Paper No. 531

A STUDY OF PROBLEMS OF WATER SUPPLY AND DREAINAGE OF LAHORE ZONE USING THE NUMERICAL MODELLING

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ABSTRACT

Water supply of Lahore is out of ground water. At present for a population of about 40-lakhs, 600 cusecs are being pumped out from an area of nearly 200 square miles. This corresponds to a withdrawal of about 3.0 cusecs per square mile. This has caused a decline of groundwater from a depth of about 15 feet to a maximum of 70 feet. It is estimated that during the next two decades Lahore population will rise to 75.0 lakhs and about 1300 cusecs shall have to be pumped which will result in the decline of groundwater to 90 feet. So far no information has been collected about the depth of water bearing formation. The results of 1280 feet bore near Niazbeg has given a very bleak picture. The possible inflow of saline groundwater from Raiwind side just 12 miles from Lahore has not been studied. If Lahore is to continue withdrawing groundwater, one must study the possibilities of recharge of the aquifer and relieve the Lahore residents from doubtful and ever increasing cost of pumping. Large amount of surface water from Tehsils of Sialkot district is available close to Lahore which can be used to recharge the aquifer. This will result in a large saving of flood and rain water and also bring 45,000 disastrous acres for production of winter crop. In this paper Computer Studies have been carried out to determine the best successful method of recharge, possibilities of inflow of saline water and its counter measures.

MAIN TEXT

Lahore is the second largest city of Pakistan. Its population is increasing at a rapid rate of about 3.7 percent per year. In 1901 Lahore population was two Lakh three thousand which by 1987 increased to 36.7 Lakhs. Considering the yearly increase it is estimated by 2000 it will increase to 56 Lakhs. Some idea of the populatin in different years can be had from Table - 1.

Table - 1

INCREASING POPULATION OF LAHORE

YEAR	1901	1987	1990	1995	2000	2010
Population present and anticipated in millions	0.203	3.67	4.10	4.90	5.60	7.50

LAHORE PUBLIC WATER SUPPLY

Lahore population for their water supply had always depended on withdrawal of groundwater. Before 1876 the water withdrawn from open well was the source of supply. In 1878 year a water-works was constructed in Badammi Bagh just near the northern wall of Lahore Fort. Water collected from groundwater gallaries was pumped by a reciprocating pump operated by steam engine. It was forced into a water tank constructed at the highest elevation in the city. Piped water supply was provided to the citizens. With the development of centrifugal pump and electric supply, tubewells were started to be installed during the second decade of 20th century. By 1930, due to the expansion of the city outside the walled city, water supply was arranged by pumping groundwater from individual tubewells. Groundwater had always been available very close to surface at a depth of about 15 feet. Withdrawal was carried out generally by centrifugal pumps although Turbine pump had also been developed by 1934.

The city started to expand during the 1950 decades and large number of tubewells had to be installed. Their present location is illustrated in Fig-1. New tubewells are generally of 4 Cs. These are provided with 167 H.P. motors to lift 4-Cusecs to a head of 210 feet. By 1987, out of 206 tubewells of WASA, 188 were in operation. Their yield was estimated equal to 413 cusecs. The exact estimate of output, however, is quite difficult as the yield depends upon the total head which cannot be maintained as per design. It was noted that during high demands with decrease of head, tubewells pumped high discharge sometimes equal to 8 cusecs. Similarly during winter with decreased demand the pressure sometimes increases to shut-off pressure of about 270-feet. NESPAK estimated the ouput of WASA tubewell in 1987 equal to 413 cusecs and that being pumped out by other Government and private agencies equal to 180 cusecs giving a total output of 593 cusecs.

NESPAK had estimated that in the coming years the number of tubewells and their pumpage will increase to as shown below:

Table - 2

ESTIMATED NUMBER OF TUBEWELLS AND THEIR OUTPUT FOR LAHORE CITY

YEAR	ASSUMED NO. OF TUBEWELLS		WATER ABSTRACTION	
	Installed	In Operation	m^3/Sec.	Cu.ft/Sec.
1987	206	188	11.7	413
1990	226	206	11.79	416
1995	262	239	14.79	522
2000	297	271	16.79	593
2010	414	378	23.42	827

By 2010 it is estimated that 462 cusecs will be pumped by organizations other than WASA so that the total withdrawal will increase to 1290 cusecs.

DECLINE OF GROUNDWATER LEVELS

The city started to expand during 1950-60 decade. The number of tubewells installation continued to increase. The groundwater which used to exist at about 14-15 feet started declining at a rapid rate. The elimination of irrigated lands also helped in the decline. In about 30 years (1959 to 1989) a decline of about 50 feet had occured. The deepest water now lies at a depth of 70 feet. The ground water depth contours observed during 1980 are plotted in Fig-2. Groundwater depth contours for the year 1986 are plotted in Fig. 3. The increased extent of decline of ground water after six years of pumping is apparant.

This is the deepest point. Groundwater in all areas will continue to decline at nearly the same rate. During the next 21 years Lahore will continue to extend towards east and south sides, towards Jallow, Batapur and beyond Township, Green Town and from Niazbeg along Lahore Multan and Lahore Raiwind roads. The water supply for all

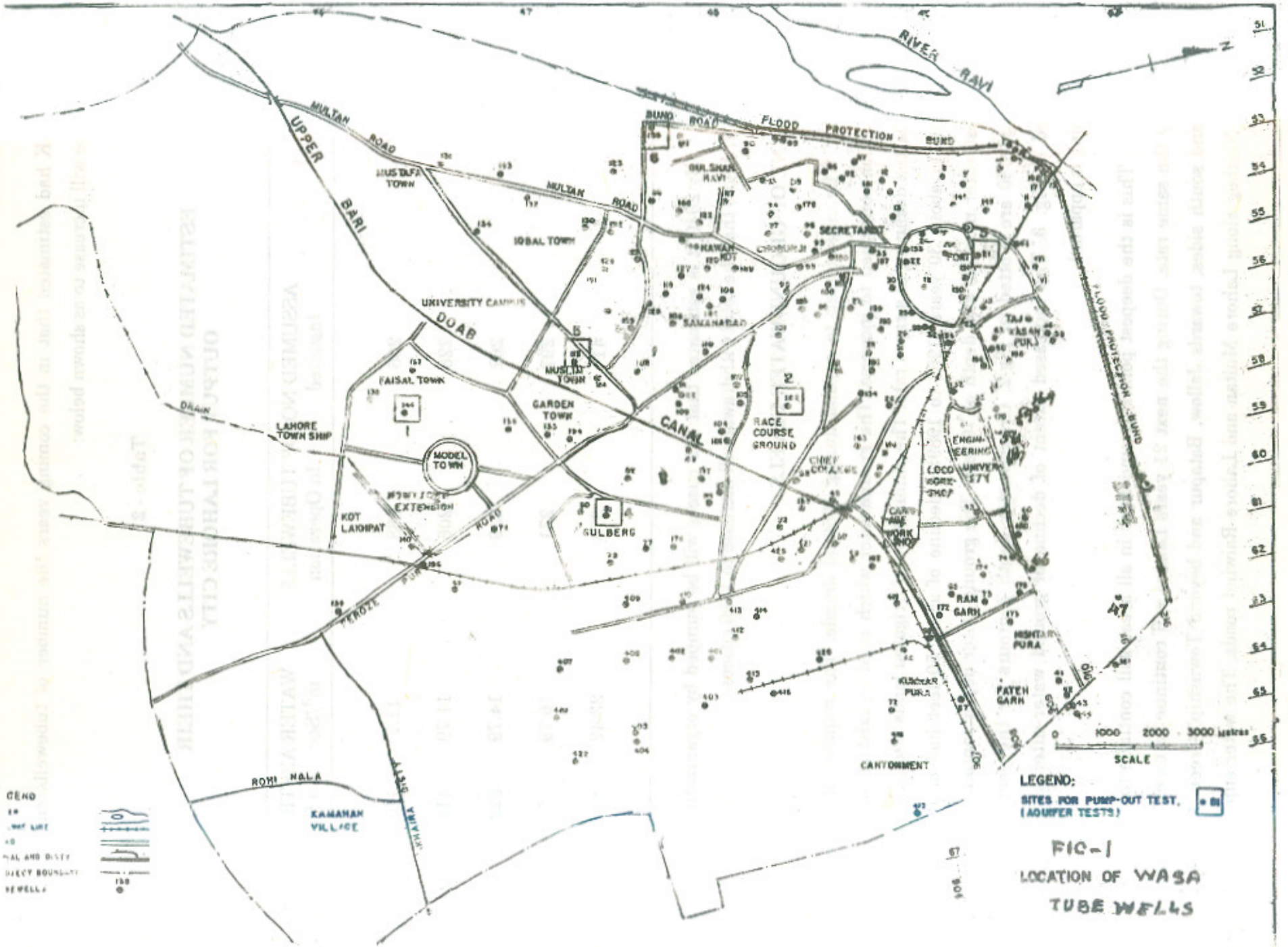


FIG-1
LOCATION OF WASA TUBE WELLS

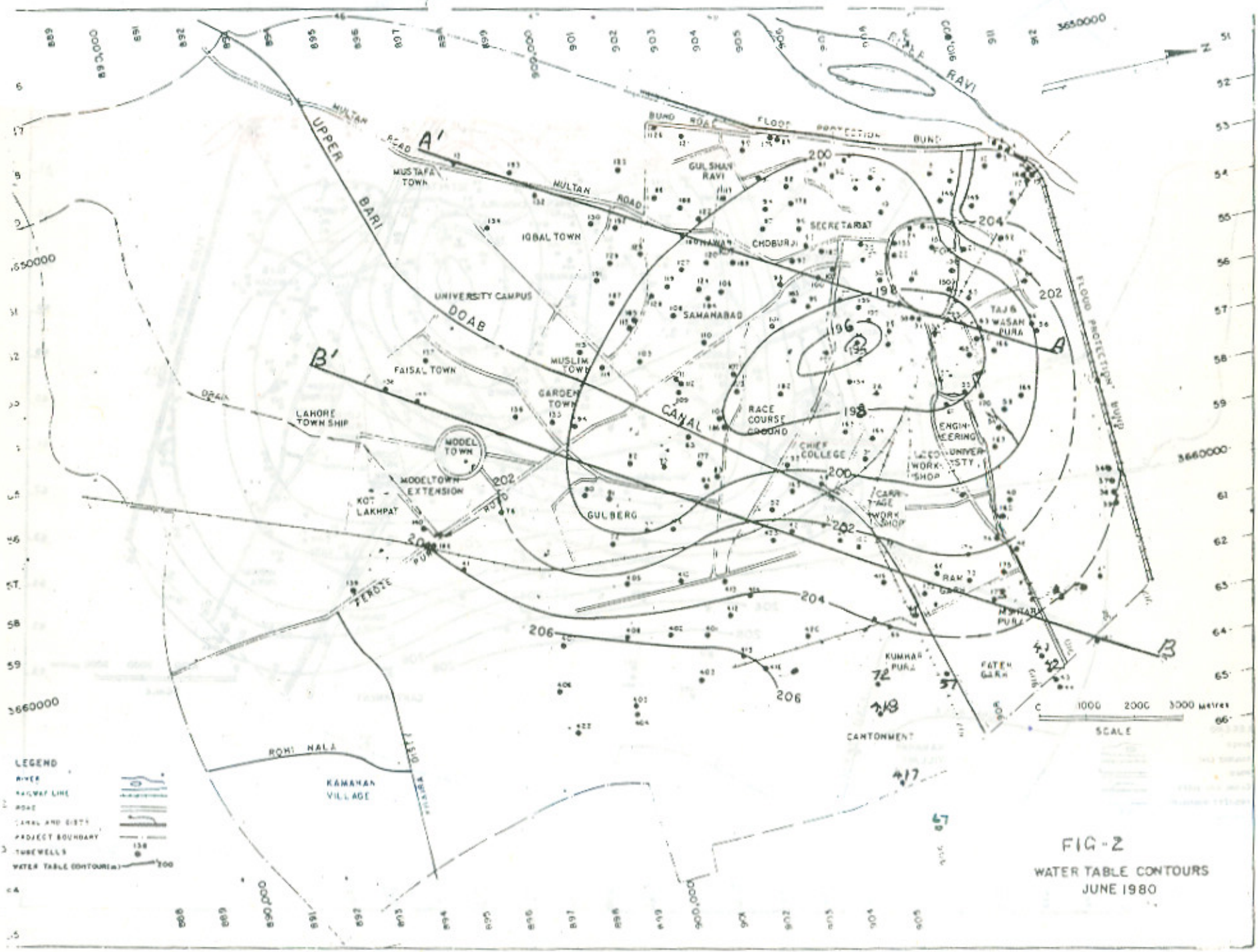


FIG-2

WATER TABLE CONTOURS
JUNE 1980

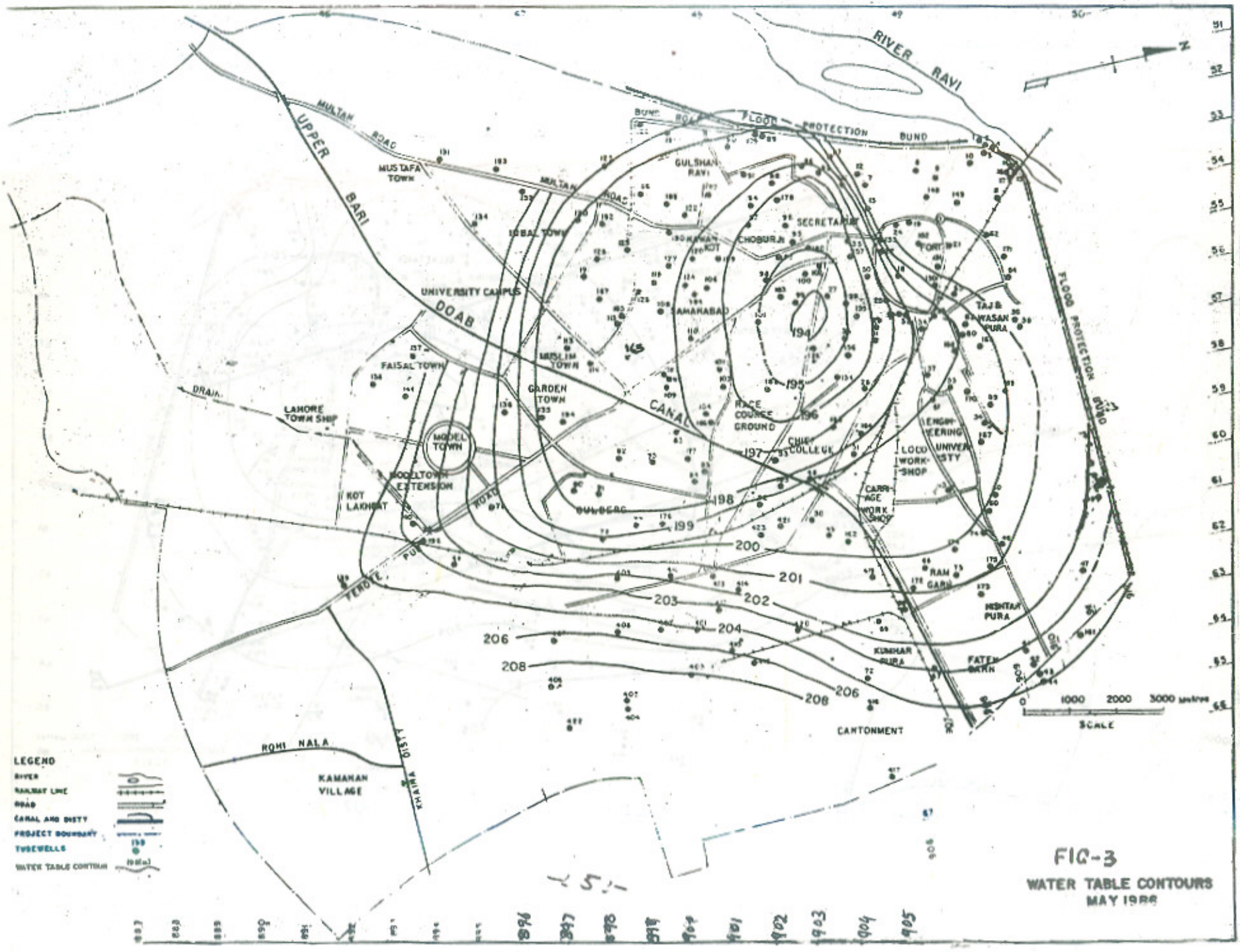


FIG-3
WATER TABLE CONTOURS
MAY 1986

areas is to be out of groundwater. At present the extent of Lahore is taken as 23 x 21 sq. Km. corresponding to 188.6 sq. miles (14.4 x 13.1 sq. miles). Assuming Lahore area equal to say 200 sq. miles then a withdrawal of 1290 cusecs will correspond to 6.45 cusecs per sq. mile. The present withdrawal of about 600 cusecs from the same area corresponds to about 3 cusecs per sq. mile.

WATER YIELD FROM THE STORAGE OF LAHORE FORMATION AND FROM EXTERNAL RESOURCES

As the fall in groundwater level is at the rate of one foot per year, assuming 25 percent as the yield out of saturated sand containing 40 percent pores, the water being yielded by the formation of 200 sq. miles is 46 cusecs, the rest is a result of periphery inflow. This assumption of 25 percent is rather too high for the type of formation under Lahore as represented by two cross sectins 'AA' and 'BB' along north south direction marked in Fig-2. The type of formation is shown in Fig. 4.

The average yield of the Indus formation is 14 percent. Lahore formation is not different from the rest of the deposits. If we assume this high order of specific yield about 550 cusecs is the periphery inflow. Assuming 60 percent inflow out of the Ravi corresponding to 330 cusecs, that being yielded from the formation area is about 220 cusecs. By 2010 with decline of groundwater to 90 ft. that expected out flow of the Ravi will be 450 cusecs and from the formation 750 cusecs.

EXPECTED CHANGES IN THE FLOW OF RAVI RIVER

At present the flood water of the Ravi enters Pakistan. The normal flow of the river is diverted by India. Thein Dam is being constructed by India upstream of Mahdopur. It is likely to be completed by 1991-92. India will try to store as much of flood water as possible. Thus to expect high flows passing the River in the zone of Lahore during Mansoon is likely to be reduced considerably.

Ravi will not completely dry out as during five summer months 15,000 cusecs of Marala Ravi Link will continues to pass through the river.

There ae five flashy streams which fall into the Ravi within the area of Pakistan. These are mentioned in Table-3 below. Three streams, Ujh, Bein and Basantar Joint the Ravi upstream of Lahore.

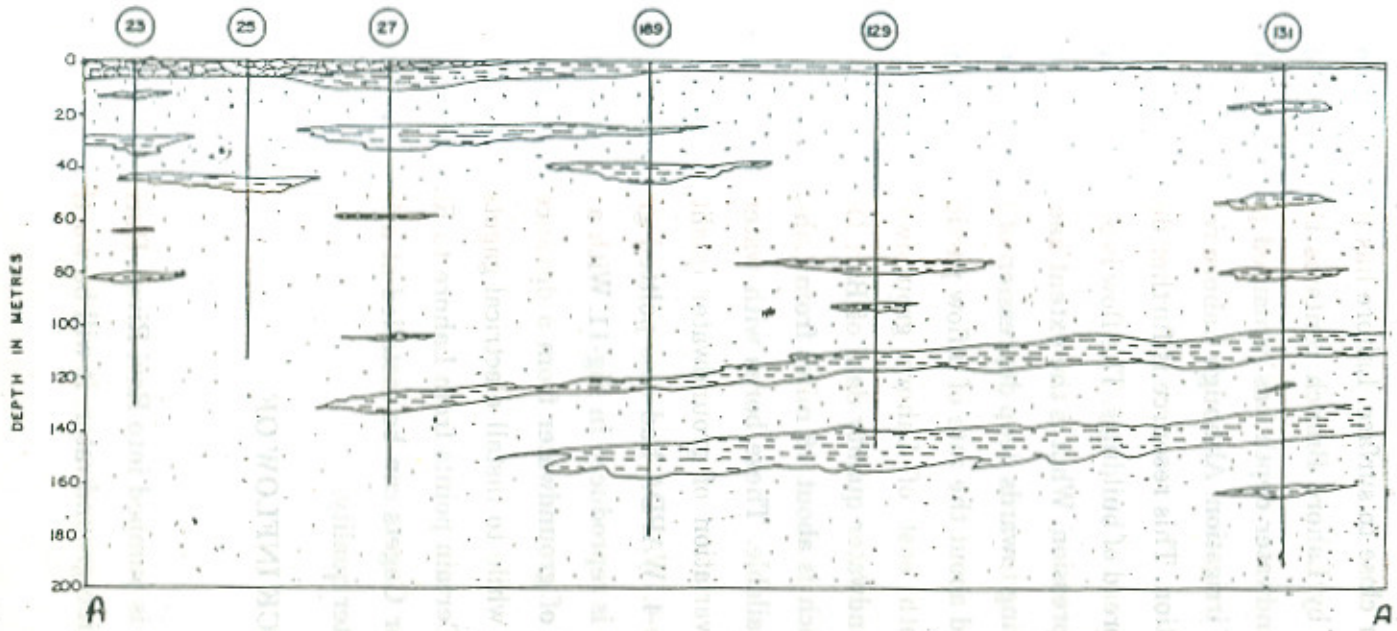
TRIBUTARIES OF RAVI JOINING IT WITHIN PAKISTAN

S. No.	Tributary	Length in Miles	Average Slope in ft. per 1000 ft.	Catchment Area (Sq. Miles)	Likely Maximum Discharge (Cusecs)
1.	Ujh	80	31.6	675	249000
2.	Bein	48	5.9	346	128000
3.	Basantar	45	6.4	224	83000
4.	Degh	160	7.4	456	100000
5.	Hudiara	62	0.25	583	10000

Thus during summer season Ravi will continue to pass sufficient water but due to decreased supplies the river will not spread in the area as at present. There will thus be considerable decrease to the underground formation so that during winter months, when the major contribution is out of the valley storage the flow will be affected considerably. Presently during February the flow at Ravi railways bridge decreases to 2 to 4 hundred cusecs. It might further decrease. How far the Ravi will be able to contribute 450 cusecs is a difficult question to visualise.

NATURE OF WATER BEARING FORMATIONS

In Lahore in connection with the construction of water supply tubewells boring has been carried down to 650 feet. No deeper boring even for exploration has been carried out. A few bores in the Indus Plains have been drilled to 1500 feet. The alluvium formation has generally been encountered. The deposits in water particularly close to bed rock have shown one characteristics. The deposit on the bed rock has generally been clay. It was followed by fine sand. Illustration of three bore logs carried down to bed rock are shown in Fig-7. Recently a few bores were drilled to bed rock in an area between Jhang Branch and the Chenab near Chinot for water supply of Fasilabad. In four bores clay deposit was found on the bed rock followed by fine sand. These instances are illustrated in Fig-8. Results of drilling carried down to bed rock near Niazbeg is also shown. Below about 700 feet the deposit was silty fine sand. The available water yielding formation under



LEGEND:

CLAY, SILTY CLAY

SAND, FINE TO COARSE

DUMPED MATERIAL

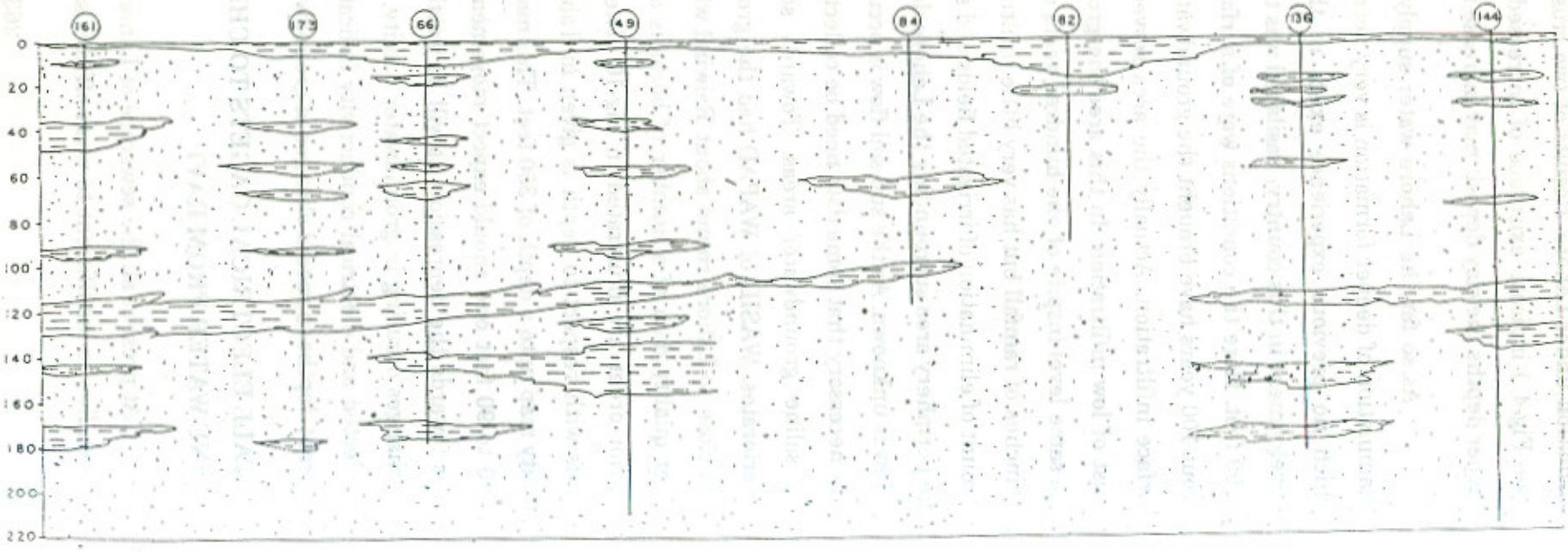
(27) TUBEWELL NO.

SCALE - VER. 1:2000
HOR. 1:50000

FIG-4

LITHOLOGICAL CROSS SECTION A A'

LITHOLOGICAL CROSS SECTION B B'



Lahore is unknown. The Niazbeg bore may be of some awakening about the water yielding formation under Lahore. Results of two cross sections 'AA' and 'BB' of Lahore formation (See Fig-4) indicate existance of increased clay deposits after a depth of 400 feet. At deeper depths the clay deposit may increase further.

As so far the Lahore water supply is based upon exploitation of groundwater, examination of deeper formation is very necessary. It is becoming an unprecident case for which no previous experience exists in this country. Before the start of Irrigation Development in this country, Fasilabad was the only area which had a groundwater depth at 90 feet. Here the conditions were of surface infiltration from various sources which in about 100 years have brought the groundwater close to surface. Lahore has practically no surface infiltration. Actually the area served by Lahore Branch contains thick top soil crust of low infiltration. In this area the groundwater depth has remained practically at the same level inspite of one hundred years of irrigation. Although Lahore receives about 20 inches of rainfall but has very little infiltration. This resource is further decreasing on account of elimination of irrigated fields and spread of buildings. The flow is occuring from the periphery area surrounding the Lahore depression. What is the extent and distance of inflow is unknown. As the sub-soil flow is occuring towards deep depression of Lahore, it is very necessary that some data need be collected about the rate of inflow particularly from the saline groundwater areas. Towards south east of Lahore groundwater quality deteriorates. WASID of WAPAD had the groundwater quality data of Bari Doab. In this area close to Lahore round about Raiwind which is about 16 miles from Lahore groundwater quality data of a number of bores is available. These bores with water quality of inferior order are illustrated in Fig-10. The variation of groundwater quality of these points with respect to depth is given in Table-4. WAPDA had also poltted groundwater quality map upto a depth of 350 feet. This map is reproduced in Fig-11. With a depression of 70 to 90 feet one should expect movement of groundwater from a distance of twelve miles towards the depression. It will be worth while to install electrical gagets to record the changes occuring in groundwater quality. Certain points from Lahore to Raiwind can be selected and electrical conductivity indicator Gagets can be installed at a few sites at different depths to record changes of groundwater quality.

INSTALL ELECTRICAL GAGETS TO CHECK INFLOW OF SALINE WATER FROM RAVI

At present all the sewerage of Lahore is pumped into Ravi River. During winter the Ravi flow is insufficient to wash off this saline groundwater. It will be worth while to

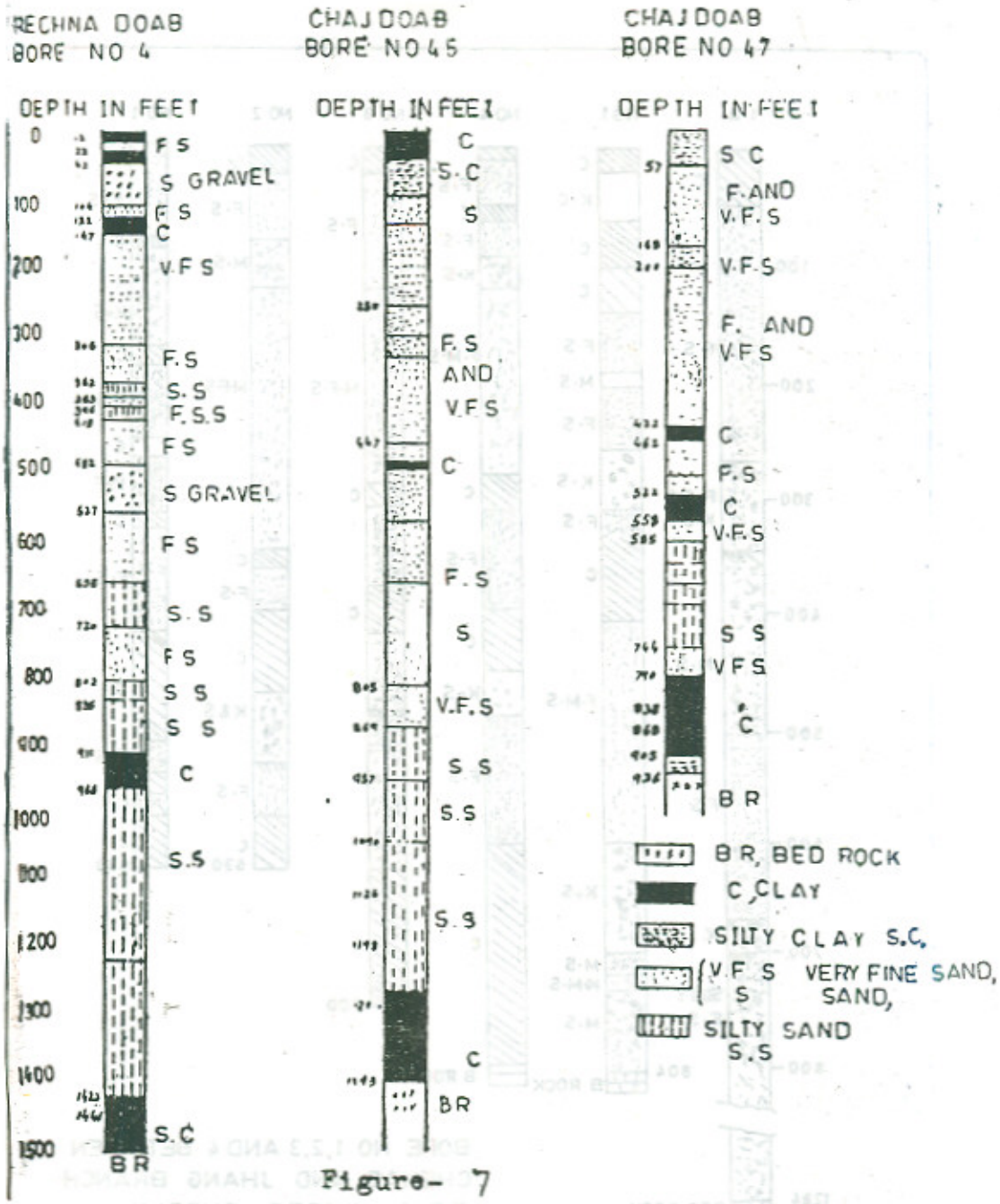


Figure- 7

Three specimen of deep bores, clay and silt deposits are in existence on the bed-rock.

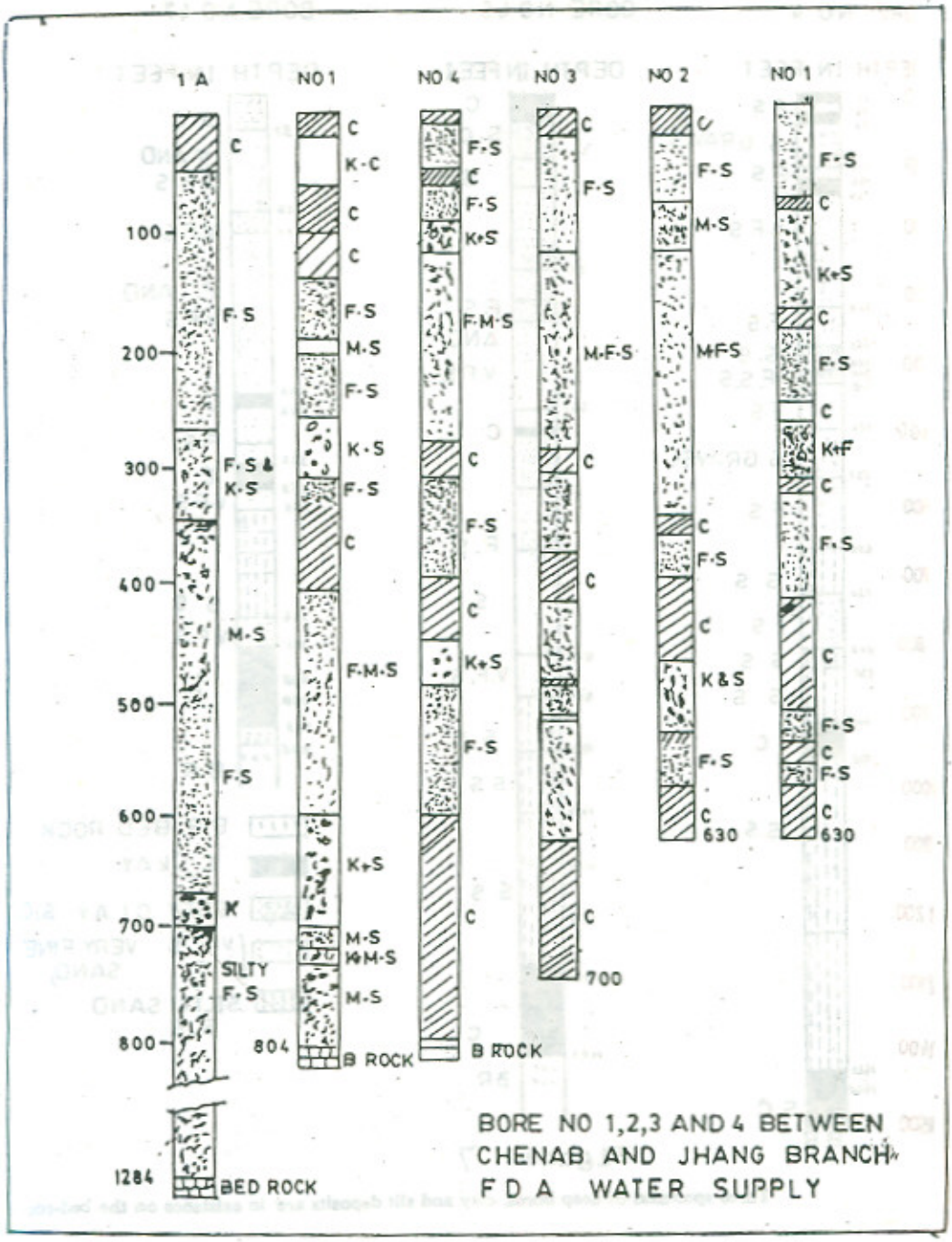


Fig 8 : DEEP BORES UP TO BED ROCK

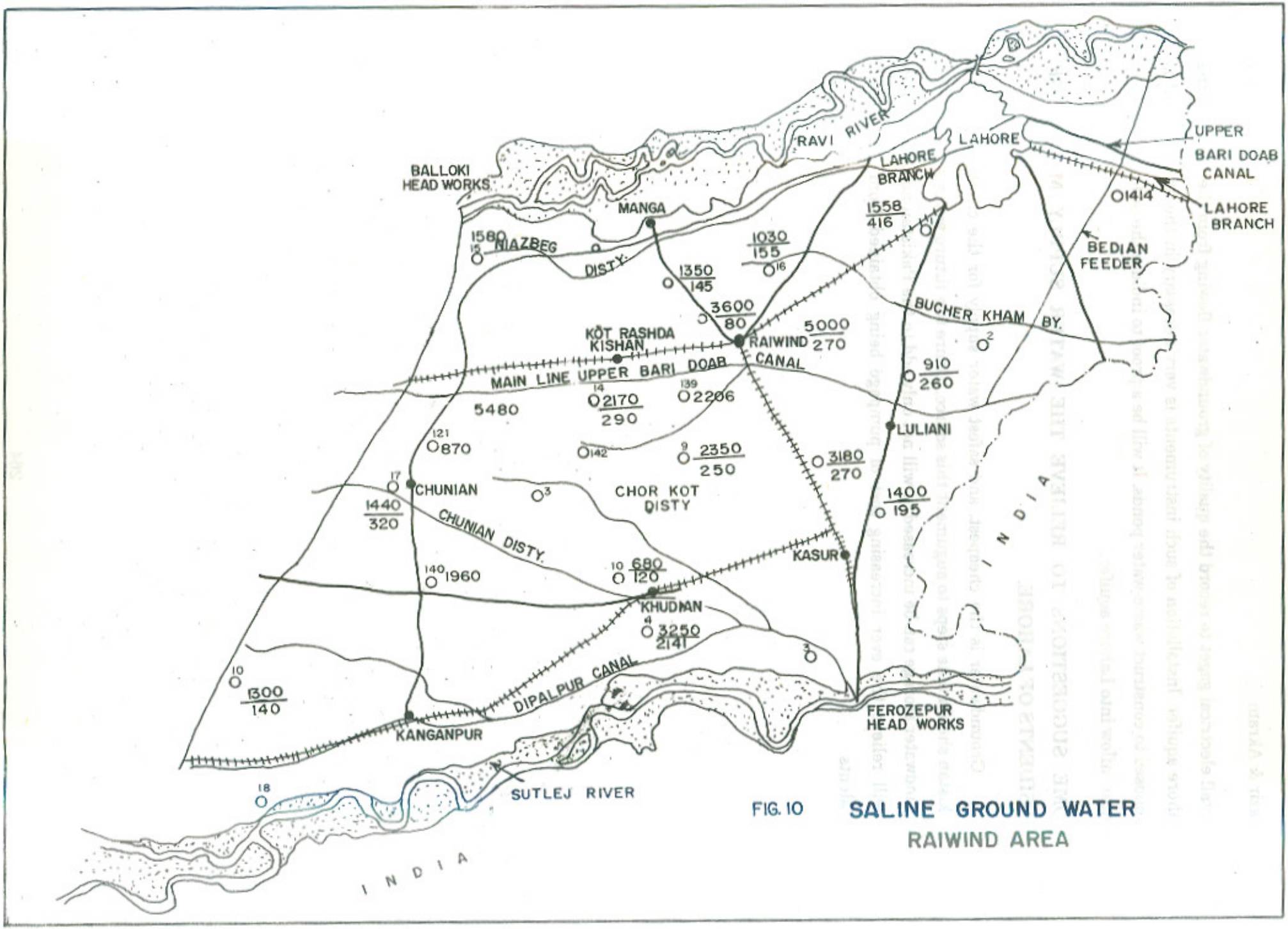


FIG. 10 **SALINE GROUND WATER**
RAIWIND AREA

install electrical gaget to record the quality of groundwater flowing from the Ravi into the Lahore aquifer. Installation of such instruments is very necessary in the area where it is proposed to construct waste-water ponds. It will be a proof to indiate the order or sewerage water inflow into Lahore aquifer.

SOME SUGGESTIONS TO RELIEVE THE WATER SUPPLY MISERY OF RESIDENTS OF LAHORE.

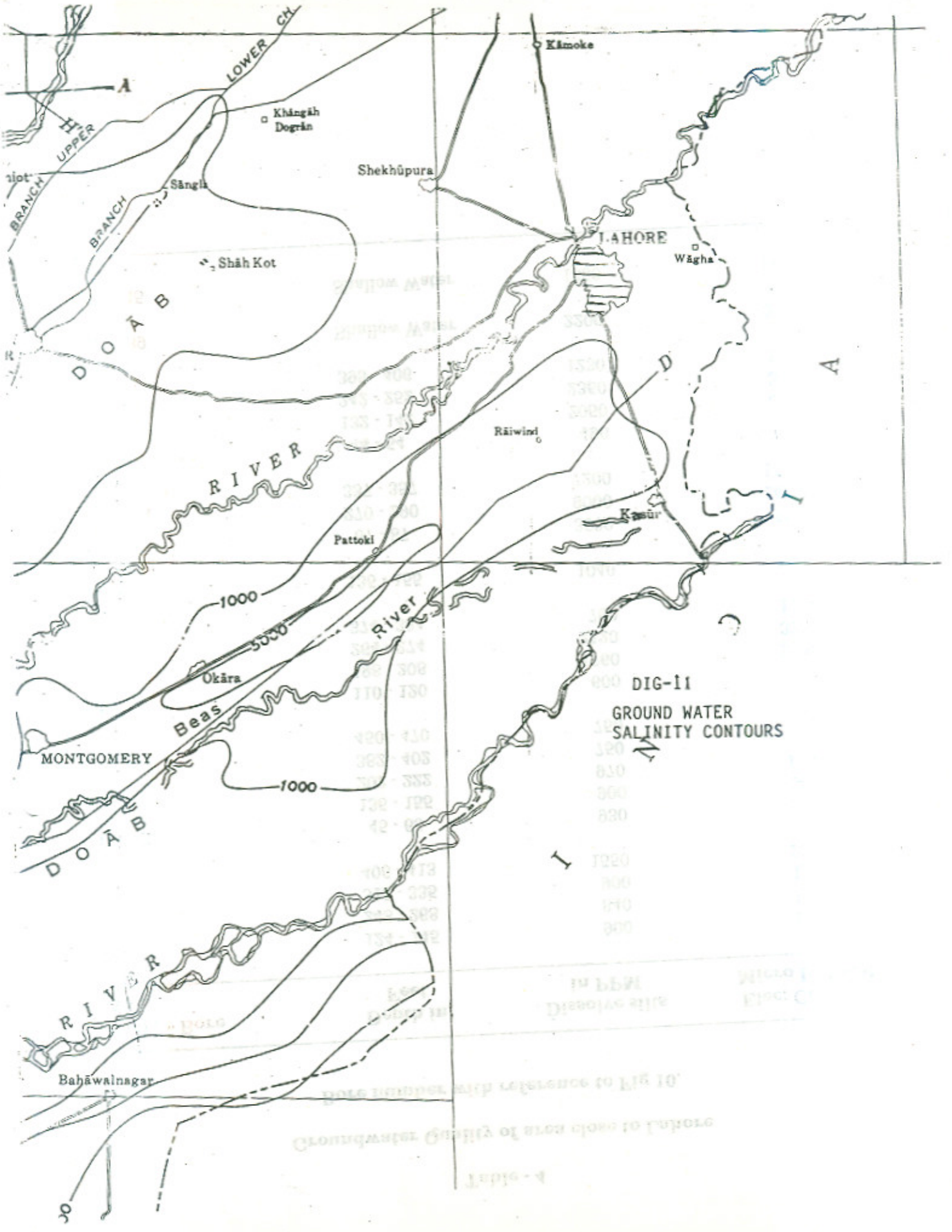
Groundwater is the cheapest, and safest water supply for the citizen of Lahore. Pakistan should take steps to augument this source, assure the future water supply. If the groundwater storage can be increased, it will not only add to the Pakistan natural resorces it will relieve the ever increasing cost of pumpage being obtained from the Lahore residents.

Table - 4

Groundwater Quality of area close to Lahore

Bore number with reference to Fig 10.

Well or Bore No.	Depth in Feet	Dissolve silts in PPM	Elec: Conduc: Micro HM/CM
BR - 1	124 - 145	900	1400
	248 - 268	840	1300
	315 - 335	900	1400
	406 - 413	1550	2380
BR - 2	45 - 65	930	1420
	135 - 155	900	1410
	202 - 222	970	1481
	382 - 402	750	490
	450 - 470	750	660
BR - 4	110 - 120	600	930
	198 - 208	1760	2740
	264 - 274	2120	3250
	374 - 384	760	1160
BR - 6	135 - 155	1040	1630
BR - 8	67 - 87	3600	5500
	270 - 290	9000	14000
	337 - 357	7200	11000
BR - 9	44 - 54	490	770
	132 - 142	2050	3190
	242 - 252	2350	3610
	395 - 406	1230	1870
BR - 139	Shallow Water	2200	3260
BR - 145	Shallow Water	1350	2000

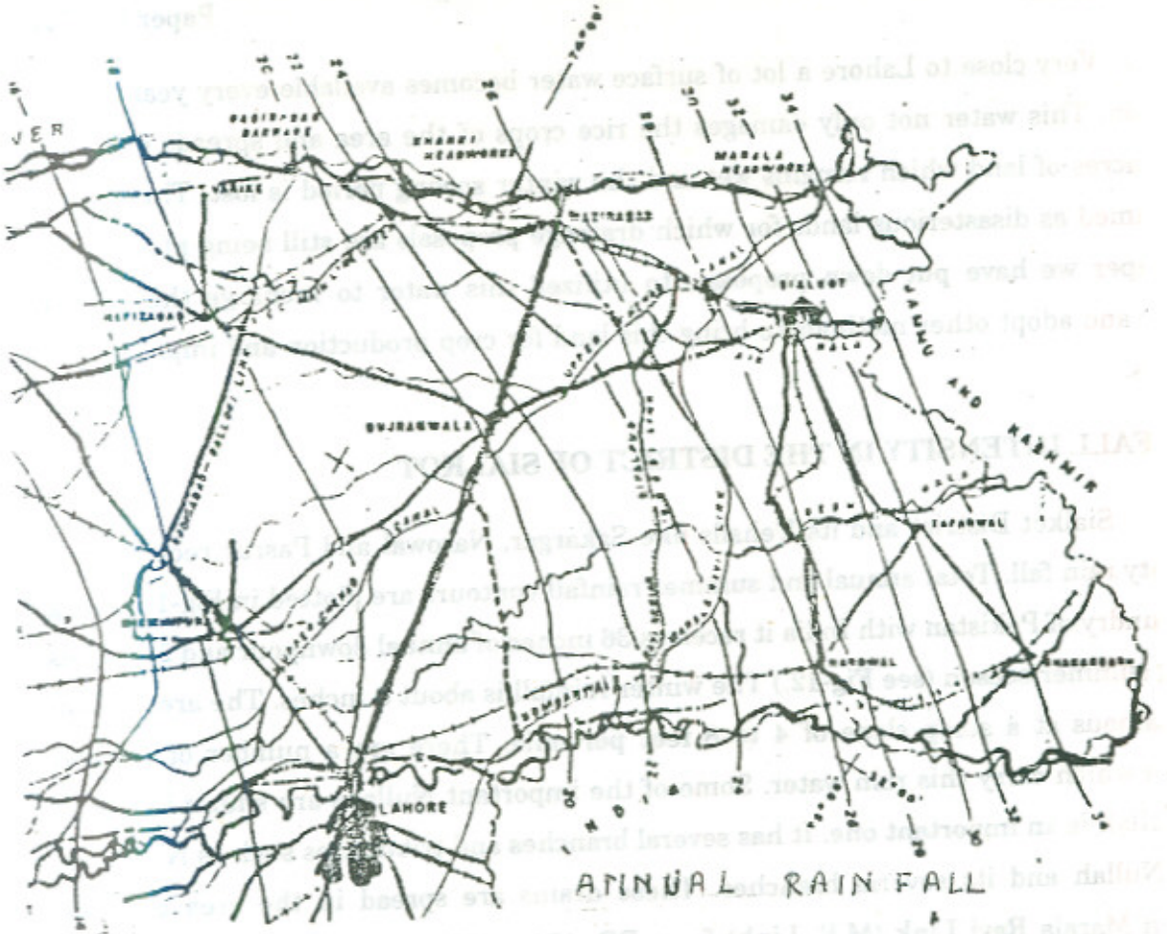

A
LOWER CH
UPPER
BRANCH
BRANCH
Khāngāh Dogrān
Kāmoke
Shekhūpura
Sāngla
Shāh Kot
LAHORE
Wāgha
DOĀB
RIVER
Rāiwind
Kasūr
Pattoki
1000
5000
River
Okāra
Beas
MONTGOMERY
1000
DOĀB
RIVER
Bahāwalnagar
DIG-II
GROUND WATER
SALINITY CONTOURS
N

Very close to Lahore a lot of surface water becomes available every year during Monsoon. This water not only damages the rice crops of the area and spreads on about 45000 acres of land which remains wet and the winter sowing period is lost. This area is now named as disasterious lands for which drainage proposals are still being planned. In this paper we have put down proposals to utilized this water to recharge the Lahore aquifer and adopt other methods to bring this land for crop production and improvement of lands.

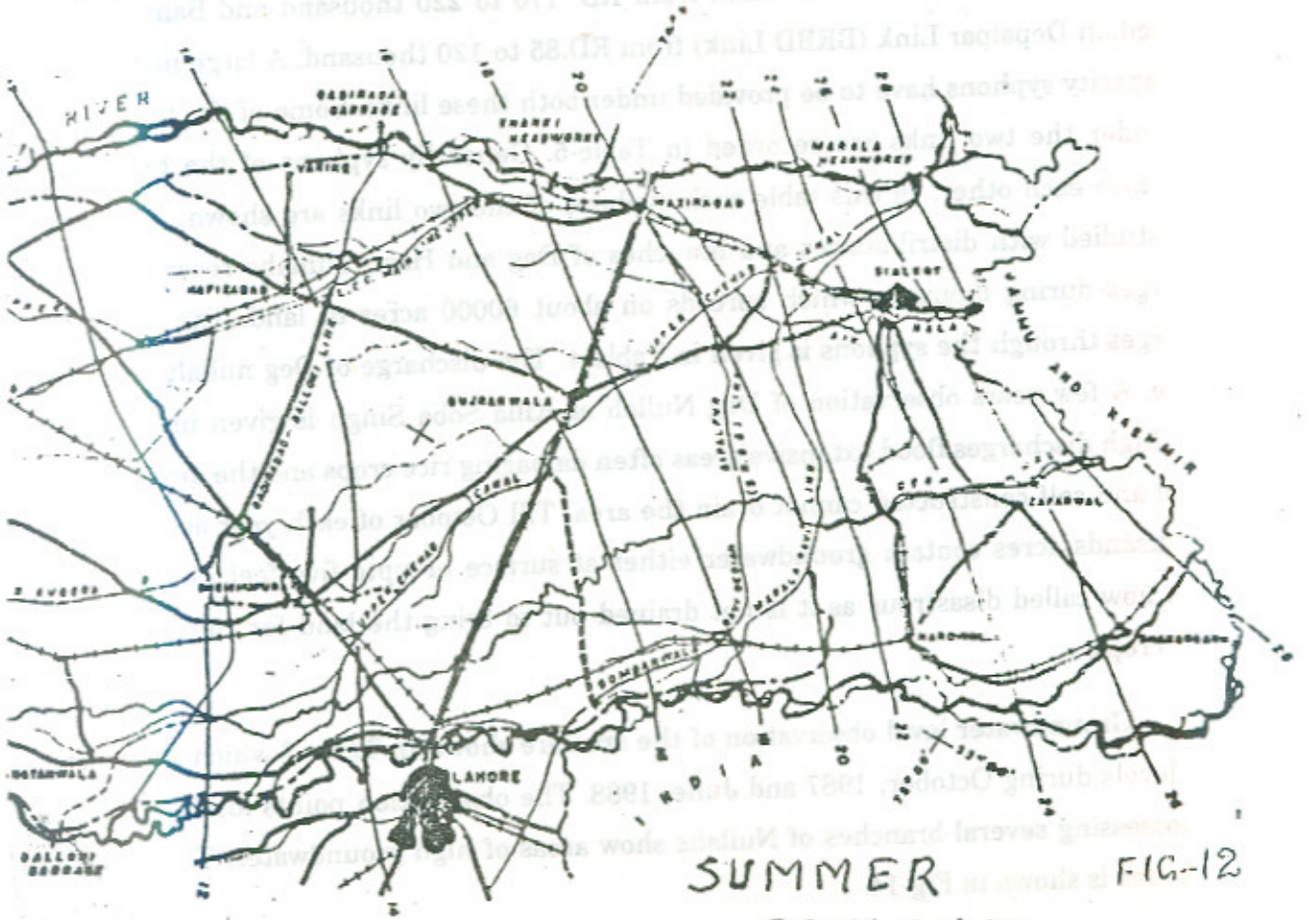
RAINFALL INTENSITY IN THE DISTRICT OF SIALKOT

Sialkot District and its Tehsils like Sakargar, Narowal and Pasrur receive high intensity rain fall. Total annual and summer rainfall contours are plotted in Fig-12. Along the boundry of Pakistan with India it receives 36 inches of annual downpour and 28 inches during summer season (see Fig-12.) The winter rainfall is about 8 inches. The area is sub-mountainous at a steep slope of 4 to 8 feet per mile. There are a number of Natural Nullahs which carry this rain water. Some of the important Nullahs are shown in Fig-13 Deg Nullah is an important one. It has several branches and tributaries such as Niki Deg., Hasri Nullah and its several branches. These drains are spread in the area enclosed between Marala Ravi Link (M.R. Link) from RD. 170 to 220 thousand and Bambanwala Ravi Bedian Depalpar Link (BRBD Link) from RD.85 to 120 thousand. A large number of high capacity syphons have to be provided under both these links. Some of the important ones under the two links are recorded in Table-5. Generally syphons of the two links nearly face each other. In this table such syphons of the two links are shown. The area being studied with distributaries and branches of Deg and Hasri Nullahs receives large discharges during monsoon which spreads on about 60000 acres of land. The order of discharges through the syphons is given in Table-4. The discharge of Deg nullah is considerable. A few years observation of Deg Nullah at Killa Soba Singh is given in Table-6. These high discharges flood extensive areas often damaging rice crops and the drains both natural and self constructed cannot drain the area. Till October of each year about 45 to 50 thousands acres contain groundwater either at surface or upto five feet depth. This area is now called disastrous as it is not drained out to bring the land for cultivation of winter crops.

Groundwater level observation of the area are shown in Table-7 which gives the water levels during October, 1987 and June, 1988. The observation points located in the area possessing several branches of Nullahs show areas of high groundwater. The extent of this area is shown in Fig-14.



ANNUAL RAIN FALL



SUMMER

FIG.-12

UPPER RECHNA RAIN FALL
(PROJECT FOUR)

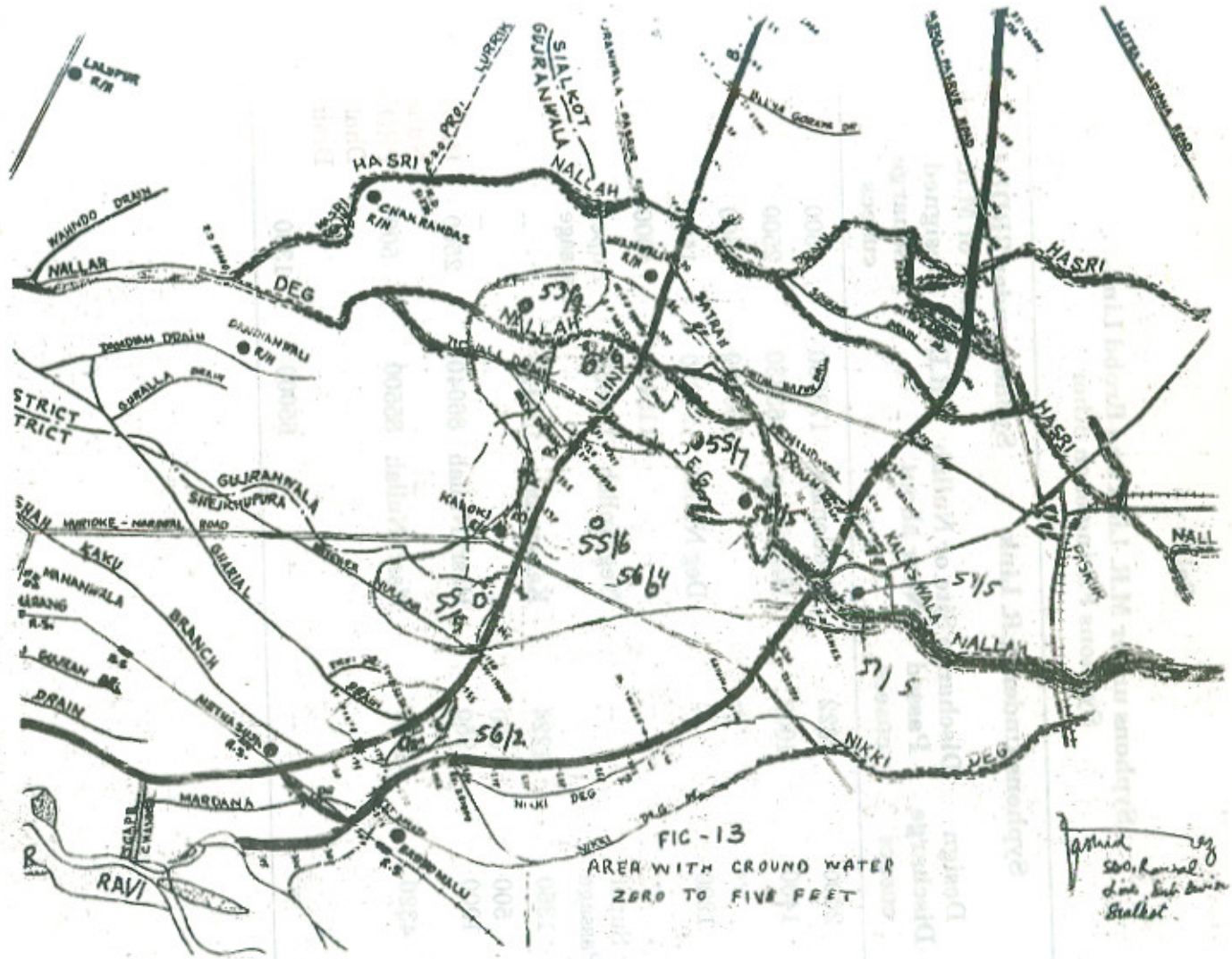

LALPUR R/H
HASRI
SIALKOT GUJRANWALA NALLAH
WAHNDO DRAIN
NALLAR
CHAK RANDAS R/H
DEG
MALLAH
DANDIANWALI R/H
GUJRANWALA SHEIKHUPURA
KAKU BRANCH
GUARIAL
DRAIN
MARDANA
RAVI
NIKKI DEG
NALL
FIG - 13
AREA WITH GROUND WATER
ZERO TO FIVE FEET

Table - 5

Syphons under M.R. Link and Brobd Link
Syphons Facing each other

Sr. No.	R.D.	Syphons Under M.R. Link			Syphon under BRDB Link Facing syphon of M.R. Link		
		Design Discharge cusecs	Discharge Passed cusecs	Site or Nullah Near about	R.D.	Designed Discharge cusecs	
1.	29500	2000	2322	Baddomalli	173660	2500	
2.	281500	1400	1008	Nikki Deg	163230	2500	
3.	--	--	--	-	150080	1500	
4.	230750	1200	--	Deg Nullah	120920	1500	
5.	--	--	--	--	115925	4000	
6.	220122	Super Passage	--	Neg Nullah	104333	Super Passage	
7.	28500	1360	1224	Kalaswala	106120	--	
8.	202865	500	600	--	--	--	
9.	190850	1000	950	Hasri Nullah	86040	2500	Hasri Nullah
10.	171700 170050	4320	5326	Nasri Nullah	85500	500	PRD. Dhola Wali Drains
11.	--	--	--	--	65000	1350	

Table - 6

Daily Discharges of Degnala at Qila Soba Singh Gage Station Main Channel
(All Figures in Cusec)

	1959			1960			1961			1962			1963		
Date	July	August	September	July	August	September	July	August	September	July	August	September	July	August	September
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1			1947	Nil	2653	1719	174	4152	405338	Nil	183	448	99	2130	1188
2			1500	Nil	27111	2637	63	2689	3309	Nil	444	294	29	342	1125
3			1800	Nil	516	6302	21	14571	2000	Nil	252	244	14	199	551
4			1800	Nil	300	2167	Nil	1241	15893	Nil	1446	184	5	121	937
5			3000	Nil	798	757	Nil	1278	2802	Nil	342	165	2	N.O	N.O
6			2696	Nil	714	461	Nil	481	1316	Nil	122	517	1	27993	1503
7			1320	1005	1147	457	347	294	55591	Nil	65	205	4	5106	673
8	Discharge		1973	1117	1154	491	125	249	45283	Nil	57	137	Nil	1488	373
9	Measurements		5500	4081	2625	302	263	31452	8110	65	296	363	Nil	724	1318
10	Not Made		2500	2512	7943	248	1832	2163	3132	22	1109	301	Nil	405	728
11			1700	2904	1703	1228	203	2381	2536	Nil	336	276	3	23542	377
12			1300	4989	1563	579	175	9833	1362	240	129	572	71	1703	292
13			1384	3927	1592	351	103	9113	990	115	220	251	171	1191	263
14			9000	3927	2538	189	21	14360	2479	50	638	207	55	580	202
15			9000	3879	2740	160	714	20558	6790	Nil	212	126	Nil	N.O	180
16			3500	4649	2717	161	8718	11930	5388	45	981	103	15	2126	188
17			1500	3084	2538	145	2074	2087	1474	103	1873	85	5	30568	148
18			1300	5056	2520	214	309	2801	1113	365	12148	123	4261	2692	163
19			2300	3784	2564	228	170	1666	682	1321	696	182	1014	2419	137
20			2500	3270	1150	118	274	1329	466	359	264	92	172	32096	113
21			1700	1709	1709	103	394	2926	465	243	2456	37859	9455	8979	108
22		7368	2000	1179	8032	92	299	748	373	167	877	61410	1673	1271	87
23		3590	1700	753	1138	83	21927	639	2296	63	526	5410	580	1458	81
24		2617	3406	766	1166	76	2697	743	8628	44	339	1865	230	N.O	78
25		2080	1700	175	596	188	942	5337	34053	N.O	135	1067	N.O	687	79
26		2079	1500	171	555	126	9072	759	8992	611	744	983	79	934	68
27		3530	1104	1709	1124	96	1144	400	987	12857	663	2654	54	450	51
28		1570	800	296	1160	74	281	575	1052	1179	14132	989	5707	368	55
29		2350	800	298	583	65	206	903	801	3039	1248	722	882	285	55
30		14400	792	3063	2538	47	12429	7406	509	798	845	501	1119	313	52
31		2925	--	1436	2957	--	19952	18618	--	620	445	--	1297	N.O	--

N.O. = Not Observed.

Table - 7

Groundwater levels observed in disaster area

S.No.	Well No.	Depth in June, 1987 ft.	Depth in October, 1987 ft.
1.	57/5	3.45	4.60
2.	56/5	7.85	4.8
3.	56/4	7.9	4.8
4.	56/3	6.8	5.3
5.	56/2	6.33	3.73
6.	55/7	6.75	3.5
7.	55/5	8.9	3.6
8.	54/6	4.7	1.5
9.	53/9	5.8	3.4
10.	53/6	7.3	2.0
11.	52/7	7.8	2.8
12.	52/6	9.4	4.2