
22/2/66	1210	2	1	1315	370	11.4	40.0	42.9	530.2	3.3	124.3	144.3	0	9.7	42.9
23/2/66	940	24	2	1715	452	15.7	37.0	61.4	720.2	1.57	38.6	322.9	-	12.3	52.9
24/2/66	1100	49	3	1801	442	12.9	54.3	57.0	760.2	0.29	42.9	340.0	-	3.1	54.3
28/2/66	1130	145	9	1886	472	11.4	57.0	58.6	800.2	0.14	42.9	360.0	-	3.6	55.7
7/3/66	1700	319	10	1972	494	14.3	60.0	64.3	840.3	0.14	55.7	371.5	-	9.7	60.0
31/8/65	-	-	17	2344	633	15.7	77.2	80.0	1010.3	0.57	47.2	394.4	-	1.7	64.3

TILE LINE C

Date	Time	Hours Following Irrigation	Sample Code No.	T.S.S.	Sodium (Na)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Chloride (Calc. as Cl.)	Phosphate (Calc. as P.)	Carbonic (CO_3)	Sulphuric (SO_4)	Nitric (NO_3)	Iron (Fe)	Silica (SiO_2)
18/3/65	1730	5½	14	1328.9	361.5	2.85	42.9	47.2	530.2	6.14	115.7	180.0	-	4.3	42.9
19/3/65	1715	30	15	1714.8	494.4	8.57	54.3	61.4	720.2	7.57	175.8	142.9	-	2.72	48.6
22/3/65	1200	96	16	1914.9	551.6	7.15	57.0	71.5	820.2	7.0	184.3	144.3	-	0.11	51.4
22/2/66	1210	4	6	1700.5	460.0	20.0	48.58	51.4	710.2	1.7	51.4	302.9	-	43.7	48.6
23/2/66	940	26	7	1543.3	418.7	5.7	51.4	50.0	640.2	2.29	158.6	155.8	-	2.29	42.9
24/2/66	1100	51	8	1614.8	471.6	7.15	48.58	55.7	670.2	3.57	158.6	144.0	-	0.11	45.7
28/2/66	1130	147	4	1686.2	483.0	4.29	54.3	57.0	700.2	1.57	180.0	145.8	-	20.9	50.0
7/3/66	1700	321	5	1786.3	528.7	7.15	54.3	64.3	740.2	9.15	201.5	118.6	-	17.1	54.3
31/8/65	-	-	18	2200.6	660.0	5.7	74.3	87.2	940.3	2.14	244.4	122.9	-	-	57.2

APPENDIX XV

PASTURE PRODUCTION

DRAINAGE TRIAL

Section 80 Long Flat

Date of Harvest	Growth Period (days)	Treatment (metres from drains)	Dry Matter (Kg/ha)						Total Kg/ha/day
			Per. Rye	Paspalum	White Clover	Other Grasses	Sundry	Total	
11/1/65		3.1	298	867	216	31	475	1977	50
		6.1	199	981	190	43	470	1938	49
	39	12.2	265	797	199	47	465	2305	59
		24.4	365	898	242	35	700	2391	62
		48.8	250	941	414	55	1124	2388	62
		Ave.	276	897	252	43	647	2200	
16/2/65		3.1	132	1177	207	47	264	2074	57
		6.1	108	1260	206	128	260	1895	53
	36	12.2	106	1329	307	52	250	1963	55
		24.4	190	1279	317	28	337	2167	60
		48.8	242	972	420	56	260	2287	64
		Ave	156	1204	291	63	274	2078	
23/3/65		3.1	58	1294	196	27	129	2138	62
		6.1	72	1662	204	50	265	2196	63
	35	12.2	74	1499	237	118	225	1995	57
		24.4	108	953	312	16	188	1803	52
		48.8	97	1207	225	28	319	2079	59
			82	1323	235	47	225	2042	

Date of Harvest	Growth Period (days)	Treatment (metres from drains)	Dry Matter (Kg/ha)						Total Kg/ha/day
			Per. Rye	Pasp-alum	White Clover	Other Grasses	Sundry	Total	
1/6/65		3.1	410	392	766	24	77	1696	25
		6.1	379	374	679	22	102	1689	25
	70	12.2	532	470	598	20	86	1596	22
		24.4	497	374	528	7	66	1636	24
		48.8	449	250	596	7	41	1248	18
		Ave.	454	372	633	16	75	1572	
21/9/65		3.1	379	28	771	114	74	1319	32
		6.1	343	12	691	115	69	1241	31
	112	12.2	433	12	681	123	41	1247	31
		24.4	389	16	652	128	30	1212	30
		48.8	357	13	654	104	101	1240	31
		Ave	390	17	690	118	63	1252	
18/10/65		3.1	473	183	1021	226	69	1988	76
		6.1	461	147	872	139	72	1848	71
	27	12.2	385	100	823	242	48	1718	66
		24.4	571	129	1009	157	35	1804	69
		48.8	448	142	856	195	82	1916	74
		Ave	468	140	916	192	62	1855	
9/11/65		3.1	497	339	1200	225	114	2389	109
		6.1	525	310	1174	112	67	2303	104
	22	12.2	479	330	1152	129	86	2253	102
		24.4	660	351	1370	91	148	2324	105

Date of Harvest	Growth Period (days)	Treatment (metres from drains)	Dry Matter (Kg/ha)						Total Kg/ha/day
			Per. Rye	Paspalum	White Clover	Other Grasses	Sundry	Total	
9/11/65 Cont.		48.8	547	312	1075	221	138	2345	106
		Ave.	542	328	1194	156	111	2323	
7/12/65	28	3.1	310	878	895	468	136	2433	87
		6.1	309	905	829	131	124	2187	78
		12.2	354	691	849	146	63	2143	76
		24.4	302	832	809	82	73	2034	73
		48.8	208	745	924	87	59	2038	73
			297	810	861	183	91	2167	
4/1/66	28	3.1	8	1314	862	92	108	2783	100
		6.1	3	1688	717	125	82	2723	97
		12.2	4	1622	737	174	82	2477	88
		24.4	-	1701	713	44	76	2619	94
		48.8	8	1291	962	68	72	2482	88
			6	1523	799	101	83	2616	
25/1/66	21	3.1	10	1370	371	17	25	1766	84
		6.1	10	1398	395	17	22	1717	82
		12.2	17	1373	418	30	31	1747	83
		24.4	16	1144	405	24	24	1701	80
		48.8	12	1437	437	17	23	1628	77
			13	1344	405	21	25	1712	

Date of Harvest	Growth Period (days)	Treatment (metres from drains)	Dry Matter (Kg/ha)						Total Kg/ha/day
			Per.Rye	Pasp-alum	White Clover	Other Grasses	Sundry	Total	
15/2/66	21	3.1	10	1447*	325	84	28	1941	93
		6.1	16	1552	273	138	28	1864	88
		12.2	12	1268	243	122	28	1763	84
		24.4	13	1185	270	19	21	1646	78
		48.8	28	1363	323	92	38	1724	82
		Ave	16	1363	287	91	29	1788	
7/3/66	20	3.1	3	1215	76	27	12	1333	64
		6.1	7	1231	129	18	28	1310	66
		12.2	3	1322	96	17	22	1482	74
		24.4	7	1465	66	7	21	1589	80
		48.8	13	1360	114	26	44	1471	74
		Ave	7	1318	96	19	26	1438	
5/4/66	29	3.1	12	1322	207	105	69	1606	55
		6.1	-	1094	158	21	22	1344	46
		12.2	10	1010	104	25	22	1149	39
		24.4	20	1047	87	25	20	1290	45
		48.8	16	1136	214	34	102	1351	47
		Ave.	14	1122	155	41	47	1348	

* L.S.D. .01 approx 330/Kg/ha

Appendix XVI

Climatic Recordings

(1) Rainfall (points)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1960 (Murray Bridge)	44	189	50	200	306	56	166	87	231	31	186	45	1591
1961 (Murray Bridge)	20	70	30	268	116	39	185	118	68	9	112	55	1090
1962 (Long Flat)	26	42	113	46	78	77	80	162	55	268	47	123	1117
1963 (Long Flat)	190	12	3	215	319	256	204	172	79	169	10	9	1469
1964 (Long Flat)	32	41	25	138	76	115	123	126	197	127	305	104	1409
1965 (Long Flat)	1	0	9	54	99	137	125	118	140	29	112	71	895

(2) Mean Humidity % at 9.00 a.m. (Tailem Bend)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1961	53.2	56.8	61.8	81.7	-	82.7	88.2	83.8	66.9	58.8	65.7	60.0
1962				68.3		78.0	81.8	79.8	66.2	66.8	53.5	61.0
1963	63.1		65.5	66.3	88.6	92.0	85.7	83.0	66.5	59.4	51.9	48.8
1964	51.5	61.0	65.9									

(3) Mean Maximum and Minimum Temperatures (Tailem Bend)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Maximum													
1960												88.3	
1961	93.0	87.2	83.1	73.2	67.1	64.3	59.7	62.6	71.8	77.6	77.8	82.2	74.9
1962	86.8	85.6	81.5	76.5	66.3	65.4	62.3	62.1	68.5	69.0	82.1	78.3	73.7
1963	83.7	84.8	80.8	74.3	64.0	61.7	58.1	62.2	69.2	78.2	80.4	84.1	73.4
1964	84.9	80.8	80.8										
Minimum													
1960												56.8	
1961	61.6	56.7	52.7	54.0	46.0	45.2	39.7	40.5	45.3	47.6	52.2	53.4	49.5
1962	56.9	56.0	54.6	48.3	47.2	46.7	43.1	44.7	45.6	47.9	51.8	52.1	49.5
1963	57.0	56.5	53.5	46.8	49.9	44.4	43.8	42.4	46.1	48.3	52.9	52.7	49.5
1964	54.7	54.9	49.5										

Murray Bridge : approx. 2 miles north of Long Flat

Tailem Bend : approx 12 miles south of Long Flat

AGRONOMY BRANCH REPORTS

INDEX

* Out of print.