- For easy operation and maintenance, the number of pump units should be as small as possible and the equal capacity units should be adopted.

- The larger the delivery may be, the higher the pump efficiency, so the largest delivery units should be used.

- For those of urban water supply, at least one stand-by unit must be provided. If the total pump units are small, the stand-by will be costly. Stand-by pumps will not be installed for the irrigation pumps; however total interruption of pumping operation shall be avoided by any means with more than two units installed.

- The number of units should be determined so as to be operated effectively corresponding to seasonal water-load fluctuation. (Fluctuation rangs from 1.25 to 0.8 times ordinarily in urban water supply.)

  As a conclusion, the number of the pump units for the urban water supply is recommended by four including one stand-by unit, while that for irrigation is four or two without using any stand-by units.

(4) Rising Main

The appropriate diameter of rising main pipe ranges between 800 mm and 1,350 mm, and steel pipes or ductile iron pipes shall be employed for those portions where high hydraulic pressure works.

D.2.4. Conduction Main

(1) Water Head Allocation and Canal Alignment

A detail field investigation was carried out after deliberate consideration of conduction main route on the map at the scale of 1 to 50,000, and to propose an alignment of the conduction main, the following factors were fully considered.

- Traditionally open canal systems have been mostly used for irrigation networks, while for conduction mains of urban water supply, closed systems in combined system with pipeline, tunnels and syphons. In case of open channels involved some parts in conduction mains, sandy flows during heavy rain would cause sediment deposits on the sills of structures to result in serious difficulty in operation and maintenance of the facilities.

- The conduction main should be so economically designed as to minimize the total length and construction cost.

- The design should be made so as to simplify construction works.

- The center line of the canal/pipeline alignments should be provided along the topographical contour lines for minimizing the construction cost and facilitating operation and maintenance works in avoiding heavy cutting works and high embankment works as much as possible.

- Tunnel is aligned to be as straight as possible .

- To minimize construction period the vertical or inclined shafts are proposed for a tunneling for the length of 4 km and over.

As a basic conception of water head allocation, it is required that an overall construction cost shall be minimized by means of allocating more water head available to such structures to need much construction costs (steep) and allotting less head to the structures that require low costs (gentle). The Dor conduction main system involves open channels, conduit, tunnel and aqueduct as the major structures. Among these structures, difference of the construction cost per unit length is relatively small. As a consequence, design velocity for each structure is determined as acceptable from the view of operation and maintenance within the allowable maximum velocity.

(2) Hydraulic Design

For calculation of average velocity for open channel, tunnel, pipeline, etc., the most suitable formula is to be applied in consideration of flow conditions. In the study, the Manning's Formula is adopted for open channels and tunnel which will have relatively large value of Reynolds number and roughness coefficient. While the Hazen-Williams Formula is employed for pipelines for the flows in transitional region between smooth and rough.

(a) Manning's Formula

$$V = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2}$$

where V = flow velocity in m/s
I = slope of energy gradient
R = hydraulic radius
= flow area/wetted perimeter
n = coefficient of roughness

Coefficient of Roughness (n)

Lining Material	n
Concrete	0.015
Concrete Block	0.017
Earth	0.025

Allowable Velocity (meter per second)

	Maximum	Minimum
Open channel (Concrete)	1.80	0.60
Concrete Conduit & Syphon	2.50	1.00
Tunnel with Lining	2.50	1.00

(b) Hazen-Williams Formula

$$V = 0.35464\ CD^{0.63}\ I^{0.54}$$
$$Q = 0.27853\ CD^{2.63}\ I^{0.54}$$

where V = flow velocity in m/s
Q = discharge in cu.m/s
I = hydraulic gradient
C = coefficient of roughness
D = inner diameter of pipe in m

Coefficient of Roughness (C)

In addition to friction loss, other losses such as bend loss are also considered to determine the value of "C" at 110.

Diameter and Design Velocity

In consideration of safe and easy operation and maintenance of the pipelines as well as appurtenant structure and equipment, the design velocity is determined empirically as below:

Pipe Diameter (mm)	Design Velocity (m/s)
75 - 150	0.7 - 1.0
200 - 400	0.9 - 1.6
450 - 800	1.2 - 1.8
900 - 1,500	1.3 - 2.0
1,600 - 3,000	1.4 - 2.5

(3) Shape, Size and Structure of Conveyance Cannels

(a) Open Canals

The side slope of the open canals shall be 1:1.5 and lined with concrete blocks. And the maintenance roads with 4.5 m width shall be provided on the right banks of the canals. Berm ditches shall be constructed at the toes of the slopes of the cutting works for eliminating rain water on the slopes and preventing the canals from inflow of sandy water, and on top of the above, the shoulder ditches shall be provided additionally to those for the longer slopes.

(b) Inverted Syphons

Precast pipes will be used for syphons because syphons have larger diameters. Commonly, since the inside hydraulic pressure to syphons is not so large, PRCC (reinforced concrete pipes with iron cylinders) shall be employed. At the crossing points of the rivers, the earth covers should be more than 3.0 m in thickness and the river bed protection works shall be provided for road/railway crossings, the earth covers shall be more than 2.0 m in thickness and reinforced concrete shall be placed for protection, if necessity requires. At the lowest portion, mud flash pipes or blow-off should be installed.

(c) Aqueduts

The aqueduts shall be provided with reinforced structure and a side walk shall be constructed on one side of the walls.

(d) Conduits

The conduits shall be of in-site placing reinforced concrete in structure because prestressed concrete pipes are deemed instable due to considerably heavy earth covers required.

(e) Tunnels

The cross-section of the tunnel has been determined in standard horse-shoe type because its superior workability, although inferior in strength to some extent in view of structure to that of the circular type. For mechanical construction, the minimum cross-section in diameter is 2.0 m. It is often necessary to construct lining concrete immediately after excavation, because that steel supports are deformed due to increase of earth pressure, especially when excavation works come across fractured fault zones. Even in such a case the minimum cross-section is requested to be kept after lining.

(f) Pipelines

PRCC (reinforced concrete pipe with iron cylinders) shall be used for the pipes for static hydraulic pressure by less than 4 kg/cm^2, while ductile iron pipes for the pressure more than 4.0 kg/cm^2, manholes shall be provided at the intervals of 500 m to 1,000 m, and at the bending portion in high position, air valves shall be equipped and release devices shall be installed at the appropriate position.

(4) Route Selection of Conduction Main

(a) Conduction Main from the Dor River to the Khanpur dam.

The length of the proposed conduction main from Nikapur point in the Dor river to Khanpur reservoir is about 26.5 km. The upstream course of 11 km is in the plain area which is deeply dissected by gullies. The middle course of 5 km is in the hilly area and the downstream course of 11 km is mountains which rise in the north Khanpur reservoir. The highest peak of the mountains rises 1,050 m A.M.S.L. (3,440 ft) and the elevation of the mountain foot is 600 to 680 m A.M.S.L. The mountains are composed of alternation of limestone and shale, and they are presumed to be heavily weathered.

Then water level at the starting point of the conduction main is about 688 m (2,257 ft) and the retention water level in the Khanpur dam is 604.1 m (1982 ft). The difference in water head between the two is about 84 m (275 ft). (Refer to Table D-2-10.)

The planned capacity of the conduction main is 5 cu.m per second, in cross-section and the gradient is determined by the maximum allowable velocity and about 30 m remains as excess water head.

The excess water head will be lost by constructing drops and shutes, but the construction cost of these structures must be minimized.

Spillways and waste-way will be constructed at three point along the route so as to drain rain-water at the time of heavy rain and release the canal water for its maintenance.

Table D-2-10 Hydraulic Calculation Sheet for Dor Conduction

Q=5.0 cu.m/sec

Station m	Tipe of Canal	Length m	Hydraulic Gradient	Energy Loss	F.S.L.	Remarks
0+00					689.00	
	C.	1,250	1/350	3.60	(2,260 ft)	
12+50					685.40	
	S.	100	1/530	0.21		V=1.96m/sec
13+50					685.19	
	O.CH.	100	1/600	0.20		V=1.67m/sec
14+50					684.99	
	C.	100	1/350	0.32		V=1.85m/sec
15+50					684.67	
	O.CH.	1,350	1/600	2.28		
29+00					682.39	
	S.	400	1/530	0.79		
33+00					681.60	One Drop
	O.CH.	1,200	1/600	5.07		ΔH = 3.00 m
45+00					676.53	
	A	100	1/780	0.16		V=1.92m/sec
46+00					676.37	
	O.CH.	500	1/600	0.87		
51+00					675.50	
	A.	100	1/780	0.16		
52+00					675.34	
	O.CH.	1,250	1/600	2.12		
64+50					673.24	
	S.	200	1/530	0.42		
66+50					672.82	
	O.CH.	1,100	1/600	1.87		
77+50					670.95	
	S.	200	1/530	0.42		
79+50					670.53	
	O.CH.	1,450	1/600	2.45		
94+00					668.08	
	S.	200	1/530	0.42		
96+00					667.66	
	O.CH.	350	1/600	0.62		
99+50					667.04	
	A.	100	1/780	0.16		
100+50					666.88	2 Drops
	O.CH.	2,850	1/600	11.82		ΔH = 7.00 m

Cont'd-

Station	Tipe of Canal	Length	Hydraulic Gradient	Energy Loss	F.S.L.	Remarks
m		m				
129+00					655.06	
	CHU.	300		8.00		
132+00					647.06	
	S.	200	1/530	0.42		
134+00					646.64	One Drop
	O.CH.	950	1/600	4.18		ΔH = 2.53 m
143+50					642.46	
	S.	450	1/530	0.88		
148+00					641.58	One Drop
	O.CH.	1,600	1/600	5.70		ΔH = 3.00 m
164+00					635.88	
	S.	150	1/530	0.32		
165+50					635.56	
	O.CH.	300	1/600	0.53		
168+50					635.03	
	CHU.	50		4.11		
169+00					630.92	
	S.	250	1/530	0.50		
171+50					630.42	
	T.	1,100	1/760	1.48		V=1.74m/sec
182+50					628.94	One Drop
	O.CH.	2,050	1/600	5.08		ΔH = 1.60 m
203+00					623.86	
	S.	350	1/530	0.69		
206+50					623.17	
	O.CH.	750	1/600	1.28		
214+00					621.89	
	S.	200	1/530	0.42		
216+00					621.47	
	O.CH.	100	1/600	0.20		
217+00					621.27	
	T.	4,400	1/760	5.82		
261+00					615.45	
	C.	400	1/350	1.18		
265+00					614.27 (2,015 ft)	

Sub Total	Open channel:	15,900 m		
	Aqueduct :	300		
	Conduit :	1,750	Total	26,500 m
	Tunnel :	5,500		
	Syphon :	2,700	Drop:	6 places
	Shute :	350		

(b) Conduction Main from L.B.C. to Irrigation Areas on the Left Bank of the Haro River

Irrigation water to the proposed irrigation expansion area of about 2,000 ha on the left bank of the Haro river shall be conveyed through the proposed off take at the point of RD 57,000 of LBC.

The conduction main, having a total length of 500 m, shall cross the river in syphon at the upstream of the railroad bridge and shall cross the Grand Trunk Road and railway in conduits.

(c) Widening or Construction of the conduction main from the Khanpur Reservoir to Sang Jani Filtration Plant

The water to be newly developed by construction of the proposed D-1 and H-4 Dams, shall be taken from the Khanpur reservoir through newly designed intake tower and the conveyed through a new pressure tunnel with the total length of 770 m. And the following three plans are conceived for further water conveyance method after passing through the tunnel.

Plan - A. The water shall be discharged from a stilling basin at the outlet of the pressure tunnel to the stream to flow about 6.0 km and shall be a conveyed via canal system after re-intake at Monra by a new diversion dam.

Plan B-1. A pipeline systems shall be laid from the stilling basin to around the outlet of the Haro river Syphon of L.B.C. and the L.B.C shall be widened.

Plan B-2. A new pipe line shall be provided to link the stilling basin with Sang Jani filtration plant.

Plan B-1, cannot be adopted although most easily approached in planning, because there will be some critical problems involved in the hydraulical structure and construction work volume.

i) In the downstream portion from the Julian syphon of LBC (RD 20,000), there many tunnels, syphons and aqueduts constructed, all of which would be extremely difficult in their expansion, and a new canal must be constructed in parallel with the existing canal.

The capacity required to increase is 2.7 m^3/sec for the canal, the construction cost per meter is comparatively high for the structures such as aqueducts and syphons due to their small scale, as for the tunnel, the designed minimum cross-section must be expanded to 2.0 m in diameter.

ii) In the immediate upstream and downstream of those three kinds of structures as above which will be expanded in parallel, joinning or branching works of flow will have to be provided and the dam-up head loss in such works as considerably large. Such phenomenon will seriously affect the water surface gradient of the existing LBC to result in shortage in water head. (Reference can be made to the case in the Second Stage of the Aichi Irrigation Project in Japan.)

Consequently, a comparative has been made on the construction costs of the two plans of Plan A and Plan B-2 and found the Plan B-2 is advantageous to the Plan A when the design discharge is less than 4 m^3/sec. Since 1.0 m^3/sec for irrigation water can be conveyed through the existing LBC, 2.7 m^3/sec of the urban water shall be supplied the proposed new pipeline.

The plan for urban water to be conveyed through the other LBC route will favourably result in mitigating heavy rain damages in water supply interruption with LBC, controlling the water quality, and keeping well maintenance of the total conveyance systems.

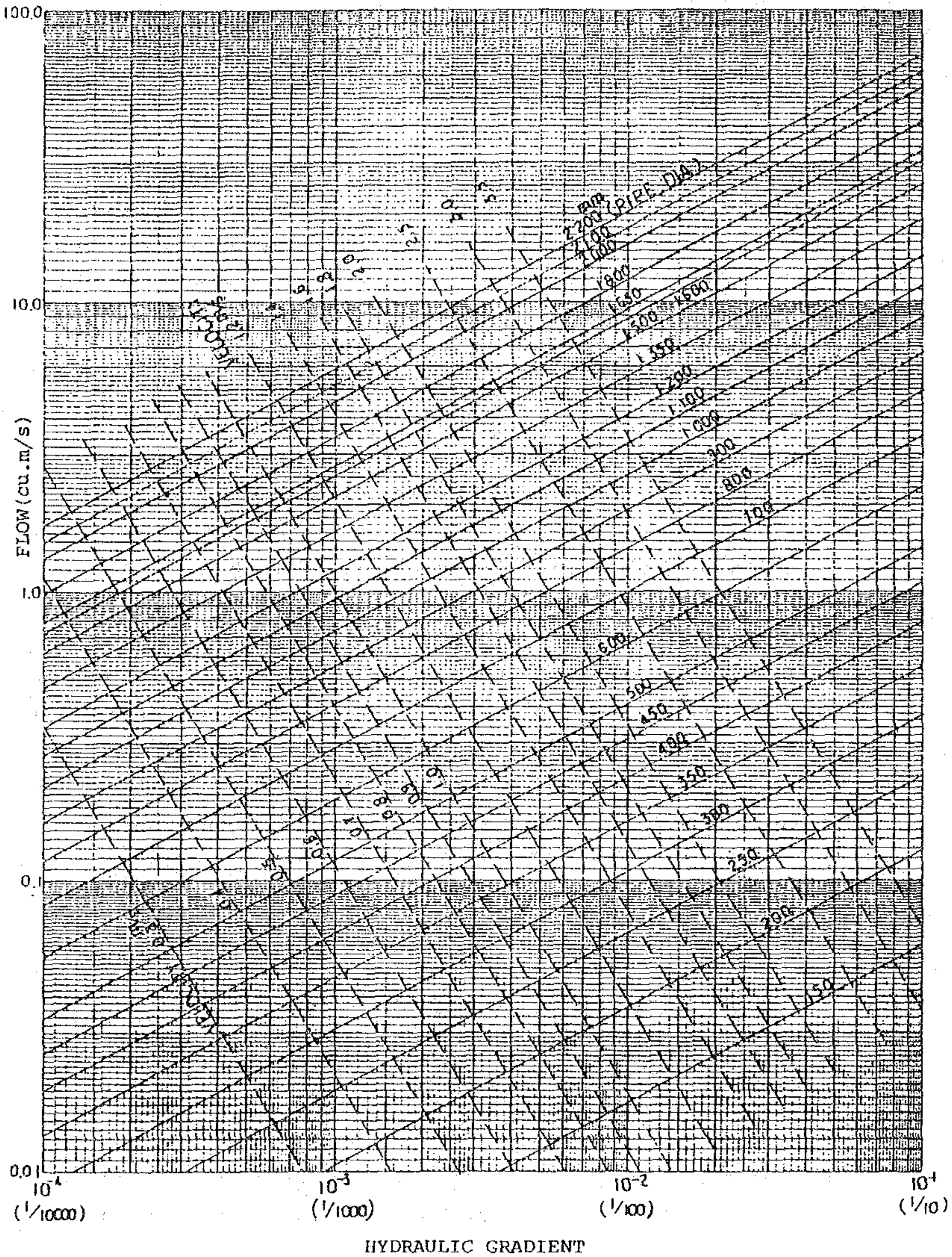
Table D-2-11. Dimensions of Pumping Station

Name	Amount (cu.m)	Pump (mm kw unite)	Suction WL. (m)	Delivery WL. (m)	Total Lift (m)	Rising Main (mm	km)
Kcp-1	5.00	ϕ700 x 2,000 x 6	521.2	633.4	122.0	ϕ1,350 x 2	2.5
Kcp-2	4.60	ϕ700 x 1,200 x 6	521.2	601.7	90.0	ϕ1,350 x 2	2.5
Lp-1	2.77	ϕ700 x 780 x 4	525.0	575.0	54.0	ϕ1,000 x 2	1.2
KLp-1	0.99	ϕ400 x 160 x 4	490.0	514.0	38.0	ϕ900	3.7
SLp-1	1.70	ϕ500 x 720 x 4	451.0	534.0	103.0	ϕ1,100	5.5
Sip-1	0.51	ϕ350 x 55 x 2	390.0	400.0	13.0	ϕ400 x 2	0.05
Np-1	1.20	ϕ400 x 500 x 4	432.5	505.8	77.0	ϕ1,100	0.2
Jp-1	2.70	ϕ600 x 1,100 x 4	387.0	491.0	108.0	ϕ1,000 x 2	0.3

Table D-2-12. Specifications of Intake and Conveyance Facilities

Item	Type and Specification			River Basin
1. Diversion Dam				
Dw-1	Floating	$H = 2.1^{m}$ $L = 194.5^{m}$		Dor River
Jw-1	"	$H = 1.9$ $L = 80.0$		Jhablat Kas
2. Pumping Station				
Kcp-1	Volute Pump,	$\phi 700^{mm} \times 2{,}000^{kw} \times 6^{unite}$	discharge $5.0^{cu.m/sec.}$	Sang Jani T.P.
Kcp-2	"	$\phi 700 \times 1{,}200 \times 6$	4.6	"
Lp - 1	"	$\phi 700 \times 780 \times 4$	2.8	Ring River
KLp-1	"	$\phi 400 \times 160 \times 4$	1.0	Kurang River
SLp-1	"	$\phi 500 \times 720 \times 4$	1.7	Sil Kas
Sip-1	"	$\phi 350 \times 55 \times 2$	0.5	Soan River
Np-1	"	$\phi 400 \times 500 \times 4$	1.2	Near Shahpur Dam
Jp-1	"	$\phi 600 \times 1{,}100 \times 4$	2.7	Jhablat Kas
3. Conduction Main				
Dc-1	Canal System,	$L = 26.5^{km}$	5.0	Dor River
Kp-1	Pipeline System,	$L = 21.0^{km}$ $\phi 1{,}500^{mm}$	2.7	Khanpur Riservor
Kc-4	Canal System,	$L = 1.0^{km}$	7.8	L.B.C.
Sc-1	Pipeline System,	$L = 11.5^{km}$ $\phi 1{,}350^{mm}$	2.4	Soan R. near Cherah
Lc-1	"	$L = 12.5^{km}$ $\phi 1{,}000^{mm} x2$	2.8	Ling River
Rc-2	"	$L = 11.0^{km}$ $\phi 1{,}350^{mm} x2$	5.2	Pind Dara T.P.
SLc-1	"	$L = 5.5^{km}$ $\phi 1{,}100^{mm}$	1.6	Sil Kas
KLc-1	"	$L = 3.7^{km}$ $\phi 900^{mm}$	1.0	Kurang River
Nc-1	"	$L = 5.0^{km}$ $\phi 1{,}100^{mm}$	1.2	Shahpur Dam
Jc-1	"	$L = 8.2^{km}$ $\phi 1{,}350^{mm}$	2.7	Jhablat Kas
Kc-8	Canal System,	$L = 0.5^{km}$	1.0	L.B.C.

FIGURE D-2-4. NOMOGRAM OF HAZEN-WILLIAMS FOUMULA (C = 110)



D.3 Cost Analysis and Comparison of Alternatives

D.3.1 Construction Costs and Operation/Maintenance Costs

(1) Basic Concepts of Cost Analysis

Construction costs of proposed facilities, storage dams, diversion dams and conveyance systems, are estimated using unit prices at January 1987.

Materials and labour costs are determined using the market costs and the next references.

- SCHEDULE OF RATES Building and Roads 1982
  (Government of Pakistan)
- FINAL REPORT FOR FEASIBILITY STUDY ON THE CONDUCTION OF WATER FROM KHANPUR TO ISLAMABAD/RAWALPINDI 1985
  (The Japan International Cooperation Agency)

(a) Construction Costs of Storage Dams

Dam construction costs are estimated for dam bodies, spillway and outlet works which are the main components of dam construction.
The construction costs of dam bodies are estimated for each damsite by using rough dam volumes and unit costs.
The construction costs of spillway and outlet works are determined using the component ratio of the costs for each work, taking difficulties of each work into consideration.
Unit prices are determined using a rough break down taking into account recently constructed dam projects in Pakistan.

(b) Construction Costs of Diversion Dams and Conveyance Systems

For Such conduction facilities as open canal, tunnel, conduit, siphon and aqueduct, cost estimate is made by using the figure indicating the relationship between planned discharge and construction cost per one meter. Cost estimate for such facilities as chutes, drops, blow-off spills, main road, rivers and railway crossing is seperately made.

Pipeline is categolized to ductile cast iron pipe which is used for high pressure zone and to reinforced concrete pipe used for low pressure zone. Its cost is estimated by using the figure indicating the relationship between pipe diameter and construction cost per one meter.

For pump station, its cost is estimated by using the figure indicating the relationship between planned lifting capacity and construction cost per one unit. Pumping station includes suction tank, delivery tank, building and pump equipments.

Construction cost of headworks, however, is estimated indipendently.

(c) Operation/Maintenance Costs

Annual operation/maintenance costs after completion of construction are obtained by applying a certain ratio to the construction costs, and electric power costs are added for pumping stations.

(2) Construction Costs and Operation/Maintenance Costs of Proposed Facilities

Cost estimation has been carried out for storage dams, diversion dams and conveyance systems based on the procedures and methodologies described above.

Table D-3-1 shows the construction costs and Operation/Maintenance costs of proposed facilities. The construction costs of the storage dams, which are composed of that of damdody, spillway, outlet works and others are shown in Table D-3-2.

Table D-3-2 Construction Costs of Proposed Dams

Unit ; M.Rs.

Dam No.	Dambody	Spillway	Outlet Works	Total Costs
D - 1	812.15	221.50	139.00	1,172.65
H - 4	1,110.33	353.29	225.69	1,689.31
S - 1	Main Dam ; 283.20 , Flank ; 98.32			381.52
L - 1	1,092.96	298.08	184.84	1,575.89
KL - 1	193.94	61.71	47.79	303.44
SL - 1	288.54	78.69	48.27	415.50
[Shahpur]	---	---	---	60.00

TABLE D-3-1. Sizes and Costs of Proposed Facilities

Classification	Name	Location	Type	Size	Capacity	Production (Annual)	Initial (M.Rs.)	O/M Cost (M.Rs./Yr.)
Storage Dam	D-1	on Dor river near Rajola	Earthfill Dam	H=85.0, L=1590	60.0MCM	107MCM	1172.7	5.5
	H-4	on Haro river near Pina/Jabri	do	H=132.5, L=510	125.0	80	1689.5	7.1
	(Khanpur)	on Haro river, Khanpur	do	H=50.9, L=472+α	112.9	160	935(*1)	2.3(*1)
	(Simly)	on Soan river, Simly	do	H=80.2, L=308	24.7	34.7→52.8		
	(Rawal)	on Kurang river, Islamabad	Masonry Gravity Dam	H=40.7, L=213	53.0	37.9→39.9+α		
	S-1	on Soan river near Cherah	C. Gravity Dam	H=65.0, L=260+1750	66.0	60	381.5	2.5
	L-1	on Ling river near Dadhochai	Earthfill Dam	H=92.5, L=1570	91.0	70	1575.9	6.7
	KL-1	on Krung river near Lohi Bher	do	H=42.0, L=300+910	16.3	34	305.4	2.5
	SL-1	on Sil Kas near Dhok Shaban	do	H=55.5, L=420	62.0	40	415.5	2.5
	(K-2)	on Upper Kurang near Dohala	? (expected)	H= , L=	?	?		
	(Shahpur)	on Nandna Kas near Shahpur	Masonry Gravity Dam	H=30.6→32.6	40.0	17.3	60.0(*2)	2.5
Head Works (Intake)	Dw-1	on Dor river near Nikapah	Floating Weir	H=2.1, L=194.5	-	(107)	74.1	2.2
	Ki-2	on Khanpur Dam	Intake Tower		Max2.7m^3/S	(67.1)	56.8	2.0
	Jw-1	on Jhablat Kas, Hassan Abdal	Floating Weir	H=1.9, L=80.0	-	70.8	27.2	2.0
	(Kurang)	on Kurang river near Bharakao				0.0→5.3		
	(Shahdara)	near Shahdara				2.9→4.0		
	(Nurpur)	near Nurpur				1.0→1.3		
(Spring)	(Saidpur)	in Saidpur	N.C.	N.C.	N.C.	1.2→1.1		
	(G.C.Old)	in National Park				3.2→2.9		
	(G.C.New)	in National Park				3.9→3.6		
	(G-10)	in Sector G-10				2.9→3.3		
	N.P-1	in National Park	Fixed Weir	(H=1.0, L=20.0)	-	?(expected)	(15.0	2.0)
	Sw-1	on Soan river near G.T. Bridge	do	(*3)				
	Sw-3	beside Soan river near Dahgal	Sump	ϕ800mm x 0.3km	-	6.4	1.1	-
Lift	Jp-1	on Jhablat Kas near H. Abdal	Volute Pump	ϕ600x1100kw x 4	Max2.7m^3/S	(70.8)	116.1	13.3
	Np-1	near Shahpur Dam	do	400 500 4	1.2	(17.3)	73.3	7.1
	Kcp-1	at Sang Jani T. Plant	do	700 2000 6	5.0	(126.4)	193.5	40.2
	Kcp-2	ditto	do	700 1200 6	4.6	(114.8)	186.0	24.9
	SLp-1	at Dam SL-1	do	500 720 4	1.7	(40)	70.5	10.3
	Lp-1	at Dam L-1	do	700 780 4	2.8	(70)	111.5	10.9
	KLp-1	at Dam KL-1	do	400 160 4	1.0	(34)	50.5	3.8
	Swp-1	at Head Works Sw-1	do	(*3)				
	Sip-1	beside Soan river near Dahgal	do	350 55 2	0.5	(5.4)	33.0	2.3
Conduction	Dc-1	from Dw-1 to Khanpur Dam	Canal System	L=26.5km	5.0	(107)	225.8	2.5
	(Kc-2)	from Khanpur Dam to Nic. Monm.	do	19.4	11.1	(188.5)	108.7	1.1
	Kp-1	from Khanpur Dam to Nich. Monm.	Pipeline System	21.0, ϕ1500	2.7	(67.1)	476.7	4.8
	Kc-4	from Nich. Monm. to Sg.Jani T.P.	Canal System	1.0	7.8	(174.1)	119.6	1.2
	Kc-8	from Nich. Monm. to HRLBCA	do	0.5	1.0	(14.2)	4.8	0.5
	Kc-6	from Sg.Jani T.P.to S.Allahditta	Pipeline System	6.4, 1350x2	5.0	(126.4)	256.0	2.6
	Kc-5	from Sg.Jani T.P. to Tomar	do	16.5, 1350x2	4.6	(114.8)	406.9	4.1
	KZo-1	from Dam K2 to Islamabad	do		?	?		
	(Simc-1)	from Simly T.P. to Islamabad	do	27.8, 900x2	1.4→2.1	(34.7→52.8)		
	(Rc-1)	from Rawal T.P. to Rawalpindi	do	6.5, 1350	1.2→1.9	(29.8→37.2)		
	SLc-1	from SL-1 to Rawalpindi	do	5.5, 1100	1.6	(40)	77.0	0.8
	Sc-1	from S-1 to Pind Dara T.P.	do	11.5, 1350	2.4	(60)	71.3	0.7
	Rc-2	from Pind Dara T.P.to Rawalpindi	do	11.0, 1350x2	5.2	(130)	161.0	1.6
	Lc-1	from L-1 to Pind Data T.P.	do	12.5, 1000x2	2.8	(70)	280.0	2.8
	KLc-1	from KL-1 to Rawalpindi	do	3.7 900	1.0	(34)	34.8	0.3
	Rc-3	from SW-1 to Rawalpindi	do	(*3)				
	Jc-1	from Jhablat Kas to HRLBCA	do	8.2 1350	2.7	(70.8)	42.7	0.4
	Nc-1	from Shahpur Dam to HRLBCA	do	5.0 1100	1.2	(17.3)	22.0	0.2
Tube Wells	(T.W.-Wah)	in Wah/Taxila area				60-70(incl.Springs)		
	(T.W.-Islm)	in Islamabad area	Deep Well almost	ϕ = 8-12"	0 150m^3/hr.	23.5→35.5		
	(T.W.-Rwl)	in Rawalpindi area		Dep=60-120m		35.6→49.5		
	T.W.-Arp	near Rakh Pind Ranjha				0.8→ 2.5		

D.3.2 Proposed Storage Dam Size

Table D-3-4 shows the initial costs, operation/maintenance costs and the unit water costs estimated for several sizes of selected storage dams.

Figure D-3-1 shows the sizing curves of the seven potential dams and the two previously proposed dams (N-1 and M-1 Dam) which had been alternated to the new proposed dams on the second field survey and study for the sake of reference. Unit water costs have a rapid increase corresponding to the increase in dam size. The optimum size for any dam shall be the point of lowest unit cost and shall give as high as possible water production.

From Figure D-3-1, there are two dam groups, one having comparatively low unit costs (D-1, S-1, SL-1, KL-1 Dams and the Shahpur Heightenning Scheme) and the other have rather high unit costs (H-4 and L-1 Dams, N-1, M-1 Dams).

The former may have increased in size upto the upper limits of dam construction technology and compensation problems.

From the technical point of view, there may not be much of a problem increasing the sizes of the dams, but S-1 Dam will have a rapid increase in objects which will be submerged at Cherah Village located just upstream of the damsite.

KL-1 Dam and Shahpur Heightenning Schemes were studied about such sizes as are considered to be the upper limits concerning the problems of compensation.

The KL-1 damsite has been proposed in the lower reach of the Kurang river basin where the command areas are broadly distributed. The normal water level of the KL-1 reservoir has been assumed EL 480 m which was considered the elevation not to submerge the beneficiary area of the project. On the other hand, the low water level has been worked out EL 475.5 m in consideration of sedimentation. In consequence, the usable water depth of the reservoir resulted in narrow range , less than 5 m, where any other alternatives could not be selected.

The normal water level of the Shahpur Dam will be raised from 1,458.25 ft (444.47 m) to 1,475 ft (449.58 m) level by the proposed Shahpur Heightenning Scheme. The value of the raising height has been determined considering not to submerge the Fatehjang Road, as shown in Appendix D.4.4.

Therefore, the dam sizes shown in Table D-3-3 shall be recommended.

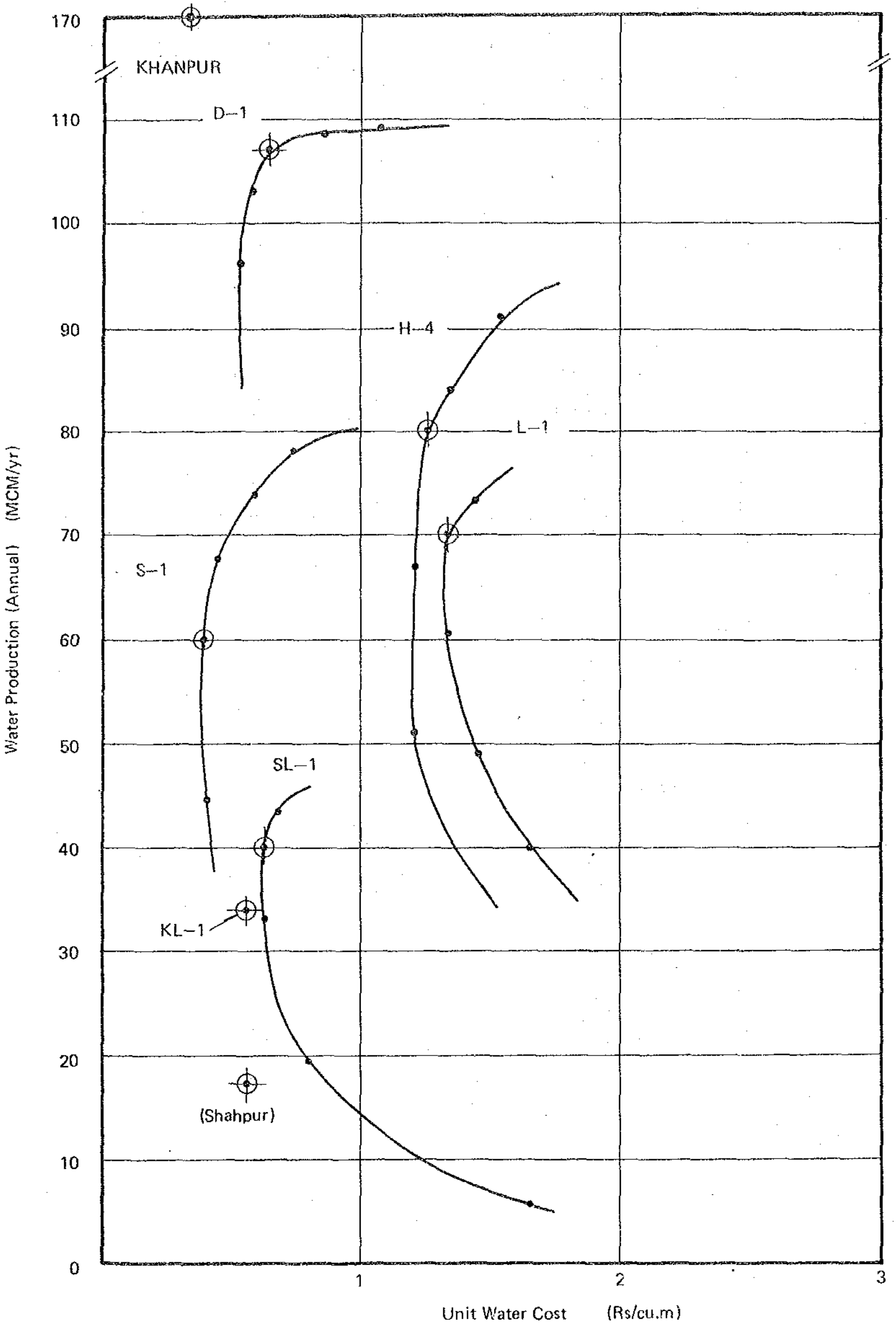
Table D-3-3 Recommended Sizes of Potential Dams

Dam Name	Annual Production	Effective Capacity	Utility Ratio
D-1 (Rajoia)	107 MCM	60 MCM	1.78
H-4 (Pina)	80	125	0.64
S-1 (Cherah)	60	66	0.91
L-1 (Dadhochai)	70	91	0.77
KL-1 (Lohi Bher)	34	16.3	2.09
SL-1 (Dhok Shaban)	40	62	0.65
Shahpur Heightenning	17.3	40	0.53

Table D-3-4. Sizes and Costs of Proposed Dams

Dam	No.	Size H(m)	Size L(m)	Capacity (Live) (MCM)	Production (Annual) (MCM)	Initial & O/M Cost (M.Rs.,	M.Rs./Yr.)	Water Cost (Rs./cu.m)
D-1	①	97	1890	100	109	1977.09	7.9	1.07
	②	91.5	1780	80	108.5	1572.77	6.7	0.86
	③	85	1590	60	107	1172.65	5.5	0.65
	④	82	1510	50	103	1017.55	5.1	0.59
	⑤	79	1390	43	96	869.40	4.3	0.54
H-4	①	148	560	200	91	2389.96	8.4	1.53
	②	137.5	530	144	84	1911.00	7.7	1.34
	③	132.5	510	125	80	1689.31	7.1	1.25
	④	124.0	480	92	67	1366.09	6.1	1.21
	⑤	114.0	445	62	51	1028.17	5.1	1.20
S-1	①	79.5	300+2070	180	78	971.16	4.9	0.74
	②	74.5	290+1990	130	74	728.13	3.6	0.59
	③	69	275+1910	88	67.5	507.65	2.5	0.45
	④	65	260+1750	66	60	381.52	2.5	0.39
	⑤	61	250+1050	43	44.5	284.89	2.5	0.41
L-1	①	95.5	1870	120	73.5	1786.85	7.4	1.43
	②	92.5	1570	91	70	1575.89	6.7	1.33
	③	89	1470	70	60.5	1355.46	6.1	1.33
	④	86	1340	50	49	1198.55	5.6	1.45
	⑤	84	1270	35	40	1102.79	5.3	1.64
KL-1		42	300+910	16.3	34	303.44	2.5	0.56
SL-1	①	60	470	100	43.5	497.06	2.5	0.68
	②	55.5	420	62	40	415.50	2.5	0.63
	③	50.5	345	37	33	334.07	2.5	0.63
	④	44	305	13	19.5	237.85	2.5	0.80
	⑤	41	280	5	6	204.21	2.5	1.64
[(Shahpur)]		30.6 →32.6	256	40	17.25	60.00	2.5	0.56
N-1	①	61	1615	140	66.5	1942.70	7.8	1.71
	②	57.5	1585	105	60	1693.95	7.1	1.66
	③	54.5	1545	76	52.5	1476.50	6.4	1.66
	④	52	1520	54	44.5	1317.65	6.0	1.75
	⑤	49.5	1495	42	38.5	1142.70	5.4	1.76
H-1	①	66.5	4120	70	32	1662.99	7.0	3.06
	②	62.5	3980	50	29.5	1321.48	6.0	2.65
	③	59	3800	35	27	1059.49	5.2	2.34
	④	53.5	3550	20	22.5	774.53	3.9	2.05
	⑤	51	3160	10	15	591.09	3.0	2.35
Upper Simly (Chaniot)	①	110	640	46	11.1	1498.65	6.5	7.98
	②	100	565	30	9.6	1129.95	5.4	7.00
	③	90	505	18	7.6	926.60	4.6	7.28
	④	80	450	9	5.1	650.80	3.3	7.63

Figure D-3-1. Unit Water Cost and Water Production



D.3.3. Alternatives to the Water Conduction from the Dor River

There is a plan proposed for water conduction from the Dor river to the Khanpur reservoir by trans-basin in diverting water immediately upstream of the Tarbela reservoir. If realization of the plan, however, should become impossible by some reasons, two alternative are worked out on the topo-map at the scale of 1:50,000; one is to divert the water immediately downstream of the Tarbela dam and the other is to take water from the Jhelum river flowing north to south about 50 km east of the Capital Territory.

The dimensions of the facilities required for the aforesaid alternatives are shown in Table D-3-6, and the necessary costs for construction and operation and maintenance are shown in Table D-3-5.

Table D-3-5. Costs for Construction and Operation/Maintenance

(Unit: Rs Million)

	Dor Canal		Jhelum Canal		Tarbela Canal	
	Construction Cost	O/M	Construction Cost	O/M	Construction Cost	O/M
Dam	1,082	5.4	-	-	-	-
Diversion Dam	131	3.9	-	-	-	-
Pumping Station	-	-	374	54	179	69
Canal	703	7.0	1,722	17	2,506	25
Total	1,916	16.3	2,096	71	2,685	94

Table D-3-6. Diversion of Facilities Required

	Dor Intake	Jhelum Intake	Tarbela Intake
Dam	Live Storage 60 MCM Dam Height 85 m Dam Length 1,800 m Dam Volume 6.0 MCM	-	-
Head Work Dam	Intake Amount 5 m^3/sec Height 2.1 m Length 194 m	-	-
Pumping station	-	Water Amount 4m^3/sec Rojgarh Sta. Pump ϕ600mm x 1,900kw x 6 units Rising ϕ1,200mm x 2 300m L1 Station ϕ600mm x 720kw x 6 units ϕ1,200 x 2 500m	Water Amount 4m^3/sec ϕ600mm x 3,500kw x 6 units ϕ1,200mm x 2 2,800m
Conduction Main	Canal system Length 26.5km (Incl.5.5km of tunnel) Capacity 5m^3/sec Pip Lin Capacity 2.7m^3/s ϕ1,500mm 21km	Pip Lin Capacity 4m^3/sec ϕ1,800mm 3.9km ϕ1,200mm x 26.2km Tunnel Diameter 2.10m Length 17.5km	Pip Lin Capacity 4m^3/sec ϕ1,500mm x 2 46.1km Tunnel Diameter 2.10m Length 5.4km

D.4. Water Resources Development Plan

D.4.1. Present Water Resources and Water Supply

In the study area, water resources have been developed to satisfy the water utilization and its increase. Major water utilization in the study area arises in Islamabad, Rawalpindi and Taxila/Wah area as urban water, and in the Haro River Right Bank Command Area as irrigation water. Other than those major water utilization, water resources have been developed to meet local water utilization for domestic and irrigation purposes in small scale.

Irrigation water for the Haro River Right Bank Command Area is supplied only by surface water developed by the Khanpur dam. Urban water for Islamabad, Rawalpindi and Taxila/Wah area is supplied by many sources of water developed by dams, diversion dams, pumps and tube wells. Those facilities and water utilization are listed in Table D-4-1 for Islamabad, in Table D-4-2 for Rawalpindi and in Table D-4-3 for Taxila/Wah area. Other water utilization than Islamabad, Rawalpindi and Taxila/Wah area is described in A.2.3. of Appendix A.

Table D-4-1. Existing Urban Water Supply Facilities (Islamabad)

Location	Water Works MLD	Shallow Well Nos.	Tube Well Nos.	Pump or Booster Nos.	Reservoir ML	Overhead Tank Nos.	Remarks
Simly	109.1						Dam
Kurang	(10.9)←suspended						Head Works
Shandara	9.1				4.5		ditto
Noorpur	3.2						ditto
Saidpur	3.6				4.5		Spring
Golf C. New	12.3				6.6		Head Works
Golf C. Old	10.0		8				ditto
National Park		34.0 MLD ←	23	2			
Hill Side					4.5+9.1		
E-10					(22.7+36.4) ← proposed		
F-5					31.8		
F-6					22.7	2	
F-8			3				
F-9			1 → 30.3 WLD in subtotal.				
F-10		1	1				
G-5			1				
G-6						1	
G-7		2	2			4	
G-8			3			4	
G-9			6				
G-10	9.1	2	1		9.1		
H-7					2.0+4.6		
H-8			3				
H-9			4			1	
I-8			2			1(under const.)	
I-9			5			2	
I-10			2				
I-11			2				
Total	220.7 (incl. Tube Wells)	5	68		99.4 (+59.1) in near future	15	

Table D-4-2. Existing Urban Water Supply Facilities (Rawalpindi)

Location (Agency)	Water Works MLS	Shallow Well Nos.	Tube Well Nos.(MLD)	Pump or Booster Nos.	Reservoir ML	Overhead Tank Nos.	Remarks
PHED	95.6			1	xx.x		Rawal F.P.
			6 (11.3) ✓				Sohan Vil.
			10 (17.8)	1	xx.x	22.7	Others
	(xx.x)←intending to rehabilitate.			1		xx.x	Hailay W.W
RMC			56 (47.1)		xx.x	00.9	
Cantonment B.			9 (19.3)		xx.x	0.45+2.73+11.82	
MES (Army)			2 (1.1)		xx.x		
MES (PAF)					xx.x		
Total	95.6		83 (96.6)		xxx.x	xx.x	

Note: Facilities entirely abandond are not included

Table D-4-3. Water Usage in Taxila/Wah Area

Surveyed in Aug., 1987

Items	H.R.F., MES, Taxila Cantt. (Heavy Rebuild Factory)	Municipal Committee Taxila	H.M.C. & H.F.F., PIDC (Heavy Mechanical Complex)	P.O.F., Wah Cantonment	Hassan Abdal Town Committ.	Others (Total)
1. Establishment	1976 ~ 77	1978	H.M.C. = 1968, H.F.F. = 1972	1950(Spring),1970(T/W)	1589(Spring),1965(System)	Others are Wah
2. Water Requirement						
Domestic	1.1 MGD (1.8 MCM)	1.0 MGD (1.7 MCM)	1.75 MGD (2.9 MCM)	5.3 MGD (8.8 MCM)	1.6 MGD (2.7 MCM)	Municipal area and many rural villages
(Population)	12,000 ~ 15,000	44,000 (of which about 60% are served)	8,000 ~ 9,000	>100,000	33,000	of which detailes are not clarified
Factory	0.7 (1.2)		0.95 (1.6)	10.6 (17.6)		yet.
Total	1.8 MGD (3.0 MCM)	1.0 MGD (1.7 MCM)	2.70 MGD (4.5 MCM)	15.9 MGD (26.4 MCM)	1.6 MGD (2.7 MCM)	A.C.C. Factory (Cement), Brick,
3. Sources & Capacity						Glass, Textile, Pump
Main Sources	T.W at Usman Khattar 0.9 MGD (1.5 MCM) 4Nos.x1/2x@1.0 = 2.0 cusecs	T.W at Subarban at Taxila 1.0 MGD (1.7 MCM) 2Nos.x45000G/hr x 12 ~ 16hrs	T.W near Haro Left Bank 1.35x2 (2.25x2) @4Nos.x2Bodies x @3.0 cusecs	Wah Springs beside Mughal Garden (Capact.=44 cusec, Opr.Cap.=35 cusec, 31.5 MCM)	Hassan Abdal Springs beside Punja Sahib 1.6 MGD (2.7 MCM)	Factories etc. of which quantities are not clarified yet.
Other Sources	T.W in the Cantt. area 0.9 MGD (1.5 MCM) 4Nos.x@0.5 = 2.0 cusecs			15.7 MGD (26.1 MCM) T.W in the Cantt. area 4.0 MGD (6.6 MCM)		Jhablat Kas Lift Irrig. Scheme since 1963 has about 2 MCM/yr. production
Total	1.8 MGD (3.0 MCM)	1.0 MGD (1.7 MCM)	2.7 MGD (4.5 MCM)	19.7 MGD (32.7 MCM)	1.6 MGD (2.7 MCM)	for 570 ha.
4. Main Facilities						
Conduction Main		ø12" SP, L=5.05km		ø27",30" Cast Iron	ø10" Cast Iron	Hassan Abdal Well
Underground-Reservoir	Domestic 1x1.0MG (1x4.5ML) Factory 1x0.26 (1x1.2ML)	1x0.02MG(0.09ML) under C.		2x2.5MG(2x11.4ML), Chlorinated.		Irrig. Scheme since 1968 has about
Overhead Tank	Domestic 3x0.2 (3x0.9ML) Factory 1x0.04 (1x0.18ML)	under C. 1x0.05(0.2), 1x0.01(0.05)		1x1.0MG+5x0.5MG+5x0.2MG = 4.5MG (20.5ML)	1x0.1MG+2x0.026MG = 0.152MG (0.7ML)	3.5 MCM/yr. production for 1200 ha.
5. Present Situation	Satisfactory	Not satisfied	Satisfactory	Not satisf.. Summer depression of T.W water makes less than 20 hrs opr./day.	Not satisfied by facilities but may be enough of resources by the spring.	There are many shallow wells in the area.
6. Further Plans	No expansion plan within 10 years. Room boad indicates 2.0 cusec water from Khanpur Dam. (≒1.1MGD→1.8MCM)	None There are some shallow wells in the area.	25 cusecs (≒13.5MGD→22.4MCM) from Khanpur dam being expected.	15 MGD (24.8MCM) from Khanpur dam being expected. Minor-1 canal completed.	Expansion facilities being proposed/requested to PHED, Punjab.	Total water usage in the area may be 60 ~ 70 MCM/yr.

D.4.2. Major Water Resources in the Study Area

According to the basic concept of water resources development mentioned in 6.1.1 of Main Report, numbers of possible water resources have been pointed out and their locations are listed up with those of the users (beneficiaries) in Table D-4-4.

Their schematic profiles by elevation are shown in Figure D-4-1.

Table D-4-5 is showing the principal conversion factors on water resources and water demand for sizing the facilities in this study.

Table D-4-4. List of Potential Water Resources and Water Users

Location Prov./Div./Dist./Teh.	Code Name of Resources	Av.Ann. Run-off (MCM/Yr.)	Potential Resources (MCM/Yr.)	Elevation (LWL) (m/MSL)	Conductions /Distances (Km)	Users	Elevation (Average) (m/MSL)	Annual Demand, 2030 (MCM/Yr.)	Location Teh./Dist./Div./Prov.
NWFP/ //Abbotabad	Dam D-1	96.2	107	981.5	--70.5-- --81.0--				
/Abbotabad//Haripur	H.W.Dw-1	154.7	(107)	690.0	--52.2-- --62.7--				
	Dam H-4	209.5	80	815.0	--54.3-- --64.8--	R.B.Irrig.	550~	57.7	//N.W.F.(66%),Punj.(34%)
	Khanpur Dam	327.0	160	579.7	--25.8-- --36.3-- ⇒	L.B.Irrig.	530~	33.9	//Punj.(78%),N.W.F.(28%)
						PIDC,Taxila	500~	22.5	Rawalpindi///Punjab
Punjab/Rawalpindi//	T.W.-Wah & Springs	-	60~70	~470~	--(0)-- ⇒	POF,Wah	475~	24.8	
//Attock/FatehJang	H.W.Jw-1	170.4	70.8	380.0	--4.8-- ⇒	H.L.Irrig.	500~	113.9	Attock & FatehJang///
	Shahpur Dam	42.5	17.3	440.4	Sang Jani T.P. ⇒	Islamabad (Urban proper)	620~	205.5	///Capital Territory
Capital/ / /Islamabad	Simly Dam	83.5	52.8	680.6	T.P. --27.0-- ⇒				
	Head Works	-	Σ21.5	-	T.P. --(0)-- ⇒				
	T.W.-Islm.	-	Σ35.5	-	--(0)-- ⇒				
					--2.5-- T.P. ⇒				
	Rawal Dam	(103.6)	xx.x	520.6	--1.0-- ⇒	R.L.Irrig.	515~	5.2	
					--6.5-- T.P. ⇒	Rawalpindi (Urban & Rural)	525~	361.0	Rawalpindi///Punjab
	Dam KL-1	102.7	34.0	475.5	--3.7-- ⇒				
	Dam S-1	130.9	60	570.0	--22.5--				
Punj./Rwlpnd.//Kafuta	Dam L-1	107.1	70	529.0	--26.2-- Pind Dala T.P. ⇒				
Punjab/Rawalpindi//	H.W.Sw-1	Succeeded by KL-1		424.3	--3.0-- ⇒				
	Dam SL-1	50.1	40.0	453.0	T.P. --5.0-- ⇒				
	T.W.-Rwl	-	Σ49.6	-	--(0)-- ⇒				
	T.W.-Arp.	-	(2.5)	~545~	--(0)-- ⇒	N.I.A.P.	~545~	2.5	
	Lift Sp-1	(638.7)	(7)	410	--4.5-- ⇒	S.R.Irrig	475~	6.4	
NWFP/Abbtbd.//Haripur	Tarbela Dam	75200	(107)	396.2	--54.3-- ⇒	Users of Khanpur Con.		(107)	studied as alternatives
Punj./Rwlpnd.//Muree	Jhelum Lift	(28400,Mng.Dam)	(107)	~450~	--60.4-- ⇒	Do (Major=Islamabad)		(107)	for the Dor Conduction

FIGURE D-4-1. Schematic Profile of Potential Water Resources and Users

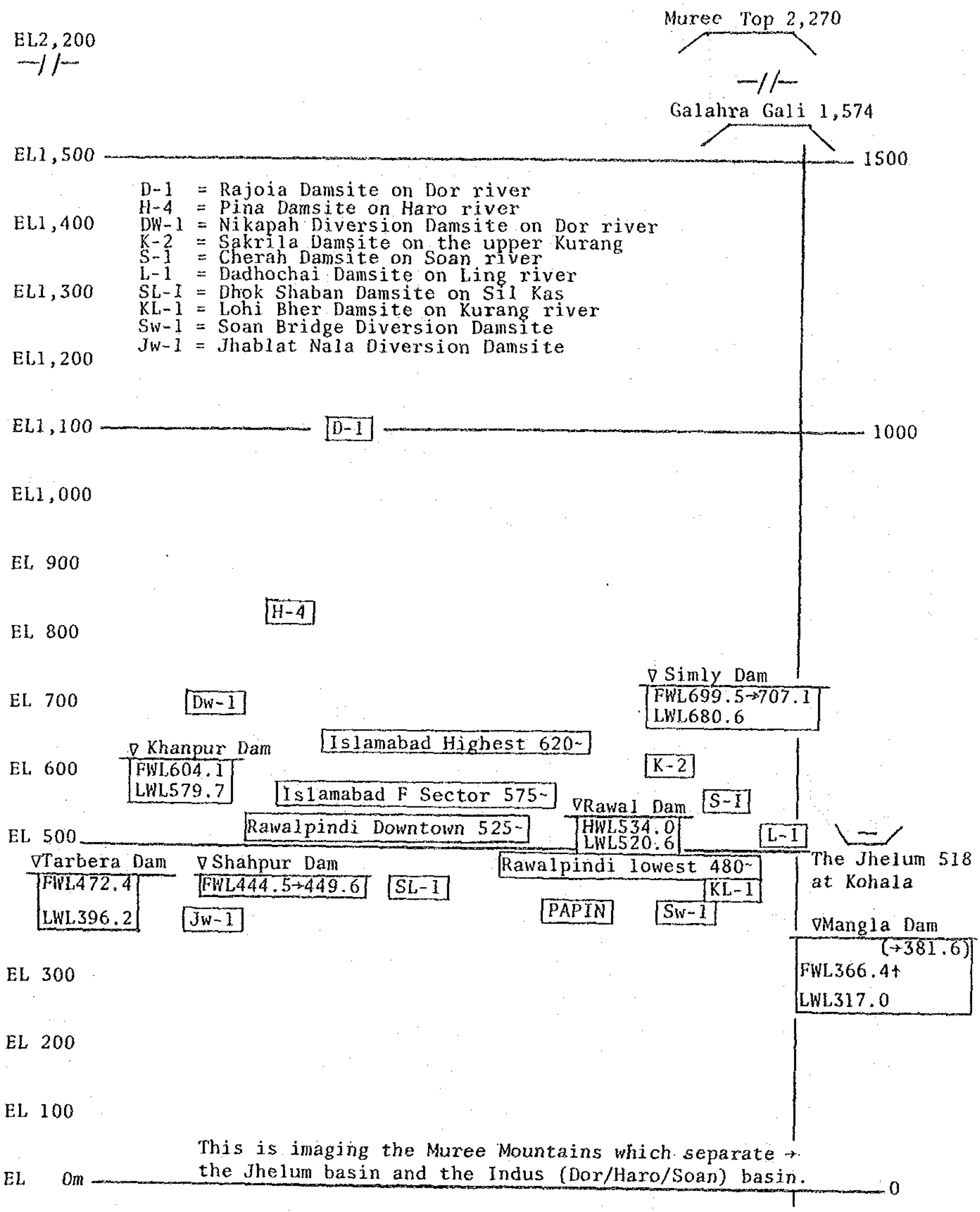


TABLE D-4-5. PRINCIPAL CONVERSION FACTORS FOR SIZING FACILITIES OF THE PROJECT

Dam

Annual Water Production = "Water Resources" in Appendix A ← Conversion-Code ① → Effective storage capacity = Dam size

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① ; see Figure A-4-2, Table A-4-8 in Appendix A

Irrigation Facility

Culturable Commanded Area x 0.93 → Irrigable Area →② → Annual Water-Demand
Irrigable Area →③ → Size of Irrigation Facility

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② ; Rate of Annual Water Demand = 7,077 cu.m/ha/yr.
∵ Available Annual Water Resource (MCM/yr.) x 141.3 = Irrigable Area (ha)

③ ; Rate of Conveyance Capacity = 0.508 cu.m/sec/1000 ha
or Size of Conveyance Fac. (cu.m/s) = 0.0718 x A.A.W.R. (MCM/yr.)

② and ③ are for 140% of cropping intencity. (refer to Appendix C)

[AF] x 1233.5 = [cu.m]

Facility for Urban Water Supply

Population served → Daily Demand→④ → Annual Average Demand
Daily Demand →⑤ → Size of Conveyance Facility

④ ; Ann. Av. Demand (MCM/yr.) = 365 x 1.05 x Daily Demand (MCM/day)
1.05 is for loss.

⑤ ; Size of Conveyance (cu.m/sec) = Daily Demand (cu.m/day) x 1.25 x 41.05/86,400
or = 0.0317 x 1.25 x Ann. Av. Demand (mcm/yr.)
1.25 is for Load-fluctuation

[cusec] x 0.5383 = [MGD], [cumsec] x 19.005 = [MGD]
[MGD] x 4.546 = [MLD], [MGD] x 1.659 = [MCM/yr.]

Annual Facility Cost (Amortization and Operation/Maintenance)
= Initial Cost x ⑥ + O/M Cost

	E. Life of Facility	Ann. Interest = 5%
⑥ ;	20 years	⑥= 0.0802
	40	0.0583
	50	0.0548

D.4.3. Water Allocation From Khanpur Dam

Khanpur Dam, one of the most important water resources in the area, has been projected for the year 2000 with requirements by specified beneficiaries concerned. These are confirmed verbally by the team during the second phase of the study.

However in the same time, as mentioned in the Table III-2-5, Taxila/Wah area in which two (PIDC and POF) of those proposed beneficiaries are existing proved to have rather abundant groundwater (and spring water) resources. It seems as a reason why they have not taken water from the Khanpur Dam yet.

From the view point of water supply cost[1)], it is evident that groundwater resources in the vicinity have higher advantage than that of storage dam in the distance.

Note: 1) On rough estimation, concerned unit water costs shall be as follows;

Water from Khanpur Dam; approx. 1.0 Rs/cu.m.
(incl. costs of D-1 system and H-4 in order to keep the originally proposed Khanpur Dam production)
Water from Tubewells in the vicinity; 0.4 Rs/cu.m.
Water from Springs along Bauhti Nala; 0.7 Rs/cu.m.
(Estimated under an annual interest of 5% for amortization cost)

Then, the water allocation from Khanpur Dam could be tentatively revised as follows;

Table D-4-6. Water Allocation From Khanpur Dam

(MCM/year)

Beneficiaries	Original Requirement (1972 - 73)	Current Supply (1984)	Other Resources (1987)	Future Demand (2000-)	Ditto from Khanpur Dam (Recommended)
R.B.C for Irrigation	57.7	41.8[1]	None	57.7	57.7
L.B.C for Irrigation	33.9	25.0[2]	None	33.9	33.9
POF (Wah)	24.8	None	Spring etc. 32.7+	24.8+	0.0
PIDC (Taxila)	22.5	None	Tube Wells 8.2[3]+	22.5+	0.0
CDA (Islamabad)	54.6	None	Simly Dam etc.	54.6+	54.6+
PHED (Rawalpindi)	114.8	None	Rawal Dam etc.	114.8+	114.8+

Note: 1) ... 62.6% (share of R.B.C among total CCA of Khanpur) of 66.8 MCM (Annual Khanpur production computed by JICA F/S of the Khanpur Conduction in 1984. See their report II-14 and A.II-88)

2) ... 37.4% of the same above.

3) ... 8.2 MCM includes 3.6 MCM of H.R.F in Taxila Cantonment.

D.4.4. Development of Nandna Kas for the Irrigation of HRLBCA

Proposed water resources for the Irrigation of HRLBCA

1. for 10,000 ha; from Jhablat Kas through a Lift and a Pipeline
2. for 2,440 ha; from Nandna Kas trough N-1 Dam, a Lift and a Pipeline = Alternative 1
   or trough heightenned Shahpur Dam, a Lift and a Pipeline = Alternative 2
3. for 2,000 ha; from Khanpur Dam through Khanpur Conduction (Minor Kc-8)
4. for 1,660 ha; by three Small Scale Lift Irrigation Schemes

Proposed Nandna Kas Development

Alternative 1: Construction of N-1 (Dhok Baloch) Dam, a Lift and a Pipeline

L.W.L = EL416.0 m (1365 ft)
N.W.L = 435.0 (1427)
H.W.L = 440.0 (1444)
Dam Top = 442.5 (1452)
Mean Annual Run-off ≈ 84.8 MCM
Live Storage ≈ 105.0 MCM
Mean Annual Production = 60.0 MCM

Demerits 1. High cost of dam construction.

2. Removal of 500 KV extra high voltage Transmission Line (Tarbela - Gatti (Faisalabad) Line)

3. Submergency of a part of Shahpur Dam and CCA of the Project.

Elevation of CCA = EL441 m (1350 ft) - 442 m (1450 ft)

Dam body; Base = EL418 m (1370 ft),
Top = EL449 m (1472 ft)

Alternative 2: Heightenning of Shahpur Dam

	Original	Madified
L.W.L	= EL442.72 m (1452.5 ft) 1)	EL440.4 m 2) (1445.0 ft)
N.W.L	= 444.47 (1458.25 ")	449.58 m 3) (1475.0 ")
H.W.L	= 447.55 (1468.35 ")	449.58 m 4) (1475.0 ")
Dam Top	= 448.77 (1472.35 ")	450.8 m 5) (1479.0 ")
Mean Annual Run-off	= 20.6 MCM (16,700Af)	43.0 MCM (34,860Af) 6)
Live Storage	= 5.031 MCM (4,079Af)	40.0 MCM (32,410Af)
Mean Annual Production	= 10.4 MCM (8,447Af)	10.4 + 17.3 MCM (22,100Af)

Demerits 1. Heightenning works may interrupt the original irrigation scheme.[7)]

2. G.T road (Nandna Bridge) may be submerged.[8)]

3. Water conveyance cost may be high.[9)]

Note: 1) Present dimensions of Shahpur Dam Project are by P.C.I, Oct. 1980

2) L.W.L440.4 m, Sediment 7.28 MCM = 203.9 sq.km x 357 cu.m/sq.km/yr. x 100 yr.
357 cu.m/sq.km/yr = 0.75 Ac-ft/sq.mile/yr. (This is a annual specific sediment for the Area "E" of Small Dams Projects on the ADB Report)

3) Assumption of 1475 ft. as Normal Pond Level is preliminary based on the upper limit of pond-capacity data on the P.C.I (page 47).

4) To keep H.W.L lower than G.T road, gated spillway could be proposed.

5) Freeboad of the dam is same as the original.

6) Mean annual run-off could be revised as studied in A.4.5 (2) b in Appendix A.

7) To keep the continuous function of existing Shahpur Dam, the heightenning works should be done at the downstream side of the dam.

8) Elevation of G.T. road bridge is about 1482 ft. that is higher than proposed H.W.L (1475 ft).

9) Water conveyance cost is under study. It may be lower than that of Jhablat Kas Conduction.

D.4.5. Alternative Irrigation Method by Groundwater Lifting

1. Water demand for 3000 ha irrigation

- Peak irrigation water requirement:

$$Q = 3{,}000 \text{ ha} \times \frac{0.508 \text{ m}^3/\text{sec}}{1{,}000 \text{ ha}} = 1.524 \text{ m}^3/\text{sec}$$

- Annual average water requirement:
  V = 6.045 MCM/1,000 ha x 3,000 ha
  = 18,135,000 m^3 = 14,700 Acft.

2. Water production expected by tube well

- Unit production per one tubewell per one day (around 16hr operation) will be about 300 m^3 in an average.

- Annual operation days of lift pump will assume about 200 days. That is to say that annual production per one unit of tubewell is estimated at about 60,000 m^3.

- Required number of tubewell for entire area is about 300 unit. (18,350,000 ÷ 60,000 = 300)

3. Initial and operation/maintenance cost

- Initial cost of tubewell: 0.9 MRs x 300 = Rs. 270 Million
  Operation/maintenance cost: Rs 12.8 M/year

$$\frac{0.163 \times 300 \times \frac{1}{16 \times 60} \times 100 \times 1.15}{0.50} = 12 \text{ kw}$$

4. Unit Water Cost

- Total annual cost of the facility

$$C = \frac{270\ (0.05 \times (1 + 0.05)^{20})}{(1 + 0.05)^{20} - 1} + 12.8$$

$$= 21.67 + 12.80 = 34.47 \text{ Million Rupees}$$

- Unit Water Cost

U.W.C. = 34.47 ÷ 18.14 = <u>Rs. 1.90 per cu.m</u>

5. Comparison

- In case of Shahpur dam heightenning

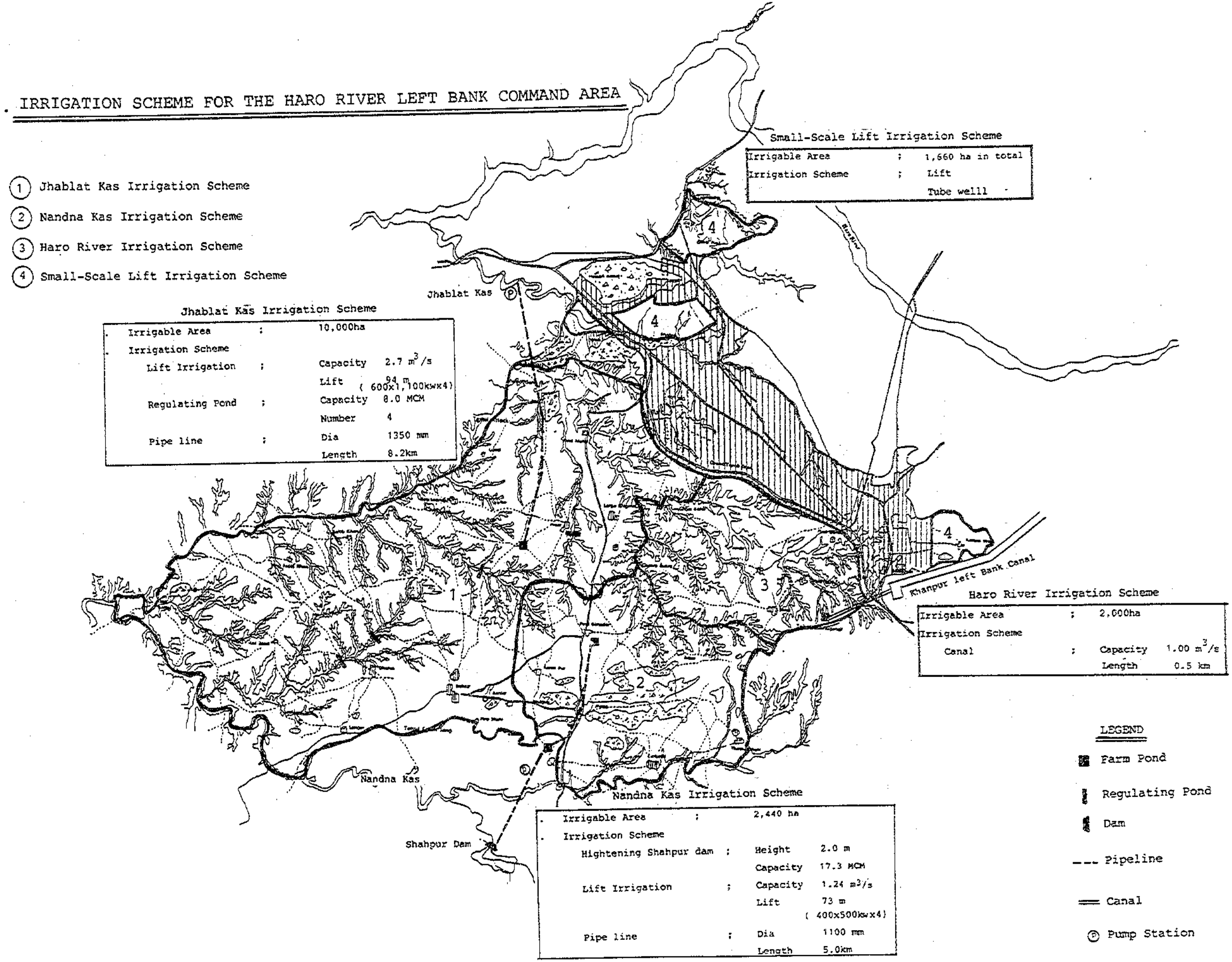
Item	Shahpur Dam.	Lift Pump	Pipeline
Initial cost (M.Rs)	60.0	73.3	24.6
OM cost/yr (M.Rs)	2.5	7.1	0.2
Durable lift (Yr)	50	20	40
Annual cost (M.Rs)	5.79	13.0	1.63
Annual production (MCM)	21.2	21.2	21.2
Unit water cost (Rs/cum.)	0.27	0.61	0.08
Ditto accumulated (")	0.27	0.88	0.96

- In case of groundwater development

Unit water cost: 1.90 Rs/cu.m

Therefore, shahpur dam case is cheaper than that of groundwater case.

Figure D-4-2. IRRIGATION SCHEME FOR THE HARO RIVER LEFT BANK COMMAND AREA



D.5 Recommendation on the Future Operation/Maintenance for the Existing Dams (Rawal, Simly and Khanpur)

D.5.1 Present Status on the Operation/Maintenance of the Existing Dams

Through field survey and review existing reports, the present operation/maintenance of Rawal, Khanpur and Simly Dams are summarized in Table D-5-1 and D-5-2.

(1) Purpose and Organization of the Existing Dams

The three existing dams were constructed in adjacent river basins and have functioned as independent dam projects for the purpose of urban water supply and or irrigation to each beneficiary. The dams have not functioned as one of the dam series which have been proposed in this Report for the water resourses development for the metropolitan area of Islamabad/Rawalpindi.

The authorities of the three dams are shown in Table D-5-1, but the organizations of each beneficiary are complicatedly consist of several organizations. For a instance, the Khanpur Dam has been constructed to provide water to Islamabad and Rawalpindi for domestic purposes, to the various industries at Wah and Taxila and irrigation water for culturable command areas of both the Left and Right Bank Cannal.

(2) Operation

Generally speaking, the operation of reservoirs are carrid out in order to satisfy the purposes of the projects, such as water supply, hydroelectric generation and flood control, etc.

Because the three dams have only the purpose of water supply, the operation of intake gates and spillway gates are required for the operation of the reservoirs.

Table D-5-1 Salient Features of Existing Dams

Name	Rawal	Khanpur	Simly
Authority	Irrig. Dpt. (SDO)	WAPDA	CDA
River	Kurang	Haro	Soan
Catchment Area (sq.km)	275.1	778.0	152.8
Live Storage (MCM)	53.0	112.2	24.7
Dam Type	Masonry Gravity	Earthfill	Earthfill
Dam Height (m)	40.7	50.9	80.2
Purpose			
Urban Water (cu.m/day)	104,600	680,400	109,100
Irrigation (cu.m/day)	24,500	250,700	--
Gates			
Intake	Sluice 3 Nos. 3'Wx5'H	Fixed Wheel 5.5'x5.5'	Butterfly Valve 2 Nos. ø36"
Spillway	Radial 8 Nos. 30Wx102.5"H	Radial 5 Nos. 40'Wx35'H	2 Nos. 25'H in future
Rainfall Gauging	2	Nil	1
Water Level Gauging			
Catchment Area	2	Nil	1
Dam	1	2	2
Construction Year	1952-62	1967-83	1972-82

Table D-5-2 Operation/Maintenance of Existing Dams

1. OPERATION	RAWAL	KHANPUR	SIMLY
Intake Gate			
- Operation Rule	- Based on water demand	- Based on water demand	- Based on water demand
- Hoist	- Manual hoist	- Manual hoist	- Manual hoist
Spillway Gate			
- Operation Rule	- Correspond to reservoir level, not based on inflow data	- Correspond to reservoir level, not based on inflow data	- Ungated Spillway, installation of gate is planned in future
- Hoist	- Electro-manual hoist	- Electro-manual hoist	
- Control	- Machine side & remote control (not individual)	- Machine side & remote control of each gate	
2. MAINTENANCE			
O/M Manual	- Exist	- Under preparation	- Completed '87
Inspection & Patrol	- Civil-Mechanical Works	- Embankment dam, Spillway, Outlets, Diversion tunnel, Mechanical equipment	
Monitoring	- Carried out by Dam Monitoring Organization	- Movement, Piezometer, Seepage - Sonar Survey	- Seisomology

(a) Operation of intake gates

Intake gates are operated in accordance with the operation rules based on seasonal water demand fluctuations. They are operated manually because the size of intake gates are rather small and daily changing of gate openings, and the operation to correspond to inflow discharge into the reservoir are not required.
For these reasons, the overall catchment area hydrological data collection systems have not been prepared.

(b) Operation of spillway gates

Spillway gates are operated in accordance with the operation rules corresponding only to fluctuations in reservoir water level.
Data collecting systems which would enable inflow discharge into reservoir to be forecast are lacking as mentioned previously.
The hoists of spillway gates are both automatic and manually operated, but auxiliary power systems, such as engine generators in the case of electric failure, are not provided in the present.

(3) Maintenance

The maintenance of dam facilities are carried out in order to secure the functions of facilities necessary for satisfing the purpose of the dam projects. The facilities to be maintained are dambodies, spillways, intake structures, outlet works and mechanical equipments, etc. Besides these facilities, the prevention measures for securing the storage capacities and the water qualities, described in chapter A.7, are to be considered.

Maintenance works are mainly consist of daily patrol, routine inspection, special inspection, monitoring and remedial works for dambodies and appurtenant structures.

Dam monitoring is undertaken in order to grasp the behaviors of dams and appurtenant structures for the security of the safety of dams.

Maintenance of the three dams are appropriately carried out corresponding to the types of dams and the passage of time after completion.

As Rawal Dam has experienced the filling of the reservoir during about twenty-five years after completion, the behaviors of the dam are considered to become in a stable condition. For this reason, it is considered reasonable that the items and frequencies of the maintenance works are not so district ones compared to that of Khanpur Dam and Simly Dam.

On the other hand, Khanpur and Simly Dams are both earthfill dams which have experienced only five year's filling of the reservoirs after completion. The items and frequencies of the maintenance works adopted at the both dams are considered appropriate and reasonable considering that monitoring is one of the most important factors to secure the safety of a dam, and judging from the field survey.

D.5.2 Assessment of the Present Operation/Maintenance System

It is recommended that the three existing dams shall be provided with modernized dam operation/control systems including hydrological gauging stations with telemetering systems, dam data processing systems and discharge warning systems in the final stage, and that the present gate operation rules shall be improved to include the rules relating to inflow discharge into the reservoir.

The major reasons for these recommendations are summarized as follows;

- To utilize water resources effectively by reducing undesirable spillage during moderate intensity floods through the integrated operation of dam series including the dams newly proposed in this study.
- To obtain data useful to the dam discharge warning system which are expected to be greately required in near future at downstream of dam.
- To obtain data useful to judge the fluctuations of water demands at each beneficiary, especially during rainny seasons.

- To secure the safe operation of spillway gates by preventing rapid increases in reservoir water level through by forecasting inflow discharge into the reservoir during extraordinary floods which will have flashy flows with high peaks of short duration.

D.5.3 Improvement Schedule of Dam Operation/Control System

The three existing dams are expected to function not only as individual dams, but also one of the most important parts of dam series necessary for water resources development to serve the metropolitan area.

The schedule for the improvement of dam operation/control systems should follow the schedule for the water resources development programs.

Table D-5-3 shows the items to be improved and schedules of dam operation/control systems of the existing dams.

(1) First Stage (Upto 1990)

The year of 2000 is considered to be the target year for the extension program of the three existing dams. The said dams will function as individual water supply dams upto this year. Therefore, a modernization of dam operation/control systems are not necessarily required.

But, the safe operation of spillway gates is indispensable to the safety of dam itself. Therefore, the following improvements in the dam operation/control systems are requested, as soon as possible.

- Rain gauge stations
  - . Approximately 1 station per 100 sq.km
  - . Automatic record type is desirable, at least manual type shall be installed.
- Water level gauge stations
  - . Approximately 1 station per main river and tributary
  - . Automatic record type is desirable, at least manual type shall be installed.

- Transmission systems
  . Telemetering systems are not necessarily required.
- Discharge warning systems
  . Necessity should be judged from social needs.
- Auxiliary power system for spillway gates
  . Engine generators shall be provided as soon as possible.

1990 shall be the target year for improvements taking the safety of the dams into consideration.

(2) Second Stage (Upto 2000)

The extension program for the three existing dams will be completed by the year 2000. The construction of the proposed dam series will then be commenced.

After the year 2000 the existing dams will play important parts in the dam series for water resources development. They shall be provided the modernized dam operation/control systems so that water resources developed may be utilized effectively.

The items to be improved are summarized as follows;

- Rain gauge stations
  . Automatic record type
- Water level gauge stations
  . Automatic record type
- Transmission systems
  . Telemetering systems
  . Power systems; solar cells
- Dam data processing systems
  . Electronic computer systems for the collection of telemetering data, processing of dam data.
- Discharge warning systems
  . Siren and speaker connected telemetering system

- Gate opening facilities
  . All gate hoists shall be automated and auxiliary power systems shall be provided.
- *Dam operation/control office*
  . New offices provided with the above mentioned systems .

Such modernized systems shall also be provided for the proposed new dam series.

(3) Third Stage (Upto 2010)

The eight dams including the three existing dams will be completed by the year 2010, contributing to water supply for the metropolitan area.

Around this year several dam series in a same river basin will be completed and necessity of dam series operation will be emphasized.

The Central Dam Operation/Control Office will integrate all informations on dam operation/control for the related river basins. They shall be established under the supervision of the Integrated Organization described in Chapter 8.3 at proper locations in the river basins.

The Central Dam Operation/Control Office which integrate concerned dams, will be established in the following two river basins.

Haro & Dor river basin: Khanpur, D-1, H-4, Shahpur
Soan river basin : Rawal, Simly, S-1, L-1, KL-1, SL-1

The dam operation/control systems to be provided are as follows;

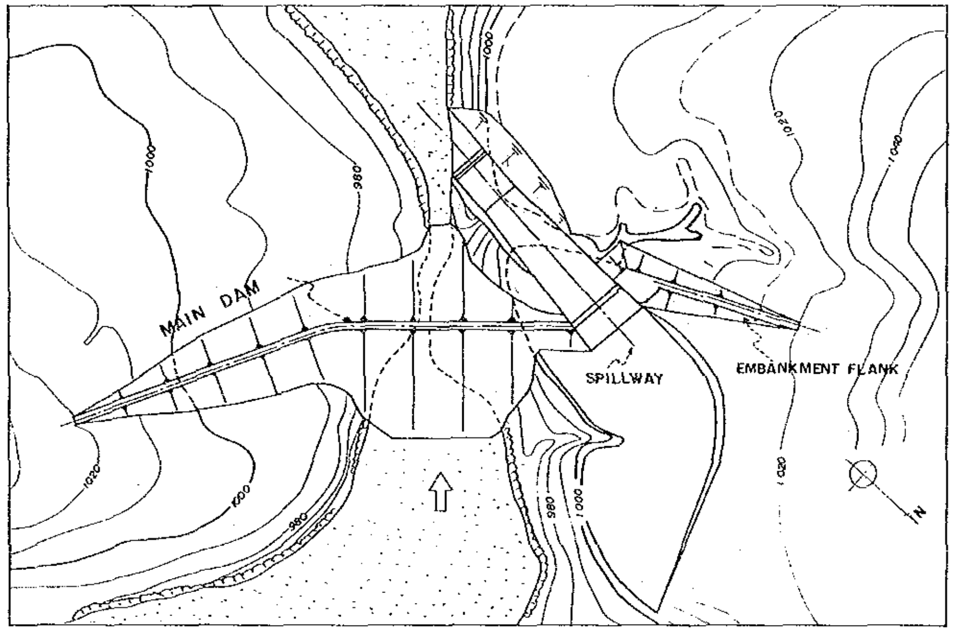
- Radar rain gauge stations
  . One or two stations in the whole catchment area
- Transmission systems between Central Dam Operation/Control Office and Dam office
- Central Dam Operation/Control Office

In this stage the forecasting of rainfall in the catchment area concerned will become a very important factor in the effective utilization of water resources.

It is recommended that the hydrological data collection systems be connected with the existing hydrological transmission networks established by such organizations as WAPDA and Pakistan Meteorological Department (PMD), and be utilized either for efficient utilization of water resources, or for flood forecasting and warning in conjunction with the Federal Flood Commission (FFC).

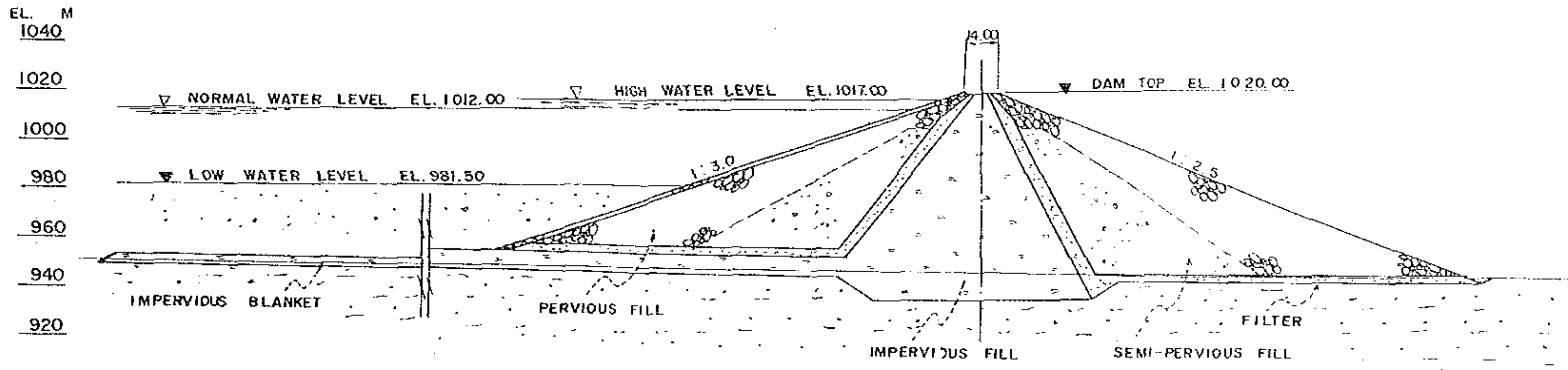
Table D-5-3 Improvement Schedule of Dam Operation/Control System

		1st Stage (Upto 1990)	2nd Stage (Upto 2000)	3rd Stage (Upto 2010)
Hydrological Data Collecting System	. Rain Gauge	Manual Type	Automatic Record Type (Tilting Rain Gauge)	Radar rain Gauge System
	. Water Level Gauge (Discharge)	Water Staff Gauge	Automatic Record Type (Float Type Water Level Gauge)	
	. Transmission	Telephone	Telemetering System	
Dam Data Processing System		Manually	Electronic Computer System	
Discharge Warning System		Near the Damsite by Siren	Siren/Speaker by Telemetering System	
Gate Operating Facilities		Spillway; engine generator	All gates to be mobilized and engine generator	
Dam Operation/Control Office		Existing Dam Office	New Dam Operation/Control Office	Connection to Central Dam Operation/Control Office



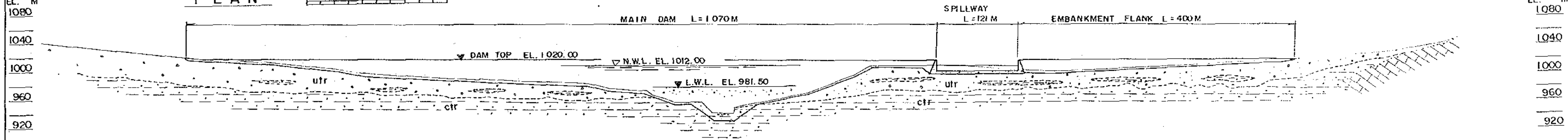
PLAN

0 250 500m



TYPICAL SECTION

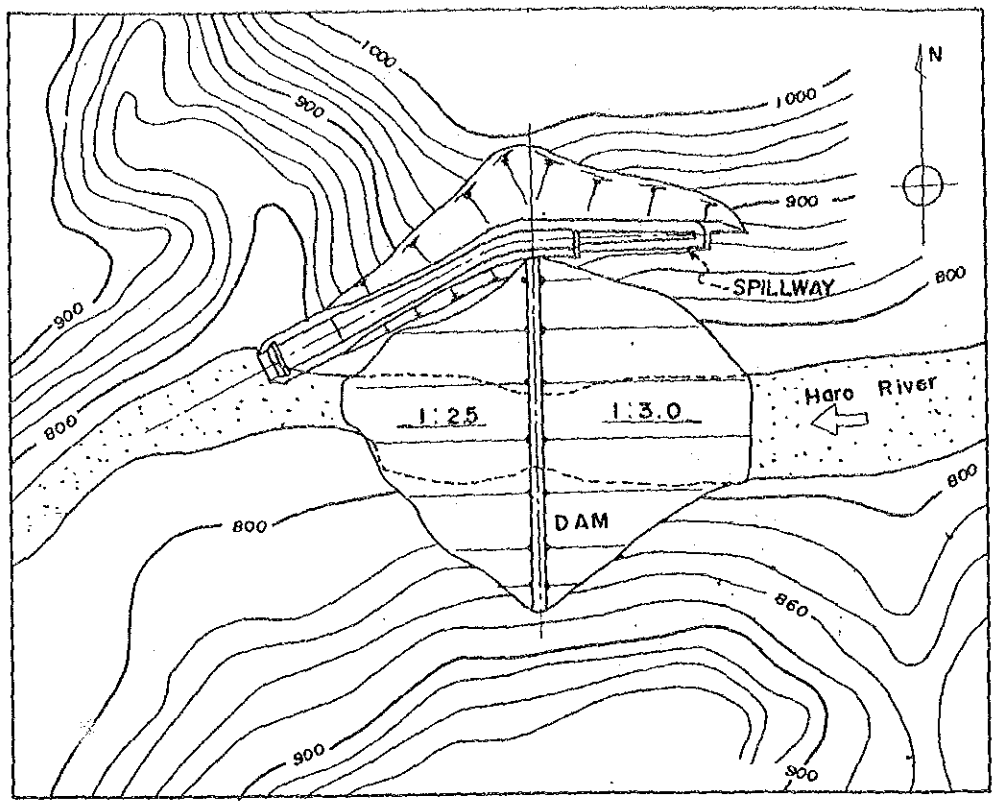
0 50 100m



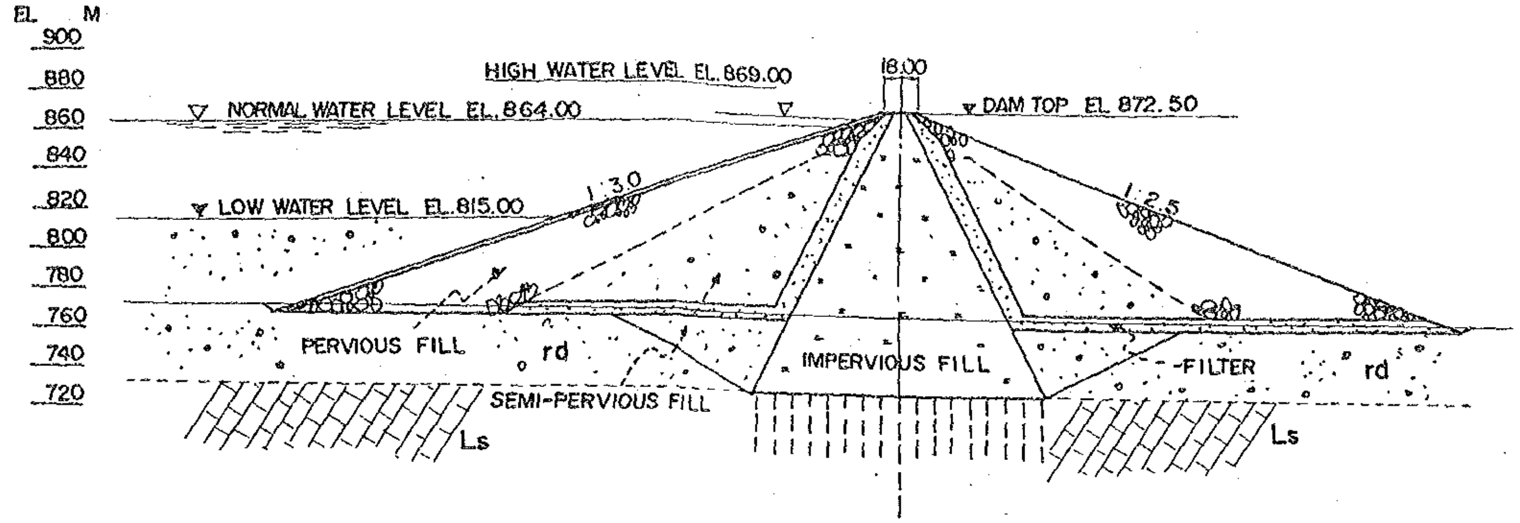
PROFILE OF DAM

0 100 200m

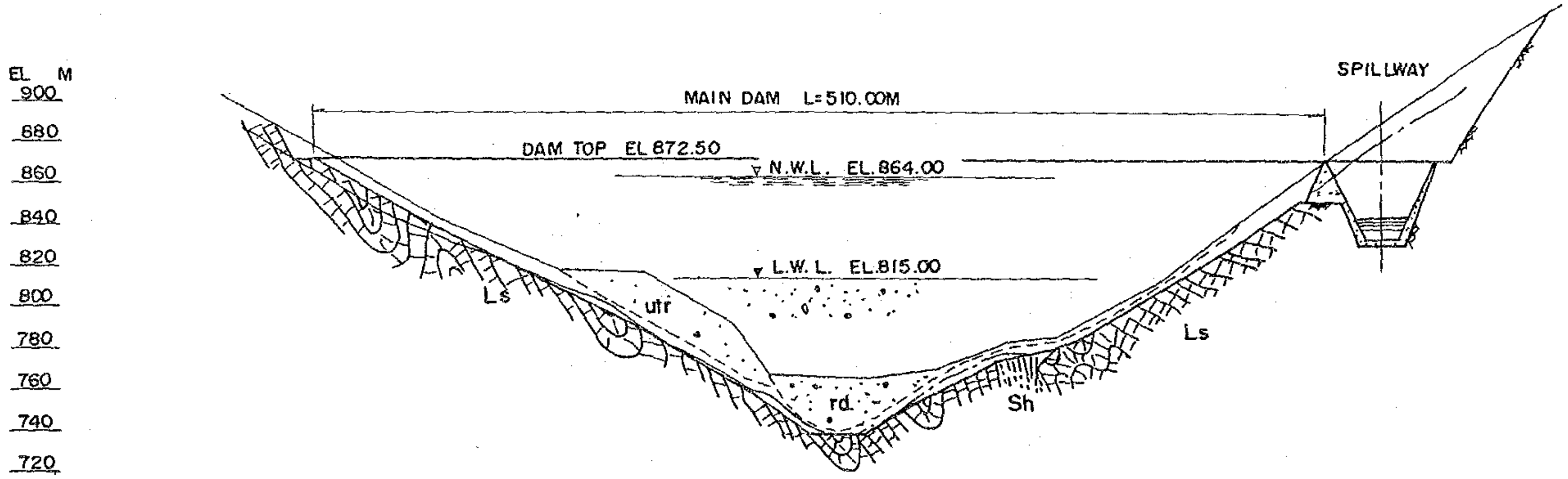
THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY			
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA			
PRELIMINARY DESIGN OF D-1 DAM			
DATE		DWG. NO.	1
JAPAN INTERNATIONAL COOPERATION AGENCY			



PLAN 0 250 500m

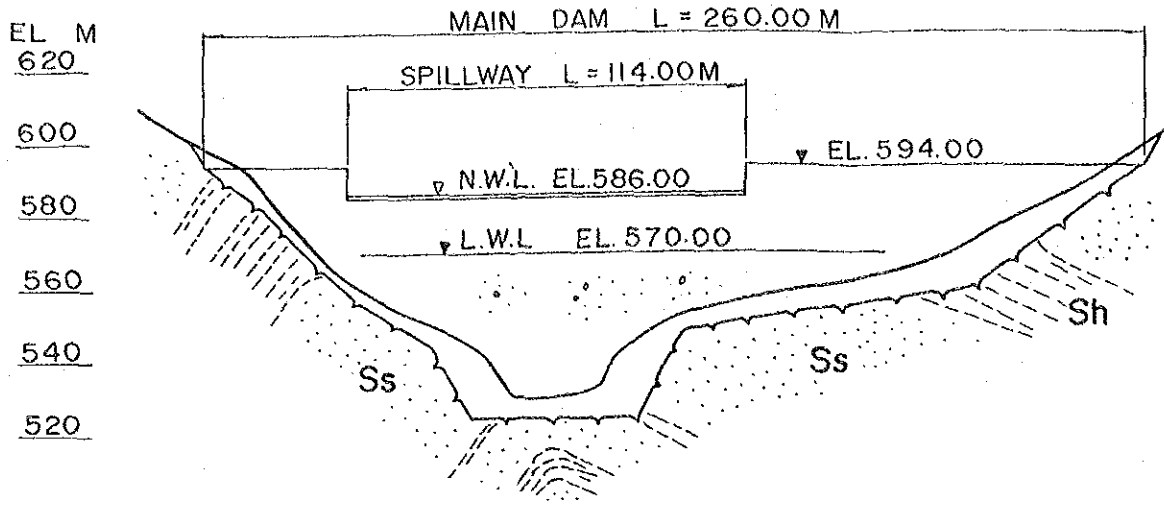


TYPICAL SECTION 0 50 100m



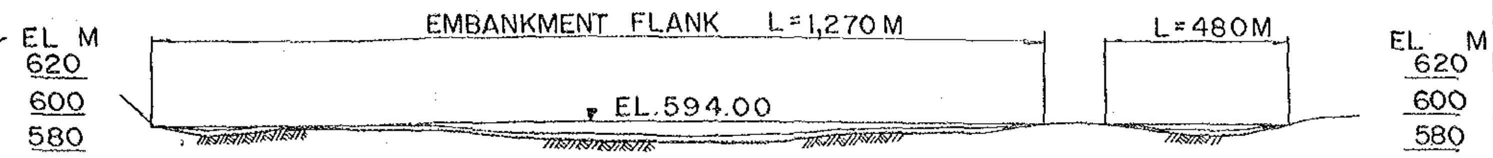
PROFILE OF DAM 0 50 100m

THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY			
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA			
PRELIMINARY DESIGN OF H-4 DAM			
DATE		DWG. NO.	2
JAPAN INTERNATIONAL COOPERATION AGENCY			



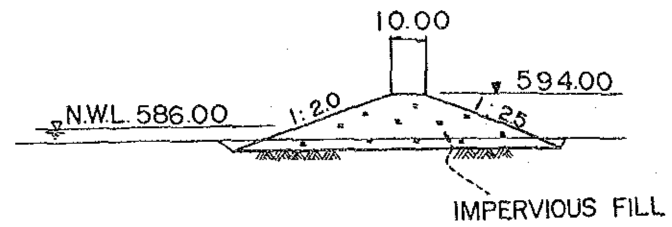
PROFILE OF MAIN DAM

0 50 100M



PROFILE OF EMBANKMENT FLANK

0 250 500M



TYPICAL SECTION

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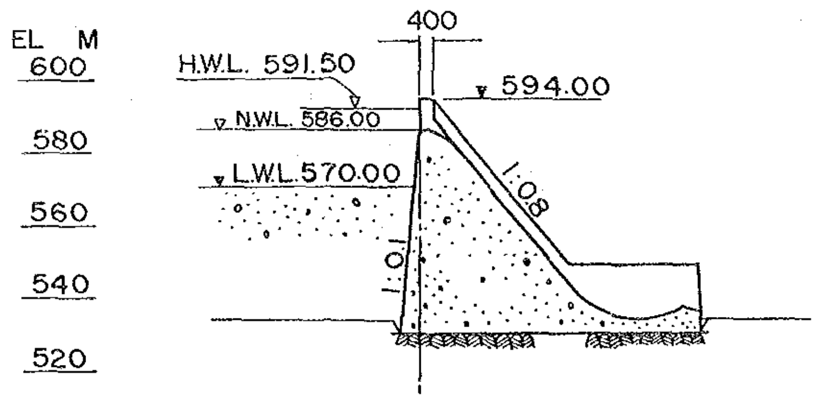

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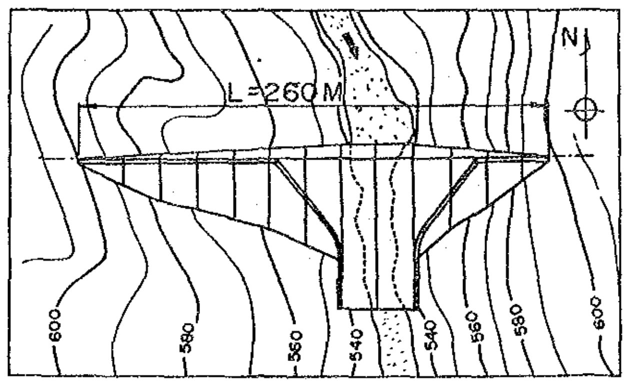
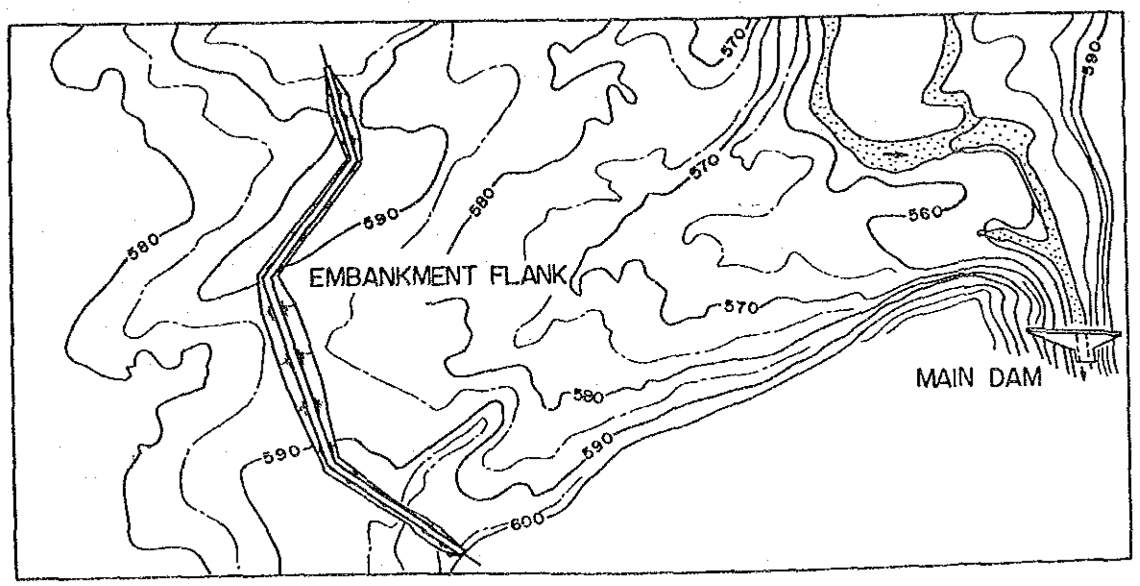


PLAN 0 50 100M



PLAN 0 500 1000M

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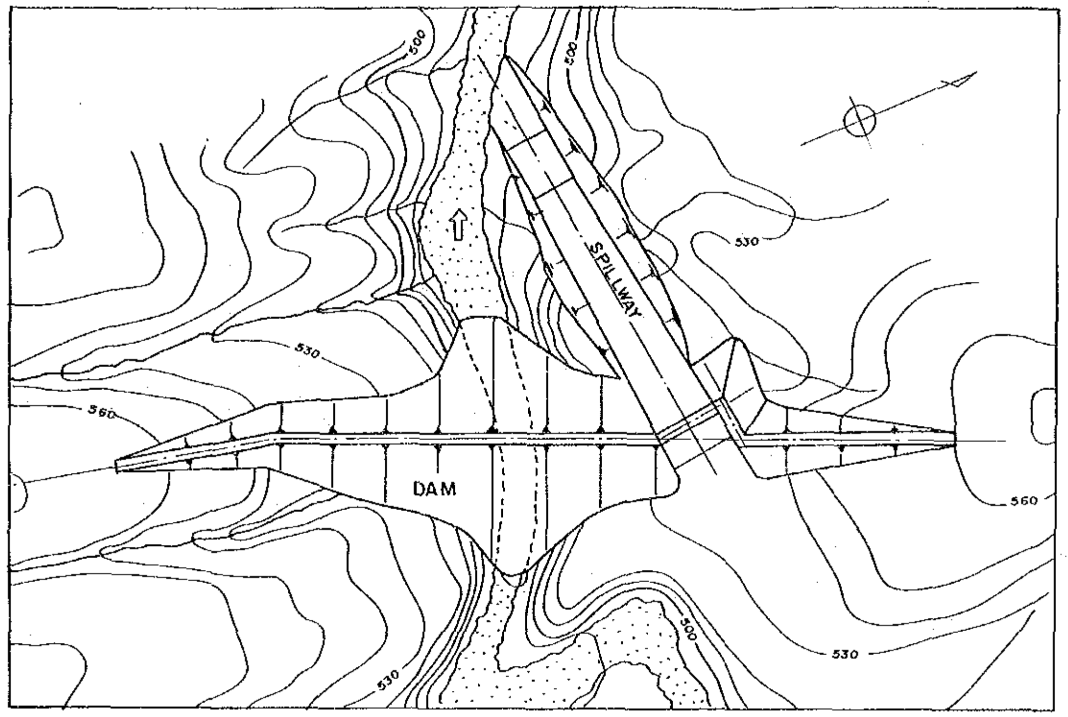
THE REGIONAL STUDY FOR
WATER RESOURCES DEVELOPMENT POTENTIAL
FOR THE METROPOLITAN AREA

PRELIMINARY DESIGN
OF S-I DAM

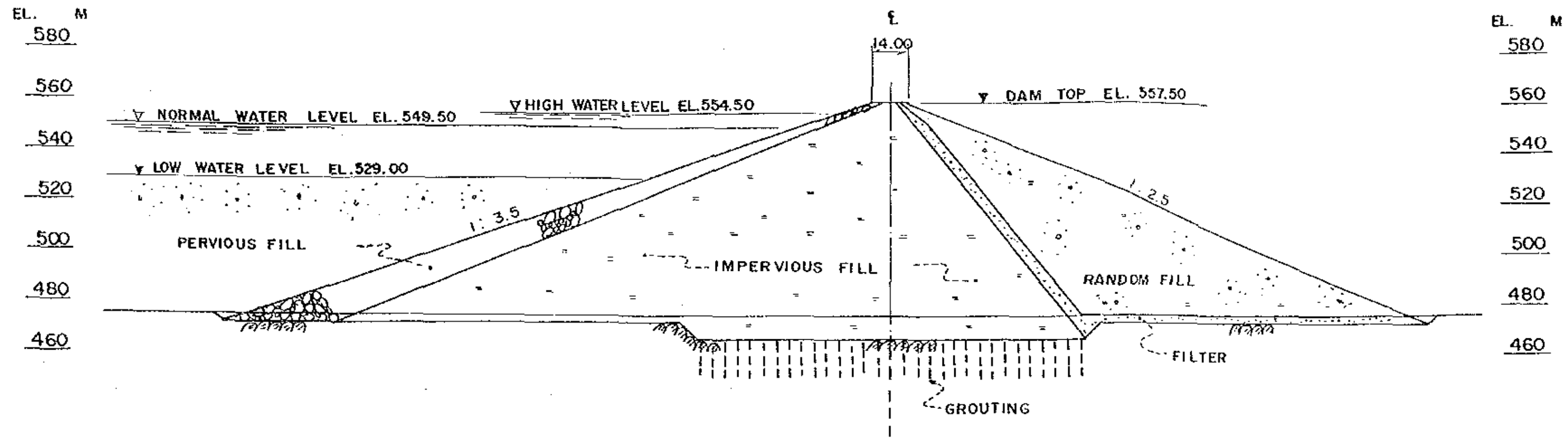
DATE		DWG. NO.	3

JAPAN INTERNATIONAL COOPERATION AGENCY



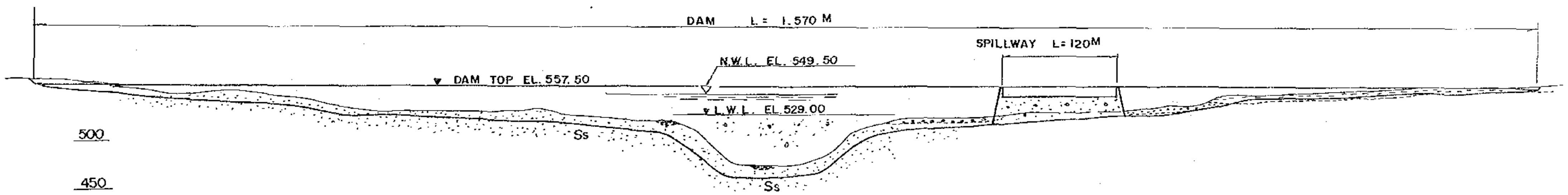
PLAN

0 250 500m



TYPICAL SECTION

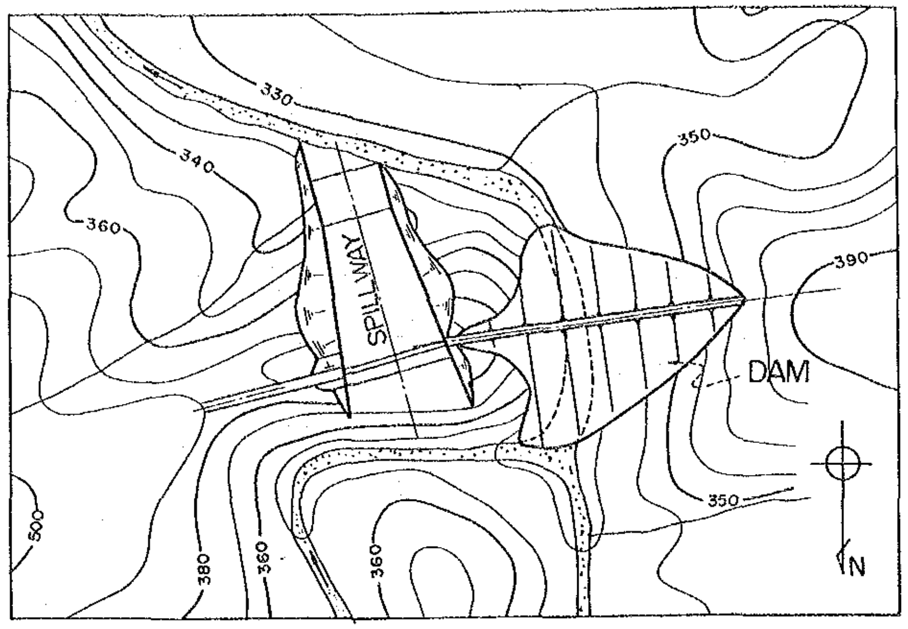
0 50 100m



PROFILE OF DAM

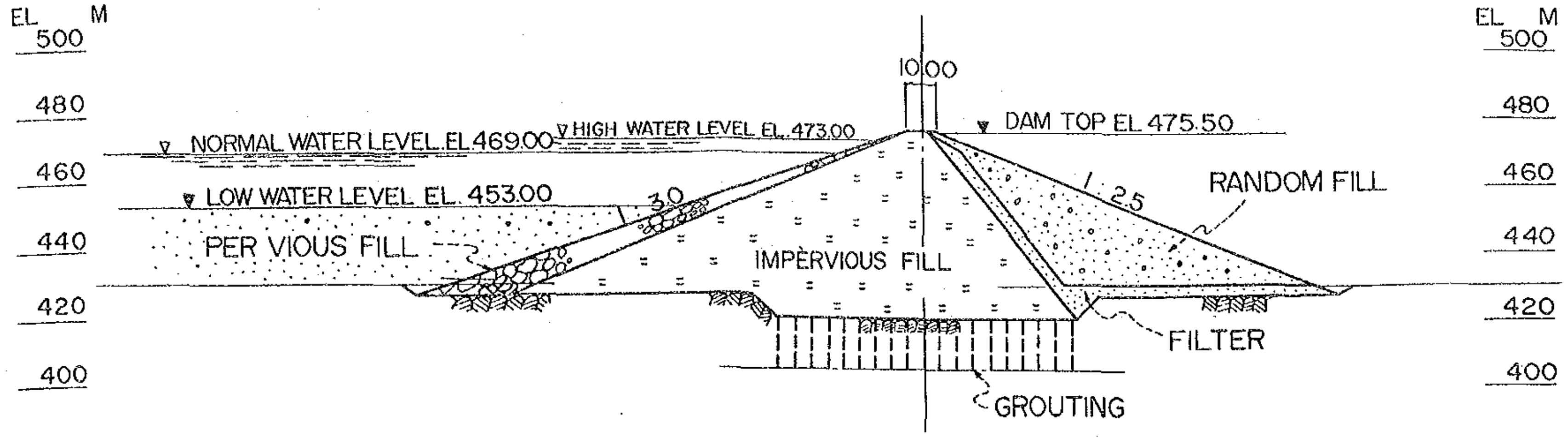
0 100 200m

THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY	
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA	
PRELIMINARY DESIGN OF L-I DAM	
DATE	DWG. NO. 4
JAPAN INTERNATIONAL COOPERATION AGENCY	



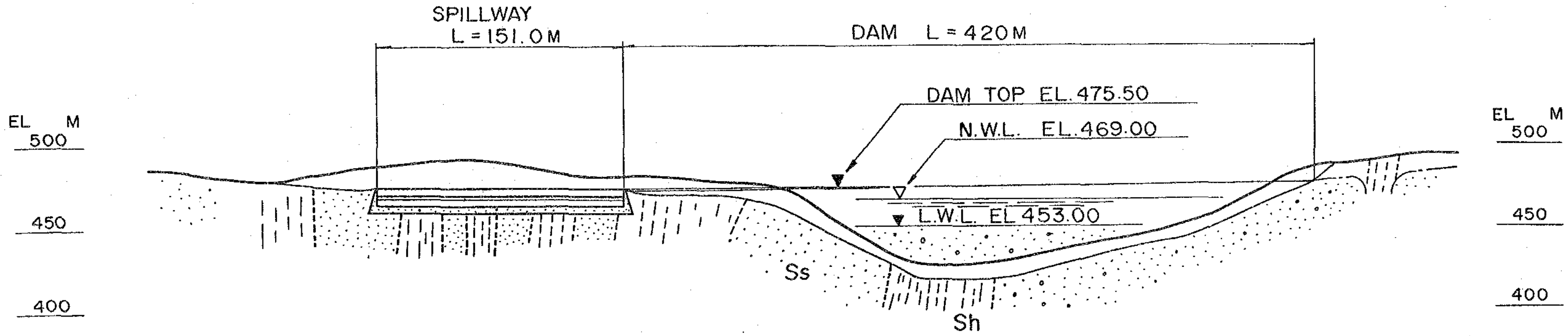
PLAN

0 250 500M



TYPICAL SECTION

0 50 100M



PROFILE OF DAM

0 100 200M

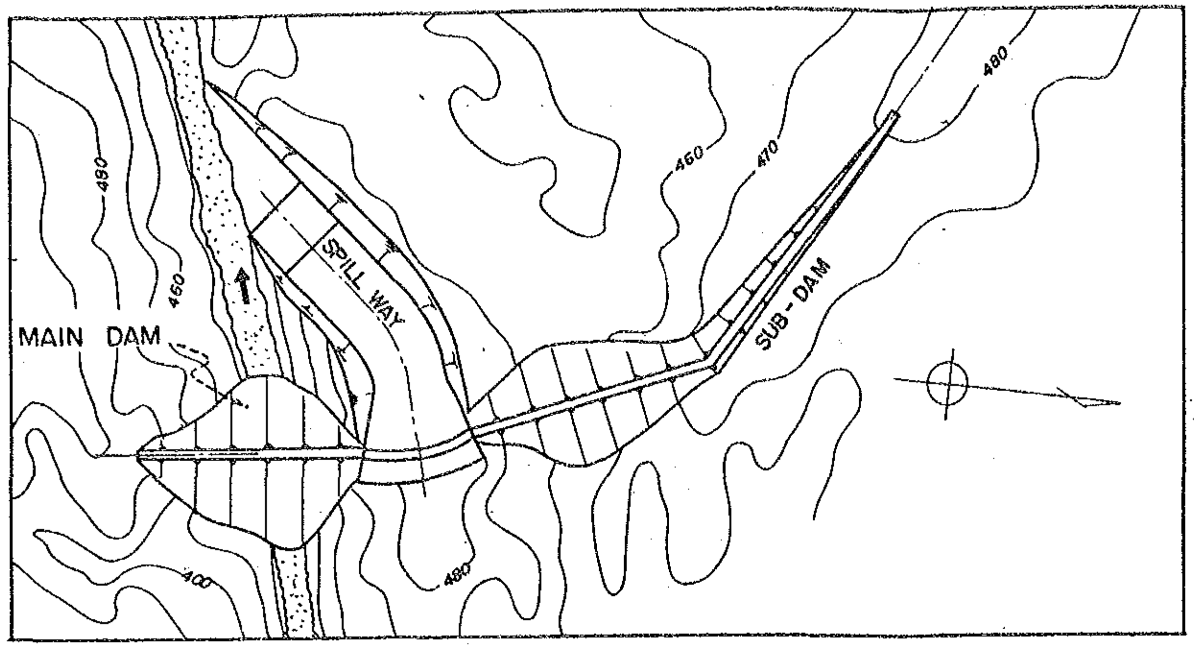
THE ISLAMIC REPUBLIC OF PAKISTAN
CAPITAL DEVELOPMENT AUTHORITY

THE REGIONAL STUDY FOR
WATER RESOURCES DEVELOPMENT POTENTIAL
FOR THE METROPOLITAN AREA

PRELIMINARY DESIGN
OF SL-I DAM

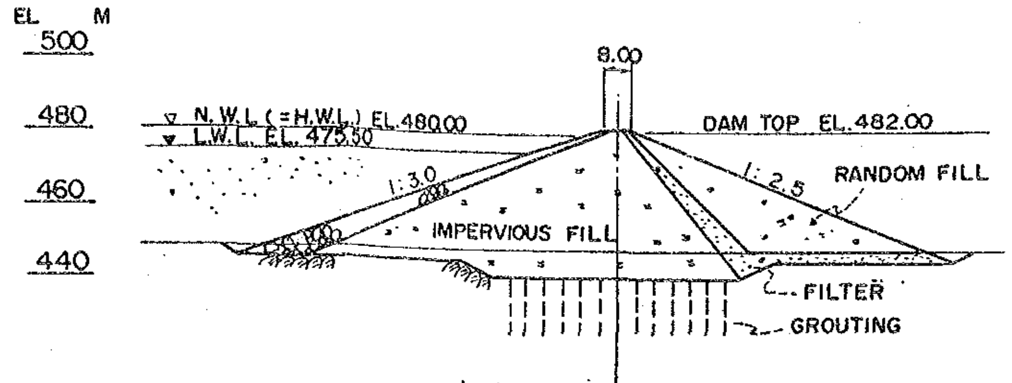
DATE		DWG. NO.	5

JAPAN INTERNATIONAL COOPERATION AGENCY



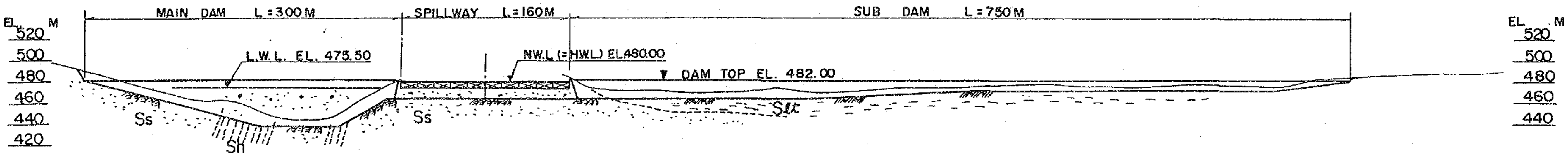
PLAN

0 250 500m



TYPICAL SECTION

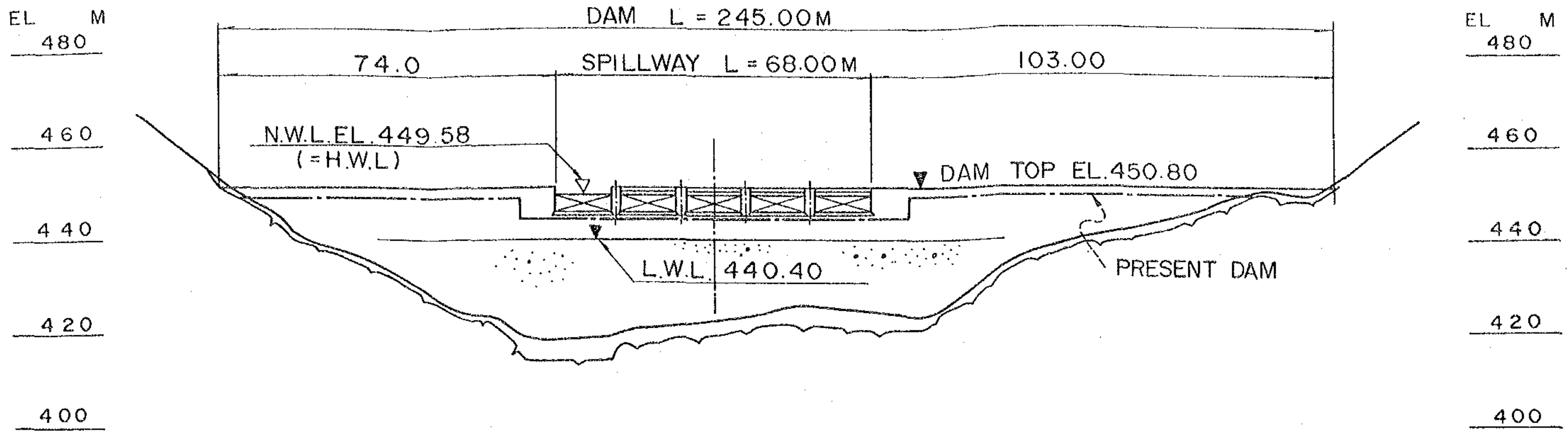
0 50 100 m



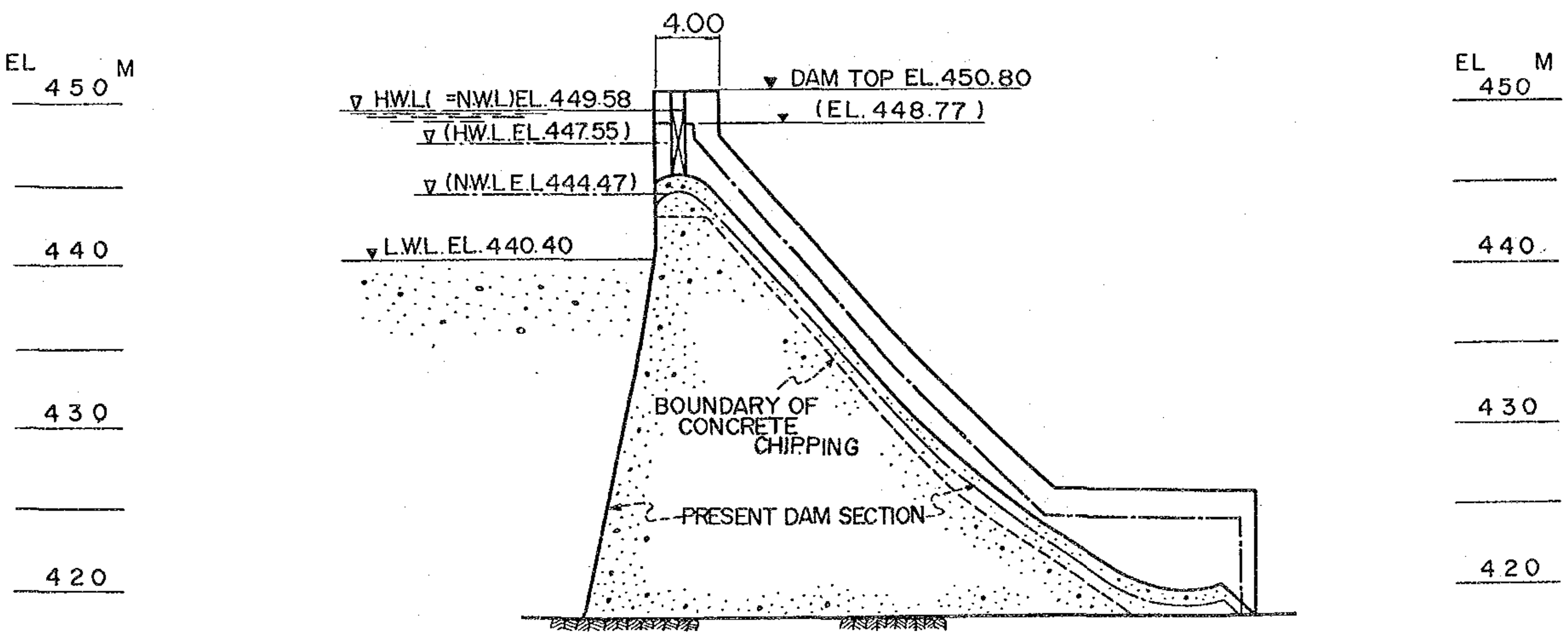
PROFILE OF DAM

0 250 500m

THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA
PRELIMINARY DESIGN OF KL-I DAM
DATE		DWG. NO. 6
JAPAN INTERNATIONAL COOPERATION AGENCY

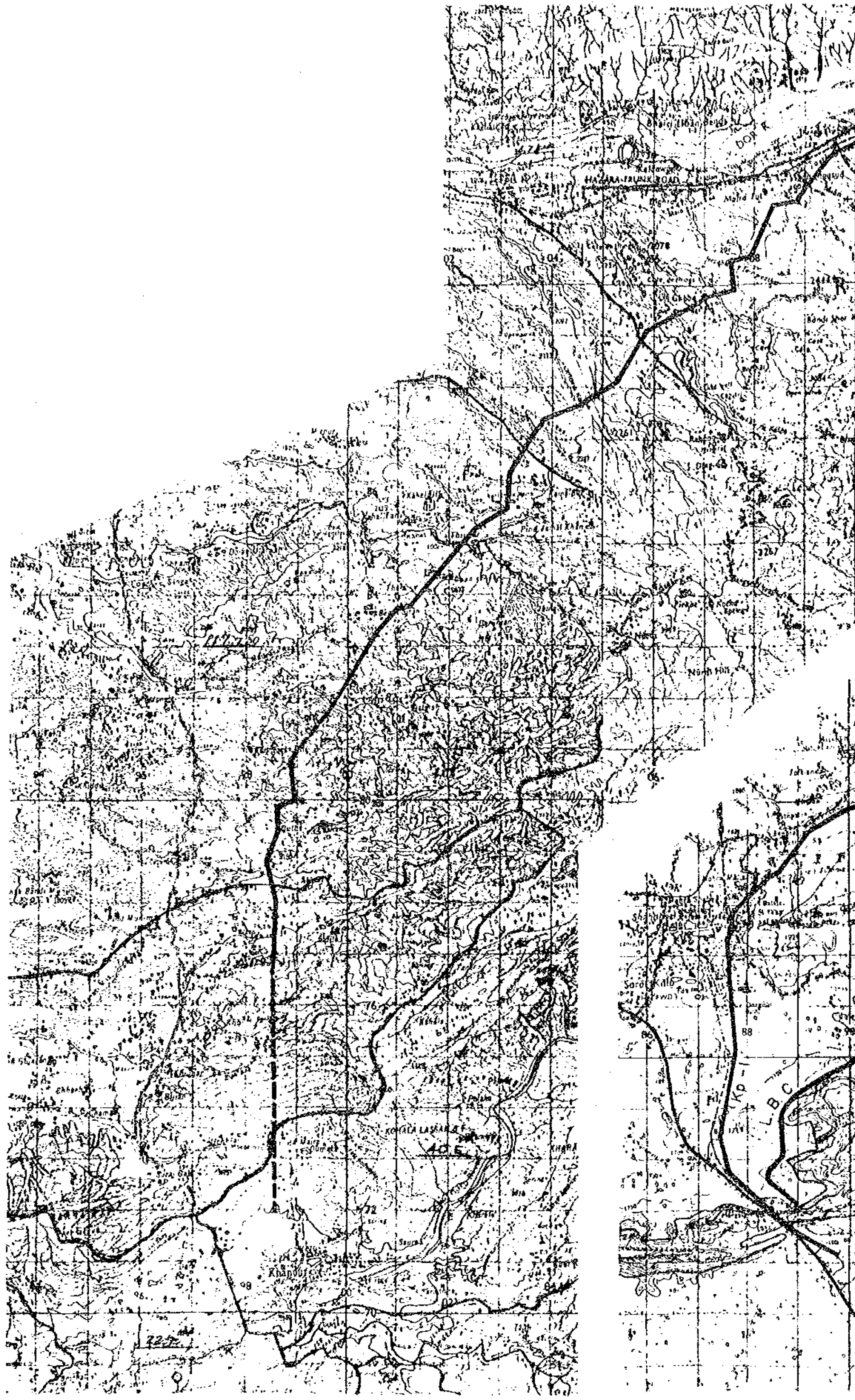


PROFILE OF DAM

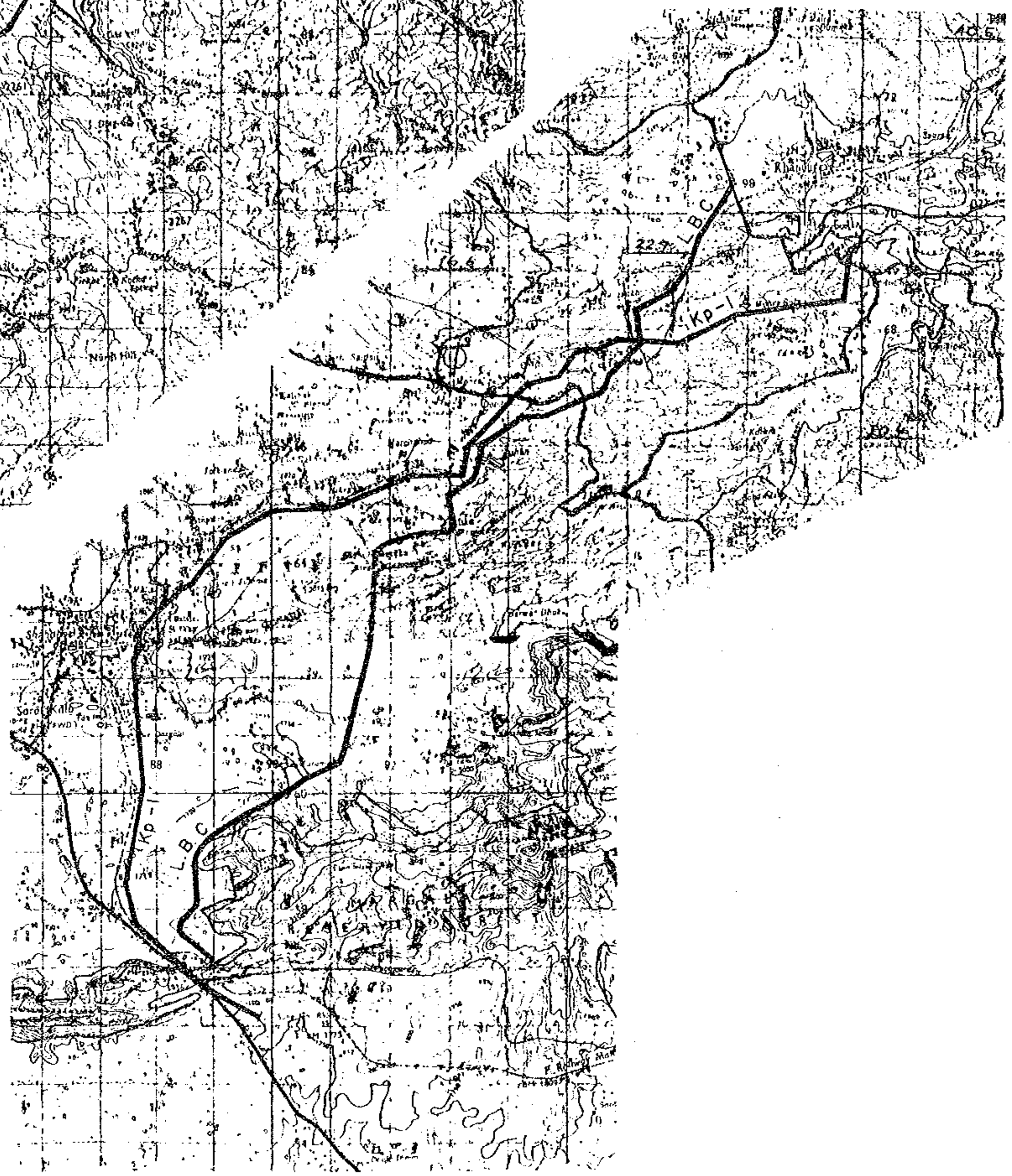


TYPICAL SECTION

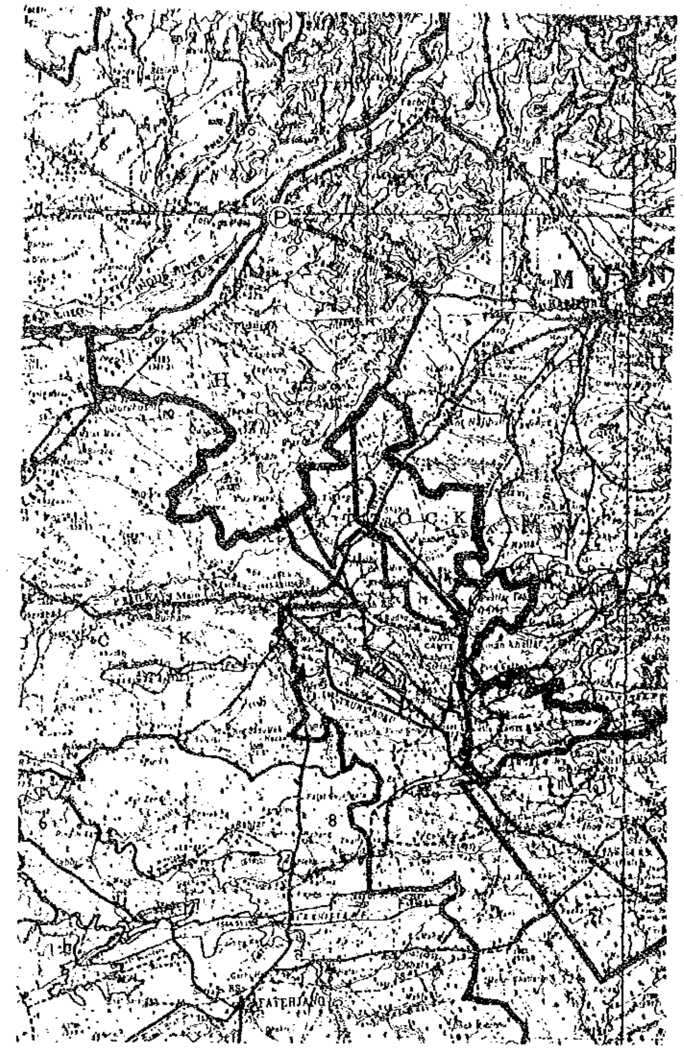
THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY		
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA		
PRELIMINARY DESIGN OF SHAHPUR DAM HEIGHTENNING SCHEME		
DATE	DWG. NO.	7
JAPAN INTERNATIONAL COOPERATION AGENCY		



Dc-I CONDUCTION MAIN
SCALE 1 100,000



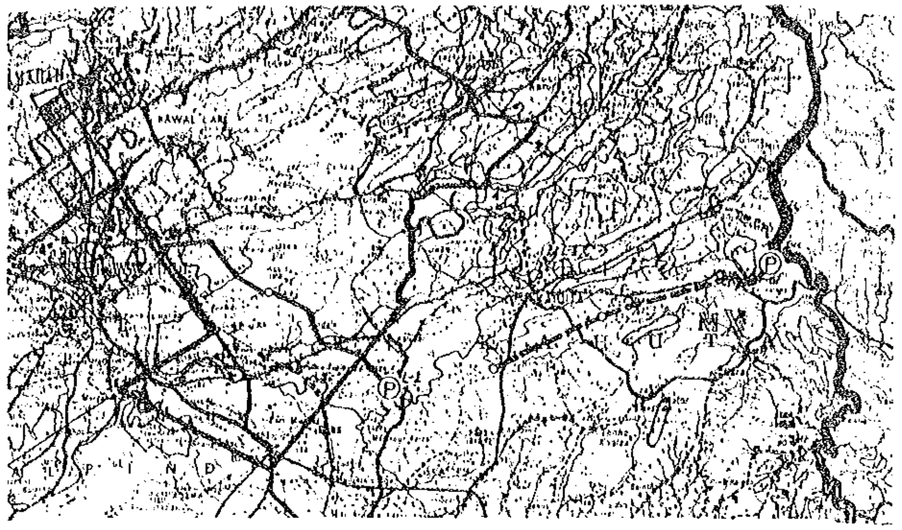
Kp-I CONDUCTION MAIN
SCALE 1 100,000



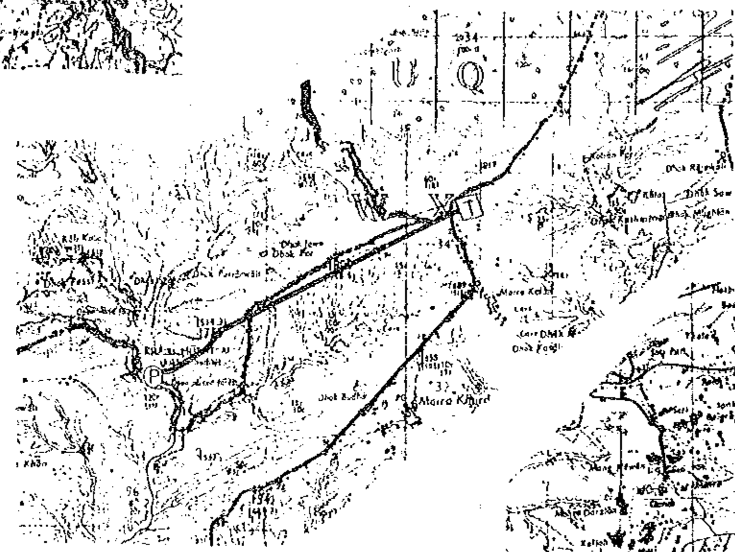
TARBELA CONDUCTION MAIN
SCALE 1: 500,000

THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY			
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA			
ROUTE OF CONDUCTION MAIN (I)			
DATE		DWG. NO.	8
JAPAN INTERNATIONAL COOPERATION AGENCY			

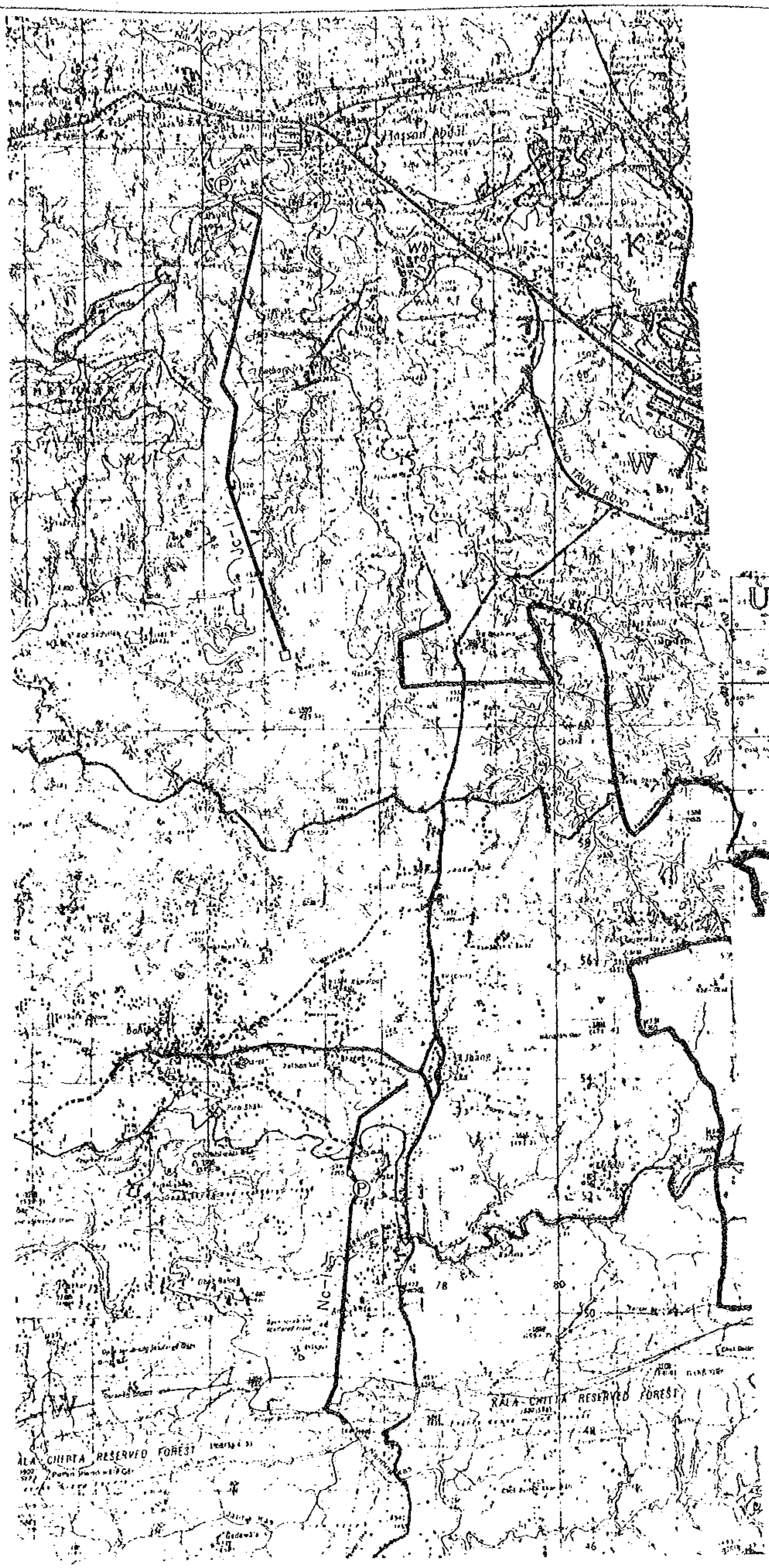
THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY			
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA			
ROUTE OF CONDUCTION MAIN(2)			
DATE		DWG. NO.	9
JAPAN INTERNATIONAL COOPERATION AGENCY			



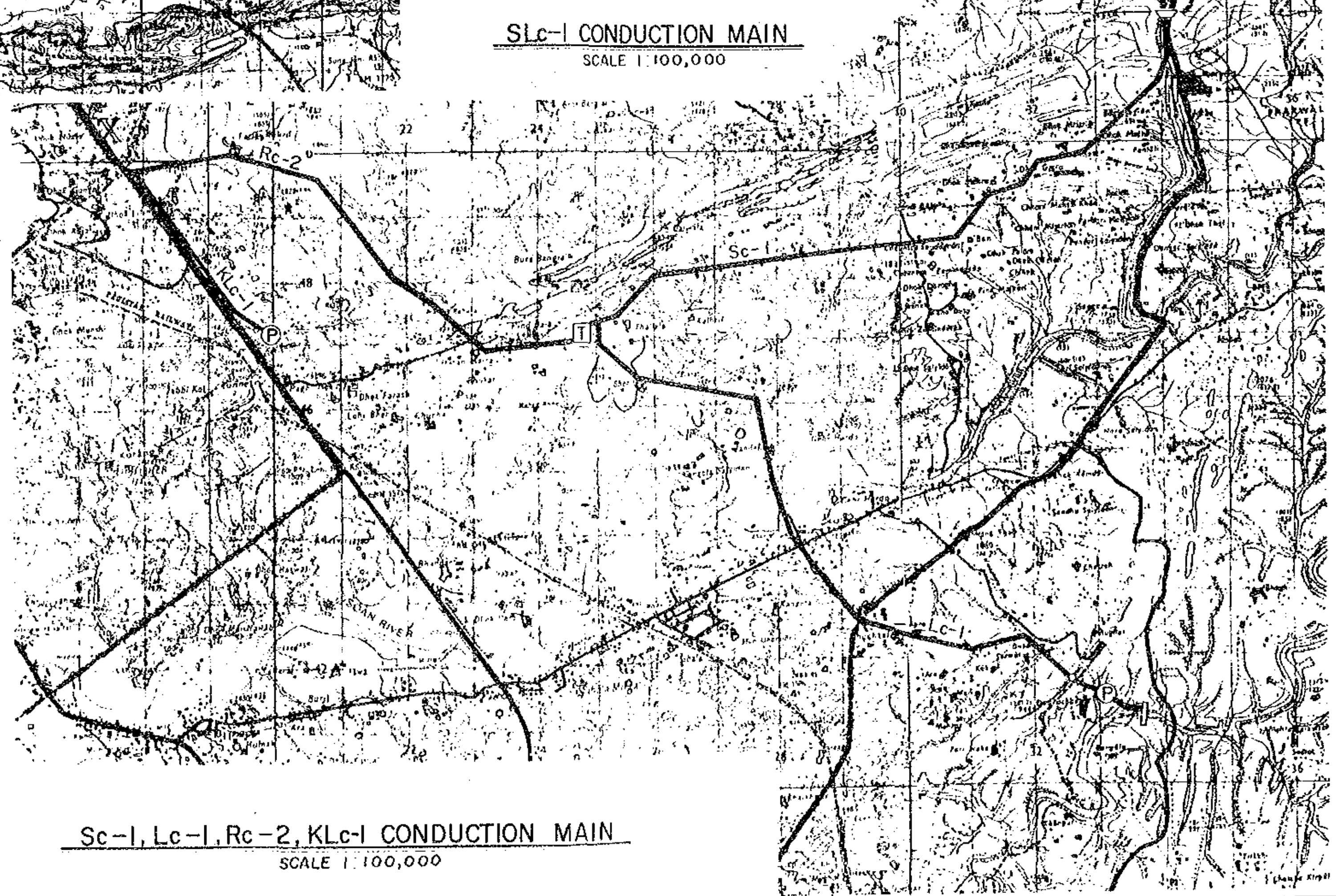
JHELUM CONDUCTION MAIN
SCALE 1:500,000



SLc-1 CONDUCTION MAIN
SCALE 1:100,000



Jc-1, Nc-1, Kc-8 CONDUCTION MAIN
SCALE 1:100,000



Sc-1, Lc-1, Rc-2, KLc-1 CONDUCTION MAIN
SCALE 1:100,000

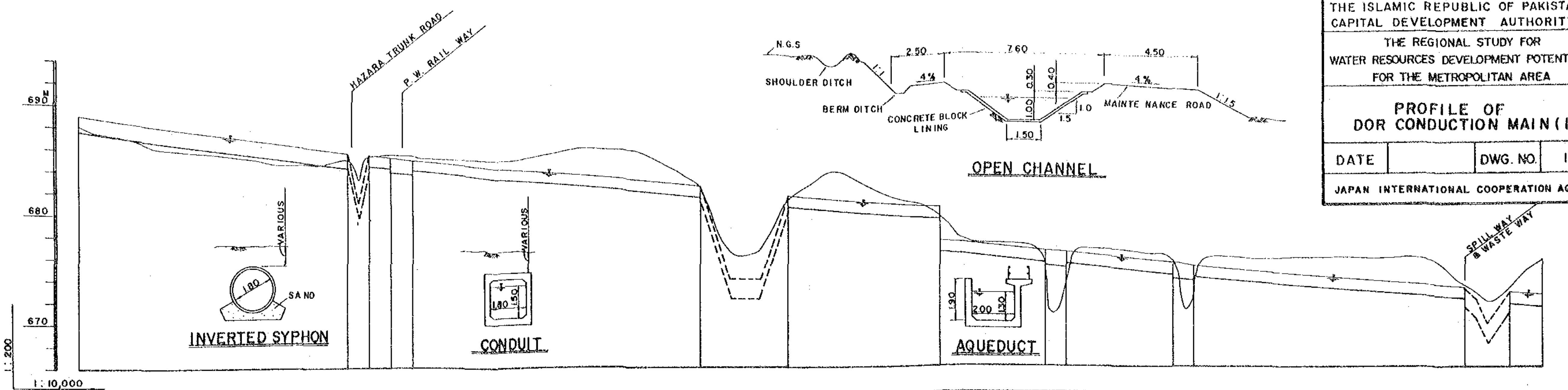
THE ISLAMIC REPUBLIC OF PAKISTAN
CAPITAL DEVELOPMENT AUTHORITY

THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA

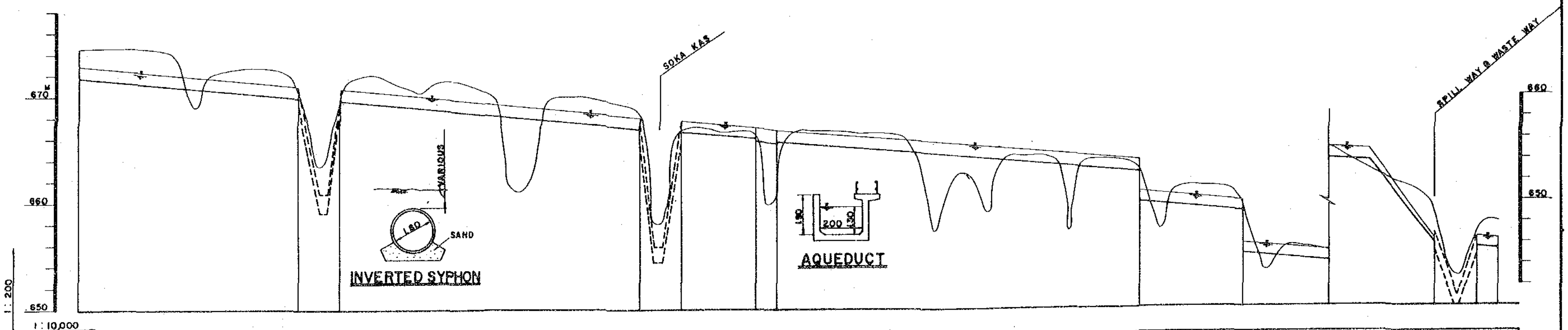
PROFILE OF DOR CONDUCTION MAIN (I)

DATE		DWG. NO.	10

JAPAN INTERNATIONAL COOPERATION AGENCY



CANAL TYPE	CONDUIT, SYPHON, O.CH., CONDUIT, OPEN CHANNEL, SYPHON, OPEN CHANNEL, DROP, AQUEDUCT, O.CH., AQUEDUCT, OPEN CHANNEL, SYPHON
F.S.L.	689.00, 685.40, 685.19, 684.99, 684.87, 682.39, 681.60, 680.40 / 677.40, 676.53, 676.37, 675.50, 675.34, 673.24, 672.82, 672.65
BED SLOPE	1:350, 1:600, 1:350, 1:600, 1:600, 1:600, 1:780, 1:600, 1:780, 1:600, 1:600
DISTANCE	1,250, 100, 100, 100, 1,350, 400, 700, 500, 100, 500, 100, 1,250, 200
STATION	0+00, 12+50, 13+50, 14+50, 15+50, 29+00, 33+00, 40+00, 45+00, 46+00, 51+00, 52+00, 64+50, 66+50, 67+00



CANAL TYPE	OPEN CHANNEL, SYPHON, OPEN CHANNEL, SYPHON, O.CH., AQUDUCT, OPEN CHANNEL, DROP, DROP, CHUTE, SYPHON
F.S.L.	672.65, 670.95, 670.53, 668.08, 667.66, 667.04, 666.88, 663.91 / 660.91, 660.06 / 656.06, 655.06, 647.06, 646.64, 646.47
BED SLOPE	1:600, 1:600, 1:600, 1:780, 1:600, 1:600, 1:600, 1:600
DISTANCE	1,100, 200, 1,450, 200, 350, 100, 1,750, 500, 600, 300, 200
STATION	67+00, 77+50, 79+50, 94+00, 96+00, 99+50, 100+50, 118+00, 123+00, 129+00, 132+00, 134+00, 135+00

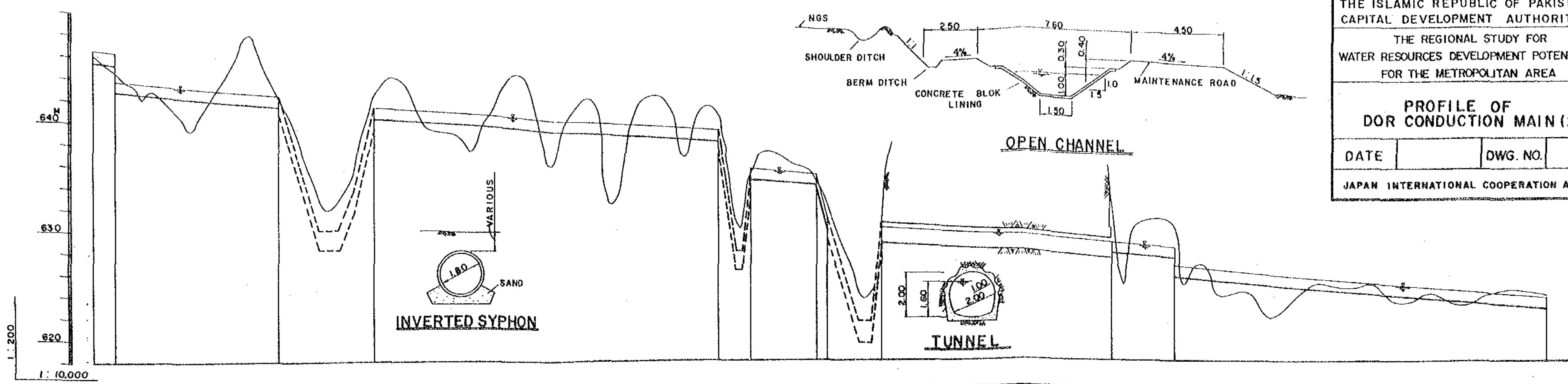
THE ISLAMIC REPUBLIC OF PAKISTAN
CAPITAL DEVELOPMENT AUTHORITY

THE REGIONAL STUDY FOR
WATER RESOURCES DEVELOPMENT POTENTIAL
FOR THE METROPOLITAN AREA

PROFILE OF DOR CONDUCTION MAIN (2)

DATE		DWG. NO.	11

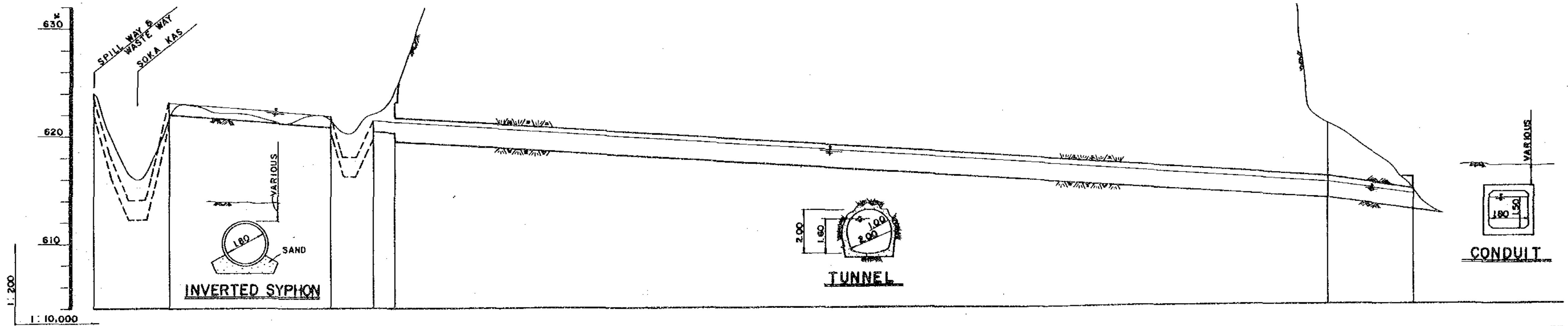
JAPAN INTERNATIONAL COOPERATION AGENCY



CANAL TYPE: DROP | OPEN CHANNEL | SYPHON | OPEN CHANNEL | SYPHON | O.CH. | CHU. | SYPHON | TUNNEL | DROP | OPEN CHANNEL

BED SLOPE: 1:600 | 1:600 | 1:600 | 1:600 | 1:760 | 1:600 | 1:600

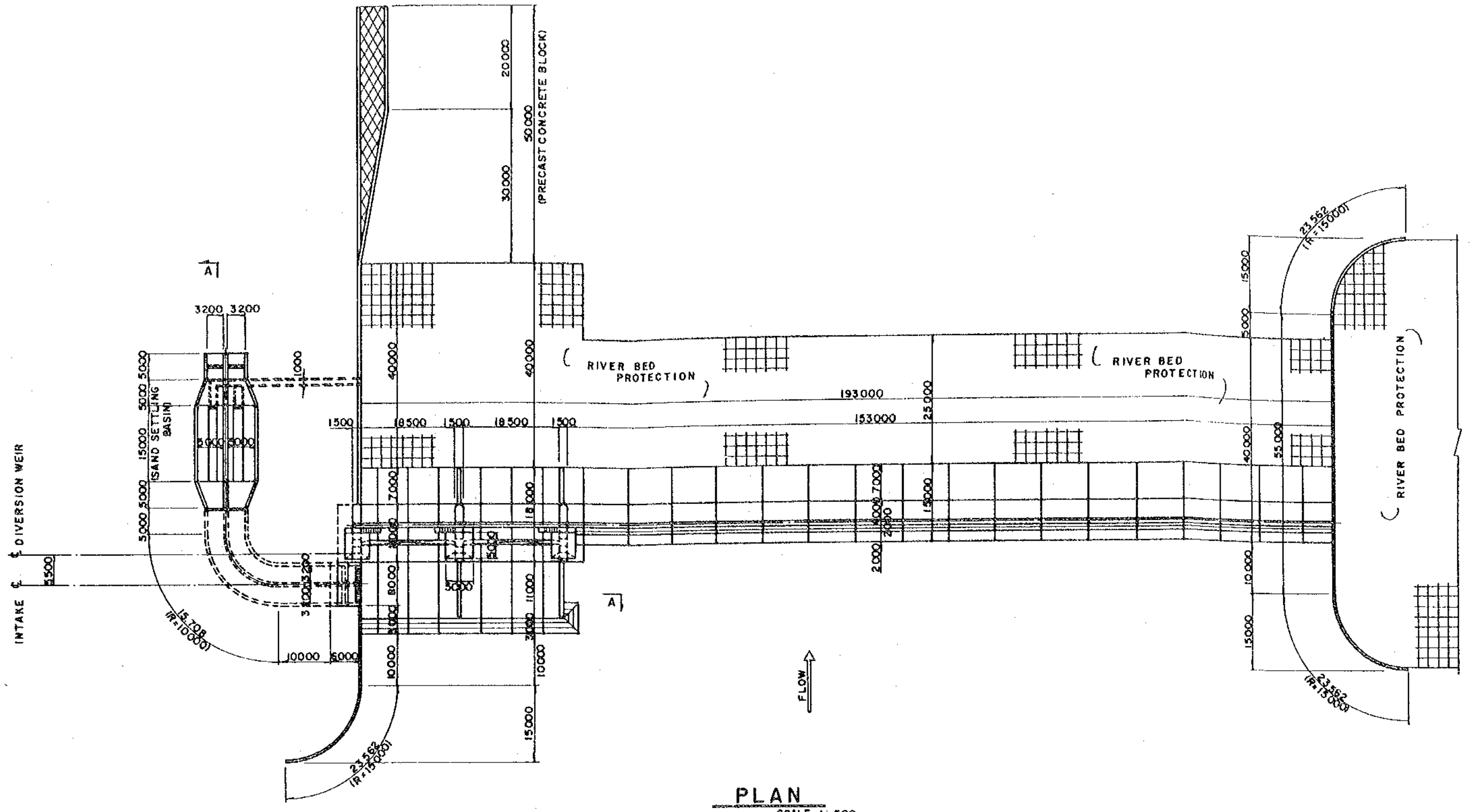
STATION	135+00	136+00	143+50	148+00	164+00	165+50	168+50	169+00	171+50	182+50	185+50	203+00
DISTANCE		100	750	450	1,600	150	300	50	250	1,100	300	1,750
F.S.L.	646.41	646.24 643.71	642.46	641.58	638.68 635.68	635.56	635.03	630.92	630.42	628.94	628.44 626.78	623.86



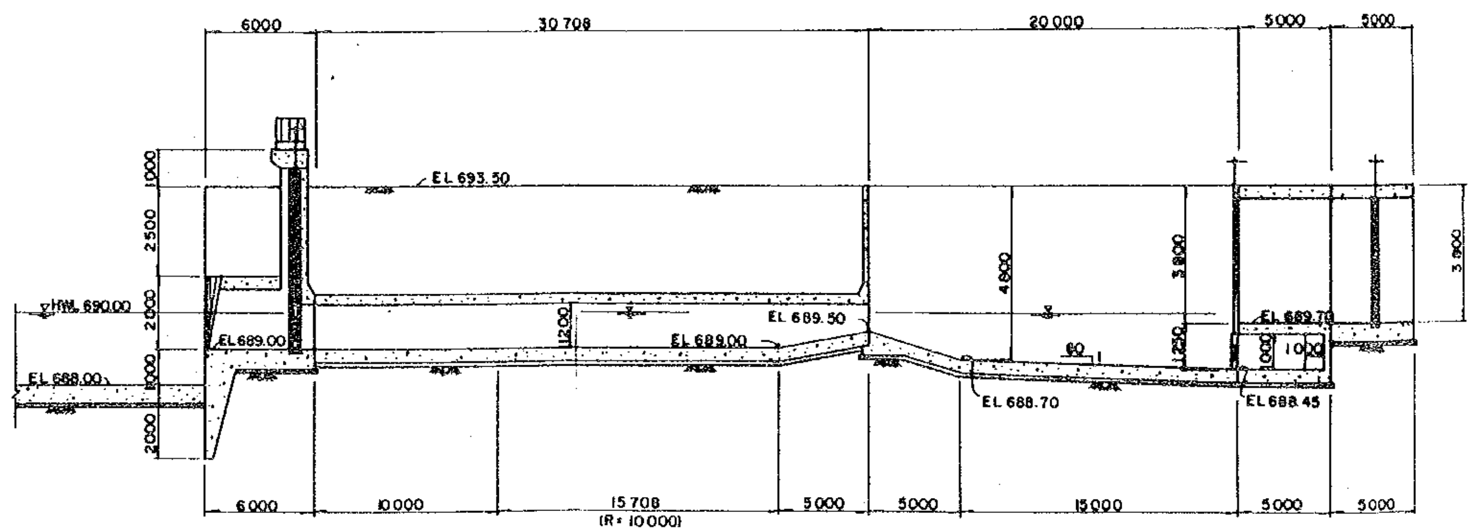
CANAL TYPE: SYPHON | OPEN CHANNEL | SYPHON | O. CHANNEL | TUNNEL | CONDUIT

BED SLOPE: 1:600 | 1:600 | 1:760 | 1:350

STATION	203+00	206+50	214+00	216+00	217+00	230+00	240+00	250+00	261+00	265+00
DISTANCE	1,750	350	750	200	100				4,400	400
F.S.L.	623.86	623.17	621.89	621.47	621.27				615.45	614.27

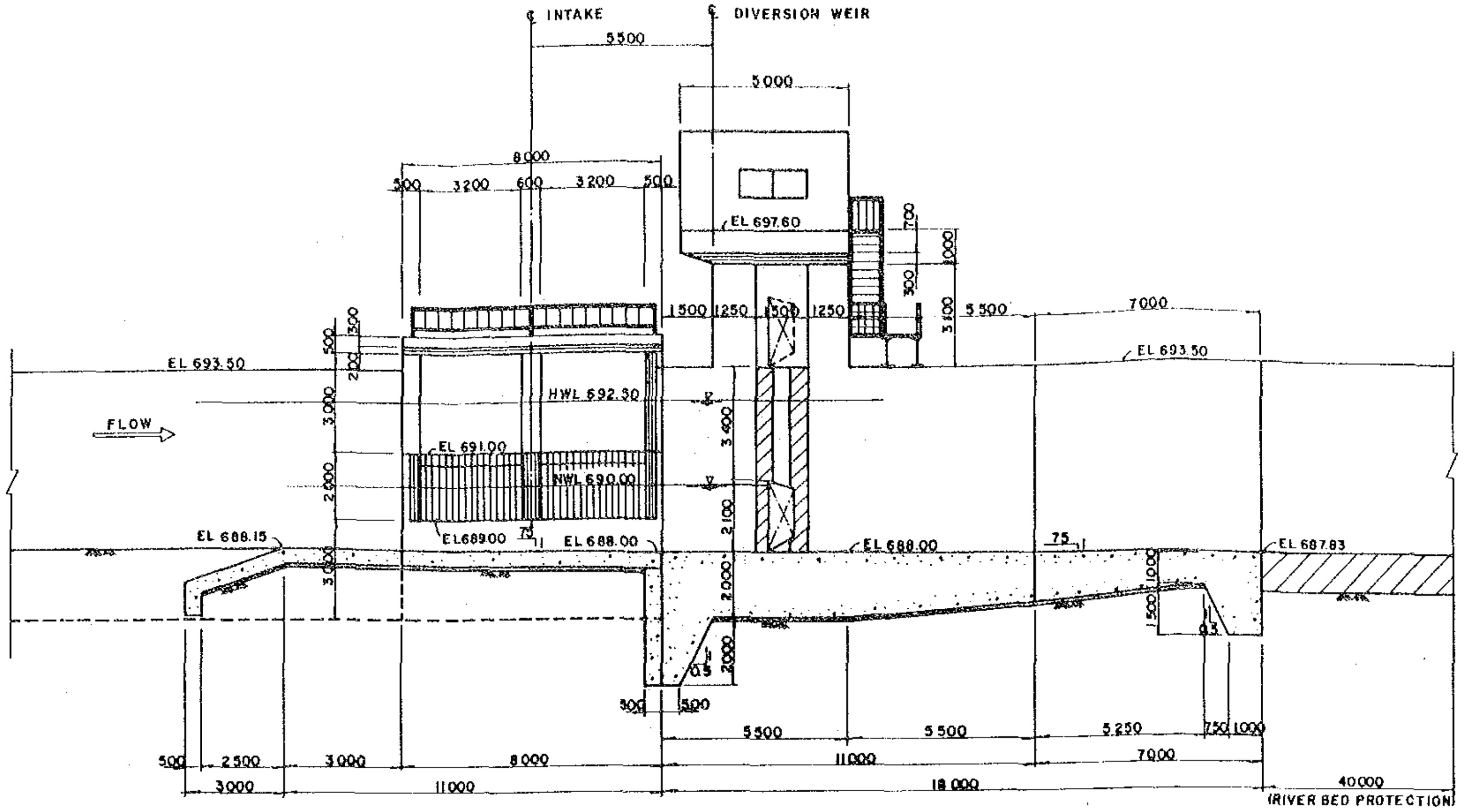


PLAN
SCALE 1: 500

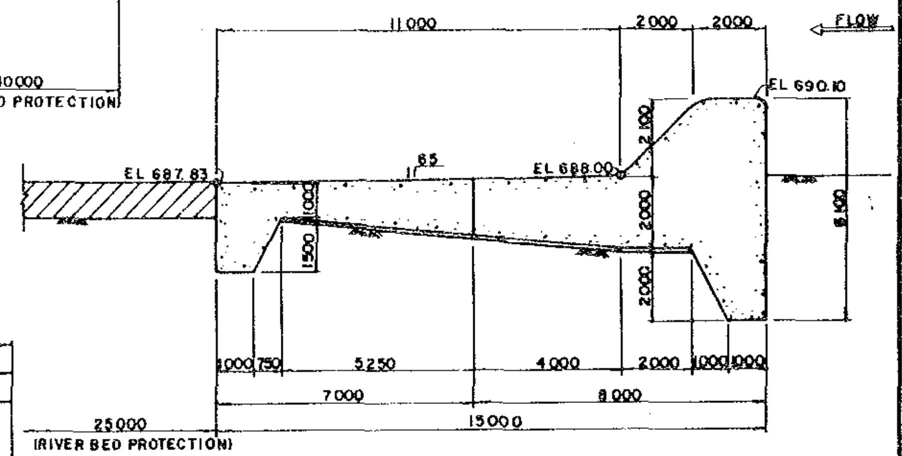


SECTION A-A
SCALE H=1:200 V=1:100

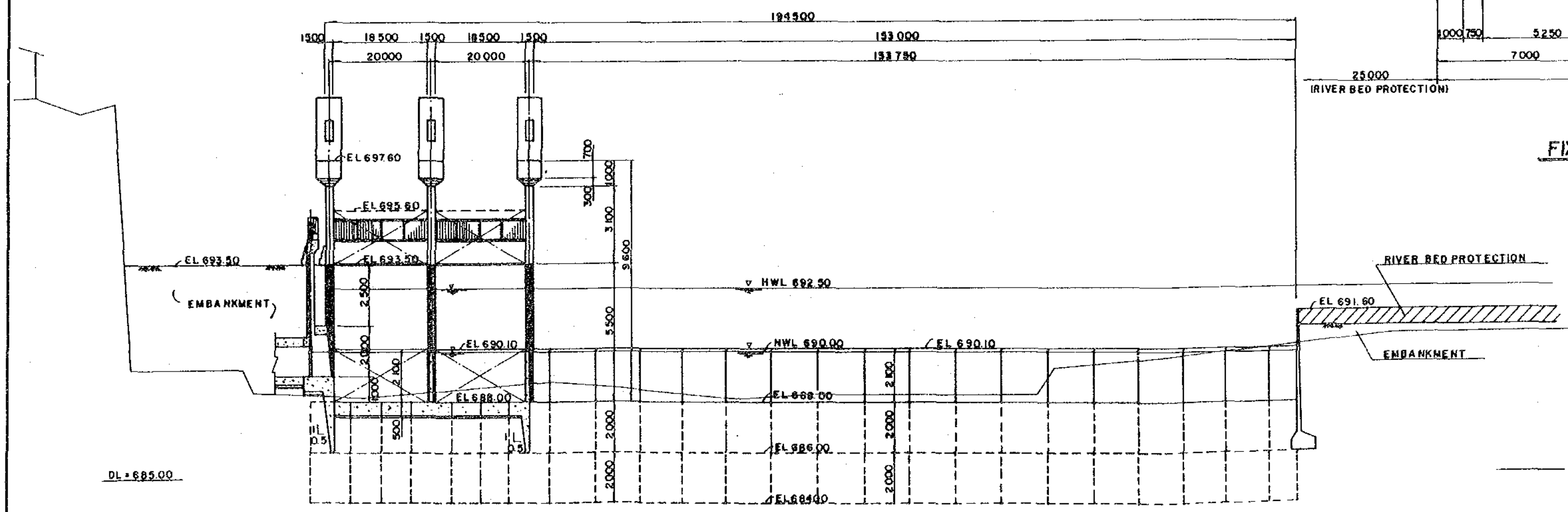
THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY			
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA			
DOR DIVERSION DAM (I)			
DATE		DWG. NO.	12
JAPAN INTERNATIONAL COOPERATION AGENCY			



MOVABLE WEIR-PROFILE
SCALE 1 : 100

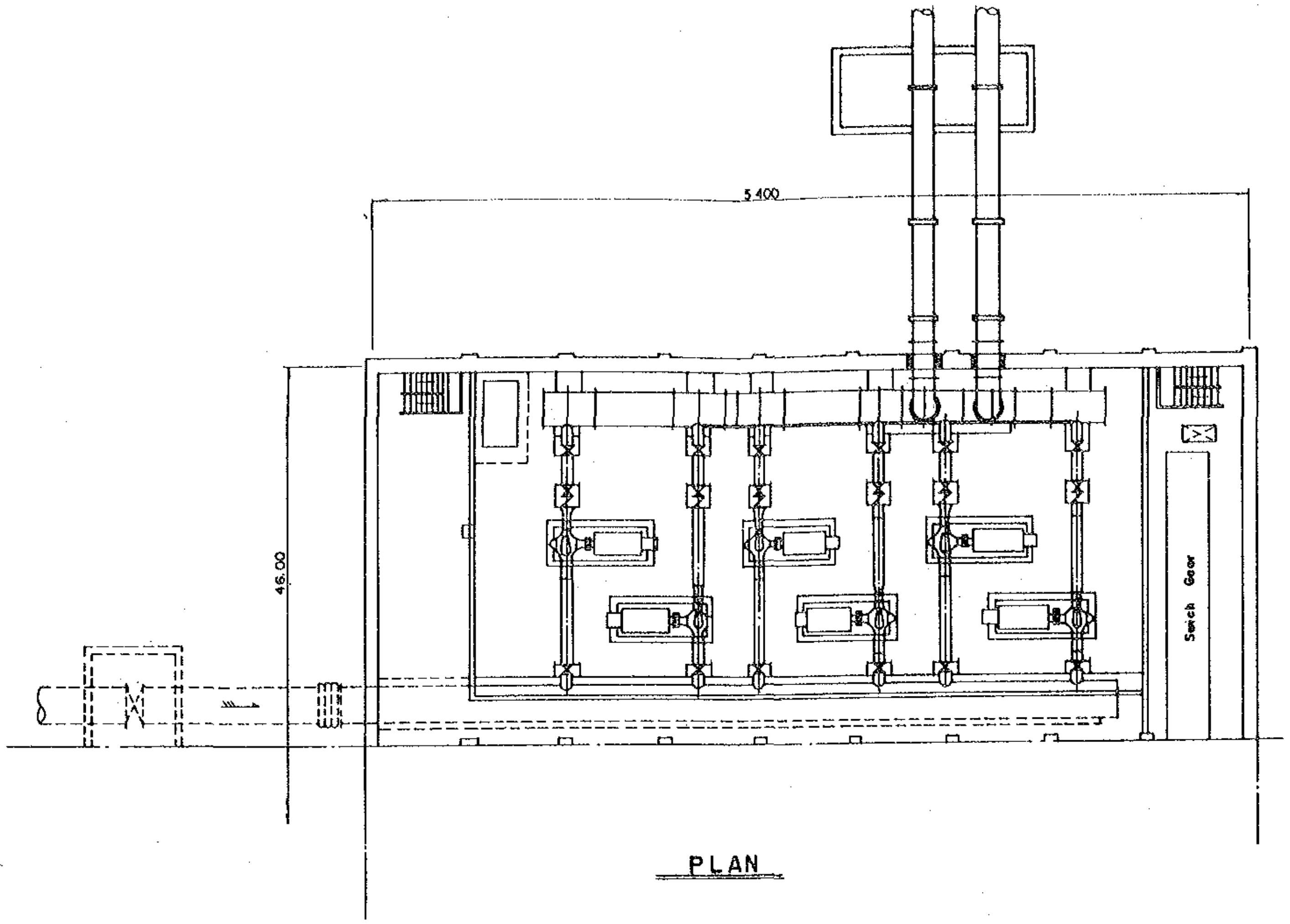


FIXED WEIR-PROFILE
SCALE 1 : 100

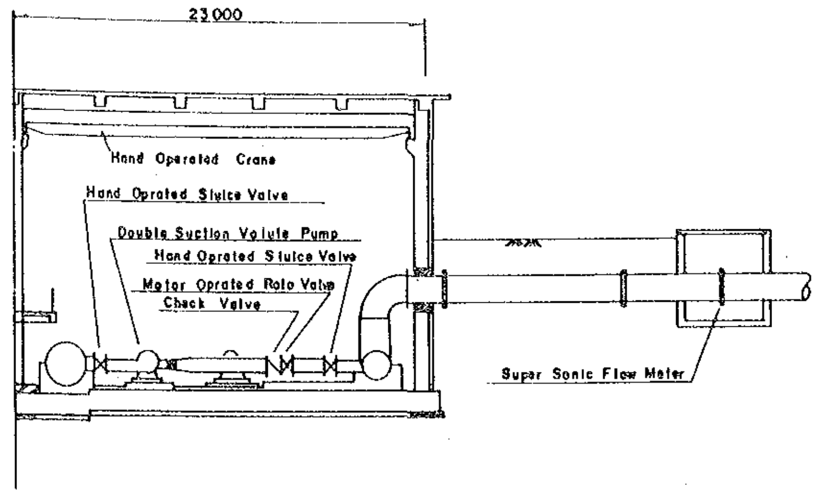


FLONT ELEVATION
SCALE H=1:500 V=1:100

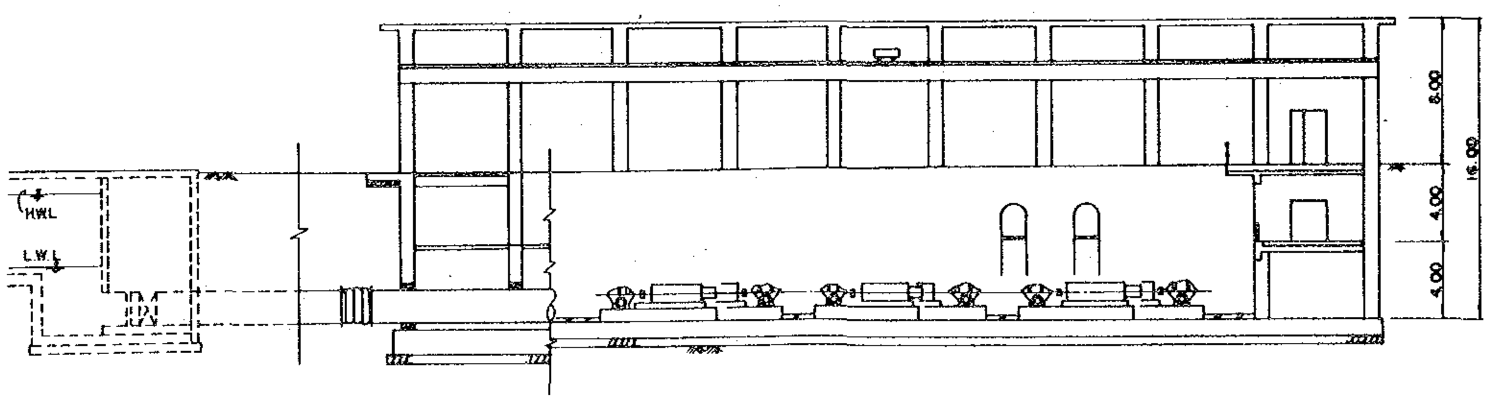
THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY			
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA			
DOR DIVERSION DAM (2)			
DATE		DWG. NO.	13
JAPAN INTERNATIONAL COOPERATION AGENCY			



PLAN

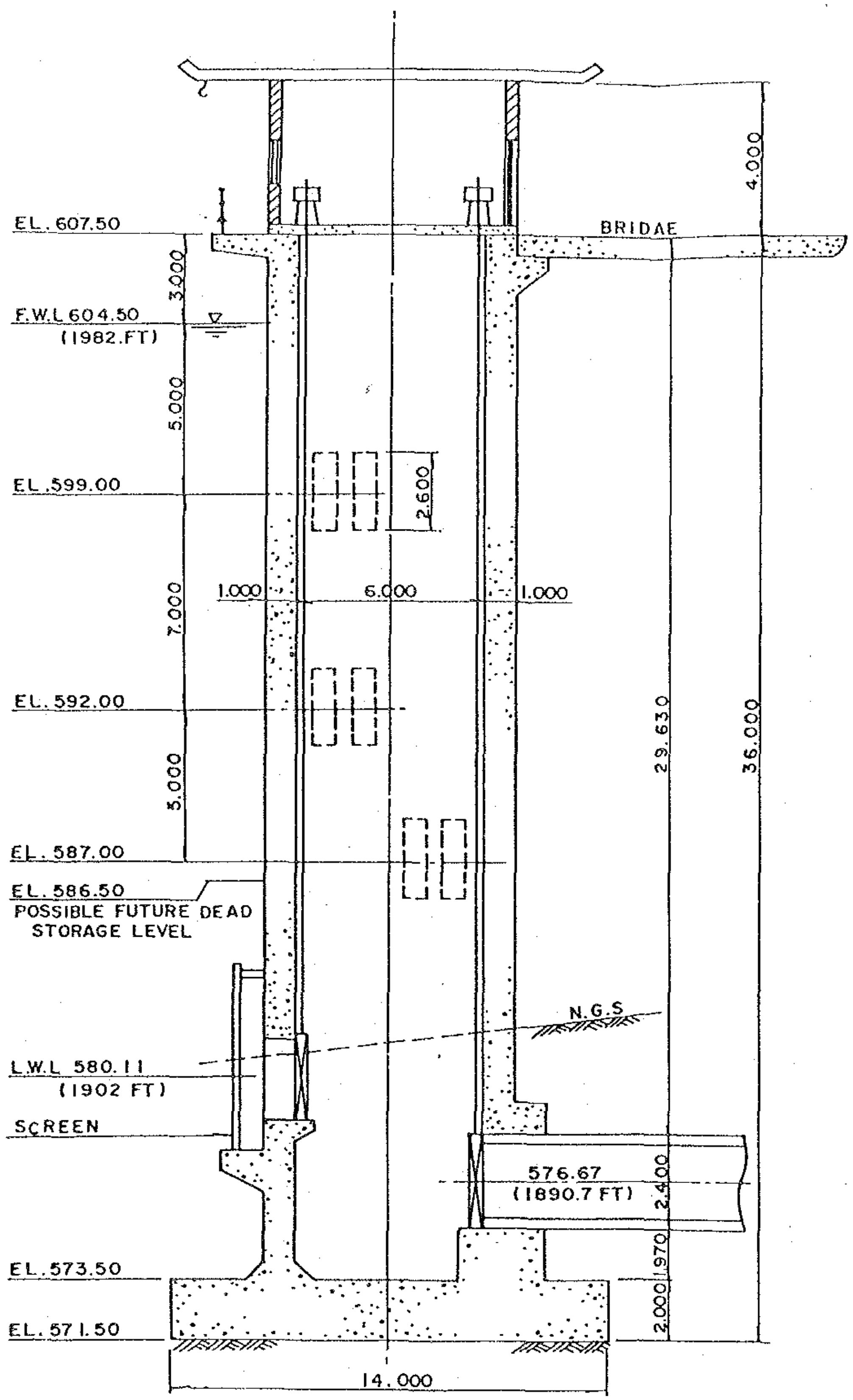


CROSS SECTION

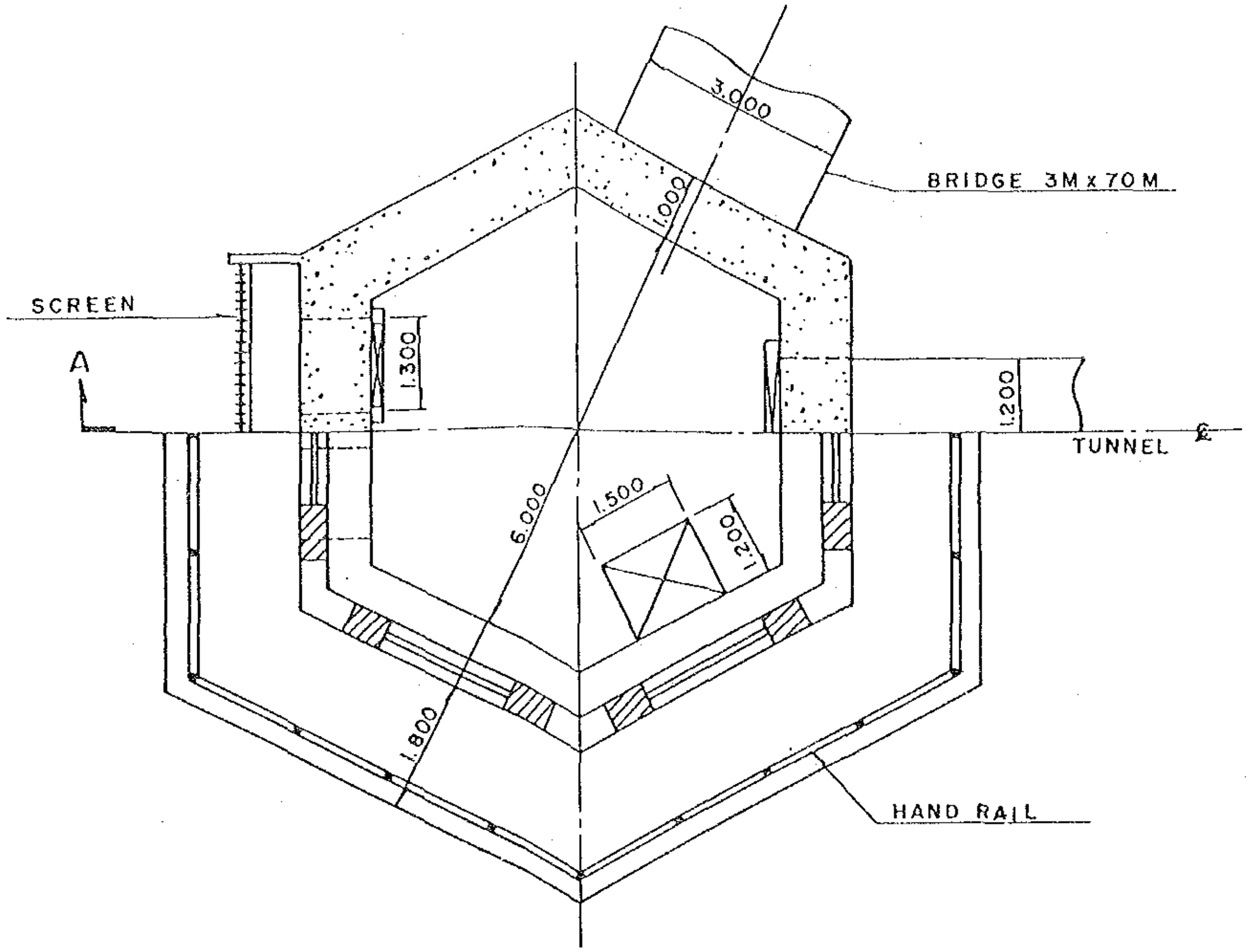


LONGITUDINAL SECTION

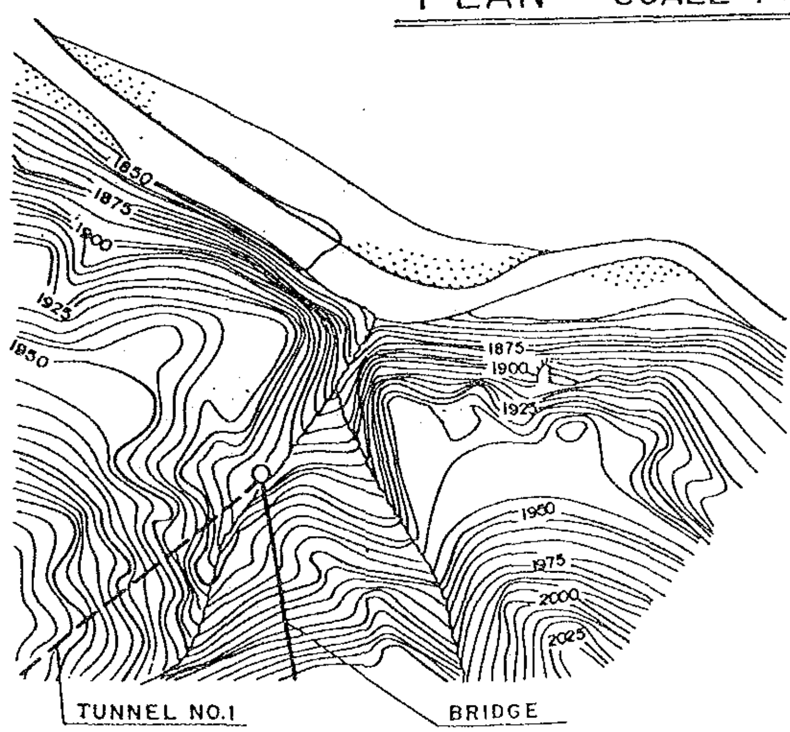
THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY			
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA			
PUMPING STATION			
DATE		DWG. NO.	14
JAPAN INTERNATIONAL COOPERATION AGENCY			



SECTION A–A SCALE 1:200

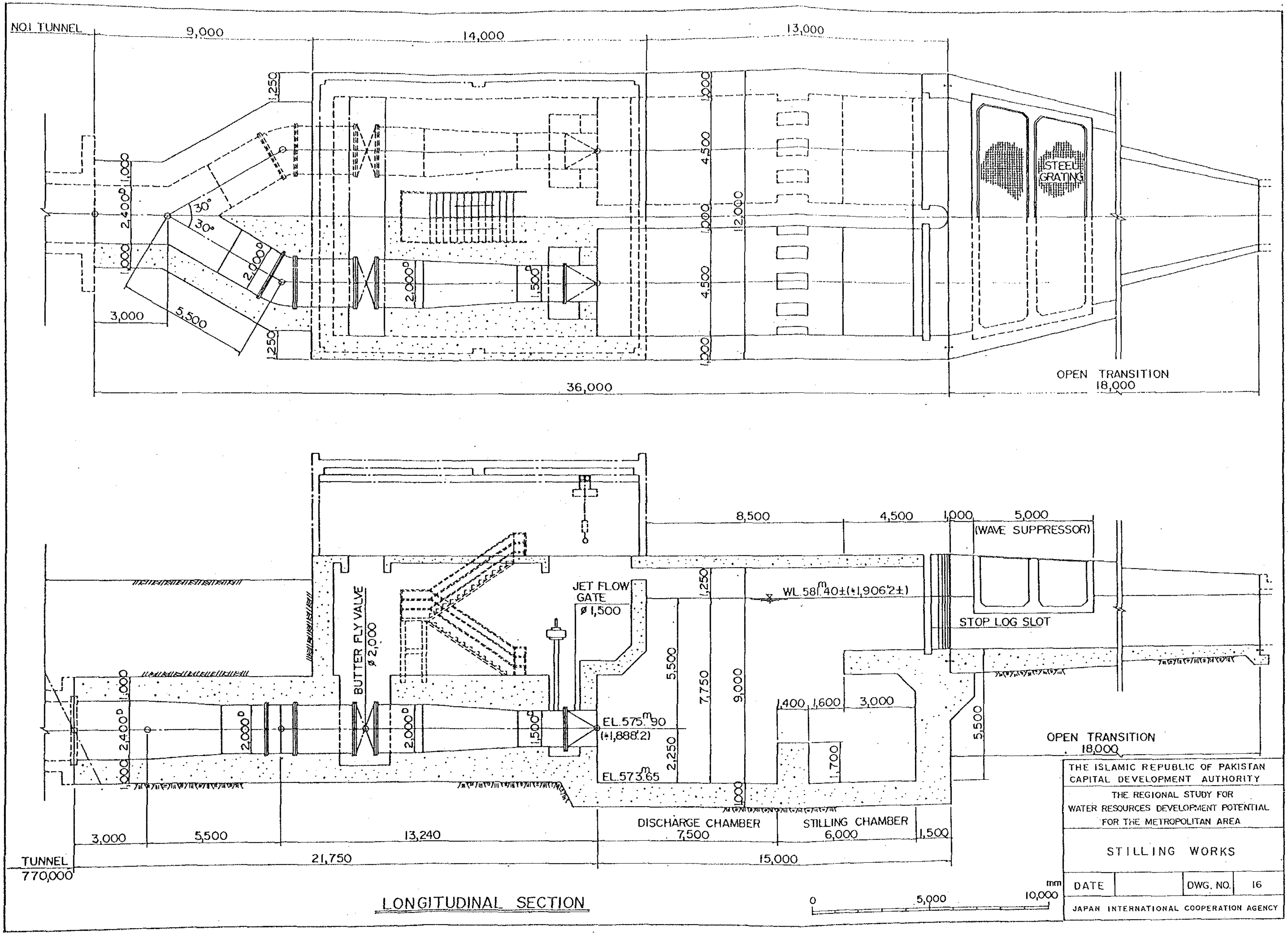


PLAN SCALE 1:100



LOCATION MAP SCALE 1:3000

THE ISLAMIC REPUBLIC OF PAKISTAN CAPITAL DEVELOPMENT AUTHORITY			
THE REGIONAL STUDY FOR WATER RESOURCES DEVELOPMENT POTENTIAL FOR THE METROPOLITAN AREA			
INTAKE TOWER			
DATE		DWG. NO.	15
JAPAN INTERNATIONAL COOPERATION AGENCY			


NO.1 TUNNEL
9,000
14,000
13,000
STEEL GRATING
30°
30°
3,000
5,500
36,000
OPEN TRANSITION
18,000
8,500
4,500
1,000
5,000
(WAVE SUPPRESSOR)
JET FLOW GATE
ø 1,500
BUTTER FLY VALVE
ø 2,000
WL. 581.40±(+1,906.2±)
STOP LOG SLOT
EL. 575.90
(+1,888.2)
EL. 573.65
DISCHARGE CHAMBER
7,500
STILLING CHAMBER
6,000
1,500
13,240
21,750
15,000
TUNNEL
770,000
LONGITUDINAL SECTION
0
5,000
10,000
mm
THE ISLAMIC REPUBLIC OF PAKISTAN
CAPITAL DEVELOPMENT AUTHORITY
THE REGIONAL STUDY FOR
WATER RESOURCES DEVELOPMENT POTENTIAL
FOR THE METROPOLITAN AREA
STILLING WORKS
DATE
DWG. NO. 16
JAPAN INTERNATIONAL COOPERATION AGENCY

JICA