資料2－4

GEOLOGICAL SURVEY OF PAKISTAN
Information Release No. 174

GEOLOGY OF JHELUM AREA
JHELUM DISTRICT, PUNJAB
PAKISTAN

574
LIBRARY
Sindata Centre, G.S.P.
ISLAMABAD

Mohammad Akhtar

1984

Issued by the Director General, Geological Survey of Pakistan, Quetta,
July 1984

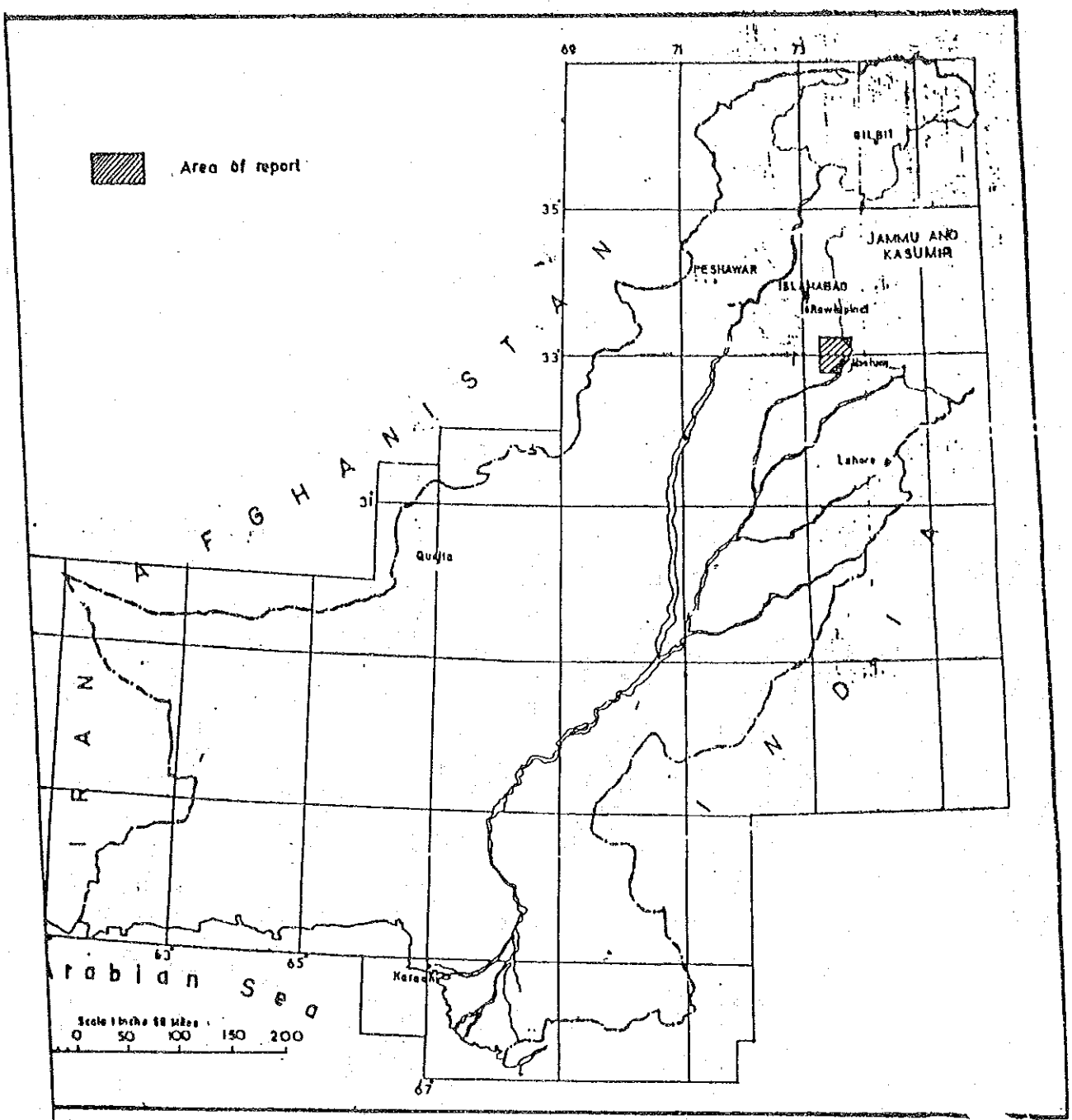


FIG.1. INDEX MAP

資料－3 Seismologic Data

資料－3

Northern Pakistan - Islamabad & Northern Area

S.No.	Year of event	Intensity on M.M.Scale	Magnitude on Rifter Scale	Focal Depth KMs
1.	25 AD	9-10	7.0-8.0	-
2.	1504	6-7	4.9-5.6	-
3.	1505	7-8	5.6-6.3	-
4.	1505	7-8	5.6-6.3	-
5.	1519	6-7	4.9-5.6	-
6.	1669	6-9	4.9-7.0	-
7.	1669	5-7	4.3-5.6	-
8.	1669	8-9	6.3-7.0	-
9	1780	5-7	4.3-5.6	-
10.	1828	9-10	7.0-8.0	-
11.	1829	5-7	4.3-5.6	-
12.	1834	6-7	4.9-5.6	-
13.	1834	4-5	3.8-4.3	-
14.	1840	6-8	4.9-6.3	-
15.	1842	8-9	6.3-7.0	-
16.	1842	8-9	6.3-7.0	-
17.	1842	8-9	6.3-7.0	-
18.	1842	7-8	5.6-6.3	-
19.	1842	6-7	4.9-5.6	-
20.	1863	6-7	4.9-5.6	-
21.	1865	5-7	4.3-5.6	-
22.	1868	7-8	5.6-6.3	-
23.	1868	7-8	5.6-6.3	-
24.	1869	7-8	5.6-6.3	-
25.	1869	7-8	5.6-6.3	-
26.	1869	7-8	5.6-6.3	-
27.	1871	6-8	4.9-6.3	-
28.	1871	7-8	5.6-6.3	-
29.	1874	9	7.0	-
30.	1874	9	7.0	-
31.	1874	8-9	6.3-7.0	-
32.	1874	9	7.0	-
33.	1874	8-9	6.3-7.0	-
34.	1874	9	7.0	-

S.No.	Year of event	Intensity on M.M.Scale	Magnitude on Rifter Scale	Focal Depth KMs
35.	1874	8-9	6.3-7.0	-
36.	1875	7-8	5.6-6.3	-
37.	1875	7-8	5.6-6.3	-
38.	1875	7-8	5.6-6.3	-
39.	1875	7-8	5.6-6.3	-
40.	1878	6-7	4.9-5.6	-
41.	1878	6-7	4.9-5.6	-
42.	1878	6-7	4.9-5.6	-
43.	1878	6-7	4.9-5.6	-
44.	1878	6-7	4.9-5.6	-
45.	1883	6-7	4.9-5.6	-
46.	1885	6-7	4.9-5.6	-
47.	1885	6-7	4.9-5.6	-
48.	1885	8	5.6	-
49.	1885	7.0	5.6	-
50.	1885	8.0	6.3	-
51.	1885	8.0	6.3	-
52.	1885	8.0	6.3	-
53.	1885	8.0	6.3	-
54.	1885	9-10	7-8	-
55.	1886	6-7	4.9-5.6	-
56.	1893	6-7	4.9-5.6	-
57.	1893	6-7	4.9-5.6	-
58.	1902	7-8	5.6-6.3	-
59.	1909	7-8	5.6-6.4	-
60.	1909	7	5.6	-
61.	1937	7-8	5.6-6.3	-
62.	1937	7-8	5.6-6.3	-
63.	1939	6-7	4.9-5.6	-
64.	1953	6-7	4.9-5.6	-
65.	1956	6-7	4.9-5.6	-
66.	1952	7	5.6	-
67.	1960	6-7	4.9-5.6	-
68.	1962	6-7 q	4.9-5.6	-
69.	1963	7-8	5.6-6.3	-

S.No.	Year of Event	Intensity on M.M.Scale	Magnitude on Rifter Scale	Focal Depth KMs
70.	1966	7-6	4.9-5.6	-
71.	1966	6-7	4.9-5.6	-
72.	1967	6-7	4.9-5.6	-
73.	1969	6-7	4.9-5.6	-
74.	1905	10.0	8.00	0-50
75.	1920	7	5.6-	33
76.	1926	7	5.6	135
77.	1928	7	6.0	50
78.	1929	7	6.0	110
79.	1933	7	5.6	33
80.	1934	7	5.6	61
81.	1937	6	5.3	35
82.	1940	7	5.8	200
83.	1947	8	6.8	120
84.	1947	6	5.2	49
85.	1953	6	5.5	39
86.	1954	7	5.7	9
87.	1955	6	5.5	51
88.	1956	8	6.5	11
89.	1956	6	5.0	48
90.	1956	8	6.2	1
91.	1956	8	6.1	0-50
92.	1957	6	5.2	32
93.	1957	6	5.5	0-50
94.	1962	6	5.5	48
95.	1963	6	5.4	22
96.	1965	6	5.5	33
97.	1966	6	5.0	54
98.	1966	6	5.1	59
99.	1967	6	5.0	20
100.	1967	6	5.2	55
101.	1967	6	5.0	66
102.	1968	6	5.2	33
103.	1968	6	5.2	38
104.	1968	6	5.2	16
105.	1968	6	5.0	41

S.No.	Year of Event	Intensity on M.M.Scale	Magnitude on Rifter Scale	Focal Depth KMs
106.	1969	6	5.0	49
107.	1969	6	5.2	76
108.	1970	6	5	45
109.	1970	6	5	46
110.	1971	6	5.0	43
111.	1971	6	5.6	82
112.	1971	6	5.0	15
113.	1971	6	5.2	55
114.	1972	6	5.0	49
115.	1972	6	5.2	17
116.	1972	8	6.1	47
117.	1972	8	6.2	45
118.	1972	6	5.2	49
119.	1972	7	5.6	46
120.	1972	6	5.3	50
121.	1972	6	5.2	53
122.	1972	6	5.1	49
123.	1972	6	5.1	50
124.	1972	6	5.1	41
125.	1972	6	5.7	57
126.	1972	6	5.0	33
127.	1972	6	5.3	57
128.	1972	6	5.2	60
1]9.	1972	7	5.4	38
130.	1972	6	5.0	15
131.	1972	6	5.0	54
132.	1972	6	5.4	69
133.	1973	6	5.1	39
134.	1973	6	5.4	33
135.	1973	6	5.0	52
136.	1973	6	5.1	48
137.	1973	6	5.2	47
138.	1974	6	5.0	33
139.	1974	6	5.3	70
140.	1974	8	6.2	22
141.	1974	6	5.0	33

S.No.	Year of Event	Intensity on M.M.Scale	Magnitude on Rifter Scale	Focal Depth KMs
142.	1974	6	5.0	33
143.	1974	6	5.0	33
144.	1975	6	5.0	37
145.	1973	6	5.1	38
146.	1977	6	5.2	27
147.	1977	6	5.0	47
148.	1978	6	5.0	25
149.	1980	6	5.3	209
150.	1980	7	5.2	3
151.	1980	7	5.2	12
152.	1981	6	5.1	53
153.	1983	6	5.6	184

資料4－1

SWHP Publication No. 19

Pakistan
Water And Power Development Authority
Hydrology And System Analysis Organization
Surface Water Hydrology Project

1979 Annual Report
OF
River And Climatological Data
OF
Pakistan

Vol. I, II, III (Part A, B)

RIVER DISCHARGE, SEDIMENT AND QUALITY DATA

Prepared By Surface Water Hydrology Project
H & S. A Org. Wapda, Lahore

SWHP Publication No. 14

PAKISTAN

WATER AND POWER DEVELOPMENT AUTHORITY

HYDROLOGY AND INVESTIGATION ORGANISATION

SURFACE WATER HYDROLOGY PROJECT

1973 ANNUAL REPORT OF RIVER AND CLIMATOLOGICAL DATA OF PAKISTAN

Dec' 1977.

(Sheikh Mohammad Hussain)
Project Director,
Surface Water Hydrology Project
Hydrology & Investigation Organisation
WAPDA, Lahore.

VOL. I

RIVER DISCHARGE, SEDIMENT AND QUALITY DATA

PREPARED BY SURFACE WATER HYDROLOGY PROJECT
H AND I ORG. WAPDA, LAHORE

PREFACE

This report is published by Surface Water Hydrology Project, under the direct supervision of Chief Engineer Hydrology, with co-operation and support of other Divisions of WAPDA. The record presented in this report has been collected during the year 1973 under the control of Chief Engineer, Water and Soils Investigation Division, (Defunct).

The report consists of three Volumes, Surface Water flow, sediment and chemical composition data as Volume I; daily and hourly precipitation data as Volume II, evaporation, temperatures, solar radiation, relative humidity and wind movement data as Volume III. Previously, the report was published in one volume from 1960 to 1962 two volumes from 1963 to 1965 and in three volumes thereafter. These changes from time to time were necessitated because of an increase in the number of stations, all of which could not be accomodated in one volume.

All the field record presented herein was collected, analysed, interpretted and compiled by the personnel of Surface Water Hydrology Project. Chemical analysis of Water Samples were done in the quality of Water Laboratory, Central Monitoring Organisation.

Dated: Dec' 1977.

(Sheikh Mohammad Hussain)
Project Director,
Surface Water Hydrology Project,
Hydrology & Investigation Organisation,
WAPDA, Lahore.

CONTENTS

	Page
INTRODUCTION.	1
DEFINITION OF TERMS AND ABBREVIATIONS	2
EXPLANATION OF DATA	
River discharge, sediment and chemical data.	3
Maps of location	9
RIVER DISCHARGE, SEDIMENT AND CHEMICAL DATA	
DISCHARGE STATION RECORDS (arranged in d/s order)	
Indus River Basin	
Shyok River at Yugo	17
Indus River near Kachura.	21
Hunza River at Dainyour Bridge	27
Gilgit River at Alam Bridge.	31
Indus River at Partab Bridge.	35
Indus River at Besham Qila.	41
Brandu River near Daggar	47
Indus River near Darband.	53
Siran River near Phulra.	61
Siran River at Thapla.	67
Chitral River at Chitral	73
Swat River at Kalam	79
Swat River at Chakdara.	85
Bara River at Jhansi Post	91
Kabul River at Nowshera.	97
Indus River at Mandori. . . . . (about 5 miles d/s Attock Bridge)	102
Haro River near Khanpur.	109
Haro River at Sanjwal.	115
Haro River at Gariala.	121
Soan River at Chirah	127
Soan River near Rawalpindi	133
Sil River near Chahan	139
Soan River at Dhok Pathan.	145
Indus River at Massan	153
Kurram River at Thal	159
Gomal River at Kot Murtaza	165

CONTENTS

	Page
Jhelum River Basin	
Jhelum River at Chinari.	171
Kisnanganga at Muzaffarabad.	177
Kunhar River at Naran.	183
Kunhar River at Garhi Habib Ullah.	189
Jhelum River at Kohala.	195
Jhelum River at Karot	201
Kanshi River near Palote	207
Poonch River near Kotli.	213
Jhelum River at Mangla Cableway	219
Nari River Basin	
Khost River at Chapper Rift.	225
Indus River near Sehwan	231
Hub River at Bund Murad Khan.	237
Windor Dhora near Goth Amun	243
Porali River at Sinchi Bent	247
Kud River near Mai Gondrani.	253
Dasht River near Mirani Dam	259
DATA AT MISCELLANEOUS SITES	
Summary of discharge measurements	265
Summary of sediment analysis data	271
Summary of Chemical analysis data	273
REVIEW OF DATA	
Chitral River at Chitral - 1971	281
Chitral River at Chitral - 1972	285

(Typed by Zarar Ali Stenographer-II T.C.Section)

Organisation

The Surface Water Circle was created by WAPDA with effect from Ist July 1960 with the responsibility of Collecting surface water data required for WAPDA Projects and General Investigations. The Mangla Hydrometeorological Division was used as a nucleous and various project hydrologic activities were included. The Circle was designated as Surface Water Hydrology Project in June 1966.

Purpose and scope of report

The purpose of this report is to present the data collected by the Surface Water Hydrology Project in 1973, its fourteenth year of operation. This is the fourteenth in a series of annual reports to be published. The report is being published in three volumes. In this volume of the report observations taken at discharge stations by the Surface Water Hydrology Project are documented. The data in this volume include river discharge, suspended sediment concentration, chemical analysis and water temperature.

Maps on pages 9 to 14 show the hydrologic stations that have been operated and for which data are published. Some stations were operated for which only field data have been published because the records were incomplete or found to be below acceptable standards. These are indicated on the map as "Partial records". Only stations that are operated by the Surface Water Hydrology Project and for which records are published in this report are shown on the maps.

Discharge records are being collected by other agencies at some of the stations operated by the Surface Water Hydrology Project. Past records are available for some of these stations. These are discussed under "records available" in each station description. A more complete listing of availability of records is given in the "Inventory of Surface Water Hydrology Stations."

The data given herein were collected and computed by the best methods available and are considered to be accurate enough for general use. All field data and computations by the Surface Water Hydrology Project are on record in Lahore and open to inspection.

The definitions of hydrologic terms as used in this report are given below:

Cusecs: (Cubic foot per second) is the rate of discharge of a stream whose cross-sectional area is one square foot and whose velocity is one foot per second.

Cusecs per square mile (Cs/mi) is the average rate of discharge from each square mile of area drained, assuming that the runoff is distributed uniformly in time and area.

Runoff in inches: (in) is the quantity of water discharged from an area (drainage basin) in a given period of time, measured in terms of mean depth over the area.

Acre foot: (ac-ft) is the quantity of water required to cover an acre of area to a depth of one foot.

PPM: Parts per million.

me/l (Milliequivalents per litre), one thousandth of an equivalent of an ion or a compound in one litre of solution.

RIVER DISCHARGE, SEDIMENT AND CHEMICAL COMPOSITION DATA

Gauge height record

Records of river stage are obtained either from periodic readings of a staff gauge, or wire weight gauge, or from an automatic water-stage recorder which gives a continuous record of stage fluctuations. The non-recording gauges are generally read from 08:00 to 16:00 hours daily during periods of low flow and at more frequent intervals during floods.

Daily mean gauge heights for non-recording gauges are the arithmetic average of the observations during periods of uniform flow or are computed from gauge-height graphs based on observations during periods of rapidly changing stage. Daily mean gauge heights for automatic recording gauges are computed directly from the pen trace.

Discharge measurement

Measurements of discharge are made using the small price AA current meter and following the general methods used by the U.S. Geological Survey. This method consists of taking depths and observations of velocity in a cross-section of the stream, with the sections spaced so that not more than 5 percent of the discharge is measured in any one section. Velocity observations between 40 and 70 seconds are taken at 0.2 and 0.8 of the depth. If the flow is shallow, the velocity observation is taken only at 0.6 or 0.5 of the depth. In very small streams a pygmy current meter is used. Various suspensions for the current meters are used. These include calibrated rods for wading measurements and lines with sounding weights suspended from reels for use on bridges, overhead cableways, or boats.

The frequency of discharge measurement varies from station to station depending on such factors as stability of the channel and importance or accessibility of the station. At most stations, measurements are made twice a month except during flood periods when these may be made as often as several times a day.

Discharge computations

Daily mean discharges are computed by application of daily mean gauge heights to rating tables prepared from stage-discharge relation curves based on discharge measurements. Any day showing rapid changes of gauge height is subdivided for daily discharge computation. Any extensions to the rating curves that are necessary to define extremes of discharge are made on the basis of logarithmic plotting, Velocity area studies, or indirect determinations of peak discharge such as slope-area or contracted opening measurements or computation of flow over dams or weirs.

The discharge is computed by the shifting-control method if the stage-discharge relation is subject to change because of frequent changes in the physical features that form the control. In this method correction factors, based on discharge measurements are used in applying the gauge heights to the rating tables.

Presentation of discharge data

The data presented for a discharge station include a station description and a table of daily, monthly and yearly discharges. Observations of sediment concentration and results of chemical analysis which are also listed, are described separately.

The description of each discharge station gives location, drainage area, records available, average discharge, extremes of discharge, description of the gauge, methods of measurement and remarks concerning accuracy, factors affecting the record and items of general interest. The location of the discharge station and the drainage area are taken from the most accurate maps available. Under "Records available" are listed, first those records obtained by the Surface Water Hydrology Project and then known records obtained by other agencies. "Average discharge" for the period of record is given only for stations with four years or more of record. Under "Extremes", the maximum instantaneous gauge heights and discharges observed for the current year and for the period of record are given. It should be noted that in the case of a non-recording gauge the highest gauge height observed may be considerably lower than the actual maximum figure. For the minimum discharge, the daily mean figure is given rather than an instantaneous value because, quite frequently, the instantaneous minimum discharge is caused by artificial means such as changes in irrigation diversion and is, therefore not representative of the flow except for a very short period.

In the table of daily discharge, the figures given are derived from gauge heights, with exceptions noted at the bottom of the page. Days on which discharge measurements were made are indicated by asterisks except where they were made very frequently in which case the frequency is indicated under "Discharge measurements" in the station description.

In the monthly summary at the bottom of the table of daily discharge, the line headed "mean" gives the average flow for the month in cubic feet per second; mean per square mile (cs/mi); runoff depth in inches over the drainage basin (in) and acre-feet (af) or million acre-feet (Maf). Values for cubic feet per second per square mile and runoff depth in inches are omitted if consumptive use or diversions in or out of the drainage basin make these values unrepresentative of natural conditions.

The yearly values shown are the average flow in cubic feet per second, the average runoff in cubic feet per second per square mile, the total runoff depth in inches over the drainage basin, the total runoff in acre feet and the maximum and minimum daily mean discharge.

Downstream order of stations

Discharge stations are listed in downstream order along the Indus main stem. Stations on a tributary entering above a main stem station are listed before that station. If the tributary enters between two main stem station it is listed between them. A similar order is followed in listing stations as first rank, second rank and other ranks of tributaries. To indicate the rank of any tributary, each indention in the listing of gauging stations in the table of contents of this report represents one rank. This downstream order and system of indention show which gauging stations are on tributaries between any two stations on a main stem and the rank of the tributary on which each gauging station is located.

Accuracy of discharge data

Accuracy of stream flow records depends primarily on (1) stability of the stage-discharge relation, or if the relation is unstable, frequency of discharge measurements; (2) accuracy of observations of stage and measurements of discharge; (3) accuracy of interpretation of the field data.

In this volume, probable accuracy of discharge records is evaluated as follows:

Excellent	. . Probable error less than	5%
Good	. . probable error less than	10%
Fair	. . probable error less than	15%
Poor	. . probable error greater than	15%

In general, monthly and annual mean values are more accurate than daily values because of compensation of random errors.

Discharge at partial-record stations and miscellaneous sites

The number of streams on which stream flow information is desired exceeds the number of stream-gauging stations it is feasible to operate at one time, so the Surface Water Hydrology Project, WAPDA has collected limited stream flow data at sites other than full time stream gauging stations. Data collected at these partial-record stations or at miscellaneous sites are usable in preliminary, low or perennial flow analysis. Often partial-record stations are operated initially untill the necessity of the data justifies building major discharge measureing cableways or security and access allow full time collection of stream flow data.

Discharge measurements made in 1973 for these sites in the area covered in this report are presented under "data at Miscellaneous Sites".

Sedimentation data

Suspended sediment concentration is determined from water samples collected using sediment samplers designed to take in water without disturbing the flow. The samplers are of two general types. The depth-integrating sampler takes water in continuously while the sampler is moved at a uniform rate in a vertical section, from the surface to the bottom and back. The point-integrating sampler is used to obtain a sample at a specific point in the vertical.

Samples are usually taken at three verticals in the stream, so located that each represents approximately one-third of the flow. At low stages when the water is relatively clear, only one sample is taken at the centre of the flow. A set of samples is taken at the time of each discharge measurement, but may be taken more frequently during monsoon season at certain important stations. Water temperature is observed at the time of each sampling.

The samples are analysed either for total concentration by drying and weighing, or for particle size distribution by use of bottom withdrawal or visual accumulation tubes, pipettes and sieves using distilled water as settling media. It should be noted that these samples include only sediment suspended in water and not that transported as bed load.

Results of analysis of sediment samples for each discharge station are listed in chronological order following the table of daily discharges. The figures given on each line are the total concentration in parts per million of suspended solids by weight and the size distribution in percent of the total. The temperatures and discharges given are instantaneous values for the time at which samples were taken.

Chemical analysis

All natural waters contain dissolved mineral matter. As streams flow from the head reaches to the plains or sea, the water is in contact with soils or rocks and dissolves some minerals. The quantities of dissolved mineral matter depend primarily on the type of rocks or soils the water comes in contact with and the duration of the contact. Most streams are fed by both surface runoff and ground water, which reflect the chemical character of their concentration. Groundwater is generally more highly mineralized than natural surface runoff because it remains in contact with the rocks and soils for much longer periods. The concentration of dissolved solids in a river is frequently increased by man made causes namely for drainage of mines or oil fields, increased disposal of industrial and municipal wastes and drainage from irrigated lands.

The samples for chemical analysis have been collected at or near points on streams where gauging stations are operated by the Surface Water Hydrology Project, for which chemical analysis has been made by the Quality of Water Laboratory of Central Monitoring Organization of WAPDA.

The following determination are made on the samples:

Calcium (Ca) is determined by titration with the versenate (E.D.Y.S) using ammonium purpurate indicator in the presence of sodium hydroxide solution and colour change.

Magnesium (Mg) is determined by titration similar to calcium and colour change. Calcium and Magnesium are calculated as Vol. of versenate X normality of versenate X 1000/ml in aliquat.

Sodium (Na) is determined by Sodium Flame Photometer.

Carbonate and Bicarbonate (CO_3 and HCO_3) are determined by titrating the water samples with a standard solution of sulphuric acid using phenol-phathalein and methyle orange indicators. The end points of titration are selected as the inflection point in the titration of sodium carbonate with sulphuric acid. The carbonate end-point is taken at PH 8.2 and the bicarbonate at PH 4.5.

Chloride (Cl) is determined by titrating the sample with standard silver nitrate solution using potassium chromate as indicator.

Sulphate (SO_4) is determined by adding known quantity of barium chloride to the sample to precipitate all the sulphate ions.

Dissolved Solids (D.S) are determined by evaporation to give the total amount of soluble salt per million cc of water. A know volume of the water sample is evaporated at 105 °C.

Electrical conductivity (EC) is measured by means of a Wheat-stone Bridge where resistance is equated to the resistance of the unknown solution surrounding electrodes in a conductivity cell. The conductivity is expressed in micro-mhos per ~~centimeter~~ usually at 25 °C. Conductivity is closely related to the sum of cations and anions in solution and is a rapid method to know the total dissolved solids in a solution.

pH the hydrogen ion concentration is determined by a pH meter using glass and calomel-Kol electrodes.

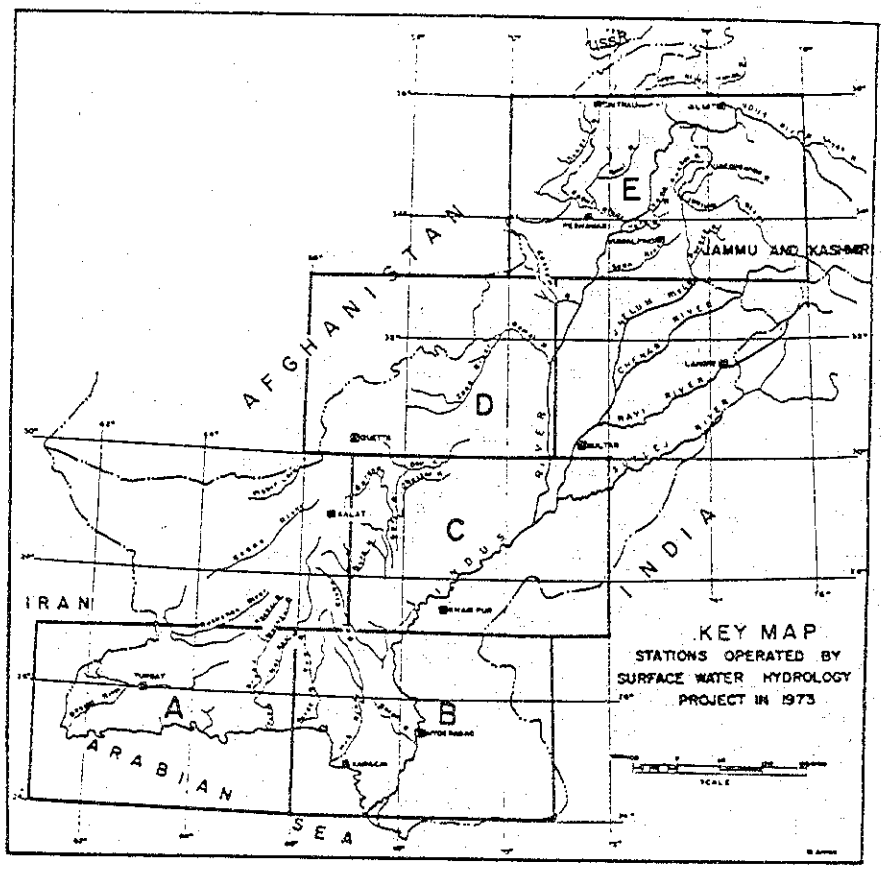
Sodium Adsorption Ratio (SAR) is an index of the sodium or alkali hazard expressing the relative activity of sodium ions in exchange reactions with the soil. It is expressed as follows.

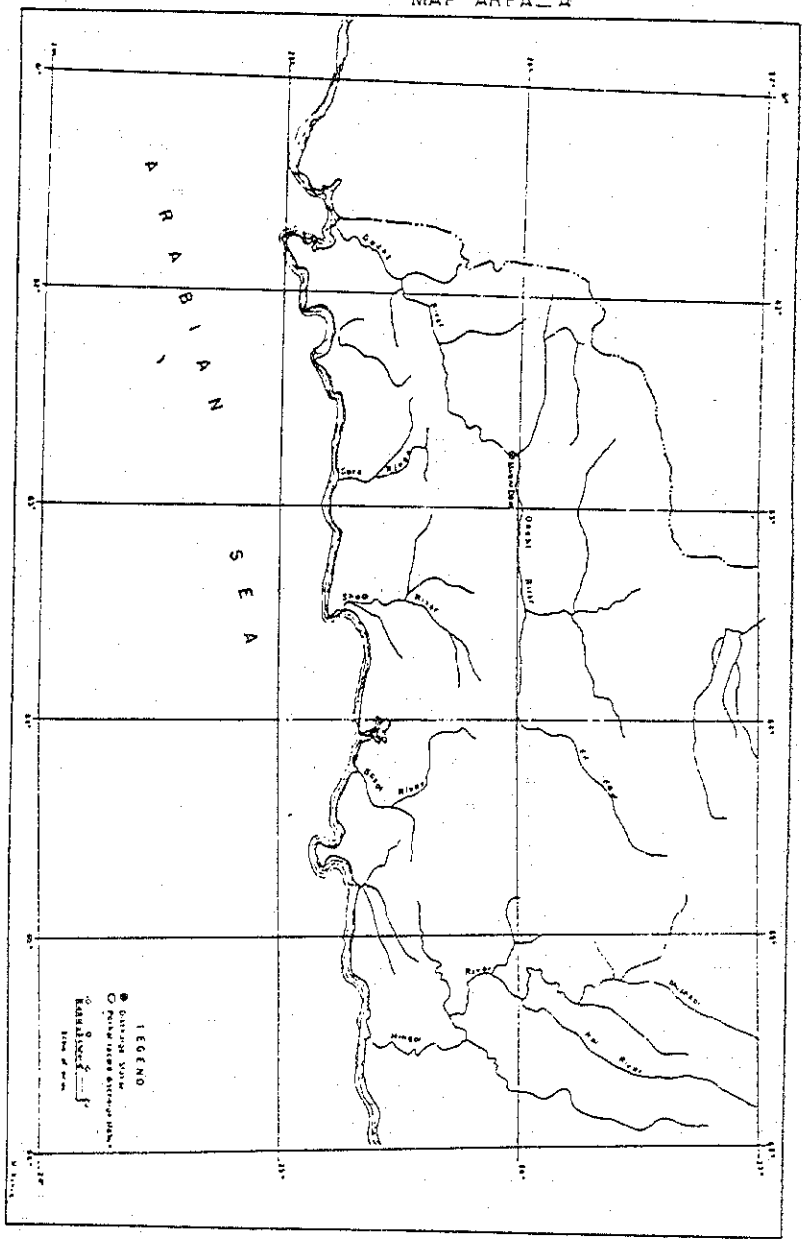
$$SAR = \frac{Na^{+}}{\left(\frac{Ca^{++} + Mg^{++}}{2}\right)^{\frac{1}{2}}}$$

Where the concentrations of the three soluable cations are given in milliequivalents per litre (me/l).

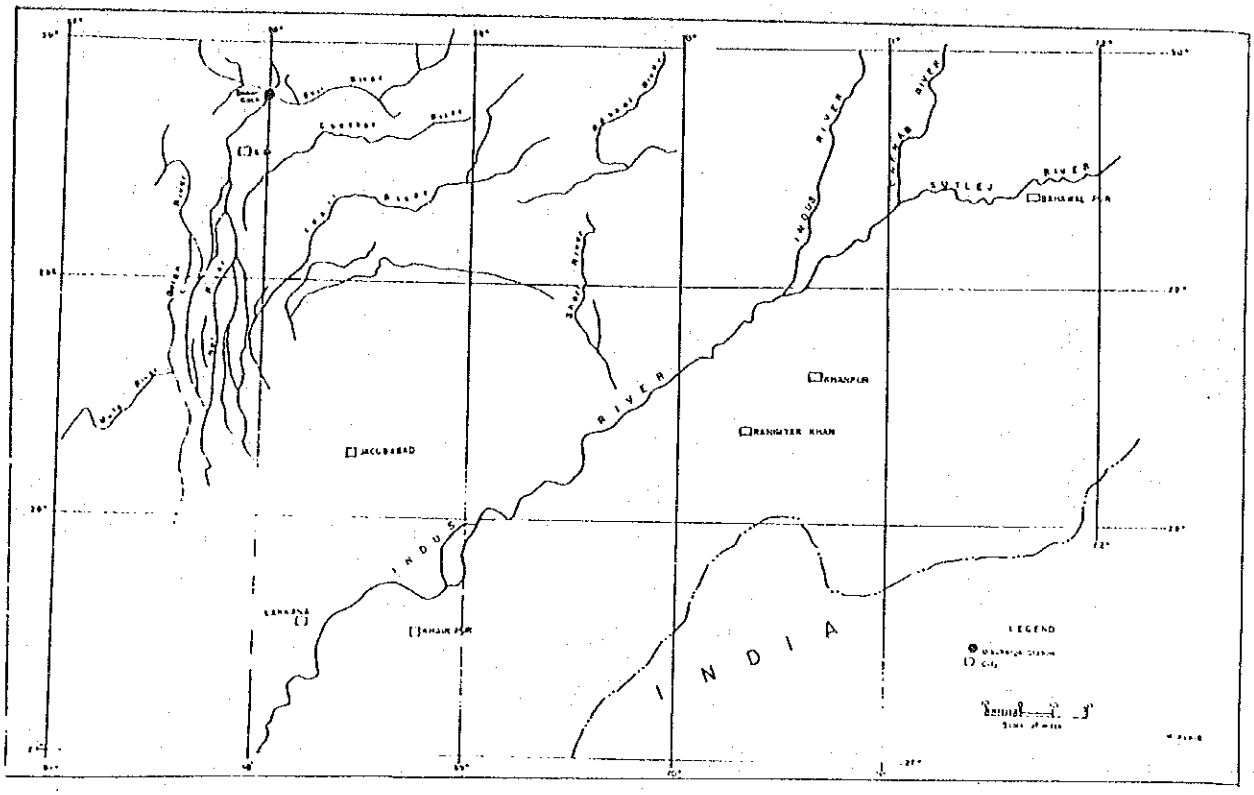
Residual Carbonate (Res CO_3) is expressed as the sum of the Carbonate and Bicarbonate anions minus the sum of the Calcium and Magnesium cations.

$$Res\ CO_3 = (CO_3^{--} + HCO_3^{--}) - (Ca^{++} + Mg^{++}).$$

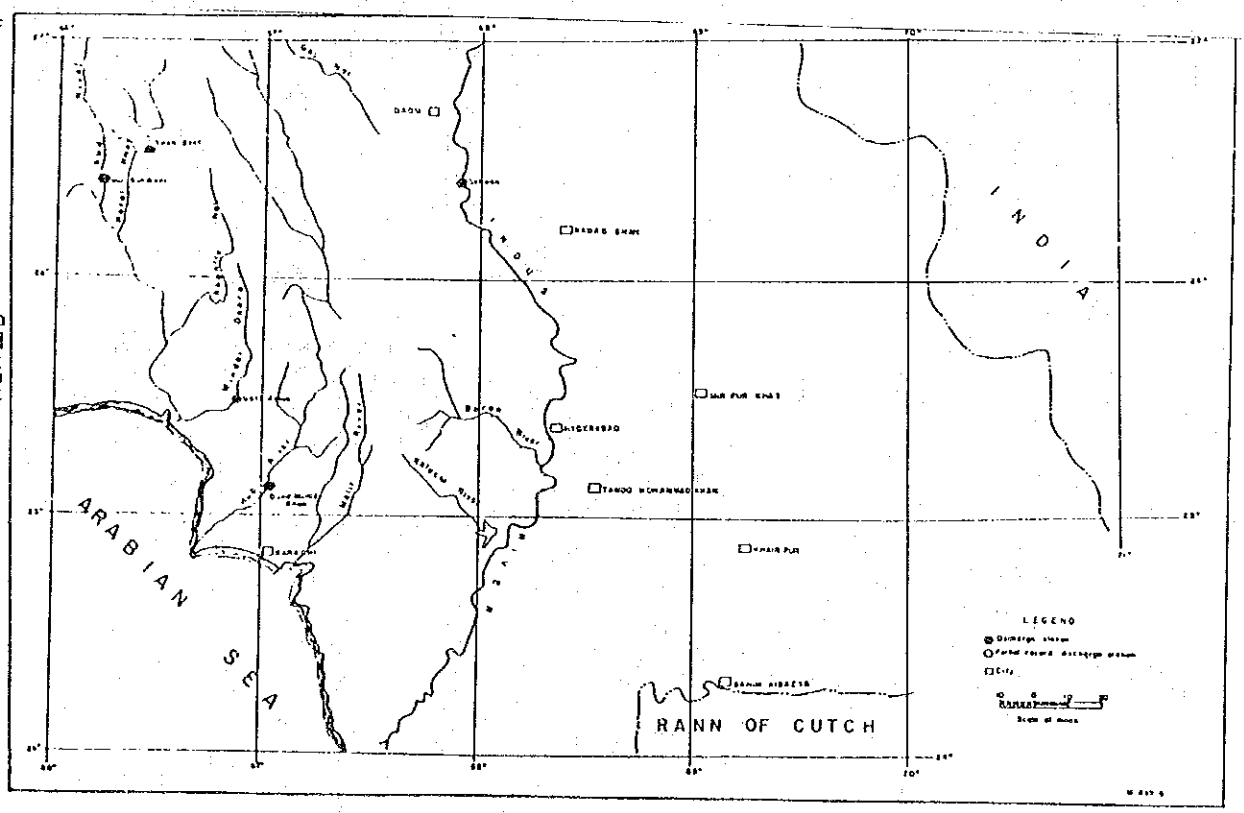

USSR
AFGHANISTAN
JAMMU AND KASHMIR
IRAN
INDIA
ARABIAN SEA
A
B
C
D
E
KEY MAP
STATIONS OPERATED BY
SURFACE WATER HYDROLOGY
PROJECT IN 1973
SCALE


MAP AREA_A
ARABIAN SEA
LEGEND

MAP AREA _ C

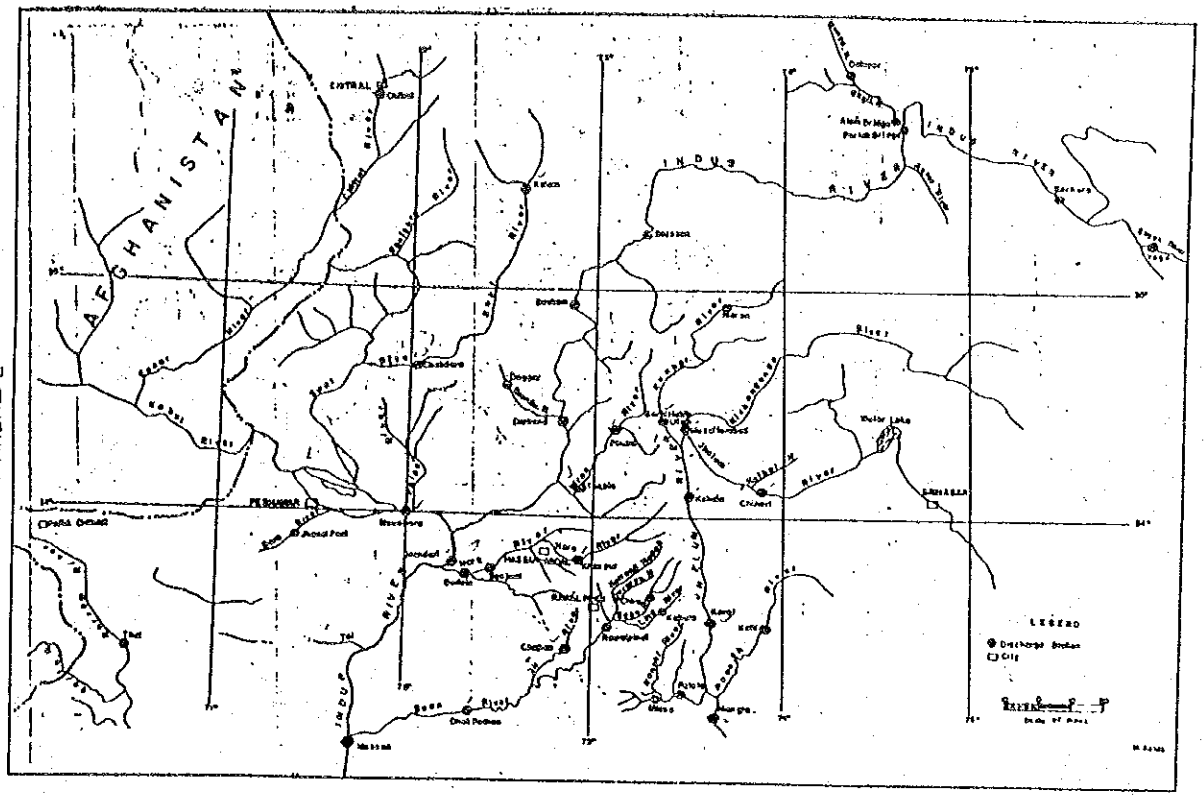


MAP AREA _ B



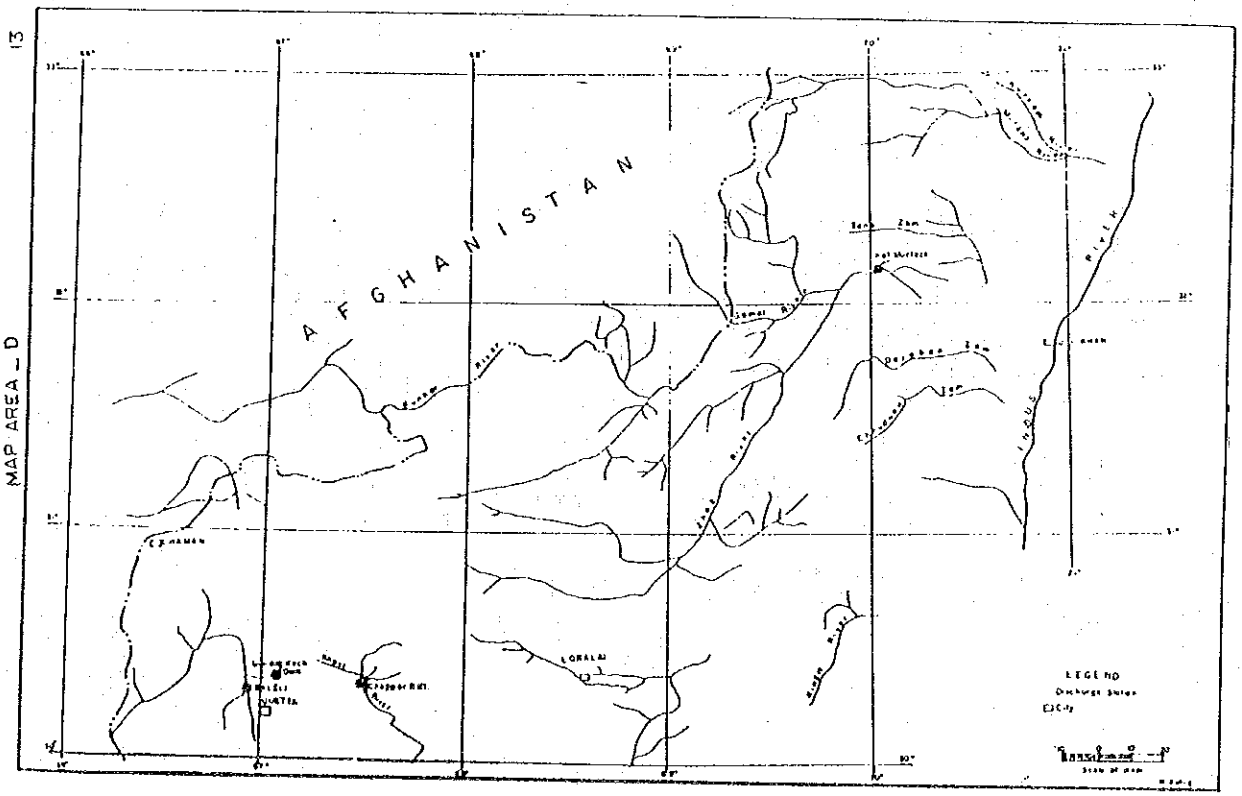
14

MAP AREA_E



13

MAP AREA_D



RIVER DISCHARGE, SEDIMENT AND CHEMICAL STATION RECORD

(Arranged in downstream order

Location Latitude 33°45', Longitude 72°26', near dam site at Sanjwal village, about 5 miles downstream from Grand Trunk Road, about 20 miles upstream from Indus River.

Drainage area 695 square miles.

Records available Discharge record January 1960 to date by Surface Water Hydrology Project, WASID, WAPDA. Gauge height record and measurements 1959 to June 1962 by Hydrology Directorate of Irrigation and Power Department. Details of record obtained from old Irrigation Project Circle gauge, a quarter of a mile upstream from present gauge, not known.

Average discharge 595 cusecs (431,000 acre-feet per year or 11.7 inches runoff per year). Average taken for 14 years from 1960 to 1973.

Extremes Maximum discharge observed during the year 34,300 cusecs on 23 August (gauge height 34.50 feet); minimum daily discharge 200 cusecs on 1 June.

1960-73; Maximum discharge 55,300 cusecs on 2 Septe[illegible]r 1961; minimum daily discharge 187 cusecs on 20 June 1970.

Gauge Staff gauge graduated at 0.1 foot intervals painted on masonry base on bed rock from 4.5 to 37.0 feet on left bank and on angle iron from 36.0 to 46.0 on right bank, gauge read from 0800 to 1600 hours daily during low flow and more often during floods.

Measurements Fifty seven discharge measurements were made periodically by current meter using 0.2 and 0.8 depth method by wading in low flow and from car on overhead cableway half a mile upstream from gauge in high flows. Fifty six sets of sediments samples were taken by depth integration method using DH-48 sampler while wading and D-49 sampler from cableway. Ninteen of these were analysed for particle size distribution and the rest for total concentration. Eleven surface samples were collected and analysed for chemical composition.

Determination of discharge This station has a rock control apparently not affected by sand movement. Discharges were computed by applying daily mean gauge heights to rating dated 11.5.1962 with shift adjustments where necessary.

Remarks Record good.

Discharge in cusecs for year 1973

Date	Jan	Feb	Mar	Apr	May	Jun
1	314	321	688	327	235	200
2	295	324	840	425	253	207
3	289	309	604	420	234	207
4	*283	293	541	417	229	205
5	301	*289	490	403	224	204
6	295	272	451	*391	224	204
7	298	268	448	365	217	201
8	280	287	481	360	219	205
9	270	278	850	360	213	*204
10	261	267	4,190	336	*211	205
11	*256	256	2,210	*336	2 208	211
12	256	*254	1,580	309	205	413
13	256	254	1,360	300	206	*213
14	267	244	*1,210	326	210	202
15	254	229	1,080	400	211	199
16	253	222	1,010	341	*213	207
17	253	220	935	302	420	205
18	251	221	895	291	*616	207
19	383	*221	*845	276	336	201
20	1,780	217	770	*270	274	464
21	825	211	774	267	256	1,190
22	596	212	712	265	242	409
23	534	217	672	257	*224	352
24	860	225	604	248	221	849
25	*428	397	576	245	213	302
26	409	*1,290	555	241	211	247
27	388	1,020	*534	*238	206	380
28	374	792	492	242	204	416
29	*349	----	478	235	202	*245
30	341	----	448	235	*204	244
31	331	----	441	---	201	---
Mean	404	343	908	323	243	307
Cs/mi	0.58	0.49	1.31	0.46	0.35	0.44
In	0.67	0.51	1.51	0.52	0.40	0.50
Ac-ft:	24,900	19,100	55,800	19,200	14,900	18,200

1973 Year: Mean 703 Cs/sq mi 1.01 Inches 13.7

Note : * Discharge measurement made on this day.

Discharge in cusecs for year 1973

Date	Jul	Aug	Sep	Oct	Nov	Dec
1	245	454	3,240	569	263	265
2	949	708	1,750	502	274	267
3	613	530	*3,680	572	268	258
4	*289	*3,210	1,870	*492	265	270
5	5,180	2,240	1,390	461	263	269
6	1,790	*4,650	1,210	416	261	267
7	1,440	1,760	*4,590	403	265	261
8	3,870	1,260	2,110	394	261	259
9	1,140	*1,940	1,420	385	259	258
10	435	1,320	1,000	360	256	263
11	*336	1,080	1,050	*346	256	*265
12	*285	985	2,710	339	256	263
13	550	*3,950	*1,370	324	258	263
14	*3,100	2,000	980	314	256	263
15	632	2,100	835	307	259	263
16	890	2,560	*792	620	*259	280
17	461	1,350	752	438	261	300
18	391	1,160	738	334	265	*293
19	*1,970	1,630	700	326	258	291
20	1,040	1,350	*644	314	261	291
21	544	950	660	*314	270	291
22	652	885	600	293	261	291
23	431	9,040	*548	307	259	291
24	492	*1,210	509	291	261	*291
25	*8,450	910	792	289	261	289
26	*7,220	830	739	285	261	274
27	*1,100	*4,070	576	276	261	274
28	708	2,420	*537	276	*263	274
29	548	1,420	513	278	261	272
30	555	2,030	565	272	263	270
31	541	*6,600	---	265	---	270
Mean	1,510	2,146	1,296	367	262	274
Cs/mi	2.17	3.09	1.86	0.53	0.38	0.39
In	2.50	3.56	2.08	0.61	0.42	0.45
Ac-ft.	92,700	132,000	77,100	22,500	15,600	16,800

Acre-feet: 509,000 Maximum day 9,040 Minimum day 199

Suspended sediment concentration - 1973

1973 Date	Discharge in cusecs	Temp. of Water °F	Total PPM by weight	Percent Sand	Silt	Clay
4 Jan	283	55	32			
11 Jan	254	59	18			
25 Jan	428	54	130			
29 Jan	349	51	56			
5 Feb	289	60	26			
12 Feb	254	61	42			
19 Feb	221	63	74			
26 Feb	2,340	58	7,770	1	86	13
5 Mar	499	62	232			
14 Mar	1,200	65	1,760	1	51	48
19 Mar	845	68	374			
27 Mar	530	73	164			
6 Apr	397	66	56			
11 Apr	336	76	130			
20 Apr	272	70	55			
27 Apr	239	77	44			
10 May	212	73	51			
16 May	212	72	85			
18 May	541	78	379			
23 May	212	71	135			
30 May	202	85	83			
9 Jun	205	100	120			
13 Jun	211	96	358			
19 Jun	200	92	179			
29 Jun	259	89	1,280	3	20	77
4 Jul	287	70	166			
11 Jul	344	68	208			
12 Jul	289	90	166			
14 Jul	3,630	79	22,200	1	69	30
19 Jul	363	89	602	1	15	84
25 Jul	1,730	84	4,720	3	41	56
26 Jul	23,300	76	77,800	16	79	5
27 Jul	955	84	4,070	16	45	39
4 Aug	2,320	81	3,260	3	67	30
6 Aug	8,230	84	15,100	8	86	6
9 Aug	1,890	86	5,160	1	75	24
13 Aug	2,910	81	7,020	4	74	22
24 Aug	1,040	90	1,470	2	42	56
27 Aug	9,110	78	17,800	11	84	5
31 Aug	12,500	78	15,700	3	89	8

HARO RIVER AT BANJWAL

Chemical Analysis of Water Samples - 1973

Date	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	NO_3	F	Total Cations	Total Anions	SiO_2	Fe	B	D.S. by Evap.	$CC \times 10^6$ at 25 °C	pH	Res CO_3	SAR
	Milliequivalents per Litre												Parts per Million						meq/l	
Jan 11	2.34	1.71	0.80	-	0	3.60	0.30	1.00			4.85	4.90				260	450	8.0	0	0.6
Feb 5	1.60	1.98	0.73	-	0	2.36	0.45	1.50			4.31	4.31				240	410	7.5	0	0.5
Mar 5	1.75	1.39	0.71	-	0	2.15	0.30	1.40			3.85	3.85				212	360	8.0	0	0.6
Apr 6	1.50	1.60	0.62	-	T	1.80	0.50	1.40			3.72	3.70				192	350	8.2	0	0.5
May 10	1.59	1.70	0.70	-	0	2.00	0.30	1.70			3.99	4.00				220	380	8.1	0	0.5
Jun 9	2.18	1.32	1.34	-	.20	2.00	0.59	1.80			4.54	4.59				248	420	8.4	0	0.6
Jul 11	1.60	1.60	0.52	-	0	2.45	0.21	1.00			3.72	3.66				204	350	8.1	0	0.4
Aug 4	2.00	1.60	0.70	-	0	2.70	0.31	1.10			4.30	4.21				232	430	8.1	0	0.5
Sep 3	1.39	1.00	0.45	-	0	1.79	0.26	0.70			2.75	2.75				152	243	8.0	0	0.6
Oct 4	2.58	0.88	0.74	-	0	2.26	0.26	1.70			4.20	4.22				234	[illegible]	8.1	0	0.6
Dec 11	2.50	1.68	0.85	-	0	2.98	0.45	1.50			5.01	4.93				272	430	8.1	0	0.6

HARO RIVER AT BANJWAL

Suspended sediment concentration - 1973

1973 Date	Discharge in cusecs	Temp. of water °F	Total PPM by weight	Percent Sand	Percent Silt	Percent Clay
3 Sep	7,470	81	5,260	6	65	29
7 Sep	8,340	82	5,610	5	51	44
7 Sep	2,060	82	2,780	6	49	45
13 Sep	1,140	85	889	3	50	47
15 Sep	806	80	161			
20 Sep	524	83	101			
23 Sep	551	81	51			
28 Sep	541	80	129			
4 Oct	486	76	159			
11 Oct	346	79	150			
21 Oct	316	75	182			
16 Nov	259	65	150			
28 Nov	263	61	41			
11 Dec	270	68	70			
18 Dec	293	59	30			
24 Dec	291	58	22			

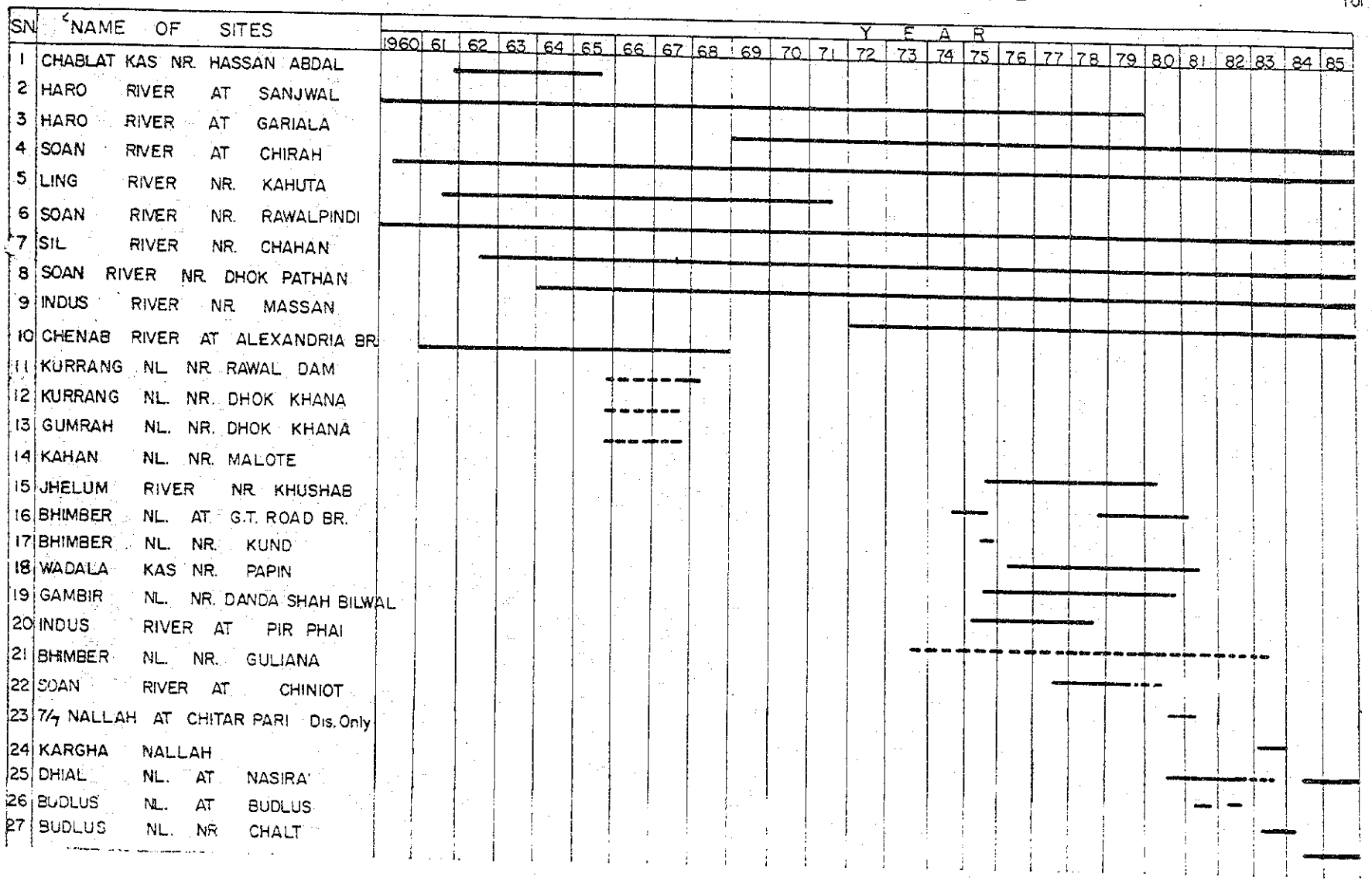
Note : Sand is all sizes above 0.0625 mm.
Silt is all sizes between 0.0625 mm and 0.0005 mm.
Clay is all sizes smaller than 0.0005 mm.

資料6

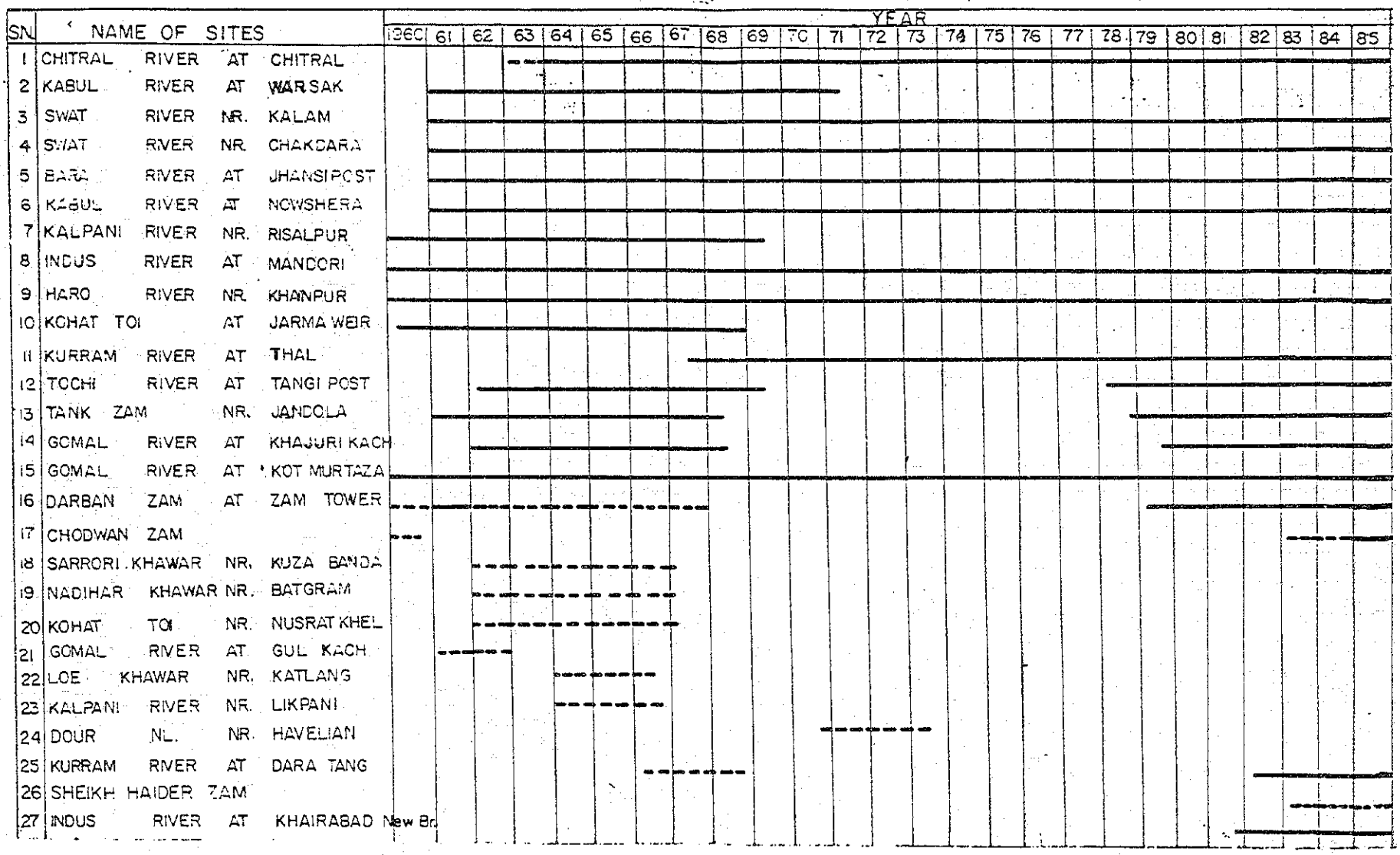
EXHIBIT V 1 of 30

資料—6

STREAM GAUGING SEDIMENT SAMPLING AND WATER QUALITY STATIONS OPERATED BY SWHP WAPDA IN PUNJAB

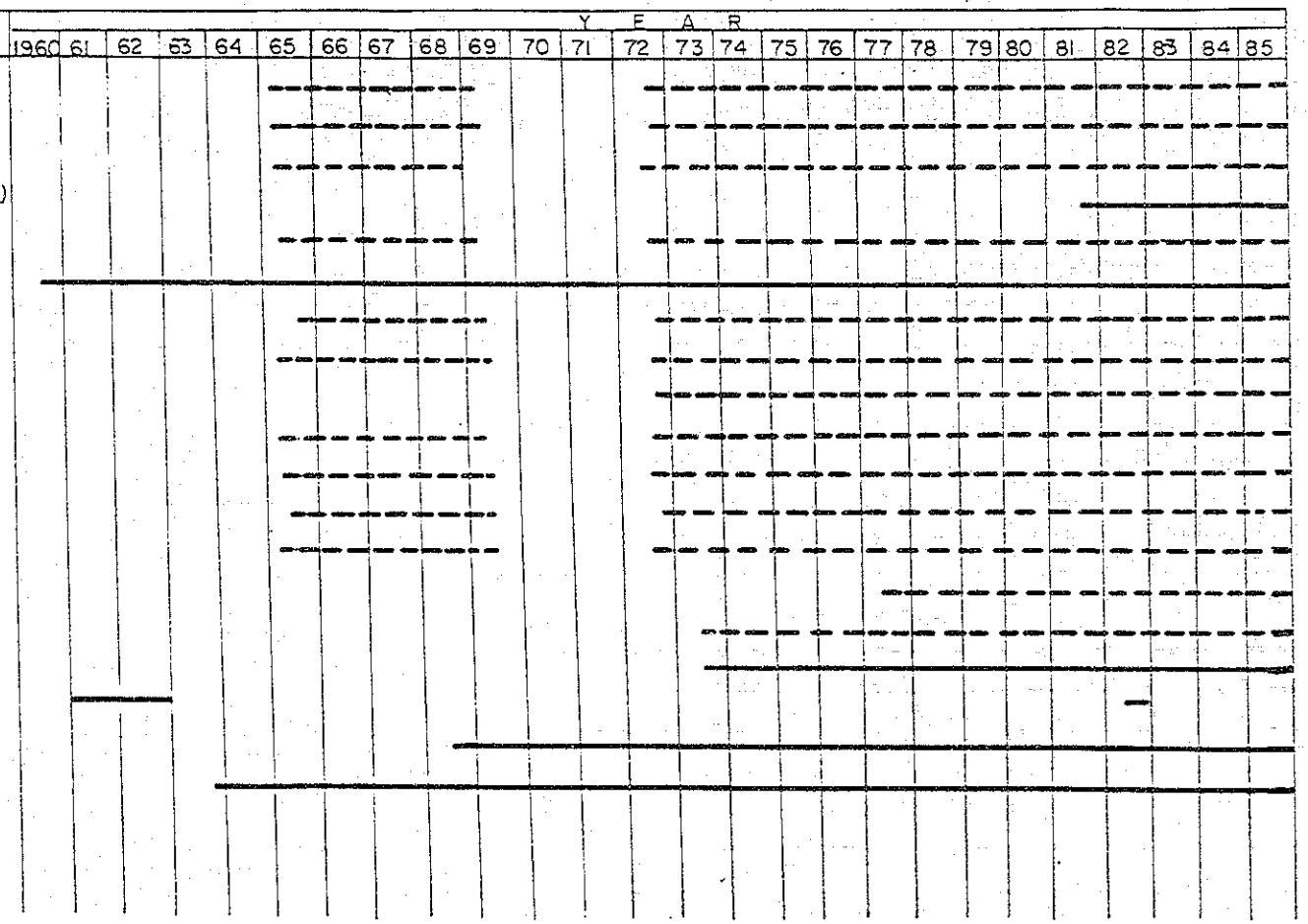


STREAM GAUGING, SEDIMENT SAMPLING AND WATER QUALITY STATIONS OPERATED BY SWHP, WAPDA IN N-W-F-P-

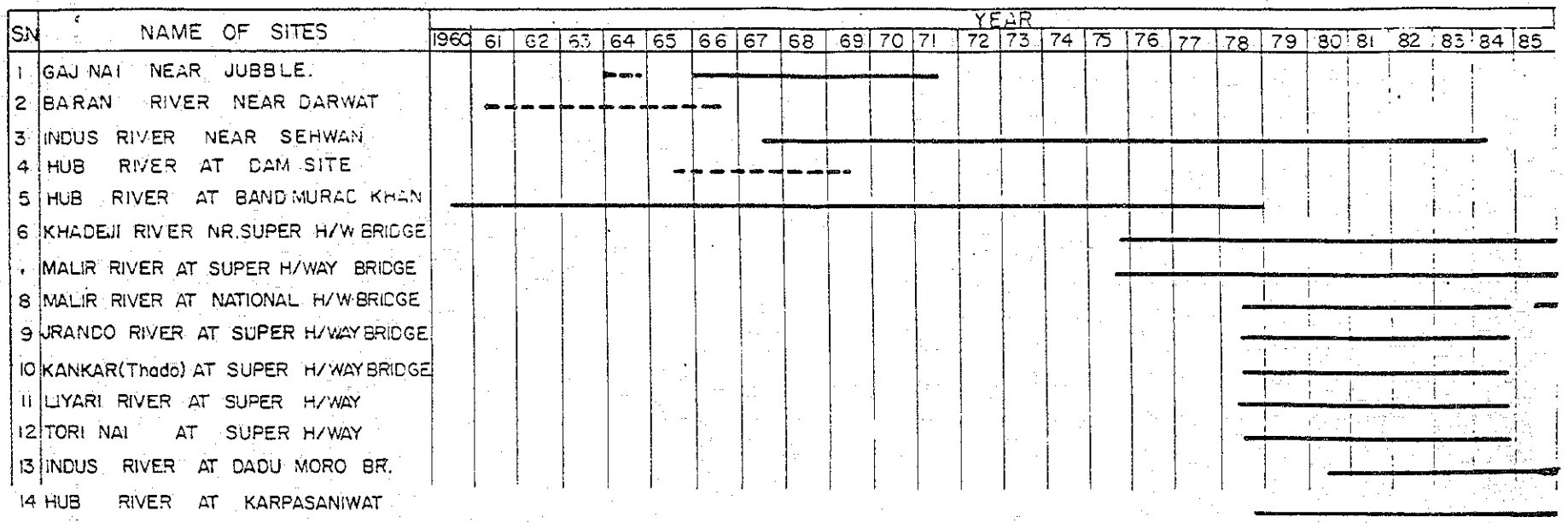


STREAM GAUGING, SEDIMENT SAMPLING AND WATER QUALITY STATIONS OPERATED BY SWHP WAPDA IN KALABAGH DAM

SN	NAME OF SITES
1	KABUL RIVER AT PIR SABAK
2	KABUL RIVER AT AKORA KHATTAK
3	KABUL RIVER AT JAHANGIRA
4	INDUS RIVER AT KHAIRABAD(new br)
5	INDUS RIVER AT ATTOCK (old br)
6	INDUS RIVER AT MANDORI
7	INDUS RIVER AT THOA
8	INDUS RIVER AT MAMAKHEL
9	INDUS RIVER AT BATA
10	INDUS RIVER AT SHAHDIPUR
11	INDUS RIVER AT CHORLUKI
12	INDUS RIVER AT KHUSHALGARH
13	INDUS RIVER AT RAISI BANDA
14	INDUS RIVER AT MAKHAD
15	INDUS RIVER AT PIR PHAI
16	INDUS RIVER AT MASSAN
17	INDUS RIVER AT KALABAGH
18	HARO RIVER AT GURRIALA
19	SOAN RIVER AT DHOK PATHAN



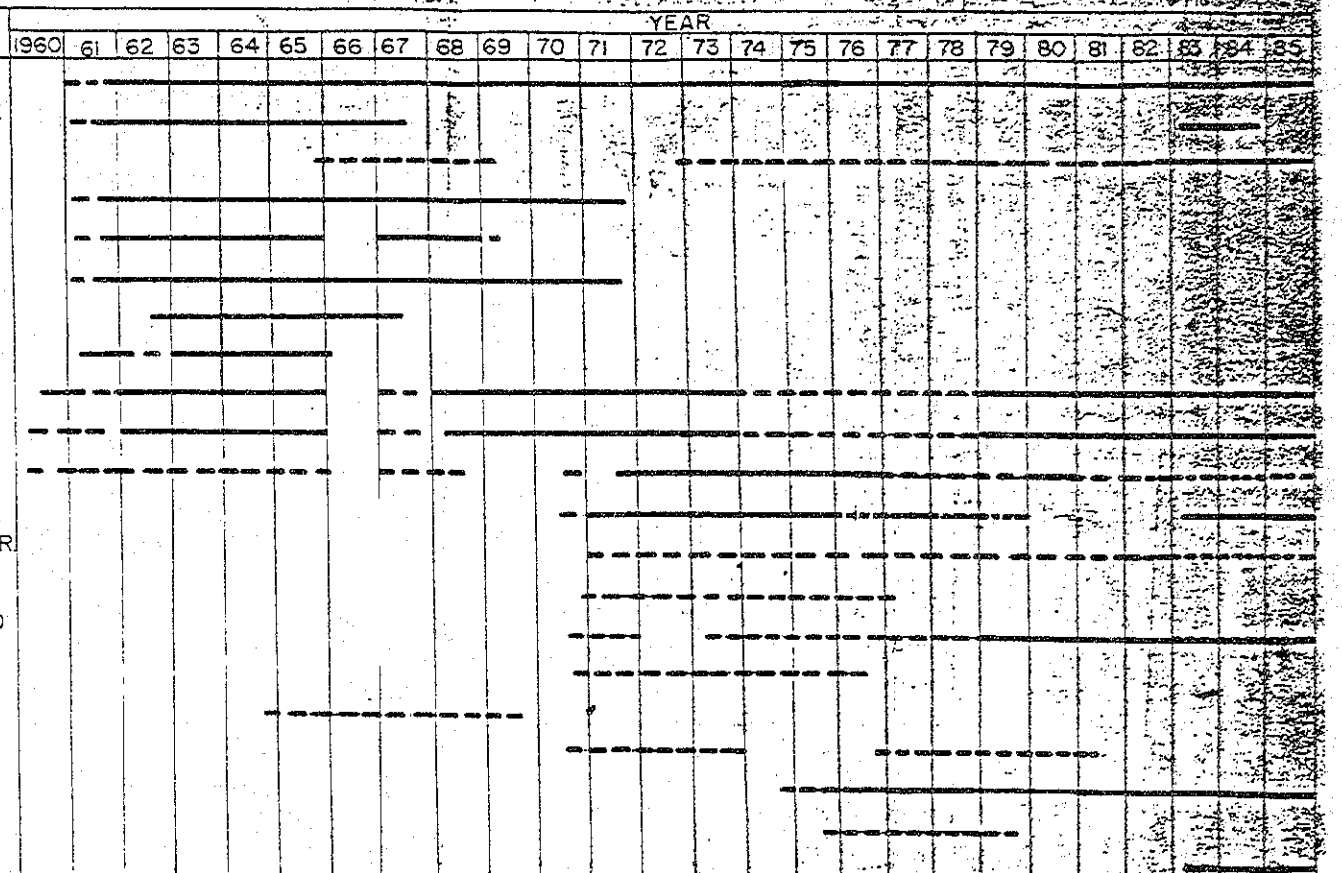
STREAM GAUGING SEDIMENT SAMPLING AND WATER QUALITY STATIONS OPERATED BY SWHR, WAPDA IN SIND.



NOTE CONTINUOUS LINE INDICATES THAT RATING CURVE HAS BEEN ESTABLISHED DOTTED LINE INDICATES OCCASIONAL DISCHARGE OBSERVATION WITH OR WITH OUT GAUGE HEIGHT RECORD

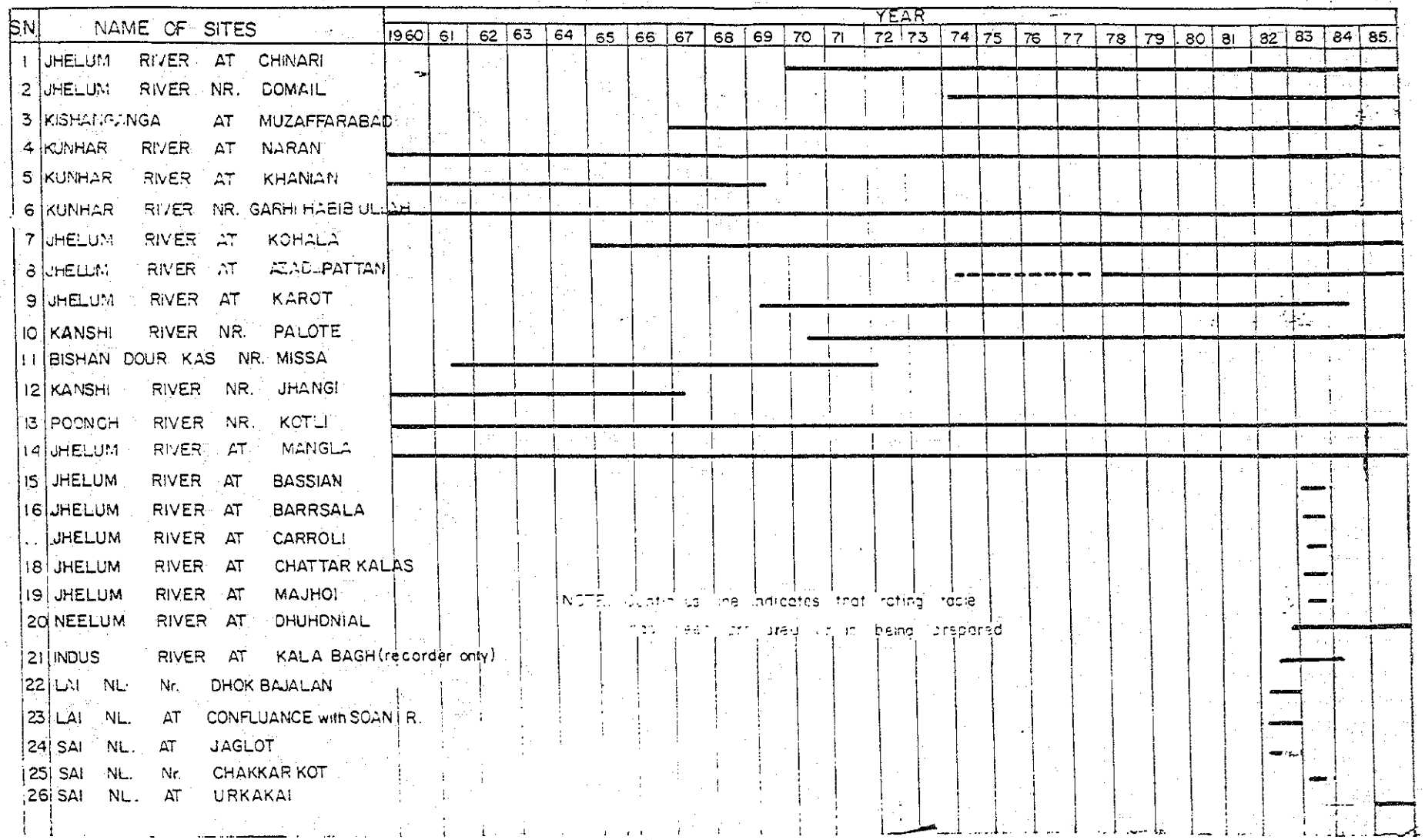
EXHIBIT 'A'
FIG. 01/3

STREAM GAUGING, SEDIMENT SAMPLING AND WATER QUALITY STATIONS OPERATED BY SWHP WAPDA IN BALUCHISTAN



Note. Continous line indicates that rating curve has been established, dotted line indicates occasional discharge observations with or without gauge height record.

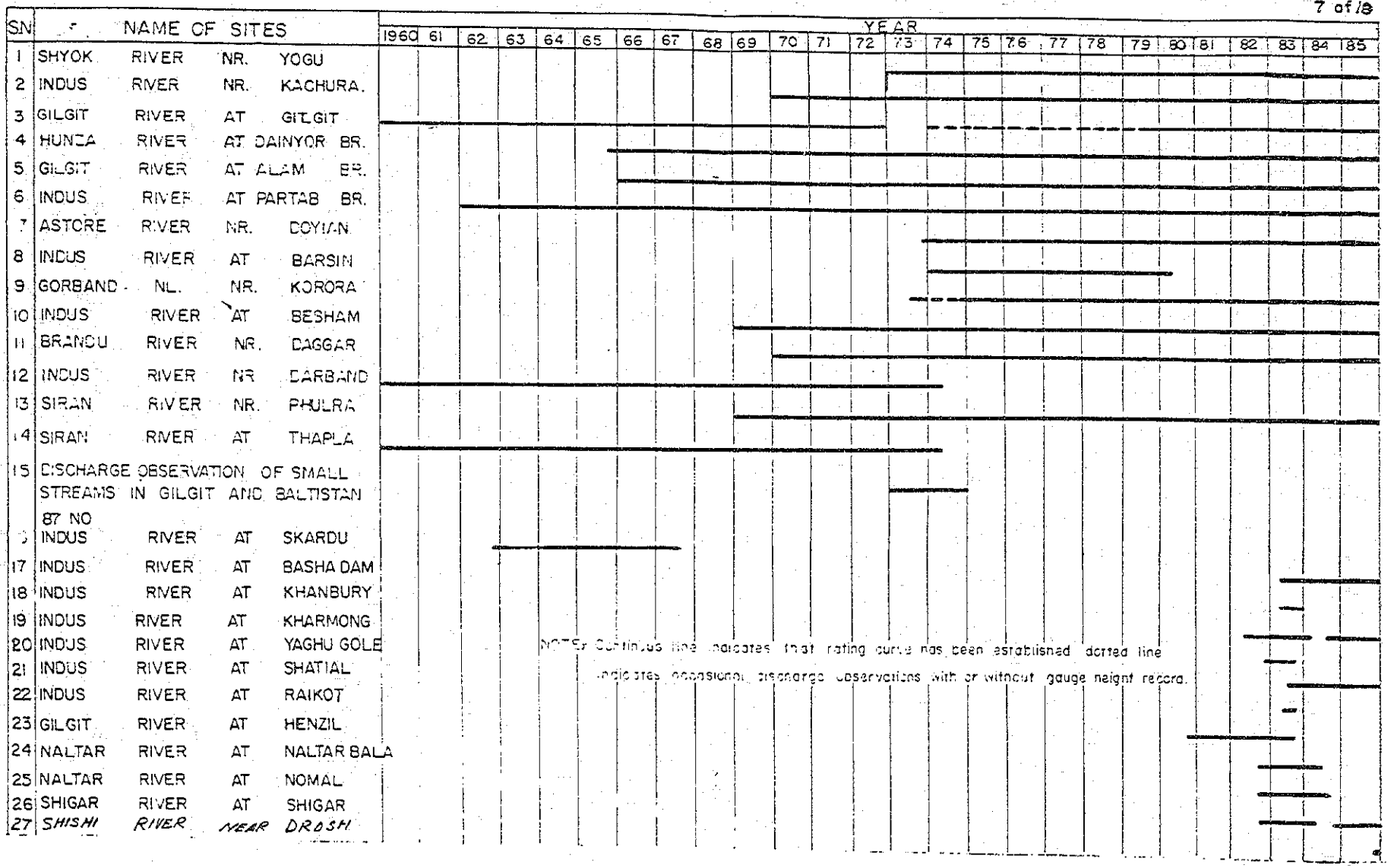
STREAM GAUGING, SEDIMENT SAMPLING AND WATER QUALITY STATIONS OPERATED BY SWHP, WAPDA MANGLA RESERVOIR CATCHMENT



STREAM GAUGEING, SEDIMENT SAMPLING AND WATER QUALITY STATIONS OPERATED BY S.W.H.P. WAPDA IN TARBELA. RESERVOIR CATCHMENT

EXHIBIT V

7 of 18



STREAM GAUGING SEDIMENT SAMPLING AND WATER QUALITY STATIONS OPERATED BY SWHP WAPDA IN N.W.F.P. & AZAD KASHMIR

SN	NAME OF SITES	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
	CHASHMA RIGHT BANK CANNAL (F.S.D)																										
1	GOMAL RIVER AT AZAM																										
2	HAUZ N AT YARK VILL.																										
3	KAUR NL AT KAUR QILA																										
4	KHAO SAGGU NL NR. BUDH																										
5	LONI NL AT SOOR QAMAR																										
6	LONI NL. AT HAZARA VILL.																										
7	LONI NL. AT SAGAR																										
8	MOCHI WALA NL. NR. GOMAL UNIVERSITY																										
9	TAKWARA NL. NR. PUSHA VILL.																										
10	SANGAR NL. AT TUNSA SHARIF																										
11	VEHORA NL AT BAZDAR																										
	LOW FLOW OF SMALL HYDEL. POWER SCHEME IN A.K.																										
1	ALIABAD NL. NR. KHUTHA																										
2	BATAR NL. NR. KHUTHA																										
3	CHHAM NL NR. CHHAM																										
4	CHUTIARI NL AT LUIAT																										
5	JAGRAN NL AT KUNDAL SHAHI																										
6	JAGRAN NL. NR. DULLAR																										
7	KASHMIR NL. AT DHUDHNIAL																										
8	KATHA QAZI NAG AT LEEPA																										
9	NARAIL NL. NR. KEL																										
10	NAGDAR NL. NR. NEELUM																										
11	RATI GALI NL. NR. DAWARIAN																										
12	SHANTAR NL. AT KEL																										

STREAM GAUGING SEDIMENT SAMPLING AND WATER QUALITY STATIONS
OPERATED BY SWHP WAPDA IN A.K, SIND AND N.W.F.P.

S.N	NAME OF SITES	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
		YEAR																									
13	SURGEN NL AT SHARDI																										
14	GUIN RIVER NR. PALANDRI																										
15	KATHAI NL NR. KATHAI																										
16	MAHL NL NR. BAGH																										
17	MANDAL NL NR. PATIKA																										
18	NAGDAR NL AT NAGDAR																										
19	KATHA NOWSHERA NR.DOPATA																										
20	RANGHAR NL NR. KOTLI																										
21	DOARA HAR AT CHANGAN																										
22	CHANJAL NL NR. KAHUTA																										
	MANCHAR AND CHUTIARI LAKE																										
1	ARAL MANCHAR																										
2	AJO ESCAPE																										
3	ARAL LAKE																										
4	BANDHNI NAI																										
5	CONFLUANCE OF THREE NAI																										
6	CHUTIARI LAKE																										
7	DANSTAR CANAL																										
8	GAJ NAI RD 50																										
9	MANCHAR LAKE																										
10	NARA CANAL RD 211																										
11	NARA CANAL RD 215																										
12	PIR ARI NAI																										
13	RANTO ESCAPE																										
14	WADKI ESCAPE																										
	PEHURE HIGH LEVEL CANAL G.H.DATA JULY TO SEP.																										
1	BADRI KHAWAR NR. TOTALI																										
2	PULA KHAWAR NR. GUNDAF CAMP																										
3	UCH KHAWAR NR. MAINI																										

STREAM GAUGING STATIONS
OPERATED BY SWHP WAPDA IN PUNJAB

SN.	NAME OF SITES	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
		YEAR																									
28	CHAK BANDI DRAIN R.D. 87303																										
29	MADDUANA BRANCH DRAIN R.D. 144592																										
30	MADDUANA BRANCH DRAIN R.D. 64867																										
31	PAHARANG MAIN DRAIN RD. 94844																										
32	SUMMANDRI MAIN DRAIN R.D. 49000																										
33	SUMMANDRI BRANCH DRAIN RD. 10365																										
34	T.R. TRY DRAIN KHURRIANWALA																										
35	AW.G.T BRANCH DRAIN R.D. 27730																										

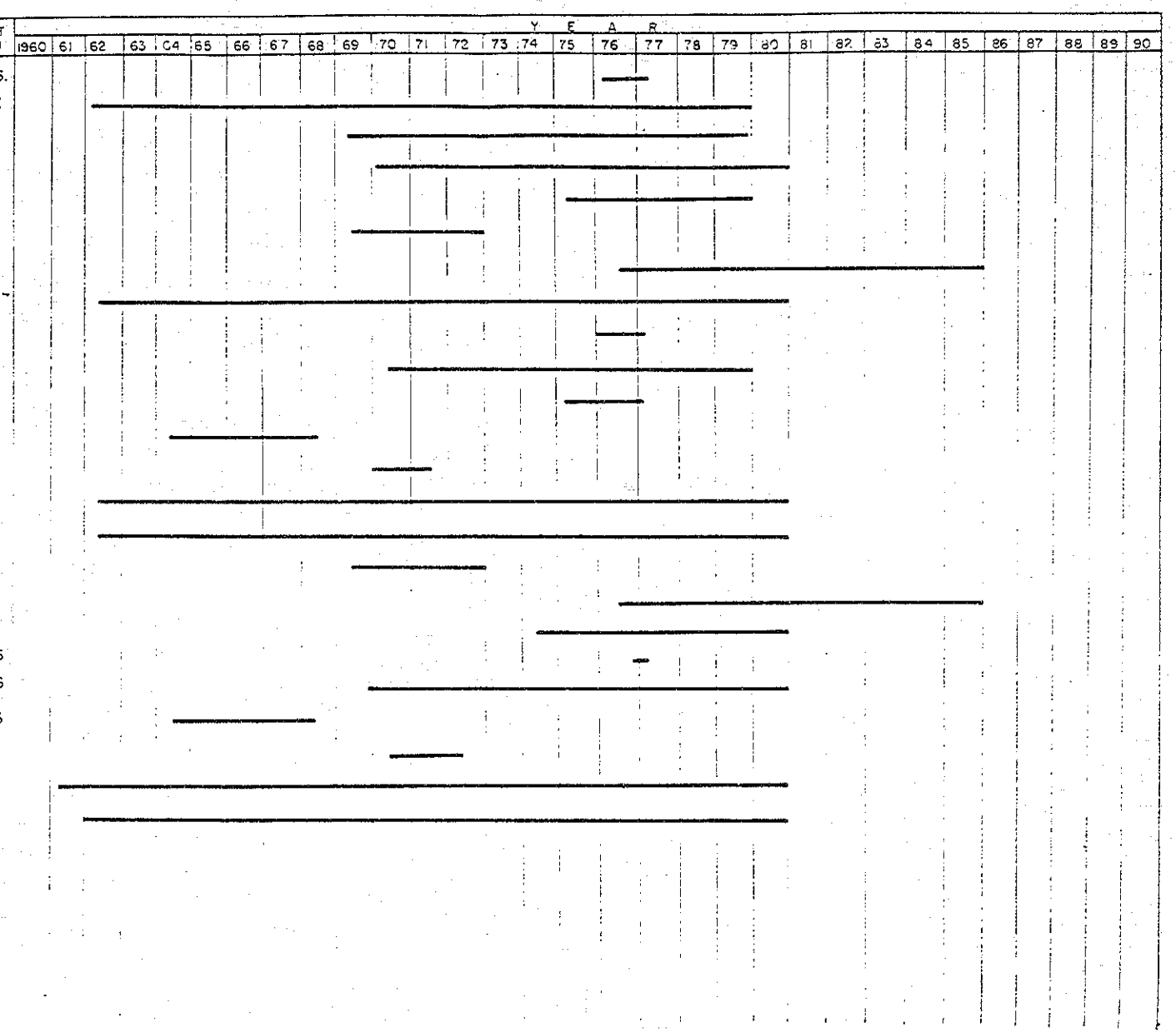
EXHIBIT—VI

資料 8

資料—8

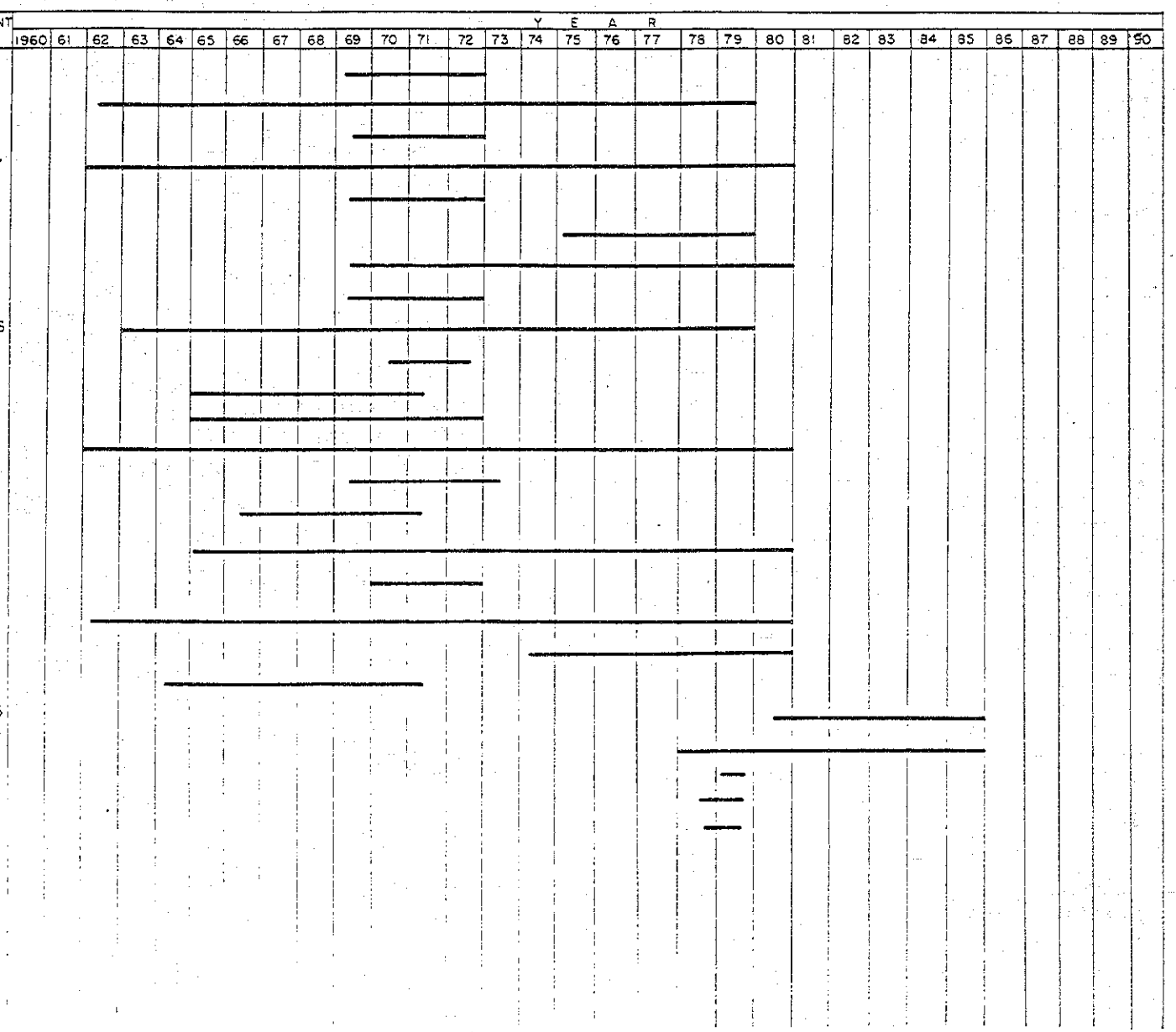
CLIMATOLOGICAL STATIONS OPERATED BY SWH WAPDA IN PUNJAB

S.N.	NAME OF SITE	INSTRUMENT INSTALLED
1	ARIFWALA	1.2.3.4.5.6.
2	BAHAWALNAGAR	1.2.3.4.5.6.7.
3	BAHAWALPUR	1.3.4.5.
4	BHAKKAR	1.3.4.5
5	BHIMBER	1.2.3.4.5.6.
6	CHAK QAZI	1
7	CHIRAH BRIDGE	1
8	CHUHARKANA	1.2.3.4.5.6.7.
9	CHUNIAN	1.2.3.4.5.6.
10	DHOK PATHAN	1.2.3.4.5.
11	DANDA SHAH BILAWAL	1.2.3.4.5.6
12	GOHAR	1.3.4.5
13	GOHARWALA	1.3.4.5
14	GOJRA	1.2.3.4.5
15	GUJRANWALA	1.3.4.5.6
16	GUKHIANI	1
17	GURRIALA	1
18	JAMALI BALUCHAN	1.2.3.4.5.6.
19	JAHANIAN	1.2.3.4.5.6
20	JATOI JANUBI	1.2.3.4.5.6
21	KATHIALA KHURD	1.2.3.4.5.6
22	KHANPUR	1.3.4.5.6
23	KOTLA	1.2.3.4
24	LEIAH	1.3.4.5.6



CLIMATOLOGICAL STATIONS OPERATED BY SWH WAPDA IN PUNJAB

S.N	NAME OF SITE	INSTRUMENT INSTALLED
25	MIANI	1
26	MIANWALI	1.3.4.5.6
27	MELOWAL	1
28	MUZAFFAR GARH	1.3.4.5.6.7
29	PAKHOWAL	1
30	PAPIN	1.2.3.4.5.6
31	PHULARWAN	1.2.3.4.5.6
32	RAIB	1
33	RAWALDAM	1.2.3.4.5.6
34	ROHELAN WALI	1
35	SAHIWAL	1.2
36	SARDARPUR	1
37	SARGODHA	1.2.3.4.5.7
38	SATGHARA	1
39	SHAKARGARH	1.2.3.4
40	SIALKOT	1.2.3.4.5
41	SIT PUR	1
42	WASU	1.3.4.5
43	MASSAN	1.2.3.4.5
44	CHAK DAFFAR	1.3.4.5.6
45	CHASHMA	1.2.3.4.5.6
46	MAKHAD	1
47	BURANA	1.5
48	NURPUR	1.5
49	SHERGARH	1.5



CLIMATOLOGICAL STATIONS OPERATED BY SWHP | WAPDA IN SIND

SN	NAME OF SITES	INSTRUMENT INSTALLED	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
1	BADIN	1,2,3,4,5,6																										
2	BAND MURAD KHAN	1																										
3	CHHOR	1,3,4,5,6																										
4	CHILYA	1,2,3,4,5,6																										
5	DADU	1,2,3,4,5,6																										
6	DARWAT	1,3,4,5																										
7	DOKRI	1,2,3,4,5,6																										
8	GAGGAR	1,3,4,5,6																										
9	GAHRO	1,3,4,5,6																										
10	GAJ REST HOUSE	1,3,4,5																										
11	GHOTKI	1,2,3,4,5																										
12	HUB DAM SITE	1,3,4,5,6,7																										
13	JACCBABAD	1,3,4,5																										
14	JAMECABAD	1,3,4,5																										
15	JATI	1,3,4,5																										
16	KABOOL PUR	1,3,4,5																										
17	KARCHAT	1,2																										
18	KHAIR PUR	1,3,4,5,6,7																										
19	KOT DIJI	1,3,4,5																										
20	MALIR SUPPER H.WAY																											
21	MIANI FOREST	1,2,3,4,5,6																										
22	NABISAR ROAD	1,3,4,5,6																										
23	NAWAB SHAH	1,3,4,5																										

CLIMATOLOGICAL STATIONS OPERATED BY SWHP WAPDA IN SIND

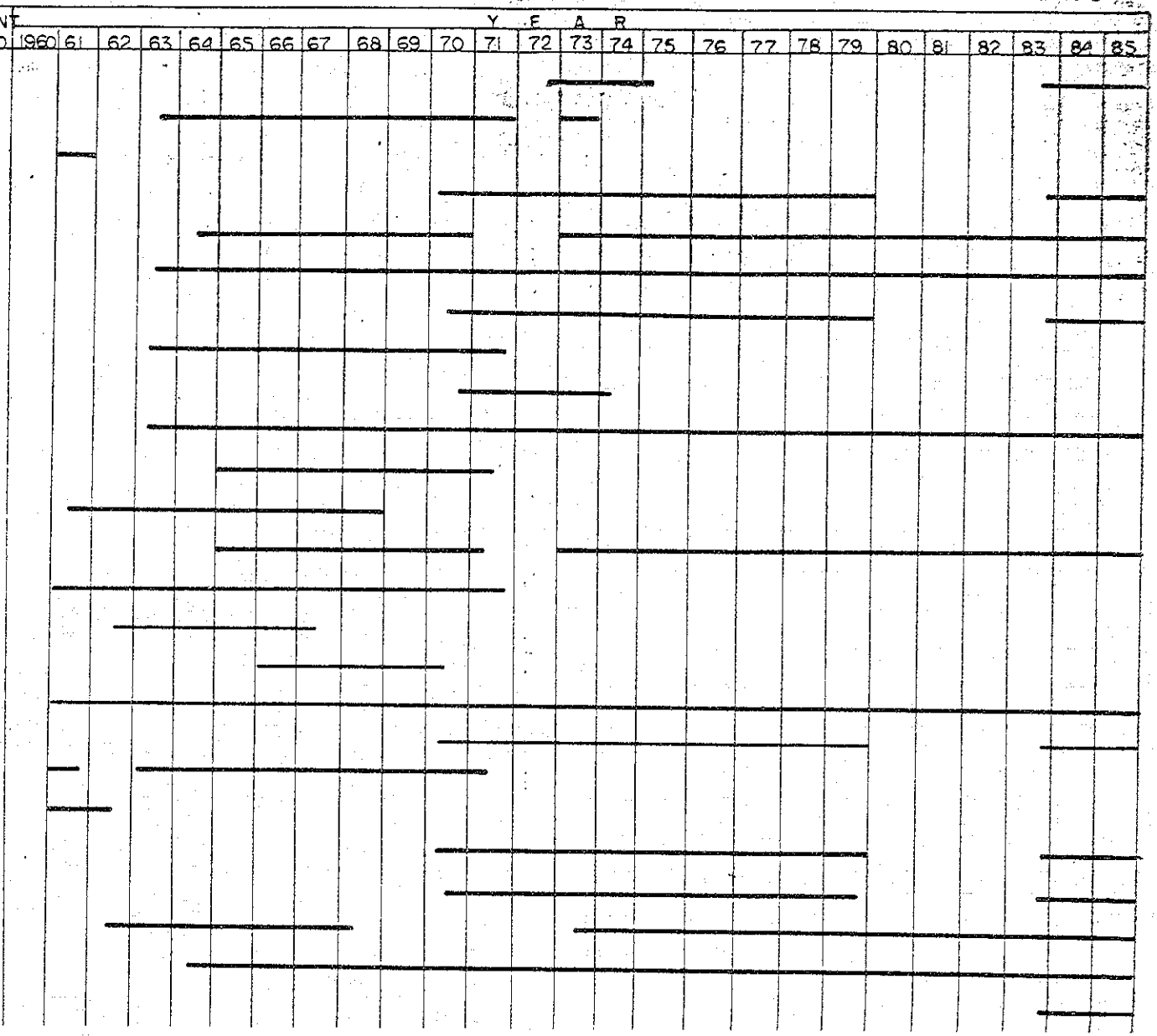
SN.	NAME OF SITES	INSTRUMENT	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
24	PADIDAN	1,3,4,5,6																										
25	PADRI-GO-GOTH	1,3,4,5,6																										
26	PAL FOREST	1,2,4,5,6																										
27	SAKRAND	1,2,3,4,5																										
28	SEHWAN	1,2,3,4,5,6																										
29	SARI SANG	1,2																										
30	THANO BULA KHAN	1,3,4,5,6																										
31	THANA SHAH BEG																											
32	USTA MOHAMMAD	1,2,3,4,5,6,7																										
33	DHAL	1,2																										
34	ROOP KANI	1,2																										
35	GOTH HAJI SHAH MOHD	1,2																										
36	GOTH HABIT	1,2																										
37	GUJRI BANGLOW	1,2,3,4,5																										

1. Non Recording Rain Gauge
2. Recording Rain Gauge
3. Air Temperatures
4. Dry And Wet Bulb Temperatures
5. Evaporation Pan
6. Anemometer
7. Solar Radiation
8. Wind Intensity

BAR CHART
- 8 10 8

CLIMATOLOGICAL STATIONS OPERATED BY SWHP IN BALUCHISTAN

S.N	NAME OF SITES	INSTRUMENT INSTALLED
1	AWARAN	1
2	BABAR KACH	1·2·3·4·5·6
3	BADRI	1
4	BALGATTAR	1
5	BANDAT JUNGLE	1·2·3·4·5
6	BELA	1·2·3·4·5·6
7	BIT BULEDA	1
8	BAGH	1·3·4·5·6
9	CHANKANI	1
10	CHAPPER RIFT	1
11	CHATTAR	1
12	DERA BUGTI	1
13	DUKI	1·3·4·5·6
14	DUREJI	1·2·3·4·5·6
15	GHATTI BRIDGE	1
16	GANDAVA	1·2·3·4·5·6
17	GOTH AMUN	1·2·3·4·5·6
18	GOTH HAJI KAREEM BUX	1·2·3·4·5·6
19	GOTH HAJI KHAMISA	1
20	GOTH NOOR MUHAMMAD	1
21	GWADAR	1
22	GWAR MANZIL	1
23	HARNAI	1, 2
24	MUSLIM BAGH	1·2·4
25	MUSHKAI	1



CLIMATOLOGICAL STATIONS OPERATED BY SWHP WAPDA IN BALUCHISTAN

BAR CHART
5 to 8

S.N	NAME OF SITES	INSTRUMENT INSTALLED	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
26	HANIDAN	1																										
27	HOR	1																										
28	JHAL	1																										
29	JHAL JHAO	1																										
30	JHUMAK	1.2																										
31	JIWANI	1																										
32	JOHAN	1																										
33	KAHAN	1																										
34	KANRACH THANA	1																										
35	KHAZINI	1																										
36	KHURKEIRA	1																										
37	KHIRZAN	1																										
38	KHOST	1																										
39	KHUZDAR	1.2																										
40	KUCHA JAT	1																										
41	KORIK	1																										
42	KOHLU	1.2																										
43	KILLI KOTWAL	1·2·3·4·5																										
44	KACH	1·3·4·5																										
45	KUDAN	1																										
46	KORI	1																										
47	LEHRI	1																										
48	MACH	1.2																										
49	MAND	1·3·4·5																										

CLIMATOLOGICAL STATIONS OPERATED BY SWHP WAPDA IN BALUCHISTAN

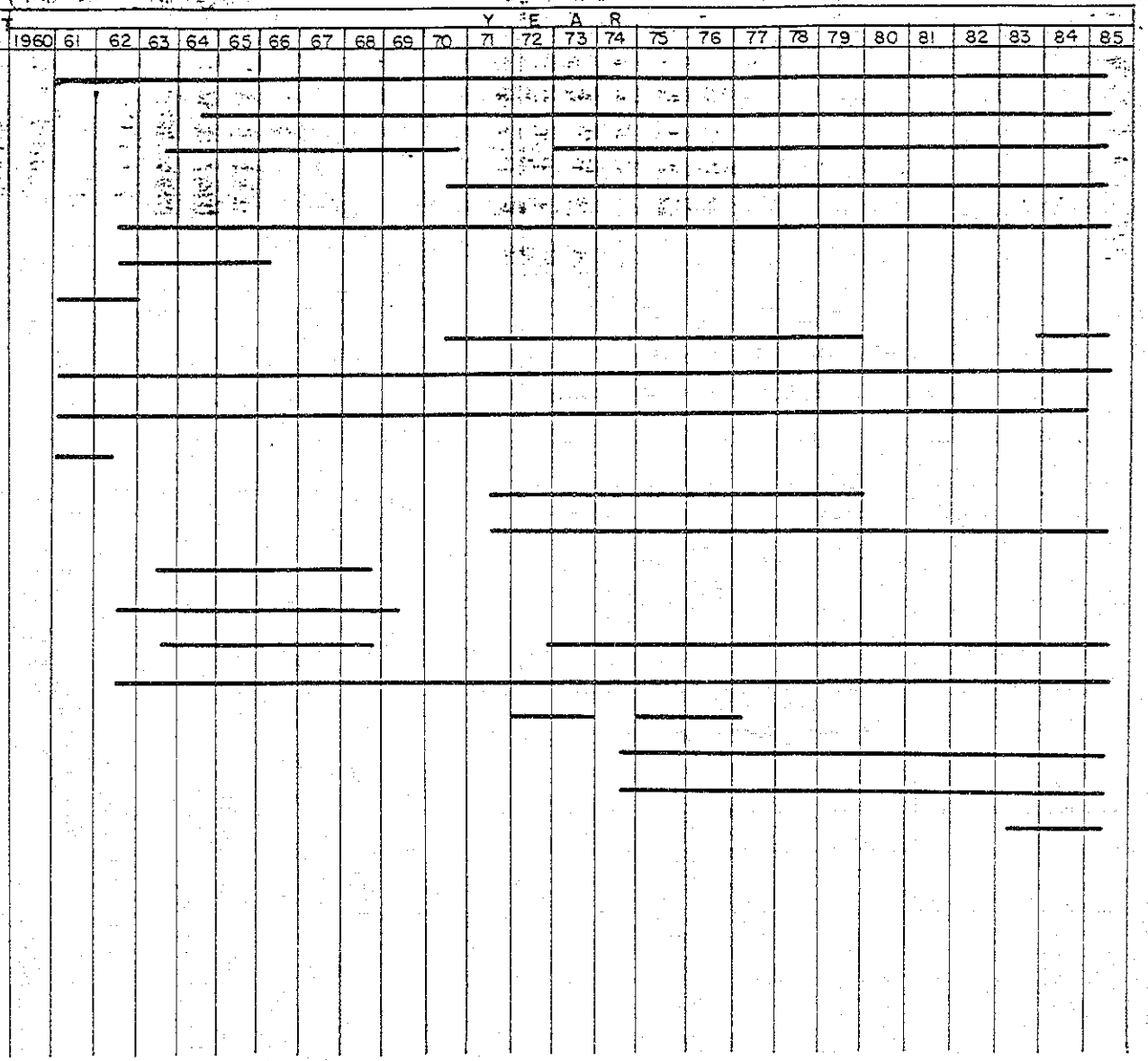
BAR CHART
4 to 8

SN	NAME OF SITES	INSTRUMENT INSTALLED	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
50	MAKRI MAS	1																										
51	MANGO CHAR	1																										
52	MAI GONDRANI	1																										
53	MEHANDAR	1																										
54	MAWAND	1																										
55	MURGHA KIBZAI	1																										
56	MANGI	1·3·4·5·6																										
57	NANA SAHIB	1																										
58	NAL	1																										
59	NAULANG	1																										
60	NIVANO	1 . 2																										
61	ORNACH	1																										
62	PADARAK	1																										
63	PANJGUR	1.5.6																										
64	PIR MUSHANI	1																										
65	SANJAWI	1																										
66	SANNI	1																										
67	SARUNA	1 . 2																										
68	SARIAB	1																										
69	SARI PAROM	1																										
70	SHARIG	1																										
71	SHORI	1																										
72	SHANGLOON	2																										
73	SIBI	1·3·4·5·6																										

BAR CHART
810 B

CLIMATOLOGICAL STATIONS OPERATED BY SWHP WAPDA IN BALUCHISTAN

S.N	NAME OF SITES	INSTRUMENT INSTALLED
74	SINCHI BENT	1
75	SIRAN TANGI	1
76	SPIN TANGI	1
77	SPEZAND	1
78	SURAB	1
79	TALLI TANGI	1
80	TIARO PIR	1
81	TURBAT	1,2,3,4,5,6
82	UTHAL	1,2,3,4,5,6
83	WAD	1,3,4,5,6
84	WADINGAR	1
85	WALI DAF	1
86	WALI TANGI	1, 2
87	ZAGAR	1
88	ZEHRI	1
89	ZANDRA	1
90	ZIARAT	1,2,3,4
91	ZARI CHASMA (Snow Gauge)	1
92	BADIN ZAI	1,2,3,4,5,6
93	SHIRAN JOGOZAI	1
94	AGORE	1,2,3,4



1 NON RECORDING RAIN GAUGE
2 RECORDING RAIN GAUGE
3 AIR TEMPERATURES
4 DRY & WET BULB TEMPERATURES
5 EVAPORATION PAN
6 ANEMOMETER
7 SOLAR RADIATION
8 WIND INTENSITY

EXHIBIT-VI
9 of 11

CLIMATOLOGICAL STATION OPERATED BY SWHP WAPDA IN MANGLA CATCHMENT

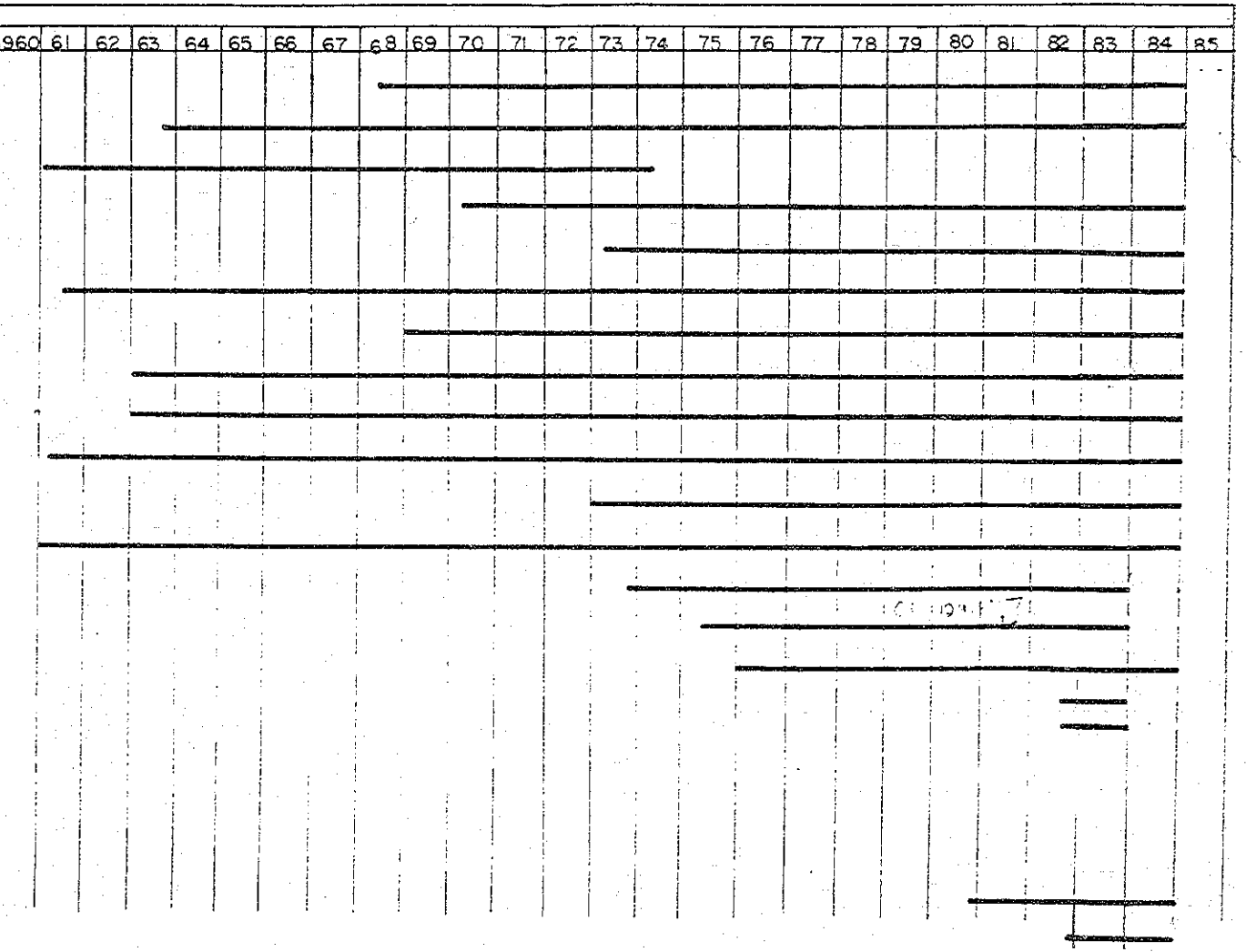
SN	NAME OF SITE	INSTRUMENT INSTALLED	1960	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
			YEAR																									
1	BAGH	1,2,3,4																										
2	GUJAR KHAN	1,2,3,4,5,6																										
3	JHANGI	1																										
4	KALLAR	1,2																										
5	KHANDAR	1,2																										
6	MANGLA	1,2,3,4,5,6																										
7	MUZAFFARABAD	1,2,3,4,5,6																										
8	FALAK	1																										
10	FALANDRI	1,2,3,4																										
11	RAWALAKOT	1,2,3,4																										
12	[illegible]	1,2																										
13	[illegible]	1,2																										
14	[illegible]	1,2																										
15	INTAKE MANGLA	1,2																										

1. NON-RECORDING RAIN GAUGE
2. RECORDING RAIN GAUGE
3. AIR TEMPERATURES
4. DRY & WET BULB TEMPERATURES
5. EVAPORATION PAN
6. ANEMOMETER
7. SOLAR RADIATION
8. WIND INTENSITY

CLIMATOLOGICAL STATIONS OPERATED BY SWHP WAPDA IN TARBELA CATCHMENT

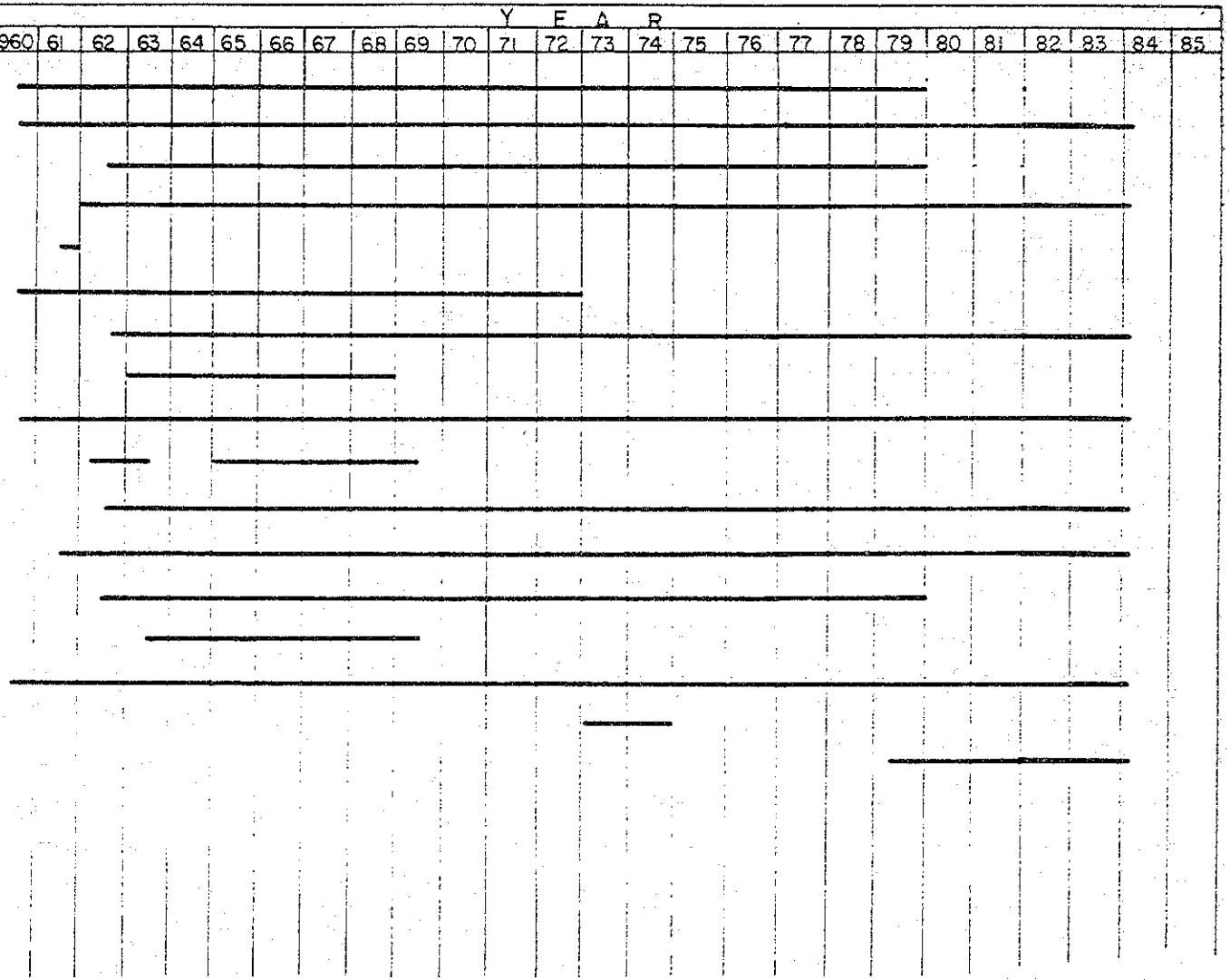
SN	NAME OF SITE	INSTRUMENT INSTALLED
1	BESHAM QILA	1,2,3,4,5
2	DAGGAR	1,2,3,4,5
3	DARBAND	1,3,4,5,6
4	KACHURA	1,2,3,4,5,6
5	KARIMABAD	1,2
6	OGHI	1,2,3,4,5,6
7	PHULRA	1,2,3,4,5,6
8	PURAN	1
9	SHAH PUR	1
10	CHINKIARI	1,2,3,4,5,6
11	YOGO	1,2
12	TARBELA	1,2,3,4,5,6
13	JABBAR	1,2
14	BARSIN	1,2,3,4,5
15	DOYIAN	1,2,3,4,5,6
16	NOMAL	1,2,3,4,6
17	NALTAR	1,2,3,4,6
18	DAINYOR	1,2,3,4,5,6
19	DUDHNIAL	1,2,3,4

1. NON-RECORDING RAIN GAUGE
2. RECORDING RAIN GAUGE
3. AIR TEMPERATURES
4. DRY & WET BULB TEMPERATURES
5. EVAPORATION PAN
6. ANEMOMETER
7. SOLAR RADITION
8. WIND INTENSITY



CLIMATOLOGICAL STATIONS OPERATED BY SWHP IN N. W. F. P.

S.N	NAME OF SITE	INSTRUMENT INSTALLED
1	BALA KOT	1,2,3,4,5,6
2	BANNU	1,2,3,4,5,6
3	BARKOT	1,2
4	FORT LOCK HART	1,3,4,5
5	GARHI HABIB ULLAH	1,2,3,4,5,6
6	HARIPUR	1,2,3,4,5,6
7	KALAM	1,2,3,4,5
8	KHAJURI KACH	1,3,4,5,6
9	KOHAT	1,2,3,4,5,6
10	KUZA BANDA	1
11	MARDAN	1,2,3,4,5,6,7
12	NARAN	1,2,3,4
13	SAIDU SHARIF	1,2,3,4,5,6
14	WANA	1,3,4,5,6
15	TANK	1,2,3,4,5
16	ZIARAT POST	1,2,3,4,5
17	JANDOLA	1,2,3,4



1. NON-RECORDING RAIN GAUGE
2. RECORDING RAIN GAUGE
3. AIR TEMPERATURES
4. DRY & WET BULB TEMPERATURES
5. EVAPORATION PAN
6. ANEMOMETER
7. SOLAR RADIATION
8. WIND INTENSITY

資料－9

Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY At point	VELOCITY Mean in vertical	Average Velocity	Area	Average Depth	Discharge

.0 .10 .20 .30 .40 .50 .60 .70 .80 .85 .90 .92 .94 .96 .97 .98 .99 1.00 .96 .95 .97 .95 .94 .92 .90

GAGE READINGS

Time

資料－9

SURFACE WATER HYDROLOGY
WASID-WAPDA

W. P. P.-Lahore—Job No.

DISCHARGE MEASUREMENT NOTES

Meas. No. .....
Comp. by .....
Checked by .....

Doan River at Kachhiana

Date 6-2 1974 Party M. J. Safdar, C. Gr. O

Width 43 Area 41.0 Vel. 1.89 G. H. 11.20 Disch. 77.7

Method 6 No. secs. 25 G. H. change nil in 40 hrs. Susp. rod

Method coef. 1.02 Hor. angle coef. 1.0 Susp. coef. 1.0 Meter No. 992172

GAGE READINGS				
Time	G. H.	Recorder	Inside	Outside
12:15	11.20			
12:30	11.20	S		
13:10	11.20	F		
Weighted M. G. H.				
G. H. correction				
Correct M. G. H.	11.20			

Date rated July 1973 Used rating for rod ..... susp. Meter ..... ft. above bottom of wt. Tags checked .....

Spin before meas. OK after OK

Meas. plots ..... % diff. from ..... rating

Wading, cable, ice, boat, upstr., downstr., side bridge 140 feet, mile, above, below gage, and .....

Check-bar, chain found ..... / changed to ..... / at .....

Correct .....

Levels obtained .....

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions: Cross section Irregular gravel bed

Flow Low Weather Cloudy

Other ..... Air 11.0°F @ 1315

Gage OK Water 11.0°F @ 1320

..... Record removed ..... Intake flushed .....

Observer Pleasant

Control Natural

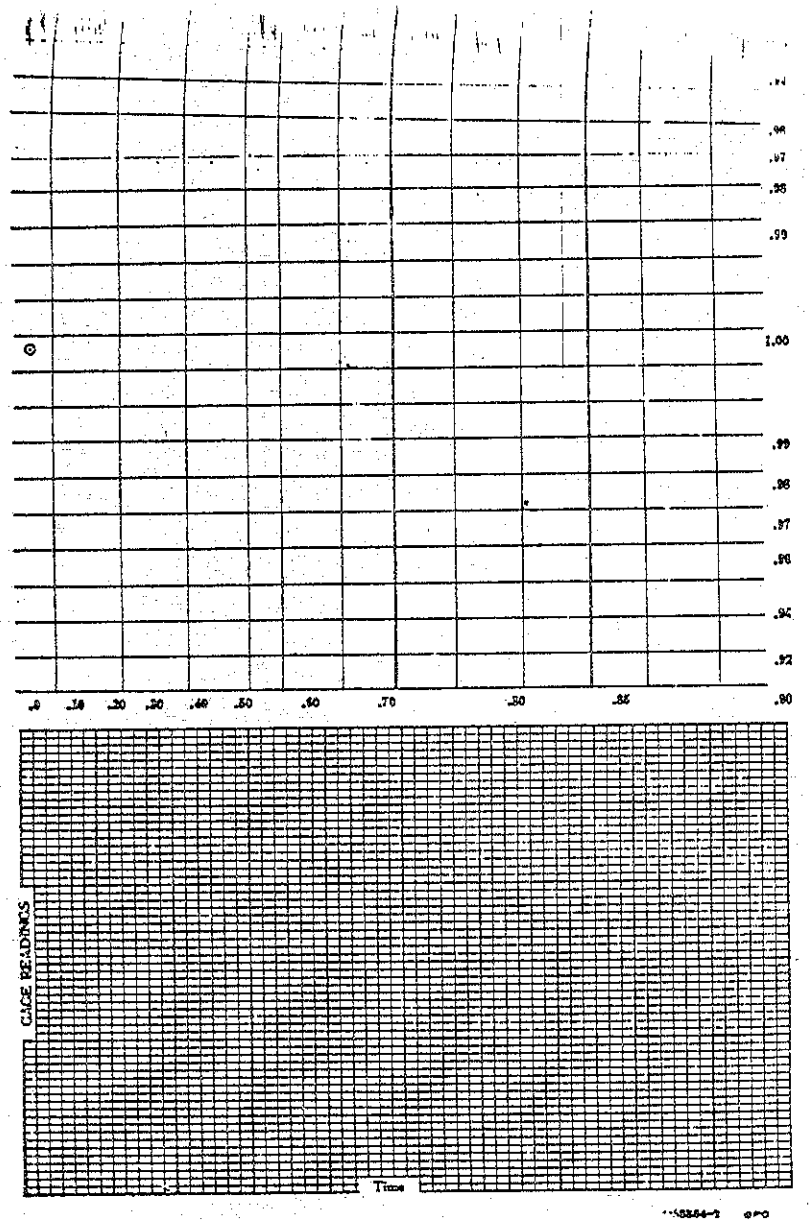
Remarks Fair Good Sample DH-1 used and chemicable DH-2

G. H. of zero flow ..... ft.

Form- 6

資料－9

Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY At point	VELOCITY Mean in vertical	Adjusted for hor. angle or	Area	Discharge
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				12 :	3.0
	100	1.0	W-E								1.96
	98	2	.6	.6	30	44	1.63			1.20	1.95
	96	2	1.4	"	40	44	2.17			2.80	6.08
	94	2	0.15	"	30	44	1.63			0.30	.49
	92	2	1.45	"	40	40	2.34			2.90	6.80
	90	2	1.45	"	50	42	2.83			2.90	8.21
	88	2	1.35	"	40	48	1.99			2.70	5.40
	86	2	1.48	"	50	46	2.56			2.96	7.64
	84	2	1.1	"	40	50	1.91			2.2	4.20
	82	2	1.3	"	30	45	1.60			2.6	4.16
	80	2	1.1	"	25	47	1.28			2.2	2.82
	78	2	0.8	"	15	40	.91			1.6	1.46
⊙	76	2	1.00	"	25	40	1.50			2.00	3.00
	74	2	1.1	"	50	45	2.64			2.2	5.81
	72	2	1.1	"	50	43	2.76			2.2	6.07
	70	2	1.05	"	40	40	2.34			2.10	5.00
	68	1.50	.7	"	25	45	1.34			1.05	1.41
	67	.50			W	E					1
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33.9	67.5
	0	1.0	W-E								70.52
	2	2	0.7	"	5	42	.31	x1.02	.316	1.40	.42
	4	2	0.9	"	15	46	.80			1.80	1.44
	6	2	1.00	"	20	43	1.12			2.0	2.24
	8	1.50	1.22	"	20	41	1.15			1.83	2.15
	9	1	1.1	"	15	45	.81			1.10	0.89
	10	.50	W-E							7.43	7.142
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			33.9	67.5 7052
	43	43								41.03	94.43
											77.662



SURFACE WATER HYDROLOGY
WASID-WAPDA

W. P. P., Lahore—Job No.

DISCHARGE MEASUREMENT NOTES

Meas. No. .....
Comp. by .....
Checked by .....

DOR RIVER NR. HAVELINA

Date 27-2, 1974 Party M. Siddique Alvi

Width 35.0 Area 25.9 Vel. 3.9 G. H. 11.98 Disch. 101

Method 5-6-5 No. secs. 22 G. H. change nil in hrs. Susp. Rod

Method coef. 0.85 Hor. angle coef. 1.00 Susp. coef. 1.00 Meter No. G.W.D.-6

GAGE READINGS				
Time		Recorder	Inside	Outside
11:45				11.98
12:00				11.98
13:00				11.98
Weighted M. G. H.				
G. H. correction				
Correct M. G. H.				11.98

Date rated 2/71 Used rating for rod ..... susp. Meter ..... ft. above bottom of wt. Tags checked .....

Spin before meas. ok after ok

Meas. plots ..... % diff. from ..... rating

Wading, cable, ice, boat, upstr., downstr., side bridge 3.0 feet, mile, above, below gage, and .....

Check-bar, chain found ..... changed to ..... at .....

Correct .....

Levels obtained .....

Measurement rated excellent (2%), good (5%), fair (8%), poor (over 8%), based on following conditions: Cross section REGULAR, SINGLY REED

Flow SMOOTH Weather .....

Other ..... Air 64 °F @ 13:00

Gage STAFF, ok Water 58 °F @ 13:10

..... Record removed ..... Intake flushed .....

Observer .....

Control NATURAL

Remarks SEDIMENT SAMPLE NO KP135 collected.
CHEMICAL SAMPLE NO KP136

G. H. of zero flow ..... ft.

Form- 6

Note:- Stop watch is out of order, Wrist watch is used during Discharge measurement.

ID 19.

Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY At point	VELOCITY Mean in vertical	Adjusted for hor. angle or	Area	Discharge
			L.	B	STA	RT	D	T 12:00			
	0	0.5	W.	E							
	1	1.0	.20	S	15	41	1.84	x.85	.71	.20	.14
	3	2.0	.60	.6	25	40	1.43			1.20	1.72
	5	2.0	.75	.6	60	40	3.42			1.50	5.13
	7	2.0	1.10	.6	100	47	4.84			2.20	10.6
	9	2.0	1.18	.6	80	40	4.55			2.36	10.7
	11	2.0	1.25	.6	100	46	4.94			2.50	12.4
	13	2.0	1.20	.6	100	39	5.83			2.40	14.0
	15	2.0	.75	.6	50	40	2.85			1.50	4.28
	16	1.0	.33	.5	20	43	1.07			.33	.35
	17	0.5	W.	E							
			2nd channel								
	27	0.5	W.	E							
	28	1.5	0.40	.6	60	40	3.42			.60	2.06
	30	2.0	0.60	.6	80	45	4.05			1.20	4.86
	32	2.0	0.90	.6	80	48	3.79			1.80	6.82
	34	2.0	1.20	.6	80	44	4.14			2.40	9.94
	36	2.0	1.20	.6	80	49	3.72			2.40	8.93
	38	2.0	0.70	.6	60	43	3.42			1.40	4.79
	40	2.0	0.50	.6	50	40	2.85			1.00	2.85
	42	2.0	0.30	.5	40	50	1.83			.60	1.10
	44	1.5	0.22	S	25	42	1.36	x.85	1.16	.33	.38
	45	0.5	W.	E						25.92	~~61.05~~
		35.0	R.	B	FIN	SH	D	T 13:00			101.05
									Say	25.9	~~61.1~~ Say
										Say	101

資料－10

資料１０

RAWALPINDI WATER SUPPLY AND SEWERAGE PROJECT

DRAFT FINAL REPORT
VOLUME I

ASIAN DEVELOPMENT BANK
MANILA, PHILLIPINES

MAY, 1980

ASSOCIATED ENGINEERING SERVICES LTD

AESL

資料－11

CAPITAL DEVELOPMENT AUTHORITY
(TUBE WELLS DIVISION)

No. CDA/WS/TW/10/1712 Islamabad, 08.02. 1986.

Subject: DAILY PRODUCTION REPORT

Sub. Division wise daily production reports are attached. Brief summary is as under:

Sub Division	Total	WAPDA Fault	Defective	Working	Production
Sub Div. I	24	—	—	24	3.94 MGD
Sub Div. II	22	—	—	22	2.69 MGD
Sub Div. III	27	—	—	27	7.83 MGD
Grand Total	73	—	—	73	14.46 MGD

Submitted for your kind information please.

HADEEZ ALI,
DY. DIRECTOR, (TW)

Distribution

1. C.C.O. to Chairman, CDA
2. Dy. Director General (S), CDA
3. Director, W&S (Maint), CDA

DAILY WATER PRODUCTION REPORT SUB DIVISION-I

7.02.86

S.No.	T/Well No.	Area	Yield	Present production	Remarks
1.	28/1	Golf Course	0.23	0.14	MGD
2.	29/2	" "	0.25	0.15	
3.	30/3	" "	0.23	0.14	
4.	31/4	" "	0.24	0.14	
5.	32/5	" "	0.25	0.15	
6.	33/7	" "	0.18	X	Abondoned
7.	34/8	" "	0.25	0.15	
8.	76	" "	0.30	0.18	
9.	45	H-8 Old	0.30	0.18	
10.	46	H-9	0.30	0.18	
11.	47	H-9/2	0.25	0.15	
12.	48	H-9/3	0.20	0.✓	Turbine lowered
13.	49	H-9/4	0.30	0.17	
14.	50	I-8/4	0.30	0.18	
15.	51	I-8/2	0.23	0.13	
16.	52	I-9	0.30	0.17	
17.	53	I-9/1	0.23	0.12	
18.	54	I-9/4	0.30	0.18	
19.	55	I-9/2	0.23	0.14	
20.	56	I-9/4	0.30	0.18	
21.	57	I-10/3	0.18	0.12	
22.	58	I-10/3	0.30	X	Abondoned.
23.	59	I-11/1 No.	0.23	0.14	
24.	60	I-11/2 No.	0.23	0.14	
25.	67	H-8/2 New	0.58	0.45	
26.	71	I-10/4	0.50	0.30	

Detl. 355 HISD.

8/4/86

Daily Water Production Report Zubair

07-2-86.

S/No.	T/Wells No.	Area	Yeild	Present Production	
					MGD
1	37	G-5-2.	0.1	.06	
2	39	G-7-2 (old).	0.1	.06	
3	40	G-8-1 (Gilani Colony)	0.1	.06	
4	41	G-9/3.	0.25.	.15.	
5	42.	G-9/4. (old).	0.30	.19.	
6	43.	G-9/4 (MKZ)	0.15.	.08.	
7	44	G-9/4 (Narsim)	0.15.	.08.	
8	61	G7/3-2	0.30	.18	
9	62	G8/1 (Lab Colony)	0.20	.12	
10	63	G-8/4	0.23	.14	
11	64	F8/1	0.20	.12	
12	65	F8/4	0.23	.14	
13	66	G-9/3.	0.18	.11	
14	69	F10/3.	0.55.	.34	
15	70	F9/4.	.18	.08.	
16	72	G9/1 (NCA).	0.47	.29.	
17	73	G10/3.	0.15.	.08.	
18	74	G-10/4	—	—	Abandoned.
19	77	G7/2 WI	0.10	.06	
20	78	" WII	0.10	.06.	
21	SWI	G-10 - WI	0.09	.05.	
22	SWII	G10 - WII	0.08.	.05	
23	36	F-8 - MKZ.	0.3	.18.	

TOTAL:- 2.69 MGD

8/7/86

ASSH Director WT

DAILY WATER PRODUCTION REPORT SUB. DIV. III

7.02.86

S.No.	T/Well No.	Area	Present Production	Yield	REMARKS
1.	[illegible]	N.P.A.	0.35	0.48	MGD
2.	2 Nos.	"	0.14	0.20	
3.	3 Nos.	"	0.41	0.59	
4.	4 Nos.	"	0.41	0.61	
5.	5	"	0.37	0.53	
6.	6	"	0.61	0.91	
7.	7	"	0.10	0.25	
8.	8	"	X		Not executed
9.	9	"	0.58	0.87	
10.	10	"	0.14	0.25	
11.	11	"	✓	0.25	
12.	12	"	0.14	0.20	
13.	13	"	0.47	0.72	
14.	14	"	0.58	0.78	
15.	15	"	0.58	0.98	
16.	16	"	0.38	0.55	
17.	17	"	0.38	0.55	[illegible] Y.S
18.	18	"	0.35	0.55	
19.	19	"	0.53	0.85	
20.	20	"	X	0.20	Abandoned
21.	21	"	0.53	0.83	
22.	22		X		Not executed
23.	23	"	0.41	0.67	
24.	24	"	✓	0.50	
25.	25 N.I	"	0.16	0.25	
26.	26 N.2	"	X	0.25	Abandoned
27.	27 N.3	"	0.16	0.28	
28.	28	Gow[illegible]	0.15	0.25	J.E. MCD
29.	29	Humak Sharqi	0.14	0.24	
30.	30	Humak Gharbi	0.14	0.24	
31.	31	Poona Faqiran	0.15	0.27	

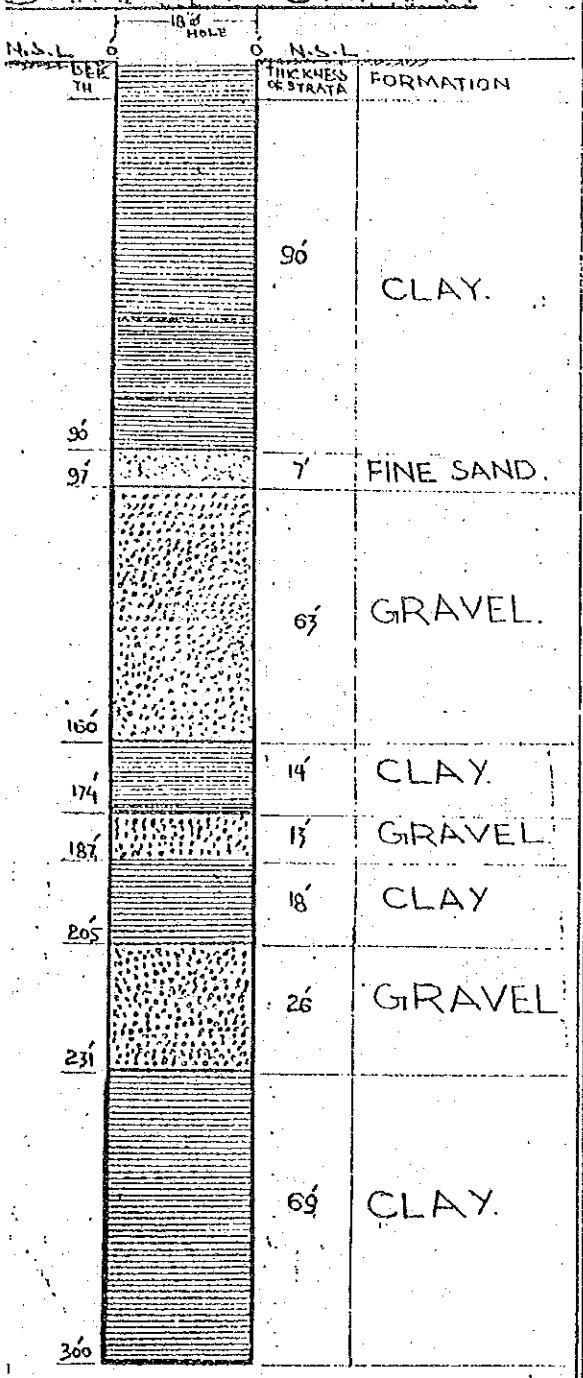
INCHARGE S.D.O. 9/2/86

資料－13

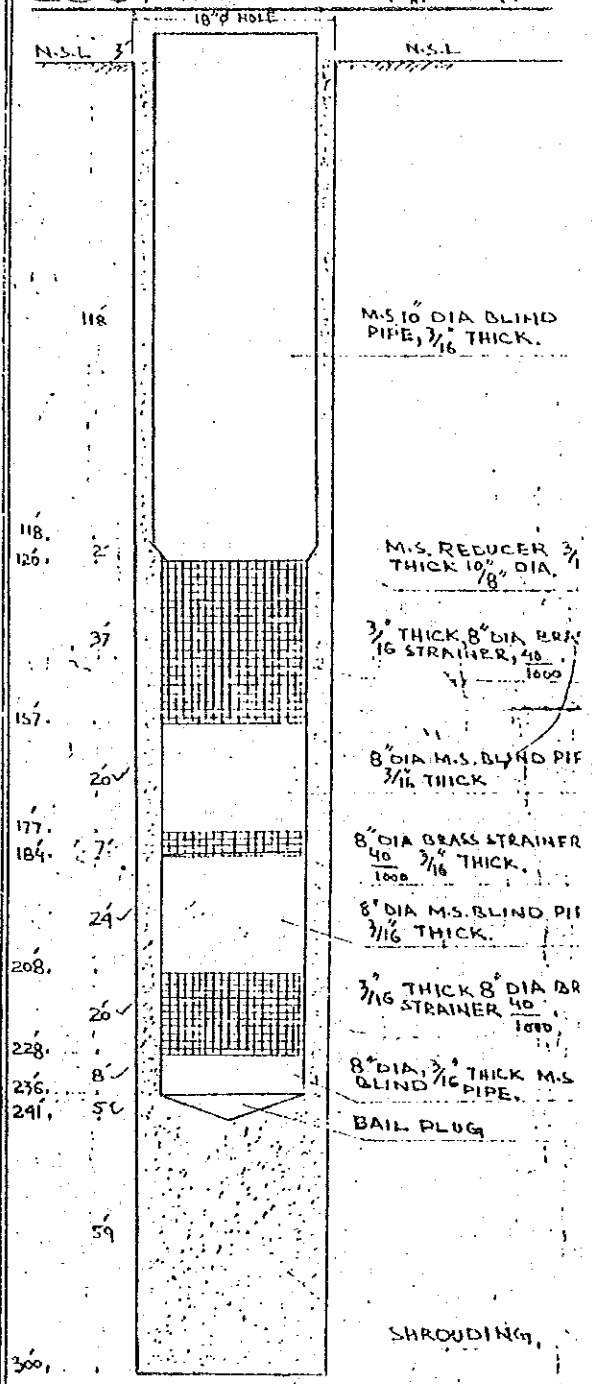
NAME OF WORK: INSTALLATION OF TUBE WELL AT P-7, IN SECTOR I-9/2 ISLAMABAD.

AGENCY : M/S STANDARD TUBE WELL BORING Co.

STRATA CHART



LOCATION CHART



資料－14

WAPDA PROJECTS

IN BRIEF

JANUARY, 1986

PUBLIC RELATIONS DIVISION, WAPDA
WAPDA HOUSE, LAHORE

CONTENTS

	Page
Charter of Duties	1
Annual Development Plans	2
Financial Resources	2
Organisation Chart	3
WATER DEVELOPMENT	
Indus Basin Projects	4
Mangla Dam	5
Tarbela Dam	6
Link Canals	6
Barrages	7
Surface Water Development	9
Rawal Dam	9
Tanda Dam	10
Guddu Barrage	10
Khanpur Dam	11
Hub Dam	12
Projects Under Construction	13
Chashma Right Bank Canal Project	13
Kalabagh Dam Project	14
Ground Water Development	16
Extent of Salinity & Waterlogging	16
Regional SCARP Plans	16
Completed/On-going SCARPS	19
Province-wise Summary of SCARP Programme	22
POWER DEVELOPMENT	
Power Generation	23
Power Transmission	27
Power Distribution	31
Financial Benefits from Tarbela & Mangla	33

WAPDA — FOR PROGRESS AND PROSPERITY

The rationale to set up an institution vested with adequate powers to develop the country's water and power resources on an integrated basis derived from the fact that hitherto the Government Departments charged with this responsibility had failed to do so at a pace commensurate with the urgency to achieve these objectives. These Government Departments/Agencies were burdened with strict rules and procedures that made for inordinate delays in taking decisions and implementing them. There was growing recognition of the organic unity of the natural resources of a river basin and the imperative necessity of developing these resources in an integrated manner for the greater economic and social good of the country as a whole. This made the Government to embark on this new experiment in its anxious search for new instruments with which to accelerate the pace of development.

As a result of this re-thinking, Water and Power Development Authority popularly known as WAPDA was set up by an Ordinance issued in February 1958 which was amended in March 1959 to cover the transfer of the Electricity Department to it.

Since its establishment in 1958-59, WAPDA has successfully discharged these responsibilities in the fields assigned to it.

Charter of Duties

The Charter of duties of WAPDA includes investigations, planning and execution of schemes in the following fields :—

- Generation, transmission and distribution of power.
- Irrigation, water supply and drainage.
- Prevention to waterlogging and reclamation of waterlogged and saline lands.
- Flood control and
- Inland navigation.

Authority

The Water and Power Development Authority is headed by a Chairman, and comprises Member (Finance), Member (Power) and Member (Water). The Members Water and Power also act as Managing Directors of their respective Wings and are thus the executive heads of the Organizations working under them.

Annual Development Plans

WAPDA prepares its Annual Development Programme for the water and power sectors in accordance with the objectives outlined in the Five-Year Plans and the policy directions given by the Federal Government. WAPDA also undertakes execution of projects on behalf of the Provincial Governments in the water sector for which funds are allocated by the respective Provincial Governments.

Financial Resources

For financing its projects, the Authority as a Corporate body, is entitled to draw upon Authority Fund. The Authority Fund comprises loans and grants made by the Federal and Provincial Governments. Foreign aids and loans are also obtained from the International Bank of Reconstruction and Development, Asian Development Bank, Canadian International Development Agency, German Development Bank and other International Donor Agencies on such terms and conditions as may be approved by the Federal Government.

Funds for water projects are provided by the Federal and respective Provincial Governments depending upon the nature of the projects. On completion, the projects are handed over to respective Provincial Government Departments for operation, alongwith their liabilities.

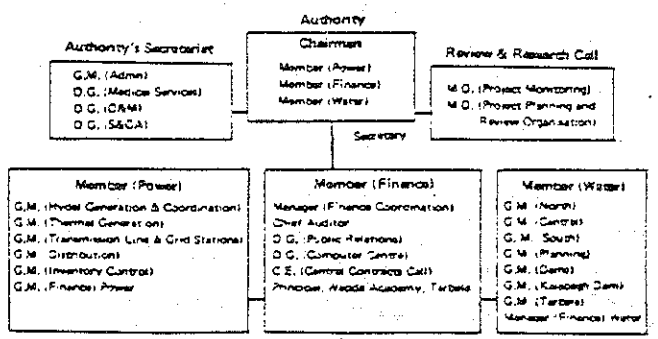
The Power Annual Development Programme is financed by the Federal Government through foreign loans and cash development loans in rupees. The power projects on completion are operated and maintained by WAPDA, while Scarp projects and some small Dams are handed over to the Provincial Irrigation Departments. The debt servicing liability and payment of interest in respect of power schemes is the responsibility of WAPDA.

WAPDA also generates revenue through the sale of electricity and ploughs back surplus on revenue account into development. This is known as 'Self Financing'.

WAPDA has grown into one of the largest organizations in Pakistan today. It employs about one hundred thousand persons in its regular and workcharged cadres for execution of various projects and operation of the countrywide power distribution system. Over the years it has built up a reservoir of technical know-how and expertise which has made it into a modern and progressive organization, which can be judged from the development that has taken place in the fields of water and power resources. In recent years WAPDA also embarked on the path of research and advancement in the technology in order to keep abreast of the latest techniques in service and technology.

A brief description of WAPDA Projects is given in the following pages. However, if more projects details are required, these can be had from the Public Relations Department, WAPDA.

ORGANIZATION CHART



INDUS BASIN SETTLEMENT PLAN

The Indus Basin Project was the outcome of Indus Waters Treaty signed by India and Pakistan in September, 1960. It was meant to transfer the waters of the three western rivers, namely, the Chenab, Jhelum and the Indus to the three eastern rivers, namely, the Sutlej, Beas the Ravi, since transferred to India, under the treaty, through a net-work of link canals and barrages. WAPDA was entrusted with the execution of gigantic Indus Basin Projects in 1960 as Agent to the Government of Pakistan.

The Indus Basin Projects except for some modification/repair work on the Tarbela Dam have since been completed and are in operation. These projects have contributed substantially towards national economy in terms of irrigation supplies to agriculture and availability of increment of power supply to all sectors of the economy.

The Indus Basin Settlement Plan consists of the following projects :

- Mangla Dam on the river Jhelum
- Tarbela Dam on the river Indus
- Eight inter-river Link Canals : Trimmu-Sidhnai, Sidhnai-Mailsi, Mailsi-Bahawal, Rasul-Qadirabad, Qadirabad-Balloki, Balloki-Suleimanki II, Taunsa-Panjnad, Chashma-Jhelum.
- Five Barrages and one gated Syphon :

  Sidhnai, Rasul, Marala, Qadirabad, Chashma Barrages and a Syphon on Mailsi.

- Remodelling of :

  (a) Three existing Links — Balloki-Suleimanki Link, Marala-Ravi Link, Bombanwala-Ravi-Badian-Depalpur Link.

  (b) Two existing Head Works : Balloki and Trimmu.

  (c) Some existing irrigation canal system affected by the new construction. This includes canal system of Depalpur etc.

Project-wise details of each component of Indus Basin Settlement Plan are given hereunder :—

MANGLA DAM

Mangla Dam which is an earth-fill structure, was built across the river Jhelum and completed in 1967. It is a multi-purpose project and is designed to conserve and control the flood waters of river Jhelum. It is primarily meant for the purpose of replacement of water supplies from the three eastern rivers, i.e. the Sutlej, Beas and Ravi which have been given over to India by those of the three western rivers, i.e. the Chenab, Jhelum and Sind. The Project comprises main dam, a subsidiary dam at Jari and a dyke at Sukhian located on left side of the reservoir.

Besides supplying water for irrigation purposes, Mangla Power House generates hydel power through its eight units of 100 MW each, while two more units of 100 MW are now under erection.

Technical Data

Height	380 feet (above river bed)
Length	10,300 feet
Gross storage	5.88 MAF
Live storage	5.34 MAF
Main spillway capacity	11,00,000 cusecs
Emergency spillway capacity	2,30,000 cusecs
Lake area	100 sq. miles.

Cost

- Rs. 3199.73 million.

TARBELA DAM

Tarbela Dam was built across the river Indus at a distance of about 50 miles north-east of Islamabad. It is world's largest earth-fill dam designed to store water during the monsoons when the mighty 'Indus' swells and the flood waters either cause disaster in surrounding areas or go waste into the sea. Indus is the only river in Pakistan with a sizeable surplus flows whose regulation can optimize development of Pakistan's water resources. Tarbela Dam can impound about 15 per cent of the annual flows of Indus.

Technical Data

Height	485 feet
Length	9,000 feet
Gross storage	11.1 MAF
Live storage	9.3 MAF
Main spillway capacity	6,50,000 cusecs
Auxiliary spillway capacity	8,40,000 cusecs
Lake area	100 sq. miles.

Tarbela Dam started supplying water for irrigation purposes in 1975 through its reservoir and hydel power in 1977 through its first four units. Now it has ten units of 175 MW capacity each in operation. The ultimate hydel power potential of this Tarbela Dam has been assessed at about 4,000 MW, making it one of the biggest hydel stations in the world.

Cost

The total cost of the project (excluding the Power Station) is around Rs. 5195.41 million with a foreign exchange component of Rs. 2473.71 million. The expenditure on ten units power station comes to Rs. 5195.41 million including a foreign exchange component of Rs. 2473.71 million.

LINK CANALS

Eight link canals, described below, were built under WAPDA'S supervision, as agents to the Government of Pakistan for the execution of Indus Basin Projects to transfer waters from the three western rivers to the three eastern rivers. Construction of these canals was progressively completed between 1965 and 1970 and they collectively are more than 400 miles in length. A total of 102,900 cusecs of water is carried through these link canals when in full operation.

With the exception of Chashma-Jhelum Link Canal and Taunsa-Panjnad Link Canal, all other link canals have been transferred to the Provincial Irrigation Department for maintenance and operation purposes :

Technical Data

(Link Canals)	Capacity (cusecs)	Length (miles)	Excavation (million yards)
Trimmu-Sidhnai	11,000	44	21.0
Sidhnai-Mailsi	10,100	62	31.3
Mailsi-Bahawal	3,900	10	2.4
Rasul-Qadirabad	19,000	30	38.3
Qadirabad-Balloki	18,600	80	80.3
LCC Feeder (Component of QB Link)	4,100	20	8.0
Balloki-Suleimanki-II	6,500	39	20.5
Chashma-Jhelum	21,700	63	118.9
Taunsa-Panjnad	12,000	38	22.5

Cost

These link canals have been constructed at a cost of Rs. 1382.547 million.

BARRAGES

Five barrages and one-gated syphon were also constructed under the Indus Basin Treaty to provide river control and to divert waters where necessary. These barrages can divert a total of 100,000 cusecs of water into the link canals. These barrages were completed progressively between 1964 and 1971.

With the exception of Chashma Barrage which has a storage capacity of 0.81 million acre feet for use during winter for irriga-

tion purposes, all the barrages were transferred to the Provincial Irrigation Departments for operation and maintenance purposes :

Technical Data

Name of Barrage/Syphon	Location on River	Designed Discharge Capacity (cusecs)	Structure Length (feet)
Sidhnai Barrage	Ravi	1,50,000	712
Qadirabad Barrage	Chenab	900,000	3373
Rasul Barrage	Jhelum	850,000	3209
Chashma Barrage	Indus	950,000	3556
Marala Barrage	Chenab	1,100,000	4475
Mailsi Syphon	Sutlej	429,000	1601

Cost

The total cost of the barrages has been estimated at Rs. 1514 million.

SURFACE WATER DEVELOPMENT

Wapda has completed a number of surface water projects which include the following:

RAWAL DAM

Rawal Dam which is a gravity dam was built across the Korang river in 1962. It passes through the heart of the Federal capital, Islamabad and is supplying 14 million gallons of drinking water daily to Rawalpindi and Islamabad. It has live storage capacity of 43,000 acre feet and irrigates 12,000 crop acres of land lying in the vicinity of Rawalpindi.

The three square miles Rawal lake has been converted into a beautiful holiday resort. The project has since been transferred to Irrigation Department of the Punjab Government for operation and maintenance purposes.

Technical Data

Height	113.50
Length of Crest	700 feet
Area of Lake	3 square miles
Gross storage capacity	47,500 acres feet
Spillway gates	8 Nos. electrically manually operated gates of 30 x 10-2½

Cost

Rs. 21.2 million

TANDA DAM

Tanda Dam is an earthen type which was completed by WAPDA in 1965. Located six miles from Kohat city, it provides irrigation to about 3200 acres in Kohat Valley. The reservoir's annual useable capacity of 64,000 acre feet is fed by the flood waters from a small barrage on Kohat Toi and is conveyed to the reservoir through a tunnel and a lined canal.

The project after completion was handed over to Provincial Irrigation Department for operation and maintenance purposes :

Technical Data

Height	115 feet
Length	2340 feet
Gross reservoir capacity	78,400
Live storage capacity	14,400 acre feet
Spillway	Open-cut (no gate)
Capacity of discharge	2000 cusecs
Length of 6 feet tunnel	350 feet
Total canals mileage	56 miles

Cost

The project was completed at a cost of Rs. 66.8 million.

GUDDU BARRAGE

Guddu Barrage, the second largest in Pakistan, spanning the mighty Indus river, was inaugurated on 1st March, 1963. It is about 10 miles from Kashmore (Sind) and is meant to irrigate an area of about 2.9 million acres of land including a forest area of about 2,23,000 acres in Jacobabad, Larkana, and Sukkur districts of Sind Province and Nasirabad district of Baluchistan. As a result of its operation, there has been a rise in the national income by over Rs. 300 million through increased agricultural production.

Guddu Barrage has since been handed over by WAPDA to the Provincial Irrigation Department for operation and maintenance purposes.

Technical Data

Type	Gate-controlled weir with a navigation lock.
Number of spans	64 including one navigation lock
Width of each span	60 feet
Maximum discharge at which designed.	1.2 million cusecs

Right Bank

(i) Begari Sind Feeder
(ii) Pat Feeder

Left Bank

Ghotki Feeder

Regulators	589
Road bridge over cross regulators	836
Miscellaneous	33

Cost

The project was completed at a cost of Rs. 474.8 million.

KHANPUR DAM PROJECT

Khanpur Dam which is an earthen dam has been constructed in Hazara district across the river Haro near village Khanpur. Originally this project was conceived as a purely irrigation scheme to irrigate land situated in Abbottabad, Attock and Rawalpindi districts. Subsequently, the scope of the project was enlarged when large demands for water supply were received from Capital Development Authority, Islamabad, Ordnance Factory, Wah Cantt. and Heavy Engineering Complex, Taxila.

Under the revised scheme, it was proposed to irrigate 36470 acres in Abbottabad, Rawalpindi and Attock districts in order to

raise their cropping intensity to 130 percent and to supply 131 million gallons of water daily to Islamabad, Rawalpindi, Pakistan Ordnance Factory, Wah and industries around Taxila.

Technical Data

Height	167 feet
Length	1547 feet
Live storage	91,000 acre feet
Gross storage	1,06,000 acre feet
Spillway capacity	1,66,000 cusecs
Spillway crest length	232 feet
Spillway gates	5 radial gates 40' x 35'

The project has been completed and the Khanpur Dam commenced supply of water for agricultural and drinking purposes from August 1983 onwards.

Cost

The project has been financed by its beneficiaries which are Provincial Governments of Punjab, NWFP and the Government of Pakistan. Its estimated cost is Rs. 1203 million with a foreign exchange component of Rs. 83.5 million.

HUB DAM PROJECT

(Karachi Irrigation Project)

Hub Dam is an earthen type dam built on Hub river about 35 miles north-east of Karachi. Originally, this project was conceived as a purely irrigation scheme to irrigate lands falling in the districts of Karachi and Lasbela. However, in view of the growing demand for water for domestic and industrial uses in the city of Karachi and district of Lasbela, the scope of the scheme was enlarged.

Under the revised scheme, this project irrigates 1000 acres in Karachi district and 21,000 acres in Lasbela district in addition to supplying 89 million gallons of water for domestic purposes to the Karachi Development Authority and 15 million gallons daily for the industries in Lasbela district of Baluchistan. It is now in operation both for agricultural and water supply purposes.

Technical Data

Height	151 feet
Length	21,360 feet
Gross storage	9,24,000 acre feet
Reservoir capacity	8,57,000 acre feet
Culturable commanded area	22,000 acres
Gross commanded area	34,382 acres
Spillway capacity	458,000 cusecs
Water supply	104 million gallons daily

Cost

The revised project cost is Rs. 1090.57 million with a foreign exchange component of Rs. 32.57 million.

PROJECTS UNDER CONSTRUCTION

CHASHMA RIGHT BANK CANAL PROJECT

The scheme envisages construction of a canal off-taking from Chashma Barrage on river Indus. It is an inter-provincial project and on completion will provide irrigation facilities to 3,50,000 acres in D. I. Khan district of N.W.F.P. and to 2,20,000 acres in D. G. Khan district of Punjab. The project is to be constructed in three stages as follows on the basis of revised schedule.

Stages	Canal Reach & Connected Works	Completion Period
Stage-I	RD 0 + 000 to RD 260 = 52 miles	6 years—1980-86
Stage-II	RD 260 to RD 380 = 24 miles	2 years—1986-88
Stage-III	RD 380 to Tail = 93 miles	3 years—1988-91

Technical Data

Type	Gravity
Flood capacity	4879 cusecs
Length of main canal	172 miles (partially brick-lined)
Length of Distributaries	375 miles (unlined)
Length of Service Road	492 miles
Canal syphon	9
Cross-drainage structures	93
Bridges (main canal)	85
Earthwork involved	60 million cubic yards
Remodelling of the existing Paharpur canal	70 miles

Earthwork and lining on main canal as well as distributaries for stage-I i.e. from RD 0+000 to RD 260+000 are almost complete while the auxiliary works such as structures comprising of bridges, head regulators, cross-drainage structures and syphons for the said stage in different sections are nearly 60% accomplished. The remaining work's construction is in progress and scheduled to be completed in all respect by December 1986.

Cost

The estimated cost of the project is Rs. 3479 million. The Asian Development Bank has agreed to provide foreign financing for the project to the extent of Rs. 503.373 million.

KALABAGH DAM PROJECT

Kalabagh Dam Project is a multipurpose project to be built across the river Indus. Basically, it is a power project which aims at accelerating the tempo of economic development in Pakistan. Its important functions will include the following:—

(a) To generate 3600 MWS of cheap hydro-electric power.

(b) To augment the live storage capacities of Mangla and Tarbela reservoirs, which are being gradually depleted due to sedimentation.

(c) To provide additional storage on the Indus for better system control and management for the assured, adequate and timely irrigation releases for crops.

(d) To regulate and control the flood peaks of the Indus.

(e) To increase substantially Pakistan's capacity to manage its water distribution and power generation system through conjunctive use of the Tarbela and Kalabagh reservoirs.

Project Features

According to the Project Summary Report (November 1984) the principal features of different component structures of the project are as follows:—

MAJOR PROJECT STATISTICS

RESERVOIR

Retention level	925 ft (281.9m) SPD
Minimum reservoir level	825 ft (251.5m) SPD
Volume at retention level	9,375,000 AF (11,600 million cu m)
Area at retention level	1,39,000 acres (56,000 hectares)

EMBANKMENT DAMS

Crest elevation	945 ft (288.0m) SPD
Crest width	50 ft (15.2m)
Total volume	36 million cu. yd. (27.5 million cu m)

OVERFLOW SPILLWAY

Spill level	860 ft (262.1m) SPD
Number and size of radial gates	10-50 ft (15.2m) Wx65 ft (19.8m) H

ORIFICE SPILLWAY

Spill level	785 ft (239.3m)
Number and size of radial gates	9-36 ft (11m) Wx40 ft (12.2m) H

POWER STATION

Type	Indoor
Number of units	8 (initial) 12 (ultimate)
Installed capacity	2400 MW (initial) 3600 MW (ultimate)
Generators nominal/maximum rating	300/345 MW

WORK SCHEDULE

According to the approved PC-II proforma, the detailed investigation have been in progress and as per three-stage work plan, the progressive completion of the project will be as shown hereunder:—

Stage-I Detailed investigations, Project Planning Studies and Project Planning Report (completed in March 1984).

Stage-II Detailed design reports and tender drawings of project civil works, cost estimates and tender documents for civil works (completed in September 1985).

Stage-III Detailed specifications and tender documents for electro mechanical equipment, economic studies and technical report evaluation of bids for civil works (completion schedule June 1987).

Stage-IV Awards of civil works contract(s) construction of project works in commissioning of the power station. (July 1987/September 1993).

GROUNDWATER DEVELOPMENT

Waterlogging and Salinity has posed a very serious problem for our agriculture. The responsibility for tackling this problem was taken over by WAPDA in 1958 in terms of its charter.

Depth of the Malady

According to investigations carried out in June 1982, about 8.1 million acres or about 33% of the gross area of 24.6 million acres under the irrigation system in the province of Punjab, was affected by the waterlogging and rising of water-table within 10 feet of the ground surface. In addition, an area of about 1.8 million acres or about 7% was affected by soil salinity in Punjab. Similarly in the province of Sind, out of a gross area of 13.8 million acres under the irrigation system, about 3.9 million acres or 28% of the gross area was affected by soil salinity. It is estimated that an area of about 16.9 million acres in Punjab was underlain by fresh groundwater which can be used directly for irrigation purposes and that another 3.3 million acres have a groundwater that can be used for irrigation after mixing it with surface water. The potential of groundwater is comparatively less extensive in the Province of Sind and an area of 2.3 million acres is estimated to be underlain by fresh groundwater.

Regional Plans

WAPDA formulated two regional plans, one for the Upper Indus Plain covering the province of Punjab and Bahawalpur and the

other for the Lower Indus Plain covering the province of Sind, on the basis of the results of the investigations completed earlier.

These plans, apart from suggesting measures for the control of waterlogging and salinity, deal with the optimum development of fresh groundwater resources for intensified and sustained irrigated agriculture within the existing irrigation system. According to the Regional Plan for the Upper Indus Plains, where the sub-surface conditions are generally favourable tubewells will be constructed for irrigation and drainage. Similarly in the Lower Indus Plains where there is a suitable acquifer and the groundwater is of suitable quality, tubewells will be constructed to provide drainage and additional irrigation supplies. Where there is a suitable acquifer but the groundwater is too saline to be used for irrigation, tubewells still provide the most economical means of drainage to eliminate waterlogging. To dispose of the tubewell effluent, a system of surface drains will also be required in the saline groundwater area. Where there is no suitable acquifer for tubewells, tile drains will be provided. In the non-perennial, pre-dominantly rice growing areas where high water-table conditions do not interfere with cultivations, priority has been given to the areas with fresh groundwater, since increased irrigation supplies from tubewells can bring about an early increase in agricultural production.

PERSPECTIVE PLANNING

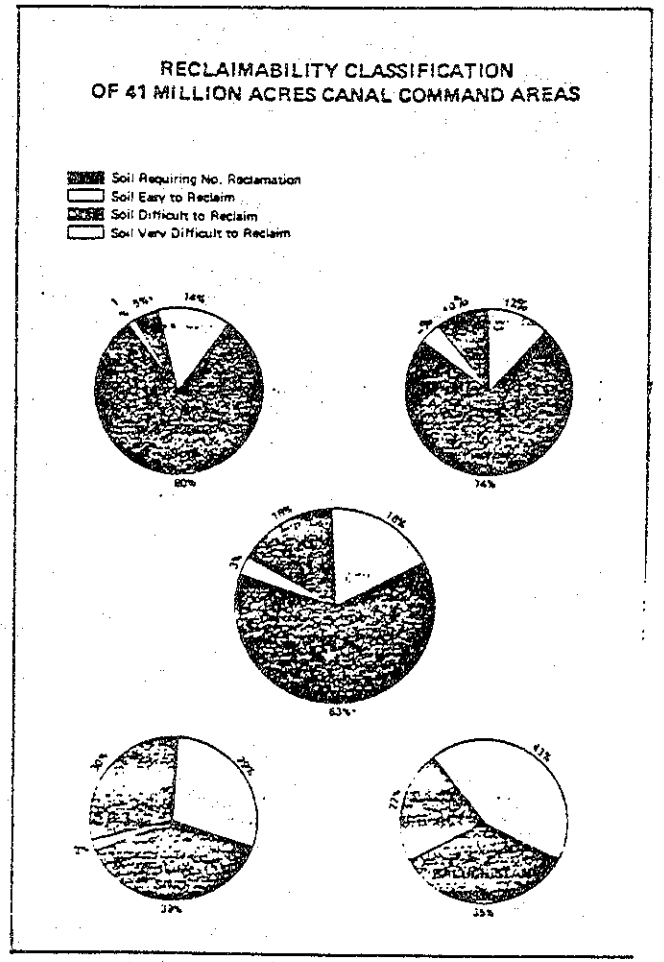
Wapda's Master Planning Cell prepared a Revised Action Programme in 1974 for the development of the irrigated agriculture upto 1990 and thereafter a Perspective Plan upto 2000. This organisation was afterward converted to Perspective Planning.

The Perspective Planning is a key to the effective development and management of water resources of the country which plays an important role in the economic growth of the country. Planning is a continuous process required for constant revision of long-term plans in the light of which regional plans are finalised for short-term gains.

The following reports have so far been published:

1. First Interim Report 1976

2. Second Interim Report 1977
3. Sketch Plan 1977
4. Revised Action Programme Main Report (3 Volumes and Supporting Reports 18 Nos. on different disciplines). 1979



PUNJAB

ompleted Scarps

Names	Area CCA (M.A.)	Location (districts)	No. of tubewells (Completed as on 30-6-1985)
1	2	3	4
Scarp-I (Central Rechna Doab)	1.141	Sheikhupura, Gujranwala Faisalabad and Jhang	1796 tubewells (+) 272 tubewells installed by Irrigation Department. Total = 2069 tubewells.
Scarp-II (Chaj Doab)	1.96	Gujrat, Sargodha and Jhang	2205 tubewells in fresh groundwater area and 821 in saline groundwater area. 652 KM of surface drains completed in July 1985.
Scarp-III (Lower Thal Doab)	1.050	Muzaffargarh and Jhang	1635 tubewells in FGW area and 61 in saline groundwater area. 225 KM of surface drains completed.
Scarp-IV (Upper Rechna Doab)	0.56	Sheikhupura, Gujranwala and Sialkot	935 tubewells.
Scarp Fordwah Sadiquia - Pilot	0.073	Bahawalpur and Bahawalnagar	226 tubewells (203 FWG + 23 SGW).
Scarp Shorkot Kamalia - Pilot	0.154	Faisalabad and Jhang	101 tubewells.
Scarp Panjnad Abbasia Unit-1 Allahbad	0.202	Bahawalpur and Rahimyar Khan	623 tubewells.
Scarp Shahpur	0.090	Sargodha	258 tubewells.
Scarp Satiana Pilot	0.098	Faisalabad	20 tubewells FGW 51 tubewells SGW. Total = 71 tubewells.
Anti-waterlogging measures along TP link	0.020	Muzaffargarh	80 tubewells (16 FGW + 64 SGW tubewells).
Anti-waterlogging measures along RQB link	0.054	Gujrat, Gujranwala, Sheikhupura	85 (SGW tubewells).
Anti-waterlogging measures along CJ link	0.020	Sargodha and Mianwali	35 km. of surface drains completed. Project completed in June 1985.
Replacement of tubewells - Phase I	—	Scarp I, II, III & IV	800 tubewells completed.
Anti-waterlogging measures along TSMB link	0.090	—	56 tubewells drilled, 20 tubewells energised and 36 M. Cft. Earthwork completed.
Fordwah-Sadiquia Unit-II	0.100	Bahawalpur, Bahawalnagar	55 M. Cft. Earthwork completed.
Lower Rechna (Khairwala)	0.100	Faisalabad	154 M. Cft. Earthwork completed.
C.B.D.C. (Pandoki)	0.174	Lahore—Kasur	40 SWG tubewells alongwith 75 M. Cft. Earthwork completed.
Punjnad-Abbassia Unit II-V	1.267	Rahimyar Khan	331 M. Cft. Earthwork from canals, 253 M. Cft. from drains and 12 test wells completed.
Replacement of deteriorated tubewells (Phase-II)	0.650	650 tubewells in areas of 1 & IV to be replaced	605 tubewells completed + 7 (Rehabilitated)
Scarp Lower Rechna remaining	0.295	Faisalabad	13 M. Cft. Earthwork completed.

Completed Scarps

Names	Area CCA (M.A.)	Location (districts)	No. of tubewells (Completed)
1	2	3	4
1. Scarp Khairpur	0.380	Khairpur	175 fresh groundwater tubewells, 365 saline groundwater-tubewells, 550 KM of disposal channels and 5 outfall pumping stations completed
2. Scarp-North Rohri	0.686	Khairpur and Nawab Shah	1192 fresh groundwater tubewells completed
3. Larkana-Shikarpur Stage-I, II	0.594	Sukkur, Khairpur and Larkana	762 KM of main, branch and subsurface drains, 5 outfall pumping stations completed
4. Sukkur Right Bank Fresh Groundwater Project	0.130	Sukkur and Larkana	400 fresh groundwater tubewells completed
5. Shikarpur-Pilot	0.014	Shikarpur	50 tubewells completed
6. Sukkur-Pilot	0.004	Sukkur	18 tubewells completed
7. Larkana-Pilot	0.005	Larkana	35 tubewells completed
8. Kand Kot-Pilot	0.012	Jacobabad	26 tubewells completed

On going Scarps

1. Scarp-Sourth Rohri	0.426	Hyderabad, Sanghar and Nawab Shah	180 tubewells out of a total of 1350 tubewells completed. Contract for 250 tubewells awarded to M/S NTCC. So far 146 tubewells drilled at site.
2. Ghotki Fresh Groundwater Project	0.045	Command of Ghotki Feeder canal on Left Bank of river Indus under Guddu Barrage	410 tubewells have been completed.
3. North Dadu Surface Drainage	0.514	Larkana and Dadu	185 KM drain out of 834 KM. 461 allied structures and 4 pumping stations completed.
4. East Khairpur Tile Drainage	0.045	Sukkur and Khairpur	613 KM of Tile drains completed.
5. Left Bank Outfall Drain (LBOD)	1.192	Sanghar, Tharparkar and Badin	420 KM of drains involving 116 M. Cft. of Earthwork out of 1434 allied structures completed.

Names	Area CCa (M.A)	Location (districts)	No. of tubewells (completed)
1	2	3	4
6. Kotri Surface Drainage	3.3	Major part of Thatta and Badin	183 M. Cft. Earthwork out of 404 M. Cft. and 651 allied structures completed.
7. Replacement of tubewells, North Rohri and Khairpur Project	—	Khairpur and Nawab Shah	203 tubewells out of 250 tubewells completed.

III—NORTH WEST FRONTIER PROVINCE

Completed Scarps

1. Peshawar City Anti-waterlogging Project	0.002	Peshawar City Cantonment and northern part of Peshawar valley	97 tubewells and 50 dug wells completed
2. Kafur Dheri Project	0.026	North West of Peshawar	48 tubewells + 3 dug wells completed
3. Pabbi Unit-I & II	0.028	In and around Peshawar City	All 84 tubewells and 85.5 KM of surface drains completed
4. Jue Shaikh Unit	0.052		All 22 tubewells and one dug well completed
5. Naranji (Pilot)	0.025		3 tubewells & 10 dug wells completed
6. Mardan Scarp (Phase-I)	0.180	Mardan	65 tubewells, 35 dug wells, 7.5 KM surface drains alongwith 17 KM of tile drains completed
7. Bannu Scarp	0.080	Bannu	176 tubewells & 27 KM of Surface drains completed

IV—BALUCHISTAN

Hair Dain Drainage Project	0.074	—	195 KM of surface drains completed

POWER GENERATION

At the time of Independence in 1947, the country's power generating capacity stood at a meagre 31.3 MW. When WAPDA took over the Electricity Department in 1959, the power generating capacity was only 119 MW which by June 1985 had risen to 4349 MW.

Data regarding Wapda's power generating system comprising 12 hydel and 11 thermal power station is given below:

Hydel Stations	Year of Commissioning	Installed Capacity (MW)
Mangla	1967-81 (8x100 MW)	800
Tarbela	1977-85 (10x175 MW)	1750
Warsak	1960-81 (6x40 MW)	240
Dargai	1954 (4x5 MW)	20
Malakand	1938-51 (3x3.3 MW 2x5 MW)	20
Rasul	1951 (2x11 MW)	22
Chichoki Mallian	1959 (3x4.4 MW)	13
Shadiwal	1961 (2x6.75 MW)	13
Nandipur	1963 (3x4.6 MW)	14
Kurrum Garhi	1958 (4x1 MW)	4
Renala	1925 (5x0.22 MW)	1
Chitral	–	1
		2898

23

PROVINCE-WISE SUMMARY OF SCARPS PROGRAMME UPTO 30.06.1985

Province	Scope of work					Progress upto 30.06.1985			
	Area C.C.A. (M.A)	FGW tubewells (Nos.)	SGW tubewells (Nos.)	S Drains (K.M.)	Tile Drains (K.M.)	FGW tubewells (Nos.)	SGW tubewells (Nos.)	S Drains (K.M.)	Tile Drains (K.M.)
1	2	3	4	5	6	7	8	9	10
Punjab	7.594	8214	1048	2560	–	8065 (1209)	1135	1271	–
Sind	7.307	1412 (250)	365	8277	1125	590	365	605	613
N.W.F.P.	0.393	507	–	675.5	3478	507	–	226	17
Baluchistan	0.074	–	–	195	–	–	–	195	–
TOTAL (Pakistan)	15.368	13017 (1700)*	1413	11707.5	4603	9125 (1340)	1500	2297	630

* Replaced tubewells have not been added in totals.

22

Thermal Stations	Year of Commissioning	Installed Capacity (MW)
Multan	1960-63 (4x65 MW)	260
Faisalabad Steam Power Station	1967 (2x66 MW)	132
Faisalabad Gas Turbine Station	1975 (8x25 MW)	200
Shahdara	1966-69 (2x13.25 MW, 4x14.75 MW)	85
Guddu	1974-80 (2x110 MW, 1x210 MW, 1x9 MW)	439
Hyderabad	1960-65 (2.7.5 MW, 1x5.7 MW, 1x8 MW, 1x15 MW)	43
Sukkur	1965-67 (4x12.5 MW)	50
Kotri	1970-81 (2x15 MW, 4x25 MW)	130
Quetta	1964-84 (2x7.5 Steam, 1x5.7 MW, 1x7.5 MW 1x12.25 MW, 1x25 MW, 1x35 MW Gas Turbine)	83
Repco	1981 (1x1.5 MW, 1x2.28 MW, 1x3.5 MW steam)	9
Mesco	1981 (2x10 MW)	20
		1451
	Grand Total	4349

Energy Generation

Energy generation by WAPDA's power system has maintained a continuous upward trend rising from 781 MKWHs in 1959-60 to over 18 billion KWHs in 1984-85.

Completion Status of On-going Power Stations

1.	Guddu Unit-4 (1X210 MW)	210 MW	1986
2.	450 MW Combined Cycle Power Plant Guddu (4X75 MW Gas Turbine (2X75 MW Steam Turbine)		1986-87
3.	400 MW Gas Turbine Power Station Kot Addu (4X100 MW)	400 MW	1986-87
4.	250 MW Oil-Fired Steam Unit at Jamshoro (1X260 MW)	260 MW	1988-89
5.	Lakhra Coal-Fired Thermal Power Station (1X300)	300 MW	1990
6.	Tarbela Unit 11 & 14 (94X406 MW) (4X406 MW)	(4X406 MW) (1624 MW)	1989-90
7.	Multan Power Station (3X210 MW)	630 MW	1990-91

POWER TRANSMISSION

At the time of WAPDA's take over of power management in 1959, the length of transmission and distribution lines in the country was about 7,000 kilometres, while the number of grid stations was 59 with a total of 2810 MVA capacity. By June 1985 the total length of the transmission and distribution lines of various capacities had crossed the figure of 1,74,000 kilometres and the number of grid stations had gone upto 459 with transformation capacity of 11469 MVA as illustrated below:

TRANSMISSION AND DISTRIBUTION LINES UNDER WAPDA'S SYSTEM BY END OF JUNE 1985

Province	500 KV	220 KV	132 KV	66 KV	33 & 11 KV	LT	Total
Punjab	849	954	5,086	4,819	64,121	34,907	1,10,736
Sind	440	120	2,163	1,358	19,490	7,461	30,932
NWFP	–	77	1,061	896	12,162	10,337	24,553
Baluchistan	–	152	994	252	4,418	1,998	7,814
	1,289	1,303	9,304	7,325	100,191	54,703	1,74,015

27

The annual energy generation in WAPDA's power system since its inception is given below:–

YEAR	HYDEL		THERMAL		TOTAL
	Generation (MKWHs)	% of Total	Generation (MKWHs)	% of Total	(MKWHs)
1	2	3	4	5	6
1959-60	507	65	274	35	781
1960-61	645	65	342	35	987
1964-65	1,362	55	1,101	45	2,463
1969-70	2,915	57	2,159	43	5,074
1970-71	3,449	60	2,291	40	5,740
1974-75	4,359	54	3,682	46	8,041
1975-76	5,436	66	2,840	34	8,276
1976-77	5,183	59	3,553	41	8,736
1977-78	7,466	74	2,608	26	10,074
1978-79	8,359	79	2,250	21	10,609
1979-80	8,717	72	3,390	28	12,106
1980-81	9,046	68	4,160	32	13,206
1981-82	9,525	65	5,243	35	14,768
1982-83	11 366	69	5,120	31	16,486
1983-84	12,822	71	5,193	29	18,015
1984-85	12,243	68	5,850	32	18,093

28

SECONDARY AND PRIMARY GRID STATIONS

As on June 30,1985

Secondary	Grid Stations	MVA Capacity
132 KV	239	5702
66 KV	202	2,488
33 KV	8	21
Primary		
220 KV	9	2358
500 KV	1	900
Total	459	11,469

The commissioning of big hydel power stations such as Mangla and Tarbela, posed a problem of transmitting big chunks of power from the north to the central areas of Punjab and Sind Provinces which are the main power consuming areas. The 132 KV and 66 KV transmission lines could not carry such big blocks of power over long distances without high transmission losses and the resultant poor voltage. WAPDA accordingly undertook to transmit power on high voltages i.e. on 220 KV and 500 KV (one of highest voltage in Asia). This has enabled WAPDA to take power from these two big hydel stations in northern regions to southern regions during summer and from Guddu and Multan Thermal Power Stations to the central areas of Punjab and NWFP during low water periods. It has also helped reducing the transmission losses.

PROJECTS UNDER CONSTRUCTION

Some of big transmission projects so far undertaken and completed by WAPDA or under execution are briefly described below :—

1 Northern Zone Transmission Line Project

Planned to transmit power on 220 Kv from Mangla Power House and feed it into the major load centres, construction of 220 KV transmission line from Mangla to Kala Shah Kaku (166.4 KM) and from Kala Shah Kaku to Faisalabad (144.4 KM) was completed in June 1971.

2. Two 220 KV D/C Tarbela-Wah (Burhan) Transmission Lines Project

Planned to transmit power from the first four units of Tarbela Hydel Power Station and to feed it into the grid system to cater for the load requirements of NWFP, Lahore and Faisalabad Load Centres. The project which involved construction of 67.2 KM long transmission lines, was completed in October, 1976.

3. 220 KV/132 KV Guddu-Sibi-Quetta Transmission Line

This transmission line extends the National Grid to the province of Baluchistan through 220 KV line from Guddu to Sibi (272 KM) and a D/C 132 KV line from Sibi to Quetta (163 KM). The inter-link was commissioned on 132 KV in February 1977 and on 220 KV from Guddu to Sibi in February 1982.

4. 220 KV D/C Tarbela-Mardan Transmission Line Project

Aimed to transmit power from Tarbela Hydel Power Station to NWFP. Work involved construction of 68 kilometres of 220/132 KV line and a sub-station at Mardan. The project was completed in January 1983.

5. 500 KV Tarbela—Faisalabad Transmission Line

First stage of the scheme which comprises erection of a 500 KV inter-link from Tarbela to Hyderabad with intermediate grids at Faisalabad, Multan, Guddu and Jamshoro (Hyderabad). The section of 500 Kv line from Tarbela to Faisalabad comprising 329.6 KM transmission line completed and commissioned with a 500/220 KV grid station at Gatti in September, 1979.

6. 500 KV Faisalabad—Guddu Transmission Line

This is the second stage of EHV 500 KV transmission Project. Designed to transmit 1000 MW of power of Tarbela to the Southern regions with 500/220/132 KV sub-stations at Multan and Guddu. This section involved construction of 519 KM long transmission line between Faisalabad and Guddu via Multan. It was

commissioned on 220 KV in March, 1981.

7. 500 KV Guddu—Jamshoro Transmission Line

Third and last stage of the EHV 500 KV transmission system involved construction of 440 KM of transmission line between Guddu and Jamshoro and two grid stations at Dadu and Jamshoro. The 284 KM long Guddu-Dadu Section alongwith 220 KV sub-station at Dadu was put into operation in August 1983. The Dadu-Jamshoro Section of the transmission line and 220 KV Jamshoro sub-station were commissioned in February 1984.

8. 220 KV Jamshoro-Karachi Interconnector Project

The 130 kilometres long 220 KV double circuit line which is part of the 500 KV Tarbela-Jamshoro Karachi transmission line. It has connected the Karachi Electric Supply Corporation with WAPDA system in 1984.

9. 500 KV Upgrading Project

With an increase in generation capacity at Tarbela Hydel Power Station, Wapda has planned to transmit more hydel power from northern to southern parts of the country by upgrading the existing 220 KV Multan, Guddu, Dadu and Jamshoro grid stations. The project also includes extension of 500 KV Gatti (Faisalabad) sub-station.

10. 500 KV Tarbela-Faisalabad Second Circuit Project

Planned to further facilitate flow of electricity from the power stations to the main consuming centres, the second circuit of 500 KV extra high voltage transmission line between Tarbela and Gatti (Faisalabad) was completed in August 1985, i.e. seven months ahead of schedule.

11. 220 KV Double Circuit Faisalabad-Sahiwal Transmission Line Project

The work involves construction of 94 kilometres long 220 KV double circuit transmission line from 500 KV/220 KV Gatti grid station to Sahiwal and a 320 MVA, 220/132 KV grid station, Sahiwal. The project is likely to be completed by July 1986 (Revised Schedule).

POWER DISTRIBUTION

The Power Distribution (Electricity Operations Wing) of WAPDA is responsible for taking power from the Secondary Grid Stations to ultimate consumers in whole of Pakistan except Karachi. It provides new connections to various categories of consumers, take steps to stabilize the distribution network and is also responsible for renovation of the system particularly in big cities at frequent intervals. More than 70% of WAPDA employees are working for the Electricity Operation Wing.

In 1958-59, there were 3,00,000 consumers on WAPDA's Power System which have now increased to 4.6 million. The year-wise increase in the number of consumers is given below province-wise, which underlines the increasing quantum of work of this Wing.

NO. OF CONSUMERS ON WAPDA'S SYSTEM

Year	Punjab	NWFP	Sind	Balu-chistan	Total Pro-gressive
1959-60	1,75,000	1,16,552	19,244	—	3,11,596
1970-71	8,62,053	2,41,101	1,60,684	20,384	12,84,224
1977-78	15,49,207	4,03,432	2,88,593	39,209	22,80,441
1978-79	17,19,910	4,37,713	3,23,081	47,511	25,28,215
1979-80	18,87,172	4,86,622	3,64,240	56,757	27,94,791
1980-81	22,70,826	5,38,372	3,90,769	69,978	32,69,945
1981-82	25,03,185	5,91,291	4,11,991	81,775	35,88,242
1982-83	27,32,685	6,46,673	4,32,406	89,672	39,01,436
1983-84	29,75,651	7,04,038	4,57,494	94,367	42,31,550
1984-85	31,84,071	7,66,768	4,73,071	100,085	45,23,995

By the end of June 1985 of the total of 45,23,995 consumers 35,00,086 were domestic, 7,70,465 commercial, 1,28,441 industrial and 1,20,905 agricultural consumers i.e. mostly for running tube-wells.

VILLAGE ELECTRIFICATION

Before WAPDA took over there were 609 electrified villages in Pakistan of which 100 were in Punjab and 509 in NWFP. Due to Wapda efforts the number of villages electrified has now increased to over 20,000 (more than 12,000 of these received electricity during the past eight years). The province-wise details of villages electrified are given below:

Year	Punjab	NWFP	Sind	Balu-chistan	Total	Total progressive
1959-60	177	116	2	–	195	904
1970-71	20	60	17	1	98	2,487
1977-78	850	342	371	43	1,606	7,609
1978-79	586	348	259	53	1,246	8,855
1979-80	651	329	271	55	1,306	10,161
1980-81	550	344	347	40	1,181	11,342
1981-82	925	415	297	64	1,701	13,043
1982-83	1,367*	455	304	41	2,167	15,210**
1983-84	1,355	380	408	182	2,325	17,564**
1984-85	681	212	280	227	1,705	19,269

* Includes 800 villages electrified outside A. D. P. for the Punjab Government.

** Figure includes villages electrified in Federally Administered Tribal Area from 1975-76 onward, the total number of which is 1,629 by end of June 1985 and villages electrified all over the country under ADB and Kuwait Projects.

TARBELA

Financial Benefits

Upto 30th June, 1985 some 39,616.74 million KWHs of power were generated which at the present day cost means approximately a saving of Rs. 3,961.68 million worth of natural gas/oil which could be conserved and utilized elsewhere. About 90.07 MAF of water has been released from the storage at Tarbela including re-regulation which in monetary terms would roughly mean an input to the national economy worth Rs. 18,014.00 million at national value.

Total benefits from the Project upto June 30, 1985 are estimated to be of the order of Rs. 21,975.68 million. Tarbela has thus a potential to pay back to the economy many times over the burden which the nation undertook in its construction and restoration.

WATER AND POWER BENEFITS FROM TARBELA

(July-June)	*** Release MAF	* Benefits Rs. Million)	Generation MKWH	** Benefits Rs. Million)	Total Rs. Million)
1975-76	3.33	666.00	–	–	666.00
1976-77	9.07	1814.00	138.3	13.83	1827.83
1977-78	10.00	2000.00	3367.2	336.72	2336.72
1978-79	8.71	1742.00	3726.00	372.60	2114.60
1979-80	9.91	1982.00	4123.00	412.30	2394.30
1980-81	10.63	2126.00	4128.08	412.88	2538.88
1981-82	11.33	2266.00	4200.05	420.05	2686.05
1982-83	9.12	1824.00	5228.02	522.82	2346.82
1983-84	9.18	1836.00	7450.08	745.08	2581.08
1984-85	8.79	1758.00	7253.94	725.40	2483.40
Total	90.07	18,014.00	39,616.74	3,961.68	21,975.68

* At Rs. 200 per acre foot since July, 1974.
** At Rs 0.10 per KWH since July 1976.
*** Releases include re-regulation also.

MANGLA

Benefits

The table below shows total benefits derived from the project in terms of irrigation releases and power generation upto 30th June, 1985.

Year July-June	Storage Release (MAF)	Water Benefits (Rs. million)	Power Generation (MKWH)	Power Benefits (Rs. million)	Total Benefits (Rs. million)
1967-68 to 1974-75	36.28	3,588.50	18,051.1	903.12	4,491.62
1975-76	4.55	910.00	4,393.4	219.70	1,129.70
1976-77	4.92	984.00	4,218.0	421.80	1,405.80
1977-78	4.25	850.00	3,204.0	320.40	1,170.40
1978-79	3.92	784.00	3,570.90	357.09	1,141.09
1979-80	4.49	898.00	3,702.24	370.24	1,268.34
1980-81	4.15	830.00	3,877.59	387.76	1,217.76
1981-82	5.30	1,060.00	4,090.33	409.33	1,469.03
1982-83	4.82	964.00	4,917.01	491.70	1,455.70
1983-84	5.35	1,070.00	4,162.51	416.25	1,486.25
1984-85	5.39	1,078.00	3,884.60	388.40	1,466.40
Total	83.42	13,016.50	58,073.86	4,685.49	17,781.99

Mangla Fisheries

A total of Rs. 24.486 million have so far been received on account of leasing of Fishing Rights in Mangla Reservoir. The income for the year 1984-85 was 82 percent higher than the previous years income of Rs. 4.272 million.

Chashma Fisheries

A total of Rs. 1.09 million have so far been received on account of leasing of Fishing Rights in Chashma Reservoir.

Groundwater Investigations in Baluchistan

Groundwater investigations in promising alluvial areas of Baluchistan were continued, and as a result over all progress since 1973 included 681 test holes drilled, and 309 tubewells installed.

Following these investigations, groundwater deposits of as much as 850 cusecs within 28,000 square miles scattered throughout Baluchistan were discovered which when fully developed would irrigate a total of approximately 85,000 acres of virgin land in Rabi and Kharif seasons, which would greatly boost the economy of this backward area.

PROGRESS AT A GLANCE

	Subject	1959-60	1984-85	Percentage Increase
	Power			
1.	Installed generating capacity (MW)	119	4349 MW	36 Times
2.	Generation (MKWHS)	781	18,093	23 Times
3.	Units sold (MKWHS)	741	13,756	18 Times
4.	Revenue collected (Million Rs.)	70	8991	128 Times
5.	Consumers (Nos)	3,11,596	45,23,995	14 Times
6.	Villages electrified (Nos)	904	19,269	21 Times
7.	Transmission Lines (KMS)	7,000	1,74,000	25 Times

資料－15

RESTRICTED
For official use only
Not for publication

REPORT TO THE PRESIDENT OF THE INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT AS ADMINISTRATOR OF THE INDUS BASIN DEVELOPMENT FUND

STUDY OF THE WATER AND POWER RESOURCES OF WEST PAKISTAN

VOLUME I

General Report

Prepared by a Group of the World Bank Staff

Headed by

Dr. P. Lieftinck

July 28, 1967

CURRENCY EQUIVALENTS

4.76 rupees	=	U.S. $1.00
1 rupee	=	U.S. $0.21
1 million rupees	=	U.S. $210,000

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

Washington, D.C.
July 28, 1967

Mr. George D. Woods
President
International Bank for
Reconstruction and Development
as Administrator of the Indus Basin
Development Fund

Dear Mr. Woods:

On November 14, 1963 you reached an understanding with Field Marshal Mohammad Ayub Khan, President of Pakistan, to the effect (among others) that the Bank would organize a Study of the water and power resources of West Pakistan which would serve as a basis for development planning in the water and power sectors of the economy. It was agreed that the first objective of the Study would be the completion of a report covering the technical feasibility, construction cost, and economic return of a dam on the Indus at Tarbela. On February 15, 1965 I presented that report to you, as Part I of the Study. It reached the conclusion -- now confirmed in the second, comprehensive phase of the Study -- that the Tarbela Project is technically and economically feasible, and that in order to meet Pakistan's urgent needs for greater agricultural production and to derive the greatest advantage from the Project when completed, a major effort must be made in the interim to modernize agriculture by improvement of farm practices and wider use of technical inputs such as fertilizer.

The second part of the Study, now presented, deals comprehensively, as was intended, with West Pakistan's water and power resources as a whole. It considers the need for increased supplies of irrigation water, relative to other means of increasing agricultural production, and finds them essential complements to one another. It analyzes in detail the several alternative means of providing more water for irrigation purposes -- enlargement of canals to enable increased diversions from the rivers, storage of flood flows in surface reservoirs for release in winter when river flows are low, and development of West Pakistan's extensive groundwater resources by means of tubewells. Implications of each alternative mode of water development for electric power -- both hydroelectric potential at dam sites and requirements of energy for tubewell pumping -- have been studied in the context of the long-term development of the entire electric power system of the Province. The potential of each mode of development

has been assessed in the light of the contributions it can make, both on the irrigation side and on the power side, to further economic development in West Pakistan.

The report that follows consists of four volumes, with their various annexes. The first volume of the report is concerned with integrating the results of all the studies and relating these combined results to the context of development and development planning in West Pakistan. The second volume deals with the agricultural potential of the Province and the steps needed to realize that potential -- not only surface and ground water development projects but also policies and institutional measures to secure improvements in farming standards and wider usage of farm inputs. The third volume treats in detail the several alternative sites for surface water storage which have been identified -- in particular Tarbela, Kalabagh and High Mangla -- and sets forth a tentative schedule for their development. The fourth volume projects the long-term growth of power loads in West Pakistan and proposes a program for meeting those loads.

Specific water development projects have been selected for execution in the years before 1975 and their relative priority has been assessed, on the basis of detailed studies of the long-term potential for integrated water resource development, assessment of what part of this potential it may be physically, administratively and financially feasible to realize before 1975, and preliminary studies establishing the technical feasibility of the specific projects, their anticipated investment and operating costs, and the benefits they could yield to the economy of West Pakistan.

Beyond an Action Program proposed for development of agriculture, irrigation and power in the years before 1975, the report also deals with prospects through the remainder of this century but especially with suggested steps for further development of the irrigation and power systems of the Province in the decade 1975-85. These steps can only be formulated more tentatively than those needed in the early years, but it is intended that they should be a useful guide to future development possibilities. All the proposed programs, whether for the early period or for later years will need continuous revision and updating in the light of new information as it becomes available.

I have been impressed by the priority which the Pakistani authorities are attaching to the development of agriculture and by the measures that they are taking in expression of this priority. I believe that greatest success will be achieved if increased emphasis is laid on the role and the capabilities of the individual farmers and of those who advise them; technical and financial assistance to enable them to meet their needs, as they see them, must be made available in greater quantity, and incentives must be

structured in a manner which is conducive to the modernization of agriculture. With such a framework of incentives the heavy burden which the programs proposed will lay on the public sector could be reduced by greater reliance on the private sector whose enterprise and activity are such a heartening feature of development in West Pakistan.

Execution of the Study has taken longer than originally envisaged. The main phase of the work started in the spring of 1964 when the consultants who had been retained first gathered in Pakistan. Delays were inevitably encountered. Moreover it was found that the scope of the Study -- combining general planning to identify directions of development in the sectors of agriculture, irrigation, surface storage and power, with preparation of feasibility reports for selected projects -- was such as to require more time than originally envisaged for investigations, analyses and final integration of results into phased multi-sectoral programs for systematic exploitation of West Pakistan's water resources.

The Study has been made possible only by intensive international cooperation -- as regards its financing and as regards the sources from which ideas and expertise have been drawn as well. Close contact was maintained throughout the course of the Study between the Bank Group, which formed my immediate team, and our consultants and between them and the Pakistani authorities and their consultants. We have had many rounds of discussions, both formal and informal, in Pakistan and the United States and at the European headquarters of the consultant firms involved. These frequent contacts and the fruitfulness of them were practical expression of the spirit of international cooperation which was at the heart of the Study. I would like here to express my deep appreciation for the assistance afforded us by the Pakistani authorities and by our and their consultants. Our consultants accomplished a major task in preparation of their comprehensive reports, totaling more than thirty volumes, and their knowledge and technical judgment were invaluable to the Bank Group.

In coordinating and directing execution of the Study and in preparing this final report -- following the one on Tarbela -- I have been assisted by selected staff members of the Bank. Jointly we formed the Bank Group for whose findings, opinions and recommendations, as expressed in these reports, I assume full responsibility. Each of the staff members associated with the Study has given a great deal of his thought and effort, some of them over a period of several years, to this challenging experiment in comprehensive sectoral planning. I feel deeply indebted and most grateful to them for their individual contributions, their spirit of cooperation and their unfailing loyalty.

I want to thank you sincerely, Mr. Woods, for the opportunity you offered me to make this Study and for your confidence. I hope that, despite its shortcomings, which I fully recognize, the voluminous report I herewith submit will go some length in serving the purposes you had in mind when arranging for the Study with President Ayub and including it in your supplemental agreement with the members of the Indus Club. It was not an easy but certainly a most rewarding assignment you gave me.

Sincerely,

Pieter Lieftinck

TABLE OF CONTENTS

Page No.

PREFACE

PROPOSED PROGRAMS AND PRINCIPAL RECOMMENDATIONS i

I. INTRODUCTION 1

II. THE DEVELOPMENT OF THE IRRIGATION SYSTEM 7

III. THE INADEQUACY OF THE PRESENT SYSTEM 18

The Lag in Agriculture 18
The Shortage of Electric Power 20
Crop Yields and Agricultural Inputs 21
The Need for More Irrigation Water 24
The Choice Between Water and Other Inputs 24
The Effect of the Indus Basin Works 28

IV. FOUR TECHNIQUES OF WATER DEVELOPMENT 32

Canal Remodeling and Enlargement 33
Surface Storage 39
Private Tubewells 48
Public Tubewells 50

V. PROJECT IDENTIFICATION AND SELECTION 55

Identification of Irrigation Projects 57
Selection of Irrigation Projects 63
Sequential Analysis 66
Project And Program Review 67
Agricultural Development 68
The Formulation of the Power Development Program 68
Joint Planning for Power and Irrigation 69

VI. AGRICULTURAL IMPROVEMENTS AND IRRIGATION PROJECTS 72

Crops 73
Livestock 74
Farms And Farmers 74
Fertilizer 75
Improved Seeds 78
Plant Protection 81
Agricultural Implements and Mechanization 82
Livestock Development 83
Improved Farming, Physical Inputs and Water 86
Irrigation Development -- Third Plan Period 87
Irrigation Development -- Fourth Plan Period 97
Irrigation Development -- Fifth Plan Period 108
Irrigation Development -- Sixth Plan Period 111
Irrigation Development After 1985 112
The Growth of Irrigation Supplies 113
Expected Results of Development 114

TABLE OF CONTENTS
(Cont'd)

		Page No.
VII.	SURFACE WATER STORAGE	120
	Introduction	120
	Current Storage Development	120
	Future Storage Developments	121
	Flows Available for Storage	122
	Surface Storage Requirements	125
	Recommended Program of Surface Storage Development	126
	First Stage Storage on the Indus	127
	Tarbela and Kalabagh	128
	The Benefits of Tarbela	133
	The Silt Problem on the Indus	138
	Financial Requirements for Tarbela	141
	Second Stage Storage on the Indus	141
	Sehwan-Manchar Project	142
	Four Major Alternatives	143
	Side Valley Storage	143
	Upper Indus Sites	145
	Thal Storage Scheme	146
	Second-Stage Storage -- Assessment	147
	Further Storage Projects on Tributaries	149
	The Project for Raising Mangla	150
	The Swat-Ambahar Project	151
	Chiniot Project on the Chenab	151
	Financial Requirements of the Proposed Program	152
VIII.	ELECTRIC POWER	155
	Introduction	155
	The Structure of the West Pakistan Power System	155
	Recent Growth of Electricity Consumption	156
	Load Forecast	157
	Agricultural Pumping	159
	Residential and Commercial Load Forecast	159
	Industrial Load Forecast	160
	Contingency Load Forecasting	161
	The Existing Power Situation and Current Programs	163
	Stone & Webster Bulk Power Supply Program	165
	Bank Group's Adjustments to Stone & Webster's Program	167
	The Evaluation of Tarbela	168
	The Scarcity Value of Thermal Fuel	169
	EHV Interconnection Between the Major Power Markets	170
	The Timing of Interconnection	172
	Operation of Mangla and Tarbela Reservoirs	172
	Annual Operating Decisions and Hydrological Uncertainty	175
	Peaking at Mangla and Tarbela	176