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# *Urban Runoff Analysis & Modelling - Lahore Study*



## *Interim Report*

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Institute of Hydrology (IH), Wallingford. U.K.

Centre of Excellence in Water Resources Engineering (CEWRE)

University of Engineering & Technology, Lahore, Pakistan

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Sponsored by:

Overseas Development Administration (ODA). U.K.

# Interim Report

on

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Sponsored by:-

*Administration!*

*Overseas Development Agency (ODA) U.K.  
(Through Institute of Hydrology- U.K.)*

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## 1. INTRODUCTION

Urban population in the developing world is growing rapidly. There are high pressure on the urban drainage facilities. There is lack of understanding about the urban runoff and rainfall relationships. Urban runoff control in developing world needs to be investigated.

To improve the environmental and sociological conditions in developing countries, one of the important factors is to improve the drainage systems of the cities/towns. Lahore is the second largest city of Pakistan. Its population is more than 3.5 million and area is about 311 Km<sup>2</sup> (120 square miles). For such a large population, the drainage system is inadequate, especially during the period of Monsoon. In previous 20 years WASA (Water and Sanitation Agency, Lahore) has completed a number of sewerage and drainage projects which brought some improvements. But due to the lack of clear understanding of urban runoff mechanism and storm runoff data, the proper design of the system could not be achieved. The reconnaissance of the area suggests to carry out research for proper understanding of urban runoff in semi arid developing world. In this regards, a portion of Lahore drain which originates from Cantt. area and passes through Gulberg, Shah Jamal and Shadman is selected for the study. The area is accessible and is highly suitable to understand urban storm runoff mechanism in semi-arid region.

## 2. OBJECTIVES

The project is funded by Overseas Development Agency UK. The studies are taken up by Centre of Excellence in Water Resources Engineering, University of Engineering & Technology, Lahore, Pakistan in collaboration with Institute of Hydrology, Wallingford, UK. The main objectives are :

- i. To make understanding about urban storm runoff.
- ii. To select a favorable urban area suitable for the study.
- iii. Acquisition of necessary instruments required to collect the field data. These instruments will mainly be supplied by Institute of Hydrology, Wallingford UK.
- iv. Installation of instruments to collect data especially during Monsoon.
- v. Collection of already available data / reports of the area from the local agencies.
- vi. Urban storm runoff analysis in the selected region.
- vii. Preparation of project report / research report.

### 3. THE PROJECT

#### 3.1 The Study Area

Lahore city is located at an elevation of 293 m (690 feet) above mean sea level (fig.1). The area is bounded by the River Ravi flood protection bund along the North and West, with Hudiarra drain to the South. Before 1951, the population of the city was 790,000. Now the population has increased by more than 4.5 times due to various factors. Those factors include the influx of refugees from India, expansion of Government services, industrialization and other business activities. The annual growth rate is about 3.5 %. The population of Lahore as recorded and estimated in the Nihon Suido report of 1967 is given below:

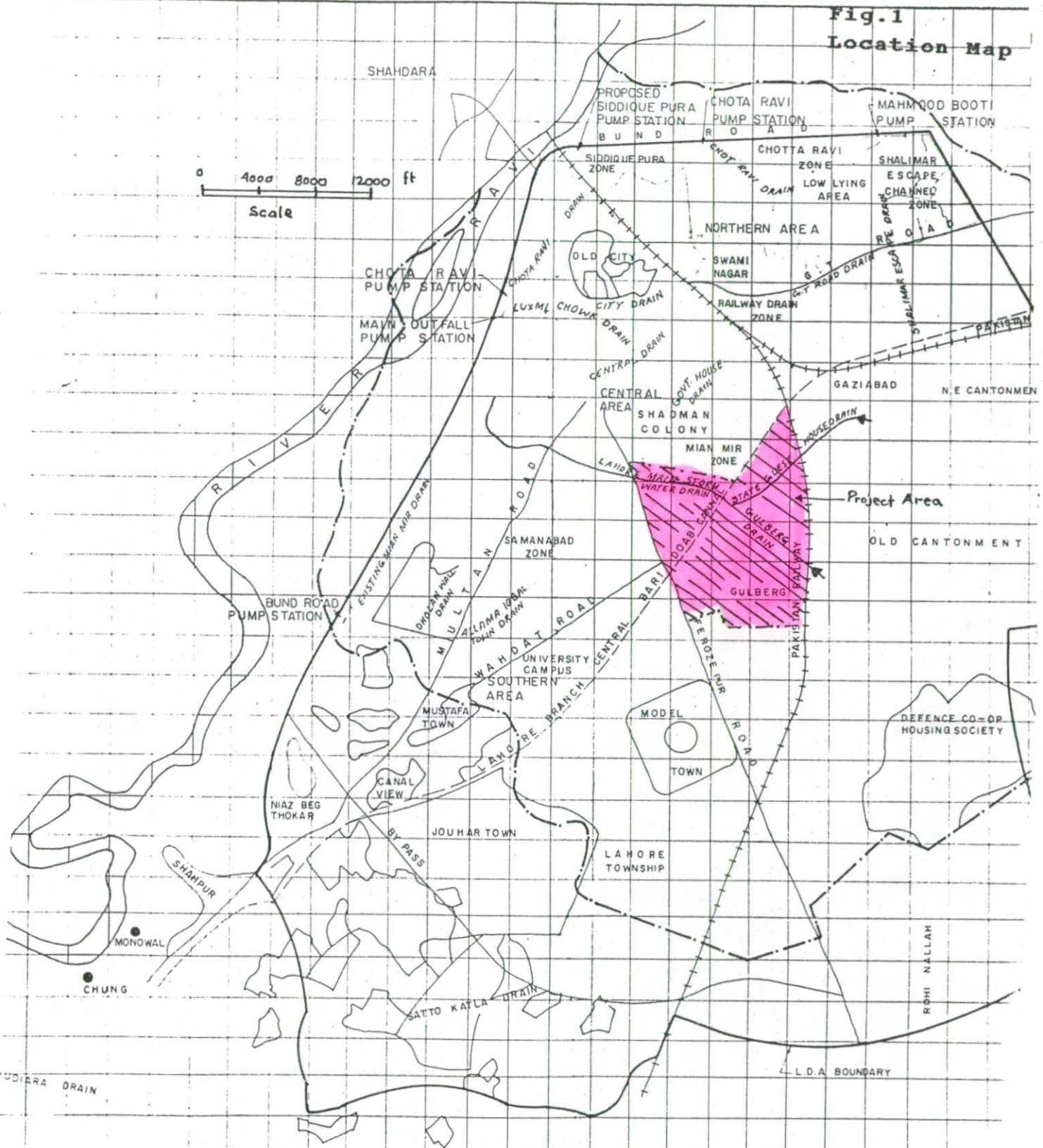
Year	Population of Lahore	Annual % Increase
1951	790,000	(Prior to 1951 % = 3.8)
1961	1,280,000	4.9
1971	1,800,000	3.5
1981	2,539,000	3.5
1991	3,581,000	3.5

The Study Area is shown in fig.2

#### 3.2 History of the existing Drainage System

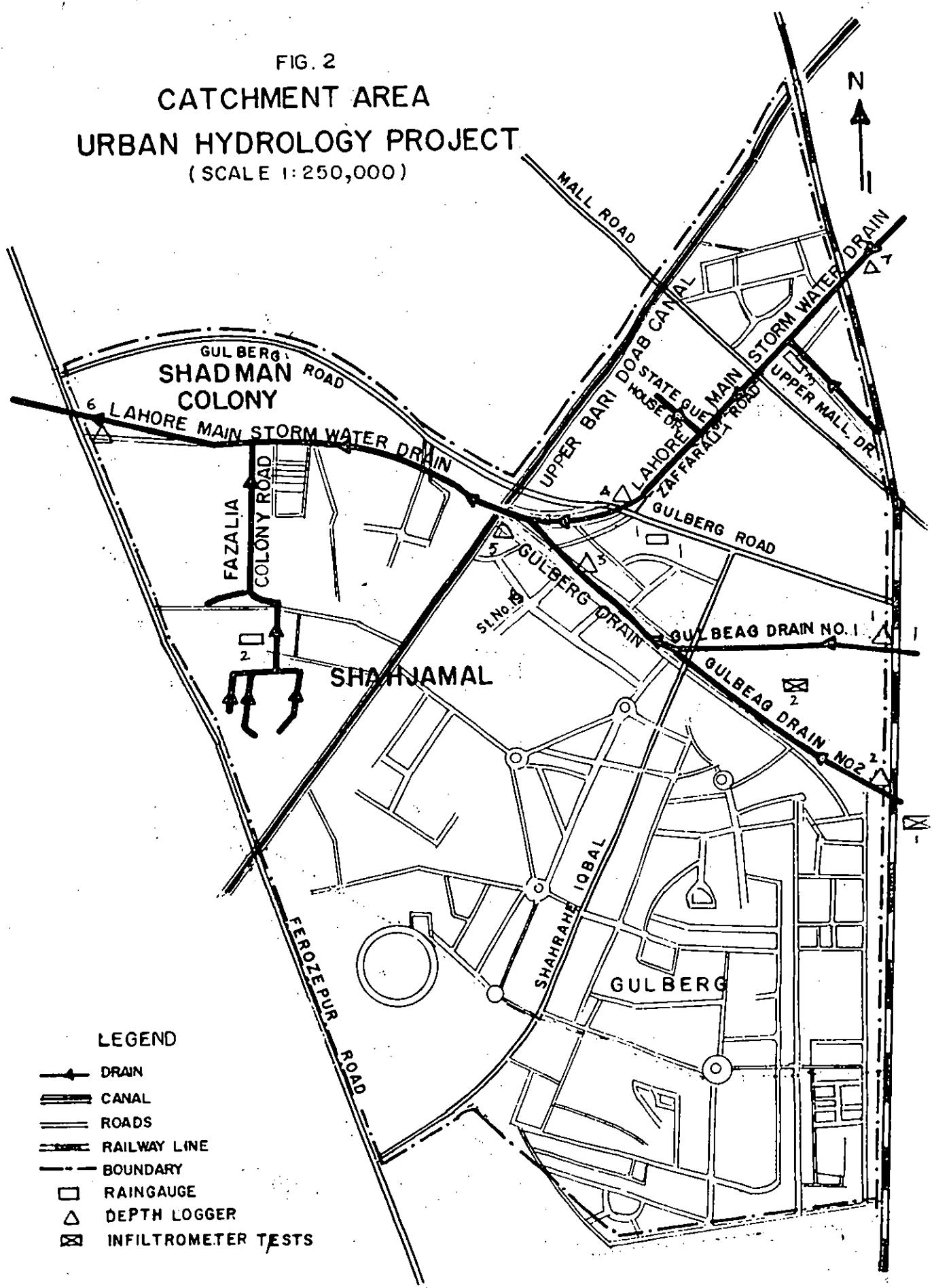
Almost 35 years back, when there was no protection bund for Lahore against the high water levels of the River Ravi, floods used to occur every year during the rainy season. Under flood

**Fig. 1**  
**Location Map**



3640 3641 3642 3643 3644 3645 3646 3647 3648 3649 3650 3651 3652 3653 3654 3655 3656 3657 3658 3659 3660 3661 3662 3663 3664

FIG. 2  
 CATCHMENT AREA  
 URBAN HYDROLOGY PROJECT  
 (SCALE 1:250,000)



- LEGEND**
- DRAIN
  - CANAL
  - ROADS
  - RAILWAY LINE
  - BOUNDARY
  - RAINGAUGE
  - DEPTH LOGGER
  - INFILTRATION TESTS

conditions the drainage systems for the city were badly effected. There are pump stations on the drainage channels. Because the pumping capacities were less than required, certain areas of the city were used to be submerged for a number of hours, before the flood receded. With the construction of Mahmood Boti Bund, the city was protected from the floods of the River Ravi, but this bund itself became a barrier of the natural drainage of the city. Consequently the city drains were overloaded, resulting in flooding of many areas. Other artificial barriers preventing good natural drainage are:

- Pakistan Railway
- Lahore Branch Canal of Lower Bari Doab
- Roads and buildings in low lying areas

The problem of city drainage has been mainly aggravated due to maintenance problems of the city network. Numerous encroachments and coverings have abstracted access for cleaning, aggravating the problem. Lack of full separate sewerage networks in the city has forced the population to directly discharge sewage into the storm drains. Therefore many of the city storm drains have been converted into sewage carriers. Also the sewers tend to overflow, even during rainfall of moderate intensity.

In 1969, Lahore Improvement Trust (LIT) engaged Nihon Suido Engineering Consultants from Japan with Associated Consulting Engineer from Pakistan, to prepare a master plan for improvement of the storm drainage system of Lahore. They proposed following three phase improvements.

- i) Short range phase I (1967-70)
- ii) Long range phase II (1971-75)
- iii) Long range phase III(1976-80)

Accordingly, certain portions of the drainage network were rehabilitated and remodelled. But the drainage problem still exists.

### 3.3 The Drainage Problem

The city of Lahore was built on raised ground sloping towards the River Ravi. With the passage of time, the city expanded in all direction but the storm drainage system generally remained the same resulting in severe problems. Several ponds in the city have been created due to many reasons. Some of these reasons are:

- Removal of clay from the land surface to provide material for the brick industry
- People, in certain areas, used the soil to build their houses, thus creating ponds in the lawns and other public places

During the rainy season, at certain location, the existing drains overloaded and the number of empty depressions became pools which imposed a risk to human life. These pools proved also breeding areas for mosquitoes.

Lahore city is mainly flat and the slopes provided barely gain velocities greater than 0.76 m/s (2.5 ft/s) when running full. Due to low velocities significantly less than 0.76 m/s (2.5 ft/s) causes sedimentation of heavy particles in the drains. This problem is exacerbated by the public who dump their solid waste into these drains. As a result many of the existing drains are badly silted at present. The storm drains in the area were designed and built as storm water carriers. At certain locations sewer were connected to these drains, for ultimate disposal into the River Ravi. Many people living near these drains, have no sanitary sewers. They have connected effluent from their premises directly to the storm water drains. So practically, these storm water drains remain converted into sullage carriers for approximately nine months of the year.

Drains partially block with silt and rubbish. When the heavy rains come, the full section is not available to allow the storm flows to pass.

#### **4. Previous Investigations**

In 1967, Nihon Suido Engineering Consultants from Japan, in association with ACE (Pvt) Ltd. Pakistan, were appointed consultants to examine and evaluate conditions of the storm drainage system of Lahore city and to propose remedial solutions. Five years of rainfall record were reviewed for the design of drains. The intensities were calculated using Talbot formula and the peak flows were calculated using the Rational formula, adopting a suitable runoff coefficient for the Lahore drainage area. Manning's formula was used in calculations of a discharge and

velocity computation.

In 1975, Camp Dresser and Makey, Consultants in Sanitary Engineering from USA, were appointed to review the design by Nihon Suido and ACE. Minor changes were recommended most of which were adopted during the construction phase.

In 1987, National Engineering Services of Pakistan (NESPAK) was engaged by WASA/LDA to prepare project report for a part of Lahore city (48 km of Urban Drainage including associated structures).

In 1991, Mott MacDonald International Ltd in association with ACE (Pvt) Ltd was appointed to prepare design consultancy report of Lahore Urban Drainage. Their reports were comprehensive and helpful as initial data reports in our studies.

## **5. Hydrological Studies**

### **5.1 General**

The basic aim of the project is to measure runoff in the selected urban catchment at various locations and to make an understanding between rainfall and urban runoff. In this connection reconnaissance of the Lahore city urban area was made for selecting a suitable site (urban catchment) for the study.

## 5.2 Site Selection

To select a suitable site for the studies, following considerations were made.

- The gaging sites and catchment should be easily accessible.
- The gaging sites should be located at certain locations where there are minimum chances of damaging of instruments by storms or by local people.
- The catchment should be comparatively small.
- The catchment should be near to the project office which is located at CEWRE, Lahore.
- The maps of the catchment should be available.
- The cross-sections at various RD and L-sections of the drainage should be available from the concerned agencies.
- The drains should be less influenced by the effluent from sewers, industries or any other man made effects.

Based on the above consideration, urban catchment starting from Lahore Cantt. upto Ferozpur Road at Shama Cinema was selected for the study.

## 5.3 Available Data

### 5.3.1 Rainfall Data

There are two meteorological stations in Lahore. These are located at Lahore Airport and Jail Road. Daily rainfall data from these two stations are available from 1940 to date though few years are missing.

Station	Data Available		
	24-hours Maximum	3-hours Maximum	Autographic
City	1940-90	1940-90 <sup>2</sup>	1940-87 <sup>4</sup>
Airport	1948-90 <sup>1</sup> (1949 is missing)	1955-90 <sup>3</sup>	-

- 1) 1945 is missing
- 2) 1941, 1949, 1971-73, 1976-77 are missing
- 3) 1961, 1973-75 are missing
- 4) 1941, 1943-46, 1953-54, 1958, 1962-64, 1967, 1976-77, 1979, 1986 are missing

Maximum daily and hourly rainfall in each year at the two stations is collected from the already published material. It is presented in table 1 and table 2. In table 3 maximum 24-hr rainfall at Lahore city and Lahore airport is given. Using the annual maximum daily rainfall series as a base, annual series of maximum rainfall with increments 3, 6, 9, 12 and 24-hour has been prepared by previous investigators. The data is presented in table 4.

The data show that much of the recorded annual maximum daily rainfall in Lahore occur within a 3-hours period. The autographic data of rainfall at city meteorological station has been used to determine the typical intensity duration curve for Lahore. (see section 5.4.1)

Table.1 Rainfall at Lahore City Station

Year	Max 24 Hr Rain (mm)	Month	Date	Hours																						
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1940	56	Aug	10									56														
1941	58	Aug																						31		
1942	58	Aug	22								6		69													
1944	37	Jul	19									37														
1945	49	Jul	11																							
1946	59	Jul	10									17												42		
1947	33	Aug	31																					6		
1948	92	Jul	14									82											11			
1949	29	Jul	25										9										6		6	
1950	92	Sep	20																					18	43	
1951	72	Jul	29																							
1952	30	Jul	10																							
1953	136	Jul	12	133																			3			
1954	228	Sep	24	57	148																				23	
1955	116	Sep	9																				69	18	25	
1956	80	Aug	15																				14	1		
1957	90	Aug	26	0																			6	15	12	
1958	205	Sep	4																				106	5	30	
1959	121	Aug	15																				6	4	4	
1960	44	Sep	11																						36	
1961	67	Jul	31	17																					2	
1962	87	Jul	21																						77	
1963	66	Jul	22																						1	
1964	200	Aug	18	30																					24	
1965	44	Aug	4																						1	
1966	51	Feb	13	1																					8	
1967	60	Dec	27																						2	
1968	73	Aug	4																						72	
1969	124	Jul	24																						1	
1970	58	Aug	28	1																					6	
1971	38	Jul	2																						1	
1972	90	Aug	15																						1	
1973	119	Jul	16																						1	
1974	44	Jul	25	36																					5	
1975	70	Jul	17																						19	
1976	211	Aug	1																						9	
1977	86	Jun	9																						1	
1978	95	Mar	2																						85	
1979	69	Aug	9																						10	
1980	208	Jul	31	39																					47	
1981	125	Jul	25																						13	
1982	73	Aug	9	9																					20	
1983	94	Aug	20																						85	
1984	61	Aug	28	40																					2	
1985	117	Oct	9	40																					2	
1986	65	Jul	8	38																					31	
1987	59	Jul	12																						6	
1988	77	Sep	25	35																					1	
1989	73	Jul	22																						7	
1990	83	Aug	14	4																					14	

Table.2 Rainfall (mm) at Lahore Airport Station

Year	Max 24 Hr Rain (mm)	Month	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1948	81	Jul	14																								
1949																											
1950	92	Sep	20																								
1951	72	Jul	29																								
1952	30	Jul	10																								
1953	118	Jul	12																								
1954	122	Sep	24																								
1955	52	Sep	9					8		43		1															
1956	88	Aug	18	1				60		1																	
1957	106	Aug	26	2				8		14		34				23		15				9					
1958	279	Sep	4	10				109		72		23				50		2				13					
1959	131	Aug	15			6										8		116				2					
1960	33	Sep	11								2		31														
1961	118	Jul	31																								
1962	91	Jul	12			91																					
1963	45	May	14	7		20																					
1964	207	Aug	18	32		13		1		29		17				25		41				17					
1965	120	Jul	28					108		12																	
1966	51	Feb	13	4		7		1		9		18				2		5				5					
1967	48	Mar	26					6		14		6				11		9				1					
1968	42	Aug	19					41		1																	
1969	65	Jul	28			65																					
1970	58	Aug	26	1										37		14		7									
1971	40	Sep	8					21		20																	
1972	73	Aug	15					2		48		18				5											
1973	97	Aug	9																								
1974	83	Jul	16																								
1975	52	Jul	20																								
1976	185	Aug	1					11		35		30				33		50				26					
1977	64	Sep	3							64																	
1978	132	Jul	17	10		122																					
1979	89	Jul	21	7		13										70											
1980	332	Jul	31	53		105		97		70		8															
1981	105	Jul	25					30		40		35															
1982	69	Jul	20	56		13																					
1983	67	Aug	20			4							55			7		2									
1984	96	Aug	28	87				6																		3	
1985	157	Oct	9	57		35										35		15				15					
1986	101	Jul	8	40		15		45																		1	
1987	50	Aug	14			3		6		30		14															
1988	85	Sep	25	50		26		1		2		1														6	
1989	125	Jul	30	63		62																					
1990	106	Aug	14	1		74										15		5				11					

Table 3  
Maximum Annual Rainfall (mm)

Year	City Rainfall	Airport Rainfall
	24 Hr	24 Hr
1953	136	
1954	228	
1955	116	52
1956	81	62
1957	93	106
1958	205	279
1959	125	131
1960	44	33
1961	55	
1962	88	91
1963	66	45
1964	200	207
1965	44	120
1966	49	51
1967	51	48
1968	73	42
1969	123	65
1970	50	58
1971		40
1972		73
1973		
1974	42	
1975	70	
1976		185
1977		64
1978	95	132
1979	56	89
1980	205	332
1981	125	105
1982	68	69
1983	94	67
1984	61	96
1985	117	157
1986	65	101
1987	59	53
1988	77	85
1989	38	125
1990	83	106

Table.4  
Maximum Rainfall (mm) with 3-hr Increments

Year	City Rainfall					Airport Rainfall				
	3 Hr	6 Hr	9 Hr	12 Hr	24 Hr	3 Hr	6 Hr	9 Hr	12 Hr	24 Hr
1953	133	136	136	136	136					
1954	204	204	204	205	228					
1955	69	86	115	116	116	43	52	52	52	52
1956	66	66	66	80	81	60	62	62	62	62
1957	36	46	60	75	93	34	56	72	86	106
1958	106	111	111	156	205	109	181	203	253	279
1959	106	108	111	112	125	116	123	125	125	131
1960	44	44	44	44	44	31	33	33	33	33
1961	43	43	53	55	55					
1962	77	82	82	88	88	91	91	91	91	91
1963	29	29	36	36	66	20	27	27	27	45
1964	71	76	100	115	200	49	90	115	132	207
1965	39	44	44	44	44	108	120	120	120	120
1966	14	27	31	39	49	18	27	28	33	51
1967	28	28	48	49	51	14	20	31	40	48
1968	72	73	73	73	73	41	42	42	42	42
1969	117	118	123	123	123	65	65	65	65	65
1970	36	44	44	49	50	37	50	57	57	58
1971						21	40	40	40	40
1972						48	66	71	73	73
1973										
1974	36	37	42	42	42					
1975	42	51	70	70	70					
1976						50	83	109	139	185
1977						64	64	64	64	64
1978	85	95	95	95	95	122	132	132	132	132
1979	38	49	56	56	56	70	70	70	70	89
1980	74	119	166	205	205	105	201	272	325	332
1981	71	112	125	125	125	40	75	105	105	105
1982	39	47	47	58	68	56	69	69	69	69
1983	85	90	90	90	94	55	61	63	63	67
1984	40	40	42	43	61	87	87	93	93	96
1985	36	76	76	76	117	57	92	92	92	157
1986	38	60	60	60	65	45	60	100	100	101
1987	59	59	59	59	59	30	44	50	53	53
1988	35	56	56	56	77	50	76	77	79	85
1989	24	31	38	38	38	63	125	125	125	125
1990	61	66	66	66	83	74	75	75	75	106

### 5.3.2 FLOW DATA/WATER DEPTH DATA

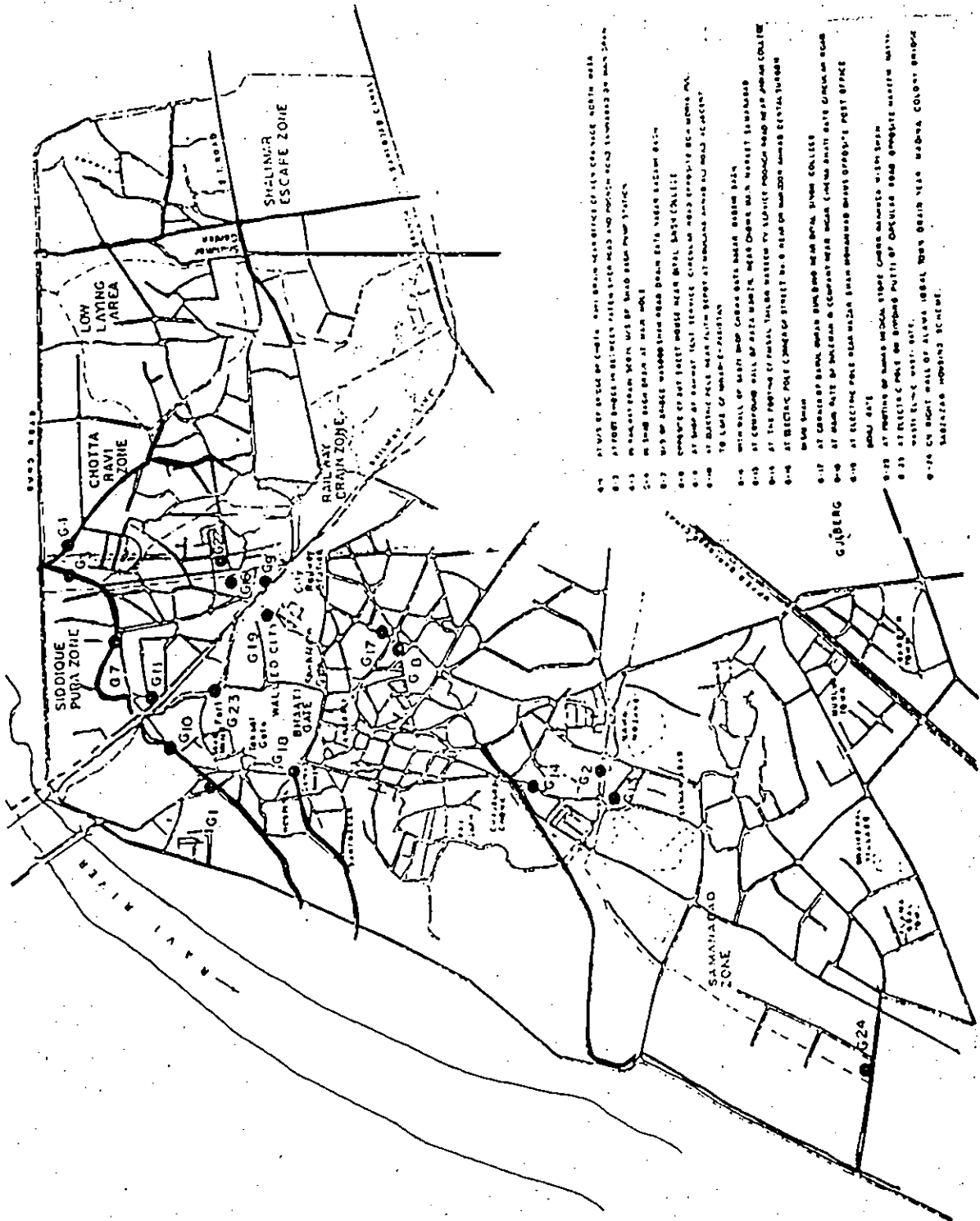
No discharge data of the selected drains have been published by the concerned agencies. Some gauge level recordings were made by Mott MacDonald International (MMI) Limited in Lahore city during August-September, 1990 and 1991. In 1990, only the maximum water levels for each significant rainstorm were measured. For 1991, velocities were recorded in the existing channels. Fig.3 shows the location of water level gauges by MMI in Lahore city. Their investigations show that the rain storms falling around Lahore often cover only a small area. Therefore, at many instances when little or no rainfall was recorded at the Met Office, a comparatively heavy storm occurred at one or more of the gauging sites.

No autographic recording was made during MMI investigation. The data is presented in table 5. The data may be helpful to understand rainfall-runoff relationship in the region.

#### i) Discharge of River Ravi

As described in section 3.3, Lahore city was built along River Ravi. Discharge and depth levels of water of the river at Shahdara were collected for the period 1977 to 1991 from already published material. The data is presented in table 6. The data reveal that average water levels in the River Ravi at Shahdara vary between 207m (679ft) and 209m (685ft). During the period between May and October, the river remains in high stage.

Fig. 3  
Location of Gauges in table.5



- G-1 AT JUNCTION OF CANAL AND RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS
- G-2 AT POINT WHERE RAILWAY CROSSING MEETS RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS
- G-3 AT POINT WHERE RAILWAY CROSSING MEETS RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS
- G-4 AT POINT WHERE RAILWAY CROSSING MEETS RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS
- G-5 AT POINT WHERE RAILWAY CROSSING MEETS RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS
- G-6 AT POINT WHERE RAILWAY CROSSING MEETS RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS
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- G-22 AT POINT WHERE RAILWAY CROSSING MEETS RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS
- G-23 AT POINT WHERE RAILWAY CROSSING MEETS RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS
- G-24 AT POINT WHERE RAILWAY CROSSING MEETS RAVI NEAR BRIDGE OF NEW CIVIC WATER MAINS

Table.5  
Rainfall and Water Levels in Lahore Drainage System

Year	Month	Day	Rainfall (mm) (Hours)						Gauge.1	Gauge.2	Gauge.3	Gauge.4	Gauge.7
			0	3	6	9	12	15	(m)	(m)	(m)	(m)	(m)
Max Water Levels													
1990	Aug	7							210.99	208.27			211.52
1990	Aug	10							210.89	208.38			211.21
1990	Aug	14	4.3	61.5				14.5	211.19	209.18			211.71
1990	Aug	28							211.19	208.22			
1990	Aug	29		41.1				4.3	211.36	207.97			210.81
1990	Sep	4							211.27	209.13			211.02
1990	Sep	8	15.2	17.5					211.29	209.39			211.16
1991	Aug	3							210.99	208.39			
1991	Aug	23							210.81		208.90	208.84	
1991	Aug	25							210.49	208.00	208.71	208.67	
1991	Aug	27		8.6					210.57	208.00	208.76	208.55	
1991	Aug	29			1.3				210.49	208.03	208.81	208.72	
1991	Sep	1							210.59	208.20	208.73	208.71	
1991	Sep	8							210.39	208.00	208.68	208.76	
Discharge (m <sup>3</sup> /s)													
1991	Sep	8							2.349	1.501	1.098	0.569	Stagnant

Gauge	Location
1	Chotta Ravi Drain
2	Mian Mir
3	Railway Drain
4	Shadbagh Drain
7	Data Nagar Drain

Table.6  
River Ravi Mean Monthly Water Levels and Discharges

River Ravi Mean Monthly Water Levels (m)

Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual Mean	Ann M
1977	207.20	207.26	206.92	207.16	207.84	208.26	209.42	209.27	208.96	207.68	207.29	207.16	207.87	210
1978	207.16	207.20	208.26	207.84	208.48	208.63	209.36	209.54	208.90	207.84	207.47	207.47	208.17	210
1979	207.53	207.80	208.72	208.41	208.60	208.75	208.96	208.99	208.48	207.47	207.35	207.29	208.20	209
1980	207.35	207.47	207.41	207.29	207.99	208.75	209.21	208.96	208.32	207.16	207.01	207.32	207.87	210
1981	207.53	207.93	207.96	208.05	208.45	208.57	208.96	208.81	208.20	207.38	207.29	207.13	208.02	209
1982	212.65	207.38	208.38	208.45	208.08	208.20	208.54	208.84	208.14	207.10	206.98	206.92	207.84	209
1983	212.62	207.41	208.08	208.29	208.17	208.45	208.63	208.93	208.66	207.80	207.29	207.23	207.99	209
1984		207.13	207.32	207.32	207.87	208.23	208.48	208.72	208.32	207.16	206.95	206.95	207.68	209
1985	207.13	206.89	206.74	206.95	207.44	207.84	208.26	208.66	207.99	207.50	206.80	206.89	207.44	209
1986	207.47	207.10	207.44	207.59	207.77	207.96	208.38	208.54	207.77	207.35	207.10	207.53	207.65	209
1987	207.20	207.16	207.56	207.44	207.87	207.84	208.41	208.08	208.08	207.13	206.71	206.71	207.47	208
1988	206.62	206.77	207.41	207.26	207.32	207.77	208.41	208.69	208.69	207.41	206.59	206.52	207.47	211
1989	206.80	206.40	206.55	206.55	206.89	207.04	207.29	207.50	207.26	206.49	206.43	206.52	206.80	209
1990	206.49	206.71	207.16	206.92	207.29	207.47	207.84	208.11	208.08	207.16	206.77	206.77	207.23	
1991	207.10	207.07	207.59		207.59	207.74	207.62	207.90	207.77				207.56	
Mean	207.20	207.23	207.59	207.59	207.90	208.17	208.60	208.72	208.29	207.35	207.01	207.04	207.71	209

River Ravi Mean Monthly Discharges (m<sup>3</sup>/s)

Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual Mean	Ann M
1977	73.45	71.12	31.20	77.25	162.11	282.35	1122.70	945.88	640.92	92.69	78.07	24.62	300.20	2504
1978	23.21	25.59	301.02	147.18	354.41	436.78	1064.92	1184.64	567.75	141.31	71.89	53.07	364.32	1921
1979	60.24	156.02	496.88	305.21	325.84	322.73	487.50	494.50	214.25	29.98	24.00	20.54	244.80	1207
1980	22.39	33.64	29.10	20.91	141.77	409.10	841.34	732.76	345.17	57.38	50.10	90.37	231.17	2898
1981	134.74	224.20	244.35	255.54	377.61	349.50	637.66	545.96	250.38	75.18	70.87	51.52	268.12	1691
1982	57.24	82.77	358.91	373.56	241.94	246.61	365.23	565.97	253.05	49.93	41.80	32.73	222.47	1289
1983	50.81	99.01	236.38	294.76	268.89	353.07	452.96	639.95	485.21	191.64	77.56	60.56	267.55	830
1984		48.82	86.65	74.44	197.48	282.74	385.26	497.42	350.44	59.82	30.43	29.56	185.75	758
1985	54.63	19.01	7.20	28.88	108.70	179.14	346.53	580.82	258.77	171.44	28.65	52.99	153.07	1295
1986	0.34	98.50	164.95	200.62	286.74	326.55	514.40	488.27	240.10	140.15	89.57	115.81	222.16	1115
1987	102.61	97.85	181.07	167.27	276.76	289.01	252.51	354.46	356.50	103.97	37.74	39.61	188.27	718
1988	37.40	50.58	201.50	151.71	155.99	341.74	677.73	759.71	1221.28	454.55	126.64	137.09	359.65	9240
1989	230.07	67.61	119.81	208.27	245.99	273.56	390.71	516.86	364.47	91.13	60.22	82.37	220.91	1898
1990	58.35	112.92	294.39	179.63	344.94	701.84	603.32	816.95	825.90	317.82	176.42	147.55	381.61	
1991	183.65	203.15	353.90		394.70	480.56	402.55	586.00	535.53				392.52	
Mean	70.59	82.66	189.15	177.36	241.85	314.85	579.97	639.02	426.78	127.63	60.58	60.84	248.34	2105

The average discharges vary between 56.68 m<sup>3</sup>/s (2000 cfs) and 623.45 m<sup>3</sup>/s (22000 cfs).

The slope of the River Ravi is about 0.0356 m per 304.9 m upstream of Shahdara and 0.0609 m per 304.9 m downstream of Shahdara. The water levels in River Ravi and simultaneously in drains, as taken from MMI investigation, are given below:

	Shad Bagh	Shahdara	Babu Sabu
Distance from Shahdara (m)	3048.7	0	13,109.7
Water level on 16-10-1991 (m) AMSL	205.6	205.7	202.4
Difference in level from Shahdara (m)	+ 0.488	-	- 3.29

### 5.3.3 Soil Type/ Land Use

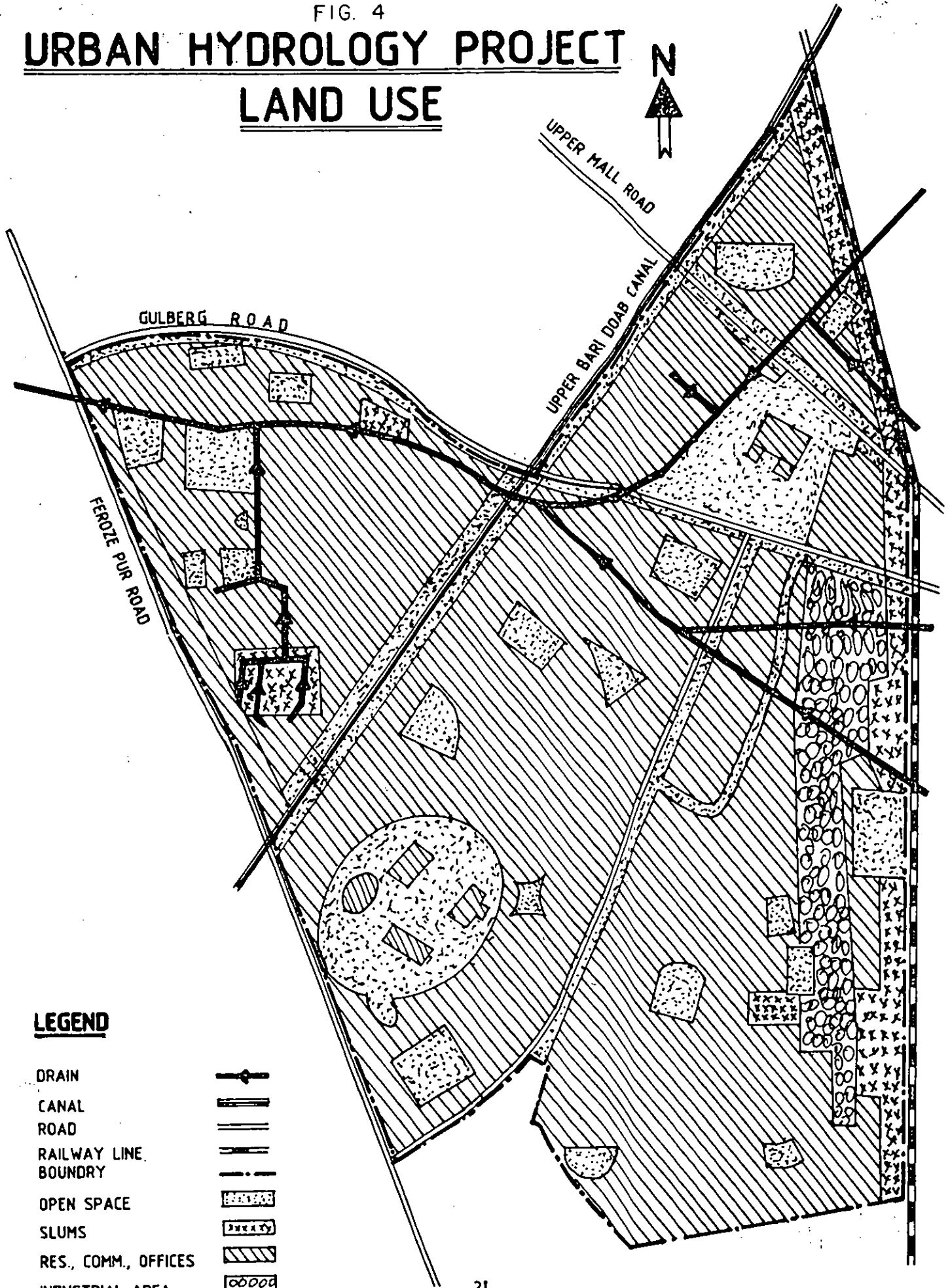
A major part of the catchment is occupied by residential area, commercial buildings and offices. The land use characteristics of the catchment is shown in fig.4. Following land use type have been identified on the map (fig.4).

#### i. Open Spaces

Open spaces are scattered in the form of small patches. The soils in the open spaces are composed of generally calyey silt to silty clay with little sand covered by grass at most of the places. Tree covers are seen at certain locations. Large open areas are at Qaddafi stadium and Golf course as shown on fig.4. The grounds are well covered by grass.

FIG. 4

# URBAN HYDROLOGY PROJECT LAND USE



## LEGEND

- DRAIN
- CANAL
- ROAD
- RAILWAY LINE
- BOUNDARY
- OPEN SPACE
- SLUMS
- RES., COMM., OFFICES
- INDUSTRIAL AREA

ii. Slums

Slums have been identified near Fazlia colony and near Shah Jamal Zariat. The area is overcrowded, squalid with poor houses and poor sewer drainage.

iii. Residential / Commercial Offices

Most of the catchment is occupied by residential area/ commercial buildings and offices. In Gulberg area there are mainly bungalows, commonly from 1 Kanal to 8 Kanal for the residences of locals. Nearly each bungalow contains lawn or open space. The roofs of these houses are made of concrete and bricks. The sewerage system is better in this part of the catchment. Similarly in Shadman and Shah Jamal areas the houses are comparatively big (1 to 4 Kanal). Small houses are located near Shama cinema (which is the outlet point of the catchment) and near Shah Jamal Zariat.

iv. Industrial Area

In the east and south east of catchment, industrial area have been identified. Glass industry and Pepsi Cola are located in the area. The effluent from these industries drains into the drainage system. The area is marked on fig.4

## 5.4 HYDRAULIC DATA

X-sections and L-sections of the drains are available from WASA and already published reports by different consultants. The X-sections of the area of interest were collected, and used for the study. ( fig.9 through 13 and table.10)

### 5.3.5 Climatological Data

Long term data of temperature, evaporation and wind velocity etc. are available from Met Department. The weather in summer is extremely hot and in winter it is moderately cold. Evaporation rates are high during summer. Due to high rate of evaporation and high temperature, the soil absorbs large fraction of rainfall as initial abstraction.

## 5.4 ANALYSIS OF AVAILABLE DATA

### 5.4.1 Rainfall Analysis

Frequency analysis on maximum annual daily rainfall data, from previous investigations suggested:

Return Period (Yr)	Max. Daily Rainfall mm(in)	
	City	Airport
1.25	58.2	56.6
2	81.3	84.6
5	125.2	130.6
10	159.5	167.4

It has been suggested that it is acceptable to use the 3-hours to 12-hours maximum for the city rainfall station. It is

further suggested that 2-years return period is relevant for the design of the drain.

To determine short duration rainfall, the help from the autographic record was taken where 18 years were missing. Table.7 shows the data accumulated into the highest 15, 30, 60 and 120 minute period. There are 25 instances where there are data for both the autographic and 3 hourly records. Regression analysis is carried (as reported from already published material) relating the 3-hr intensity to lower duration intensities such as 15, 30, 60 and 120 minutes duration. These relationships when the rainfall is in inches are given below:-

Duration (min)	Relationship	Correlation ( $R^2$ )
15	$0.2747 * 3 \text{ HR} - 0.339$	0.54
30	$0.5485 * 3 \text{ HR} - 3.763$	0.57
60	$0.7515 * 3 \text{ HR} - 5.469$	0.67
120	$0.8957 * 3 \text{ HR} - 4.644$	0.80

$R^2$  value showed that large duration has better correlation. Frequency analysis was carried out following results were obtained (Ref: MMI 1991).

Fitted Distribution (inches)	Duration							
	15 min	30 min	1 hr	2 hr	3 hr	6 hr	9 hr	12 hr
Return Period (Yr)								
2 yr	0.53	0.92	1.29	1.65	2.03	2.47	2.61	2.75
5 yr	0.85	1.56	2.18	2.70	3.16	3.73	3.87	4.12
10 yr	1.12	2.11	2.91	3.54	4.12	4.65	4.91	5.28
Intensity (in/hr)								
2 yr	2.1	1.85	1.29	0.83	0.68	0.41	0.29	0.23
5 yr	3.38	3.12	2.18	1.35	1.05	0.62	0.43	0.34
10 yr	4.49	4.73	2.91	1.77	1.37	0.73	0.55	0.44

Table 7  
Short Duration Maximum Rainfall (mm)

Year	Duration in minutes				3 Hourly
	0-15	0-30	0-60	0-120	Record
1940	23	42	52	52	56
1941					
1942	9	17	25	36	55
1943					
1944					37
1945					
1946					42
1947	6	6	8	10	31
1948					82
1949	6	7	8	10	13
1950	5	10	18	25	43
1951	9	14	16	29	
1952	9	15	23	23	
1953					133
1954					148
1955	14	28	56	85	69
1956	11	20	36	56	66
1957	7	9	9	15	36
1958					106
1959	28	47	57	66	69
1960	13	23	31	37	44
1961	13	21	30	34	26
1962					77
1963					24
1964					71
1965	12	13	13	22	39
1966	7	10	11	12	14
1967					28
1968					72
1969	8	16	24	27	117
1970	8	14	22	33	36
1971	10	18	26	29	
1972	8	11	19	35	
1973	23	39	54	70	
1974	10	20	34	36	36
1975	32	41	41	41	42
1976					
1977					
1978	33	66	76	80	85
1979					38
1980	20	30	48	65	74
1981	13	24	29	46	71
1982	15	25	36	40	40
1983	20	39	62	77	85
1984	10	19	19	36	40
1985	10	20	30	34	40
1986					38
1987	10	18	26	26	59
1988					35
1989					24
1990					61

i) Intensity Duration Curves:

Intensity Duration curve relationship may be fitted to the plotted points by following equation:-

$$I = \frac{a}{(T_d + b)^c}$$

Where

I = average rainfall intensity in mm/hr

$T_d$  = storm duration in minutes

a, b, c = constants

The above expression may be written as

$$\text{Log}(I) = \text{log}(a) - [c * \text{log}(T_d + b)]$$

The already published material suggests the following values of a b c for Lahore.

Constant	Return Period (yr)		
	2	5	10
a	1653	4448	6148
b	40	48	46
c	0.8502	0.9406	0.9536
R <sup>2</sup>	0.999	0.998	0.997

The design short duration intensities for Lahore, calculated, by above coefficients are given in table 8. The intensity duration frequency curve for Lahore is presented in fig.5. To derive synthetic storm profiles based on IDF curves, MMI (1991) suggested that it was a typical Chicago storm profile, in which the volume below the IDF curve was presented throughout the specified duration of the storm.

#### 5.4.2 Flow Analysis

As reported in previous publications, the discharge of the drains in Lahore city generally varies between 0.567 m<sup>3</sup>/s (20cfs) and 2.834 m<sup>3</sup>/s (100 cusecs) in monsoon period. The discharge of the Mian Mir drain as recorded on 5.9.91 and 8.9.91 by MMI, at foot bridge in between Fateh Sher Road and Poonch Road Samanabad (downstream of our last gauging station at Shama Bus Stand) was 1.436 m<sup>3</sup>/s (50.70cfs) and 1.5 m<sup>3</sup>/s (52.96 cusecs) respectively. While the velocity of flow was 1.57 and 1.64 ft/s.

Hydrographs of the River Ravi show that maximum flow in the river is generally during the month of August. Mean monthly discharge in August (1977-91) is 639 m<sup>3</sup>/s (22551 cfs). In few years the discharge in July was higher than that of August. The variation in monthly discharges and water levels in River Ravi can be observed from Fig.6.

Table.8  
Design Short Duration intensities for Lahore

Time Mins	2 Yr		5 Yr		10 Yr	
	Intensity mm/hr	Rainfall mm	Intensity mm/hr	Rainfall mm	Intensity mm/hr	Rainfall mm
5	65.0	5.3	106.2	8.9	144.5	11.9
10	59.4	9.9	97.5	16.3	132.1	22.1
15	54.9	13.7	90.4	22.6	121.9	30.5
20	50.8	17.0	84.1	27.9	113.0	37.6
25	47.5	19.8	78.7	32.8	105.4	43.9
30	44.7	22.4	73.9	36.8	98.8	49.3
35	42.2	24.6	69.6	40.6	93.0	54.4
40	39.9	26.7	66.0	43.9	87.9	58.4
45	37.8	28.4	62.5	47.0	83.3	62.5
50	36.1	30.0	59.7	49.8	79.0	65.8
55	34.5	31.5	56.9	52.1	75.4	69.1
60	33.0	33.0	54.4	54.4	71.9	71.9
65	31.5	34.3	52.1	56.4	68.8	74.7
70	30.5	35.6	50.0	58.4	66.0	77.0
75	29.2	36.6	48.0	60.2	63.5	79.2
80	28.2	37.6	46.5	61.7	61.0	81.3
85	27.2	38.6	44.7	63.2	58.7	83.3
90	26.4	39.6	43.2	64.8	56.6	85.1
95	25.7	40.4	41.7	66.0	54.9	86.9
100	24.6	41.1	40.4	67.3	53.1	88.4
105	24.1	42.2	39.1	68.6	51.3	89.9
110	23.4	42.9	38.1	69.6	49.8	91.2
115	22.6	43.4	36.8	70.9	48.3	92.5
120	22.1	44.2	35.8	71.9	47.0	93.7
125	21.6	45.0	34.8	72.6	45.5	95.0
130	21.1	45.5	34.0	73.7	44.4	96.0
135	20.6	46.0	33.0	74.4	43.2	97.0
140	20.1	46.7	32.3	75.4	42.2	98.0
145	19.6	47.2	31.5	76.2	40.9	99.1
150	19.1	47.8	30.7	77.0	40.1	100.1
155	18.8	48.3	30.0	77.7	39.1	100.8
160	18.3	48.8	29.5	78.2	38.1	101.9
165	17.8	49.3	28.7	79.0	37.3	102.6
170	17.5	49.8	28.2	79.5	36.6	103.4
175	17.3	50.0	27.4	80.3	35.8	104.1
180	16.8	50.5	26.9	80.8	35.1	104.9
185	16.5	51.1	26.4	81.3	34.3	105.4
190	16.3	51.3	25.9	82.0	33.5	106.2
195	16.0	51.8	25.4	82.6	32.8	106.7
200	15.7	52.1	24.9	83.1	32.3	107.4

Fig.5  
Intensity Duration Curve

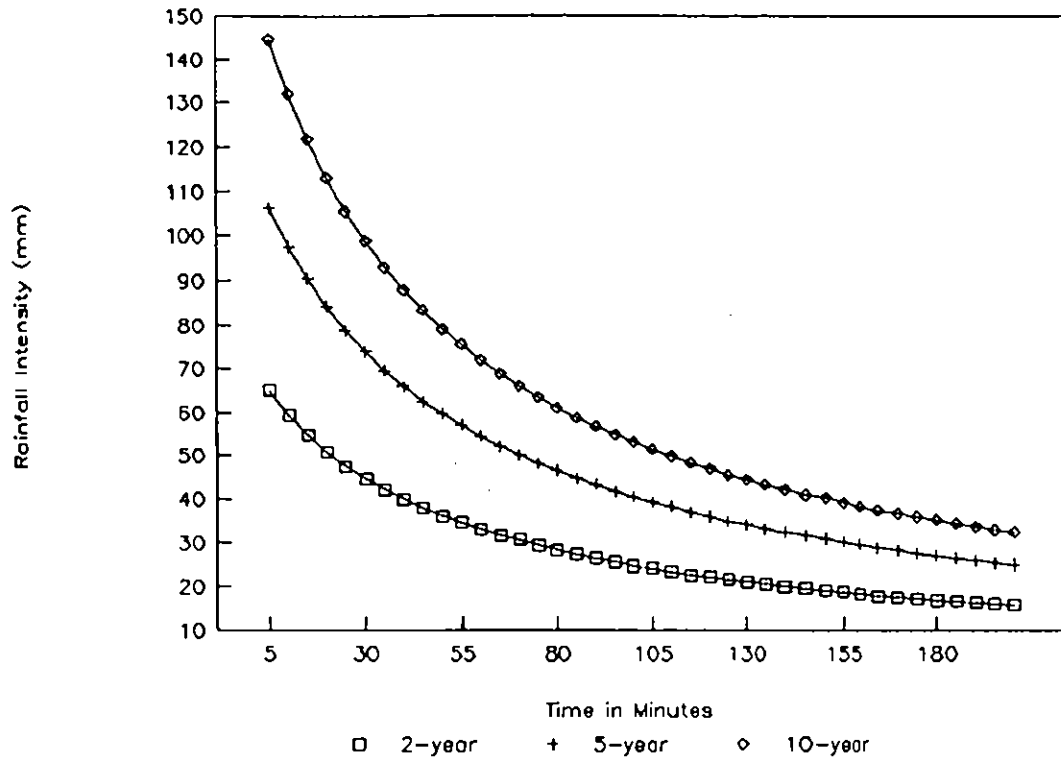
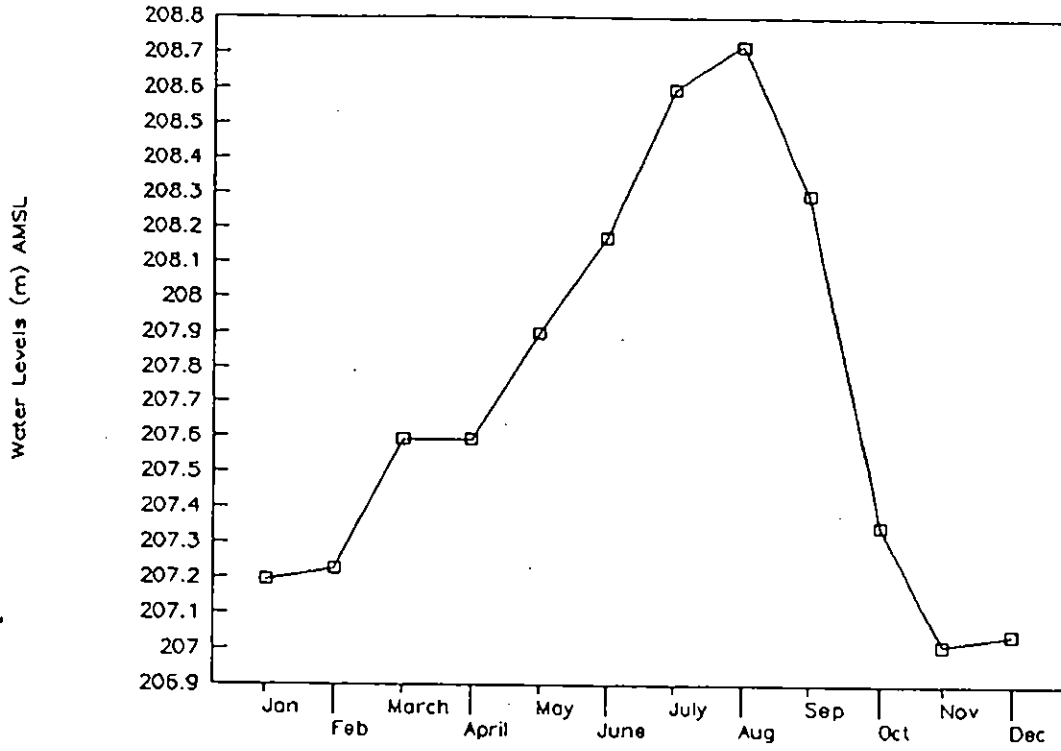
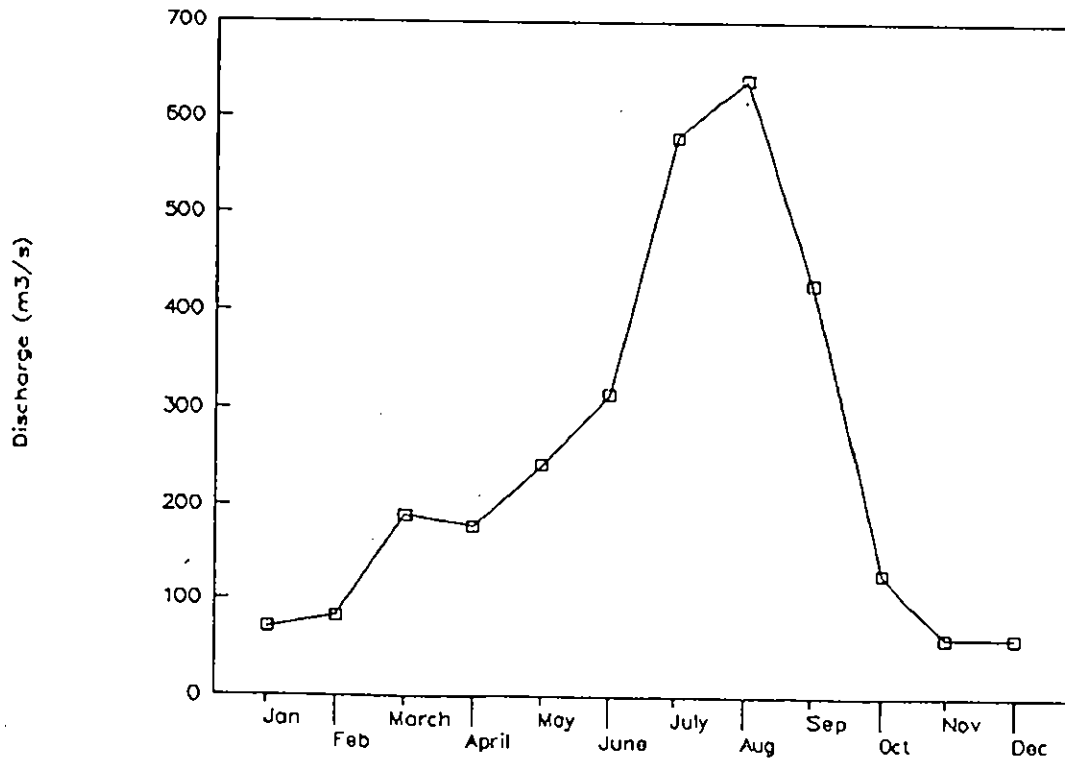


Fig.6

Mean Monthly Water Levels In Ravi River



Mean Monthly Discharge of Ravi River



#### 5.4.3 Models Used in Previous Design Studies

Several alternative models have been discussed but few were considered to be fit for the design, these are

- Rational formula
- The TRRL approach
- The WALLRUS model
- ILLUDAS
- The USSCS approach
- Kinematic wave approaches
- The MIDUSS model
- The hydro model

##### i) Rational Formula

The formula is given by:

$$Q_p = C I A$$

Where

- $Q_p$  = peak discharge in cumecs
- $i$  = Average intensity during time of concentration  
(m/s)
- $A$  = Area of the catchment in sq. meters.

It is proposed to calculate time of concentration by SCS equation

$$T_c = \left[ 0.87 \frac{L^3}{H} \right]^{0.385}$$

Where

- $T_c$  = Time of concentration  
 $L$  = Length of stream in Km  
 $H$  = The level difference in meters between the high and low ends of the catchment

After calculating  $T_c$ , the intensity of rainfall for the return period required is read from Fig.5. The value of  $C$  varies between 0 and 1. In previous studies the value of  $C$  is generally adopted as 0.7 for use in Lahore.

#### ii) The TRRL Approach

The method (Technical paper TP 55, Road Research Laboratory, 1962, 1963, updated Note 35, 1976) employs a time area diagram for calculating a hydrograph of overland flow contributing to individual pipes in the network and then uses storage routing to route these through the sewer network. Some limitations of the model are overcome in computer program HYDRAN. However the approach is not considered suitable for Lahore catchment (MMI 1991).

#### iii) The ILLUDAS Model

The model was developed for Illinois Urban Drainage area,

USA (Terstriep and Stall 1974). It is based on TRRL approach. The unpaved areas are considered in more detail. The main limitations relate to the computation of travel times for unpaved areas and the storage routing technique resulted in conservative design.

iv) The USSCS Method

The US Soil Conservation Services (McCuen 1982) developed the method for small watersheds. Effective rainfall for runoff is calculated by

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

Where

- Q = Depth of effective rainfall in inches
- P = Depth of rainfall in inches
- S = Potential storage in soil

$$S = \frac{1000}{CN} - 10$$

- CN = Curve Number obtained from soil type and cover complex etc.

The method does not provide the means for routing through piped systems.

v) The MIDUSS Model

MIDUSS (Micro-computer Interactive Design of Urban Storm Water System) was originally developed by Department of Civil Engineering at McMaster University, Hamilton, Ontario, 1985. the main features of the model are:

- preparation of design storm profile
- calculation of effective rainfall by the SCS method, the Horton method or the Green and Ampt method.
- Routing the effective rainfall to the drainage network overland by a rectangular option, a triangular option, a linear reservoir option or the SWMM/RUNOFF option.
- The design of a drainage system, piped or open channel and routing runoff through this by Kinematic wave routing.

The runoff models available are

- rectangular response function
- triangular unit hydrograph
- Linear reservoir
- The SWMM/RUNOFF option

In the NESPAK report, the design discharge for the proposed network is calculated for 2-years return period storm, with the help of triangular hydrograph method. For catchments where time of concentration is less than 1 hour, Rational method was

used.

The MMI report, uses MIDUSS model by selecting SCS option and routing through the pipes.

vi) The HYDRO Model

HYDRO model (developed by Mott. MacDonald) is a one dimensional dynamic flow simulation model to produce accurate information of the river or drainage system.

The model uses mass conservation at each node

$$\sum Q_o - \sum Q_r = 0$$

and mass conservation within channels

$$\frac{dQ}{dx} + \frac{dA}{dt} - q = 0$$

Where

A = Flow area

q = lateral inflow per unit length

A comparison of recorded and simulated water levels on discharges at important locations is required to calibrate and validate the model. the model is extensive and can be used in connection with MIDUSS which computes inflow hydrographs from storm

rainfall, as reported in the MMI report.

### 5.5 CHARACTERISTICS OF DRAINAGE AREA

A part of Lahore drainage system is selected for the study. The selected area starts from Lahore Cantt and Mian Mir Railway Crossing and ends at Shama Bus Stop at Ferozpur Road. The drainage area is mainly Urban. A major part of the area is covered by residential houses, and buildings, with network of roads. In Gulberg and Shadman/Shah Jamal area, nearly each residential house contains lawn with grass cover. Some major lawns like, Golf course, are located within the catchment. The area of drainage basin is generally flat with little gentle slopes at places.

An important feature of the catchment is this that a big canal (Lower Bari Doab Canal) passes almost in the middle of the catchment. The storm drain crosses the canal through an underground syphon at canal park area. The ground level at upstream reach of channel at Lahore Cantt is 214.5 m. AMSL while at downstream end at Shama cinema at Ferozpur Road is 210.6 m AMSL. The catchment area is shown in Fig.2.

### 5.6 SELECTION OF GAUGING SITES

To initiate the research studies, it was necessary to acquire the water levels/flow data of the drainage system especially during the monsoon period which starts usually by the end of June. The gauging site selection was mainly based on channel network condition of the storm drainage system. As per fig.2 the

gauging was installed at the upper boundary of catchment (inflow points), at confluences (where two or more drains meet) and at outlet of the project area. Seven depth meters, three rain gauges and one velocity/depth meter WATER RAT have been installed. the selected sites are marked on Fig.2 and are detailed below:-

	<u>Site No.</u>	<u>Location</u>	<u>Logging Start on</u>
i) Depth Meter	1	Railway Crossing near Sherpao Bridge Lahore Cantt	7-9-1994
	2	Railway line at Ch.Niaz's house, Lahore Cantt.	31-8-1994
	3	G-block at WASA pumping station Gulberg-II	7-9-1994
	4	Bridge of Jail Road at Zafar Ali Road	7-9-1994
	5	Bridge of LBD canal at Canal Park Gulberg	7-9-1994
	6	Bridge on Ferozepur Road near Shama Bus Stop	8-9-1994
	7	Near Railway Bridge at Mian Mir	12-7-1994
ii) Velocity meter (RAT)	3	G-block at WASA pumping station Gulberg-II	13-9-1994
iii) Rain Gauge	1	Main Gulberg near Kabana	8-8-1994
	2	WASA office at Shah Jamal	8-8-1994
	3	Upper Mall, WASA office	8-9-1994

## **5.7 INSTALLATION OF GAUGING INSTRUMENTS**

### **5.7.1 General**

The installation of gauging instruments in the project area was initiated in the month of August 94. The monsoon was already started. The delay in installation was due to the problems in clearance of instruments from custom. The instruments were installed in a very protective and safe manner. For depth loggers and RAT, special type of boxes, made of metal, were designed and being made from the market workshop. The loggers are placed in these boxes and locks are provided to each box-to prevent any mishap at the site. These boxes are fixed at a nearby wall (e.g. pillar of a bridge) about 6 feet high from ground level. the connecting cables between sensor and logger were covered by special type of spiral pipes which could be easily bended in all direction. The sensors were placed in the centre of the drain in such a location where there is a minimum chance of sensor displacement by sediments or cows at certain times in the drain.

Each rain gauge was installed at the top roof of single storied building. These were fixed on the roofs with nets and bolts. Stair case was used to down load the data. The rain gauges were quite safe.

### **5.7.2 Depth Loggers and Data Acquisition**

The depth logger are NEWLOG sx type. The calibration was carried out for each logger before to install. The batteries power of the loggers are checked whether these are ok or not. At each

site, the logger and sensor are installed and their serial No. is recorded for reference and record. These are given below:-

Site	Logger No.
1	194276341
2	194276340
3	194276337
4	194276338
5	194276336
6	194276339
7	

For location of sites see section 5.6. The Newlogs were downloaded regularly. A laptop computer was provided for data acquisition. A GPS (General purpose software) was used for communication with depth loggers. The minimum time base for depth loggers is 30 minute. The data was saved to the files with extension NWL (e.g. DATA 02.NWL). These files are then translated to the Report Files (ASCII files) with the help of GPS software. The data so acquired are placed in Annexure-1.

### 5.7.3 Autographic Rainfall Recorders

These are 400 cm<sup>2</sup> tipping bucket gauge made by Casella London Limited, England. the instrument employs a light weight plastic injection molded 'flipping bucket' and support assembly. At each tip of the bucket a magnet, contained within the bucket molding, closes a reed switch mounted in the support assembly. The pulses thus emitted represent discrete amounts of rainfall which can be counted by a number of methods.

Three number rain gages are installed at various locations in the catchment (see section 5.6). The power of batteries was checked and the instruments were calibrated as per manual instructions. The instruments were installed at same place to avoid any mishap in the field (see section 5.7).

To download the data, the software RAINLOG was used. It was installed in the laptop computer. The software was developed by Prolec Ltd, U.K. The software is communicated with RAINLOG data logger which is compact rainfall measuring logger used in the rain gage, for storing the data.

The software RAINLOG is an interactive menu driven program to download the data from the rain logger and to save it in the appropriate data file (s). The graphs of the rainfall hyetograph can also be obtained from the package, with the help of view graph/plot options. All the recorded data downloaded from the three rain gauge sites are placed in Annexure.2.

#### 5.7.4 Flow Survey Loggers (WATER RATS)

At this stage of the project, WATER RAT flow survey logger could only be installed at one site. These loggers are made by PROLEC Ltd, U.K. to collect velocity and depth information for fluids flowing in open and closed pipes principally sewers. The data may be used in the assessment of the hydraulic performance of sewers and open channels. These are approved for use in hazardous areas. As reported, it may be used in all situations normally found in sewers.

Velocity is measured using Doppler shifted ultra sound techniques, and the depth using a pressure-transducer. The two transducers are mounted in a stream lined PVC housing that can be fitted to securing strap located in the sewer. With the help of laptop IBM compatible computer, and HYDROLOG software the parameters are set, and instrument is calibrated. The rechargeable batteries of the RAT are charged properly before to install at site.

Site 3 (G. Block, Gulberg-II) was selected for RAT. The data was download for the recorded period with the help of HYDROLOG software for onward transmission to the CEWRE computer system for subsequent analysis. The HYDROLOG software was developed by Prolec Ltd., U.K. It is a menu driven interactive program, saving the data in appropriate files and plot the depth and velocity on graph if desired. (For details please see the manuals). The data from site were downloaded regularly and placed in Annexure-3.

#### 5.7.5 Infiltrometer Tests

At this stage of the project, two infiltrometer tests were performed to determine the infiltration capacity of soil in the catchment. The location of infiltrometer test sites are shown in Fig.2, as detailed below:

<u>Test</u>	<u>Site</u>	<u>Date</u>	<u>Physical Appearance of Soil</u>
1	Grave Yard, near drain No.2 near Ch.Niaz house (Depth logger site 2)Cantt.Area	30-8-94	Clayey silt with little sand (dense)
2	St.Mary's High School, Gulberg (Ground)	31.8.94	Clayey silt with little sand (dense)

The inner dia of infiltrometer ring is 30 cm while the inner dia of buffer area ring is 45 cm. The levels of water in inner ring and buffer ring was kept constant. The buffer area is filled with water for 1/2 hour before to fill the inner area. A level recorder was placed in the inner ring to measure the drop of level at intervals of 5, 10, 15, 20, 30, 30, 30 minutes. The detailed test results are presented in table.9 and infiltration curves are plotted in Fig.7 and 8 and summary is given below:

<u>Site</u>	<u>Test</u>	<u>Constant infiltration rate</u>	<u>Maximum initial rate</u>
1	1	1.10 cm/hr	9.6 cm/hr
2	2	0.80 cm/hr	1.8 cm/hr

## 5.8 Data Handling and Tabulation

### 5.8.1 Rainfall Data

The data from all the three sites of autographic rainfall measuring stations (fig.2) are downloaded for the monsoon period on about 7-15 days intervals. Because the gauges were at higher elevations (located on high roofs of offices), there was less danger of any man made mishandling of the instruments. However the gauges were checked regularly on short intervals in a week. To download the data IBM compatible laptop computer with RAINLOG software have been used. The data are saved by the DOWNLOAD option of the software in individual subdirectries of each sites. Each time, after downloading the data the memory of the RAIN logger is cleared with the help of SETUP/STATUS/EDIT option of the program to make room for the next data storage. The printouts and plots were obtained with the RAINLOG software options. The data so obtained from the three sites in the catchment are presented in Annexure.1.

Table.9  
Infiltration Test No.1  
Location Near Depth Logger Site.2 Lahore Cantt. (Ch Niaz House)

Sr. No.	Time min	Elapsed Time	Infiltration cm	Infiltration cm/hr
1	5	5	0.8	9.6
2	15	10	0.6	3.6
3	30	15	0.7	2.8
4	50	20	0.7	2.1
5	80	30	0.8	1.6
6	110	30	0.65	1.3
7	140	30	0.55	1.1

Infiltration Test No.2  
Location: St. Mary's High School (Ground)

Sr. No.	Time min	Elapsed Time	Infiltration cm	Infiltration cm/hr
1	5	5	0.15	1.8
2	15	10	0.15	0.9
3	30	15	0.2	0.8
4	50	20	0.2	0.6
5	80	30	0.4	0.8
6	110	30	0.4	0.8
7	140	30	0.4	0.8

Fig.7  
Infiltration Test.1 at Site.2

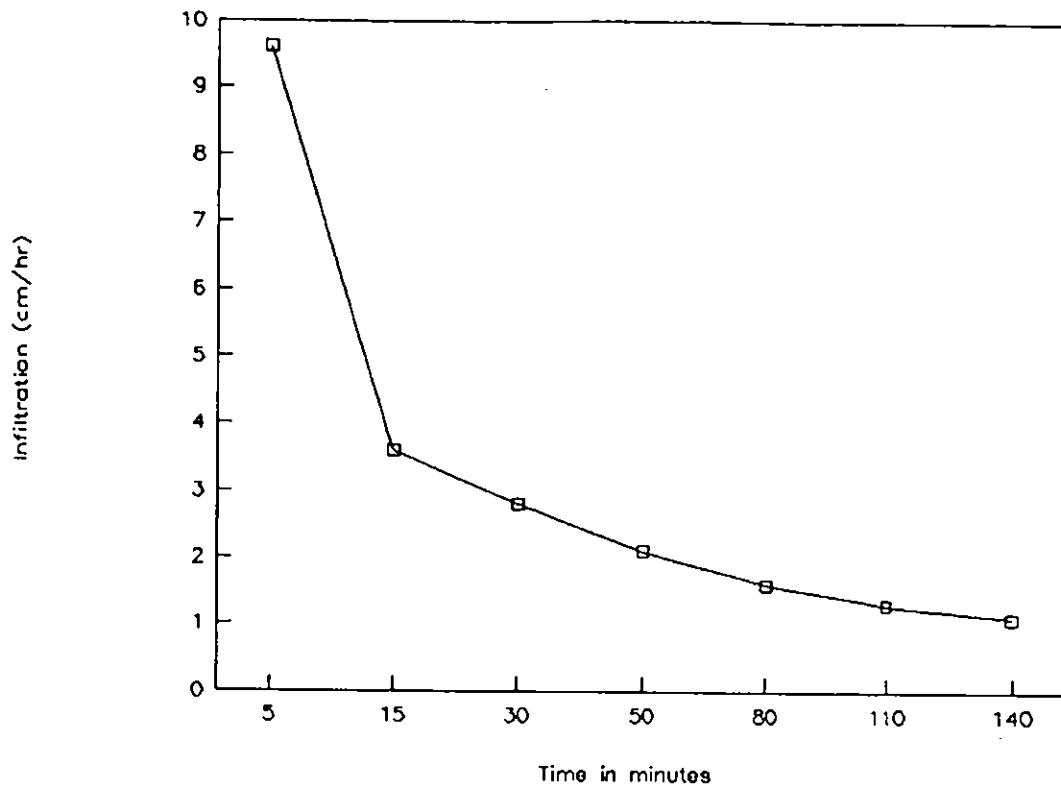
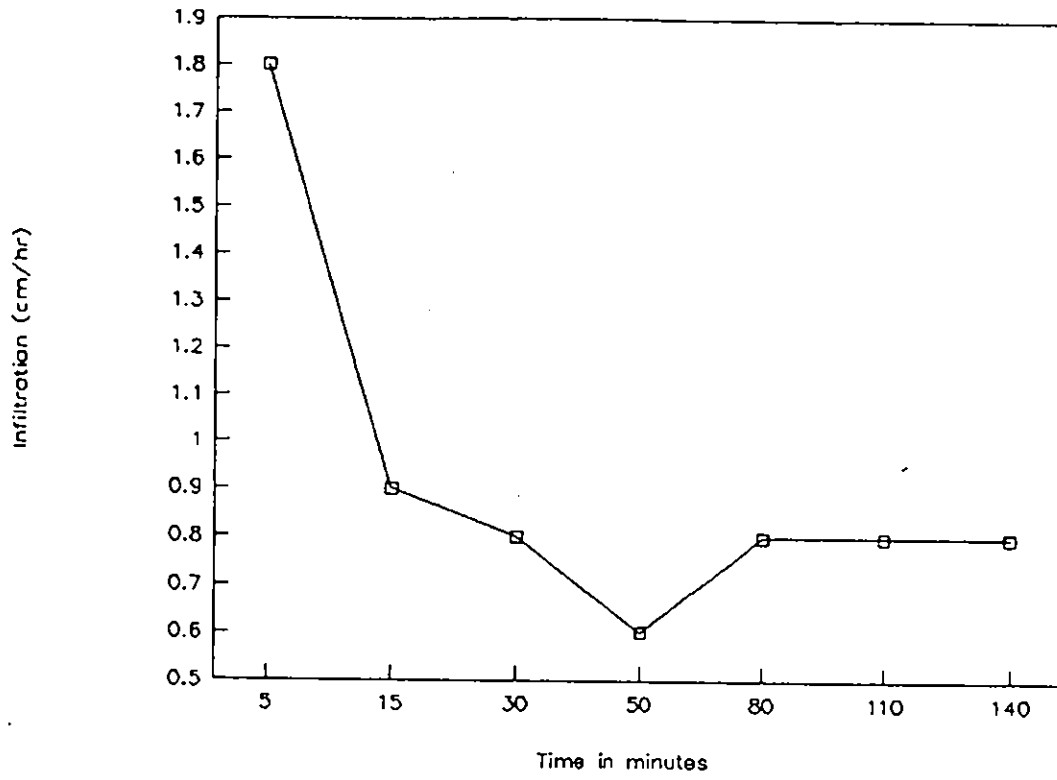


Fig.8

Infiltration Test.2 at St Mary School



### 5.8.2 Depth Logger Data

The data from all the seven sites (fig.2) are downloaded for the monsoon period on about 7-15 days basis. However the correct placement of pressure transducer in the bottom of the drain is regularly monitored on short intervals in a week. To download the data IBM compatible laptop computer with GPS software have been used. The data are saved by the READ menu of the GPS software in individual files of each sites. These data are saved in the files with names DATA\*.NWL where \* represents any digit (e.g.01). These files are in GPS software format. These are then transformed to ASCII files with the help of REPORT option in GPS software. Each time, after downloading the data the memory of the each logger is cleared with the help of STOP/STANDBY/CLEAR option of the program to make room for the next data storage.

Another option to get ASCII files of the data and to plot the data is the program NWLREAD written by J Packman in FORTRAN. The program is helpful to store the data in each subdirectory created for each site and to get ASCII format of Data. Plots of the data with depth vs time were obtained with the help of program NWLREAD. The minimum time base of the depth loggers is 30 minutes.

The data so obtained from the seven sites on the selected drainage system are presented in Annexure 2.

### 5.8.3 Velocity/Depth Logger Data (WATER RATS)

Unfortunately at this stage of the project, WATER RATS could only be installed at one site due to perhaps some calibration problem with the instruments. The WATER RAT was installed at Depth logger site No.3 (fig.2). The data are downloaded for the monsoon period on about 7-15 days basis. However the correct placement of pressure transducer in the bottom of the drain is regularly monitored on short intervals in a week. However the data at this stage is less reliable due to less familiarity with the instrument. To download the data IBM compatible laptop computer with HYDROLOG software have been used. The data are saved by the DOWNLOAD option of the software in the subdirectory of the HYDROLOG file of site.3. Each time after downloading the data the memory of the WATER RAT is cleared with the help of SETUP/STATUS/EDIT option of the program to make room for the next data storage. The printouts and plots were obtained with the HYDROLOG software options.

The data so obtained from the site.3 are presented in Annexure 3.

### 5.8.4 Cross sections and L-Sections of the Drainage System

At each gauging site of the drain the cross sections across the Nala were prepared . These are presented in fig.9 through 13. The dimensions of the drain at various sections are tabulated in table.10. It includes top levels, depth of drain, Top width, bed width, water surface level, and ground level at each selected section.

PARAMETERS FOR SECTIONS OF DRAINS

Table 10  
Sheet 1 of 2

SECTIONS	TOP LEVELS		INVERTED LEVELS (METERS)	DEPTH OF DRAIN (METERS)	TOP WIDTH (METERS)	BED WIDTH (METERS)	M.S.L (METERS)	N.S.L	TOP LEVEL OF DRAINS
	LEFT (METERS)	RIGHT (METERS)							
1-1	213.676	213.613	211.156	2.52	3.40	3.40	0.75	213.676	213.676
2-2	214.799	214.474	212.089	2.71	3.13	3.13	0.75	214.799	214.799
3-3	213.099	214.720	213.610	1.11	3.50	3.50	0.53	214.720	214.720
4-4	212.429	212.837	211.367	1.47	2.10	3.10	0.63	213.397	212.837
5-5	212.373	212.525	211.125	1.40	3.32	4.32	N.A	213.425	212.525
6-6	211.951	211.710	210.491	1.46	10.48	10.48	0.55	213.241	211.951
7-7	211.235	211.616	210.386	1.23	3.48	3.48	0.65	212.765	211.616
8-8	210.264	210.760	209.357	0.91	9.05	9.05	0.65	211.800	210.267
9-9	210.489	208.437	209.039	1.45	5.00	5.00	0.40	212.089	210.489
10-10	210.042	210.225	209.125	1.10	6.50	6.50	0.60	211.750	210.225
11-11	210.273	209.461	208.092	1.50	5.50	5.50	0.30	211.573	209.592
12-12	214.382	214.498	213.340	1.10	4.00	4.00	0.40	214.498	214.440
13-13	214.228	214.228	213.389	1.10	5.00	5.00	0.40	214.489	214.489
14-14	214.300	213.819	212.728	1.5	2.80	2.80	0.40	214.300	214.228
15-15	213.739	213.773	213.200	1.10	5.00	5.00	0.40	213.773	214.300
16-16	213.400	213.453	212.573	1.20	4.00	4.00	0.20	213.452	213.773
17-17	213.274	213.269	212.152	1.30	4.00	4.00	0.40	213.274	213.452
18-18	213.199	213.498	211.774	1.50	6.00	6.00	0.30	213.498	213.274
19-19	213.317	212.992	212.398	1.10	4.30	4.30	0.40	212.992	213.498
20-20	210.595	210.533	212.317	1.00	3.40	3.40	N.A	212.725	213.317
21-21	214.469	214.983	212.726	2.00	6.80	6.80	0.70	214.983	214.726
22-22	214.050	214.148	213.548	0.60	2.10	2.10	0.45	214.148	214.148
23-23	214.020	214.303	213.103	1.20	2.40	2.40	0.45	214.303	214.303
24-24	214.459	214.159	212.659	1.50	3.10	3.10	0.40	214.459	214.159
25-25	211.858	211.157	210.143	1.50	4.10	4.10	N.A	213.158	211.643
26-26	211.373	210.756	210.023	1.35	10.21	10.21	0.45	212.763	211.373
27-27	211.630	211.320	210.100	1.53	5.97	5.97	0.39	212.680	211.630
28-28	210.425	210.361	208.711	1.65	6.50	6.50	0.30	211.475	210.361
29-29	211.245	211.400	208.600	1.35	5.55	5.55	0.30	211.400	210.00
30-30	211.250	211.178	208.500	1.35	3.50	3.50	0.30	211.250	209.995
31-31	209.557	209.185	208.357	1.20	10.50	10.50	0.30	210.985	209.557
32-32	209.716	209.533	208.966	0.75	10.30	10.30	0.30	210.716	209.716
33-33	209.381	209.718	208.718	1.00	12.8	12.8	0.40	211.101	209.718

PARAMETERS FOR SECTIONS OF DRAINS

SECTIONS	TOP LEVELS		INVERT LEVEL (METERS)	DEPTH OF DRAIN (METERS)	TOP WIDTH (METERS)	BED WIDTH (METERS)	W.S.L (METERS)	N.S.L	TOP LEVEL OF DRAINS
	LEFT (METERS)	RIGHT (METERS)							
34-34	208.018	207.633	206.633	1.00	7.8	7.8	0.65	210.683	207.633
35-35	208.152	208.200	206.700	1.5	9.8	9.8	0.60	210.35	208.200
36-36	210.406	210.594	207.744	1.2	6.5	6.5	0.60	210.944	208.944
37-37	210.979	210.729	207.529	1.5	7.0	7.0	0.30	210.979	209.029
38-38	210.550	219.894	205.894	1.5	6.0	6.0	0.60	210.550	207.394
39-39	211.170	211.050	207.700	2.1	3.35	3.35	1.40	211.170	209.800
40-40	210.850	210.130	208.100	1.2	7.3	7.3	0.30	211.93	209.380
41-41	209.887	209.887	207.087	1.0	15.0	15.0	0.40	209.887	208.087
42-42	209.667	209.700	206.900	0.9	14.2	14.2	0.45	209.700	207.750
43-43	209.000	209.750	206.400	0.9	6.5	6.5	N.A	209.000	207.200
44-44	209.930	209.730	206.080	0.85	7.0	7.0	0.40	209.930	206.930
45-45	210.640	210.567	205.990	1.65	13.3	13.3	0.75	210.640	207.640

### 5.8.5 Acquisition of Data after Monsoon Period

After the monsoon period the instruments were temporarily removed from the sites for the maintenance and battery charging/replacing etc. Also it was not save to place the instruments at sites for a longer period due to the chances of any damage with the instruments as the area is densely populated. When winter started the instruments were again temporarily installed at each site to get data for the winter season. Some new sites are also identified to get good correlation and data for the same were collected. Details of the data collected in winter by depth logger are given below:

Site	Location	Date	Depth (m)
1	Lahore Cantt	22.12.94	
2	Ch.Niaz House Cantt	22.12.94	
3	G block Gulberg II	31.12.94	0.330
4	Jail Rd/Zafr Ali Rd	21.12.94	0.389
5	Canal bank/Canal Pk	31.12.94	0.459
6	Near Shama cinema	31.12.94	0.373
7	Mian Mir colony	21-12-94	
New Sites			
8	Gulberg-III, Sichuan Chinese Restaurant	22.12.94	
9	Gulberg-III, Drain.2 at Home economics college	22.12.94	0.457
10	Gulberg-III, Drain.1 at Home economics college	22.12.94	0.457

Unfortunately the WATER RATS did not work properly perhaps due to some instrument problems. Therefore current meters were tried to get velocity, but these were also no successful due to high sediments in the drains. It was imperative to get the data with help of float area method. The procedure was adopted for all the sites. The data is presented given below:

Site	Location	Date	Discharge(m <sup>3</sup> /s)
1	Lahore Cantt.	22.12.94	0.235
2	Ch.Niaz House Cantt	22.12.94	0.714
3	G block Gulberg II	31.12.94	0.571
4	Jail Rd/Zafr Ali Rd	21.12.94	0.819
5	Canal bank/Canal Pk	31.12.94	1.528
6	Near Shama cinema	31.12.94	2.335
7	Mian Mir colony	21-12-94	0.443
New Sites			
8	Gulberg-III, Sichuan Chinese Restaurant	22.12.94	-
9	Gulberg-III, Drain.2 at Home Economics college	22.12.94	0.658
10	Gulberg-III, Drain.1 at Homeconomics college	22.12.94	0.610

The details of the winter discharge data with float area method is presented in table.11

# DRAIN DISCHARGE DATA

Table II

NO.	FLOW DEPTH (METERS)	FLOAT METHOD PARAMETERS		SURFACE VELOCITY (M/SEC)	AVERAGE VELOCITY (M/SEC)	AREA OF X-SECTION (METER <sup>2</sup> )	AVERAGE DISCHARGE (CM/SEC)
		TIME (SECONDS)	DISTANCE (METERS)				
1.	0.483	64.00	21.107	0.3298	0.2638	1.6524	0.4433
2.	0.4698	80.00	26.8190	0.3352	0.2682	3.0537	0.8190
3.	0.3429	33.00	19.5048	0.5911	0.4728	4.3891	2.0752
4.	0.4863	85.98	30.1714	0.3509	0.2807	4.1483	1.1644
5.	0.4571	62.00	25.2190	0.4068	0.3254	1.8741	0.6098
6.	0.4571	47.67	25.2388	0.5294	0.4235	1.5541	0.6582
* 7.	0.5719	29.22	6.7048	0.2295	0.1836	3.8888	0.7140
8.	0.2540	104.40	30.1714	0.2890	0.2312	1.0160	0.2350
9.	0.6476	90.00	30.5000	0.3389	0.2711	8.6131	2.3350
OLD 03.	0.3240	51.25	18.9100	0.3690	0.2952	1.9343	0.5710
OLD 05.	0.459	74.00	29.8900	0.4040	0.3232	4.7277	1.5280

## DESCRIPTION

- NO.1 AT MIAN MIR NEAR RAILWAY OVERHEAD BRIDGE.
- NO.2 BRIDGE AT THE JUNCTION OF GULBERG & ZAFAR ALI ROADS.
- NO.3 BRIDGE AT UPPER BARI DOAB CANAL (CONFLUENCE OF GULBERG & MAIN STORM WATER DRAINS).
- NO.4 FOOT BRIDGE INSIDE THE NURSARIES NEAR CONFLUENCE OF GULBERG DRAIN NOS. 1&2.
- NO.5 BRIDGE AT MAIN BLOUARD ROAD (LEFT OF COLLEGE OF HOME ECONOMICS).
- NO.6 BRIDGE AT MAIN BLOUARD ROAD (RIGHT OF COLLEGE OF HOME ECONOMICS).
- NO.7 BRIDGE AT GULBERG DRAIN NO.2 (500 FEET FROM RAILWAY LINE).
- NO.8 FOOT BRIDGE NEAR RAILWAY CROSSING (100 FEET FROM RAILWAY LINE).
- NO.9 BRIDGE AT FEROZEPUR ROAD (SHAMA BUS STOP).
- NO.OLD 03. BRIDGE IN G-BLOCK NEAR HASA SUB STATION.
- NO.OLD 05. BRIDGE AT SYPHON NEAR UNDER-PASS OF GULBER ROAD.

## 5.9 Understanding Rainfall Runoff Relationships

### 5.9.1 Analysis of Data (Preliminary)

From the collected data during monsoon the rainfall and water levels in the drain during a storm were analyzed. It has been seen that the rainfall in catchment is variable. A less rain is reported at a certain location while, it is high at another location. The response of rainfall to drain levels in upper reaches are comparatively less. Sewer component in the drains creates problem at certain location to understand rainfall runoff relationship. This component need to be investigated. Duration of rainfall over the catchment is variable in space domain. It effects the time of concentration of drain discharge. A detail analysis of the data with urban runoff techniques is in hand and it is hoped to get interesting results in near future.

## 5.10 Problems in Data Acquisition

### 5.10.1 WATER RATS

It is not understood that how much the WATER RAT data is reliable because of the following reasons:

- i. The RATS are designed for sophisticated sewers/ covered drains (as in UK) with less sediments. But in Lahore, the drains are full of solid sediments which abstract the velocity of the flow. If the

sensor of RAT mounted on a heavy steel plate (as in our case) is dropped in the drain, it settles into the thick sediment deposited in the bottom of the drains where the flow is already abstracted.

- ii. Perhaps there is no other alternative to check the accuracy of RATS except by current metering. But these were not successful in our drains.
- iii. WATER RATS need to be charged on monthly or bimonthly basis. Sometime it creates trouble as there is no indicator on the instrument to indicate whether the battery needs charging.
- iv. A detail training is desired to handle with RATS.

#### 5.10.2 Depth Logger

Depth loggers worked successfully during the monsoon and winter periods at all the seven sites. The minimum time base to store the data is 30 minutes. This interval cannot be reduced. However it is not a big problem as the data with 30 minutes interval is sufficient for analysis.

#### 5.10.3 Siltation/Sedimentation

Lahore city is mainly flat. It causes low velocities (less than 0.76 m/s (2.5 ft/s)). It causes sedimentation and

siltation in the drains. This problem is exacerbated by the public who dump their solid waste into these drains. There is no strict law to stop the people. Consequently the flows are low especially at the bottom of the drains.

#### **5.10.4 Man made Changes in the Flow and depth of drains**

The project area is densely populated. Sometimes local people shift the pressure transducer / sensor from the place where it was installed. The cows in summer at certain locations disturb the pressure transducer /sensor. It is recommended to monitor the instruments at site regularly. with short intervals.

#### **5.10.5 Effluent from Sewers and Industries**

Effluent from sewers and industries at certain locations drains into the drainage system. It effects the flow and depth in the storm drains. It is recommended to measure this component to deduct while understanding rainfall-runoff.

#### **5.10.6 Accuracy of X-sections and L-sections**

Due to high rate of sediments/solid waste, the sections of the drains are rapidly changing. At this stage cross sections data of the drains in the catchment was collected from WASA/NESPAK. It is recommended to update the cross sections at gauging sites by hiring surveyors for the task.

#### 5.10.7 Security of instruments at gauging sites

The security problem does not arise at any site during the monsoon period data acquisition. It seems that the people are aware not to disturb the instruments. But it is recommended to make arrangements for the security of the instruments if possible.

#### 5.10.8 Problems with current metering

Current metering was not successful to measure the flows due to high rate of sediments in the drains. It is recommended to make arrangements at certain locations in the drain to measure flow with help of current meters or any other method to check the accuracy of WATER RATs.

### 5.11 Use of SWMM Model for the study

#### 5.11.1 Introduction

The Storm Water Management Model (SWMM) was developed for the EPA in 1961-71 in combined sewer systems (Metcalf and Eddy et al., 1971). The model can be applied to any every aspect of urban drainage, and to any size of catchment.

### 5.11.2 The model

The current version of SWMM (Huder et al., 1981, Bedient 1987) is segmented into the following blocks.

- i. The runoff block generates runoff from rainfall using a nonlinear reservoir method.
- ii. The transport block performs flow routing using Kinematic wave technique.
- iii. The EXTRAN block performs flow routing by an explicit finite difference solution of St. Venant equations.
- iv. The storage/treatment block routes through storage units using the Puls method.
- v. The statistics block separates continuous simulation hydrographs into independent storm events and calculates the statistics and frequency.

### 5.11.3 Data requirements

The following input parameters are required for the RUNOFF block:

Area

Width

Percent impervious  
Slope  
Manning's roughness  
Depression storage  
Green Ampt parameters

Rainfall-runoff data are required for calibration and validation. The evapotranspiration and other data relating to the system are desired for the model.

#### 5.11.4 The Simulation and Calibration

A comparison of recorded and simulated water levels or discharges at selected sites is required to calibrate and validate the model. Sufficient data is required for the calibration. Once the model is calibrated, then it can be simulated for future planning and research.

#### 5.11.5 Training in the Use of SWMM

It is desired to have training on the model to handle the problem more accurately and in detail.

### 6. COMMENTS ON DESIGN CONSIDERATIONS IN SEMI ARID AREAS

Most of the drains in urban areas in this region are designed on 2-year maximum storm. At certain locations where the catchments are bigger and rainfall is high, these have been designed on 4-year

maximum storm. The present study will also high light for selecting most suitable return period in these areas.

### **6.1 Low Flow Discharges**

The sewage flow from the residential areas and industries are draining into the system at certain location in the form of low flow discharges. The enhancement for future low flows will depend upon the increase in population. A population growth of 3.5% may be assumed for the next ten years. The existing interception points of the sewage pipes should have to be identified.

### **6.2 Permissible Velocities**

As specified by LDA/WASA the maximum design velocity in earthen drains should be 0.762 m/s (2.5 ft/s) to protect against erosion. It is recommended to review permissible velocities with the help of data collected during the present research.

## **7 FUTURE PLANS / TARGETS OF THE RESEARCH**

- i. Final changes in the observation areas.
- ii. Monitoring the operational problems.
- iii. Formal data collection for the next hydrological cycle
- iv. Survey for the data collection for model parameters.
- v. Decisions about the modification / calibration approaches.

- vi. Implementation of the decision.
- vii. Review of the model operation / training.
- viii. Preparation of the research report.

## 8. CONCLUSIONS AND RECOMMENDATIONS

The most important part of the study is the collection of autographic rainfall runoff data to understand rainfall runoff relationship in urban areas of developing world where the climate is semi arid. Such type of data with sufficient length have not been collected in this part of the area. Due to lack of discharge data of drains, the previous studies/ design were based on synthetic runoff estimated from rainfall and there was no clear understanding of the rainfall runoff relationships. The present study aims to derive methodology based on actual short duration runoff/rainfall data for urban runoff control in semi arid region.

Data for the Monsoon period have been collected and it is planned to collect for the next monsoon periods to get sufficient length. The analysis of the data will help to make an understanding between the rainfall and urban runoff in a semi arid region. The model development will determine a clear methodology for estimating runoff for urban runoff control projects, and to determine solution to sewer problems in developing world.

It is recommended to collect sufficient data both rainfall and runoff to have a good calibration of the methodology. The procedure

may then be used for future research in urban runoff control in the semi arid region. In addition, the data will be helpful for future planning and design by the concerned agencies (e.g. WASA/LDA)

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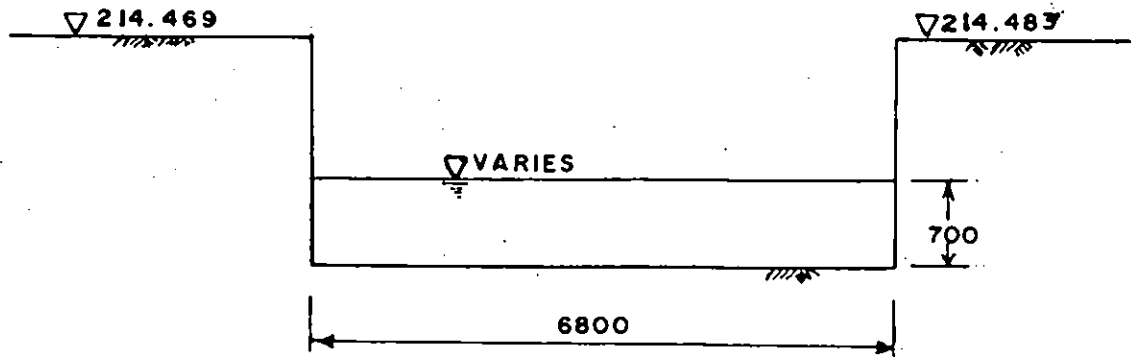
NESPAK (1988) Final Report, Lahore Urban Drainage Project Preliminary Engineering.

Terstriep ML and JB Stall (1974) ILLUDAS, The Illinois Urban Drainage Area Simulator, Bull.58, Illinois State Water Survey, Illinios.

## ACKNOWLEDGEMENTS

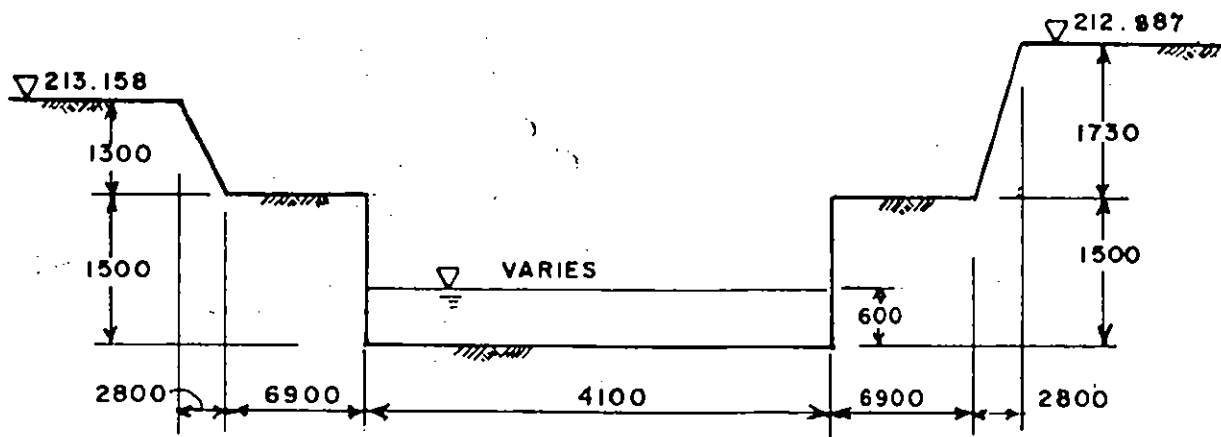
We would like to thank Mr. Abdul Khalid, Deputy Director (P & D) WASA/LDA and Mr. Peter Rowley from Haiste Group for cooperation and help in the research project. We also thank to Mr. Aqeel Azhar PGD Research Student (CEWRE) to provide help in compilation of the report.

X - SECTION OF GULBERG DRAIN NO. 1



AT INLET (UNLINED)

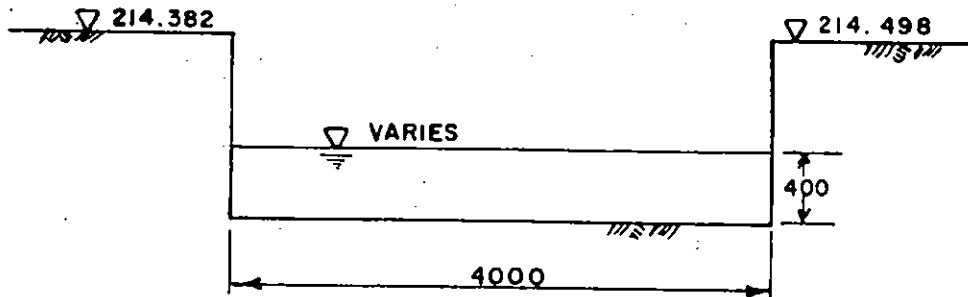
(AT A FOOT BRIDGE NEAR RAILWAY CROSSING)



AT OUTLET (UNLINED)

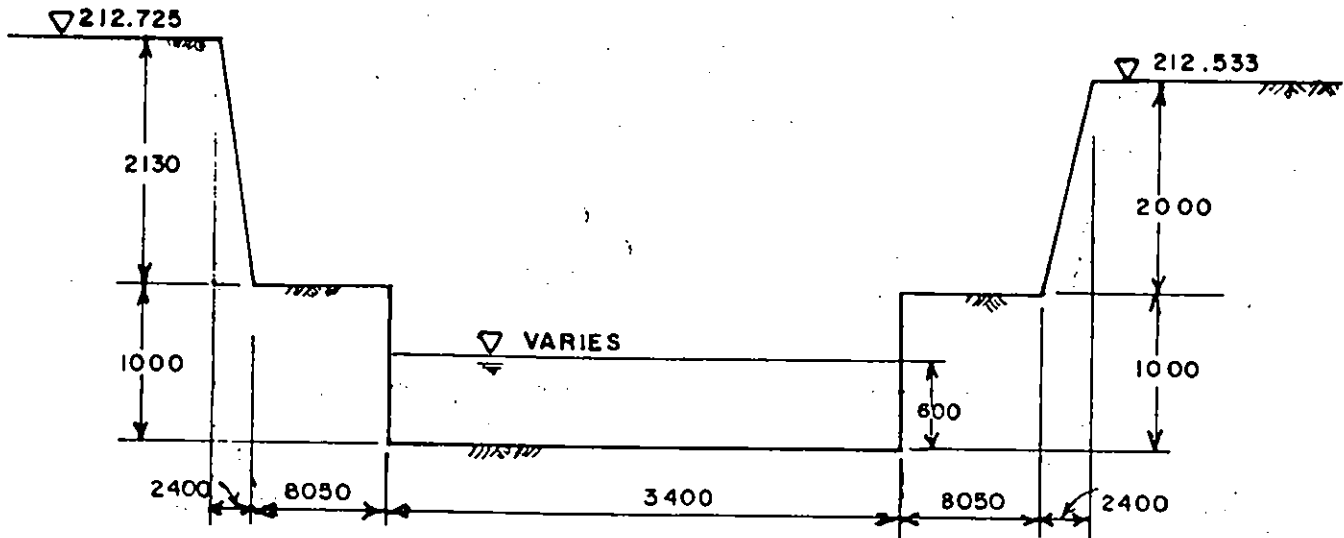
(BRIDGE AT MAIN BLOUVDARD ROAD GULBERG, RIGHT OF COLLEGE OF HOME ECONOMICS)

CROSS SECTIONS OF GULBERG DRAIN NO. 2



AT INLET (UNLINED)

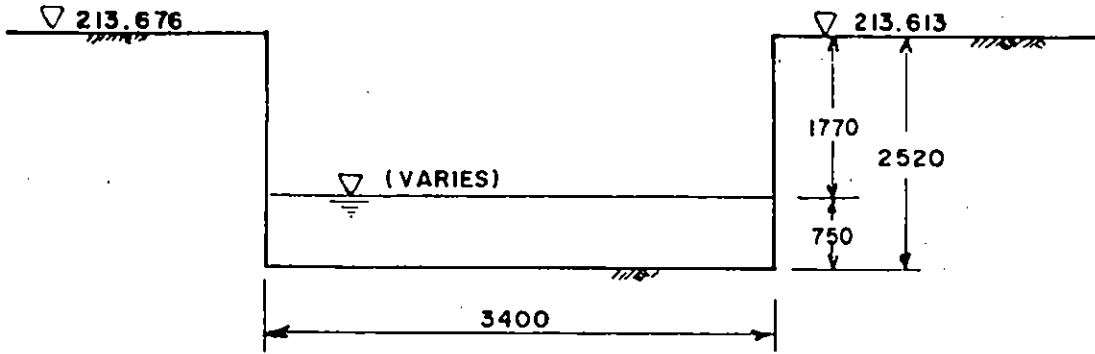
(BRIDGE AT 500 FEET FROM RAILWAY LINE  
NEAR CH. NIAZ'S HOUSE)



AT OUTLET (UNLINED)

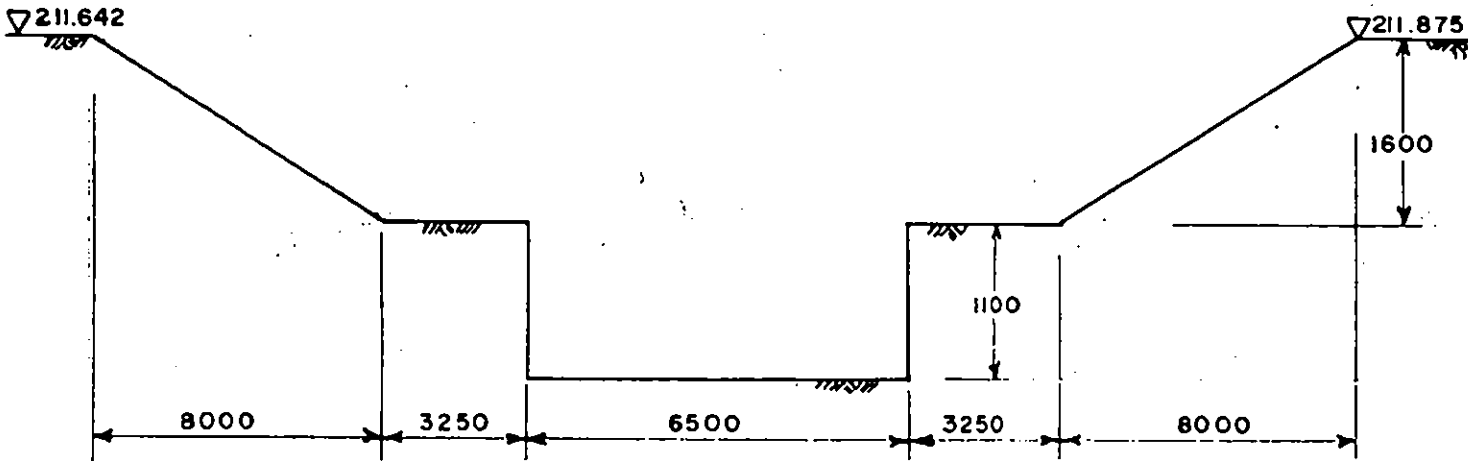
(BRIDGE AT MAIN BLOUVARD GULBERG ROAD, LEFT  
OF COLLEGE OF HOME ECONOMICS)

CROSS SECTIONS OF ZAFAR ALI ROAD



AT INLET (UNLINED)

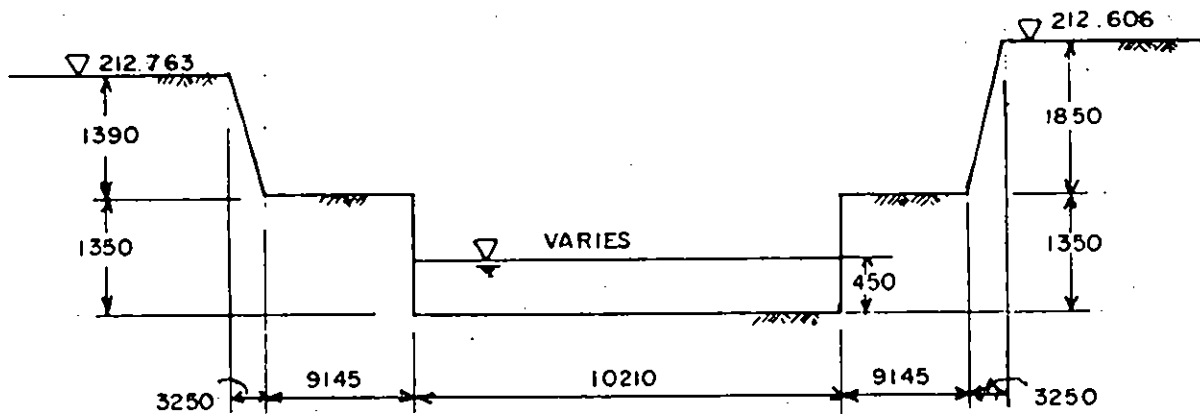
(NEAR RAILWAY O/H BRIDGE AT MIAN MIR)



AT OUTLET (UNLINED)

(BRIDGE OF JAIL ROAD AT ZAFAR ALI ROAD CROSSING)

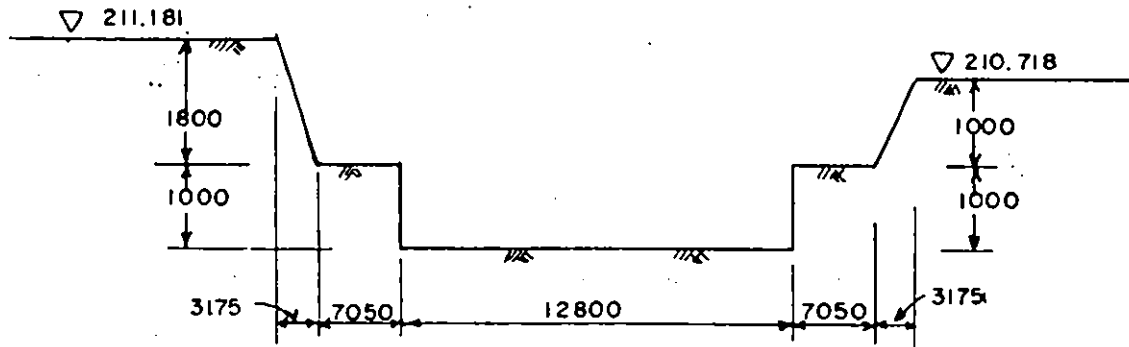
CROSS SECTION AT CONFLUENCE OF GULBERG  
DRAIN NO. 1 & 2



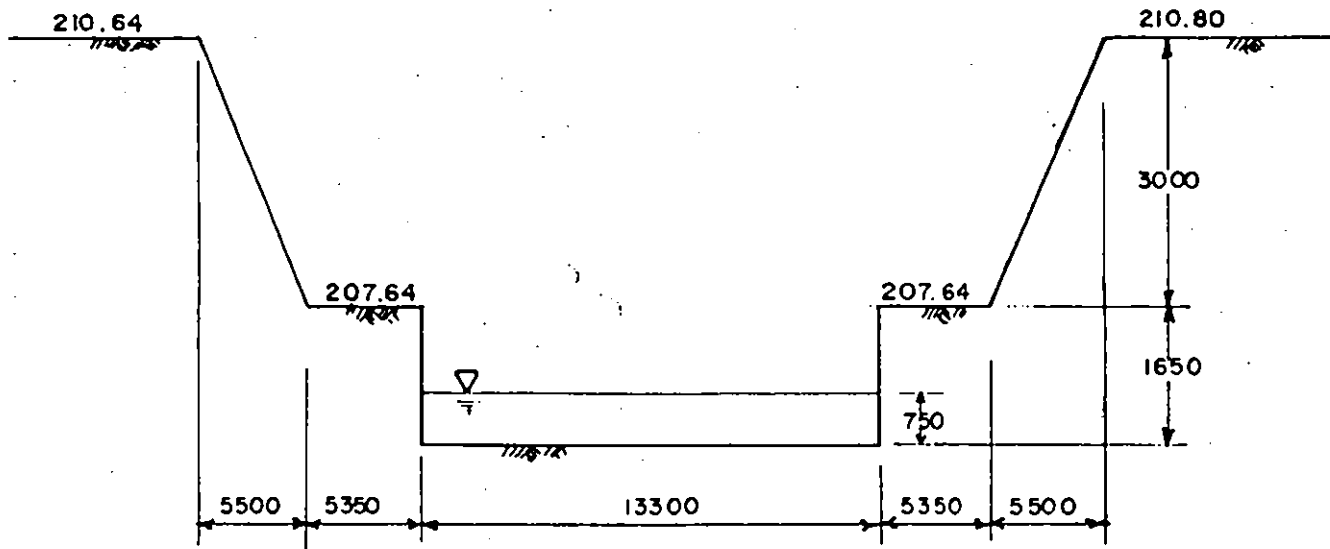
AT INLET (UNLINED)

(AT A FOOT BRIDGE INSIDE THE NURSARIES)

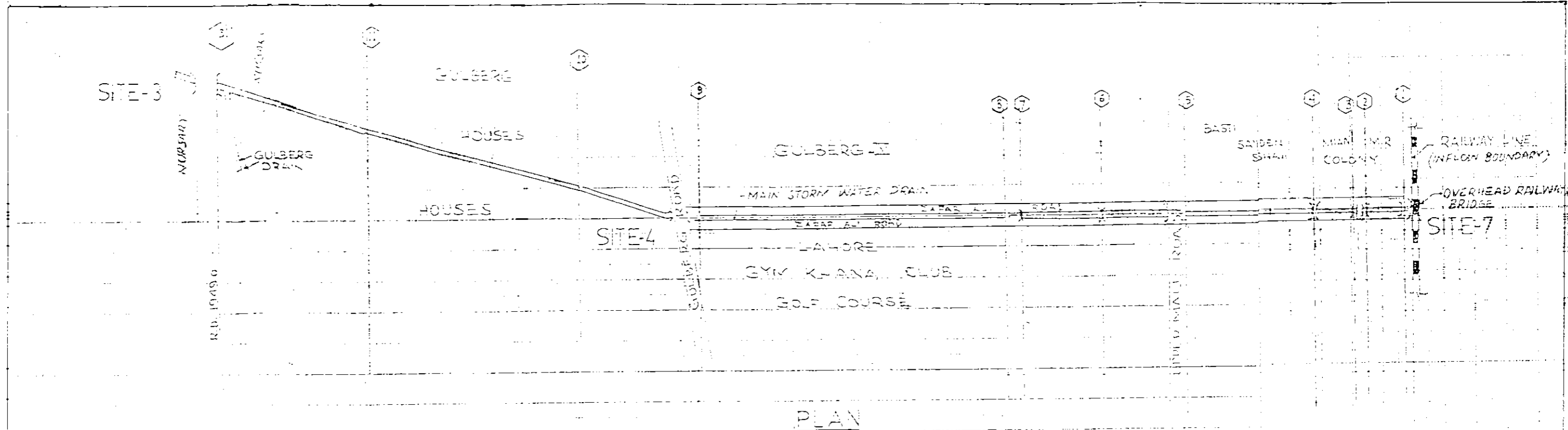
CROSS SECTIONS OF LAHORE MAIN STORM DRAIN



AT INLET (UNLINED)  
(BRIDGE OF U. B. D. CANAL)



AT OUTLET (UNLINED)  
(BRIDGE ON FERROZPUR ROAD NEAR SHAMA CINEMA)



PLAN

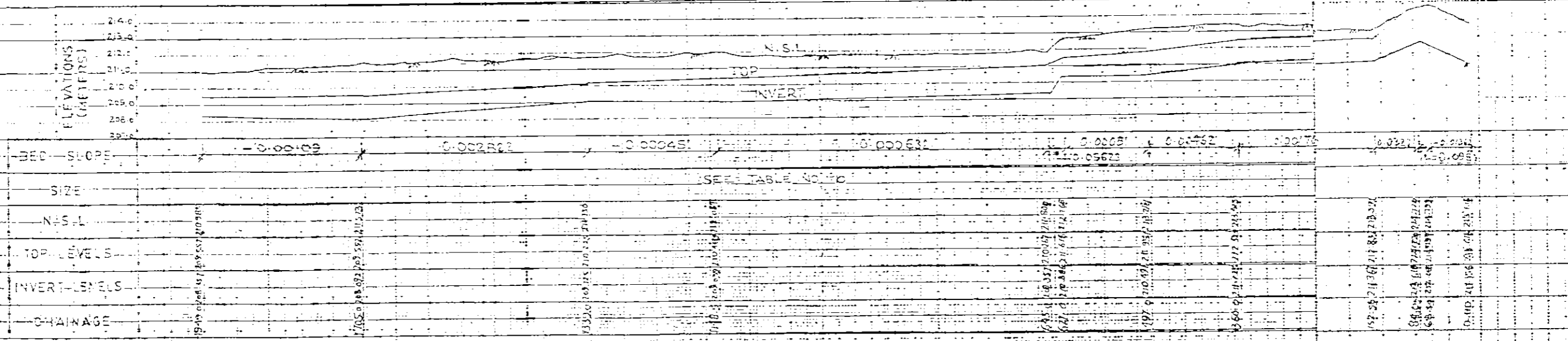


FIG. 4. CROSS SECTION OF LAHORE MAIN STORM WATER DRAIN (MIAN MIR BRIDGE TO GULBERG ROAD BRIDGE & G-BLOCK)

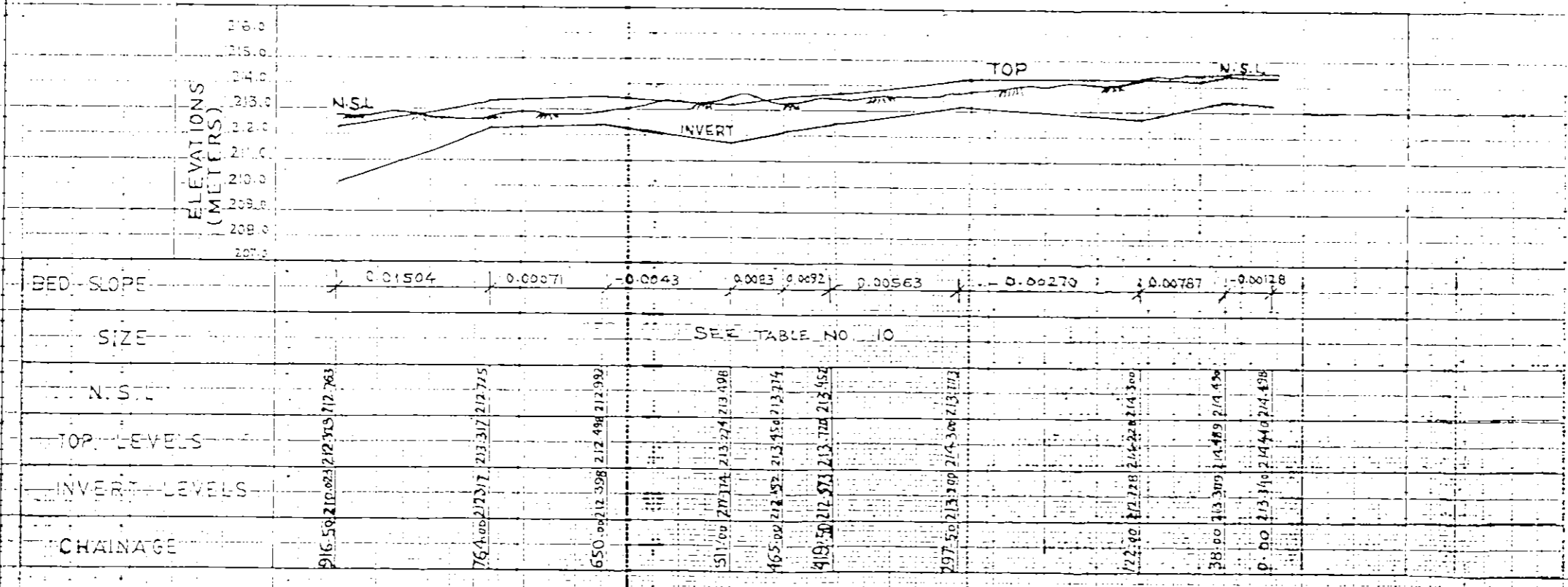
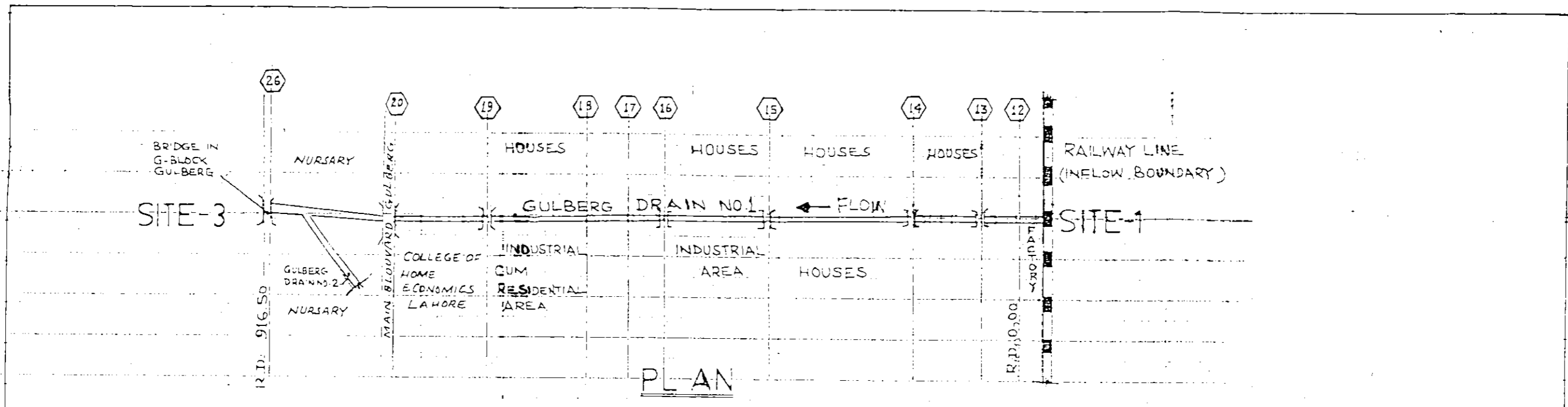
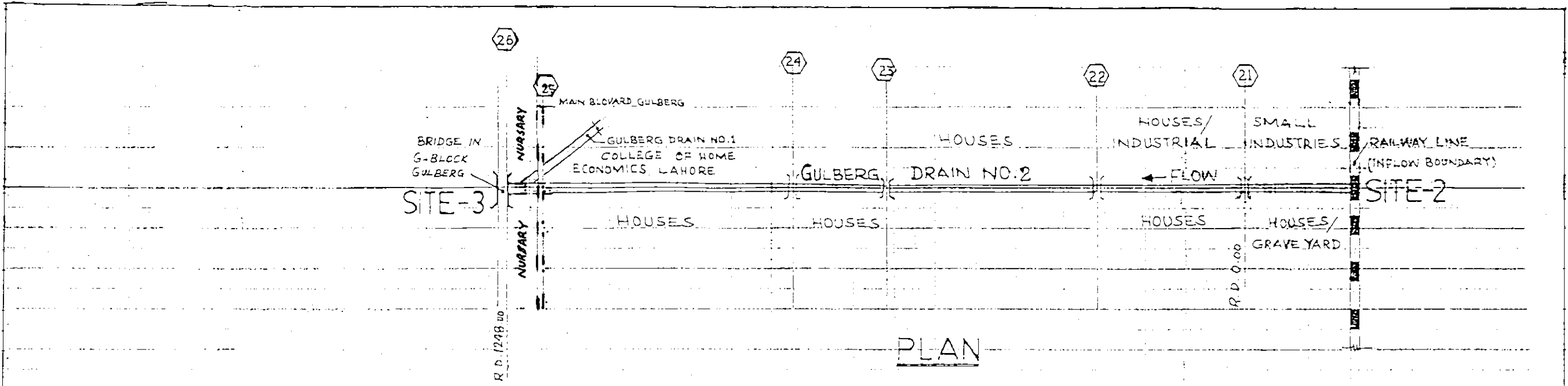


FIG. 15. L-SECTION OF GULBERG DRAIN NO. 1



PLAN

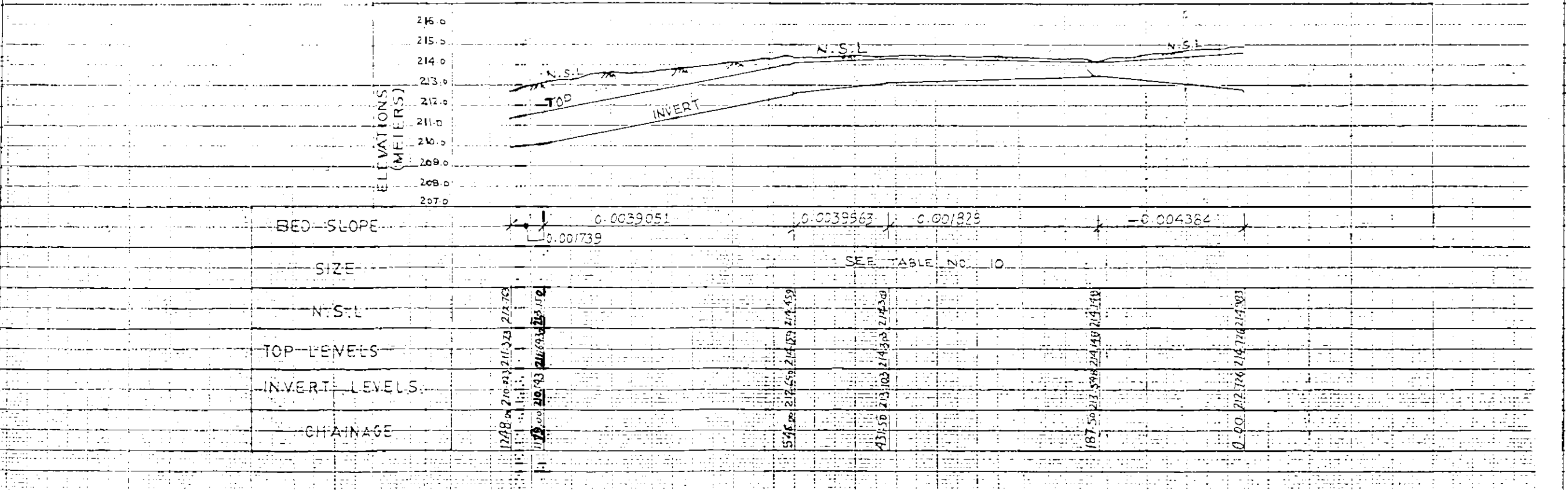
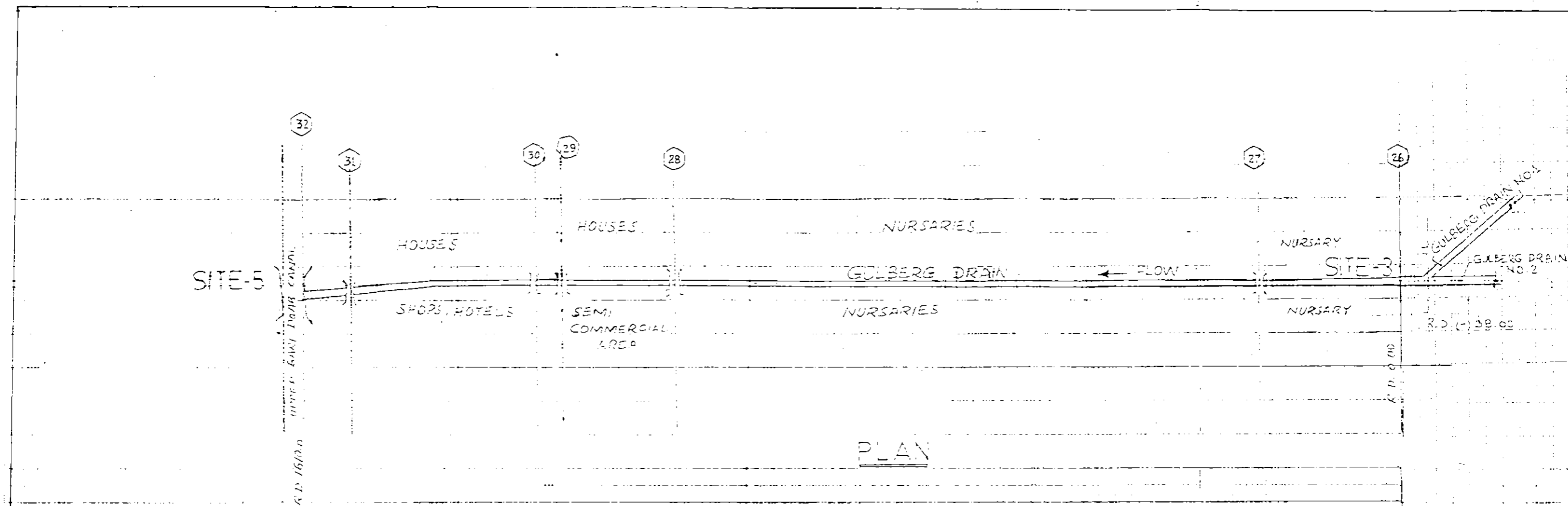


FIG 16 L-SECTION OF GULBERG DRAIN NO. 2



PLAN

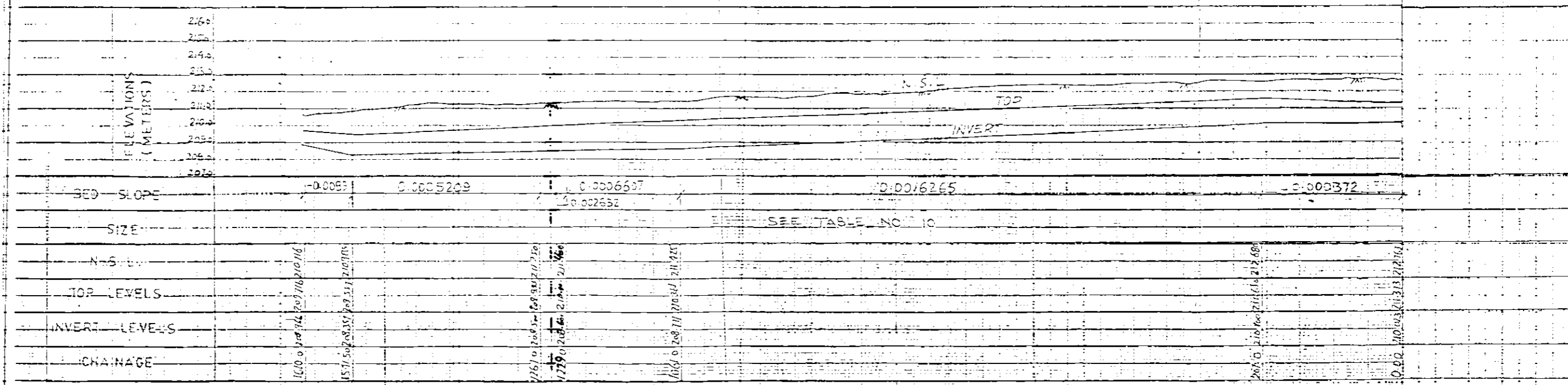
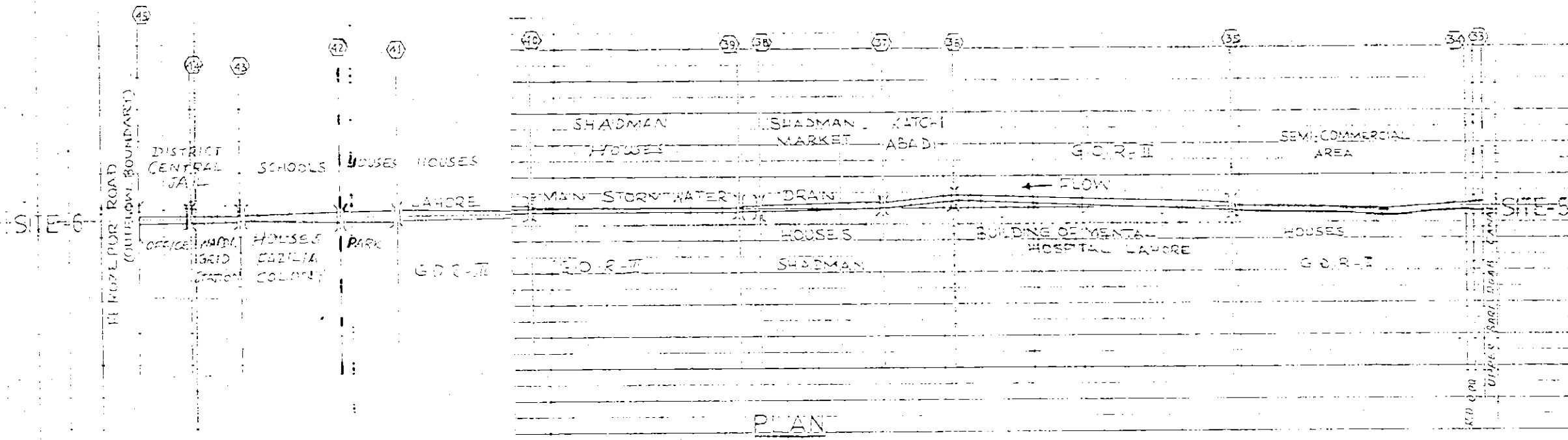


FIG. 17 L-SECTION OF GULBERG DRAIN



PLAN

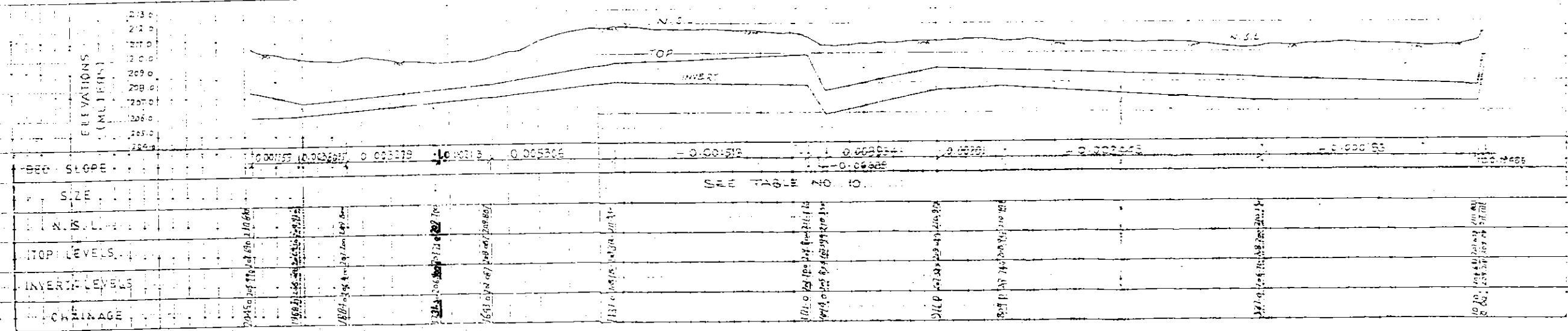


FIG. 18 - PLAN SECTION OF LAHORE MAIN STORM WATER DRAIN (UBD CANAL - FERROZE PUR ROAD)

ANNEXURE.1

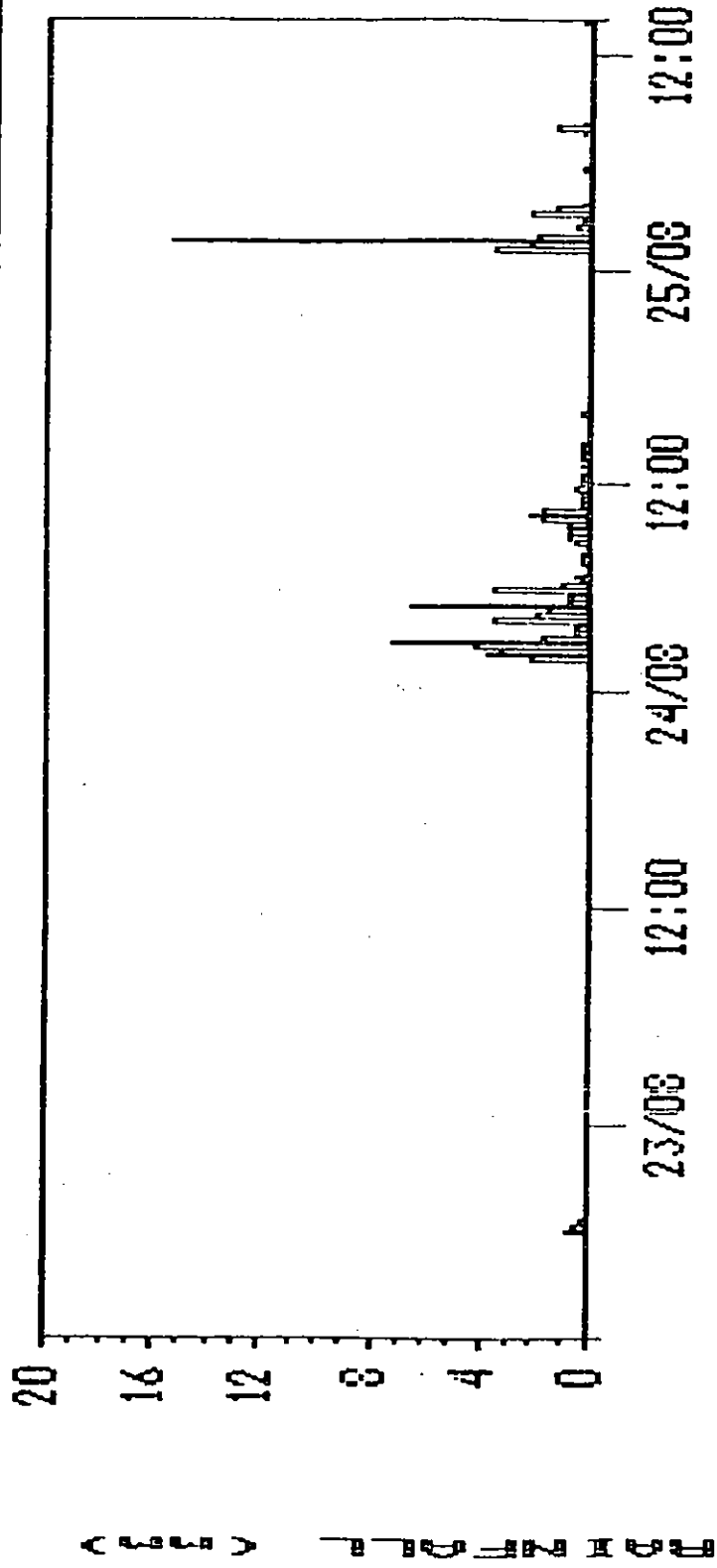
Reg'd User : Institute of Hydrology  
Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-004  
Site Number : 4446004      Site Name : 1-MAINGULBERG  
Data Range : 17/08/94 12:58      Total Rain : 0.8 mm  
                  17/08/94 12:59      Interval : 01 Min

RECORD	DATE/TIME	RAINFALL mm
1	17/08/94 12:59	0.8

Reg'd User : Institute of Hydrology  
Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-004  
Site Number : 4446004      Site Name : 1-MAINGULBERG  
Data Range : 18/08/94 00:00      Total Rain : 85.2 mm  
                  26/08/94 00:00      Interval : 01 Day

RECORD	DATE/TIME	RAINFALL mm
1	19/08/94 00:00	0.0
2	20/08/94 00:00	0.0
3	21/08/94 00:00	0.0
4	22/08/94 00:00	0.0
5	23/08/94 00:00	1.2
6	24/08/94 00:00	0.0
7	25/08/94 00:00	55.2
8	26/08/94 00:00	28.8

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LOGGER ID : RAIN2-0001-4446-004  
LOGGER NO. : 4446004  
LOGGER NAME : I-MAINGJULBERG

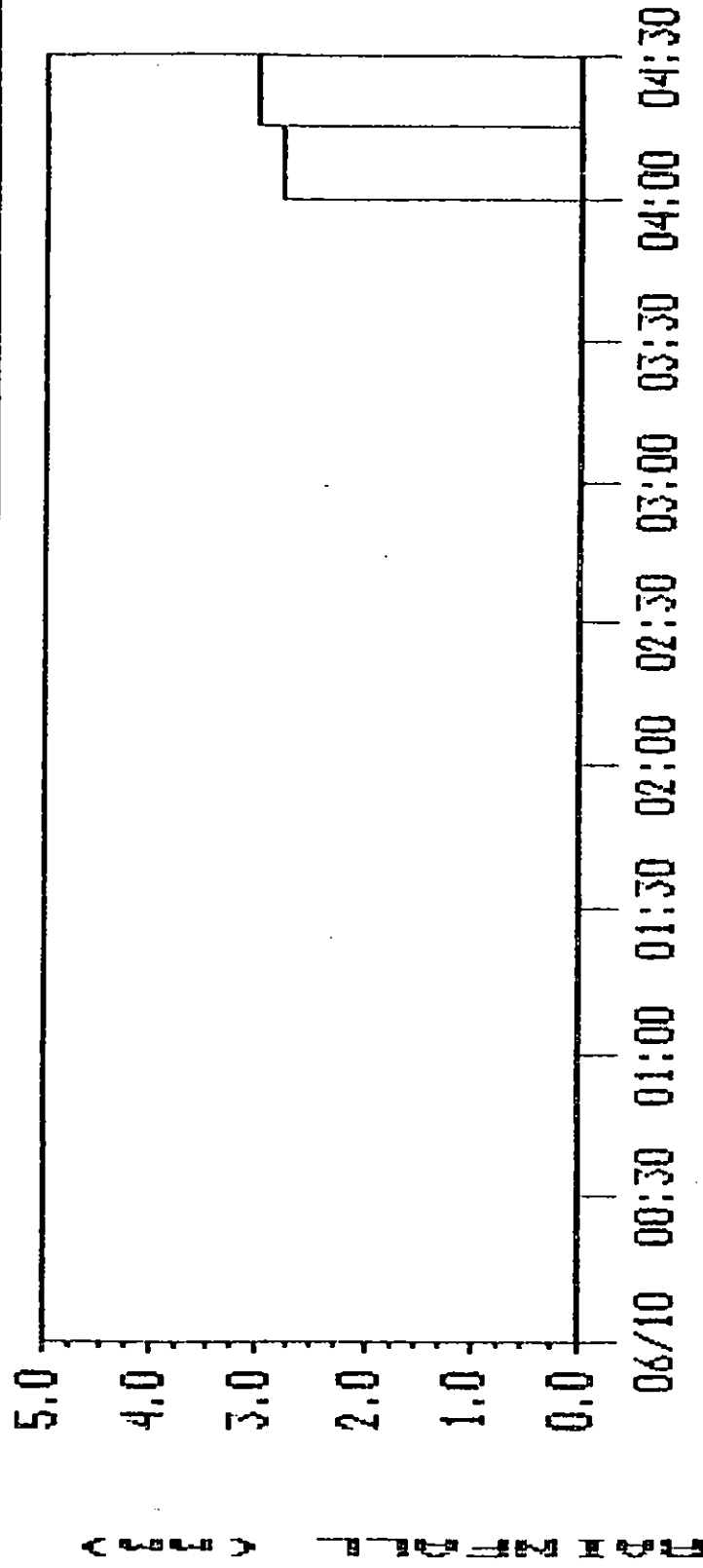
DATA RANGE : 22/08/94 12:15  
25/08/94 14:00  
Interval : 15 Mins

Reg'd User : Institute of Hydrology  
 Licence No : 0141/RLG/S/1.10  
 Site Number : 4446004  
 Data Range : 15/09/94 00:00  
 07/10/94 00:00

Logger ID : RAIN2-0001-4446-004  
 Site Name : 1-MAINGULBERG  
 Total Rain : 5.8 mm  
 Interval : 01 Day

RECORD	DATE/TIME	RAINFALL mm
1	16/09/94 00:00	0.0
2	17/09/94 00:00	0.0
3	18/09/94 00:00	0.0
4	19/09/94 00:00	0.0
5	20/09/94 00:00	0.0
6	21/09/94 00:00	0.0
7	22/09/94 00:00	0.0
8	23/09/94 00:00	0.0
9	24/09/94 00:00	0.0
10	25/09/94 00:00	0.0
11	26/09/94 00:00	0.0
12	27/09/94 00:00	0.0
13	28/09/94 00:00	0.0
14	29/09/94 00:00	0.0
15	30/09/94 00:00	0.0
16	01/10/94 00:00	0.0
17	02/10/94 00:00	0.0
18	03/10/94 00:00	0.0
19	04/10/94 00:00	0.0
20	05/10/94 00:00	0.0
21	06/10/94 00:00	0.0
22	07/10/94 00:00	5.8

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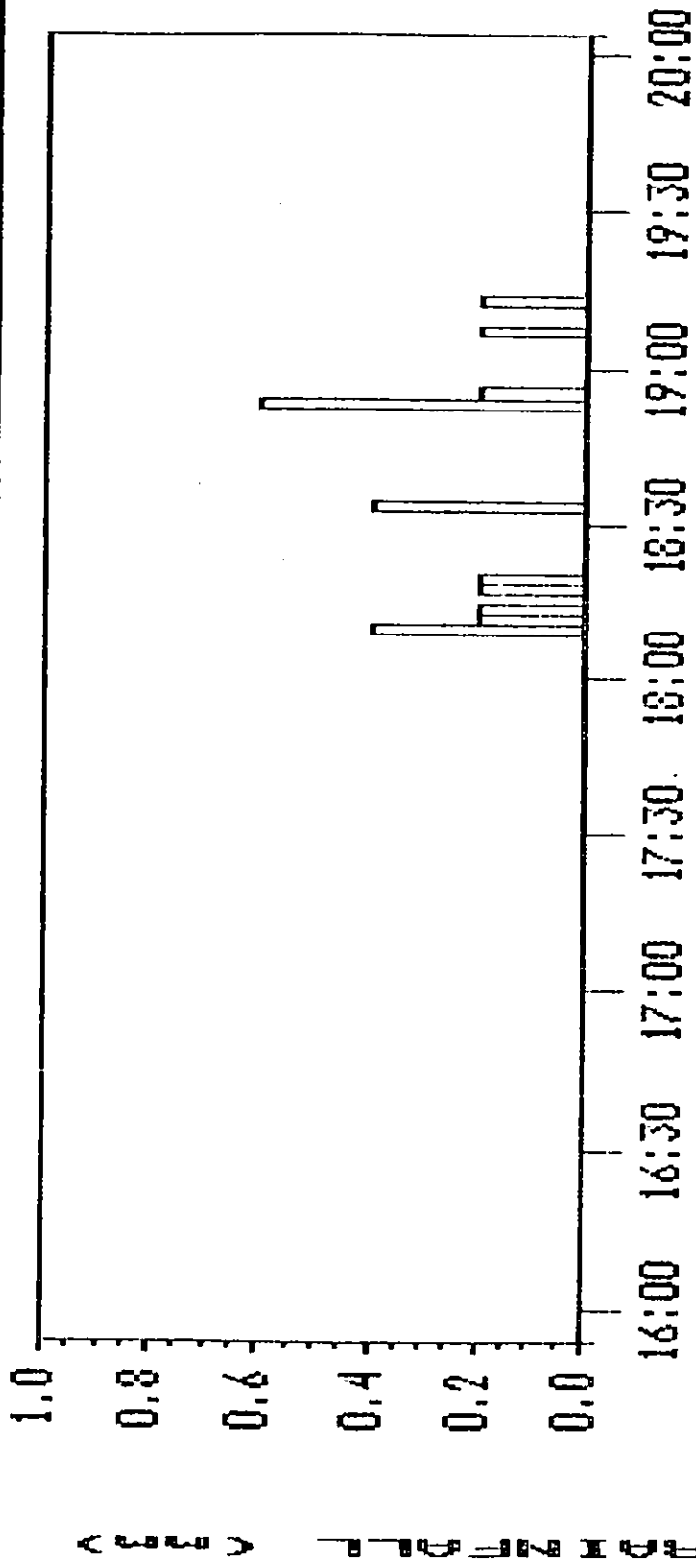
LOGGER ID : RAIN2-0001-4446-004  
LOGGER NO. : 4446004  
LOGGER NAME : 1-MAINGULBERG

DATA RANGE : 06/10/94 00:00  
06/10/94 04:30  
Interval : 15 Mins

Reg'd User : Institute of Hydrology  
 Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-004  
 Site Number : 4446004              Site Name : 1-MAINGULBERG  
 Data Range : 07/10/94 00:00      Total Rain : 3.0 mm  
               07/11/94 00:00      Interval : 01 Day

RECORD	DATE/TIME	RAINFALL mm
1	08/10/94 00:00	0.0
2	09/10/94 00:00	0.0
3	10/10/94 00:00	0.0
4	11/10/94 00:00	0.0
5	12/10/94 00:00	0.0
6	13/10/94 00:00	0.0
7	14/10/94 00:00	0.0
8	15/10/94 00:00	0.0
9	16/10/94 00:00	0.0
10	17/10/94 00:00	0.0
11	18/10/94 00:00	0.0
12	19/10/94 00:00	0.0
13	20/10/94 00:00	0.0
14	21/10/94 00:00	0.0
15	22/10/94 00:00	2.8
16	23/10/94 00:00	0.0
17	24/10/94 00:00	0.0
18	25/10/94 00:00	0.0
19	26/10/94 00:00	0.0
20	27/10/94 00:00	0.0
21	28/10/94 00:00	0.0
22	29/10/94 00:00	0.0
23	30/10/94 00:00	0.0
24	31/10/94 00:00	0.0
25	01/11/94 00:00	0.0
26	02/11/94 00:00	0.0
27	03/11/94 00:00	0.0
28	04/11/94 00:00	0.0
29	05/11/94 00:00	0.0
30	06/11/94 00:00	0.0
31	07/11/94 00:00	0.2

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LOGGER ID : RAIN2-0001-4446-004  
 LOGGER NO. : 4446004  
 LOGGER NAME : 1-MATINGULBERG

DATA RANGE : 21/10/94 15:54  
 21/10/94 20:04  
 Interval : 02 Mins

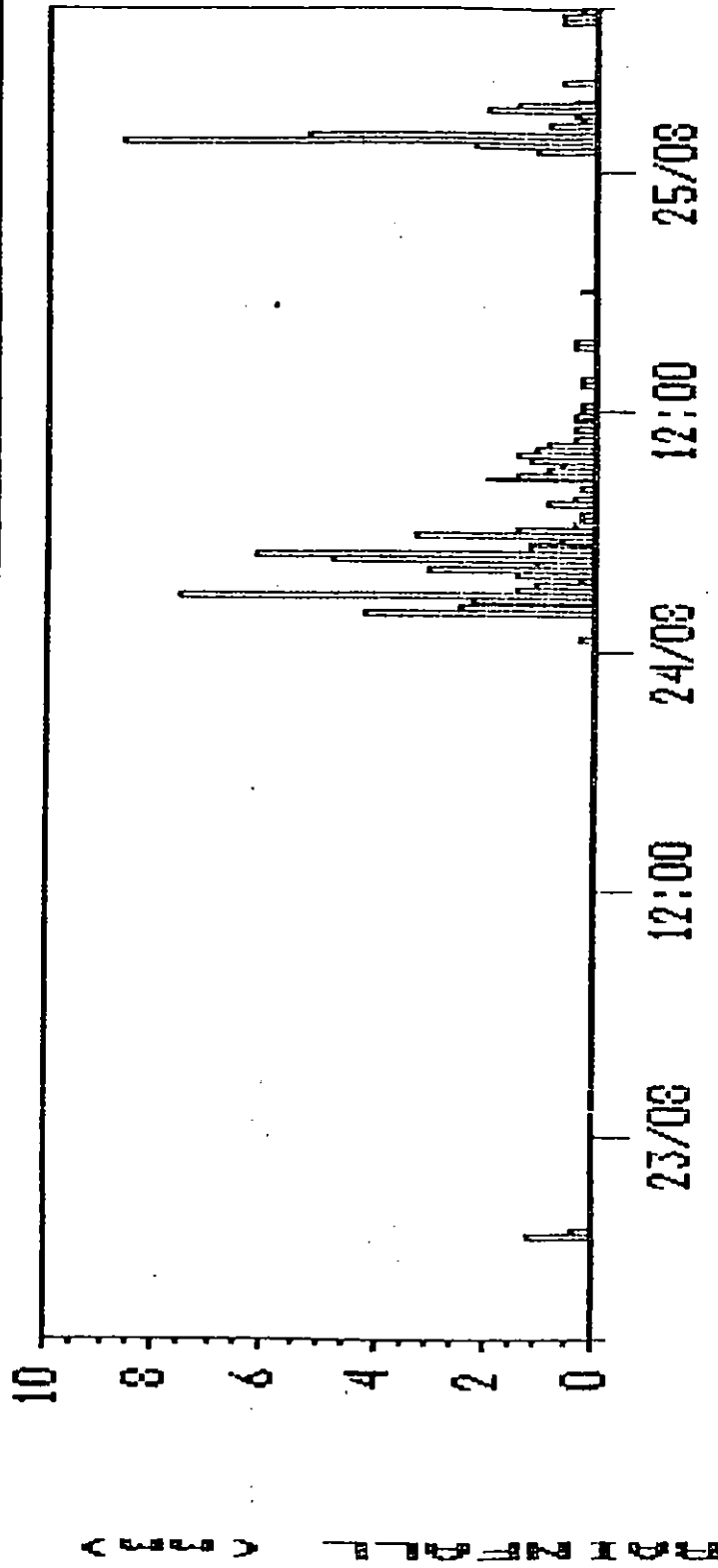
Reg'd User : Institute of Hydrology  
 Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-002  
 Site Number : 4446002              Site Name : 2-SHAHJAMAL  
 Data Range : 17/08/94 12:45      Total Rain : 0.8 mm  
               17/08/94 13:00      Interval : 15 Mins

RECORD	DATE/TIME	RAINFALL mm
1	17/08/94 13:00	0.8

Reg'd User : Institute of Hydrology  
 Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-002  
 Site Number : 4446002              Site Name : 2-SHAHJAMAL  
 Data Range : 18/08/94 00:00      Total Rain : 84.4 mm  
               26/08/94 00:00      Interval : 01 Day

RECORD	DATE/TIME	RAINFALL mm
1	19/08/94 00:00	0.0
2	20/08/94 00:00	0.0
3	21/08/94 00:00	0.0
4	22/08/94 00:00	0.0
5	23/08/94 00:00	1.6
6	24/08/94 00:00	0.0
7	25/08/94 00:00	58.6
8	26/08/94 00:00	24.2

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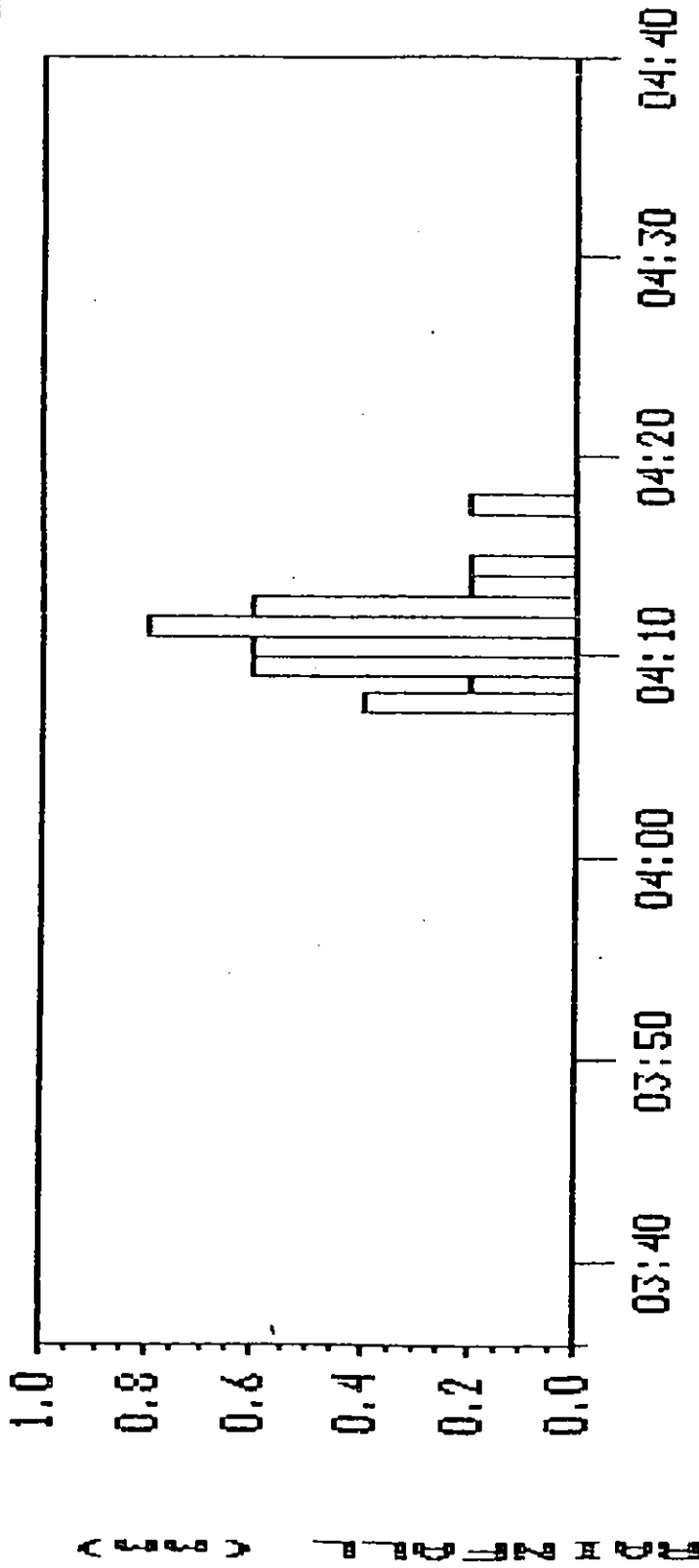


LOGGER ID : RAIN2-0001-4446-002  
LOGGER NO. : 4446002  
LOGGER NAME : 2-SHAHJAMAL

DATA RANGE : 22/08/94 14:00  
25/08/94 08:15  
Interval : 15 Mins



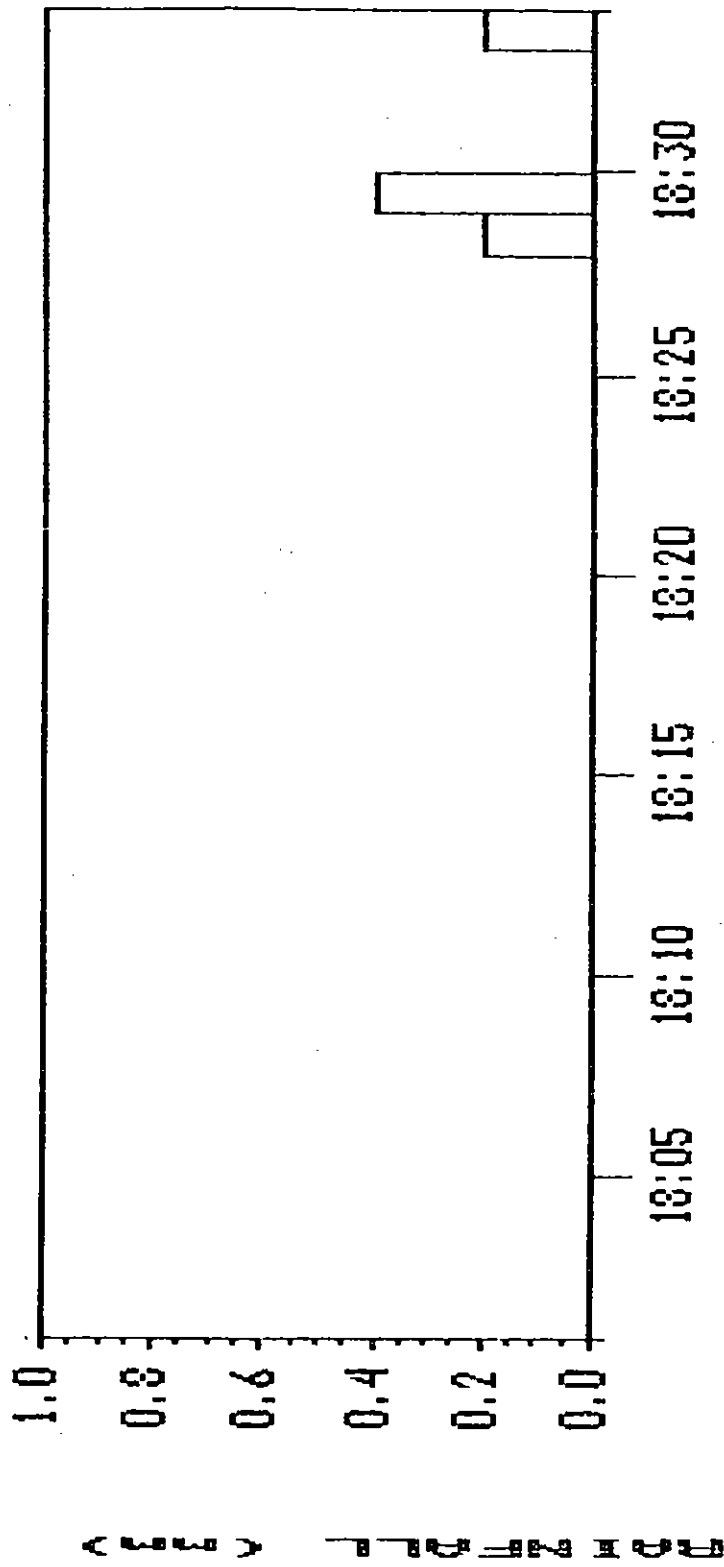
Institute of Hydrology  
 0141/RLG/S/1.10



LOGGER ID : RAIN2-0001-4446-002  
 LOGGER NO. : 4446002  
 LOGGER NAME : 2-SHAHJAMAL

DATA RANGE : 06/10/94 03:36  
 06/10/94 04:40  
 Interval : 01 Min

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LOGGER ID : RAIN2-0001-4446-002  
LOGGER NO. : 4446002  
LOGGER NAME : 2-SHAHJAMAL

DATA RANGE : 23/10/94 18:01  
23/10/94 18:34  
Interval : 01 Min

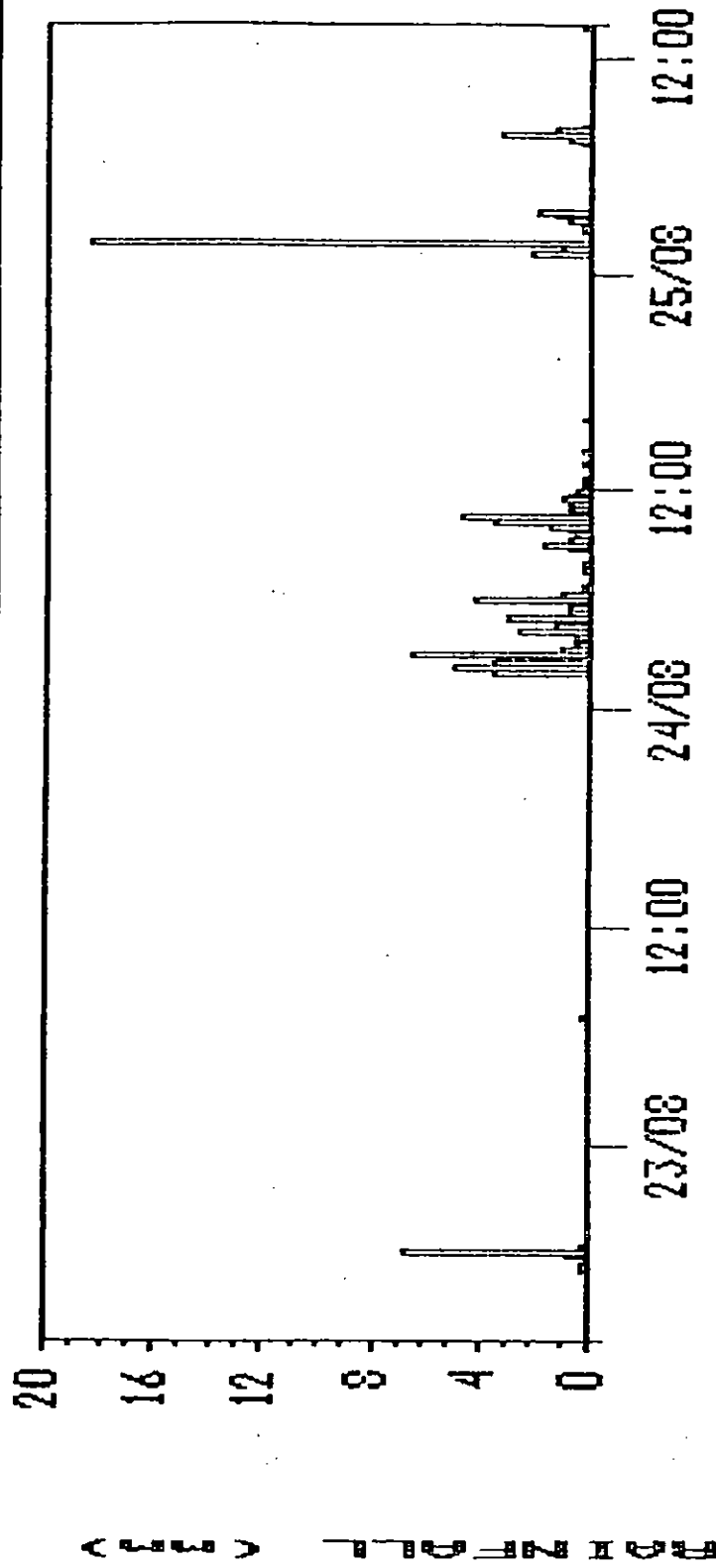
Reg'd User : Institute of Hydrology  
Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-003  
Site Number : 4446003      Site Name : 3-UPPERMALLDRAIN  
Data Range : 17/08/94 13:00      Total Rain : 0.8 mm  
                 17/08/94 13:15      Interval : 15 Mins

RECORD	DATE/TIME	RAINFALL mm
1	17/08/94 13:15	0.8

Reg'd User : Institute of Hydrology  
Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-003  
Site Number : 4446003      Site Name : 3-UPPERMALLDRAIN  
Data Range : 18/08/94 00:00      Total Rain : 98.0 mm  
                 26/08/94 00:00      Interval : 01 Day

RECORD	DATE/TIME	RAINFALL mm
1	19/08/94 00:00	0.0
2	20/08/94 00:00	0.0
3	21/08/94 00:00	0.0
4	22/08/94 00:00	0.0
5	23/08/94 00:00	8.2
6	24/08/94 00:00	0.2
7	25/08/94 00:00	58.4
8	26/08/94 00:00	31.2

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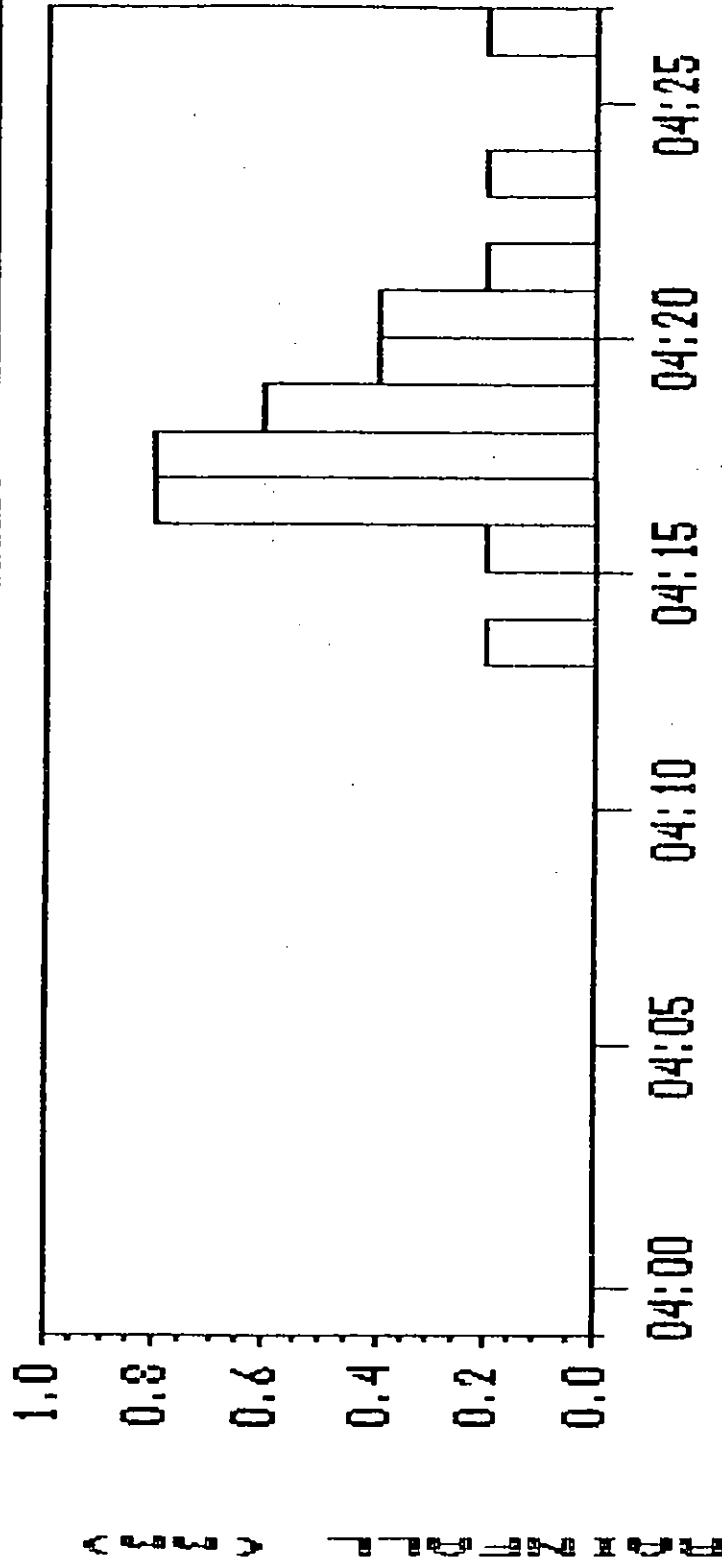
LOGGER ID : RAIN2-0001-4446-003  
LOGGER NO. : 4446003  
LOGGER NAME : 3-UPPERMALLDRAIN

DATA RANGE : 22/08/94 13:15  
25/08/94 13:45  
Interval : 15 Mins

Reg'd User : Institute of Hydrology  
Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-003  
Site Number : 4446003      Site Name : 3-UPPERMALLDRAIN  
Data Range : 15/09/94 00:00      Total Rain : 4.0 mm  
              07/10/94 00:00      Interval : 01 Day

RECORD	DATE/TIME	RAINFALL mm
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2	17/09/94 00:00	0.0
3	18/09/94 00:00	0.0
4	19/09/94 00:00	0.0
5	20/09/94 00:00	0.0
8	21/09/94 00:00	0.0
7	22/09/94 00:00	0.0
8	23/09/94 00:00	0.0
9	24/09/94 00:00	0.0
10	25/09/94 00:00	0.0
11	26/09/94 00:00	0.0
12	27/09/94 00:00	0.0
13	28/09/94 00:00	0.0
14	29/09/94 00:00	0.0
15	30/09/94 00:00	0.0
16	01/10/94 00:00	0.0
17	02/10/94 00:00	0.0
18	03/10/94 00:00	0.0
19	04/10/94 00:00	0.0
20	05/10/94 00:00	0.0
21	06/10/94 00:00	0.0
22	07/10/94 00:00	4.0

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 0141/RLG/S/1.10



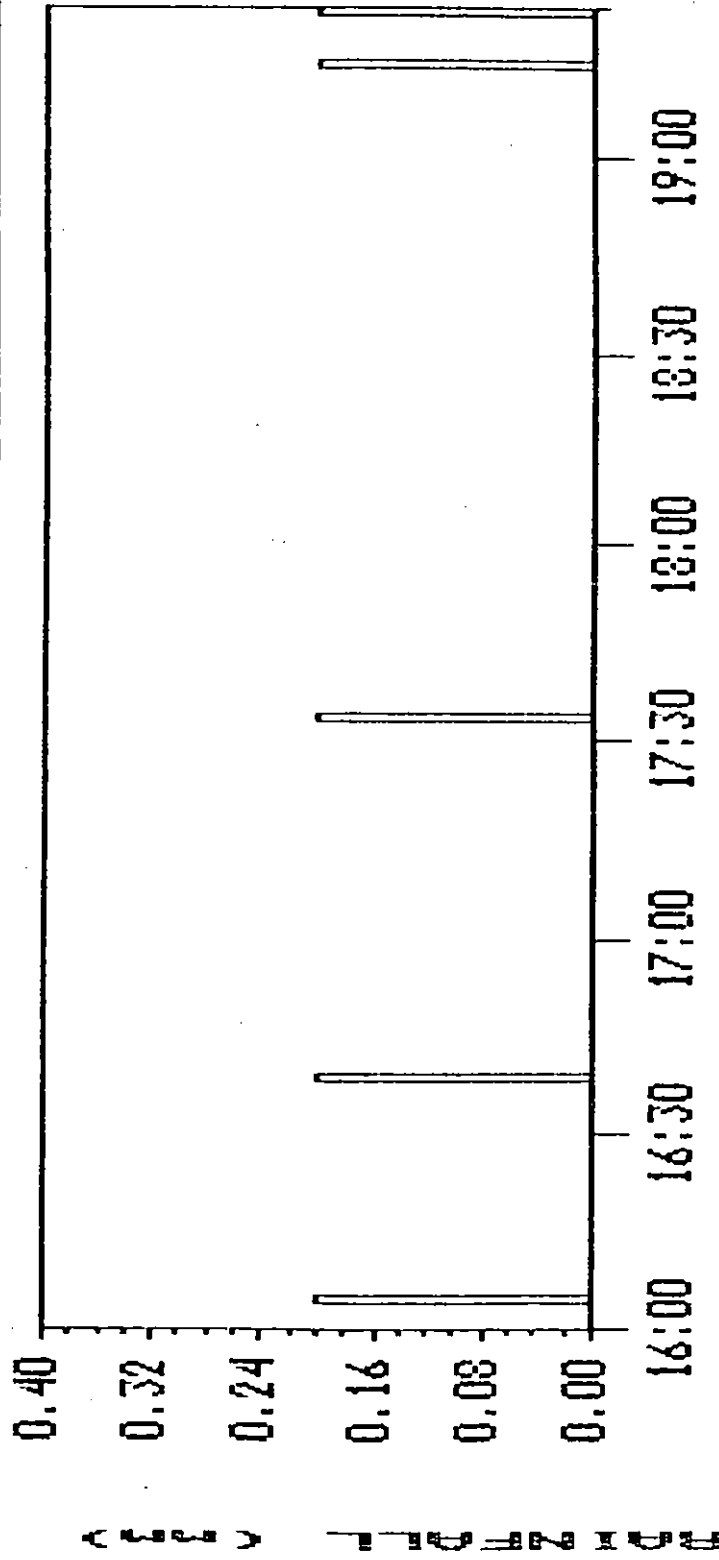
LOGGER ID : RAIN2-0001-4446-003  
 LOGGER NO. : 4446003  
 LOGGER NAME : 3-UPPERMALLDRAIN

DATA RANGE : 06/10/94 03:59  
 06/10/94 04:27  
 Interval : 01 Min

Reg'd User : Institute of Hydrology  
Licence No : 0141/RLG/S/1.10      Logger ID : RAIN2-0001-4446-003  
Site Number : 4446003      Site Name : 3-UPPERMALLDRAIN  
Data Range : 07/10/94 00:00      Total Rain : 1.2 mm  
                 22/10/94 00:00      Interval : 01 Day

RECORD	DATE/TIME	RAINFALL mm
1	08/10/94 00:00	0.0
2	09/10/94 00:00	0.0
3	10/10/94 00:00	0.0
4	11/10/94 00:00	0.0
5	12/10/94 00:00	0.2
6	13/10/94 00:00	0.0
7	14/10/94 00:00	0.0
8	15/10/94 00:00	0.0
9	16/10/94 00:00	0.0
10	17/10/94 00:00	0.0
11	18/10/94 00:00	0.0
12	19/10/94 00:00	0.0
13	20/10/94 00:00	0.0
14	21/10/94 00:00	0.0
15	22/10/94 00:00	1.0

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LOGGER ID : RAIN2-0001-4446-003  
 LOGGER NO. : 4446003  
 LOGGER NAME : 3-UPPERMALLDRAIN

DATA RANGE : 21/10/94 16:00  
 21/10/94 19:23  
 Interval : 01 Min

ANNEXURE.2

Site 1  
Lahore Cantt. near Railway Line (SherPao Bridge)

Date	Time	Depth m
07 Sep 1994	12:25:00	0.184
07 Sep 1994	12:26:00	0.184
07 Sep 1994	12:27:00	0.186
07 Sep 1994	12:28:00	0.184
07 Sep 1994	12:29:00	0.186
07 Sep 1994	12:30:00	0.186
14 Sep 1994	16:30:00	0.159
14 Sep 1994	17:00:00	0.168
14 Sep 1994	17:30:00	0.162
14 Sep 1994	18:00:00	0.162
14 Sep 1994	18:30:00	0.173
15 Sep 1994	00:00:00	0.171
15 Sep 1994	00:30:00	0.143
15 Sep 1994	01:00:00	0.137
15 Sep 1994	01:30:00	0.133
15 Sep 1994	02:00:00	0.129
15 Sep 1994	02:30:00	0.124
15 Sep 1994	03:00:00	0.121
15 Sep 1994	03:30:00	0.118
15 Sep 1994	04:00:00	0.118
15 Sep 1994	04:30:00	0.119
15 Sep 1994	05:00:00	0.122
16 Sep 1994	00:00:00	0.151
16 Sep 1994	00:30:00	0.145
16 Sep 1994	01:00:00	0.140
16 Sep 1994	01:30:00	0.133
16 Sep 1994	02:00:00	0.127
16 Sep 1994	02:30:00	0.124
16 Sep 1994	03:00:00	0.116
16 Sep 1994	03:30:00	0.113
16 Sep 1994	04:00:00	0.111
17 Sep 1994	00:00:00	0.148
17 Sep 1994	00:30:00	0.143
17 Sep 1994	01:00:00	0.138
17 Sep 1994	10:00:00	0.176
17 Sep 1994	10:30:00	0.194
17 Sep 1994	11:00:00	0.176
17 Sep 1994	11:30:00	0.171
17 Sep 1994	12:00:00	0.168
17 Sep 1994	12:30:00	0.165

Site 1  
Lahore Cantt Near Railway Line

Date	Time	Depth m
22 Sep 1994	12:00:00	0.173
22 Sep 1994	23:30:00	0.165
23 Sep 1994	00:00:00	0.159
23 Sep 1994	08:00:00	0.160
24 Sep 1994	00:00:00	0.156
24 Sep 1994	00:30:00	0.149
25 Sep 1994	00:00:00	0.176
25 Sep 1994	00:30:00	0.170
26 Sep 1994	00:30:00	0.165
26 Sep 1994	01:00:00	0.160
27 Sep 1994	02:00:00	0.135
27 Sep 1994	02:30:00	0.132
28 Sep 1994	01:00:00	0.146
28 Sep 1994	01:30:00	0.140
29 Sep 1994	01:00:00	0.151
29 Sep 1994	01:30:00	0.145
30 Sep 1994	00:00:00	0.159
30 Sep 1994	00:30:00	0.151
01 Oct 1994	02:30:00	0.133
01 Oct 1994	03:00:00	0.130
01 Oct 1994	03:30:00	0.127
02 Oct 1994	07:00:00	0.184
02 Oct 1994	07:30:00	0.168
03 Oct 1994	13:00:00	0.179
03 Oct 1994	13:30:00	0.184
04 Oct 1994	19:00:00	0.195
04 Oct 1994	19:30:00	0.195
05 Oct 1994	08:00:00	0.175
05 Oct 1994	08:30:00	0.225
06 Oct 1994	02:30:00	0.145
06 Oct 1994	03:00:00	0.140
07 Oct 1994	08:30:00	0.178
07 Oct 1994	09:00:00	0.186
08 Oct 1994	11:00:00	0.192
08 Oct 1994	11:30:00	0.186
08 Oct 1994	12:00:00	0.184
08 Oct 1994	12:30:00	0.181
08 Oct 1994	13:00:00	0.183
08 Oct 1994	13:30:00	0.194
08 Oct 1994	14:00:00	0.192
End of data		

Site 1  
Lahore Cantt Near Railway Line

Date	Time	Depth m
08 Oct 1994	14:30:00	0.195
08 Oct 1994	15:00:00	0.203
09 Oct 1994	10:00:00	0.191
09 Oct 1994	10:30:00	0.186
10 Oct 1994	04:30:00	0.137
10 Oct 1994	05:00:00	0.138
11 Oct 1994	10:30:00	0.187
11 Oct 1994	11:00:00	0.184
12 Oct 1994	16:30:00	0.171
12 Oct 1994	17:00:00	0.178
13 Oct 1994	22:30:00	0.187
13 Oct 1994	23:00:00	0.170
15 Oct 1994	04:30:00	0.118
15 Oct 1994	05:00:00	0.118
16 Oct 1994	10:30:00	0.179
16 Oct 1994	11:00:00	0.176
17 Oct 1994	05:00:00	0.129
17 Oct 1994	05:30:00	0.130
18 Oct 1994	11:00:00	0.216
18 Oct 1994	11:30:00	0.178
19 Oct 1994	17:00:00	0.173
19 Oct 1994	17:30:00	0.175
20 Oct 1994	23:00:00	0.164
20 Oct 1994	23:30:00	0.156
22 Oct 1994	05:00:00	0.130
22 Oct 1994	05:30:00	0.133
22 Oct 1994	23:30:00	0.154
23 Oct 1994	00:00:00	0.148
23 Oct 1994	00:30:00	0.141
23 Oct 1994	01:00:00	0.137
23 Oct 1994	01:30:00	0.132
23 Oct 1994	02:00:00	0.129
23 Oct 1994	02:30:00	0.127
23 Oct 1994	03:00:00	0.125
23 Oct 1994	03:30:00	0.122
23 Oct 1994	04:00:00	0.122
23 Oct 1994	04:30:00	0.127
23 Oct 1994	05:00:00	0.130
23 Oct 1994	05:30:00	0.137
23 Oct 1994	06:00:00	0.143
23 Oct 1994	06:30:00	0.200
23 Oct 1994	07:00:00	0.208
23 Oct 1994	07:30:00	0.157
23 Oct 1994	08:00:00	0.210
23 Oct 1994	08:30:00	0.195
23 Oct 1994	09:00:00	0.181
23 Oct 1994	09:30:00	0.197
23 Oct 1994	10:00:00	0.194
23 Oct 1994	10:30:00	0.178
23 Oct 1994	11:00:00	0.176
23 Oct 1994	11:30:00	0.213
23 Oct 1994	12:00:00	0.178
23 Oct 1994	12:30:00	0.179

Site 2  
Lahore Cantt. Ch Niaz House

Date	Time	Depth m
31 Aug 1994	14:25:00	0.894
31 Aug 1994	14:26:00	0.893
31 Aug 1994	14:27:00	0.893
31 Aug 1994	14:30:00	0.891
31 Aug 1994	14:31:00	0.891
31 Aug 1994	19:16:00	0.876
14 Sep 1994	16:30:00	0.858
14 Sep 1994	17:00:00	0.854
14 Sep 1994	17:30:00	0.846
14 Sep 1994	18:00:00	0.870
14 Sep 1994	18:30:00	0.888
15 Sep 1994	02:30:00	0.744
15 Sep 1994	03:00:00	0.738
15 Sep 1994	03:30:00	0.735
15 Sep 1994	04:00:00	0.732
15 Sep 1994	04:30:00	0.753
15 Sep 1994	05:00:00	0.763
16 Sep 1994	04:30:00	0.723
16 Sep 1994	05:00:00	0.723
16 Sep 1994	05:30:00	0.733
16 Sep 1994	06:00:00	0.751
16 Sep 1994	06:30:00	0.828
16 Sep 1994	07:00:00	0.872
16 Sep 1994	07:30:00	0.888
17 Sep 1994	10:00:00	0.914
17 Sep 1994	10:30:00	0.903
17 Sep 1994	11:00:00	0.885
17 Sep 1994	11:30:00	0.875
17 Sep 1994	12:00:00	0.846
18 Sep 1994	14:00:00	0.816
18 Sep 1994	14:30:00	0.821
18 Sep 1994	15:00:00	0.840
18 Sep 1994	15:30:00	0.864
18 Sep 1994	16:00:00	0.870
19 Sep 1994	05:30:00	0.769
19 Sep 1994	06:00:00	0.803
19 Sep 1994	06:30:00	0.833
19 Sep 1994	07:00:00	0.872
19 Sep 1994	07:30:00	0.891

Site 2  
Lahore Cantt Ch Niaz House

Date	Time	Depth m
08 Oct 1994	14:00:00	0.944
08 Oct 1994	14:30:00	0.939
09 Oct 1994	18:30:00	0.918
09 Oct 1994	19:00:00	0.908
10 Oct 1994	17:30:00	0.882
10 Oct 1994	18:00:00	0.879
11 Oct 1994	12:00:00	0.870
11 Oct 1994	12:30:00	0.894
12 Oct 1994	06:30:00	0.906
12 Oct 1994	07:00:00	0.918
13 Oct 1994	12:30:00	0.908
13 Oct 1994	13:00:00	0.888
14 Oct 1994	03:00:00	0.852
14 Oct 1994	03:30:00	0.851
15 Oct 1994	09:00:00	0.953
15 Oct 1994	09:30:00	0.948
16 Oct 1994	03:30:00	0.797
16 Oct 1994	04:00:00	0.800
17 Oct 1994	19:00:00	0.878
17 Oct 1994	19:30:00	0.899
17 Oct 1994	20:00:00	0.921
18 Oct 1994	13:30:00	0.857
18 Oct 1994	14:00:00	0.869
19 Oct 1994	08:00:00	0.875
19 Oct 1994	08:30:00	0.887
20 Oct 1994	07:00:00	0.912
20 Oct 1994	07:30:00	0.829
21 Oct 1994	02:30:00	0.867
21 Oct 1994	03:00:00	0.878
21 Oct 1994	21:00:00	0.909
21 Oct 1994	21:30:00	0.903
22 Oct 1994	22:30:00	0.869
22 Oct 1994	23:00:00	0.848
End of data		

Site.2

Lahore Cantt. Ch Niaz House

Date	Time	Depth m
22 Dec 1994	13:30:00	0.939
22 Dec 1994	14:00:00	0.987
22 Dec 1994	14:30:00	0.887
22 Dec 1994	15:00:00	1.023
22 Dec 1994	15:30:00	1.034
End of data		

Site 3  
G Block Gulberg II

Date	Time	Depth m
21 Sep 1994	16:00:00	0.318
21 Sep 1994	16:30:00	0.329
21 Sep 1994	17:00:00	0.323
21 Sep 1994	17:30:00	0.287
21 Sep 1994	18:00:00	0.265
21 Sep 1994	18:30:00	0.258
21 Sep 1994	19:00:00	0.258
21 Sep 1994	19:30:00	0.273
21 Sep 1994	20:00:00	0.289
21 Sep 1994	20:30:00	0.294
21 Sep 1994	21:00:00	0.292
21 Sep 1994	21:30:00	0.290
21 Sep 1994	22:00:00	0.299
21 Sep 1994	22:30:00	0.294
21 Sep 1994	23:00:00	0.287
21 Sep 1994	23:30:00	0.282
22 Sep 1994	00:00:00	0.271
22 Sep 1994	00:30:00	0.254
22 Sep 1994	01:00:00	0.228
22 Sep 1994	01:30:00	0.201
22 Sep 1994	02:00:00	0.181
22 Sep 1994	02:30:00	0.164
22 Sep 1994	03:00:00	0.146
22 Sep 1994	03:30:00	0.132
22 Sep 1994	04:00:00	0.116
22 Sep 1994	04:30:00	0.108
22 Sep 1994	05:00:00	0.103
22 Sep 1994	05:30:00	0.096
22 Sep 1994	06:00:00	0.096
22 Sep 1994	06:30:00	0.103
22 Sep 1994	07:00:00	0.119
22 Sep 1994	07:30:00	0.178
22 Sep 1994	08:00:00	0.226
22 Sep 1994	08:30:00	0.255
22 Sep 1994	09:00:00	0.276
22 Sep 1994	09:30:00	0.347
22 Sep 1994	10:00:00	0.358
22 Sep 1994	10:30:00	0.366
22 Sep 1994	11:00:00	0.364
22 Sep 1994	11:30:00	0.353
22 Sep 1994	12:00:00	0.334
End of data		

Site 3  
G Block Gulberg II

Date	Time	Depth m
22 Sep 1994	12:30:00	0.318
22 Sep 1994	13:00:00	0.310
23 Sep 1994	08:00:00	0.215
23 Sep 1994	08:30:00	0.249
24 Sep 1994	02:30:00	0.146
24 Sep 1994	03:00:00	0.135
25 Sep 1994	08:30:00	0.218
25 Sep 1994	09:00:00	0.255
26 Sep 1994	03:00:00	0.177
26 Sep 1994	03:30:00	0.167
27 Sep 1994	15:30:00	0.276
27 Sep 1994	16:00:00	0.299
28 Sep 1994	21:30:00	0.226
28 Sep 1994	22:00:00	0.225
29 Sep 1994	16:00:00	0.210
29 Sep 1994	16:30:00	0.210
30 Sep 1994	13:30:00	0.276
30 Sep 1994	14:00:00	0.273
01 Oct 1994	07:00:00	0.178
01 Oct 1994	07:30:00	0.196
02 Oct 1994	01:30:00	0.241
02 Oct 1994	02:00:00	0.225
03 Oct 1994	00:30:00	0.260
03 Oct 1994	01:00:00	0.247
04 Oct 1994	05:00:00	0.183
04 Oct 1994	05:30:00	0.186
05 Oct 1994	11:00:00	0.380
05 Oct 1994	11:30:00	0.382
06 Oct 1994	05:30:00	0.201
06 Oct 1994	06:00:00	0.239
07 Oct 1994	11:30:00	0.303
07 Oct 1994	12:00:00	0.284
08 Oct 1994	06:00:00	0.210
08 Oct 1994	06:30:00	0.209
08 Oct 1994	15:00:00	0.356
08 Oct 1994	15:30:00	0.363
08 Oct 1994	16:00:00	0.360
End of data		

Site.3  
G Block Gulberg II

Date	Time	Depth m
08 Oct 1994	16:30:00	0.360
08 Oct 1994	17:00:00	0.358
09 Oct 1994	21:00:00	0.329
09 Oct 1994	21:30:00	0.329
10 Oct 1994	20:00:00	0.311
10 Oct 1994	20:30:00	0.316
11 Oct 1994	14:30:00	0.290
11 Oct 1994	15:00:00	0.300
12 Oct 1994	09:00:00	0.340
12 Oct 1994	09:30:00	0.369
13 Oct 1994	08:00:00	0.270
13 Oct 1994	08:30:00	0.284
14 Oct 1994	02:30:00	0.233
14 Oct 1994	03:00:00	0.230
15 Oct 1994	08:30:00	0.289
15 Oct 1994	09:00:00	0.315
16 Oct 1994	03:00:00	0.178
16 Oct 1994	03:30:00	0.172
17 Oct 1994	10:00:00	0.360
17 Oct 1994	10:30:00	0.371
18 Oct 1994	16:00:00	0.315
18 Oct 1994	16:30:00	0.316
18 Oct 1994	10:30:00	0.342
19 Oct 1994	11:00:00	0.347
20 Oct 1994	09:30:00	0.356
20 Oct 1994	10:00:00	0.369
21 Oct 1994	04:00:00	0.244
21 Oct 1994	04:30:00	0.242
21 Oct 1994	22:30:00	0.311
21 Oct 1994	23:00:00	0.302
22 Oct 1994	21:30:00	0.326
22 Oct 1994	22:00:00	0.315
23 Oct 1994	14:30:00	0.319
23 Oct 1994	15:00:00	0.334

End of data

Site-3  
G Block Gulberg II

Date	Time	Depth m
31 Dec 1984	11:30:00	0.330
31 Dec 1994	12:00:00	0.318
End of data		

Site 4  
Zafar Ali Road /Jail Road

Date	Time	Depth m
10 Sep 1994	14:25:00	0.327
10 Sep 1994	14:26:00	0.327
10 Sep 1994	14:27:00	0.327
10 Sep 1994	14:28:00	0.326
10 Sep 1994	17:11:00	0.326
10 Sep 1994	17:12:00	0.326
10 Sep 1994	17:13:00	0.326
14 Sep 1994	17:30:00	0.197
14 Sep 1994	18:00:00	0.205
14 Sep 1994	18:30:00	0.195
14 Sep 1994	19:00:00	0.205
15 Sep 1994	10:00:00	0.222
15 Sep 1994	10:30:00	0.223
15 Sep 1994	11:00:00	0.225
15 Sep 1994	11:30:00	0.220
15 Sep 1994	12:00:00	0.212
15 Sep 1994	12:30:00	0.185
15 Sep 1994	13:00:00	0.177
15 Sep 1994	13:30:00	0.205
15 Sep 1994	14:00:00	0.203
16 Sep 1994	04:00:00	0.073
16 Sep 1994	04:30:00	0.057
16 Sep 1994	05:00:00	0.049
16 Sep 1994	05:30:00	0.056
16 Sep 1994	06:00:00	0.069
16 Sep 1994	06:30:00	0.086
16 Sep 1994	07:00:00	0.108
16 Sep 1994	07:30:00	0.128
17 Sep 1994	09:30:00	0.268
17 Sep 1994	10:00:00	0.269
17 Sep 1994	10:30:00	0.249
17 Sep 1994	11:00:00	0.217
17 Sep 1994	11:30:00	0.195
17 Sep 1994	12:00:00	0.215
17 Sep 1994	12:30:00	0.214
18 Sep 1994	15:00:00	0.208
18 Sep 1994	15:30:00	0.186
18 Sep 1994	16:00:00	0.165
18 Sep 1994	21:30:00	0.231
18 Sep 1994	22:00:00	0.229
18 Sep 1994	22:30:00	0.212

Site 4  
Zafar Ali Road /Jail Road

Date	Time	Depth m
22 Sep 1994	13:00:00	0.174
22 Sep 1994	13:30:00	0.174
23 Sep 1994	21:00:00	0.163
23 Sep 1994	21:30:00	0.162
24 Sep 1994	20:00:00	0.168
24 Sep 1994	20:30:00	0.168
25 Sep 1994	14:30:00	0.182
25 Sep 1994	15:00:00	0.186
26 Sep 1994	09:00:00	0.223
26 Sep 1994	09:30:00	0.228
27 Sep 1994	07:00:00	0.069
27 Sep 1994	07:30:00	0.082
28 Sep 1994	12:00:00	0.182
28 Sep 1994	12:30:00	0.171
29 Sep 1994	11:00:00	0.179
29 Sep 1994	11:30:00	0.162
30 Sep 1994	05:30:00	0.028
30 Sep 1994	06:00:00	0.051
01 Oct 1994	00:00:00	0.194
01 Oct 1994	00:30:00	0.154
02 Oct 1994	06:00:00	0.065
02 Oct 1994	06:30:00	0.083
03 Oct 1994	05:00:00	0.031
04 Oct 1994	10:00:00	0.268
04 Oct 1994	10:30:00	0.263
05 Oct 1994	08:30:00	0.188
05 Oct 1994	09:00:00	0.228
06 Oct 1994	03:00:00	0.076
06 Oct 1994	03:30:00	0.056
07 Oct 1994	09:00:00	0.234
07 Oct 1994	09:30:00	0.237
08 Oct 1994	04:30:00	0.057
08 Oct 1994	05:00:00	0.045
08 Oct 1994	13:30:00	0.191
08 Oct 1994	14:00:00	0.180
08 Oct 1994	14:30:00	0.208
End of data		

Site 4  
Jail Road / Zafar Ali Road

Date	Time	Depth m
08 Oct 1994	15:00:00	0.205
08 Oct 1994	15:30:00	0.206
09 Oct 1994	11:00:00	0.188
09 Oct 1994	11:30:00	0.185
10 Oct 1994	05:30:00	0.040
10 Oct 1994	06:00:00	0.083
11 Oct 1994	11:30:00	0.195
11 Oct 1994	12:00:00	0.195
12 Oct 1994	06:00:00	0.066
12 Oct 1994	06:30:00	0.066
13 Oct 1994	05:00:00	0.020
13 Oct 1994	05:30:00	0.030
14 Oct 1994	11:00:00	0.165
14 Oct 1994	11:30:00	0.166
15 Oct 1994	05:30:00	0.033
15 Oct 1994	06:00:00	0.042
16 Oct 1994	00:00:00	0.134
16 Oct 1994	00:30:00	0.120
17 Oct 1994	06:00:00	0.056
17 Oct 1994	06:30:00	0.082
18 Oct 1994	12:00:00	0.129
18 Oct 1994	12:30:00	0.129
19 Oct 1994	18:00:00	0.126
19 Oct 1994	18:30:00	0.125
20 Oct 1994	12:30:00	0.126
20 Oct 1994	13:00:00	0.117
21 Oct 1994	11:30:00	0.114
21 Oct 1994	12:00:00	0.116
22 Oct 1994	06:00:00	0.080
22 Oct 1994	06:30:00	0.099
23 Oct 1994	12:00:00	0.111
23 Oct 1994	12:30:00	0.111
23 Oct 1994	13:00:00	0.112
23 Oct 1994	13:30:00	0.112
23 Oct 1994	14:00:00	0.112
23 Oct 1994	14:30:00	0.114
23 Oct 1994	15:00:00	0.114
23 Oct 1994	15:30:00	0.116
23 Oct 1994	16:00:00	0.116
End of data		

Site No.4  
Location Zafar Ali Road / Jail Road

Date	Time	Depth m
21 Dec 1994	15:30:00	0.389
21 Dec 1994	16:00:00	0.365
21 Dec 1994	16:30:00	0.367
21 Dec 1994	17:00:00	0.381
21 Dec 1994	17:30:00	0.384
End of data		

Site 5  
 Canal Bank / Canal Park

Date	Time	Depth m
10 Sep 1994	15:16:00	0.437
10 Sep 1994	15:17:00	0.438
10 Sep 1994	15:18:00	0.440
10 Sep 1994	15:19:00	0.440
10 Sep 1994	15:20:00	0.441
10 Sep 1994	15:21:00	0.440
10 Sep 1994	17:26:00	0.430
10 Sep 1994	17:27:00	0.430
10 Sep 1994	17:28:00	0.430
10 Sep 1994	17:29:00	0.430
10 Sep 1994	17:30:00	0.427
10 Sep 1994	17:31:00	0.429
14 Sep 1994	23:30:00	0.398
15 Sep 1994	00:00:00	0.381
15 Sep 1994	00:30:00	0.375
15 Sep 1994	01:00:00	0.363
15 Sep 1994	01:30:00	0.341
15 Sep 1994	02:00:00	0.321
15 Sep 1994	02:30:00	0.304
15 Sep 1994	03:00:00	0.284
16 Sep 1994	02:00:00	0.309
16 Sep 1994	02:30:00	0.298
16 Sep 1994	03:00:00	0.287
16 Sep 1994	03:30:00	0.278
16 Sep 1994	04:00:00	0.267
17 Sep 1994	08:00:00	0.304
17 Sep 1994	08:30:00	0.346
17 Sep 1994	09:00:00	0.372
17 Sep 1994	09:30:00	0.410
17 Sep 1994	10:00:00	0.427
17 Sep 1994	10:30:00	0.444
17 Sep 1994	17:00:00	0.432
17 Sep 1994	17:30:00	0.441
17 Sep 1994	18:00:00	0.446
17 Sep 1994	18:30:00	0.440
17 Sep 1994	19:00:00	0.429
17 Sep 1994	19:30:00	0.427
17 Sep 1994	20:00:00	0.432
17 Sep 1994	20:30:00	0.444

Site.5  
Canal Park / Canal Bank

Date	Time	Depth m
22 Sep 1994	13:00:00	0.413
22 Sep 1994	13:30:00	0.393
23 Sep 1994	08:30:00	0.312
23 Sep 1994	09:00:00	0.353
24 Sep 1994	03:00:00	0.245
24 Sep 1994	03:30:00	0.236
25 Sep 1994	09:00:00	0.282
25 Sep 1994	09:30:00	0.335
26 Sep 1994	03:30:00	0.162
26 Sep 1994	04:00:00	0.148
27 Sep 1994	09:30:00	0.275
27 Sep 1994	10:00:00	0.310
28 Sep 1994	08:30:00	0.083
28 Sep 1994	09:00:00	0.094
29 Sep 1994	03:00:00	0.034
29 Sep 1994	03:30:00	0.037
30 Sep 1994	09:00:00	0.148
30 Sep 1994	09:30:00	0.154
01 Oct 1994	15:00:00	0.168
01 Oct 1994	15:30:00	0.174
02 Oct 1994	09:30:00	0.150
02 Oct 1994	10:00:00	0.160
03 Oct 1994	15:30:00	0.106
03 Oct 1994	16:00:00	0.113
04 Oct 1994	21:30:00	0.043
04 Oct 1994	22:00:00	0.045
05 Oct 1994	16:00:00	0.080
05 Oct 1994	16:30:00	0.079
06 Oct 1994	15:00:00	0.086
06 Oct 1994	15:30:00	0.093
07 Oct 1994	09:30:00	0.119
07 Oct 1994	10:00:00	0.144
08 Oct 1994	04:00:00	0.071
08 Oct 1994	04:30:00	0.069
08 Oct 1994	14:00:00	0.102
08 Oct 1994	14:30:00	0.099
08 Oct 1994	15:00:00	0.134
08 Oct 1994	15:30:00	0.162
08 Oct 1994	16:00:00	0.147
End of data		

Site 5  
Cana Bank / Canal Park

Date	Time	Depth m
08 Oct 1994	16:30:00	0.131
08 Oct 1994	17:00:00	0.123
08 Oct 1994	21:00:00	0.437
09 Oct 1994	21:30:00	0.449
10 Oct 1994	20:00:00	0.319
10 Oct 1994	20:30:00	0.313
11 Oct 1994	14:30:00	0.256
11 Oct 1994	15:00:00	0.258
12 Oct 1994	09:00:00	0.279
12 Oct 1994	09:30:00	0.316
13 Oct 1994	08:00:00	0.216
13 Oct 1994	08:30:00	0.259
14 Oct 1994	02:30:00	0.214
14 Oct 1994	03:00:00	0.207
14 Oct 1994	21:00:00	0.293
14 Oct 1994	21:30:00	0.298
15 Oct 1994	20:00:00	0.350
15 Oct 1994	20:30:00	0.355
16 Oct 1994	19:00:00	0.375
16 Oct 1994	19:30:00	0.358
17 Oct 1994	13:30:00	0.364
17 Oct 1994	14:00:00	0.370
18 Oct 1994	08:00:00	0.278
18 Oct 1994	08:30:00	0.309
19 Oct 1994	13:30:00	0.336
19 Oct 1994	14:00:00	0.338
20 Oct 1994	12:30:00	0.378
20 Oct 1994	13:00:00	0.383
21 Oct 1994	07:00:00	0.261
21 Oct 1994	07:30:00	0.261
22 Oct 1994	01:30:00	0.293
22 Oct 1994	02:00:00	0.279
23 Oct 1994	09:00:00	0.342
23 Oct 1994	09:30:00	0.376
End of data		

Site 5  
Canal Bank / Canal Park

Date	Time	Depth m
31 Dec 1994	13:00:00	0.459
End of data		

Site 6  
Shama Cinema at Ferozpur road

Date	Time	Depth m
10 Sep 1994	15:29:00	0.950
10 Sep 1994	15:30:00	0.950
10 Sep 1994	17:50:00	0.939
14 Sep 1994	18:30:00	0.951
14 Sep 1994	20:00:00	0.950
14 Sep 1994	20:30:00	0.955
14 Sep 1994	21:00:00	0.959
15 Sep 1994	00:00:00	0.950
15 Sep 1994	01:30:00	0.923
15 Sep 1994	03:30:00	0.864
16 Sep 1994	02:00:00	0.891
16 Sep 1994	05:00:00	0.815
16 Sep 1994	05:30:00	0.805
16 Sep 1994	06:00:00	0.801
17 Sep 1994	07:00:00	0.768
17 Sep 1994	09:30:00	0.860
17 Sep 1994	10:00:00	0.895
18 Sep 1994	05:30:00	0.797
18 Sep 1994	07:00:00	0.804
18 Sep 1994	07:30:00	0.818
19 Sep 1994	07:30:00	0.802
19 Sep 1994	08:00:00	0.807
19 Sep 1994	12:00:00	0.953
20 Sep 1994	13:00:00	1.015
20 Sep 1994	13:30:00	1.000
20 Sep 1994	16:30:00	0.900
21 Sep 1994	11:30:00	0.920
21 Sep 1994	12:00:00	0.922
21 Sep 1994	13:30:00	0.920
21 Sep 1994	14:00:00	0.919
21 Sep 1994	14:30:00	0.916

Site 6  
Shama Cinema

Date	Time	Depth m
22 Sep 1994	13:00:00	0.961
22 Sep 1994	13:30:00	0.955
23 Sep 1994	08:30:00	0.802
23 Sep 1994	09:00:00	0.818
24 Sep 1994	03:00:00	0.855
24 Sep 1994	03:30:00	0.844
25 Sep 1994	09:00:00	0.846
25 Sep 1994	09:30:00	0.864
26 Sep 1994	03:30:00	0.857
26 Sep 1994	04:00:00	0.841
27 Sep 1994	06:30:00	0.818
28 Sep 1994	01:00:00	0.916
28 Sep 1994	01:30:00	0.900
29 Sep 1994	07:00:00	0.791
29 Sep 1994	07:30:00	0.796
30 Sep 1994	01:30:00	0.902
30 Sep 1994	02:00:00	0.885
01 Oct 1994	07:30:00	0.808
01 Oct 1994	08:00:00	0.816
03 Oct 1994	14:00:00	0.944
03 Oct 1994	14:30:00	0.945
04 Oct 1994	20:00:00	0.947
04 Oct 1994	20:30:00	0.947
05 Oct 1994	22:00:00	0.961
05 Oct 1994	22:30:00	0.964
06 Oct 1994	22:30:00	0.995
06 Oct 1994	23:00:00	0.993
07 Oct 1994	10:00:00	0.902
07 Oct 1994	10:30:00	0.936
08 Oct 1994	03:30:00	0.857
08 Oct 1994	04:00:00	0.844
08 Oct 1994	15:30:00	0.951
08 Oct 1994	16:00:00	0.959
08 Oct 1994	16:30:00	0.972
08 Oct 1994	17:00:00	0.970
End of data		

Site 6  
Shama Cinema

Date	Time	Depth m
08 Oct 1994	17:30:00	0.969
08 Oct 1994	18:00:00	0.967
09 Oct 1994	13:30:00	0.975
09 Oct 1994	14:00:00	0.973
10 Oct 1994	08:00:00	0.849
10 Oct 1994	08:30:00	0.858
11 Oct 1994	02:30:00	0.897
11 Oct 1994	03:00:00	0.886
12 Oct 1994	01:30:00	0.905
12 Oct 1994	02:00:00	0.892
13 Oct 1994	13:00:00	0.931
13 Oct 1994	13:30:00	0.922
14 Oct 1994	12:00:00	0.953
14 Oct 1994	12:30:00	0.956
15 Oct 1994	06:30:00	0.816
15 Oct 1994	07:00:00	0.815
16 Oct 1994	10:30:00	0.913
16 Oct 1994	11:00:00	0.927
17 Oct 1994	16:30:00	0.955
17 Oct 1994	17:00:00	0.955
18 Oct 1994	11:00:00	0.948
18 Oct 1994	11:30:00	0.961
19 Oct 1994	17:00:00	0.941
19 Oct 1994	17:30:00	0.939
20 Oct 1994	23:00:00	0.958
20 Oct 1994	23:30:00	0.955
21 Oct 1994	22:30:00	0.975
21 Oct 1994	23:00:00	0.969
22 Oct 1994	21:30:00	0.942
22 Oct 1994	22:00:00	0.948
23 Oct 1994	16:00:00	0.942
23 Oct 1994	16:30:00	0.944
23 Oct 1994	17:00:00	0.947
23 Oct 1994	17:30:00	0.948
23 Oct 1994	18:00:00	0.955
23 Oct 1994	18:30:00	0.961

End of data

Site 6  
Shama Cinema

Date	Time	Depth m
31 Dec 1994	13:30:00	0.368
End of data		

Site 6  
Shama Cinema

Date	Time	Depth m
31 Dec 1994	14:00:00	0.373
End of data		

Site 7  
Mian Mir Upper Mall

Date	Time	Depth m
12 Sep 1994	15:16:00	0.148
12 Sep 1994	15:17:00	0.151
12 Sep 1994	15:18:00	0.150
12 Sep 1994	15:19:00	0.148
12 Sep 1994	15:20:00	0.150
12 Sep 1994	15:21:00	0.148
12 Sep 1994	15:22:00	0.148
12 Sep 1994	17:21:00	0.188
12 Sep 1994	17:22:00	0.188
12 Sep 1994	17:23:00	0.188
12 Sep 1994	17:24:00	0.191
12 Sep 1994	17:25:00	0.194
12 Sep 1994	17:26:00	0.194
14 Sep 1994	20:30:00	0.153
14 Sep 1994	21:00:00	0.150
14 Sep 1994	21:30:00	0.188
14 Sep 1994	22:00:00	0.191
14 Sep 1994	22:30:00	0.139
14 Sep 1994	23:00:00	0.139
14 Sep 1994	23:30:00	0.148
15 Sep 1994	00:00:00	0.090
15 Sep 1994	00:30:00	0.082
15 Sep 1994	01:00:00	0.068
15 Sep 1994	01:30:00	0.052
15 Sep 1994	02:00:00	0.047
15 Sep 1994	02:30:00	0.035
15 Sep 1994	03:00:00	0.003
16 Sep 1994	12:00:00	0.202
16 Sep 1994	12:30:00	0.188
16 Sep 1994	13:00:00	0.199
16 Sep 1994	13:30:00	0.206
16 Sep 1994	14:00:00	0.211
16 Sep 1994	14:30:00	0.194
16 Sep 1994	15:00:00	0.197
17 Sep 1994	15:30:00	0.202
17 Sep 1994	16:00:00	0.188
17 Sep 1994	16:30:00	0.217
17 Sep 1994	17:00:00	0.235
17 Sep 1994	17:30:00	0.221
17 Sep 1994	18:00:00	0.183
17 Sep 1994	18:30:00	0.161
17 Sep 1994	19:00:00	0.202

Site No. 7  
Upper Mall Mian Mir

Date	Time	Depth m
22 Sep 1994	11:30:00	0.189
23 Sep 1994	00:00:00	0.099
24 Sep 1994	00:00:00	0.061
25 Sep 1994	00:00:00	0.102
26 Sep 1994	00:00:00	0.065
27 Sep 1994	00:00:00	0.091
28 Sep 1994	00:00:00	0.030
29 Sep 1994	00:00:00	0.074
30 Sep 1994	00:00:00	0.076
01 Oct 1994	00:00:00	0.063
02 Oct 1994	00:00:00	0.058
03 Oct 1994	00:00:00	0.071
04 Oct 1994	00:00:00	0.058
05 Oct 1994	00:00:00	0.038
06 Oct 1994	00:00:00	0.061
07 Oct 1994	00:00:00	0.054
08 Oct 1994	00:00:00	0.022
08 Oct 1994	13:00:00	0.054
End of data		

Site 7  
Mian Mir Upper Mall

Date	Time	Depth m
08 Oct 1994	14:00:00	0.095
08 Oct 1994	14:30:00	0.113
08 Oct 1994	08:30:00	0.107
08 Oct 1994	09:00:00	0.101
09 Oct 1994	09:30:00	0.117
10 Oct 1994	10:00:00	0.107
10 Oct 1994	10:30:00	0.076
11 Oct 1994	09:00:00	0.077
11 Oct 1994	09:30:00	0.085
12 Oct 1994	15:00:00	0.071
12 Oct 1994	15:30:00	0.076
13 Oct 1994	09:30:00	0.095
13 Oct 1994	10:00:00	0.091
14 Oct 1994	15:30:00	0.082
14 Oct 1994	16:00:00	0.074
15 Oct 1994	21:30:00	0.055
15 Oct 1994	22:00:00	0.036
16 Oct 1994	16:00:00	0.038
16 Oct 1994	16:30:00	0.035
17 Oct 1994	22:00:00	0.028
17 Oct 1994	22:30:00	0.025
19 Oct 1994	15:30:00	0.115
18 Oct 1994	16:00:00	0.072
20 Oct 1994	20:30:00	0.136
20 Oct 1994	21:00:00	0.164
21 Oct 1994	15:00:00	0.143
21 Oct 1994	15:30:00	0.117
22 Oct 1994	21:00:00	0.240
22 Oct 1994	21:30:00	0.230
23 Oct 1994	08:30:00	0.222
23 Oct 1994	09:00:00	0.211
23 Oct 1994	09:30:00	0.222
23 Oct 1994	10:00:00	0.232
23 Oct 1994	10:30:00	0.213
23 Oct 1994	11:00:00	0.181
23 Oct 1994	11:30:00	0.211
23 Oct 1994	12:00:00	0.227
23 Oct 1994	12:30:00	0.222
23 Oct 1994	13:00:00	0.180
23 Oct 1994	13:30:00	0.191
23 Oct 1994	14:00:00	0.213
23 Oct 1994	14:30:00	0.208
23 Oct 1994	15:00:00	0.191
23 Oct 1994	15:30:00	0.206
End of data		

Site 7  
Mian Mir Upper Mall (*Location Slightly changed d/s of bridge*)

Date	Time	Depth m
21 Dec 1994	15:30:00	0.407
21 Dec 1994	16:00:00	0.429
21 Dec 1994	16:30:00	0.427
21 Dec 1994	17:00:00	0.422
End of data		

Site

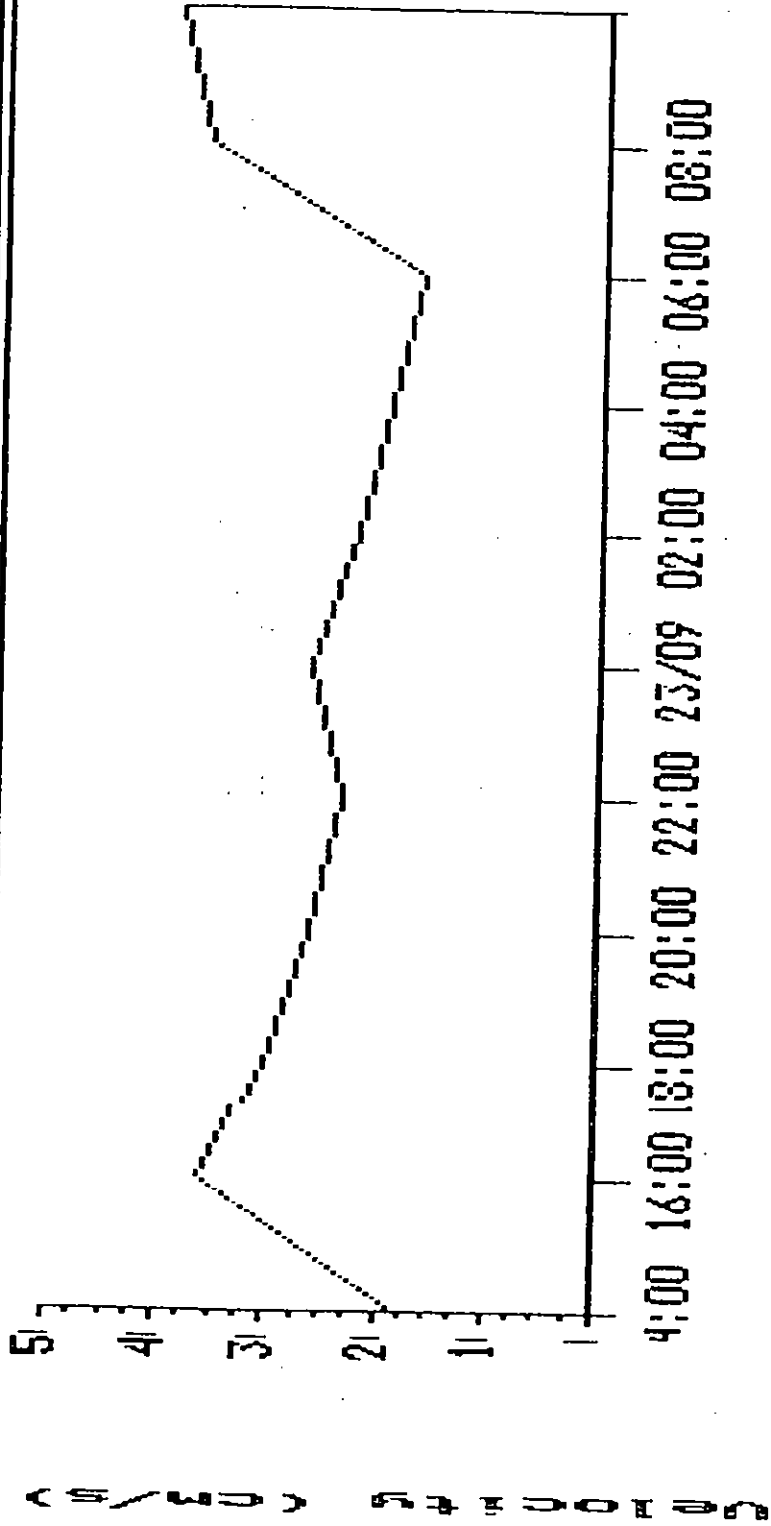
Gulberg near Sichuan Chinese Restaurent

Date	Time	Depth m
22 Dec 1994	14:00:00	0.198
22 Dec 1994	14:30:00	0.230
22 Dec 1994	15:00:00	0.243
22 Dec 1994	15:30:00	0.262
End of data		

ANNEXURE.3



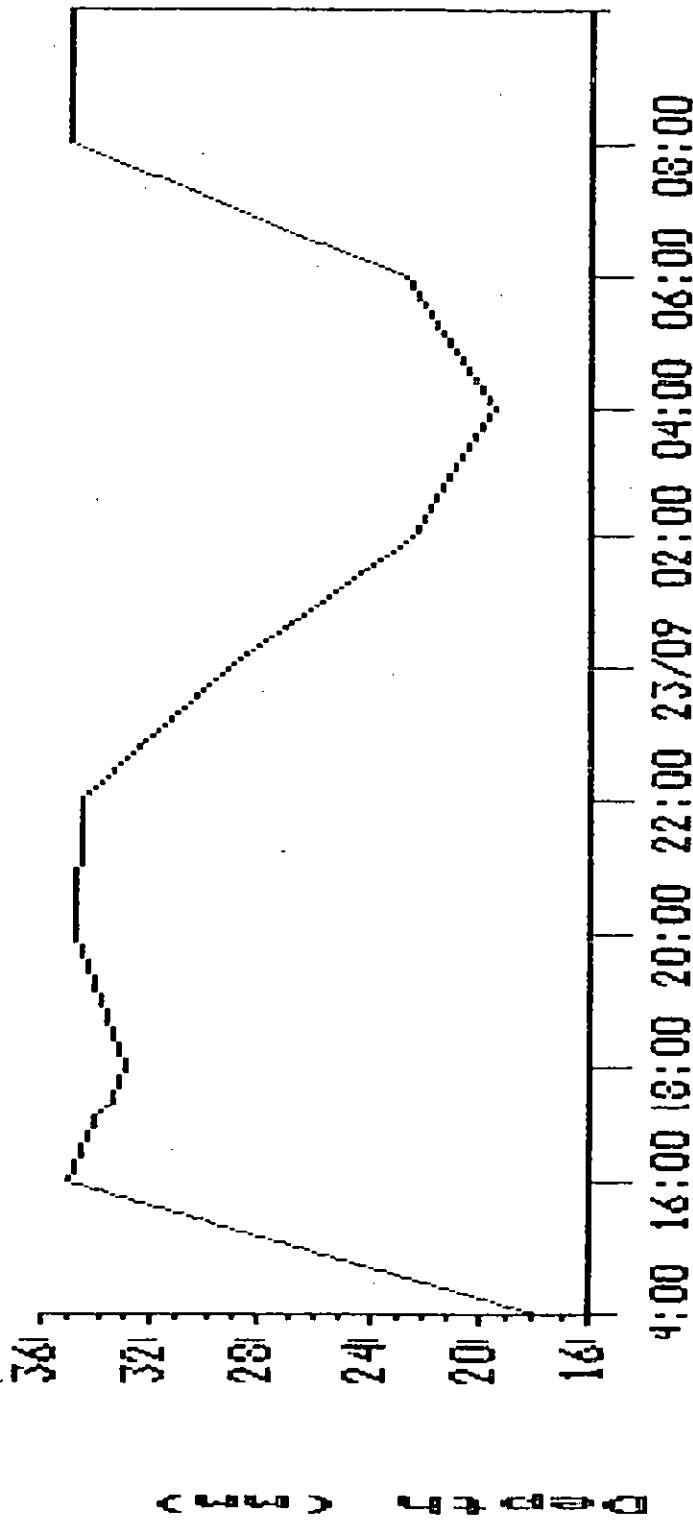
INSTITUT OF HYDROLOGY  
 0135/HYDBeta 0.06



LOGGER I : WATERM  
 LOGGER N. : 503800M  
 LOGGER NME : SITES

DATA RANGE : 22/09/94 14:00:00  
 24/09/94 03:00:00  
 INTERVAL : 2 HOURS

INSTITUT OF HYDROLOY  
0135/HYDBeta 0.06



LOGGER I : WATERM  
LOGGER N. : 508800H  
LOGGER NME : SITE3

DATA RANGE : 22/09/94 14:00:00  
24/09/94 08:00:00  
INTERVAL : 2 HOURS





Reg'd User : INSTITUTE OF HYDROLOGY

Licence No : 0135/HYD/Beta 0.06

Site Number : 50880004

Data Range : 24/09/94 10:00:00

08/10/94 14:00:00

Pipe Shape : RECTANGULAR

Dimensions : 5000 mm / 350 mm

Logger ID : WATERRAT

Site Name : SITE3

Events : 171

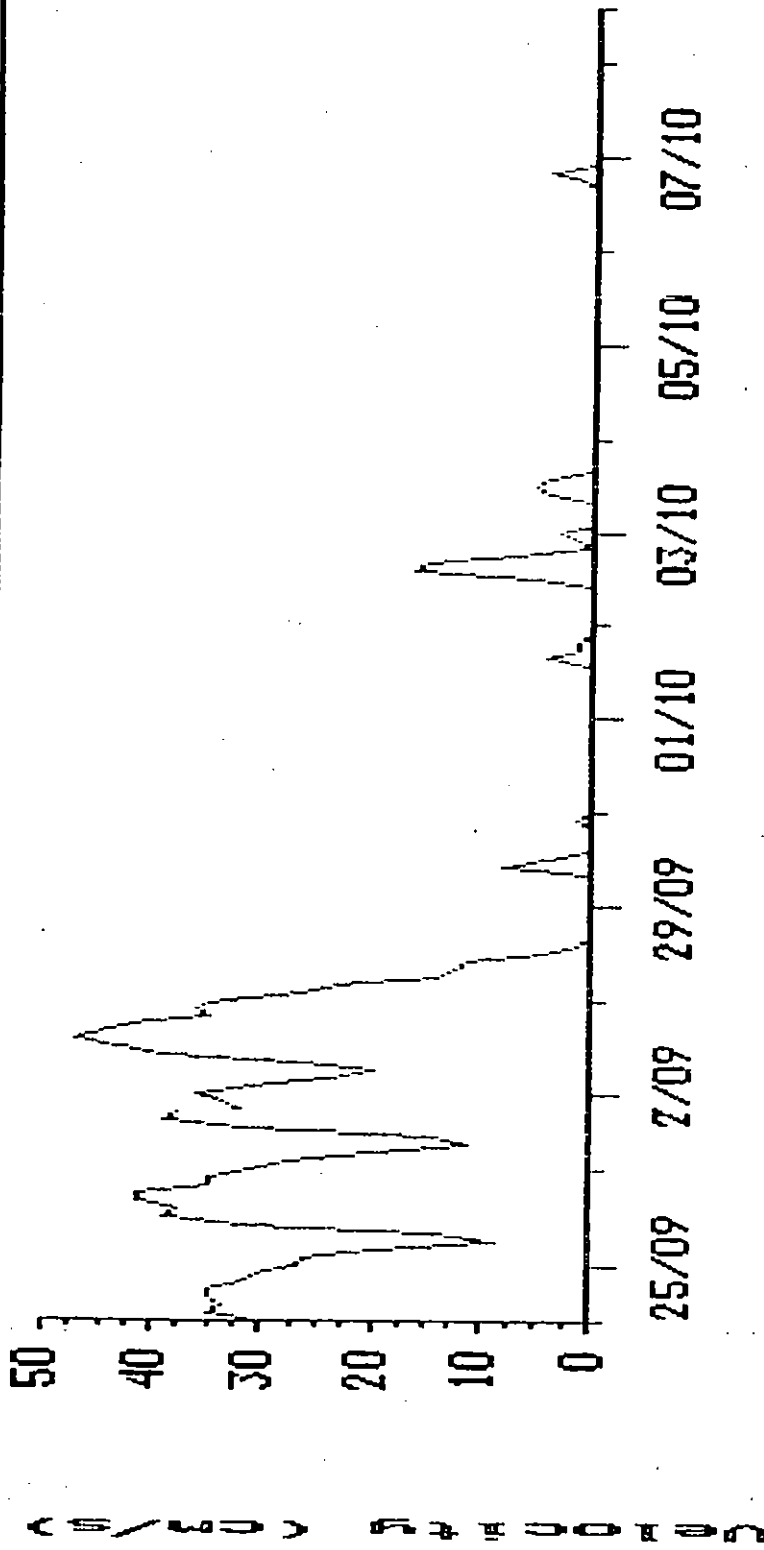
Interval : 2 HOURS

Offset : 0 mm

RECORD	DATE/TIME	VELOCITY	DEPTH	FLOW	TOTAL
93	02/10/94 02:00	0 cm/s	179 mm	0 l/s	171489.60 m3
94	02/10/94 04:00	0 cm/s	152 mm	0 l/s	171489.60 m3
95	02/10/94 06:00	0 cm/s	139 mm	0 l/s	171489.60 m3
96	02/10/94 08:00	0 cm/s	149 mm	0 l/s	171489.60 m3
97	02/10/94 10:00	0 cm/s	190 mm	0 l/s	171489.60 m3
98	02/10/94 12:00	5 cm/s	202 mm	51 l/s	171856.80 m3
99	02/10/94 14:00	16 cm/s	199 mm	159 l/s	173001.60 m3
100	02/10/94 16:00	15 cm/s	195 mm	148 l/s	174052.80 m3
101	02/10/94 18:00	7 cm/s	191 mm	67 l/s	174535.20 m3
102	02/10/94 20:00	0 cm/s	181 mm	0 l/s	174535.20 m3
103	02/10/94 22:00	1 cm/s	180 mm	9 l/s	174600.00 m3
104	03/10/94 00:00	3 cm/s	177 mm	27 l/s	174794.40 m3
105	03/10/94 02:00	0 cm/s	163 mm	0 l/s	174794.40 m3
106	03/10/94 04:00	0 cm/s	149 mm	0 l/s	174794.40 m3
107	03/10/94 08:00	0 cm/s	138 mm	0 l/s	174794.40 m3
108	03/10/94 08:00	0 cm/s	147 mm	0 l/s	174794.40 m3
109	03/10/94 10:00	4 cm/s	184 mm	37 l/s	175060.80 m3
110	03/10/94 12:00	5 cm/s	196 mm	49 l/s	175413.60 m3
111	03/10/94 14:00	4 cm/s	192 mm	38 l/s	175687.20 m3
112	03/10/94 16:00	0 cm/s	195 mm	0 l/s	175687.20 m3
113	03/10/94 18:00	0 cm/s	204 mm	0 l/s	175687.20 m3
114	03/10/94 20:00	0 cm/s	197 mm	0 l/s	175687.20 m3
115	03/10/94 22:00	0 cm/s	192 mm	0 l/s	175687.20 m3
116	04/10/94 00:00	0 cm/s	185 mm	0 l/s	175687.20 m3
117	04/10/94 02:00	0 cm/s	170 mm	0 l/s	175687.20 m3
118	04/10/94 04:00	0 cm/s	151 mm	0 l/s	175687.20 m3
119	04/10/94 06:00	0 cm/s	144 mm	0 l/s	175687.20 m3
120	04/10/94 08:00	0 cm/s	157 mm	0 l/s	175687.20 m3
121	04/10/94 10:00	0 cm/s	194 mm	0 l/s	175687.20 m3
122	04/10/94 12:00	0 cm/s	200 mm	0 l/s	175687.20 m3
123	04/10/94 14:00	0 cm/s	190 mm	0 l/s	175687.20 m3
124	04/10/94 16:00	0 cm/s	187 mm	0 l/s	175687.20 m3
125	04/10/94 18:00	0 cm/s	191 mm	0 l/s	175687.20 m3
126	04/10/94 20:00	0 cm/s	189 mm	0 l/s	175687.20 m3
127	04/10/94 22:00	0 cm/s	192 mm	0 l/s	175687.20 m3
128	05/10/94 00:00	0 cm/s	195 mm	0 l/s	175687.20 m3
129	05/10/94 02:00	0 cm/s	174 mm	0 l/s	175687.20 m3
130	05/10/94 04:00	0 cm/s	149 mm	0 l/s	175687.20 m3
131	05/10/94 06:00	0 cm/s	131 mm	0 l/s	175687.20 m3
132	05/10/94 08:00	0 cm/s	133 mm	0 l/s	175687.20 m3
133	05/10/94 10:00	0 cm/s	188 mm	0 l/s	175687.20 m3
134	05/10/94 12:00	0 cm/s	219 mm	0 l/s	175687.20 m3
135	05/10/94 14:00	0 cm/s	210 mm	0 l/s	175687.20 m3
136	05/10/94 16:00	0 cm/s	200 mm	0 l/s	175687.20 m3
137	05/10/94 18:00	0 cm/s	191 mm	0 l/s	175687.20 m3
138	05/10/94 20:00	0 cm/s	176 mm	0 l/s	175687.20 m3



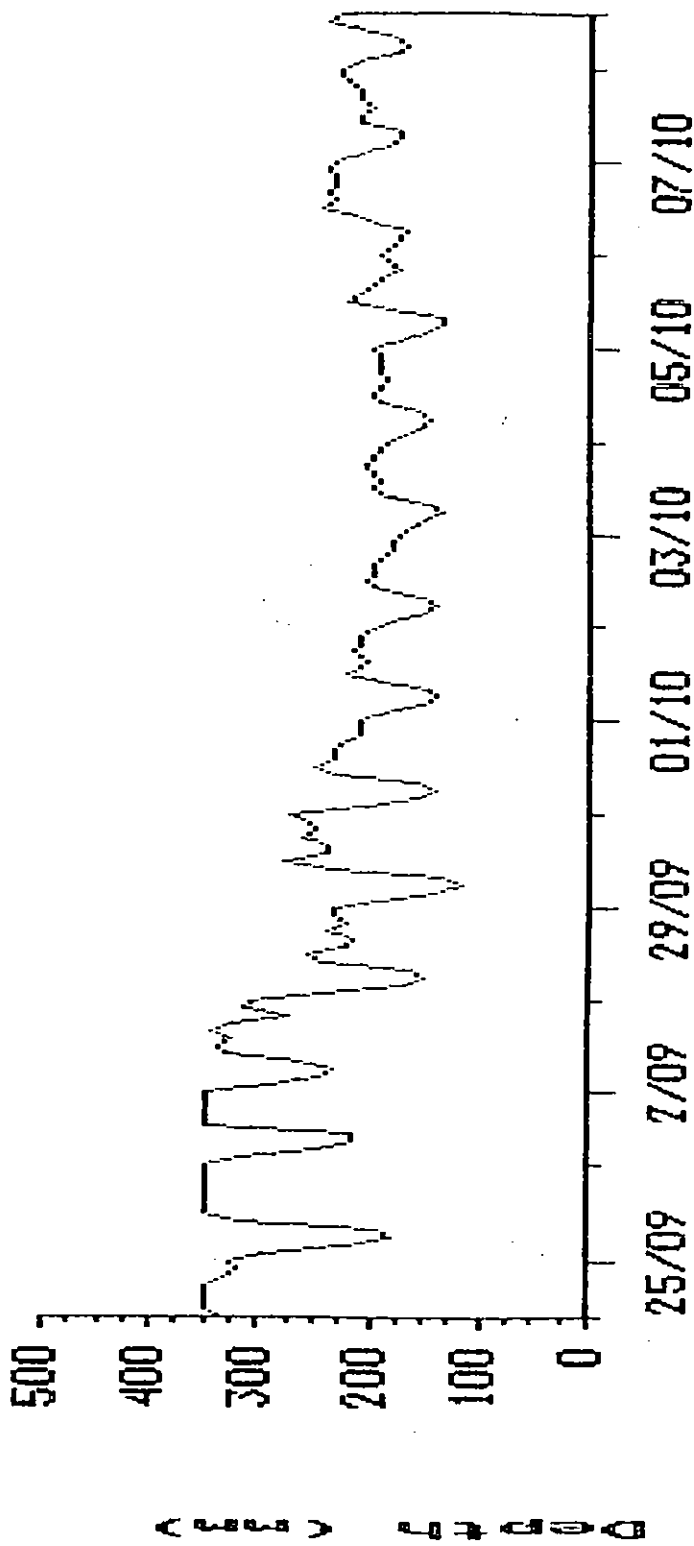
INSTITUTE OF HYDROLOGY  
0135/HYD/Beta 0.06



LOGGER ID : WATERRI  
LOGGER NO. : 508800H  
LOGGER NAME : SITE3

DATA RANGE : 24/09/94 10:00:00  
03/10/94 14:00:00  
INTERVAL : 2 HOURS

INSTITUTE OF HYDROLOGY  
0135/HYD/Beta 0.06



LOGGER ID : WATERM  
LOGGER NO. : 508800A  
LOGGER NAME : SITE3

DATA RANGE : 24/09/94 10:00:00  
08/10/94 14:00:00  
INTERVAL : 2 HOURS



Reg'd User : INSTITUTE OF HYDROLOGY

Licence No : 0135/HYD/Beta 0.06

Site Number : 50880004

Data Range : 08/10/94 16:00:00  
27/10/94 10:00:00

Pipe Shape : RECTANGULAR

Dimensions : 5000 mm / 350 mm

Logger ID : WATERRAT

Site Name : SITE3

Events : 226

Interval : 2 HOURS

Offset : 0 mm

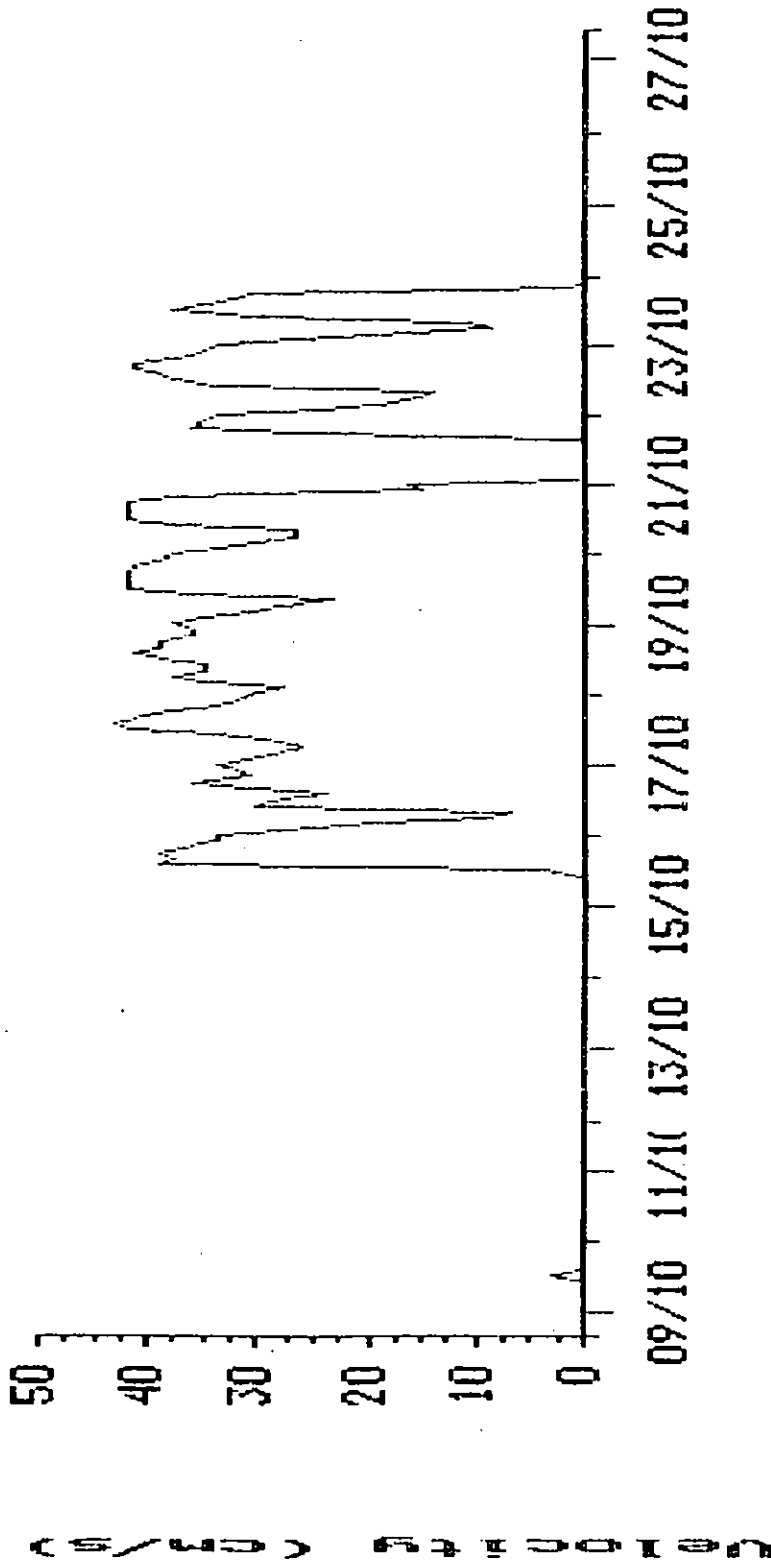
RECORD	DATE/TIME	VELOCITY	DEPTH	FLOW	TOTAL
47	12/10/94 12:00	0 cm/s	227 mm	0 l/s	252.00 m3
48	12/10/94 14:00	0 cm/s	217 mm	0 l/s	252.00 m3
49	12/10/94 16:00	0 cm/s	222 mm	0 l/s	252.00 m3
50	12/10/94 18:00	0 cm/s	214 mm	0 l/s	252.00 m3
51	12/10/94 20:00	0 cm/s	200 mm	0 l/s	252.00 m3
52	12/10/94 22:00	0 cm/s	197 mm	0 l/s	252.00 m3
53	13/10/94 00:00	0 cm/s	205 mm	0 l/s	252.00 m3
54	13/10/94 02:00	0 cm/s	194 mm	0 l/s	252.00 m3
55	13/10/94 04:00	0 cm/s	193 mm	0 l/s	252.00 m3
56	13/10/94 06:00	0 cm/s	178 mm	0 l/s	252.00 m3
57	13/10/94 08:00	0 cm/s	178 mm	0 l/s	252.00 m3
58	13/10/94 10:00	0 cm/s	195 mm	0 l/s	252.00 m3
59	13/10/94 12:00	0 cm/s	207 mm	0 l/s	252.00 m3
60	13/10/94 14:00	0 cm/s	209 mm	0 l/s	252.00 m3
61	13/10/94 16:00	0 cm/s	208 mm	0 l/s	252.00 m3
62	13/10/94 18:00	0 cm/s	211 mm	0 l/s	252.00 m3
63	13/10/94 20:00	0 cm/s	201 mm	0 l/s	252.00 m3
64	13/10/94 22:00	0 cm/s	202 mm	0 l/s	252.00 m3
65	14/10/94 00:00	0 cm/s	196 mm	0 l/s	252.00 m3
66	14/10/94 02:00	0 cm/s	181 mm	0 l/s	252.00 m3
67	14/10/94 04:00	0 cm/s	172 mm	0 l/s	252.00 m3
68	14/10/94 06:00	0 cm/s	164 mm	0 l/s	252.00 m3
69	14/10/94 08:00	0 cm/s	173 mm	0 l/s	252.00 m3
70	14/10/94 10:00	0 cm/s	201 mm	0 l/s	252.00 m3
71	14/10/94 12:00	0 cm/s	208 mm	0 l/s	252.00 m3
72	14/10/94 14:00	0 cm/s	212 mm	0 l/s	252.00 m3
73	14/10/94 16:00	0 cm/s	216 mm	0 l/s	252.00 m3
74	14/10/94 18:00	0 cm/s	211 mm	0 l/s	252.00 m3
75	14/10/94 20:00	0 cm/s	199 mm	0 l/s	252.00 m3
76	14/10/94 22:00	0 cm/s	204 mm	0 l/s	252.00 m3
77	15/10/94 00:00	0 cm/s	200 mm	0 l/s	252.00 m3
78	15/10/94 02:00	0 cm/s	174 mm	0 l/s	252.00 m3
79	15/10/94 04:00	0 cm/s	164 mm	0 l/s	252.00 m3
80	15/10/94 06:00	0 cm/s	158 mm	0 l/s	252.00 m3
81	15/10/94 08:00	0 cm/s	163 mm	0 l/s	252.00 m3
82	15/10/94 10:00	0 cm/s	204 mm	0 l/s	252.00 m3
83	15/10/94 12:00	4 cm/s	231 mm	46 l/s	583.20 m3
84	15/10/94 14:00	39 cm/s	316 mm	616 l/s	5018.40 m3
85	15/10/94 16:00	38 cm/s	335 mm	637 l/s	9604.80 m3
86	15/10/94 18:00	39 cm/s	342 mm	667 l/s	14407.20 m3
87	15/10/94 20:00	36 cm/s	292 mm	526 l/s	18194.40 m3
88	15/10/94 22:00	34 cm/s	298 mm	507 l/s	21844.80 m3
89	16/10/94 00:00	34 cm/s	296 mm	503 l/s	25468.40 m3
90	16/10/94 02:00	28 cm/s	222 mm	311 l/s	27705.80 m3
91	16/10/94 04:00	19 cm/s	174 mm	165 l/s	28893.60 m3
92	16/10/94 06:00	9 cm/s	155 mm	70 l/s	29397.60 m3







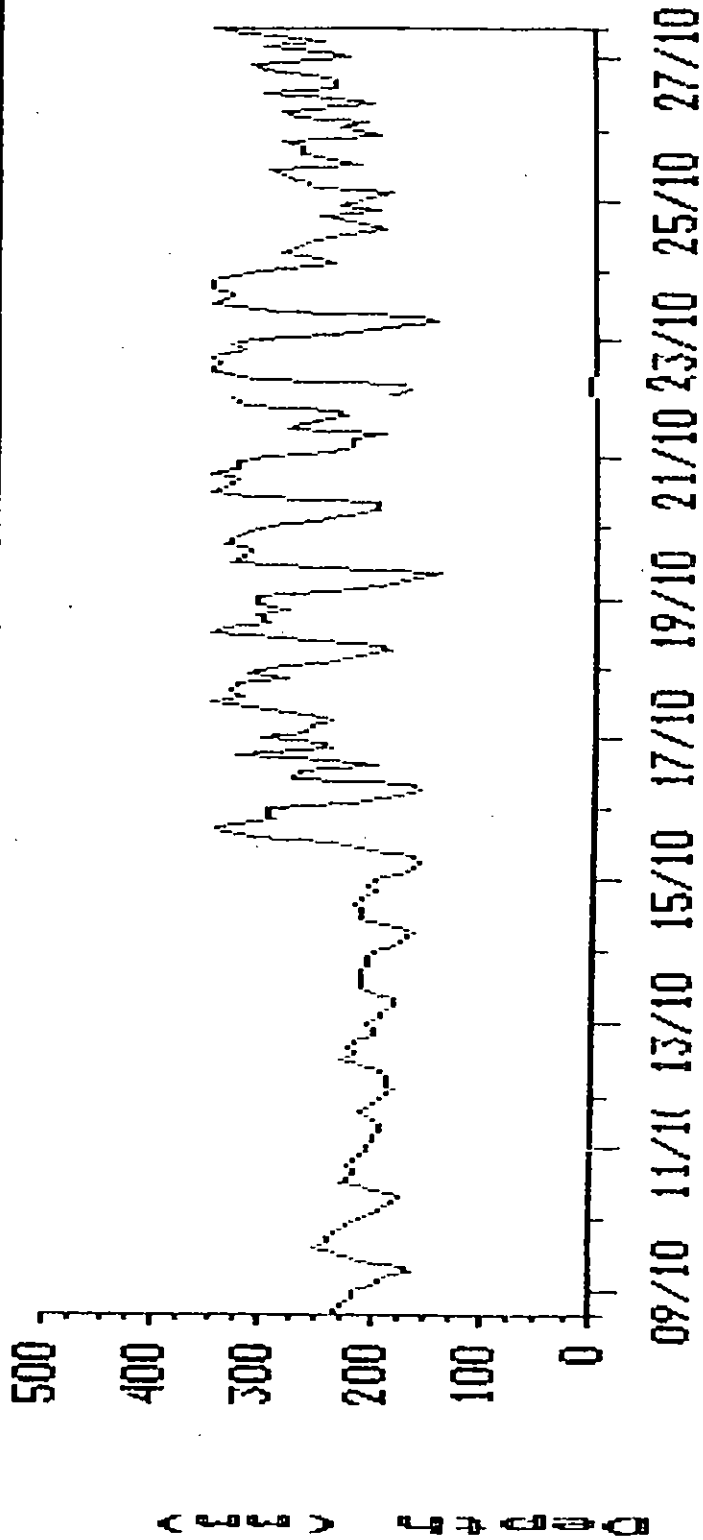
INSTITUTE OF HYDROLOGY  
0135/HYD/Beta 0.06



LOGGER ID : WATERM  
LOGGER NO. : 503300M  
LOGGER NAME : SITE3

DATA RANGE : 08/10/94 16:00:00  
27/10/94 10:00:00  
INTERVAL : 2 HOURS

INSTITUTE OF HYDROLOGY  
0135/HYD/Beta 0.06



LOGGER ID : WATERM  
LOGGER NO. : 503300H  
LOGGER NAME : SITE3

DATA RANGE : 0/10/94 16:00:00  
2/10/94 10:00:00  
INTERVAL : 2HOURS