A new conception on the water-logging and the Saliniy problem of Rechna Doab,

By

Nazir Ahmad(1), Dewan Ali(2) and Afaq Ahmad(3).

Synopsis :—

This brief note is based upon analysis of well records of Rechna Doab spread in the zones of Upper Chenab, Lower Chenab and Haveli Canals. The watertable conditions as existing in the Doab in 1955 were considered and areas with depths of watertable at 0 to 5 ft., 5 to 10 ft., 10 to 15 ft. and below 15 ft. were marked out and wells in each of the four divisions of the areas were grouped and their mean rise was worked out from the period of available records to date. It was found that a considerable consistency existed in the rise of the watertable since the canal was opened and on this basis, the true order of seepage from tbe canal was worked out. Depths below the surface at which evaporation and transpiration became effective were also determined. The cause for the rise of watertable in the region of Upper Chenab Canal, before this canal was put into operation, was also found out.

A study of the nature of formation of this doab, in the light of this rise of watertable, the conditions of sub-soil flow, existence of pockets of saline water, conditions and causes of the present water-logging in the regions of Sangla Hill, Pindi Bhattian, Chiniot etc., above the so called subterranean ridge are put forth. It is believed that a condition of water-table similar to the above mentioned areas will appear in the Lyallpur area within the next 30 years. This study discounts the effects of the ridge in holding up the sub-soil flow up-stream of it. This study also leads to the conclusions that the present method of land reclamation is of doubtful effectiveness and needs a change.

Introduction :—

The study of the problem of waterlogging and salinity of the former Punjab areas has been given a fairly close attention. A large number of persons both professional Engineers and specialist Scientists have tried to study its various phases. Before the establishment of the Irrigation Research Institute, Lahore, several engineers of the department studied the records of the rising watertable and suggested some remedies. In the proceedings of the Punjab Engineering Congress from 1917 to 1926, with the exception of

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ere sources of obstruction to the natural flow. This region is submoun inous with high rain fall above 30 inches per year. The land slope is steep id many hilly nallahs cross the country, the most famous being the ilkhu, the Aik, the Bhed, the Deg with its small and big branches, the asanter, the Hodia, the Bein etc. All these nallahs spill during summer id this spill was blocked at many places by the rails and roads. The effect this blocked drainage has been studied from the well records of the area. i the zone of U.C.C well lines marked A to 0 in Fig. 1, were selected and ese have been used for the study of the rise of the watertable. The records these are mainly available from 1907 to 1920 after which several other ells and pipes were selected or installed and new provincial and circle ies were fixed and some of the wells of the fourteen lines mentioned ove were also incorporated in new lines. Those wells which were close the spill of the rivers and had watertable nearer to the surface such as A_2, A_3, and $A_4, B_1, B_2, C_1, C_2, D_1$ etc., in the zone of the spill of the Chenab id wells No. M_3, L_4, K_8 and H_{11} etc., in the zone of the spill of the Ravi, owed steady levels from 1907 to 1912-14, the period of opening of the .C.C. Their records are given in Table 1. Some wells particularly those cated in the zone of the Ravi did start to show rise after thc opening of e canal. Other wells located in the zone of spill of the nallahs such as B_4, D_3, D_6, D_7, E_3, E_5, E_6, G_6, K_5, H_5 etc., with deep watertable showed eady rise of about 0·5 ft. per year from 1907 to 1912-14 and brisk rise om 1914 onward. This rise is plotted in Figs. 2 (a) & (b) and mean rise om 1907 to 1912-14 is given in Table 1 (a) in which the data of 20 wells cated in various regions of the canal in given.

Fluctuations in water table are noticeable even at 40 ft. below the tural surface.

Rise of watertable in the first few years after opening of the canal.

When the U.C C. started to operate in 1912-16, the seepage from e canal increased the rate of rise of watertable considerably, so that thc ove-mentioned wells located within the zone of blocked drainage started show an average rise of 2.24 ft. per year as shown in Figs. 2 (a) & (b) id Table 2. This table includes the results of five extra wells, the rise of hich is plotted in fig. 2 (c). These wells have been kept under observation om 1907 to 1955. The spill affected the watertable even 20 to 30 ft. below rface, but the level of water attained a stable order during the years when ere was no spill. The rise shown in table 2 is thus due to the combined fect of the spills of Nallahs and the seepage from the canal and if the rise ie to spills of nallahs is eliminated, wc get the true rise of watertable due seepage of the canal. This rise is equal to 2.24—0.5 = 1.74 ft. per year.

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As stated before, after the opening of U.C. canal a large number of ew observation wells were selected and these were further supplemented by bservation pipes extending to 5 miles on both sides of the canal at every h R.D. On the basis of these well records, the position of watertable isting during 1955 around the canal area is shown in Fig. 3. In this gure equi-water levels and natural surface levels are also plotted and the

the meetings held in 1920, 1924 and 1925, there was practically a paper every year dealing with some aspects of this subject. The contributions of Schonemann (1) May, (2) Iqbal Hussain (3), Elsdon (4) Middleton (5) are noticeable as the earliest attempts to probe the causes of the trouble and from 1923 to 1940 scientific study of this problem was started by Wilsdon (6,7,8,9) and several scientific investigations were undertaken to correlate the rise of watertable with the rain fall, intensity of irrigation and other causes. In 1932 Taylor came into the Picture and his investigations on various aspects of the problem spread over a period of 12 years in which scientists of the Institute played a prominent role and several memoirs, annual reports, special reports and papers were published. Some contributions of Taylor, (10,11) Mehta, (12) Bose (11) and Asghar (14) listed in the Bibliography, specially deal with the subject of waterlogging and salinity. The papers of B.N.Singh, (15)Khangar (16) gave better details of the problem and several solutions were suggested.

After independence several foreign experts started visiting this country and up to date there are about half a dozen reports (17-19) dealing with various aspects of the problem. These reports were submitted by experts sent by F.O.A. and other similar organizations of the world.

This note is another attempt of this class. It differs from the previous contributions in the manner of approach to the problem and naturally the counter measures are also at variance from those that have been suggested before.

The conditions of watertable in the zone of Upper Chenab Canal before its construction.

The earliest reliable and regular records of watertable of Rechna Doab pertain to the year 1905. However, limited data of some reliability is available from 1882. and some records of the years 1862, 1863 and 1872 are also known. Probable watertable contours in the year 1882 are shown in Fig.1. In this figure the two main irrigation canal systems, the first one being the L.C.C. system, was opened in 1892 and the second the U.C.C. system was opened in 1912, are also shown. A small link canal called the Haveli canal was opened in 1939.L.C.C., is the main Irrigation canal and both the U.C. and the Haveli canals are feeder channels with insignificant irrigation. The positions of wells on which these contours are based and those used in this study are also shown in the figure separately.

A study of the figure shows that in the zone through which the U.C. passes, the pre-canal period watertable lay at 25 to 40 ft. below surface except in the regions close to the river spills where the watertable was within 10 to 15 ft. from the surface. In the area through which the U,C.C. passes, the main railway line and G.T. Road linking Lahore with Gujranwala and Wazirabad had been constructed before 1857. There are about seventeen important natural drains which cross these rail and road lines and some of these carry heavy discharge during floods. At several sites these drains are blocked by cultivation. Roads and rails linking Wazirabad, Gujranwala and Sialkot were also made at the same period and these too

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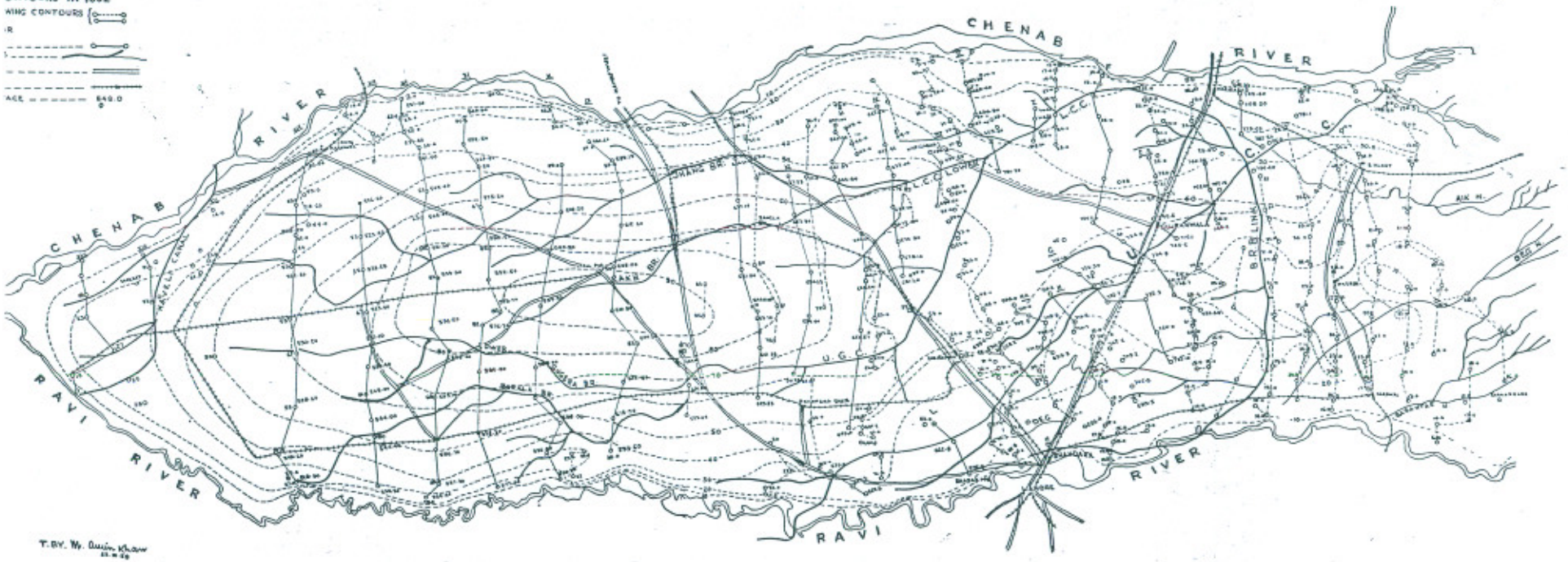
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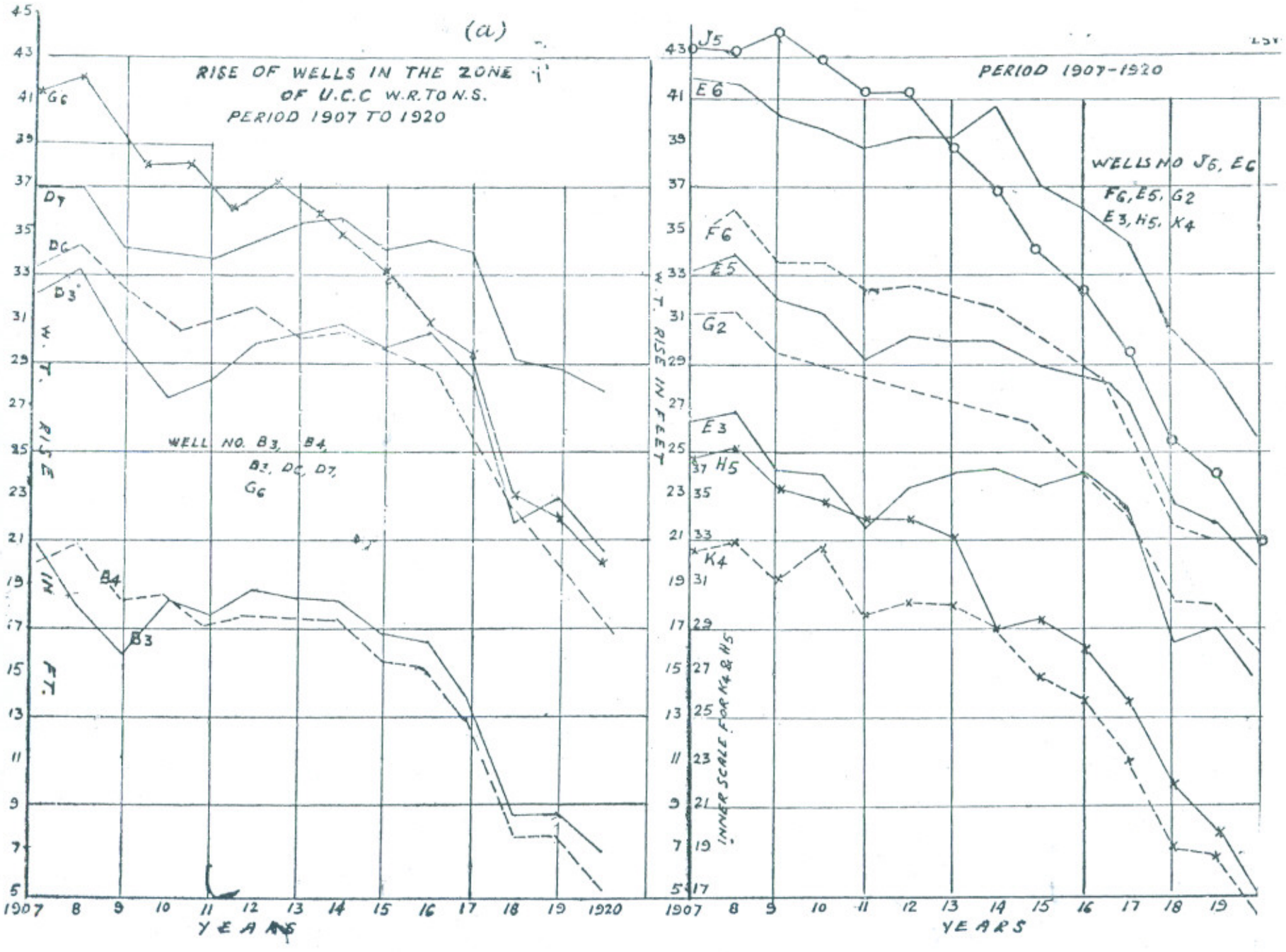
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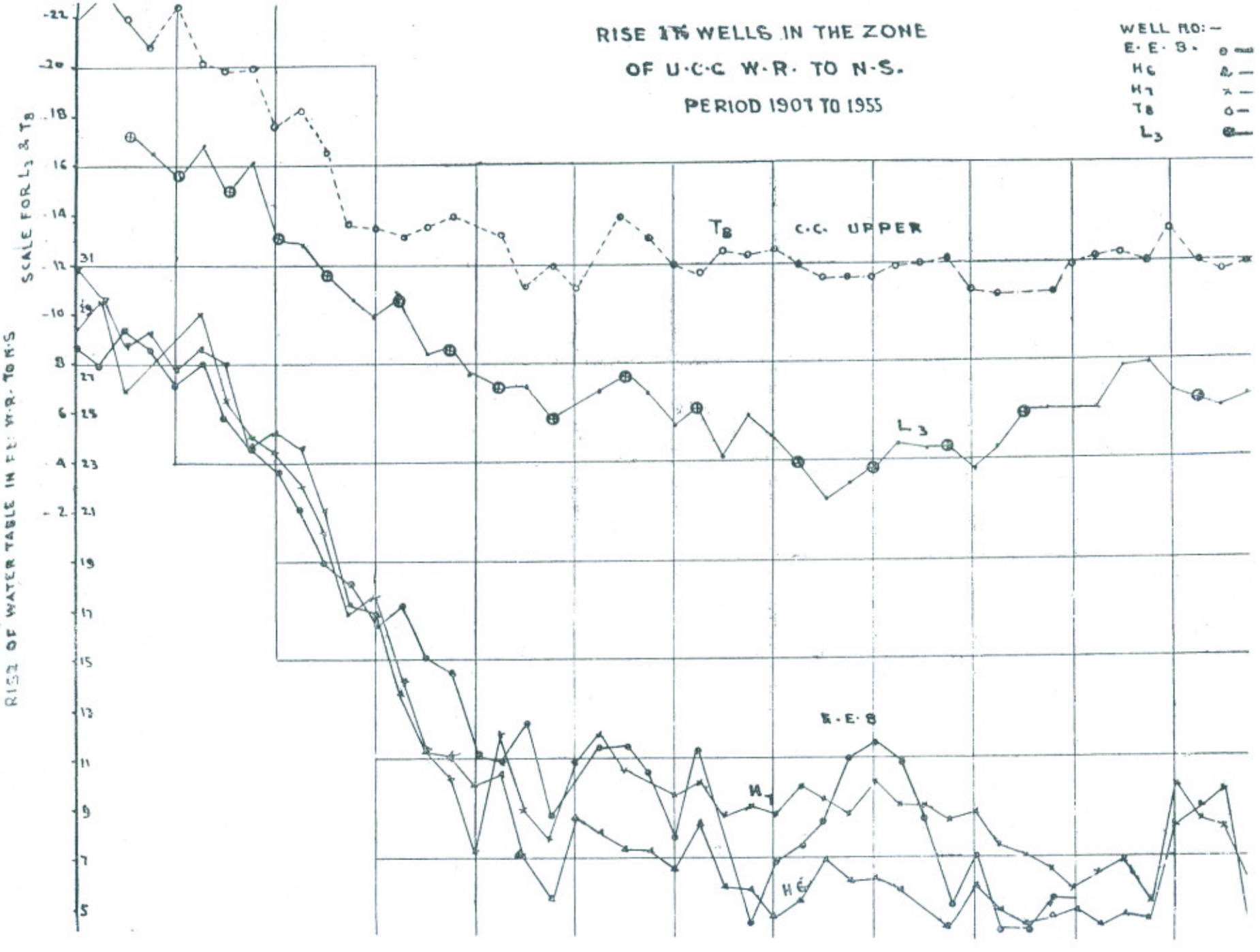
Table No. 1

Behaviour of wells in river spill area located in the zone of U. C. C. from 1907 to 1920

Years.	No. of wells. Depth below surface in ft.											
	A1	A2	A3	A4	B1	B2	C1	C2	D1	M3	L4	K8
1907	4·98	3·23	5·41	5·12	8·50	14·70	9·45	16·25	13·68	...	...	15·00
1908	6·58	9·66	8·79	7·33	9·80	19·30	11·12	17·50	15·62	...	...	16·00
1909	6·45	9·20	8 70	6·00	9·00	15·70	9·75	15·50	14·08	21·25	19 00	14·75
1910	7·00	9·58	8·00	6·15	10·00	16·00	13·15	20·05	12·58	20·75	18·80	14·00
1911	5·00	8·30	7·80	5·50	9·29	15·35	9·67	14·25	12·63	19·50	18·30	13·08
1912	6·40	9·20	9·30	6·80	10·00	17·00	10·82	15·91	13·80	21·32	19·45	14·50
1913	4·65	6·90	6·60	5·20	10·25	16·00	11·85	16·15	14·53	21·35	19·10	14·40
1914	6·50	8·90	9·00	7·40	10·27	17·66	11·80	16·00	14·88	20·02	18·70	14·20
1915	5·46	8·04	8·54	6·17	11·50	16.68	11·34	15·00	14·38	19·00	16·00	11·80
1916	5·50	7·42	8·77	7·04	10·79	18·17	12·25	15·88	15·88	17·75	15·75	13·92
1917	5·40	7·35	7·60	6·00	10·15	17·50	11·30	14·30	13·38	19·32	15·75	13·20
1918	5·10	6·60	6·30	3·45	8·90	11·20	8·80	11·30	11·02	16·10	15·10	11·75
1919	5·11	6·67	6·81	4·68	9·87	12·26	10·46	13·25	12·88	17·20	...	10·70
1920	3·81	5·77	5·01	3·70	7·67	11·76	9·78	12·20	11·68	17·50	13·13	12·53


ECHNA DOAB
ONTOURS IN 1882
CHENAB RIVER
CHENAB RIVER
RAVI RIVER
RAVI RIVER
RAVI
B.R.B. LINK
L.C.C.
U.G.
T. BY. W. Qaiser Khan


(a)
RISE OF WELLS IN THE ZONE 'i'
OF U.C.C W.R.TO N.S.
PERIOD 1907 TO 1920
WELL NO. B3, B4,
B3, DC, D7,
G6
RISE IN FT.
YEARS
PERIOD 1907-1920
WELLS NO J6, E6
F6, E5, G2
E3, H5, K4
RISE IN FEET
INNER SCALE FOR K4 & H5
YEARS


RISE IN WELLS IN THE ZONE
OF U·C·C W·R· TO N·S.
PERIOD 1907 TO 1955
WELL NO:—
E·E·S·
H6
H7
T8
L3
T8 C.C. UPPER
L3
E·E·S
H7
H6
RISE OF WATER TABLE IN FT: W·R· TO N·S
SCALE FOR L3 & T8
-22
-20
18
16
14
12
10
8
6
4
2
31
29
27
25
23
21
19
17
15
13
11
9
7
5

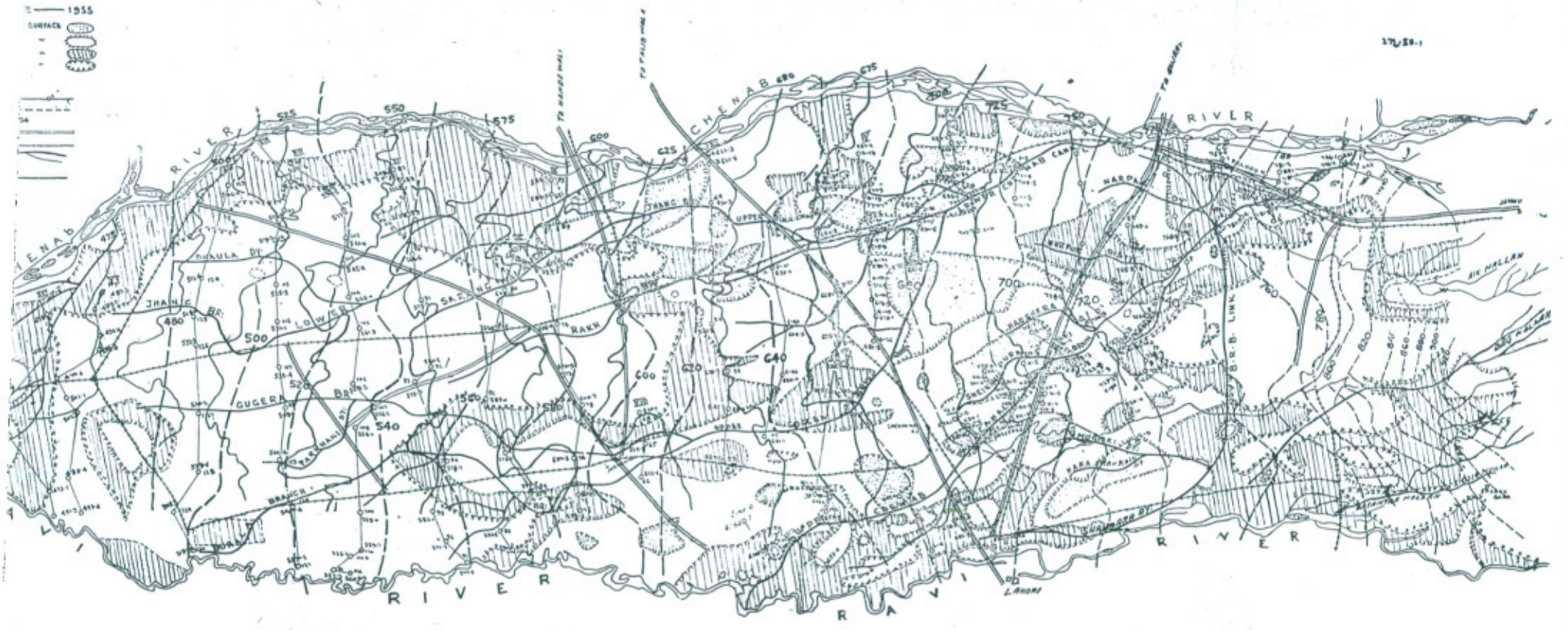

1955
CHENAB
RIVER
JHANG BR.
LOWER
RAKH
GUGERA
BRANCH
SARANG
UPPER
BARKANA
BARKERA
B.R.B. LINK
PAKA DHANNA
RAVI
LAHORE

Table No. 1 (a)

Rise of watertable from 1907 to 1915 in various Regions of Upper Chenab Canal, rise due to blockade of drainage.

Well No.	Position or zone.	Depth of Watertable in		Rise in ft. per year.
		1907	1914-15	
J_8	Lower	22·5	20·5	$\frac{2}{7}$ = 0·3
L_3	Tail	17·4	15·2	$\frac{2·2}{7}$ = 0·31
EE_8	Central	33·8	30·8	$\frac{3}{7}$ = 0·43
CC_3	Upper	32·0	29·0	$\frac{3}{7}$ = 0·43
H_6	Lower	29·4	26·4	$\frac{3}{7}$ = 0·43
H_2	Lower	29·4	26·4	$\frac{3}{7}$ = 0·43
J_5	Lower	44·0	39·4	$\frac{3·6}{6}$ = 0·60
G_6	Central	41·8	35·8	$\frac{6·2}{6}$ = 1·03
H_5	Central	36·8	33·0	$\frac{3·8}{6}$ = 0·63
K_7	Lower	33·0	29·5	$\frac{3·5}{6}$ = 0·60
D_7	Central	36·2	34·0	$\frac{2·2}{9}$ = 0·24
D_6	Central	34·0	30·4	$\frac{3·6}{7}$ = 0·51
D_3	Central	32·4	30·2	$\frac{2·2}{7}$ = 0·31
B_4	Upper	20·4	16·2	$\frac{4·2}{8}$ = 0·52
B_3	Upper	19·0	17·0	$\frac{2}{8}$ = 0·25
E_6	Central	41·2	39·0	$\frac{2·2}{7}$ = 0·31
F_6	Central	35·4	31·0	$\frac{4·4}{8}$ = 0·55
E_5	Central	33·4	28·8	$\frac{4·6}{8}$ = 0·58
G_2	Central	31·2	26·2	$\frac{5·0}{8}$ = 0·62
E_3	Central	26·8	22·0	$\frac{3·8}{8}$ = 0·48
			Mean rise in ft. per year	= 0·50

Table No. 2.

Rise of watertabe in U.C.C. Region from 1914-15 to 1920-25, Brisk rise due to blockade of Drainage and seepage, from canal.

No. of well.	Position or zone.	S.S. Water-table below N.S. in the year.		Rise in ft. per year
		Position in ft. & year	Position in ft. & year	
H_7	Lower	26.2-1913	10·0-1923	$\frac{16·2}{10}$ = 1·62
H_6	Lower	27.0-1913	10·0-1923	$\frac{17·0}{10}$ = 1·70
EE_8	Central	31.2-1913	12·0-1925	$\frac{19·2}{12}$ = 1·60
CC_3	Upper	29.0-1913	12·0-1923	$\frac{17·0}{16}$ = 1·06
DD_7	Central	33.0-1917	26·7-1920	$\frac{6·3}{3}$ = 2·10
DD_6	Central	29·3-1916	18·3-1920	$\frac{11·0}{4}$ = 2·75
DD_3	Central	29.0.1916	I7·30-1920	$\frac{11·7}{4}$ = 2·92
B_4	Upper	15·6-1916	15·4-I920	$\frac{10·2}{4}$ = 2·55
B_3	,,			
E_6	Central	40·7-1914	25·5-1920	$\frac{15·0}{6}$ = 2·50
F_6	Central	30·5-1915	18·3-1920	$\frac{12·2}{5}$ = 2·40
E_5	,,			
G_2	Central	26·0-1915	14·4-1920	$\frac{11·6}{5}$ = 2·32
E_3	,,			
J_5	Lower	38·2-1914	22·4-1920	$\frac{15·8}{6}$ = 2·63
G_6	Central			
H_5	Central	33·5-1914	18·3-1920	$\frac{15·2}{6}$ = 2·53
K_7	Lower	29·0-1914	16·4-1920	$\frac{12·6}{6}$ = 2·10
				Mean rise in ft. per year = 2·24

natural surface R.Ls. of the wells which have been selected for study are also shown. A study of the rise of watertable was carried out by separating the canal into three regions i.e. the upper, the central and the tail, and with the conditions of watertable in 1955, the number of wells lying between 0 to 5 feet 5 to 10 ft. and 10 to 15 feet were separated, their mean rise was worked out and was plotted for June af each year for each zone as shown in Figs. 4 (i) (ii) & (iii). The rise in each zone and of each group of wells showed great variation depending upon the spill and draught of each year and an attempt was made to work out a mean rise per year for each case. It was noted that from 1920 to 1925 and in some cases even upto 1935, the watertable deeper than 15 to 20 ft. showed brisk rise with average rise of 1.3 ft. per year as shown in Table III. This brisk rise stopped when the watertable was nearly 10 to 15 ft. below surface.

In several of the wells in the three zones, the watertable from 10 ft.to within 3 to 5 ft. of the surface rose at the rate of 0.072 ft. per year as shown in Table IV. Some wells particularly at the lower end of central zones, however, showed steady rise of 0.3 ft. per year (Table V) after the brisk rise of 1.3 ft per year and before the steady rise of 0.072 ft. per year. This might be considered a transition stage as brisk rise cannot suddenly slow down to 0·072 ft.

Estimation of the order of seepage from the U. C. canal :—

Main Line Upper of the U. C. C. has 300 ft bed width and its full supply depth is 14 to 16 ft. carrying a discharge of 15,000 cusecs. Its full supply level on the average is 4 to 5 ft. above the natural surface and digging has caused the removal of soil crust at many places as shown below in the Table. The Main Line Lower is 250 to 200 ft. wide and towards the tail, its depth is reduced to ten feet. Its average full supply level is 3 ft. above the natural surface. The sand, silt and clay zones under the bed are given below :—

Canal.	*Sandy sites.* R.D	*Silt or clay sites.* R.D.
Main Line Upper	From 0 to 30	From 30 to 35
,,	,, 35 to 45	,, 45 to 65
,,	,, 65 to 75	,, 75 to 115
Main Line Lower.	,, 0 to 25	,, 25 to 40
,,	,, 40 to 45	,, 45 to 72
,,	,, 72 to 82	,, 82 to 97
,,	,, 97 to 103	,, 103 to 115
,,	,, 115 to 195	,, 195 to 220
Total :—	40 miles	32 miles

Table No. 3

Brisk rise of watertable in the zone of U.C.C., without addition due to blockade of drainage.

Zone	Well lines	No. of wells	Average S.S. Watertable below N. S. in the year.				Rise in ft. per year.	Depth and well in zone taken.
			Position	Year	Position	Year		
Lower	H,HA,J JA,K,KA							0′—5′ HA-2, HA-3, HA-4
	L,M,N&O	23	13·5	1920	8·5	1924	1·25	HA-5, HA-7 J7, J7A, JA5, a/L2
Lower	,,	23	15·5	1920	9·5	1925	1·26	5′-10′ H6,H7, J5A, J8, JA6, L3, MI.
Lower	,,	23	17·75	1920	14·0	1925	0·75	10′-15′ KA-5, KA-6, KA-7, L4,
Central	DD,E.F. G & H	11	16·0	1920	8.0	1925	1·60	0′-5′ E8, G9, H5
Central	,,	11	17·0	1920	9·0	1925	1·60	5′-10′ DD-6,F6, F7, F8
Central	,,	11	18·0	1920	11·0	1925	1·40	DD-4, DD-5, E6, E7.
Upper	AA,BB,& CC	13	17·25	1920	12·5	1925	1·00	10′-15′ BB-6, CC2, CC3 & CC9.

Mean rise in ft. per year=1·27

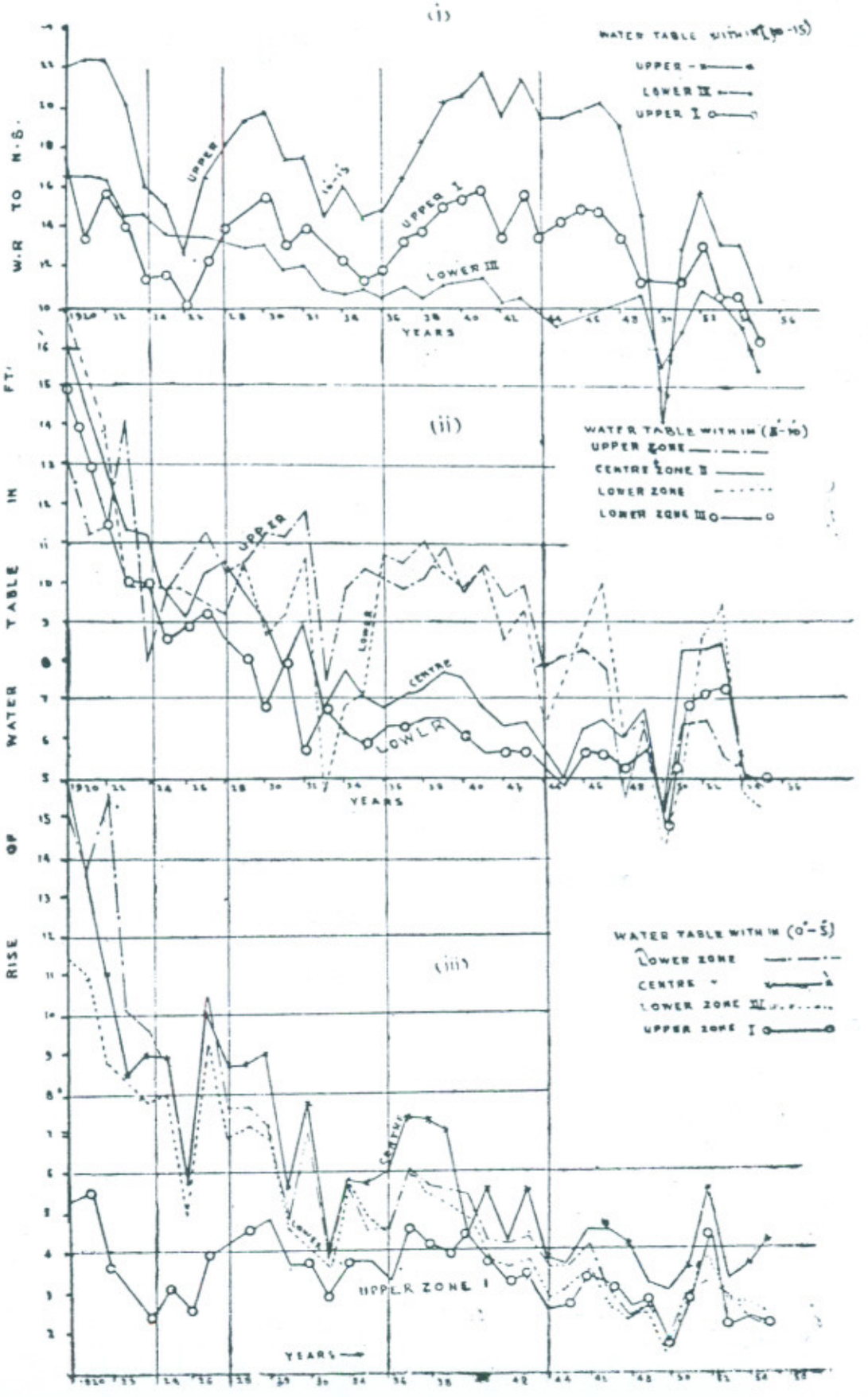

(i)
WATER TABLE WITHIN (10-15)
UPPER - II
LOWER III
UPPER I
RISE OF WATER TABLE IN FT. W.R TO M.S.
UPPER
UPPER I
LOWER III
YEARS
(ii)
WATER TABLE WITH IN (5'-10)
UPPER ZONE
CENTRE ZONE II
LOWER ZONE
LOWER ZONE III
UPPER
CENTRE
LOWER
YEARS
(iii)
WATER TABLE WITH IN (0'-5)
LOWER ZONE
CENTRE
LOWER ZONE III
UPPER ZONE I
UPPER ZONE I
YEARS

Table No. 4.

Rise of water-table in the region of U.C.C. from 1920-1925 *to* 1955 *Slow rise influenced by evaporation and transpiration, seepage etc.*

Position or Zone.	No. of well.	Average S. S. Watertable Below N.S. in the year.				Rise in ft. per year.	Remarks.
		Position.	Year	Position.	Year		
Lower	J8	30·2	1925	29·4	1955	0·8/30=0·03	
Tail	L3	26·6	1926	24·7	1955	1·9/30=0·06	
Central	EE8	13·2	1928	11·8	1955	1·4/27=0·06	
Upper	CC3						
Lower	H7	11·7	1927	9·6	1955	2·1/28=0·075	
Lower	H6	8·2	1927	6·8	1955	1·4/28=0·05	
Lower	9	4·5	1935	2·75	1955	1·75/20=0·088	0′-5′ zone
Lower	7	6·5	1935	5·2	1955	1·25/20=0·062	5′-10′ ,,
Lower	7	11·0	1935	8·5	1955	2·50/20=0·125	10′-15′ ,,
Central	3	5·8	1935	3·7	1955	2·1/20=0·105	0′-5′ ,,
Central	4	8·75	1930	7·0	1955	1·75/25=0·050	5′-10′ ,,
Central	4	11·0	1930	9·0	1955	2·0/25=0·08	10′-15′ ,,
Upper	5	4·25	1920	2·75	1955	1·50/35=0·0·43	0′-5′ ,,
Upper	4	7·5	1925	5·75	1955	1·75/30=0·058	
Upper	4	13·25	1925	11·0	1955	2·25/30=0·075	

Mean rise in ft/year=0·072

Table No. 5.

Rise of Watertable in transition stage (U. C. C.).

Position or Zone.	S.S. Water table below N.S. in 1925	S.S. water-table below N.S. in 1935	Rise in ft. per year.	Remarks.
Lower	7·25	4·50	2·75/10=0·275	Watertable between 0′—5′
Lower	9·25	6·25	3·0/10 =0·30	5′—10′
Lower	14·0	11·0	3·0/10 =0·30	10′—15′
Central	8·0	5·8	2·2/10 =0·22	0′—5′

Mean rise in ft/year=0·30

Such a big source of supply on sand having infiltration order between 800×10^{-6} and 400×10^{-6} ft/sec can have saturated connection with the ground watertable on the average 20.0 ft. below the formation, in a few hours and thus exert the infiltration pressure which can be communicated to the water contained in the pores of the sand. Those portions having silty or clay bed are not extensive but are intermixed with sandy bed, so that infiltration pressure can be communicated to those areas as well and will result in rise of water-table on the average at a rate of 1·5 ft per year close to the canal. This rise has been established for zones, five miles on the left side and ten to fifteen miles on the right side of the canal. The rate of brisk rise in the region beyond 15 miles from the canal is, however, comparatively less. Thus rise is due to the true seepage from the canal, unaffected by evaporation or transpiration.

If the watertable is supposed to exist in sand having 40% pores, its capillary height is 24 to 30 inches. If the formation consists of silty sand, the capillary height may be upto 7 ft. and the pore space may be a bit more than 40%. Now the moisture content in the capillary zone can vary from complete saturation at watertable to 30 or 35 % at the end of the capillary height, so that the infiltration water has to fill about 5 to 10% of the pore spaces. If the advancing front of this rising water can be known, the true seepage of the canal can be estimated. The canal is 83 miles long. A region of 5 miles width on the Upper and 10 miles width on the lower side showed a rise of 1·5 ft. per year. Assuming 10% moisture deficiency in the capillary region, from an area of $83 \times 15 = 1245$ sq. miles, the seepage per second works out equal to 165 cu . ft. per second. The approximate area of Rechna Doab, under the influence of this canal including the regions of Raya Branch and Nokhar Branch upto 5 miles limit on the upper side of L.C.C. Main Line and Upper Gugera Branch is 2771 sq.miles, so that if the rise is assumed at the same order of 1·5 ft. per year, then the seepage works out equal to 380·0 cusecs. However, in the zone of this canal, irrigation is not much and in the regions further off from the canal, the rise was less than 1·5 ft. per year. If we assume the above rise for 1245 sq.miles of area close to canal, and 1·0 ft per year rise for the rest of the area of 1525 sq. miles, then the total seepage works out equal to $165 + 135 = 300$ cu.ft per second. Thus, the true seepage of the canal when the watertable was on the average lower than 15 to 20 ft. below surface, was about 300 cusecs on the basis of the above assumptions.

Decrease in the rate of seepage from the canal with the rise of watertable.

The data plotted in figures 2 (a, b, c) and 4 (i, ii, iii) show that the rate of rise slowly decreased with rise of watertable. This is according to the general law of hydraulics (Darcy's relation). The rise should not have been abruptly reduced to a slower limit but it should be gradual. The abrupt variation in rise was, however, worked out for simple treatment otherwise suitable curves shall have to be found out fitting the data.

Depth below surface when evaporation, transpiration and infiltration have effective influence.

This canal is located in a zone where holding up of drainage affected the watertable even 40 ft. below the surface, it is dificult to find out the exact depth at which the infiltration, evaporation and transpiration came into effect. A study of table 4, however, does give an idea that these factors became effective with water-table 10 to 12 feet below surface when the average rise became 0·072 ft. per year.

The present condition of the canal is such that with the infiltration head more than evaporation, free water has appeared on surface. This is the position for the areas close to the canal or in depressions. At places where evaporation forces are stronger than the infiltration, the water-table is kept depressed and is stable at 2 to 5 ft. below surface. There are some areas quite far off from the infiltration head of canal and yet the water-table is quite high. The cause of this will be explained further in this note.

Well lines passing through the zone of Lower Chenab Canal system.

Lower Chenab canal was opened in *1892*. It is the main irrigation canal of the doab. It takes off from river Chenab at Khanki and upto Sagar about 26 miles from the head works, the Main Line carries a discharge of about 14,000 cusecs with bed width equal to 300 ft.and depth upto 14 ft. At Sagar it bifurcates into Upper Gugera Canal and Main Line Lower, each carrying about 6 to 7 thousand cusecs. The Main Line Lower is nearly 10 miles long abous 200ft. wide and 10 ft. deep. At Nanuana, it bifurcates into Jhang and Rakh Branches. The Upper Gugera Canal is also as wide as the Main Line Lower and carries 10 ft. deep water in a width of about 200ft. of the canal. It is about fifty six miles long, after which it bifurcates into Lower Gugera and Burala Branches.

This canal irrigates an area of nearly 6150 sq. miles. In 1882 the water table in the zone of river spill was within 20 to 30 feet below surface and in the region upstream of Jaranwala, Sangla Hill etc. it lay at 50 to 60 ft. below surface (fig. 1). In the Lyallpur region and down stream of this zone, the water-table in the centre of the doab lay at 80 ft. below the surface. At the tail end of the distributaries of L.C.C. system, Haveli Lined Canal crosses the doab and on the right side of the canal, in the triangle bounded by river Chenab and the Ravi, the water-table stood at 20 to 25 ft. below the surface. This area was also influenced by spill of the two rivers.

The records of sub soil water-table at different periods are collected from the well lines No. I to VIII which cross this region. Here the water-table now lies either at 0 to 5 or at 5 to 10 ft. and the lowest water level at a few places is upto 15 ft. below surface . Only a portion of line No.VIII passes through a zone where the water-table is still lower than 15 ft. The region lying within half the length of lines No. IX and X has water-table below 15 ft. Lines No. XI to XV practically pass

through the zones where the water-table is yet deeper than 15 ft. Line No. XVI to XVIII again pass through regions where the water-table lies within15 ft. from the surface.

Study of the rise of water-table in the region.

The records of the regular water-table observations are available from 1905. This is the case for well lines No. I to XV. The data for well lines XVI to XVIII is available from the year 1915. The position of water-table in the area in the year 1955 was considered. It is plotted in Fig. 3 and all zones of different water-tables were referred to this period.

In the zone of well lines No I to VIII, the watertable lies within 15 ft. from the natural surface, only in case of well line No. VIII about half the region is such where the watertable is still deeper than 15 ft. In order to study the rate of rise of watertable, all the wells now lying in the zone of 0 to 5 ft., 5 to 10 ft, 10 to 15 ft and below 15 ft. were grouped together and their mean rise was determined and plotted against the years and is shown is figs. 5 (a, b, c)and 6.

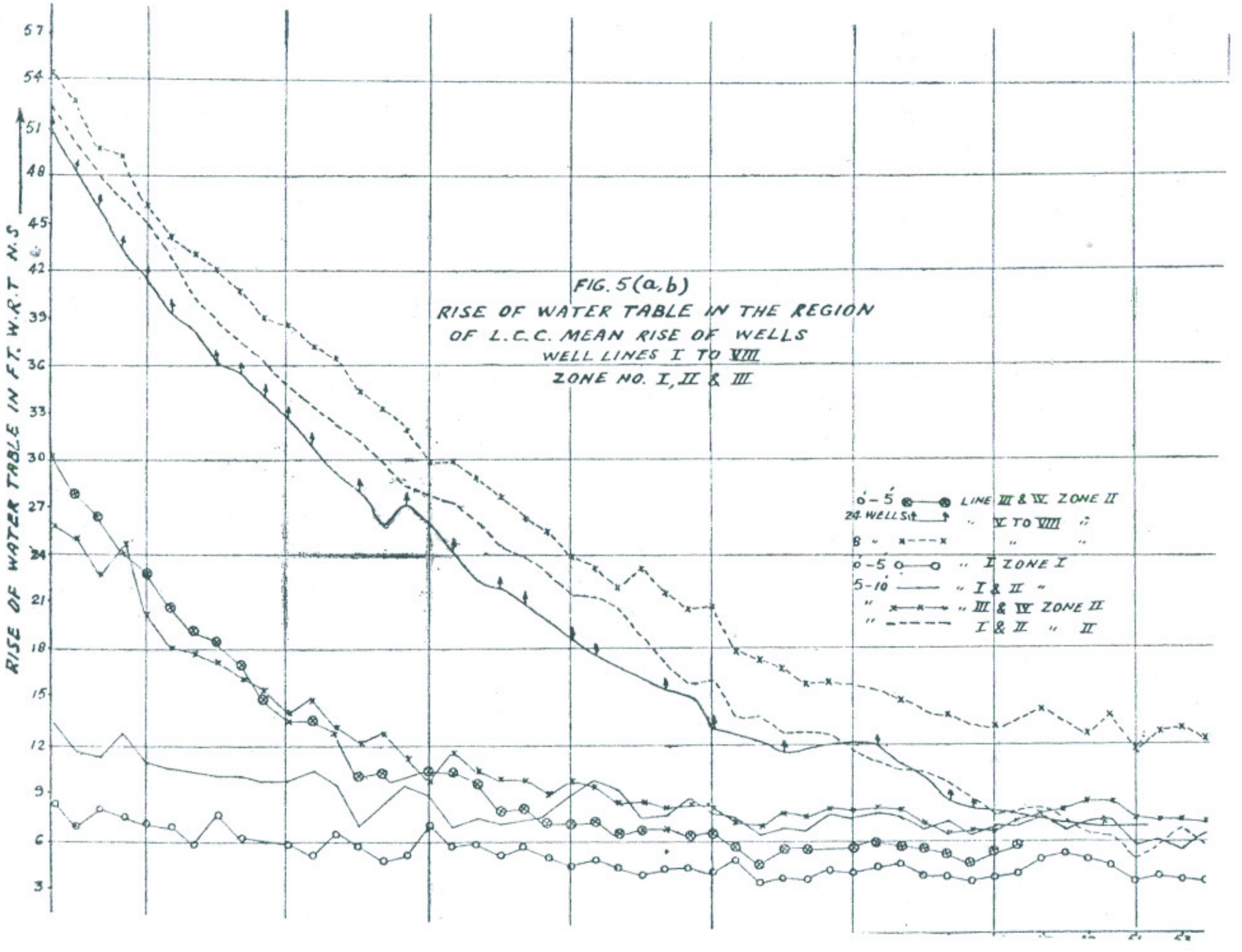
Wells lying in the zone of Heveli Canal along lines XV, XVI and XVIII are plotted in fig. 7.

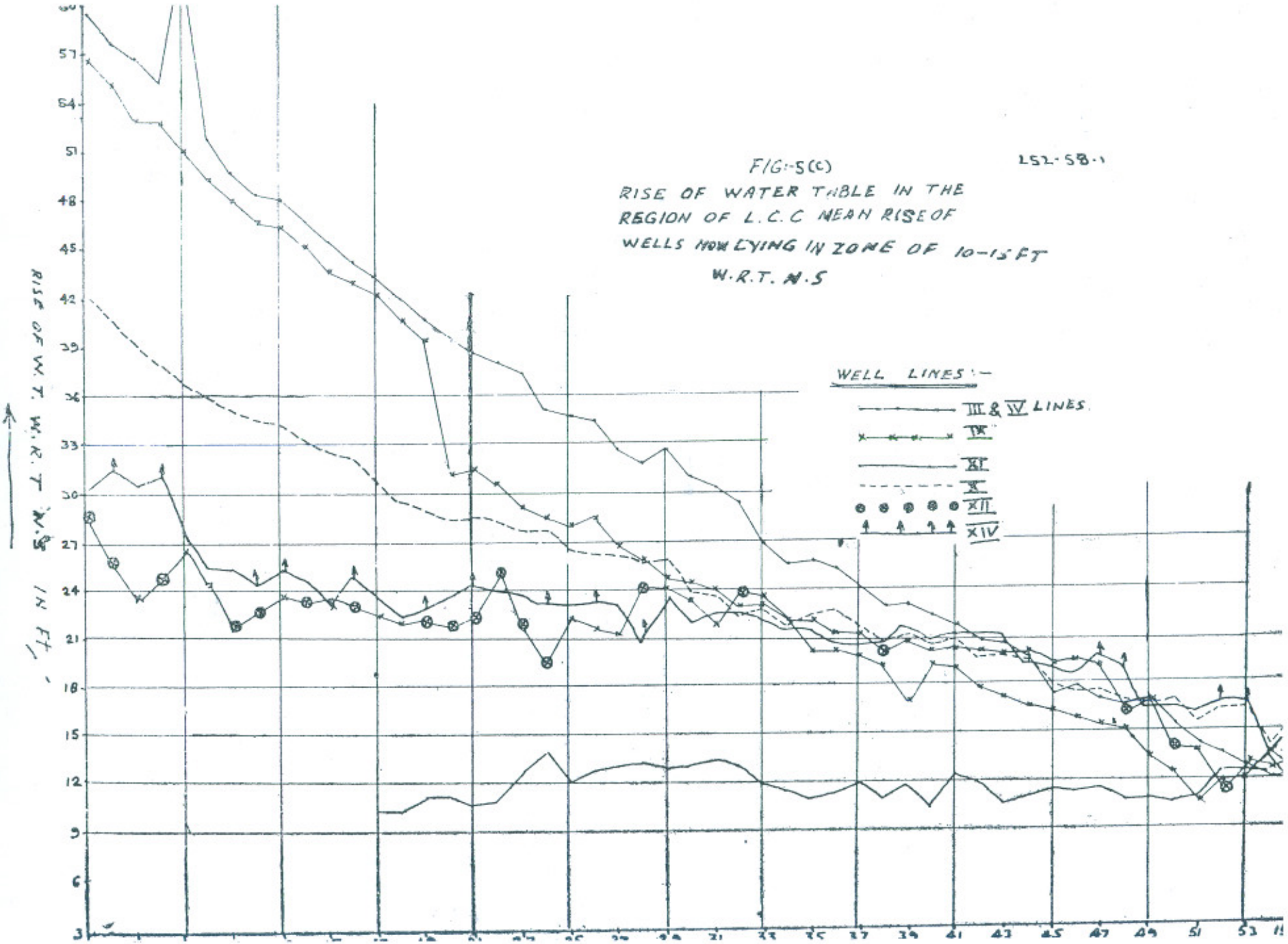
A study of these figures showed that it was possible to determine a mean value of the slope and thus to work out mean rise per year. Only those wells which were very close to rivers did not show any appreciable rise.

Rate of rise of water-table in the Lower Chenab Canal area

As stated before the conditions of water-table existing in 1955 were studied and the rise of water from the earliest systematic available records, *i.e.*, 1905 to date was plotted and mean slope representing the rise per year was studied. In Table 6 are grouped, wells existing along well lines No. 9 10, 12, 13 & 14. The mean rise of each well was worked out from the figure. Water-table in several of the wells in 1905 was 87 to 50 ft. below surface. The rise of water in each group of wells for cases where water-table lies below 15′ from N.S. is shown in part (a) of Table 6 which shows a mean rise of 1·32 ft. per year. In the same, table in part (b) are grouped the wells which now lie within the water-table from 10 to 15 ft. below surface. In this group wells of line No. 5 to 8 and 15 are also included, in addition to the wells of lines No. 9 to 14. Mean rise of these wells in the beginning was also 1· 2 ft per year. In this table, wells now lying within water depth of 5 to 10 ft. and 0 to 5 ft. are grouped in parts (c) and (d) of table 6. These include wells of lines No. 3 to 9. The mean rise was again 1·3 and 1·42 ft. per year and the over all mean rise of 110 wells from 1905 onward was found equal to 1·31 ft. per year. The rise started from a depth of 87 ft. and in some cases from 28 ft. and has continued to rise at the same rate for a certain period.

When the water-table rose within 30 to 15 ft. from the surface, the rise lowed down. This may be a transition period between the original brisk rise


FIG. 5(a,b)
RISE OF WATER TABLE IN THE REGION
OF L.C.C. MEAN RISE OF WELLS
WELL LINES I TO VIII
ZONE NO. I, II & III
RISE OF WATER TABLE IN FT. W.R.T N.S
57
54
51
48
45
42
39
36
33
30
27
24
21
18
15
12
9
6
3
0-5' LINE III & IV ZONE II
24 WELLS " V TO VIII "
8 " " " "
0-5 " I ZONE I
5-10' " I & II "
" " III & IV ZONE II
" I & II " II


FIG:-5(C)
152-58-1
RISE OF WATER TABLE IN THE REGION OF L.C.C MEAN RISE OF WELLS NOW LYING IN ZONE OF 10-15 FT W.R.T. N.S
WELL LINES :-
III & IV LINES
IX
XI
X
XII
XIV
RISE OF W.T. W.R.T. N.S IN FT.
57
54
51
48
45
42
39
36
33
30
27
24
21
18
15
12
9
6
3

252·58·2

FIG. 6

RISE OF WATER TABLE IN THE REGION OF L.C.C

MEAN RISE OF WELLS LYING 15' BELOW H.S

WELLS OF LINE NO

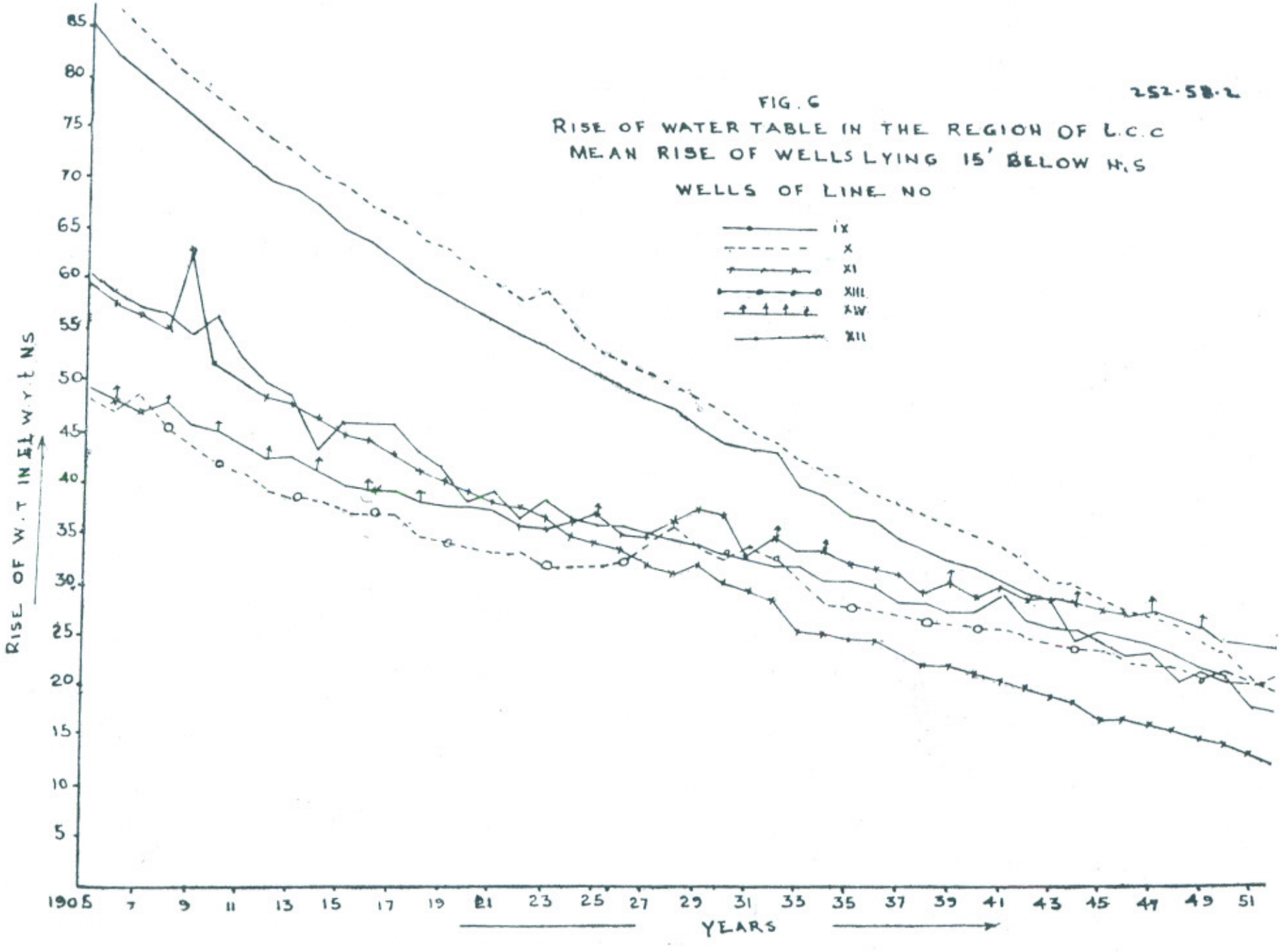


FIG. 7

RISE OF W.T. IN HAVELLI REGION

FROM LINE NO XV TO XVII W.rt N.S

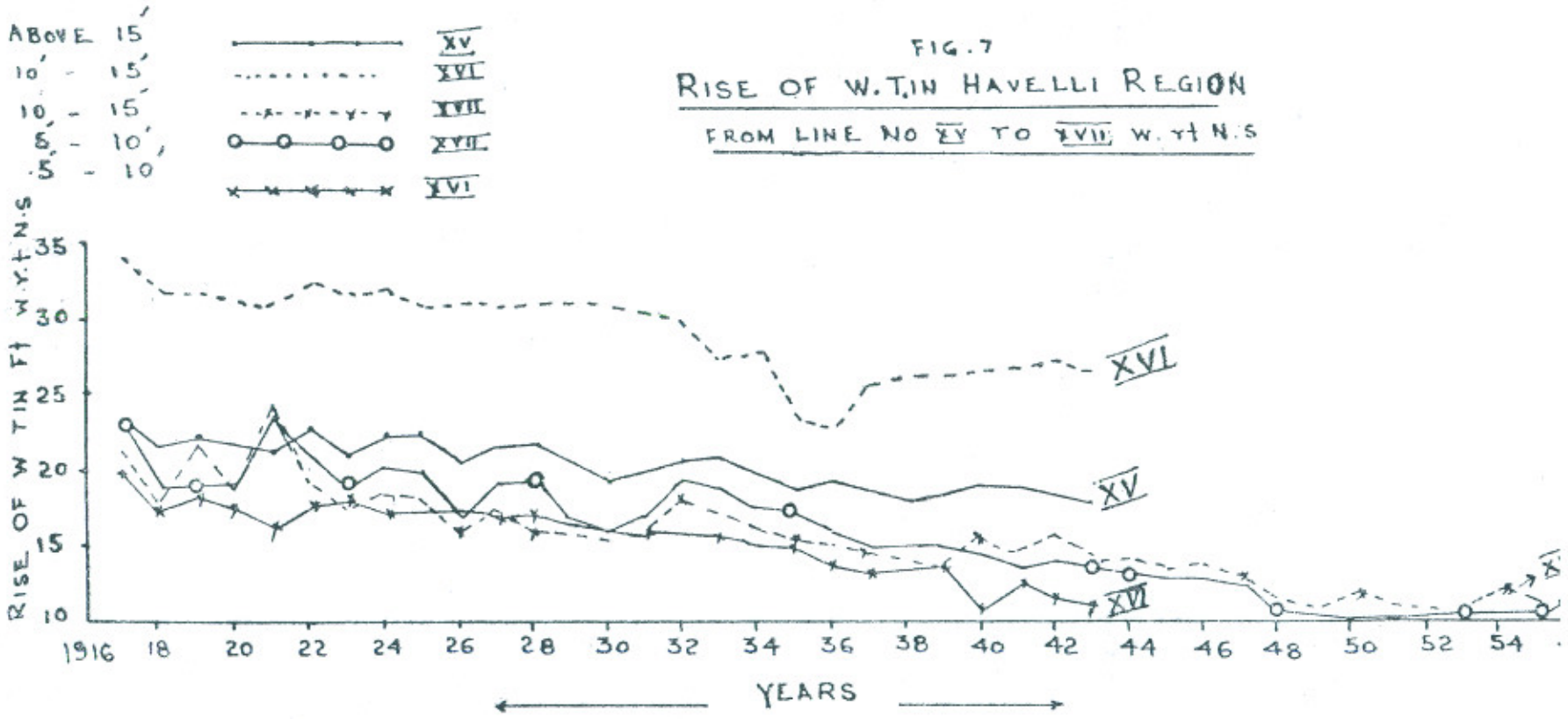


Table No. 6.

Rise of watertable in the region of Lower Chenab Canal

(a) Watertable below 15′ from N.S. in 1955.

Well Line.	No. of wells.	Year from to	Interval in years.	Rise in ft. from to	Rise in ft. per year.	Remarks.
9	4	1905-16	11	85-64	21/11=1·91	
,,	4	1916-45	29	64-26	38/29=1·31	
10	4	1905-26	21	87-61	26/21=1·20	
,,	4	1926-36	10	53-40	13/10=1·30	
,,	4	1936-54	18	39.5-20	19·5/18=1·10	
11	9	1905-12	7	57-46	11/7=1·60	
,,	9	1905-16	11	60-44·5	15·5/11=1·41	
,,	9	1916-33	17	44·5-33	11·5/17=0·68	Rejected.
,,	9	1933-52	19	33-20	13/19=0·69	,,
12	13	1905-31	26	60·5-33	27·5/26=1·06	
13	10	1905-15·5	10·5	48·5-37	11·5/10·5=I·08	
9-14	46	1905-23	18	60-40	20/18=1·10	
						Mean rise in ft. per year =1·317.

(*b*) *Watertable in wells between* 10-15 *ft. from N.S. in* 1955.

5 to 8	8	1905-21	16	531-29·6	23·5/16=1·47	
,,	8	1921-34	13	29·6-17·5	12·1/13=0·93	
9	2	1905-26	21	57·5-28·5	29/21=1·40	
10	3	1905-12	7	42-34·5	7·5/7=1·07	
,,	3	1912-20	8	34·5-28	6·5/8=0·81	
11	2	1905-16	11	60-44·5	15·5/11=1·40	
,,	2	1916-34	18	44·5-26	18·5/18=1·03	
14	2	1905-15·4	10·4	31-24	7/10·4=0·67	
9 to 14	14	1905-20	15	44-29	15/15=1·00	
15	3	1905-10	5	26·5-19·6	6·9/5=1·38	
						Mean rise in ft. per year= 1·20.

(*c*) *Watertable in wells between* 5-10 *ft. from N. S. in* 1955

3 to 4	7	1905-15	10	26·8-14·2	12·6/10=1·26	
5 to 8	24	1905-20	15	49·8-26·7	23·1/15=1·54	
,,	24	1920-34	14	26·4-12·7	13·7/14=0·98	
9	3	1905-31	26	51·0-15·0	36/26=1·4	
Mean						Mean rise in ft. per year= 1·30.

(*d*) *Watertable of wells between* 0-5 *ft. from N. S. in* 1955

3 to 4	3	1905-18	13	28·5-10	18·5/13=1·42	
Mean						Mean rise in ft. per year= 1·42

and the steady rise under the influences of evaporation and transpiration. This transition stage rise is shown in Table 7. The rise of water in 42 wells along well lines No 9 to 14 lying 15 ft. below the natural surface is given in fig. 6. It shows a mean rise of 0·6 ft. per year. In parts b, c and d of table 7 are grouped wells in which the water table now lies within 10-15 ft, 5 to 10 ft and 0 to 5 ft. below surface. In these three cases, the mean rise in the transition stage was 0·62, 0·5 and 0·35 ft. per year respectively. If the rise of group (d) in table 7 is omitted, the rise per year in these wells with the initial water-table at 30 to 15 ft. works out equal to 0·6 ft. per year. When the water-table lay at 10 to 12 ft. below the surface, the rise per year became steady *i.e.* 0·07 ft. per year. This is proved from Table 3.

Rise of water-table in the region of Haveli Canal

The well lines No. XVI, XVII and XVIII pass through the region under the influence of the Haveli Canal. There are very few wells on these lines particularly on the last line No. XVIII. A few wells of line No. XV are also under the influence of the Haveli Canal.

The mean rises of wells along these lines with water-table at 10 to 15, 5 to 10 and 0 to 5 ft. are plotted in fig. 7 and their slopes are worked out in tables 7 & 8. The data for this zone is available mainly from 1916, when the water-table was not too deep and hence the brisk rise did not take place. These wells had shown transition rise of 0·6 ft. per year and steady rise of 0·07 ft. per year when the watertable was close to the surface. Interesting conclusions are that :—

(i) The rise in the Haveli Canal zone had started since the period of record i.e. 1915.

(ii) The imposition of the Haveli Canal in 1939 did not increase the rate of rise, though the area with deeper water table was continously being reduced every year. The opening of the Haveli Canal has not deteriorated the conditions, may be it is due to canal lining or some other cause which needs careful study.

Estimation of seepage from the region of L.C.C.

As already discussed for the U.C. Canal, the average brisk rise in the whole region of this canal is found equal to 1·3 ft. per year. In this canal this rise is found not only for the region close to big main lines, but in the zone of branches as well. On the same conception as already discussed the true seepage from the canal zone having an area of 6,150 sq. miles seems to be 707 cu. ft. per sec. For this estimation, the area down-stream of Haveli Canal has been left out as from the period of available records, the rise had been 0·6 ft. per year and this is influenced by evaporation etc.

Conception about natural sub-soil drainage of the Doab

When a wide line source establishes a saturated connection with the sub soil water, the infiltration adds to the sub-soil reservoir. Now if the formation is pervious, the flow takes place horizontally and vertically upward and

Table No. 7

(Lower Chenab Canal Transition Stage)

(a) *Water-table below 15 ft. from N.S. in 1955.*

Well line	No. of wells	Years from to	Interval in years	Rise in ft. from to	Rise in ft. per year
9	4	1945—55	10	26·0—18·5	$\frac{7·5}{10}$ = 0·75
11	9	1916—33	17	44·5—33·0	$\frac{11·5}{17}$ = 0·68
,,	,,	1933—52	19	33·0—20·0	$\frac{13·0}{19}$ = 0·69
12	13	1931—55	24	33·0—21·0	$\frac{12·0}{24}$ = 0·50
13	10	15·5—55	39·5	38·5—21·0	$\frac{17·0}{39·5}$ = 0·43
14	6	1905—21·5	16·5	48·0—36·5	$\frac{12·0}{16·5}$ = 0·73
,,	6	1921·5—55	33·5	36·5—24·5	$\frac{12·0}{33·5}$ = 0·36
9-14	42	1923—55	32·0	40·0—20·0	$\frac{20·0}{32}$ = 0·625
				Mean rise in ft/year	= 0·60

(b) *Water-table between 10-15 ft. from N. S. in 1955*

9	2	1926—52	26·0	28·6-11·6	$\frac{17·0}{26·0}$ = 0·65
10	3	1912—20	8·0	34·5—28·0	$\frac{6·5}{8}$ = 0·81
,,	,,	1920—55	35·0	28·5—15·0	$\frac{13·5}{35·0}$ = 0·40
11	2	1920—34	14·0	37·2—26·0	$\frac{11·2}{14·0}$ = 0·80
,,	,,	1934—55	21·0	26·0—11·5	$\frac{14·5}{2·10}$ = 0·70
14	,,	1905—15·4	10·4	31·0—24·0	$\frac{7·0}{10·4}$ = 0·67
9-14	9	1920—55	35·0	29·0—13·5	$\frac{15·5}{35·0}$ = 0·44
				Mean rise in ft/year	= 0·62

Table No. 7—*continued.*

(c) *Watertable between* 5-10 *ft. from N. S. in* 1955

Well line	No. of wells	Year from to	Interval in years	Rise in ft. from to	Rise in ft. per year.
3 & 4	7	1915—29	14	14·2—8·2	$\frac{6·0}{14·0}$ = 0·43
5 to 8	24	1920—34	14	26·4—12·7	$\frac{13·7}{14·0}$ = 0·91
,,	24	1934—55	21	13·7—7·4	$\frac{6·3}{21·0}$ = 0·30
9	3	1943—51	8	10·0—5·0	$\frac{5·0}{8·0}$ = 0·625
16	3	1917—43	26	19·3—12·7	$\frac{6·6}{26·0}$ = 0·25
17	2	1917—55	38	20·3—10·6	$\frac{9·7}{38·0}$ = 0·26
					Mean rise in ft/year = 0·50

(d) *Water-table between* 0-5 *ft. N. S. in* 1955

3 & 4	6	1918-29	11	10·0-6·2	$\frac{3·8}{11·0}$ = 0·35
					Mean rise in ft/year = 0·35

Table No. 8

(Lower Chenab Ganal)

Zone of Evaporation and Transpiration.

(a) *Water-table between* 0-5 *ft. from N. S. in* 1955

Well line	No. of wells	Year from to	Interval in years	Rise in ft. from to	Rise in ft. per year		
18	1	1917—55	38	7·8 —4·4	$\frac{3·4}{38}$	=	0·09
3 to 4	6	1929—50	21	6·2—5·4	$\frac{0·8}{21}$	=	0·038
1 & 2	7	1925—55	30	4·6—3·7	$\frac{0·9}{30}$	=	0·030
,,	7	1905—25	20	7·5—4·6	$\frac{2·9}{20}$	=	0·15
				Mean rise in ft/year		=	0·077

(b) *Water-table between* 5-10 *ft. from N. S. in* 1955

1 & 2	5	1926—55	29	7·5—6·3	$\frac{1·2}{29}$	=	0·040
3 & 4	7	1929—55	26	8·2—6·8	$\frac{1·4}{26}$	=	0·054
9	3	1949—55	6	6·5—6·0	$\frac{0·5}{6}$	=	0·083
				Mean rise in ft/year		=	0·058

(c) *Water-table in wells between* 10-15 *ft. frow N. S. in* 1955

18	1	1917—51	34	16·8—14·2	$\frac{2·6}{34}$	=	0·08
3 & 4	5	1924—55	31	12·8—10·8	$\frac{2·0}{31}$	=	0 065
				Mean rise in ft/year		=	0·072

with the natural gradient which was fairly high in the beginning and much of the infiltered water could flow away but the formation of our land is such that during deposition of alluvium, clay, silty loam, sandy loam, medium, fine and coarse sand are deposited at the same level in small dimensions in the form of lenses. This variation in deposits of various types, occur vertically also, so that if at a certain place, clay lense occurs at one level, a few miles down stream, a clay lense may appear at the level of the medium or fine sand. The variation of occurance of impervious clay lenses is so irregular that a major portion of sub-soil flow is blocked. There is a greater possibility that either no flow or insignificant flow is taking place with the result that infiltered water of canal has risen upward instead of flowing away. This obstruction to viscous flow has caused quick local high water-table which has resulted in the penetration into relatively imprevious soil crust. This is also one cause of variation in level of S.S. water-table which under the same line source and through uniform formation should have flowed at the same level. Those zones which are in depression, or the formation is sandy, offering little resistence to upward flow and where the flow is locally blocked by a clay lense, the water-table is pretty high and is close to the surface.

These conclusions are confirmed from the starta charts of tube wells installed along canal under Rasul Tube Well Scheme and the recent exploratory borings done by Ground Water Development Organization. Even the most propagated conception that the Shahpur, Chiniot, Sangla Hill ridge is the cause of high water-table on its up-stream, is discounted. In Fig. 8 (a, b, c,) are shown some of the profiles, even close to the ridge, as explored by Ground Water Development Organization. Except slightly thicker clay layers, the picture of the formation is very similar as in the rest of the doab.

Effect of the existing sub-soil conditions on the success of Reclamation Schemes.

The most successful method to reclaim the saline soil is to leach down the excessive salts of the soil. This is possible only when excess of water is maintained on the land and the water percolates down carrying away the salts. Now if there is no sub-soil flow, then the top water either remains stagnant without washing down the salts or an insignificant flow with small driving head carries down the salts to shallow depths, temporarily which come up again within short periods. This conception is worth checking in the field. A more permanent reclamation is possible if the salts are carried away by the seeping water or are redistributed in thick formation. This conception of insignificant flow during reclamation in high water-table area is worth checking in the field. This idea seems to be specially applicable to Chakanwali farm which is under reclamation processes since 1930 and yet it is doubtful if the salts percentage has reduced from the land. Similar are the instances of other reclamation projects of Chuharkana, Jaranwala and Pindi Bhattian where the water-table is high. The reclamation success is only possible if the water is kept constantly in motion, so that local depressing of the water-table gives a chance to the salts to redistribute in greater thickness of the soil formation. This idea also throws a doubt on the effectiveness of open or tile drains as these will be effective in draining only the top few feet of soil and the deeper water will still remain stagnant

LYALLPUR

PUNJAB AQUIFER

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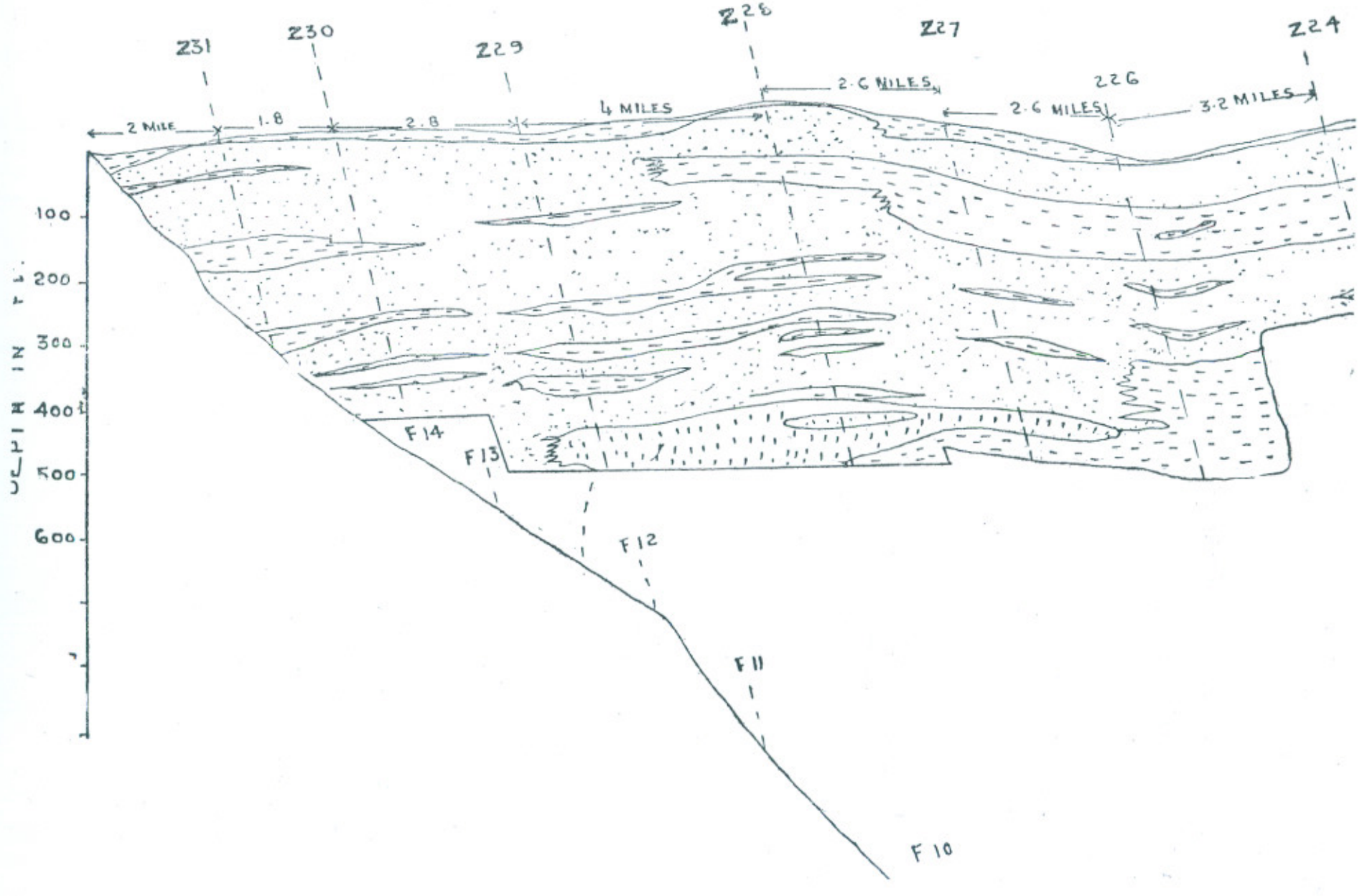
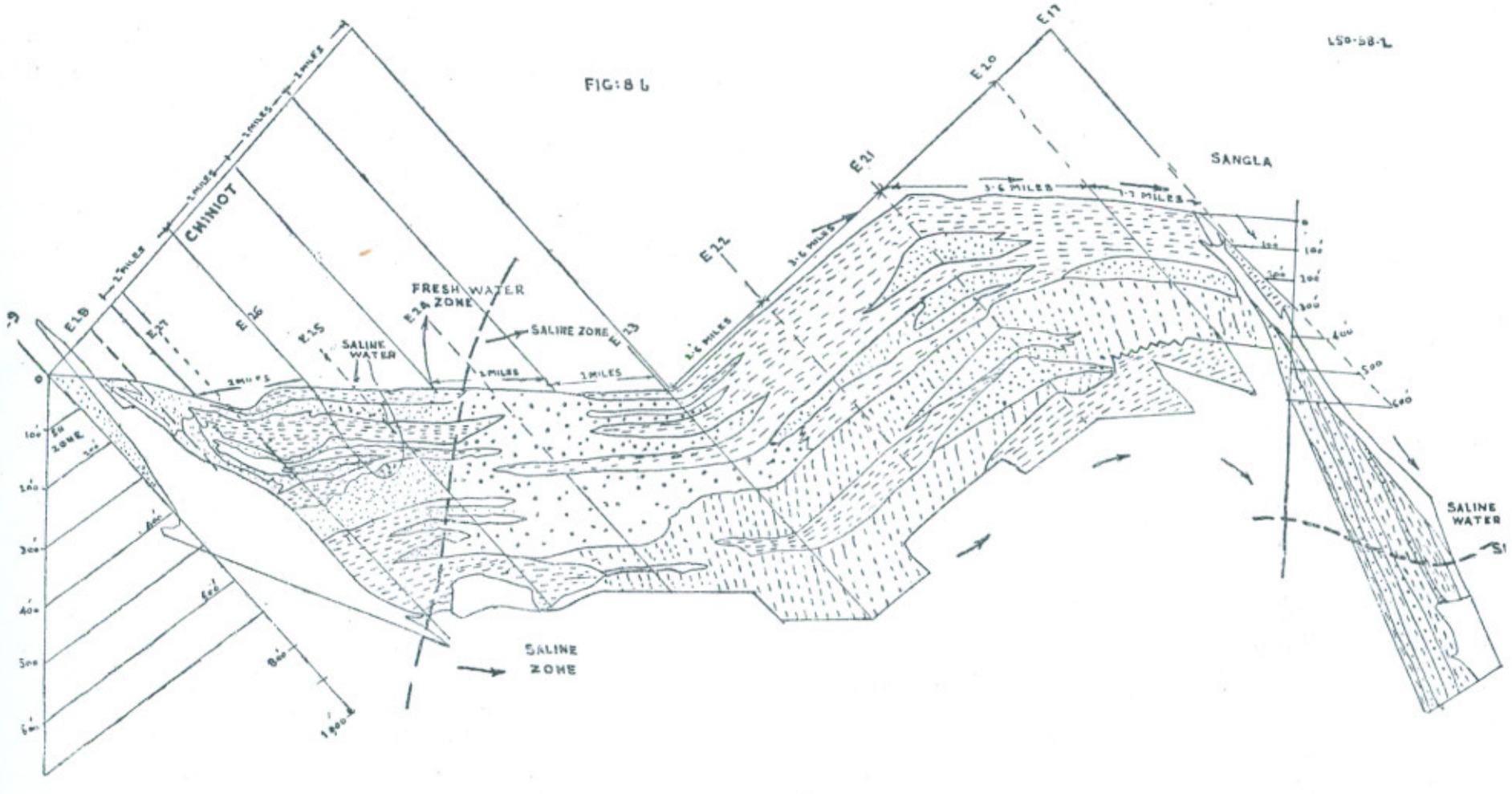


FIG: 8 b


CHINIOT
E18
E27
E26
E25
E24
E23
E22
E21
E20
E17
SANGLA
FRESH WATER
E24 ZONE
SALINE WATER
SALINE ZONE
SALINE ZONE
SALINE WATER
2 MILES
1 MILES
1·6 MILES
3·6 MILES
1·7 MILES
100'
200'
300'
400'
500'
600'
800'
1000'

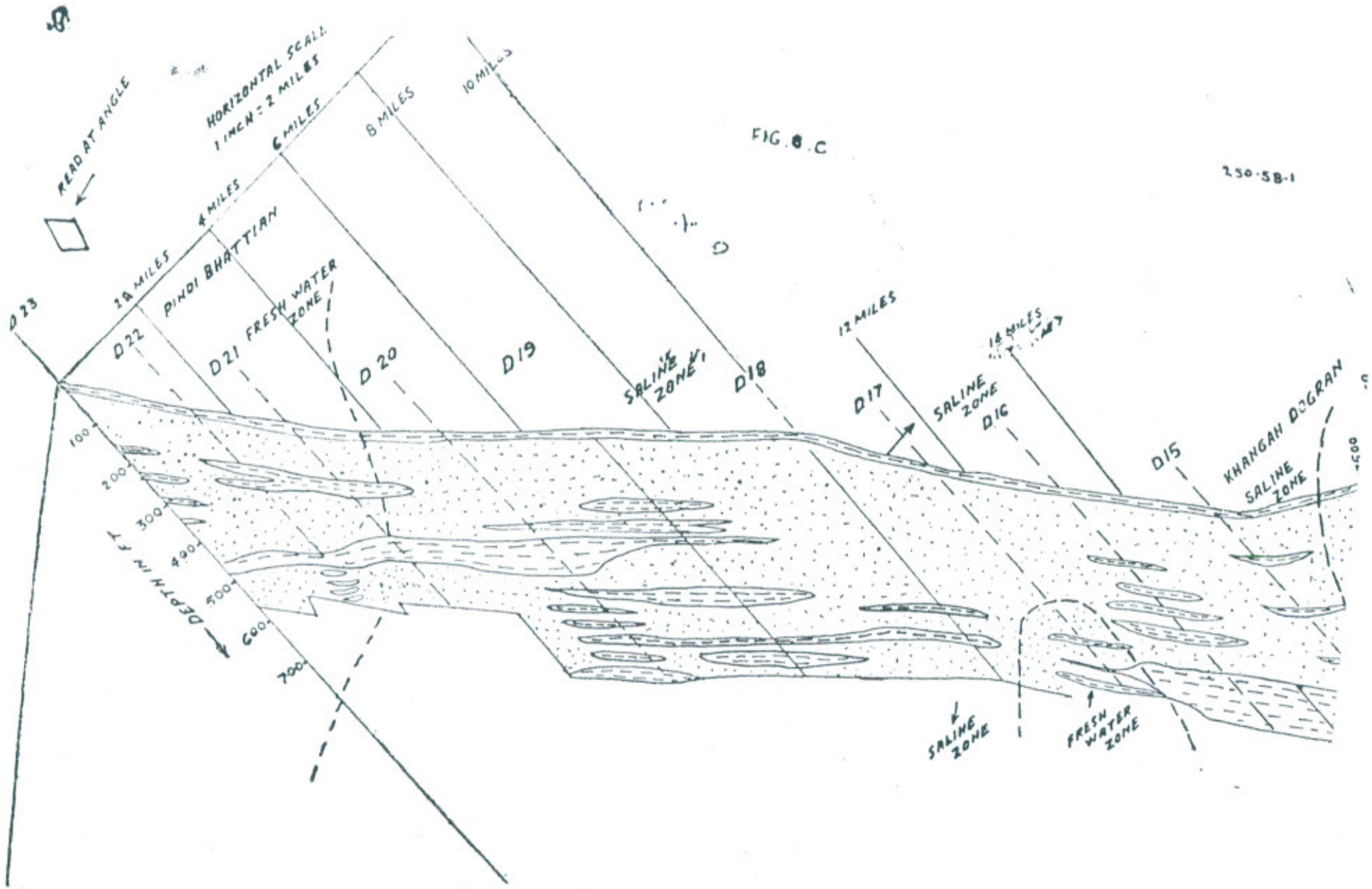


FIG. 8.C

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of local shallow and cheap pumping devices which will create not only a thick zone for salts to redistribute but will also give the stagnant water from dark zone, a chance to acquire the health giving sun rays and to absorb more of the natural gases and thus add to the nourishing qualities when applied to the irrigated fields.

Conclusions

The main conclusions drawn from this steady are summed up below:—

(i) In the zone of Upper Chenab Canal, the main Railway line, G.T. Road and other obstructions, constructed about the year 1857, affected the natural drainage of the area, so that the spill of the Nallahas was held up for a longer period to add to the water-table. A study of well records has shown that from 1907 to 1914, the water-table of the area in the zone of the spill of Nallahs continued to rise at the rate of half a foot per year.

(ii) The region close to river spills was, however, not affected permanently. The area under the influence of the Chenab, had stable water-table at 10 to 15 ft. below the surface. The effect of the Ravi was lesser as compared to the Chenab. Here the water-table was deeper at 20 to 25 ft. below the surface. In the rest of the areas, beyond the influence of the river spill, the water-table lay at 25 to 40 ft. below the surface and it was rising even before the construction of the Upper Chenab Canal. The spill seemed to have held up so long as to influence the water-table even at a depth of 40 ft.

(iii) When the canal was put in operation in the year 1912 and subsequently raised to full supply in 1916, the rise on the whole area was very brisk, so that majority of wells started to rise on an average, at the rate of 2·24 ft. per year. The canal must have been another medium obstructing the natural drainage. If, however, the rise due to blockade of the drainage is supposed to be same *i.e.* equal to 0·5 ft. per year, then the rise due to the addition from canal may be 1·7 ft. per year. In other areas, with deep water-table, the rise was at the rate of 1·3 ft. per year.

Thus it is assumed that in the area of U.C.C. within 5 miles on the upper and 10 miles on the lower regions on both sides of the canal, the brisk rise of the watertable uneffected by evaporation and transpiration, was on the average, equal to 1·5 ft. per year.

(iv) When the watertable was below 10 to 15 ft. from the surface the rise slowed down to 0·3 ft. per year.

(v) When the water-table was less than 10 ft. below the surface, the rise became slow equal to 0·072 ft. per year. At this depth, the evaporation, transpiration and infiltration had greater effects causing considerable fluctuation in the water-table. This rise is talking place in the areas where the water-table is still at a depth of 10 ft. from the surface or where the soil crust is thick, so that penetration is slow due to low infiltration head. The zone with water.table at 5 ft. from the surface is practically stable except for the seasonal fluctuation of water-table.

(vi) The zone of Lower Chenab canal was examined in a similar manner as that of U.C.C., and here it was found that after opening of the canal in 1912, the rise in the full area was at the rate 1·3 ft. per year and it is still continuing where the water-table is deeper than 20 to 30 ft. Incidently, this rise is also equal to that obtained for U. C. C., when the watertable existed at a deeper depth as mentioned above.

(vii) In 1892, the depth of water table in the upper zones closes to, Sangla Hill, Chiniot, Pindi Bhattian etc. was 25 to 40 ft. below surface and in the area lower to Lyallpur, the waterdepth was 90 ft. below surface. The rise at the rate of 1.3 ft. per year started in the whole area, the upper zone with the intial high watertable got waterlogged earlier and in the lower zone, the watertable is still rising at the same rate. It is expected that brisk rise in Lyallpur zone will stop after about 12 years and then for another 10 to 15 years the transition rise will continue. The stable condition of water table within 8 to 10 ft. is expected after 25 to 30 years if no new infiltration source is brought into operation.

(viii) The earliest regular records of watertable are available from 1907 and the canal was opened 13 years earlier. In this period, there has been about 17 ft. of rise in watertable. If this depth is subtracted from the water levels existing in the year 1907, the level of water table in 1894 is obtained. The level was nearly the same as that in 1882 when there was no source of infiltration.

(ix) The rate of rise in the transition stage in the zone of the canal was 0·6 ft· per year , when the watertable lay at 15 to 30 ft. below surface. This may be due to the decrease of head between the source and the sink. This rise is nearly double as compared to U. C. C. but the head in L. C. C. region is also nearly double as compared to U. C. C. In this canal also, where the head was smaller, the rise was less, equal to 0·35 ft. per year.

(x) All wells in which the watertable now lies at 10 to 12 ft. below the surface, are showing an average rise of 0·072 ft. per year which is a slow rise similar to those areas as listed in (*v*) above. Incidently this order is the same as determined for U. C. C.

(xi) The water table in the zone of Haveli canal lay at a maximum depth of 15 ft. below the surface in 1915. This area has also shown a steady rise of 0·6 ft. in the initial stages and now the water is rising at a slow rate of 0·072 ft. per year.

(xii) During brisk rise, the watertable was so deep that it was beyond the range of evaporation or transpiration and if it is assumed that the watertable lay in sand of capillary height equal to 24 to 30 inches with moisture deficiency upto 10% of the total volume the seepage

from the two canals is worked out as under :

S.No.	Canal.	Rise/year in ft.	Area sq. miles.	Moisture % Deficiency.	Infiltratinn cu. ft. per sec.
1.	U.C.C.	1·5	1245	10	165
2.	"	1·0	1526	"	135
3.	" mean 1·3, Total area		1771	"	300
4.	L.C.C.	1·3	6150	"	707

This seepage is on the assumption of no sub soil flow.

(xiii) The watertable in the zone under the influence of the Haveli canal started to rise from 1916, the period of available records, and it continued to rise like other areas without showing any sudden rise after the opening of the Haveli canal in 1939. This result needs explanation as to the in-effectiveness of the existence of this canal on the water-table.

(xiv) The behaviour of the rise of watertable above the so-called ridge was exactly similar to that down stream of it. In fact the conception of headiug up of water above the ridge is not borne out by facts.

(xv) The formation of the Rechna Doab above the protruding hill-at Sangla, Chiniot etc., is very similar to the formations at other places. There are irregular impervious lenses of clay which cause an obstruction to the sub-soil flow. It seems there is insignificant sub-soil flow and at places this is completely blocked due to clay lenses and this has caused the infiltered water to rise upwards rather than to establish a sub-surface gradient, carrying away the seepage from the canal. This might be true particlularly during the period of brisk rise. The same order of brisk rise in wells far off from the main canal particularly in case of L.C.C. also supports the conception of blocked sub soil flow. It is true that regeneration into rivers and drains does show under-ground flow of water but this is limited to the top few feet of the soil. This obstruction to sub soil flow may be a cause for the penetration of the water into the comparatively impervious soil formation at the surface.

(xvi) The clay lenses are also a source of local high watertable which are heading up the viscous flow, so that the watertable is high either in these regions or in depressions or where the soil is sandy and less resistant to the upward flow of water.

(xvii) If this conception is true, all our reclamation schemes need to be reviewed. If the sub-soil water is stagnant and no underground drainage exists, then the addition of water at the top has littile chance to

infiltrate down and carry away the soluble salts. Thus the present system of reclamation in which salts are depressed to shallow depths temporarily, is in fact a waste of water and energy, unless it is accompained by drainage so as to circulate or redistribute the salts in thick soil zone. It means that we must change our system of reclamation. The reclamation of Chankanwali and other places is a proof of this statement.

When the sub-soil water is stagnant, it will acquire better nourishing qualities if it is pumped out to absorb more of the oxygen and the sun light. The surface drains or tile drains will certainly drain the soil water and the deeper water will still remain stagnant and un-affected. Circulation of stagnant water and redistribution of salts in thicker zones can alone result in permanent reclamation.

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