8.2.3 Linsley, et -al, Taylor and Schwarz, Ven-Te-Chow, T & K and U.S. Corps of Engineers have given different values for basin coefficients C_t and C_p. Chow suggests computation from the data of gauged basins with similar characteristics.

8.2.4 For the purpose of this analysis, values of 't_p' and 'q_p have been taken from the curves developed by U.S. Corps of Engineers governed by the following equations:

$$t_p = 15.4 \left[\frac{L \times L_{ca}}{\sqrt{s}} \right] = .128$$

$$q_{u.p} = \frac{640 \times 0.345}{t_p}$$

$$= \frac{220}{t_p}$$

8.2.5 The average unit hydrograph peak discharge ($q_u.p$) is calculated in Table-7 for Chakbandi /Paharang drainage system. The $qu._p$ for Khairwala Drainage system is considered the same as that of Chakbandi/Paharang drainage system on the basis of similarity of characteristics of the two basins.

8.3 Rainfall - Direct Run Off Relationship

Direct surface run-off was computed in accordance with the curve number method developed by U.S. Soil Conservation Services and explained in earlier paragraphs. A curve number of 50 was adopted after due consideration of the basin characteristics viz hydrologic soil group, land use class, land treatment class, hydrologic conditions for infilteration and antecedent moisture conditions in the project area. It would be seen that the curve No. was

adopted very much on the lower side as compared to that indicated by S.C.S. in view of the fact that the method was basically intended for more humid and much steeper water sheds of the North American peninsula with many perennial and non-perennial natural streams draining the area. The slopes of American basins are as steep as 1 to 40% while in our case the land slope averages 0.02% with no operative natural drainage channel. The above analysis was also supported by a detailed study of Pandoki drainage basin.

8.4 Peak Surface Run-Off Versus Frequency

Calculations of Peak surface run-off for a particular return period involved the following steps:

1. Selecting the drainage basin and sub-basins (Fig-I) by considering the surface features.
2. Measuring L, L_{ca} slope and area of each sub-basin.
3. Computing t and q_{up} for each sub basin.
4. Determining q_{up} for the whole of drainage basin.
5. Selecting the rain-fall depth for different frequencies from Fig.VI. As 48 hours storm of a particular frequency is greater than 24 hours storm, therefore rain-fall of 48 hours storm duration was used for analysis.
6. Determination of Re for rainfall of different frequencies by SCS method.
7. Determining the peak surface run-off for a particular frequency by multiplying Re C with q_{up}. Table-8 gives the calculations of peak surface run off per sq.mile of catchment area for rain storms of different frequencies and their graphical presentation appears in Fig.VII.

8.4.1 The run off analysis of Khairwala Drainage basin based on different values of curve No. (C.N) and initial obstruction (Ia) is presented graphically in Fig.VIII as peak discharge versus recurring interval for different values of C.N and Ia. As the cost of the drain varies directly with the capacity, the cost benefit consideration would tend to limit the capacity but humanitarian and safety grounds suggest much larger values. We, therefore, have to strike a balance and in this particular case, the surface run off rate (run off factor) corresponding to a return period of 8 years and 48 hours storm has been adopted which comes to 2 Cs per square mile of the catchment area.

8.5 Drain Capacity

The drain capacities at the outfall, calculated on the basis of the above run off factor of 2 Cs per sq. mile come to:

S.No.	Name of drain	Catchment Area (sq.miles)	Discharge Capacity (Cs.)
1.	Nasrana Branch Drain	81	162
2.	Dijkot Branch Drain	282	564
3.	Khairwala Main Drain	521	1042

8.6 Longitudinal Slope

The longitudinal slope has been fixed so as to obtain the desired operational characteristics with minimum excavation and cost. The ridge reaches of Dijkot Branch Drain RD 29-68 will serve as example. A fall of over 2.6 ft. has been provided at RD 28,750 and the crest level has been selected to allow only a reasonable working slope to the drain just to reduce the quantity of excavation (total as well as below sub-soil water level).

8.7 Side Slopes

As would be observed from the typical cross sections, side slopes of 1:1 have been provided for excavation above water table and have been flattened to 1.5:1 below sub-soil water level. However, the placement of banks has been so arranged as to allow a final sloughing slope of 2.5:1.

8.8 Determination of Drain Section

The drain section parameters have been calculated on the usual Mannings equations.

8.9 Longitudinal Sections

The longitudinal sections of the three drains appear as Fig.V(a-b). Brief introduction of each appears below:

8.9.1 a) Nasrana Branch Drain

This drain in its whole length of 14 miles has been designed with a slope of 1 in 4000'. This drain could be provided with much steeper gradient almost 1 in 3000 but would have involved much larger excavation and that too under sub soil water level in addition to other problems like sloughing etc. The drain has, therefore, been provided a milder slope of 0.25% and a drop of 5 ft. at the outfall.

8.9.2 b) Dijkot Branch Drain

This drain in its first 23 miles from its source has a slope of 0.22%. and thereon to RD 29 it follows a gradient of 0.20%. Just like Nasrana Branch Drain, rather more so could be provided with a steeper grade but only a workable slope has been provided to reduce the excavations and a medium height fall of 9.6 ft. will

meet the difference. Similarly in the last 4 miles to the outfall, the excavation has been proposed to be carried out on a grade of 0.35% again to economise. However, the structures have been designed to cater for the final regime conditions and workable slope which the drain is expected to finally adopt.

8.9.3 c) Khairwala Main Drain

This drain in its 28 miles from source has been provided with a longitudinal slope of 0.24% in keeping with the swampy and weedy conditions in the old budh which it has to be negotiate. Lower down to its outfall slopes of 0.22 and 0.20% have been provided. The drain enters the riverian area by crossing the Jhang Flood Protection Bund at RD 35,000 of the drain. In the outfall reach of 7 miles, the drain has been widened to keep the water level in the drain within the natural surface level to avoid provision of banks in the riverian area which would have been continually under the action of river spill. This has, however, necessitated the provision of a fall at the crossing with Jhang Flood Protection Bund which will be combined with the V.R. Bridge.

8.9.4 Top Levels of Banks

The typical sections are as per usual practice and usual free board of 3' over F.C.L has been provided for patrol banks except on Khairwala Main Drain in which case the banks in the reach influenced by river flood levels, have been provided a free board of 6' over H.F.L.

To arrive at the length of the drain to be so affected and assessing the water levels at various points of the drain, the length and profile of back water curve anticipated to be created by the H.F.L. in the river was determined as explained in the succeeding paragraphs.

8.9.5 Back Water Curve Analysis

In the case of gradually varied flow in channels of controlled section whether varying or uniform, the back water profiles can be determined from one of the following four methods:

a. Direct integration metyod.
b. Graphical integration method.
c. Direct step method.
d. Standard Step method.

8.9.6 Out of the above listed methods the one at (c) i.e. the direct step method is the simplest to use and yields reasonably accurate results in the case of prismatic (Trapezoidal) excavated channels. The analysis based on this method appears as Table-9 which is self-explanatory. The usual terms and mathematical relationship (formula) used are however introduced below:

d= Depth of water over the bed.

A= Area of section for relevant depth = (b+d) d

W.p= Wetted perimeter = B+2.828 d

R= Hydraulic mean depth = $\frac{A}{p}$ or from $AR^{2/3} = \frac{Qn}{1.486 \times S^{\frac{1}{2}}}$

V= Velocity = $\frac{Q}{A}$

H_e= Specific energy = $d + \frac{V2}{2g}$

ΔH_e = Difference (step) between H_e at two consecutive sections.

S= Friction slope of the channel = $\frac{n^2 v^2}{2.21 R^{4/3}}$

$\bar{S}$= Average slope between two consecutive sections

e.g. $\bar{S}_1 = \frac{S_1 + S_2}{2}$ $\bar{S}_2 = \frac{S_2 + S_3}{2}$ and so on.

S_o = Designed Longitudinal water surface slope of the channel.

$\overline{S}_o$ = Difference between S_o and S.

L = Length of the individual reach between consecutive sections

$$\frac{\Delta H_e}{S_o - \overline{S}}$$

L⇒ Total cumulative or progressive length of the reach.

Y_n = F.C.L. of the channel (drain) at the designed run-off factor of 4 cs/sq.mile.

8.9.7 The back water profile has been plotted in Fig-IX which indicates that the back water effect will travel upto R.D. 99,884 of the drain.

The data yielded by the above analysis has been made the basis of determination of Bank levels and shown in the L-Section of the Drain. (Fig. V(a).

9.0 DESIGN OF STRUCTURES

The structures in the Khairwala Drainage Project can be grouped as below:

i. Railway Bridges.
ii. A.R. Bridges.
iii. D.R. Bridges.
iv. V.R. Bridges.
v. Foot Bridges.
vi. Falls/Outfalls.
vii. Aqueducts.
viii. Water Course Crossings and Inlets.

9.1 As the number of major structures included in the Project comes to 98, it is not possible to explain the design of each structure separately and so the structures have been discussed in groups and only special features in any individual structure explained briefly. For details

of all/individual structures reference may be made to the two volumes of Design of Structures in Khairwala Drainage Project.

The design parameters common to all structures are:

9.1.1 i) Discharge Capacity

All structures have been provided a minimum capacity for run off factor of 4 Cs. per square mile.

9.1.2 ii) Foundations

Deep well foundatons have been provided for all structures which are located in water logged area where the S.S.W.L. is higher than the scour level. With this criterion only one V.R.Bridge RD 37070 of Khairwala Main Drain could be provided with open footings and that too for abutments only.

9.1.3 iii) Structural Stresses

The stresses in steel and concrete have been assumed as Fs=18000, Fc=750 and m=18.

9.1.4 iv) Free Board

A minimum of 1.5' free board reckoned from the F.C.L. for the discharge corresponding to a run off factor of 4 Cs. has been provided on all structures except a few with peculiar conditions, located in outfall reach in riverian area effected by H.F.L. and so these structures may loose some part of their free-board during flood season.

9.1.5 v) Design Computations

The analysis of loads, bending moments and stresses for bridge Decks and foundation has been carried out ab-initio and also checked up with Tech Memo No.4 of Highway Department. Design of A.R. Bridges was got approved by Highway Department and that for D.R. Bridges from Zila Council concerned.

9.1.6 vi) Foundation Pressures

The permissible foundation pressures for all major structures were determined on the basis of geologic data and S.P. tests by I.R.I. For less important structures the usual practice figure suitable to geologic conditions was adopted.

9.1.7 vii) Water Way

The water-way for all the structures located in base lines has been kept as B+d which in case of Highway bridges fulfills the requirement of Highway Bridge Code, and in ridge reaches, the water way provided covers the sloughing slope with low foundation depth abutment.

A brief description of other criteria varying from group to group is as under:

9.2 Railway Bridges

The actual design for these structures has been prepared by the Railway Department themselves who are also constructing the bridges. The water-way and free board, loading etc., have been adopted according to Railway Standards. The soil bearing capacity has been determined on the basis of the geologic data and S.P. Tests by the I.R.I.

9.3 A.R. Bridges

The design of all A.R. Bridges satisfies the Highway Standard Bridge Code and Irrigation practice.

9.3.1 Loading

The decks for all the A.R. Bridges have been designed for a loading of I.R.C Class AA.

9.3.2 Roadway

The roadway for all the bridges has been kept as per requirements of Highway Department and designed

formation width of the road. Thus the roadway for bridges on Jhang Chiniot and Jhang Faisalabad road has been kept as 40' while 28' clear Road width has been provided on Jhang-Sargodha road.

9.4 D.R. Bridges

The roads serving as inter district links fall in the jurisdiction of Zila Councils and Highway Department. The designs for these bridges have, therefore, been prepared to meet their requirements and have been concurred by them.

9.4.1 Loading

I.R.C. Class A.A. Loading has been adopted for these bridges also.

9.4.2 Roadway

The width of the roadway provided on these bridges ia as under:

i.	For metalled roads controlled by Highway Department.	.. 22'-24'
ii.	For metalled roads with Zila Councils.	.. 32'
iii.	Kacha roads.	.. 14' (Irrigation Standard).

9.5 V.R. Bridges

The design of bridges on Kacha roads serving villages, has been based on Irrigation standards. The bridge decks have been designed to cater for I.R.C. Class 'A' loading and a roadway of 12' width (excluding wheel guards).

9.6 Foot Bridges

Foot bridges have been provided on important village paths where pedestrian and cattle traffic warrants provision of a bridge but the status of the path is not likely to be upgraded. A live load of 85 lbs p.s.f. has been adopted for design and a track width of 4' has been provided.

9.7 Falls/Outfalls

These hydraulic structures have also V.R.Bridges combined with them. The design of these structures have been framed according to Irrigation standards. However, the geometry of stilling basins and energy dissipating devices has been adopted after reference to the recommendations contained in Engineering Monograph No.25(U.S.B.R). The crest portions of outfall of Nasrana Branch drain and fall R.D. 28750 Dijkot Branch Drain have been proposed to be constructed in such a manner so that they can be removed step by step in layers to improve the drain operation and slopes as the need arises.

9.7.1 At the outfall of Khairwala Main Drain located at the crossing with Jhang Flood Bund, the drain section undergoes a major change as the bed width increases from 50' to 121' with consequent decrease in depth. This has necessitated long transitions and somewhat heavy wall sections.

9.8 Aqueducts

There are three aqueducts at the following sites:

1. Khairwala Main Drain at RD. 57200 for Jhang Minor.
2. Dijkot Branch Drain at RD 47800 for Jhang Branch Lower.
3. Dijkot Branch Drain RD 74000 for Nasrana disty.

9.8.1 All the three aqueducts are trough type, the trough conveying the irrigation water over the drain. The designed discharge capacities of the trough have been kept as 10' to 25% over and above the discharge of Irrigation channel, they have to carry, so that future development of areas on concerned channel and consequent increase in discharge may be safely accommodated.

9.8.2 Considering the paramount importance of these structures, extendable spans to cater for better discharge management and future extension have been provided.

9.8.3 The detailed designs of all the above structures are available in the two volumes titled "Design of Structures in Khairwala Drainage Project".

9.9 Water Course Crossings and Inlets

These water course crossings have been provided with concrete troughs. The trough sections correspond to the discharge they have to carry.

9.9.1 The Inlets are by and large barrel type. Inlets located in depression areas have been provided with double acting flap valves to stop the reverse flow from the drain into the depression. The capacity of Inlets located at the junction of some minor base line will be capable of catering for discharge from the catchment of that particular base line to save on the expenditure for outfall when such base lines are converted into tributary drains in future.

10.0 DESIGN OF TUBEWELLS

The design of the proposed 96 Drainage Tubewells and connecting disposal channels has yet to be done. The following points will be taken into consideration at the time of detailed design.

i. The tubewells will be of 2.5 Cs. capacity and provided with turbine pumping sets.

ii. The disposal channels will preferably be lined and level control to be provided to obviate flow problems during monsoon period when the water level in the receptor trunk drain is high.

iii. The operation schedule of tubewells is to be designed in accordance with the flows of River Chenab above Trimmu Head Works. The number of tubewells operating at any given time should be such that the resultant electric conductivity of the river flow upstream Trimmu does not exceed 595 micro mhos/cm.

iv. The average annual utilization of these drainage tubewells will be 50%.

v. The tubewells will be designed and installed by Wapda after completion of surface drains in June 1985.

CONCLUSIONS

1. Haig and Gulhati's formulae used in Irrigation Department uptill-now yield Direct run-off values corresponding to a return period of 3-5 years.

2. The later methods e.g. Curve No. Method and Synthetic Unit Hydrograph yield better results if duly modified to suit our Basin characteristics.

3. There is a firm need for establishing gauging stations in maximum No. of Drainage Basins or conduct co-relating research to establish suitable values of Basin characteristic constants.

4. In future the drains should be designed for higher recurrence intervals of 10-15 years.

REFERENCE

1. P.C-I — Proforma for Khairwala Drainage Scheme, Irrigation and Power Department, Punjab, 1979.
2. Project Report, Lower Rechna Remaining (Scarp-V) Project Planning Organization WAPDA, 1980 Vol: I & II.
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5. ILRI-Wagenigen Netherlands. — Drainage Principles and applications Publication No.16, Vol: I-IV.1974
6. Linsley et al — Hydrology for Engineers (I.S. Edition) 1975.
7. Ven-Te-Chow. — Hand Book of Applied Hydrology, 1974.

TABLE 1(a)

REDUCTION OF YIELDS UNDER DIFFERENT WATERTABLE CONDITIONS.

Crops	Average yields when water table is over 10' depth (mds/acre)	Percent reduction in yields under different watertable depths compared to over 10 ft.					Remarks
		Within 2 ft.	2-3'	3-4'	4-5'	5-10'	
KHARIF:							The water is highly saline and hence the reduction in yield is a combined effect of high water table and the potential salinity hazard.
Rice	21	43	29	14	14	14	
S.Cane	460	70	60	40	30	20	
Maize	13	54	46	31	23	15	
Cotton	6	67	50	50	33	17	
Fodder	322	62	54	43	37	14	
RABI:							
Wheat	23	69	35	22	22	13	
Oilseeds	6	50	33	17	-	-	
Pulses	1	57	43	29	14	-	
Fodder	460	40	40	25	20	-	

TABLE-1(b)

AVERAGE YIELD OF MAJOR CROPS IN KHAIRWALA PROJECT AREA AT DIFFERENT WATERTABLE DEPTHS.

(Maunds/acre)

Crops	Yields under different watertable depths					
	Within 2'	2-3'	3-4'	4-5'	5-10'	Over 10'
KHARIF						
Rice	12	15	18	18	18	21
S.Cane	138	184	276	322	368	460
Maize	6	7	9	10	11	13
Cotton	2	3	3	4	5	6
Fodder	122	147	184	202	276	322
RABI						
Wheat	7	15	18	18	20	23
Oilseeds	3	4	5	6	6	6
Pulses	3	4	5	6	7	7
Fodder	230	276	345	368	460	460

TABLE-2

TEXTURAL GROUP	SOIL SERIES	PERCENTAGE OF G.A.
Coarse	Jhang	2.6
Moderately Coarse	Farida	94.1
Medum	Buchiana	3.1
Moderately fine.	Chuharkana	0.2
	Total:	100.0

TABLE-3

SALIENT PHYSICAL FEATURES/DATA OF KHAIRWALA DRAINAGE PROJECT

Items	Khairwala Main Drain.	Dijkot Branch Drain.	Nasrana Branch Drain.	Total
a. Lengths (Canal Miles)	59.2	49.4	15.6	124.2
b. Catchment Area (Sq.Miles)	239	201	81	521
c. Land (Acres)	1198.5	904.31	153.28	2256.09
d. Railway Bridges.	1	2	-	3
e. A.R.Bridges	4	1	1	6
f. D.R.Bridges	3	3	1	7
g. V.R.Bridges	22	20	7	49
h. Aqueducts	1	3	-	4
i. W/C Crossing	9	10	-	19
j. Falls/ Outfalls.	1	2	1	4
k. Drainage Inlets.	59	98	32	189
l. Miscellaneous (Sui Gas, Telephone crossing etc).	4	2	-	6

TABLE-4

SUMMARY OF COST

Detail of Sub Head	Total Detail of item	Cost
1- Work.		
A-Preliminary	124.2 miles	1,56,492/-
B-Land	2256.11 Acres	1,59,32,702/-
C-Works.		
Bridges of all kinds.	65 No.	3,13,88,091/-
Aqueducts	4 No.	1,13,64,020/-
Fall/outfall	4 No.	14,53,091/-
W.C. Crossings	19 No.	24,21,343/-
Miscellaneous	6 No.	6,00,000/-
	Total:	4,72,26,545/-
K.Buildings.		46,69,071/-
L.Earth Work	262774000 cft.	5,98,87,541/-
L(i) Service and Boundary Road.	124.2 miles	2,77,214/-
M. Plantation	124.2	3,72,600/-
O. Miscellaneous	-	33,57,430/-
P. Maintenance @ 1% of above except B.Land.	-	11,59,469/-
Losses of stock	-	1,00,000/-
Special T&P		8,10,000/-
	Total:	13,39,49,064/-
Add unforeseen at 1%		13,39,491/-
Total of 1-Work		13,52,88,555/-
II- ESTABLISHMENT.		
a. Establishment charges at 12½%		1,69,11,069/-

TABLE-4 (concluded)

Detail of Sub Head	Totoal Detail of item	Cost
b) Leave Salary charges @ 6%.		81,17,313/-
c) Pension charges @ 7% of (a+b)		17,51,987/-
	Total:	2,67,80,369/-
III- T&P		
1% of 1-Work		13,52,886/-
Total direct charges (1+11+111)		16,34,21,810/-
Abatement of Land Revenue @ 5% of B.land.		7,96,635/-
Add 1% Audit and Accounts charges on 1-Work.		13,52,886/-
Total of Indirect charges.		21,49,521/-
Total direct and indirect charges.		16,55,71,331/-
Interest charges		2,92,65,000/-
	Grand Total:	19,48,36,331/-
	Say:	19,48,36,000/-

TABLE-5

ABSTRACT OF ANNUAL RECURRENCE EXPENDITURE AFTER CONSTRUCTION OF PROJECT.
(Surface drains only)

		Rupees
1.	C.Works	85,700/-
2.	L.Earth Works	11,47,806/-
3.	K.Buildings	70,036/-
4.	Maintenance Establishment.	2,05,320/-
5.	O. Miscellaneous	1,08,000/-
	Total:	16,16,862/-

TABLE-6

SUMMARY OF MAXIMUM ANNUAL RAINFALL (INCHES)

Years	24 Hours					48 Hours				
	Faisal-abad.	Amin Pur	Nar-wala	Jhang	Lakh-lana	Faisal-abad.	Amin pur	Nar-wala	Jhang	Lakh-ana.
1952	1.76	2.45	2.65	1.25	1.3	1.76	2.45	2.45	2.00	1.3
1953	1.65	1.30	1.85	1.45	1.3	1.72	1.30	2.10	2.10	1.3
1954	1.87	1.15	3.10	1.50	1.26	2.25	1.15	4.85	1.50	1.26
1955	3.17	2.04	3.42	2.00	2.45	3.57	3.13	5.17	2.50	2.95
1956	1.53	2.05	2.00	2.15	1.74	2.26	2.95	2.00	2.15	1.74
1957	2.59.	2.40	2.15	1.30	0.70	3.60	2.40	2.40	1.30	1.0
1958	2.24	3.00	2.18	2.50	2.42	2.24	3.10	2.18	3.00	2.42
1959	2.08	1.62	2.97	2.05	2.07	3.43	2.17	5.84	2.60	2.75
1960	1.60	1.22	2.90	1.60	3.80	1.78	1.22	4.10	1.60	4.30
1961	2.96	1.55	3.05	0.84	1.10	3.09	1.55	4.80	1.02	1.10
1962	2.06	1.46	3.05	1.62	1.4	2.70	1.47	3.45	1.62	1.40
1963	1.37	2.50	3.00	4.49	2.25	1.62	2.50	3.00	4.80	2.25
1964	2.56	1.68	3.10	4.60	1.34	2.56	1.76	4.75	5.49	2.34
1965	1.31	2.15	2.84	3.04	1.88	1.31	2.15	2.84	3.29	1.88
1966	1.12	1.75	1.87	0.90	1.30	1.16	1.75	1.87	1.75	1.30
1967	1.53	1.60	2.85	1.80	1.75	2.81	1.90	2.85	2.20	1.91
1968	1.51	1.75	1.93	0.60	0.90	1.51	1.75	1.93	0.60	1.15
1969	2.17	2.00	2.02	1.16	3.05	2.17	2.25	3.52	1.73	4.10
1970	0.69	1.70	1.01	0.95	2.0	0.80	1.70	1.01	0.95	2.0
1971	2.25	1.10	2.10	0.38	3.50	3.20	1.20	2.15	3.54	4.00
1972	1.97	1.50	1.97	1.52	3.0	2.06	2.50	3.00	1.52	3.50
1973	3.15	4.00	7.35	2.92	1.60	3.68	4.20	8.40	3.54	2.50
1974	1.25	3.20	2.50	1.50	1.77	2.00	3.20	4.30	2.45	3.45
1975	5.10	2.00	1.20	1.13	3.27	7.75	2.00	1.75	1.21	3.27
1976	3.10	2.60	2.00	2.25	1.73	4.65	5.10	2.04	2.25	1.94
1977	1.25	1.55	3.10	1.06	2.43	1.40	1.86	3.10	1.06	2.43

TABLE- 7

DETERMINATION OF UNIT PEAK DISCHARGE PER SQUARE MILE OF CATCHMENT AREA (CFS/SQ:MILE/INCH OF DIRECT RUN OFF)

Area No.	L Mile	L_{ca} Miles	Slope S (Ft/ft)	A Sq: Miles	$\frac{LxL_{ca}}{\sqrt{S}}$	t_p (Hrs)	$q_{u.p}$ (cfs/sq. miles/ inch of DRO)	$Q_{u.p}$ (cfs/inch of DRO = qu.pxA
1	2	3	4	5	6	7	8	9
1.	6.7	3.1	$2.0x10^{-4}$	9.4	1473	40	5.5	52
2.	7.0	3.0	2.0 "	17.8	1489	40	5.5	98
3.	3.5	1.5	2.0 "	12.7	372	33	6.7	85
4.	6.1	2.8	2.0 "	4.1	1211	38	5.8	24
5.	7.3	2.3	2.0 "	9.1	1191	38	5.8	53
6.	4.3	2.5	2.0 "	9.9	1516	40	5.5	55
7.	1.6	1.1	2.0 "	5.2	125	29	7.6	40
8.	5.3	3.5	2.0 "	14.0	1316	39	5.7	80
9.	4.0	1.8	2.0 "	13.6	511	35	6.4	87
10.	8.0	3.5	2.0 "	11.7	1986	50	5.4	63
11.	12.8	6.3	2.0 "	20.7	5719	47	4.6	96
12.	7.3	2.8	2.0 "	12.7	1450	40	5.6	71
13.	9.0	4.5	1.8 "	25.00	3022	43	5.2	130
14.	5.8	2.3	1.8 "	35.9	996	38	5.9	212
15.	4.4	2.4	2.0 "	7.0	749	36	6.2	43
16.	6.5	3.3	2.3 "	13.3	1411	39	5.6	75
17.	9.8	4.0	2.0 "	15.6	2780	43	5.2	81
18.	9.5	5.3	2.3 "	20.2	3313	44	5.1	103
19.	5.0	2.8	2.0 "	7.8	993	38	5.9	46
20.	8.3	4.3	2.0 "	16.9	2531	42	5.3	90
21.	3.0	2.0	1.8 "	5.2	448	34	6.5	34
22.	10.5	5.8	1.8 "	26.0	4545	45	4.9	127
23.	3.8	3.5	1.8 "	11.2	993	38	5.9	84
24.	11.5	6.0	2.0 "	13.8	4894	45	4.8	66
25.	6.9	3.9	2.0 "	32.1	1909	41	5.4	173
26.	5.9	4.8	2.0 "	17.5	2009	41	5.3	92

$\bar{q}_{u.p} = \frac{Q_{u.p}}{A} = \frac{2140.61}{388.4}$ = 5.5 Cfs/sq.mile/inch of run-off.

TABLE- 8

CALCULATIONS OF PEAK DRAIN DISCHARGE PER SQUARE MILE OF CATCHMENT AREA FOR VARICUS RAIN FALL FREQUENCIES.

CN = 50
Ia = 0.25

Storm Duration	Descrip-tion.	Recurrence interval (years)												
		1	2	3	4	5	6	8	10	12	14	16	18	20
Hrs. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24	Rain	1.0	1.8	2.2	2.45	2.65	2.82	3.1	3.3	3.46	3.61	3.72	3.83	3.94
	DRV	-	-	0.004	0.19	0.040	0.62	.109	0.150	0.186	0.223	0.252	0.283	0.315
	qp	-	-	0.02	0.1	0.22	0.34	0.60	0.83	1.02	1.23	1.39	1.56	1.73
48	Rain	1.15	2.15	2.72	3.15	3.45	3.73	4.15	4.48	4.72	4.95	5.15	5.31	5.48
	DRV	-	0002	0.048	.119	.184	0.255	0.380	.493	.582	.672	.754	.823	.898
	Qp	-	0.01	.26	.65	1.01	1.49	2.09	2.71	3.2	3.70	4.15	4.53	49

Rain = In inches

DRV = Direct run off volume (inches)

Qp = Peak discharge (cusecs)

TABLE-9

COMPUTATION OF BACK WATER PARAMETERS AND DETERMINATION OF WATER PROFILE FOR KHAIRWALA MAIN DRAIN RD, 35000 TO 99884(DIRECT STEP METHOD)

Reach	d (ft)	A (SVft)	W.P (ft)	R (ft)	R4/3	V (FPS)	V2/2g (ft)	HC (ft) (2+8)/9	AHC (ft) (9+9.)/10	S (ft/ft) $11=\frac{n^2\times h^2_4}{2.21\,R/3}$	$\bar{S}$ $\frac{(S+SP)}{2}$ $12=\frac{11+11P}{2}$	So−$\bar{S}$ 13=SO−12	L(ft) AHC/So−$\bar{S}$ 14, 10/13	∑L(ft) 15=14+15	Remarks. 16
1	2	3	4	5=3/4	6	7	8	9	10						
1.	13.0	819	86.76	9.44	19.95	2.44	0.093	13.093	0.491	0.000084	0.000090	0.00011	4463.6	4463.6	
2.	12.5	781	85.35	9.15	19.14	2.56	0.102	10.602	0.490	0.000097	0.000104	0.000096	5104.2	9567.8	
3.	12.0	744	83.94	8.86	18.34	2.69	0.112	12.112	0.488	0.000111	0.000120	0.000080	6100.0	15667.8	
4.	11.5	707	82.52	8.57	17.53	2.83	0.124	11.624	0.486	0.000129	0.000140	0.000060	8100.0	23767.8	
5.	11.0	671	81.11	8.27	16.73	2.98	0.138	11.138	0.484	0.000150	0.000163	0.000047	10297.9	34065.7	
6.	10.5	635	79.69	7.97	15.92	3.15	0.154	10.654	0.481	0.000176	0.000192	0.000028	17178.6	40946.4	
7.	10.0	600	78.28	7.66	15.11	3.33	0.173	10.173	0.383	0.000208	0.000224	0.000016	23937.5	64883.9	
8.	9.6	572	77.15	7.41	14.46	3.50	0.190	9.790		0.000240					

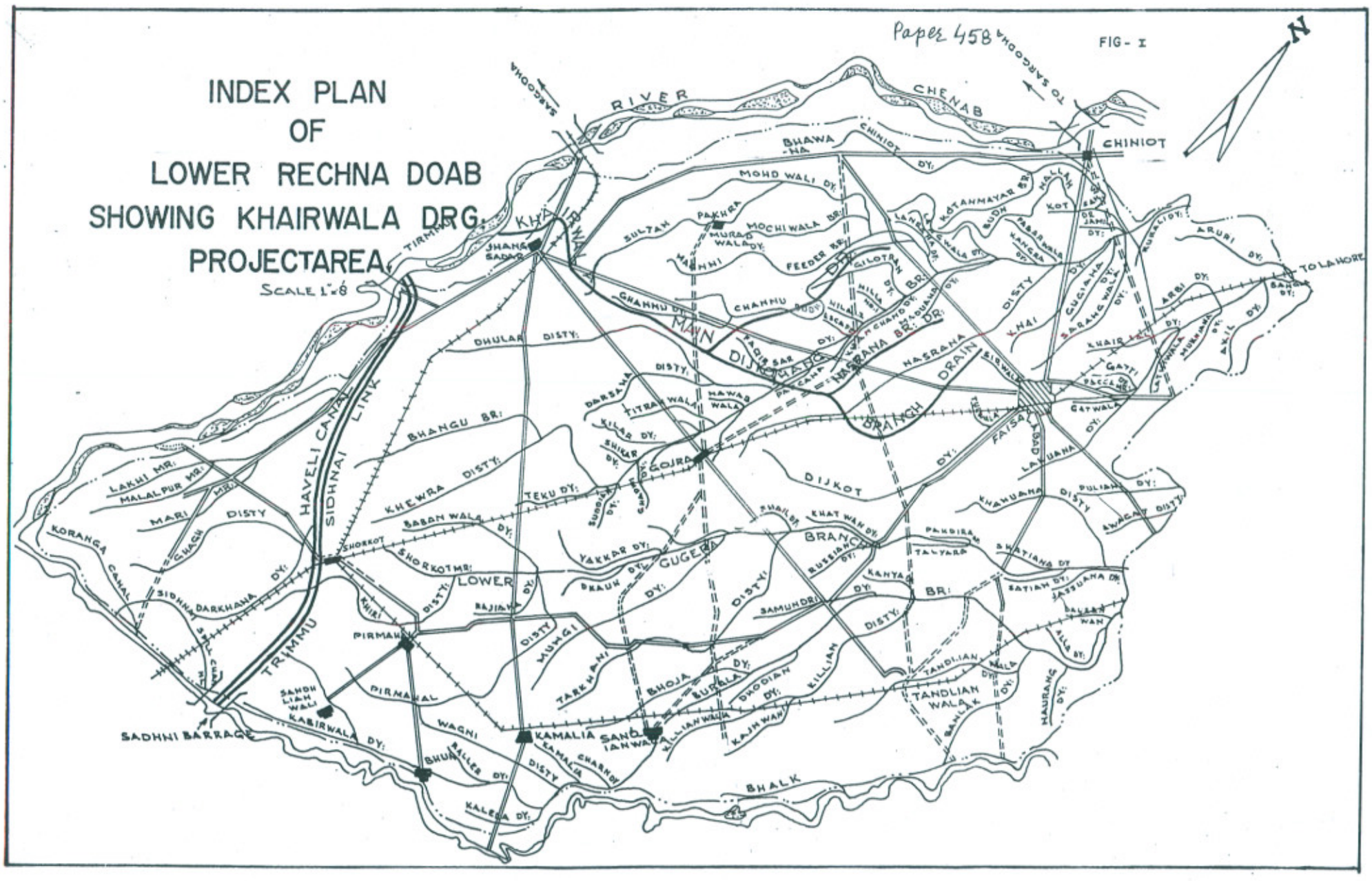
LIST OF FICURES

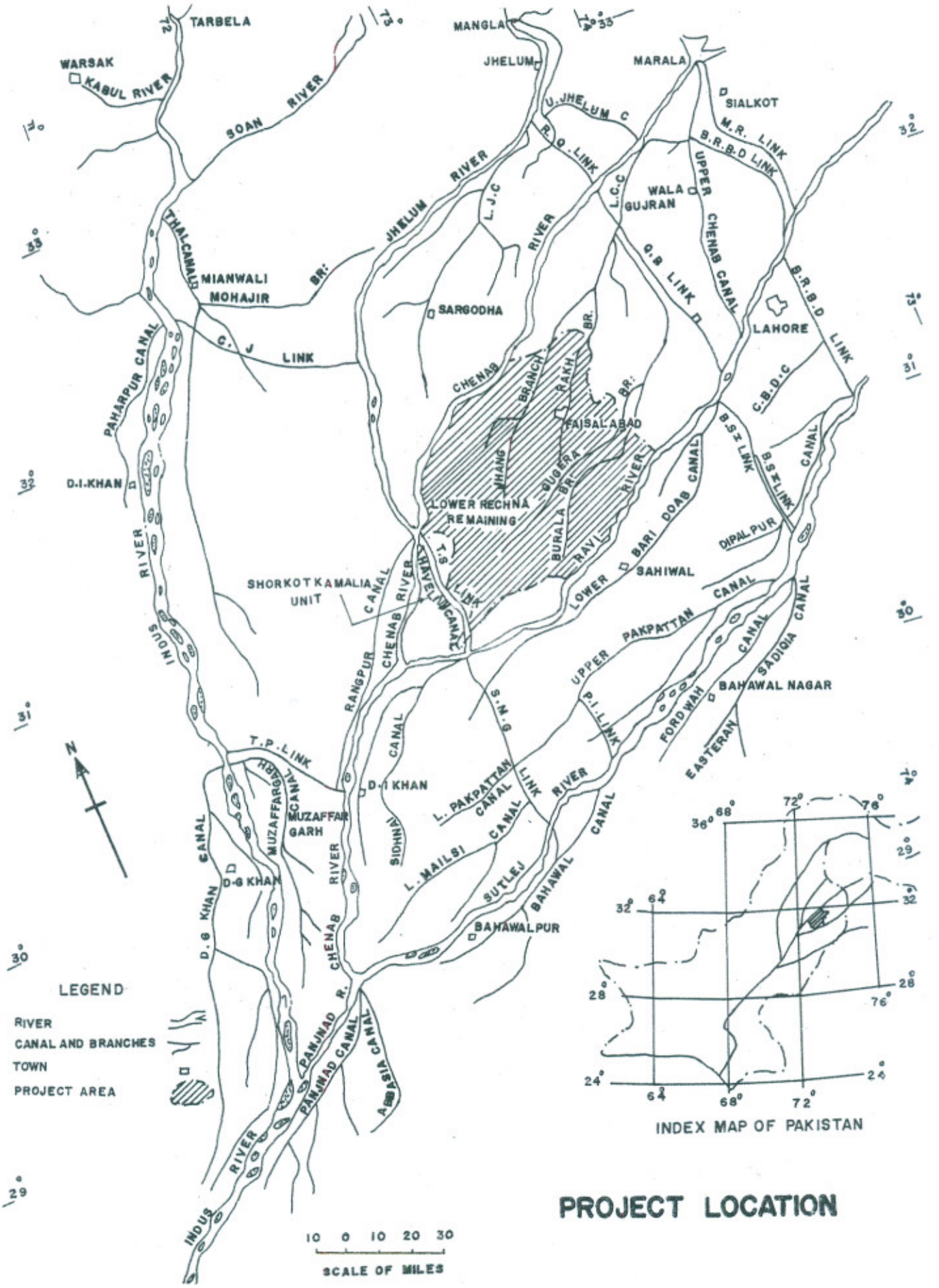
Figure No.	T i t l e
Fig.I	Index Plan of Lower Rechna Doab Showing Khairwala Drinage Project Area.
Fig-II	Project Location.
Fig-III	Khairwala Drainage Project Trunk Drains Disposal Channels.
Fig-IV	Khairwala Drainage Project Construction Schedule.
Fig-V (a)	Long Section of Khairwala Main Drain. R.D. 0-90,000
Fig-V (b)	Long Section of Khairwala Main Drain R.D. 0--255 (Source).
Fig-V (c)	Long Section of Dijkot Branch Drain R.D. 0-15.
Fig-V (d)	L-Section of Dijkot Branch Drain R.D. 115-221500 (Source).
Fig-V (e)	Long Section of Nasrana Branch Drain R.D. 0-70,000 (Source). .
Fig-V (f)	Cross Section at R.D. 40500 Khairwala Main Drain.
Fig-VI.	Rainfall Frequency Curves.
Fig-VII.	Peak Run-off V/S Return Period.
Fig-VIII.	Effect of On and Ja on Peak Runoff.
Fig-IX.	Back Water Curve Profile for Khairwala Main Drain R.D. 35000 to 99884 (Direct Step Method).

FIG - I

INDEX PLAN OF LOWER RECHNA DOAB SHOWING KHAIRWALA DRG. PROJECTAREA

SCALE 1"=8





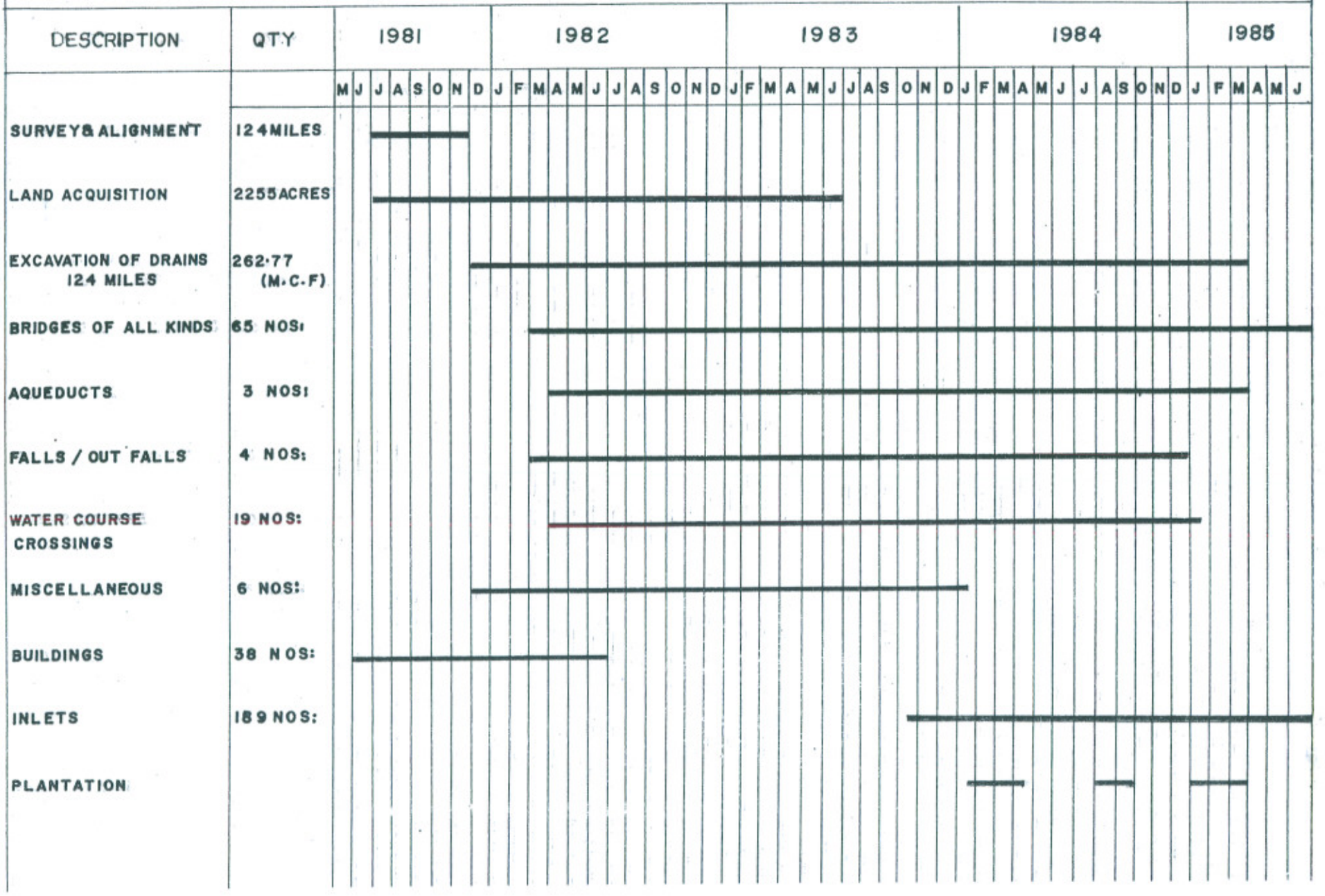
PROJECT LOCATION

KHAIRWALA DRAINAGE PROJECT

CONSTRUCTION SCHEDULE

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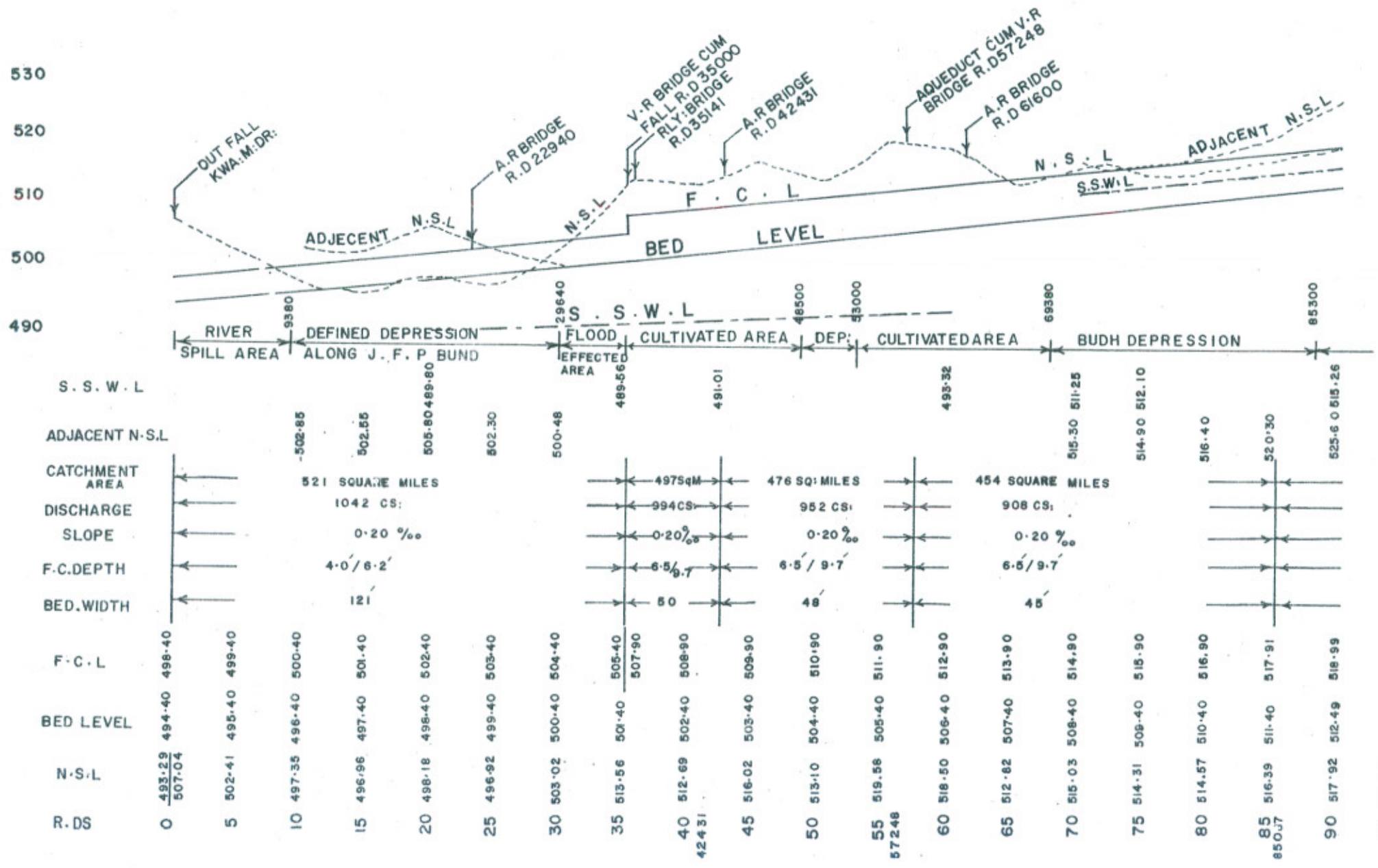
FIG - IX



LONG SECTION OF KHAIRWALA MAIN DRAIN

FIG. H (a)

RD. 0 - 90,000

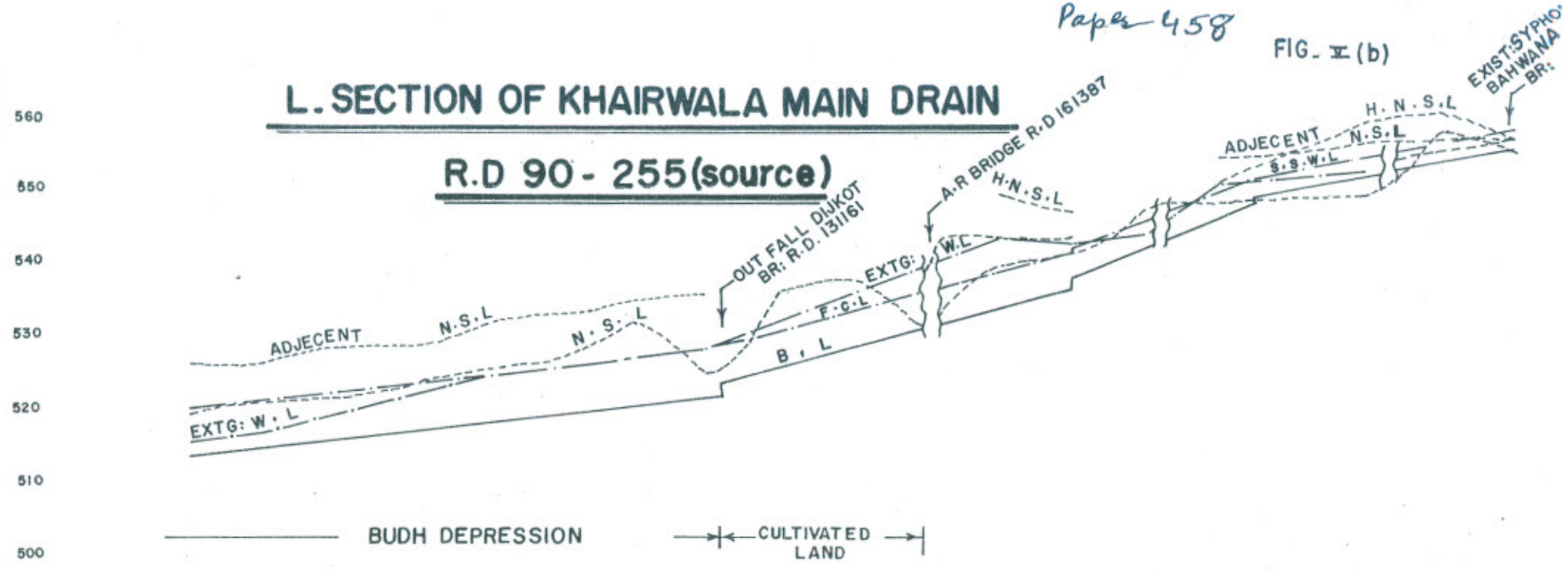


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FIG. II (b)

L. SECTION OF KHAIRWALA MAIN DRAIN

R.D 90 - 255 (source)

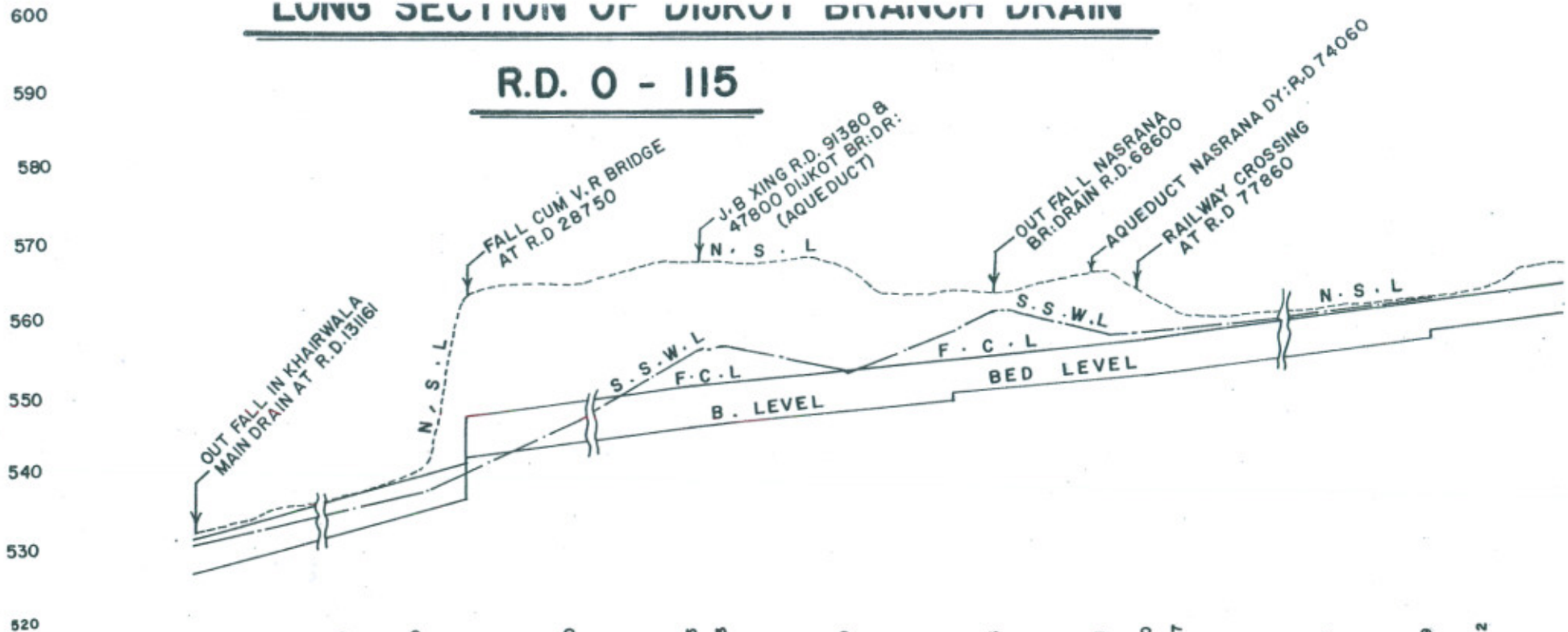


BUDH DEPRESSION ← CULTIVATED LAND →

| | | |

LONG SECTION OF DIJKOT BRANCH DRAIN

R.D. 0 - 115

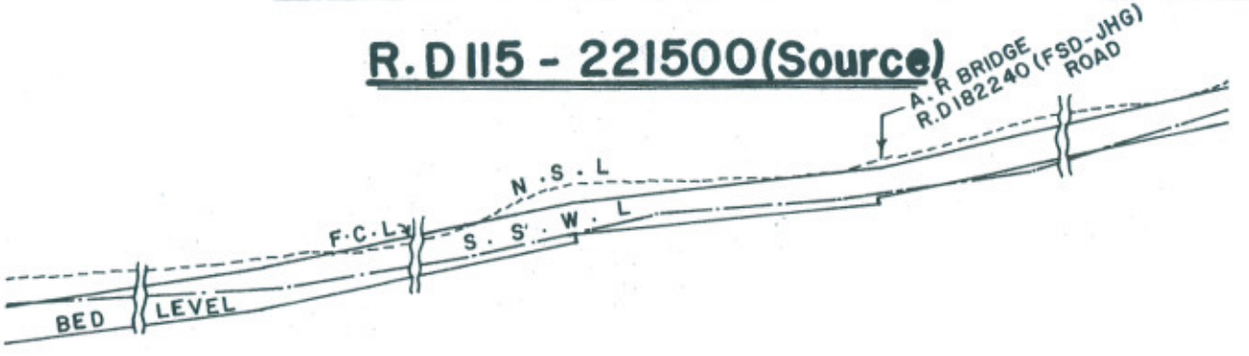


| | | |

Papu-458 FIG IX(d)

L-SECTION OF DIJKOT BRANCH DRAIN

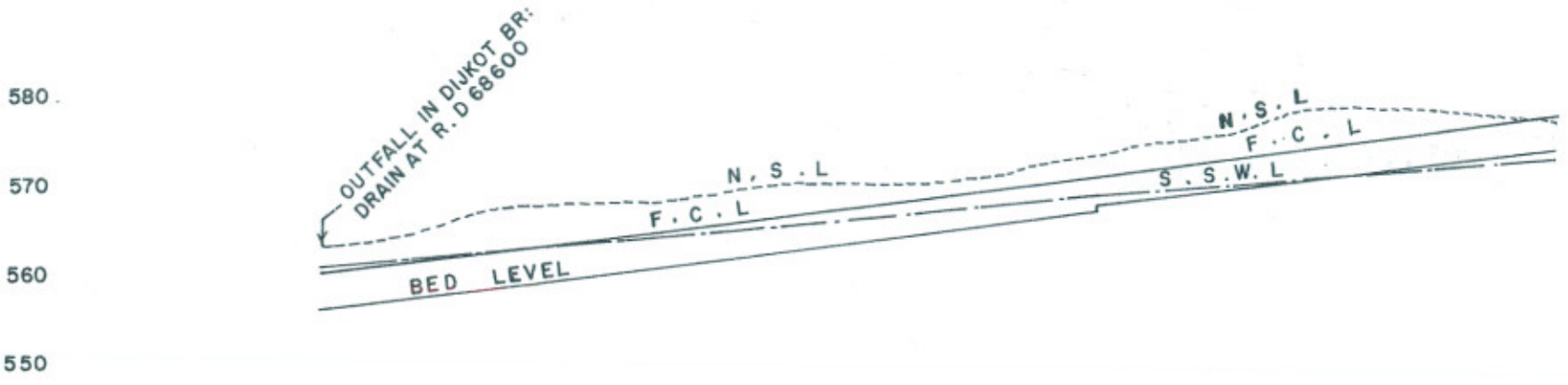
R.D 115 - 221500 (Source)



| | | |

LONG SECTION OF NASRANA BR: DRAIN

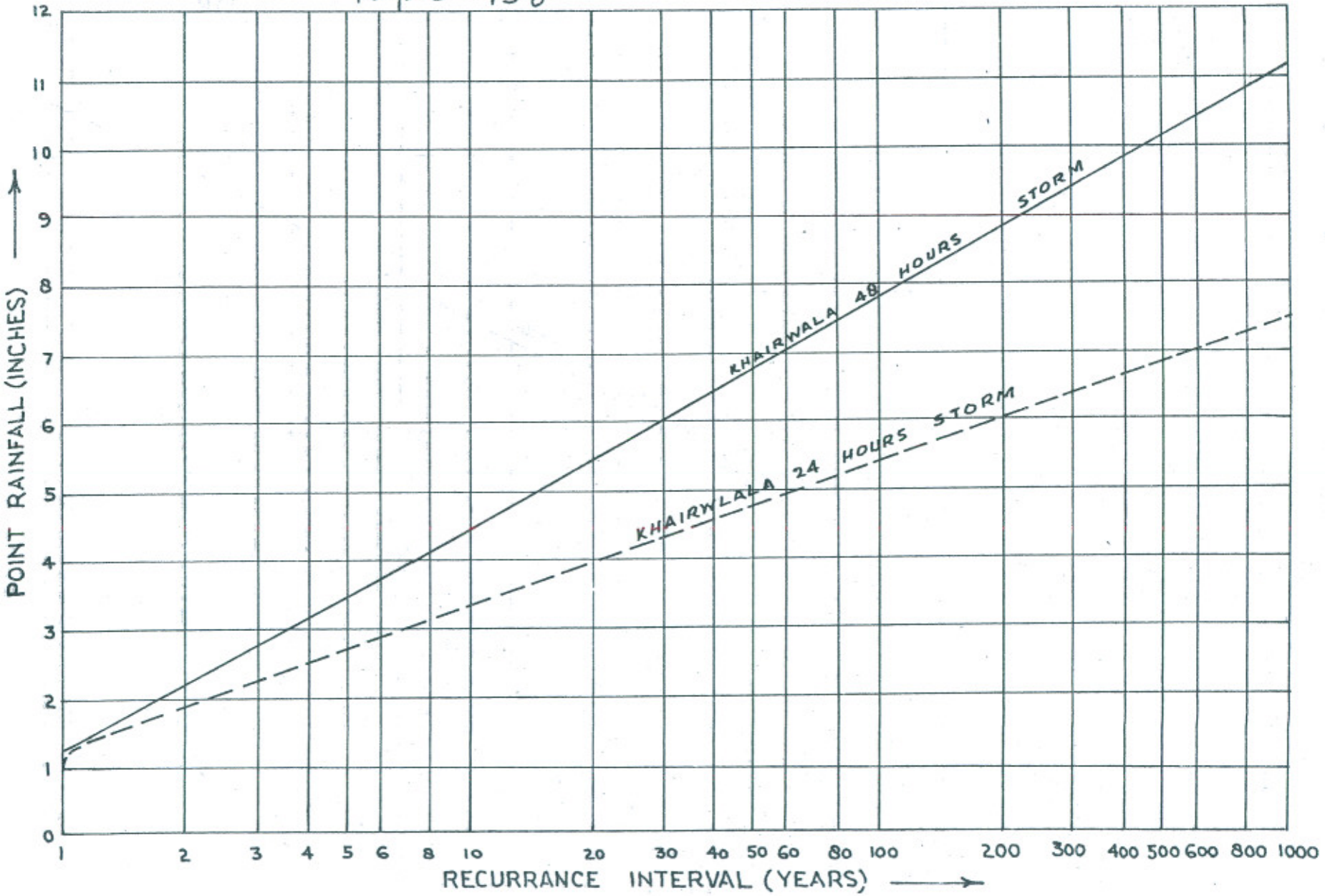
R.D. 0 - 70,000 (Source)



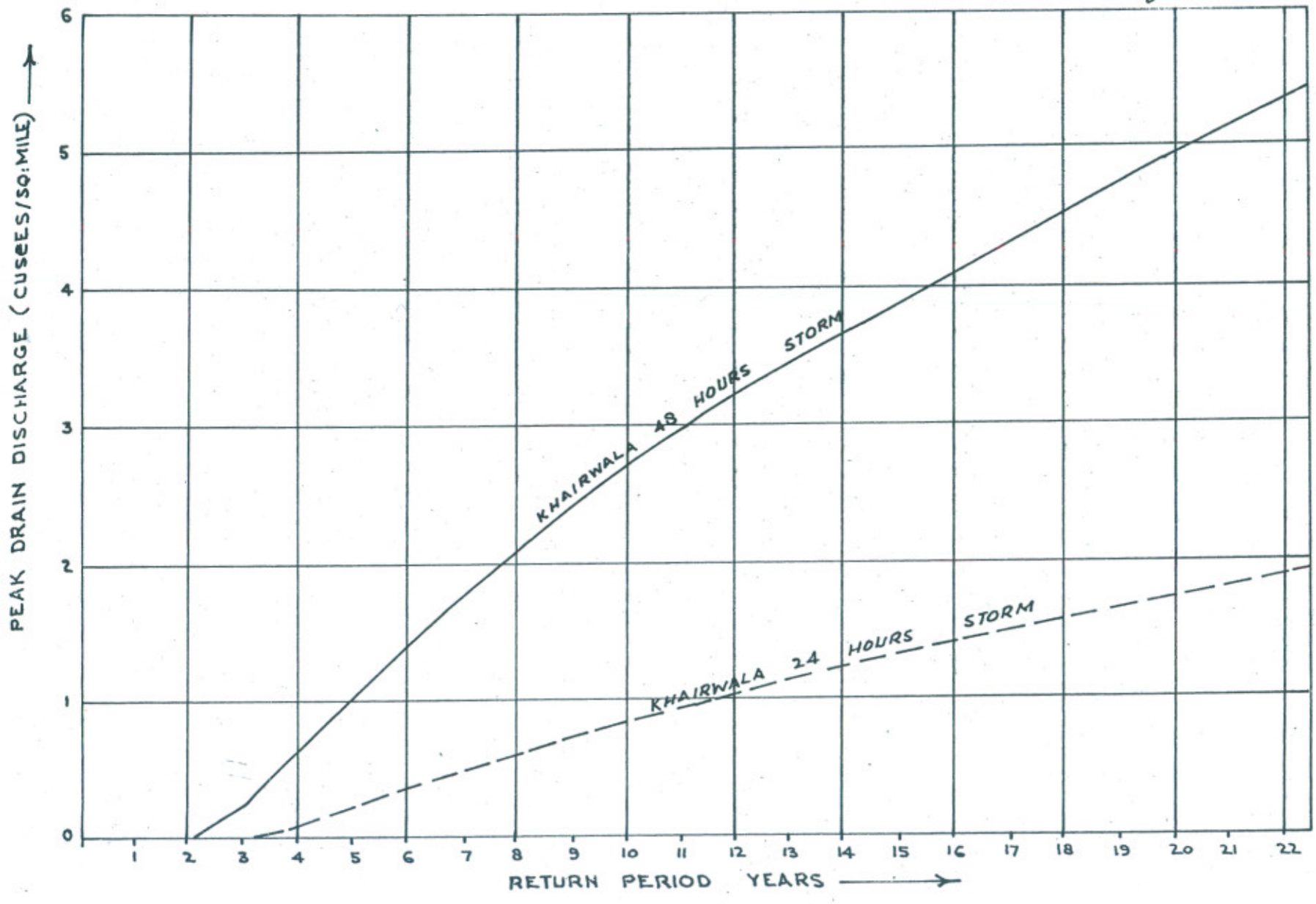
S.S.W.L	61·40						66·10						70·05						74·20			
CATCHMENT AREA	←				81·0 SQUARE MILES							→	←	56·0 SQ: MILES								→
SLOPE	←				0·25 ‰							→	←	0·25 ‰								→
DISCHARGE	←				162 CS:							→	←	112 CS:								→
F·C. DEPTH	←				3·9′ / 5·8′							→	←	3·5′ / 5·0′								→
BED WIDTH	←				18·0′							→	←	15·0′								→
F·C·L	561·00	562·25	563·50	564·75	66·00	67·25	68·50	69·75	71·00	71·99	72·25	73·50	74·75	76·00	77·25	78·50						
BED LEVEL	557·10	558·35	59·60	60·85	67·10	63·35	64·60	65·85	67·10	68·09 / 68·49	68·75	70·00	71·25	72·50	73·75	575·00						
N.S.L	564·63	65·73	68·83	68·84	69·27	71·23	71·05	71·34	73·55	74·04	74·63	76·27	78·83	79·00	78·70	78·00						
R.DS	0	5	10	15	20	25	30	35	40	43950	45	50	55	60	65	70	(SOURCE)					

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RAINFALL FREQUENCY CURVES FIG VI



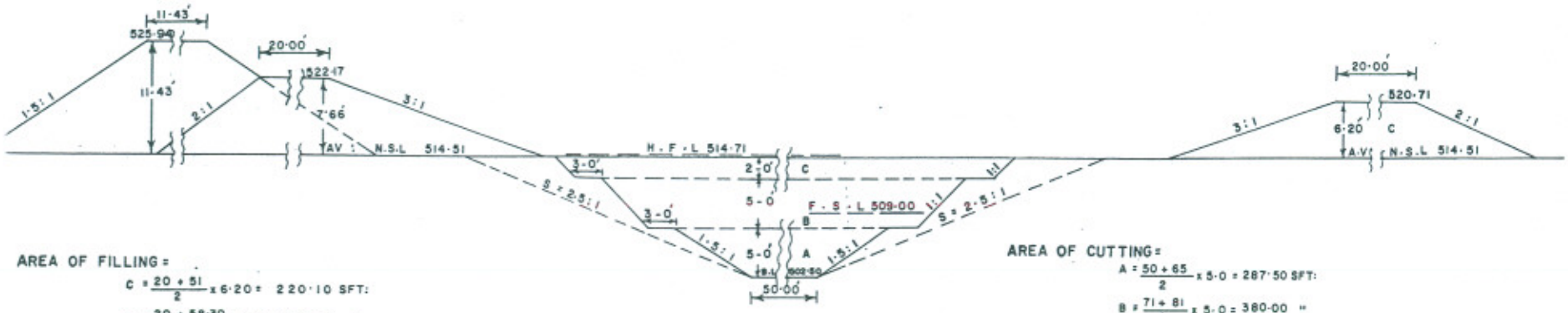
PEAK RUNOFF V/S RETURN PERIOD Paper-458 FIG VII



Paper-458

CROSS SECTION AT R.D. 40500 KHAIRWALA MAIN DRAIN

FIG- v (f)



AREA OF FILLING =

$C = \frac{20 + 51}{2} \times 6{\cdot}20 = 220{\cdot}10$ SFT:

$D = \frac{20 + 58{\cdot}30}{2} \times 7{\cdot}66 = 299{\cdot}89$ "

519·99 SFT:

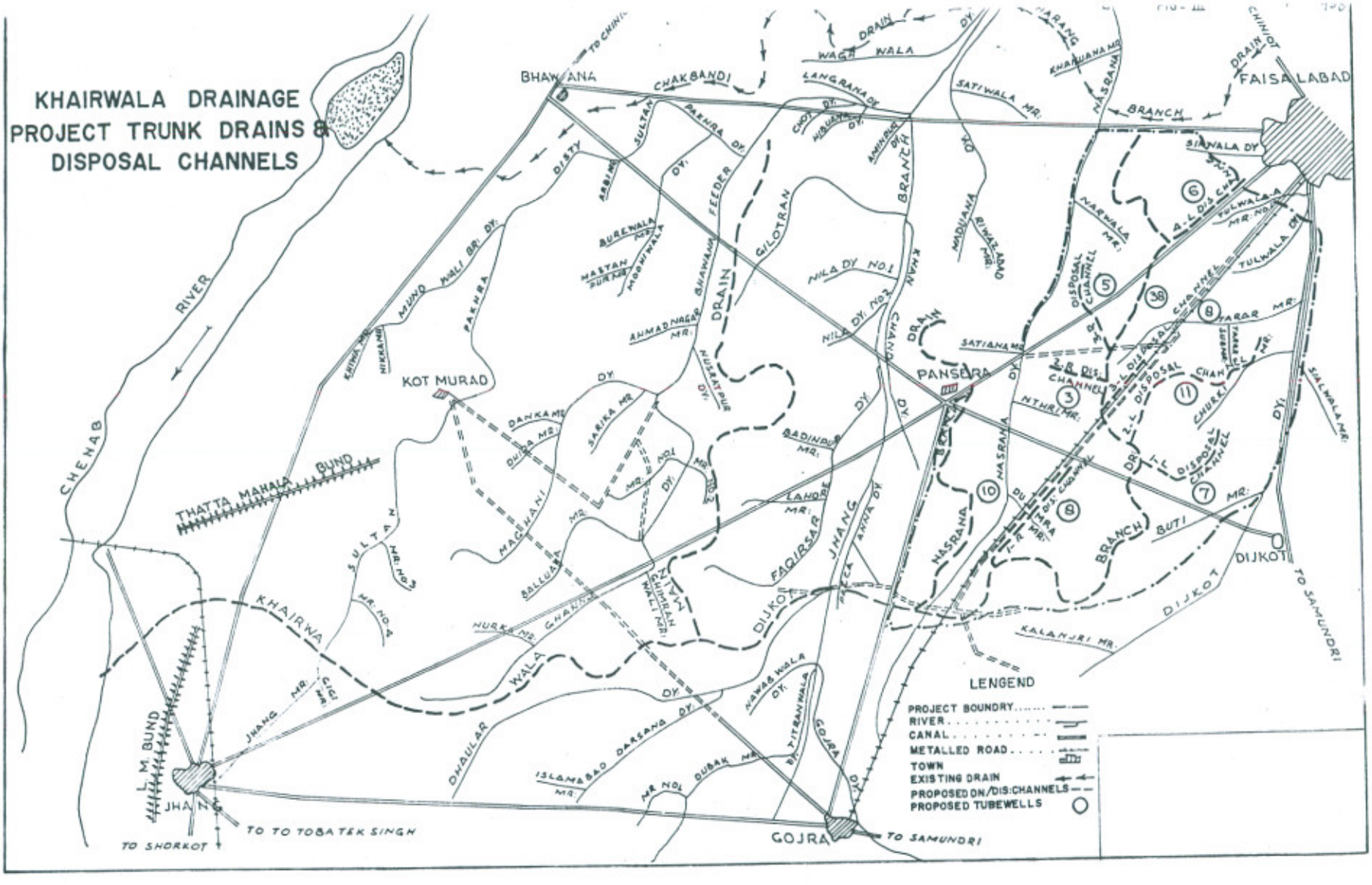
AREA OF CUTTING =

$A = \frac{50 + 65}{2} \times 5{\cdot}0 = 287{\cdot}50$ SFT:

$B = \frac{71 + 81}{2} \times 5{\cdot}0 = 380{\cdot}00$ "

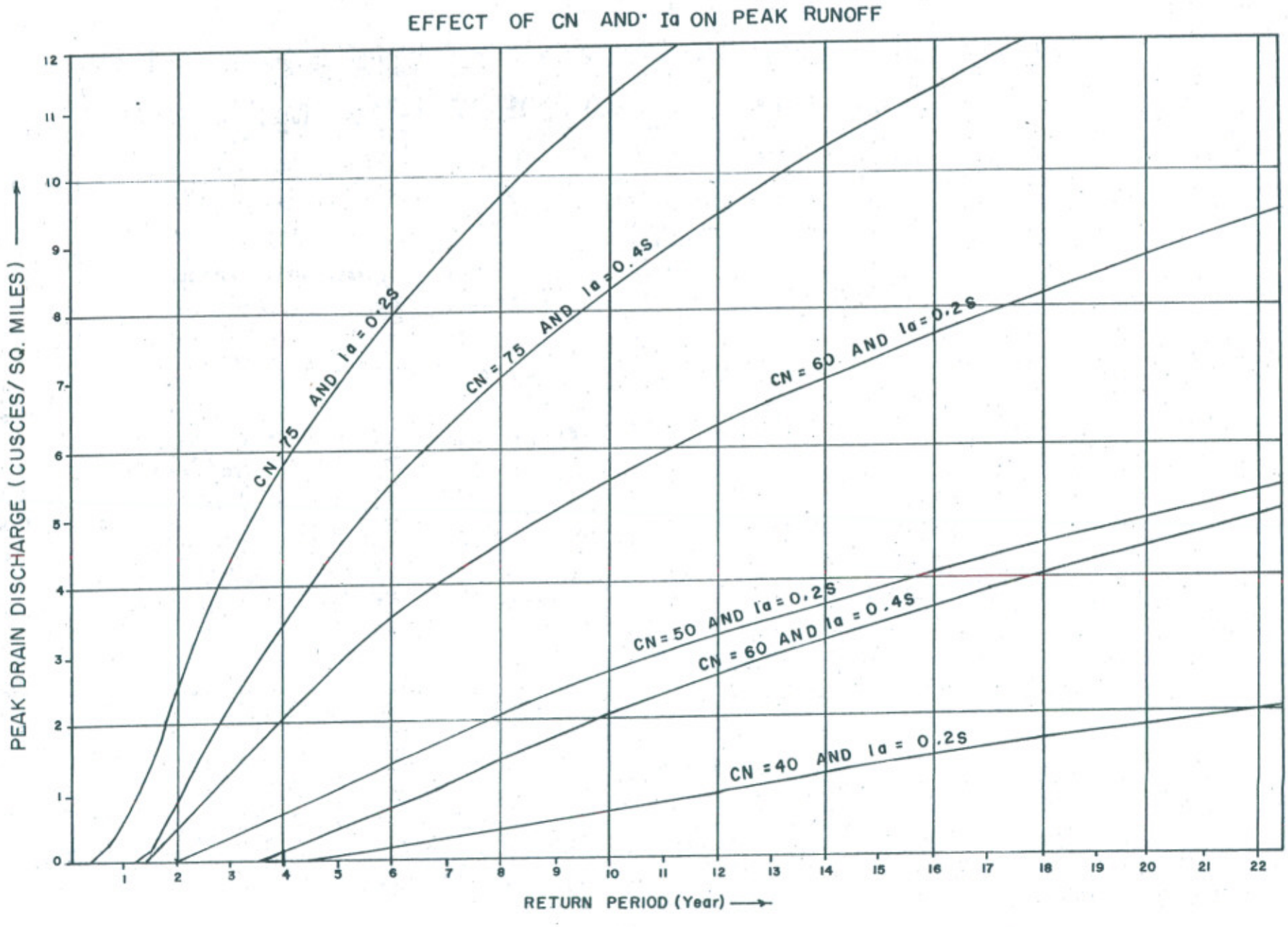
$C = \frac{87 + 91{\cdot}02}{2} \times 2{\cdot}01 = 178{\cdot}91$ "

846·41 SFT:


KHAIRWALA DRAINAGE
PROJECT TRUNK DRAINS &
DISPOSAL CHANNELS
BHAWANA
FAISALABAD
KOT MURAD
PANSERA
DIJKOT
JHANG
GOJRA
TO SHORKOT
TO TO TOBA TEK SINGH
TO SAMUNDRI
CHENAB RIVER
THATTA MAHALA BUND
KHAIRWALA
DISTY
FARHRA
DRAIN
GILOTRAN
FEEDER
BRANCH
NASRANA
JHANG
FAQIRSAR
DHAULAR
WALA
LENGEND
PROJECT BOUNDRY
RIVER
CANAL
METALLED ROAD
TOWN
EXISTING DRAIN
PROPOSED DN./DIS:CHANNELS
PROPOSED TUBEWELLS

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FIG VIII.

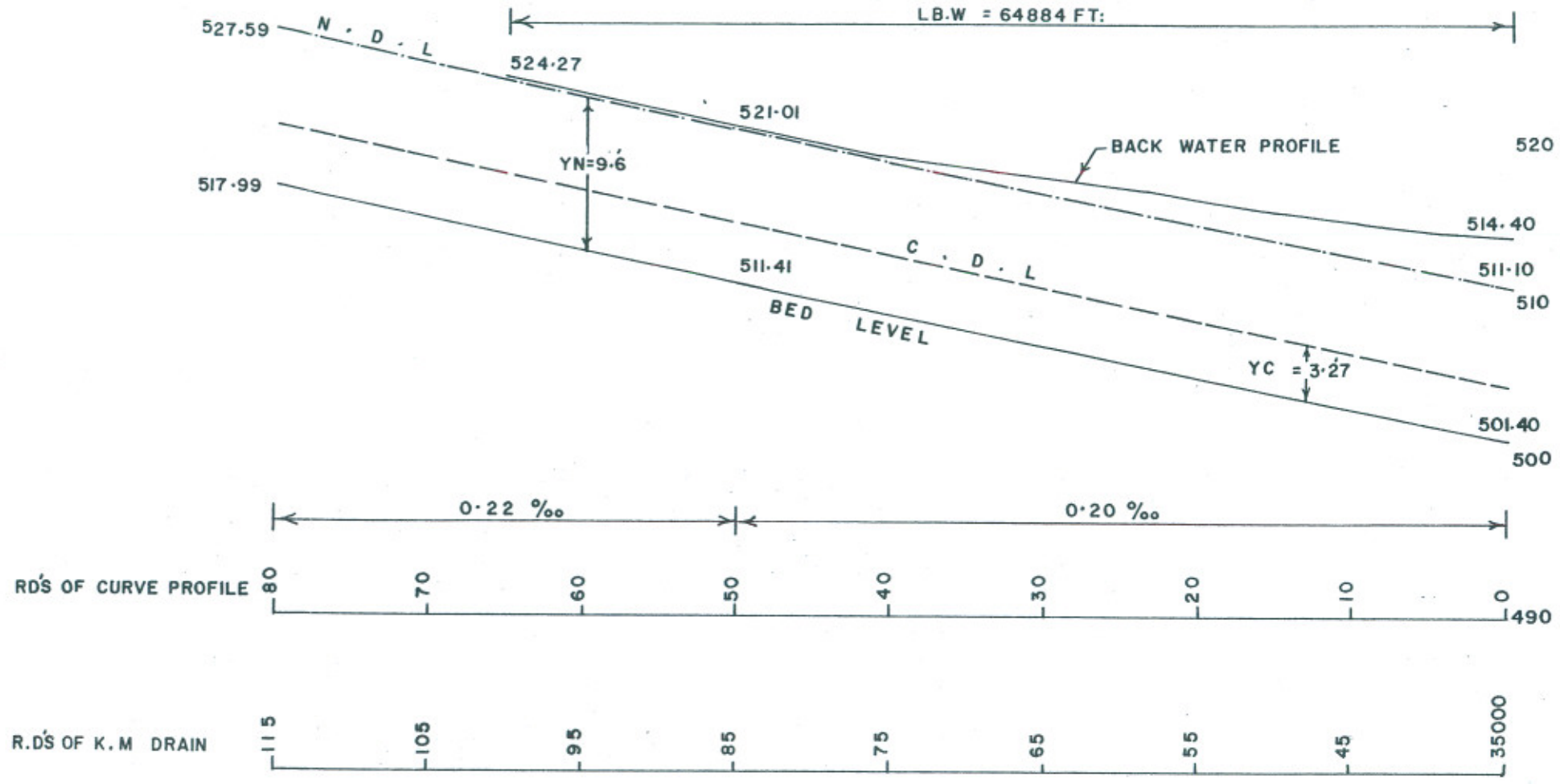


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FIG IX

BACK WATER CURVE PROFILE FOR KHAIRWALA MAIN DRAIN

R.D. 35000 TO 99884 (DIRECT STEP METHOD)



58704 - 0 R.D'S OF CURVE PROFILE

99884 - 35 R.D'S OF KHAIRWALA MAIN DRAIN