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DEVELOPMENT OF SURFACE WATER RESOURCES

by

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&

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1. INTRODUCTION

Agriculture is the back bone of Pakistan's economy. It contributes 30% of GDP. About 70% population lives in rural area and agriculture provides 55% job opportunities. This sector provides 60% of country's exports. The development of agriculture means prosperity and up lift of 70% of total population which is growing at 3% per annum.

The climate of Pakistan is arid to semi-arid. Its agriculture is dependent on irrigation. About 80% of agriculture is irrigated. The availability of assured quantity of good quality water is the major factor on which the development of agriculture sector depends. Therefore it is a dire need to use the available water resources in the most effective way and to develop new water resources to meet the growing demand.

The total area of Pakistan is 79.6 Million Hectares (MH). Out of which about 41.77 MH comprise rugged mountains, narrow valleys and foot hills, the remaining area of 37.83 MH consists of flat aggradational plains and sand deserts. About 31.2 MH can be used for cultivation, but only about 22.1 MH is currently cultivated. Remaining 9.1 MH (22.5 MA) is lying barren for lack of water. Fig. 1 presents the land use of Pakistan.

The valleys of the River Indus and it tributaries, called "Indus River Basin" constitute the heart land of Pakistan. It includes the mountain basins of the north and the west, the Indus Plains, the Kachhi Plain, Desert areas of Sindh and the Rann of Kach. Population density is the highest in the canal irrigated areas in the north east of Indus Plains. The arid Plateaus and barren mountains, on the other hand, are least inhabited. The increasing population and the associated social, technical and economic activities all depend, directly or indirectly, on the exploitation of water as a resource.

2. EXISTING WATER RESOURCES

Pakistan possesses one of the world largest contiguous irrigation system known as Indus Basin irrigation system Fig. 2. This system mainly comprises the Indus main river and its five major tributaries. After Indus Basin treaty with India in 1960, Pakistan was allotted the flows of three western rivers namely Indus, Jhelum and Chenab. The flows in these rivers are quite variable. About 84% flows occur in Kharif (Summer) season. The great variability of water flow have urged to develop and manage irrigation system in such a way so that assured and regular water supply for agriculture can be made available.

The system is comprised of two large reservoirs Mangla and Tarbela Dam, 23 barrages, 12 inter-river link canals and 48 perennial & non-perennial canal commands. The total length of main irrigation canals including distribution system is 60,000 km. The whole canal system serves about 90,000 water courses with approx length of 1 M km. Fig. 3 shows the location of Existing Water Storage Sites of Pakistan. Table 1 gives the salient of the existing water reservoirs. In addition to this there are about 5 dozen small dams built, operated and maintained by the provincial Small Dams organizations. These dams supply water in the local areas both for Irrigation and drinking..

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With the completion of Indus Basin Project, including three on-line storages, Indus Basin Irrigation System (IBIS) has now a significant facility for integration of river supplies. As a consequence, the canal head diversions in IBIS attained a peak of 133 BCM (107.73 MAF) in Post-Tarbela period as compared to 67 MAF (83 BCM) at the time of independence.

At the time of independence the population was 32 million and the per capita water availability was about 6000 m^3. It has reduced to nearly 1350m^3 per person in 2002 with further reduction sever shortage shall be felt.

3. SEDIMENTATION OF EXISTING RESERVOIRS

Tarbela Reservoir: The Indus is one of the four largest sediment carrying rivers in the World. The sedimentation rate in Tarbela reservoir is 200 Mt or 0.11 MAF per year.

According to 2002 Hydrographic survey, gross storage capacity of the reservoir has reduced from 11.620 MAF to 8.586 MAF 26.11% in 28 years. Live storage capacity of the reservoir has reduced from 9.679 MAF to 7.778 MAF 19.64%. The delta is adancing towards the dam and at present its pivot point at elevation 1369 is at about 9' miles upstream of the Main Dam. Fig. 4 presents profile of sediment delta of Tarbela reservoir.

The effect of sedimentation is loss of live storage which in turn would result in reduction in water availability for the agriculture for Rabi and early Kharif. The physical effect of sediments includes the risk of clogging of low level tunnel outlets particularly in a seismic activity. The erosive action of sediment laden water on outlet concrete structures and power turbines will result in exorbitant maintenance costs.

Protection of tunnel intakes against sediment clogging by construction of an underwater dyke in front of the intakes as proposed by the Consultants has been studied. This option not only involves tremendous stability and construction problems but also its benefits in the absence of sediment flushing from the reservoir seems minimal.

Evacuation of 200 million tons of sediments every year either by flushing/sluicing through low level high capacity outlets from the right or left bank was proposed by the Consultants. This proposal carries a large number of grey areas which need to be prudently addressed before taking it to a feasibility stage. WAPDA considers this an unprecedented option, the example of which does not exist else where in the World. Moreover, this option would in no time adversely affect the downstream hydropower Projects of Ghazi Barotha and Chashma aggrade the river bed and effect the entire irrigation system.

The dredging option in case of Tarbela reservoir is not only prohibitive in cost but also is without any precedence and completely impractical. Any dredging proposal to be effective must provide for removal and disposal of 550,000 tons of sediments every day. Realistically, the target is unattainable even if hundred of dredgers and ancillary equipment are deployed over the reservoir stretch of 100 square miles to work round the clock.

A preliminary estimate of dredging of yearly deposits of 110,000 Acre ft. (135.8 million cubic meters) sediments indicates that about Rs 27 billion at Rs 200/m^3 would be required annually.

Actions plans recommended by the Consultants M/s TAMS/H.R Wallingford are at pre-feasibility stage and WAPDA has strong reservations against their implementations.

The construction of a big storage Project by the year 2010 can only offset the water shortages in the Country.

Mangla Dam Project: Gross storage capacity of the reservoir has reduced from 5.88 MAF to 4.76 MAF with average annual sediment load of 34000 AF the reservoir is loosing its capacity at a

rate of 0.6% annually. Live storage capacity of the reservoir has reduced from 5.34 to 4.56 MAF. The major delta is advancing towards the dam and at present its pivot point is at 5 miles upstream of the Main Dam. The depths of sediment deposited at the pivot point and in front of intake structures are 149 ft. and 59 ft. respectively. Fig. 5 presents the sediment profile of delta of Mangla Reservoir.

Table 2 shows the sedimentation of the existing reservoirs.

4. WATER CONSERVATION

Water use efficiency both in Irrigation and water supply sectors in Pakistan is very low. Total future requirements of Pakistan are going to be substantially greater than total potential supply. Therefore water conservation is critical to meet the needs. This will require concerted efforts in watershed management to reduce degradation of upper catchments so that sediment is minimized. Irrigation being the largest user of water, great efforts are required in this sector. Irrigation requirement for the year 2013 would of the order of 250 Bm^3. Lining of canals, distributaries and water courses to minimize the seepage and conveyance losses. Leveling of farms, use of modern method of irrigation for optimal use of water, crop substitution and judicious use of delta are some of the methods which need to be adopted in the earnest. Ground water extractions are of the order of 48 MAF and there is limited scope of additional exploitation.

No doubt the precious water conserved by lining etc. would benefit the tail enders and add to the productivity of the given command but it cannot be transferred to another command area. Water so conserved also cannot be carried over from one season to another. Therefore, in addition to conservation of this precious natural resource, we must store all the available water for its optimal use.

5. WATER DEMAND

Pakistan's population currently at 141 million is projected to increase to 173 million in 2010-11 and 221 million in 2025. The percentage of urban population will increase from the current 35% to 42% in 2010 and 52% in 2025.

The total cultivated area in Pakistan increased from 36.31 MA in 1947 to 56.22 million Acre in 2000, while irrigated area enhanced from 20.75 MA to 44.68 MA. Cereal production increased from 5.2 million tons (Mt) to 28.5 Mt during the same period. The area under cereal crops increased by about 250 percent; the maximum rise was in case of rice which increased by about 318 percent; and area under sugarcane increased by 544 percent. There is comparatively much higher increase in the land areas for rice and sugarcane which are high delta crops. Thus, both increase in area and increase in yields have contributed to higher production. Under future scenarios also, additional land and higher cropping intensities both requiring more water would be necessary.

Since the stored water is already insufficient even to meet the needs of the existing cropped area and there is going to be a gradual reduction in stored water because of siltation of the reservoirs, the water availability for agriculture will reduce during the next 2-3 decades.

Increasing irrigation intensity of the existing cropped land, requires additional water to be available which will have to be achieved though a combination of improved water management, improved efficiency and additional water availability at critical times of the year. This would require additional expansion/strengthening of existing irrigation infrastructure.

The net irrigation water requirement for crops in Pakistan was around 77.4 MAF for the year 2000-01. The water requirement for the period 2010-2021 will be 89 MAF and 114.64 MAF for the year 2024 which disregards the contribution from rainfall. Fig. 6 presents population growth vs, water availability and canal water diversions.

The non-irrigation water demands include rural, urban and industrial. Since, a component of the non-irrigation water returns to the river system, the net non-irrigation water demand is the difference between estimated water demand and return flows/drainage to the river system. The net non-irrigation water requirement has been estimated for year 2000 as 3.6 MAF, year 2010 as 7 MAF and year 2025 as 12 MAF.

6. WAPDA's VISION 2025 PROJECTS

Background

After completion of Tarbela Dam project since 1976, the development of water storages has been at stand still. Although Ranking study of Hydropower Projects on river Indus & its tributaries was carried out in early eighties and Detailed Engineering Design & Tender Documents of Kalabgha Dam Project were prepared in mid eighties yet no project came up for implementation. Storage capacity of on line reservoirs is reducing due to siltation. The present storage capacity is only 11% of total surface flows.

The installed hydropower is only 12% of the total identified potential. In Nineties private thermal power projects were inducted in the generation system. Although this eliminated the load shedding but disturbed the hydel thermal ratio from 65:35 to reverse. Fossil fuel being imported the electricity became expensive. The Independent Power Producers (IPPs) which supplied about less than one third of the total power supply of Wapda had to be paid more than half the revenue of Wapda.

The drought, failure of monsoon, which started in 1999 continued for more than three years. Severe water shortages were experienced in the irrigation system. Realizing the situation Wapda prepared a 25 years programme of development of water and Power resources of Pakistan which was presented to the Federal Cabinet on August 30, 2000. A part of this to be implemented on fast track was approved by the Chief Executive of Pakistan in Jan 2001.

The objectives are:

- To meet the agricultural and urban demand of the growing population.
- Increase productivity by brining more area under cultivation.
- To make up the storage lost due to sedimentation
- Mitigate the effects of drought
- Inject cheap hydropower in the system to keep the cost of electricity within affordable limits
- Support economy and poverty alleviation in backward areas.
- Encourage private investment.

Projects Under Execution: Under this programme Wapda is building the following projects:

Water Sector Projects

- Gomal Zam Dam
- Mirani Dam
- Raised Mangla Dam
- Satpara Dam
- Kurram Tangi Dam
- Greater Thal Canal
- Kachhi Canal
- Rainee Canal

Hydro Power Projects

- Jinnah Barrage
- Allai Khwar
- Khan Khwar
- Duber Khwar
- Golen Gole
- Neelum Jhelum
- Low Head Hydro Power Project

The following projects are under various phases of study:

- Basha Diamer Dam project – Feasibility Detailed Design & Tenders
- Akhori Dam project – Feasibility
- Sehwan Barrage – Feasibility
- Skardu Dam – Prefeasibility
- Chashma Right Bank Canal Lift Scheme – Feasibility and Design
- Bunji Hydro Power Project – Pre-Feasibility
- Dasu Hydro Power Project. – Pre-Feasibility
- Skardu Dam – Pre-feasibility

A number of small hydel projects on various tributaries are under study. In addition to this other projects shall be taken up in phase II and phase III. Fig.7 presents the location of vision projects of Phase-I.

7. WATER AVAILABILITY

U/S Approach

Annual average surface water flows measured at rim stations is as follows:-

Indus at Kalabagh	91.26 MAF
Jhelum at Mangla	23.28 MAF
Chenab at Marala	27.13 MAF
Total at Rim Stations	141.67 MAF
NWFP Diversions above rim station	5.00 MAF
Eastern River Run Off within Pakistan	3.80 MAF
Total Surface Water available	154.50 MAF
Present utilization	106.00 MAF
Available for future use	48.50 MAF
Subtracting 10 MAF for river losses upto Kotri, the net available for future development	38.5 MAF

D/S Approach

Post Tarbela average flow downstream of Kotri Barrage (the data given by Director Regulation I&P Deptt. Government of Sind Karachi) is presented in Fig.8. On Annual average 35.2 MAF flows d/s of Kotri into sea which is available for future development. As per water accord study should be carried out to work out the water requirement to check sea intrusion. Subtracting the most conservative requirement i.e. 10 MAF, still 25.2 MAF is available for future development.

8. FUTURE DEVELOPMENT OF WATER RESOURCES

River Chenab: There is no storage site on river chenab in Pakistan

River Jhelum: After raising of Mangla Dam, no more site for water storage is available in river Jhelum. After silting up of raised Mangla, off channel storage site of Rohtas Dam can be considered.

River Indus: Enough water is available as discussed above in river Indus for storage. The sizeable (about 6 MAF) storage sites on river Indus are Kalabagh D/S of Tarbela, Basha U/s Tarbela and Skardu. There are other sites such as Buji, Dasu, Pattan, Thakot etc. where run off the river Hydro Power projects can be built but the storage is less than 1 MAF. On tributaries of river Indus there are sites with very little storage but considerable head can be created by Tunnels. Three sites Khan Khwar, Duber Khwar and Alai Khwar are under construction.

Off channel storage sites have been investigated. The preferred site which has storage of about 6 MAF and has comparatively less environmental effects, is Akhori dam site which is under feasibility study.

Sailent features of Kalabagha Dam, Basha Diamer Dam and Skardu Dam Projects are given in Table -3, 4 and 5.

Kalabagh Dam Project is located 210 km downstream of Tarbela Dam on the river Indus. The Project envisages construction of 260 ft. high rock and earth fill dam with its Maximum retention level at 915 ft. It will create a reservoir with gross & live storages of 7.9 MAF and 6.1 MAF respectively. In the event of the highest probable flood, the two spillways can dispose of flood of over 2 million cusecs. On the left bank is power house which will be connected to 12 conduits each 36 ft. dia with ultimate generation capacity of 3600 MW. The project design is complete and ready for execution. Fig. 9 shows layout of Kalabagh Dam Project.

Basha Dam Project is located 314 km upstream of Tarbela on the river Indus. The project comprises RCC dam about 908 ft. high, a reservoir with gross and live storage capacity of 9.09 MAF and 7.34 MAF respectively. The two power houses one on each bank of the Indus will have ultimate generation of about 3700 MW. The feasibility studies by the consultants are presently underway. Fig. 10 shows layout of Basha Dam Project and Fig. 10-A shows Cross Section of the project.

Skardu Dam Project is located on the Indus about 10 miles downstream of confluence of Shigar river with Indus near Skardu town. The proposed rock-earthfill dam will have height of about 755 ft. and create a reservoir with gross and live storage capacity of 15.4 MAF and 10.6 MAF respectively. There is also power generation potential of about 4000 MW. The pre-feasibility studies of the Project have been started by WAPDA. Fig.-11 shows the extent of the reservoir and the area to be submerged in it.

9. Conclusions and Recommendations

(i) Surplus surface water of at least 25 MAF is available for immediate development of a big storage on the Indus.

(ii) Sedimentation of existing reservoir is enhancing with time thereby reducing the water availability.

(iii) Studies to confirm the necessity and quantum of water to check sea water intrusion should be carried out as early as possible.

(iv) Country is likely to face serious water, food and Power shortages after 2010.

(v) If cheap hydropower is not added to the system the electricity would become more expensive.

(vi) It is strongly recommended that construction of a storage reservoir and Hydropower Project should be started immediately. Second reservoir should be constructed in the next decade.

Table-1

Existing Surface Storages

PROJECT	RIVER	HT. OF DAM (FT.)	LIVE STORAGE (MAF)	POWER (Mw)	PURPOSE
TARBELA(1976)	INDUS	470	9.68	3478	I,P
MANGLA (1966)	JHELUM	380	5.34	1000	I,P
CHASHMA (1971)	INDUS	-	0.72	-	I,P
WARSAK (1960)	KABUL	250	0.04	240	I,P
BARAN DAM (1962)	KURRAM	107	0.03	4	I,P
HUB (1983)	HUB	151	0.76	-	I,W
KHANPUR (1984)	HARO	167	0.09	-	I,W
TANDA (1965)	KOHAT TOI	115	0.06	-	I
RAWAL (1962)	KURANG	114	0.04	-	W
SIMLY DAM(1982)	SOAN	215	0.02	-	W
BKD KHAN (1900)	PISHIN	35	0.04	-	I
HAMAL LAKE	-	-	0.08	-	I
MANCHAR LAKE	INDUS	-	0.75	-	I
KINJHAR LAKE	INDUS	-	0.32	-	I,W
CHOTIARI LAKE	INDUS	-	0.78	-	I
		TOTAL	18.75	4722	I

I-IRRIGATION P-POWER W-WATER SUPPLY

TABLE – 2
SEDIMENTATION OF RESERVOIRS

Reservoir	Gross Storage Capacity (MAF)		Gross Storage Loss			
	Original	Year 2002	Year 2002 (MAF)	Year 2013 (MAF)	Year 2015 (MAF)	Year 2020 (MAF)
TARBELA	11.62 (1974)	8.59 (74%)	3.03 (26%)	4.22 (36%)	4.43 (38%)	4.98 (43%)
MANGLA	5.88(1967)	4.70 (80%)	1.18 (20%)	1.55 (27%)	1.63 (28%)	1.79 (30%)
CHASHMA	0.87 (1971	0.50 (57%)	0.37 (43%)	0.50 (57%)	0.50 (57%)	0.50 (57%)
TOTAL	18.37	13.79(75%)	4.58 (25%)	6.27 (34%)	6.56 (36%)	7.27 (40%)

Table-3

KALABAGH DAM PROJECT
Salient Features

RESERVOIR	
Gross Storage	7.9 MAF
Live Storage	6.1 MAF
Retention Level	915 Ft.
Minimum draw Down Level	825 ft.
Lake Area	110,200 Acres
MAIN DAM Earth & Rockfill	
Crest Elevation	940 FT.
Maximum Height	260 Ft.
Length	4,375 Ft.
POWER STATION	
Number of Units	12 Nos.
Installed Capacity	3600 MW
Spillways	Two
Cost	$ 5.1 Billion (US)
Construction Period	6 years

Table-4

BASHA DIAMER DAM PROJECT
Salient Features

- **Concrete Gravity Dam (Roller Compacted)**
- **Gross Storage** — **9.09 MAF**
- **Live Storage** — **7.34 MAF**
- **Dam Height** — **908 ft.**
- **Power (8X457.5)** — **3660 MW**
- **Cost** — **5.24 B $(US)**
- **Construction Period** — **7 Years**
- **Cost of Upgradation of KKH not included** — **170 B$**

Table-5

SKARDU DAM PROJECT
Salient Features

River	Indus
Dam Height	230m
Head Water Level	2316m
Tail Water Level	2134m
Reservoir Area	300 km^2
Live Storage	15.40 MAF
Dead Storage	4.86 MAF
Average Flow	951m^3/s

LAND USE IN PAKISTAN

CATEGORY	AREA (MA)
GEOGRAPHICAL AREA	196.0
AREA SUITABLE FOR AGRICULTURE	77.1
CULTIVATED AREA (IRRIGATED + BARANI)	54.5
AREA UNDER IRRIGATION (BY ALL SOURCES)	44.4
ADDITIONAL AREA THAT CAN BE BROUGHT UNDER IRRIGATED AGRICULTURE	22.5

SOURCE: AGRICULTURAL STATISTICS OF PAKISTAN 1998 -99

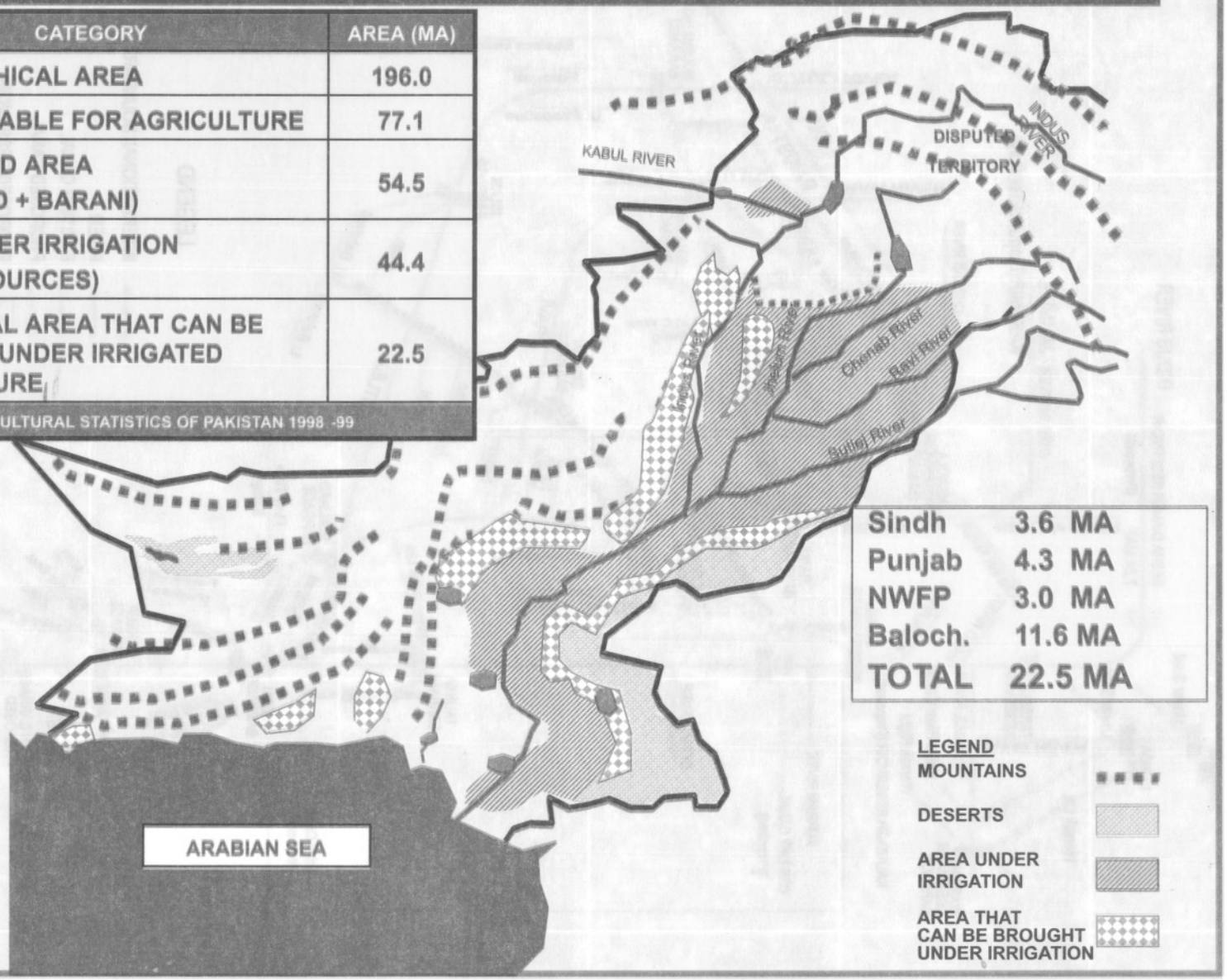
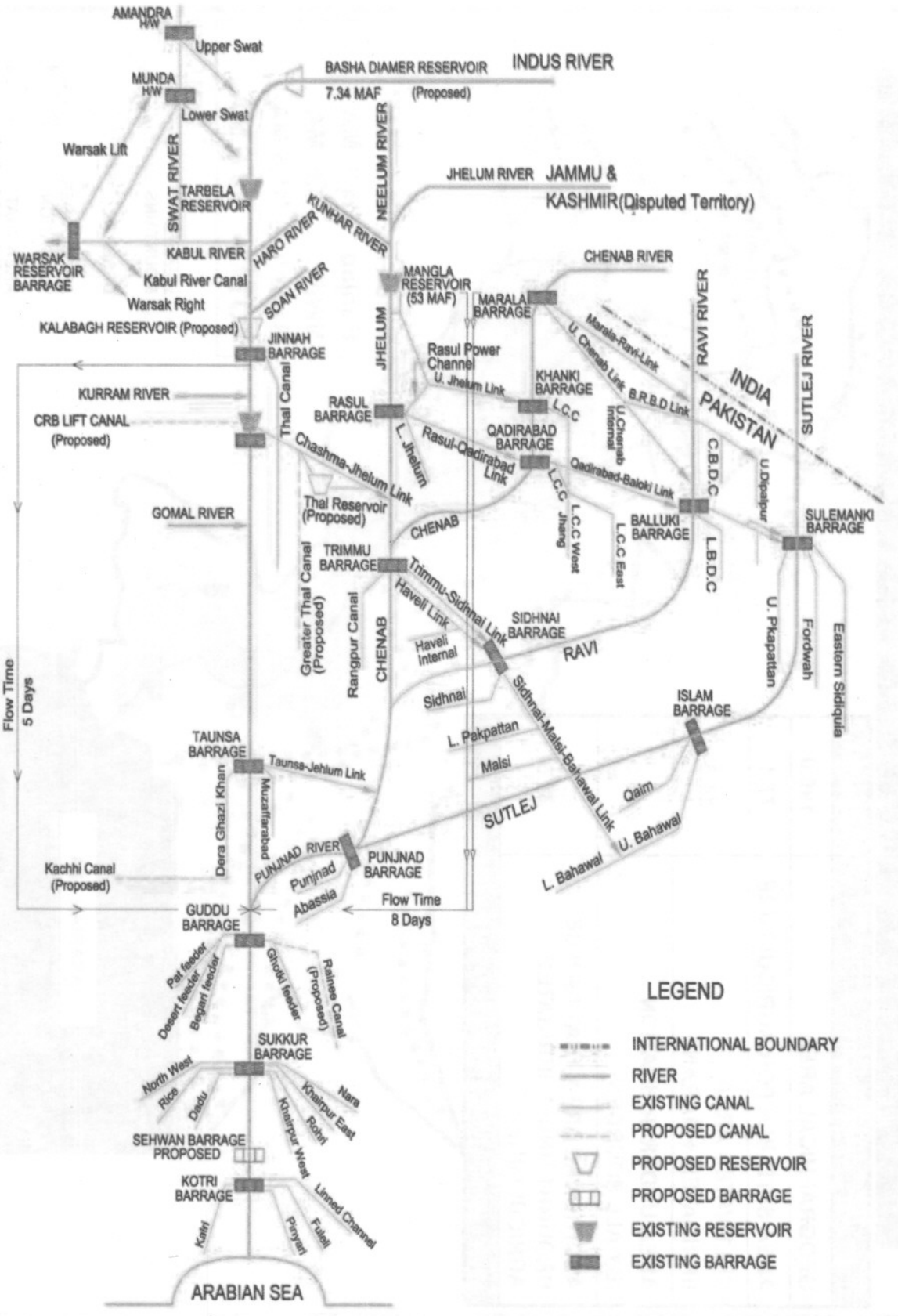


Figure -1

Figure 2


AMANDRA H/W
Upper Swat
MUNDA H/W
Lower Swat
Warsak Lift
SWAT RIVER
TARBELA RESERVOIR
BASHA DIAMER RESERVOIR
7.34 MAF
(Proposed)
INDUS RIVER
NEELUM RIVER
JHELUM RIVER
JAMMU & KASHMIR(Disputed Territory)
KUNHAR RIVER
HARO RIVER
KABUL RIVER
WARSAK RESERVOIR BARRAGE
Kabul River Canal
Warsak Right
SOAN RIVER
KALABAGH RESERVOIR (Proposed)
MANGLA RESERVOIR (53 MAF)
CHENAB RIVER
MARALA BARRAGE
Marala-Ravi-Link
U. Chenab Link
RAVI RIVER
INDIA
PAKISTAN
SUTLEJ RIVER
JHELUM
JINNAH BARRAGE
Rasul Power Channel
U. Jhelum Link
KHANKI BARRAGE
B.R.B.D Link
U.Chenab Internal
C.B.D.C
U.Dipalpur
KURRAM RIVER
CRB LIFT CANAL (Proposed)
Thal Canal
RASUL BARRAGE
L. Jhelum
L.C.C
QADIRABAD BARRAGE
Rasul-Qadirabad Link
Qadirabad-Baloki Link
Chashma-Jhelum Link
Thal Reservoir (Proposed)
GOMAL RIVER
CHENAB
L.C.C Jhang
L.C.C West
L.C.C East
BALLUKI BARRAGE
L.B.D.C
SULEMANKI BARRAGE
TRIMMU BARRAGE
Trimmu-Sidhnai Link
Greater Thal Canal (Proposed)
Rangpur Canal
CHENAB
Haveli Link
Haveli Internal
SIDHNAI BARRAGE
RAVI
U. Pkapattan
Fordwah
Eastern Sidiquia
Flow Time 5 Days
Sidhnai
Sidhnai-Malsi-Bahawal Link
ISLAM BARRAGE
L. Pakpattan
TAUNSA BARRAGE
Taunsa-Jehlum Link
Malsi
Qaim
SUTLEJ
U. Bahawal
L. Bahawal
Dera Ghazi Khan
Muzaffargarh
PUNJNAD RIVER
PUNJNAD BARRAGE
Punjnad
Abassia
Kachhi Canal (Proposed)
Flow Time 8 Days
GUDDU BARRAGE
Pat feeder
Desert feeder
Begari feeder
Ghotki feeder
Rainee Canal (Proposed)
SUKKUR BARRAGE
North West
Rice
Dadu
Khairpur East
Nara
Rohri
Khairpur West
SEHWAN BARRAGE PROPOSED
KOTRI BARRAGE
Linned Channel
Kalri
Piryran
Fuleli
ARABIAN SEA
LEGEND
INTERNATIONAL BOUNDARY
RIVER
EXISTING CANAL
PROPOSED CANAL
PROPOSED RESERVOIR
PROPOSED BARRAGE
EXISTING RESERVOIR
EXISTING BARRAGE

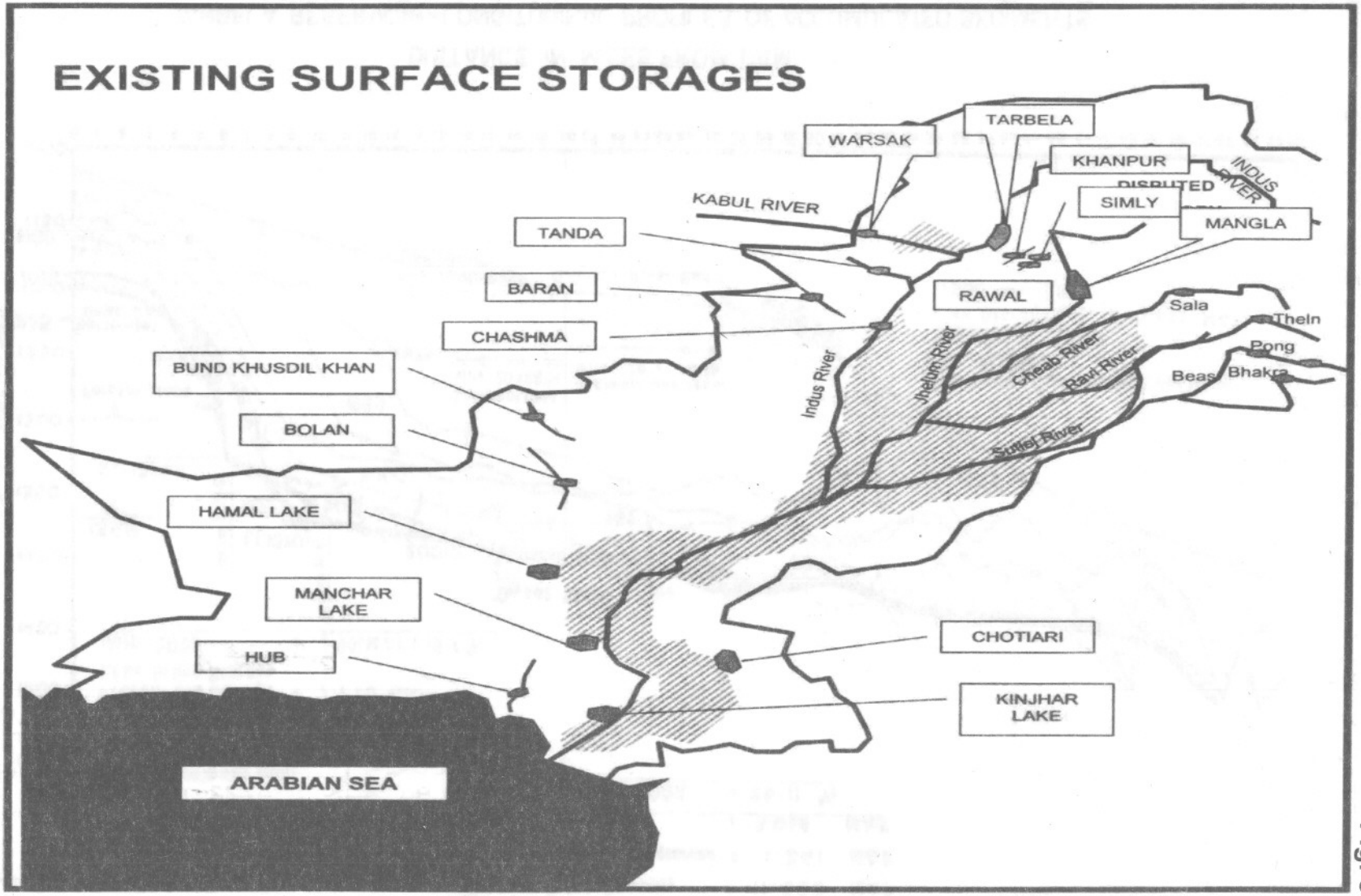
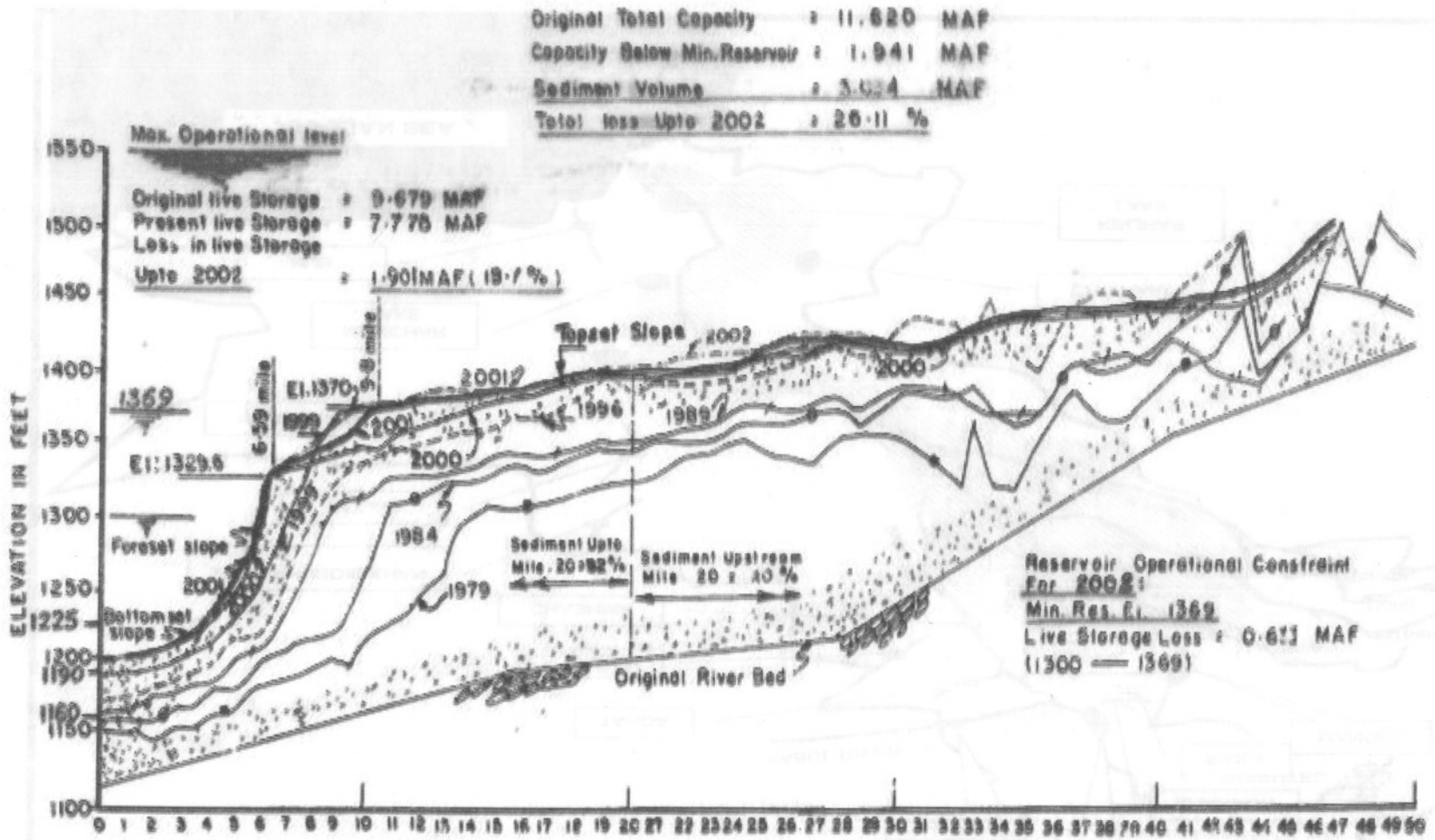

EXISTING SURFACE STORAGES
WARSAK
TARBELA
KHANPUR
SIMLY
MANGLA
KABUL RIVER
TANDA
BARAN
CHASHMA
RAWAL
Sala
Theln
Pong
Beas
Bhakra
Indus River
Jhelum River
Chenab River
Ravi River
Sutlej River
BUND KHUSDIL KHAN
BOLAN
HAMAL LAKE
MANCHAR LAKE
HUB
CHOTIARI
KINJHAR LAKE
ARABIAN SEA

Fig. 3



DISTANCE IN MILES FROM DAM

TARBELA RESERVOIR - LONGITUDINAL PROFILES OF ACCUMULATED SEDIMENTS

Figure -4

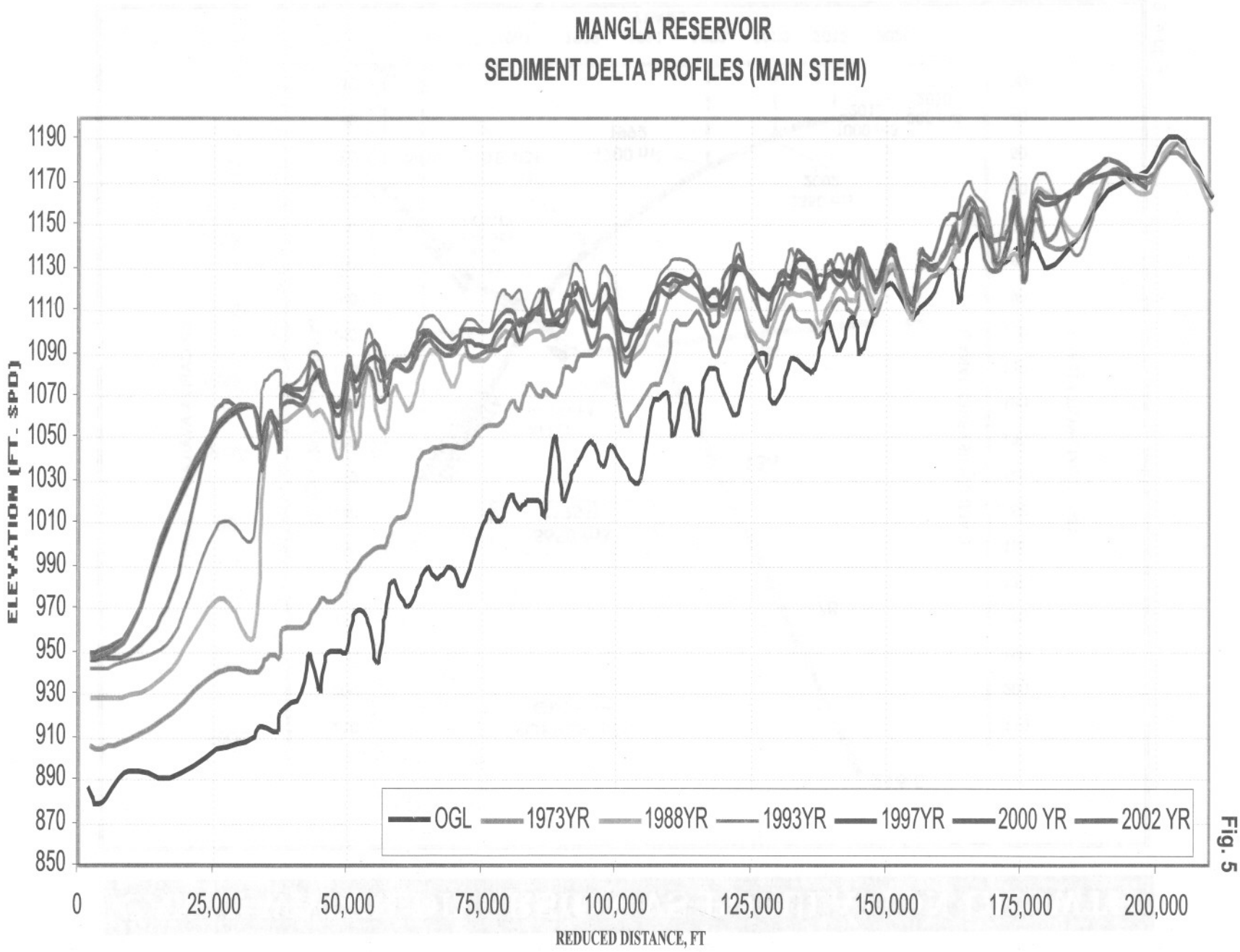

MANGLA RESERVOIR
SEDIMENT DELTA PROFILES (MAIN STEM)
ELEVATION (FT. SPD)
1190
1170
1150
1130
1110
1090
1070
1050
1030
1010
990
970
950
930
910
890
870
850
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
REDUCED DISTANCE, FT
OGL
1973YR
1988YR
1993YR
1997YR
2000 YR
2002 YR

Fig. 5

CANAL WATER DIVERSION VS POPULATION GROWTH

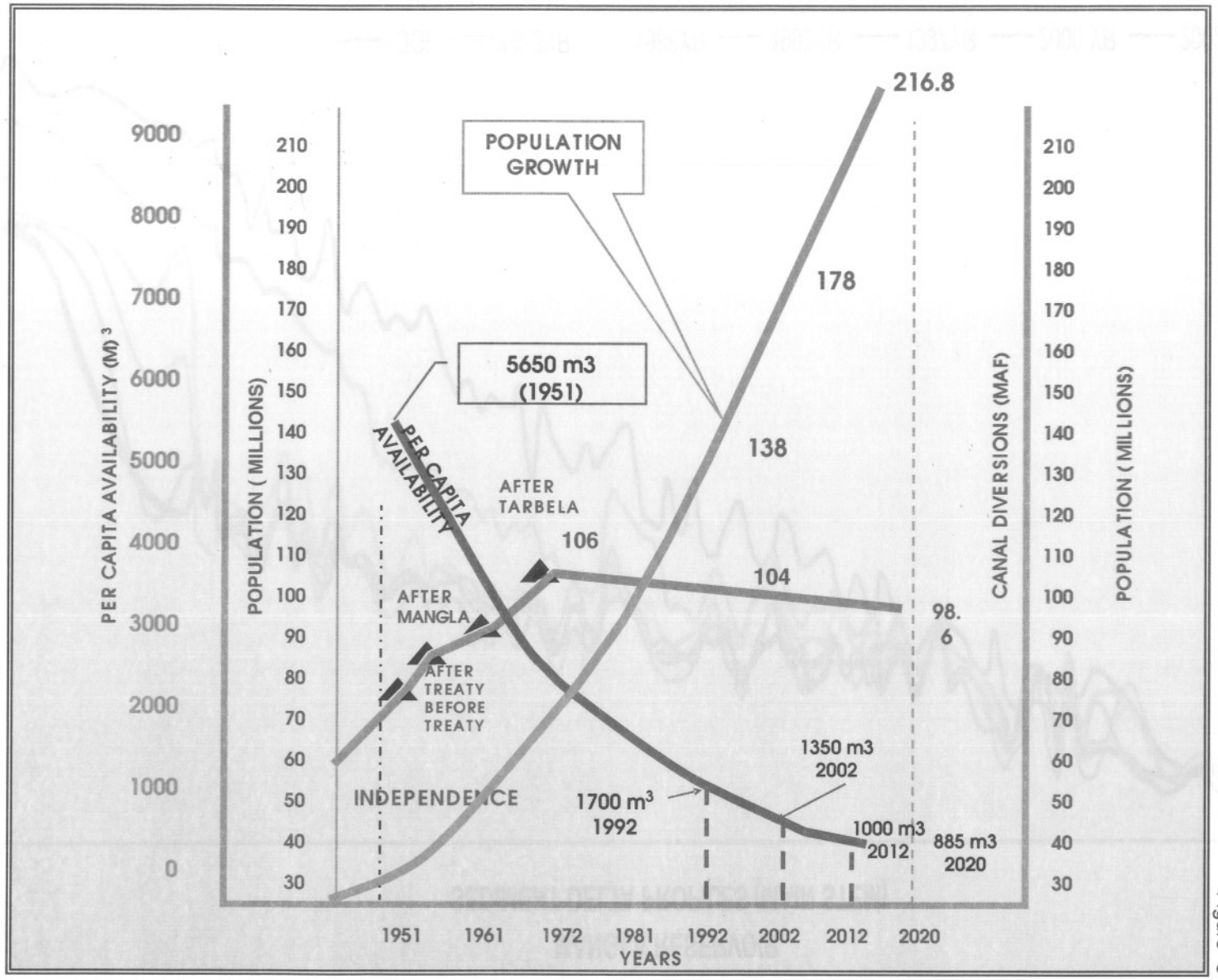


Figure -6

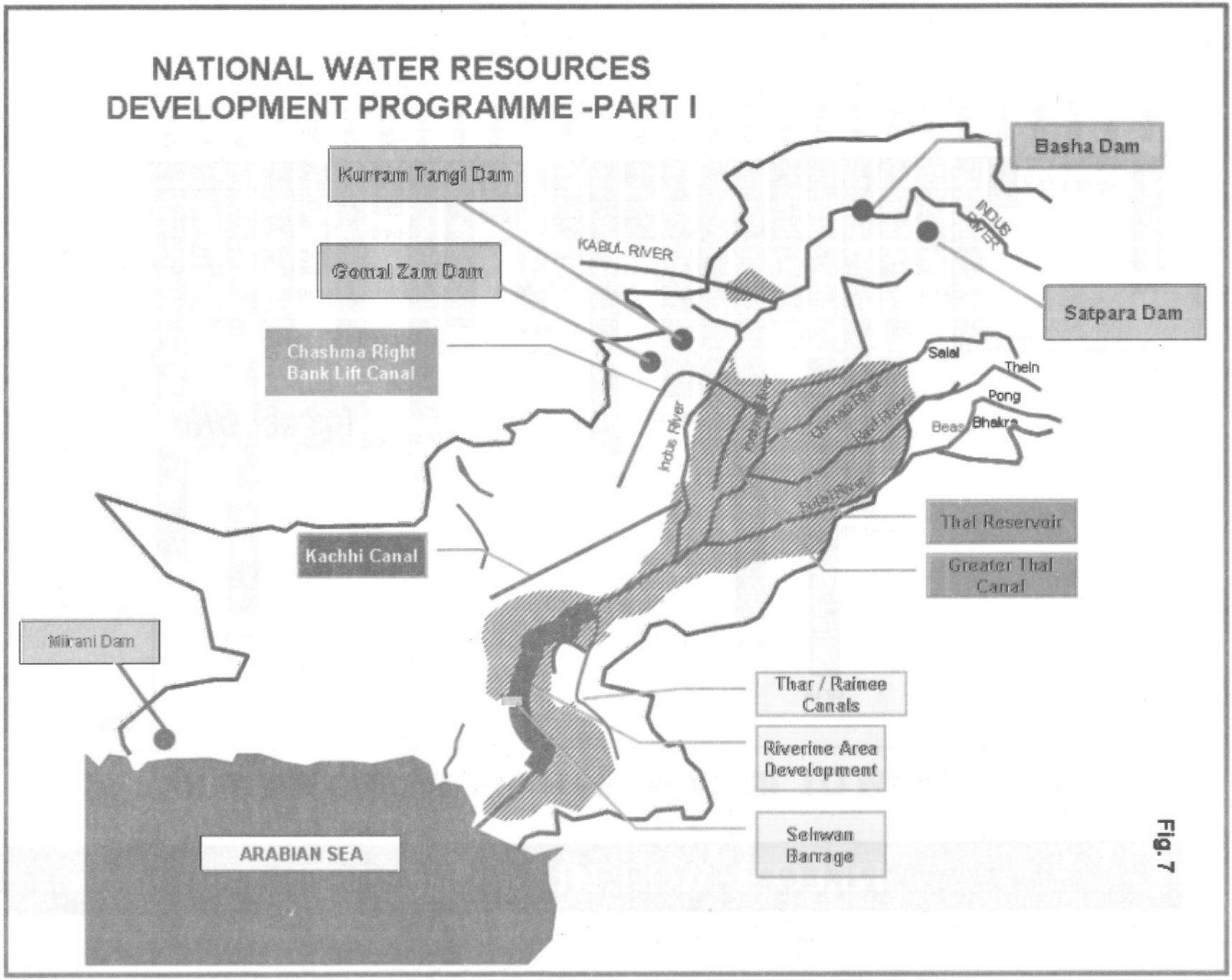

NATIONAL WATER RESOURCES
DEVELOPMENT PROGRAMME -PART I
Basha Dam
Kurram Tangi Dam
KABUL RIVER
INDUS RIVER
Gomal Zam Dam
Satpara Dam
Chashma Right
Bank Lift Canal
Salal
Thein
Pong
Bhakra
Beas
Indus River
Thal Reservoir
Kachhi Canal
Greater Thal
Canal
Mirani Dam
Thar / Rainee
Canals
Riverine Area
Development
Sehwan
Barrage
ARABIAN SEA

Fig. 7

ESCAPAGE BELOW KOTRI

(HYDROLOGICAL YEAR FROM APRIL TO MARCH)

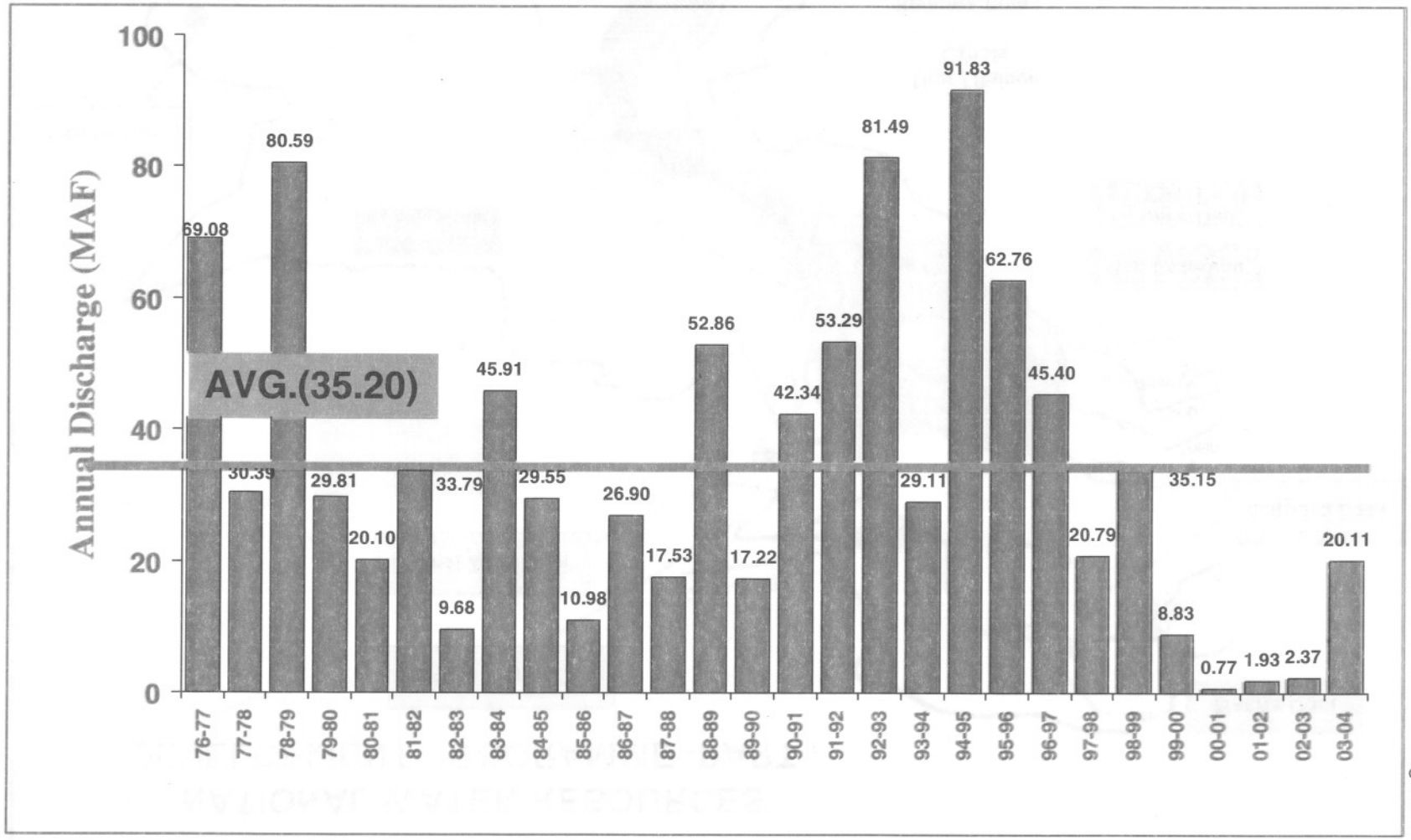
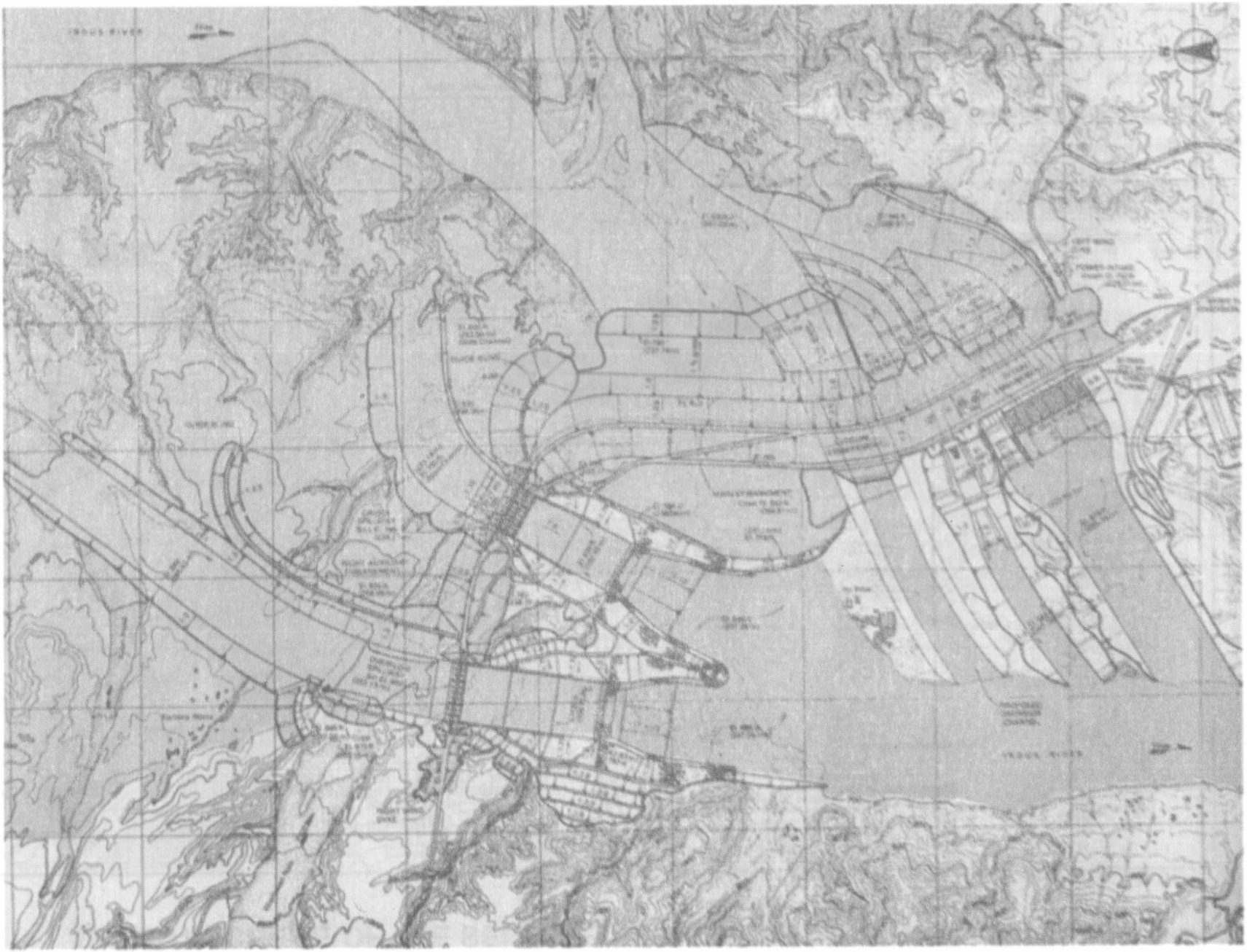


Figure -8



PROJECT LAYOUT PLAN

Fig. 9

LAYOUT SCHEME OF THE SELECTED CONCRETE GRAVITY DAM AT AXIS-D

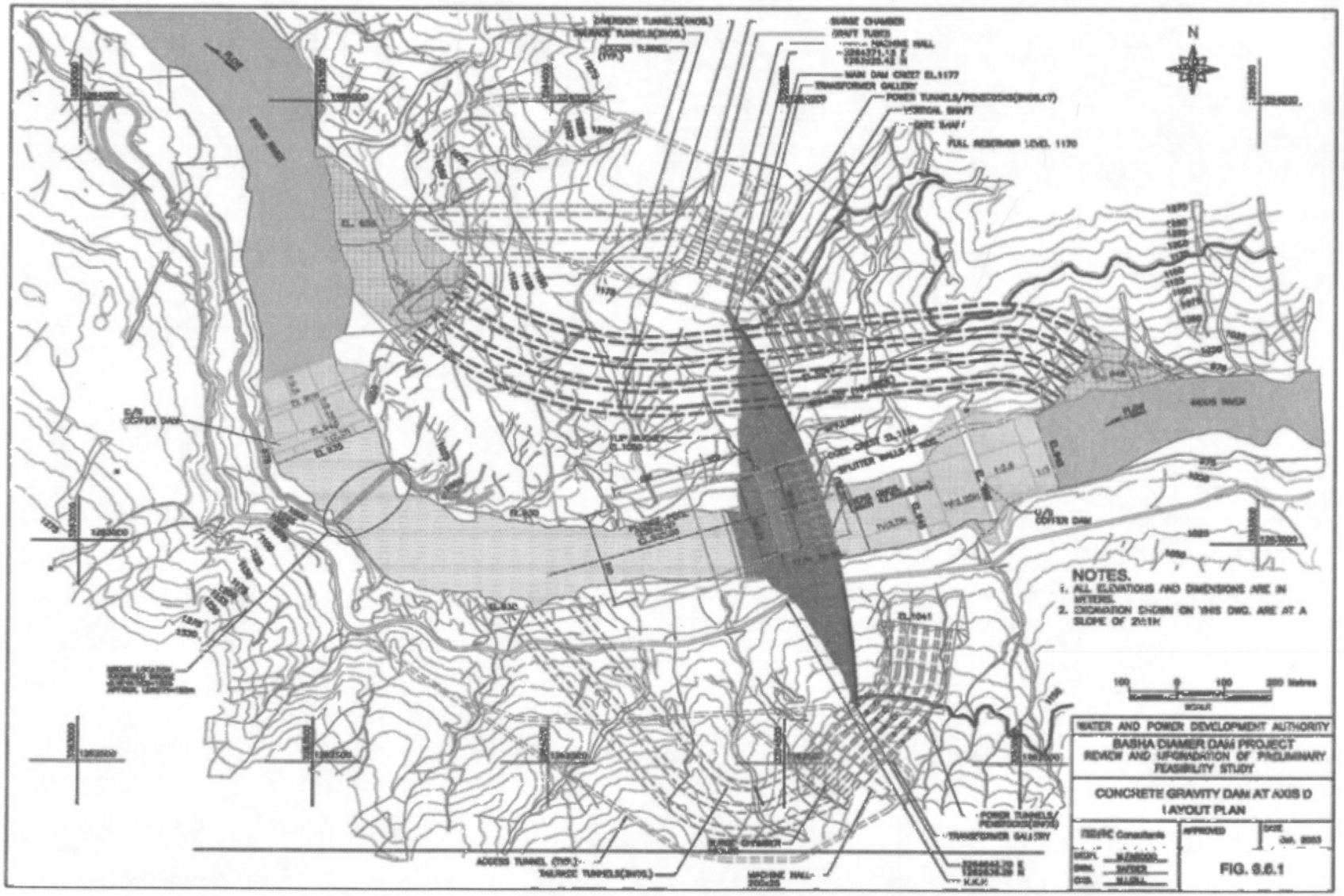
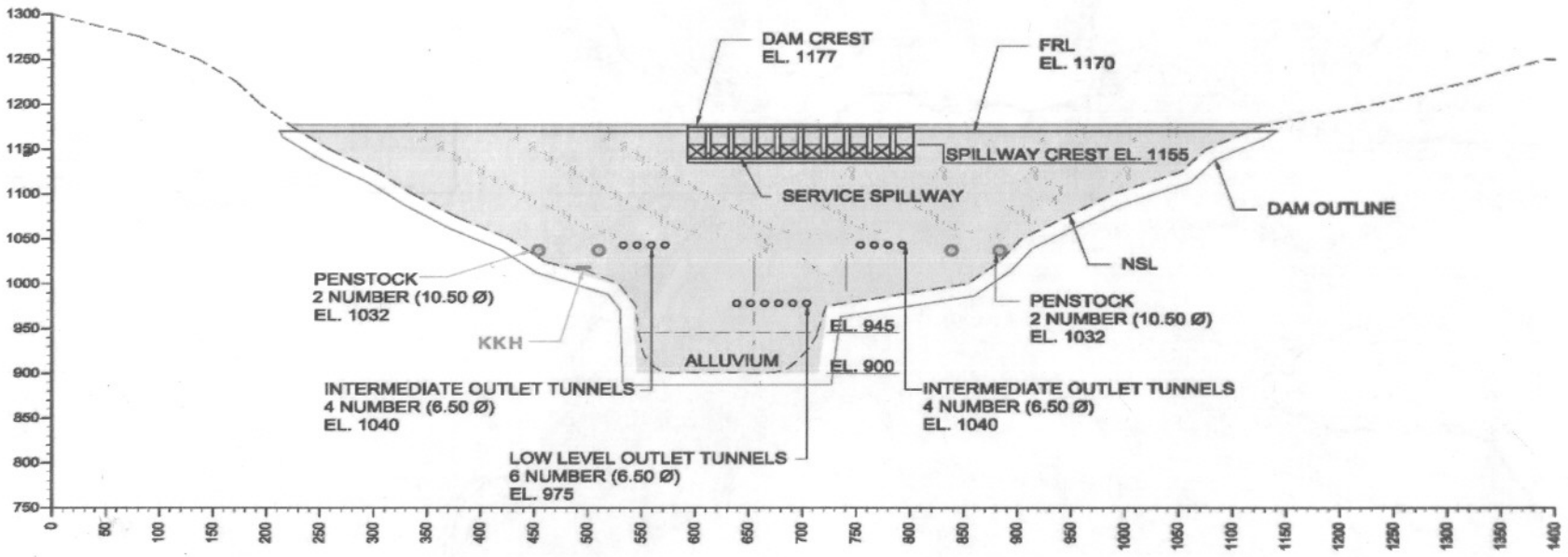


Fig. 10

BASHA DIAMER DAM PROJECT

X-SEC OF THE SELECTED CONCRETE GRAVITY DAM AT AXIS -D



L-SEC OF THE SELECTED CONCRETE GRAVITY DAM AT AXIS -D

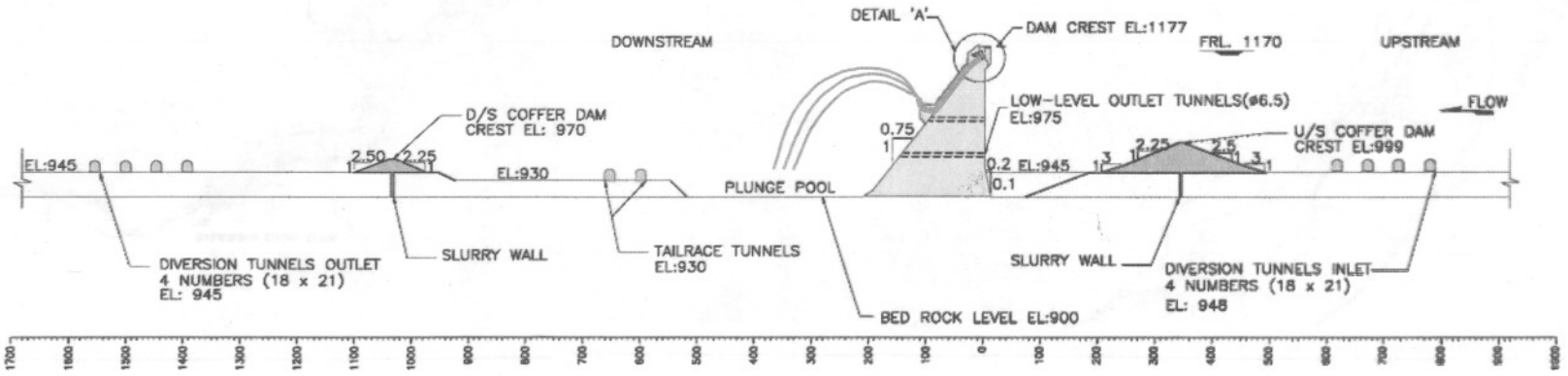


Fig. 10-A

Fig. 11

