HYDRAULIC DATA AND PRINCIPAL DESIGN FEATURES CHASHMA BARRAGE AND CHASHMA JHELUM LINK CHASHMA BARRAGE

MIAN BARRAGE

Length of Barrage between abutments ..... 3,556 feet
Total No. of Bays ..... 52 No.
No. of standard Bays ..... 41 No.
No. of urdersluice Bays ..... 11 No
Upstream Floor Level ..... 612 No
Crest Level of standard Bays ..... 622 No
Downstream Floor Level of standard Bays 604
Crest level of undersluice Bays 617
Downstream Floor Level of undersluice Bays 599

SIZE OF RADIAL GATES

a) Standard Bays ..... 60' x 35' Height
b) Undersluice Bays ..... 60' x 4' Height

Normal Pond Level 642
Maximum Storage Level 649
Maximum head across ..... 40 feet
Maximum Design Flood Discharge ..... 9,50,000 cusecs
Maximum Intensity of Discharge ..... 300 cusecs per feet
Width of Carriage Way ..... 24 feet for class AA loading

C.J.LINK CANAL HEAD REGULATOR

Designed Capacity (Initial) ..... 21,700 cusecs
Designed Capacity (Ultimate) ..... 26,000 cusecs
Crest level ..... 628 feet SPD
No. of Bays ..... 8 of 40 feet each
Width between abutments ..... 362 feet
Maximum head across at EL. 642.00 ..... 23- feet normal pond
Full supply level ..... 640 feet
Designed bed width ..... 380 feet
Designed bed slope 1:10000
Full supply depth ..... 14- feet

PAHARPUR CANAL / CRBC HEAD- REGULATOR

Designed capacity ..... 5,000 cusecs
Crest level 628.000
No. of bays ..... 2 of 40 feet each
Full supply level 640
Bed width ..... 165 feet
Bed slope 1:8000
Length between the abutments..... 86 feet
Maximum Head- across on normal pond level ..... 17 feet

PAHARPUR CANAL / CRBC CONTROL REGULATOR

Designed capacity ..... 5,000 cusecs
Crest level 626.000
No. of Bays ..... 3 of 24 feet each
Upstream full supply level 636.00
Downstream Full Supply Level 632.56

NAVIGATION LOCK

Length ..... 155 feet
Width ..... 30 feet

RIVER TRAINING WORKS

Length of Upstream left & right guide banks..... 3.669 feet each
Length of Downstream left & right guide banks ..... 633 feet each
Length of right closure bund..... 15.857.3 feet
Length of left spur ..... 10,320.8 feet
Length left branch spur..... 3,688.4 feet
Length of right spur # 1 ..... 7,685.5 feet
Length of Right Spur # 2..... 6,221.05 feet

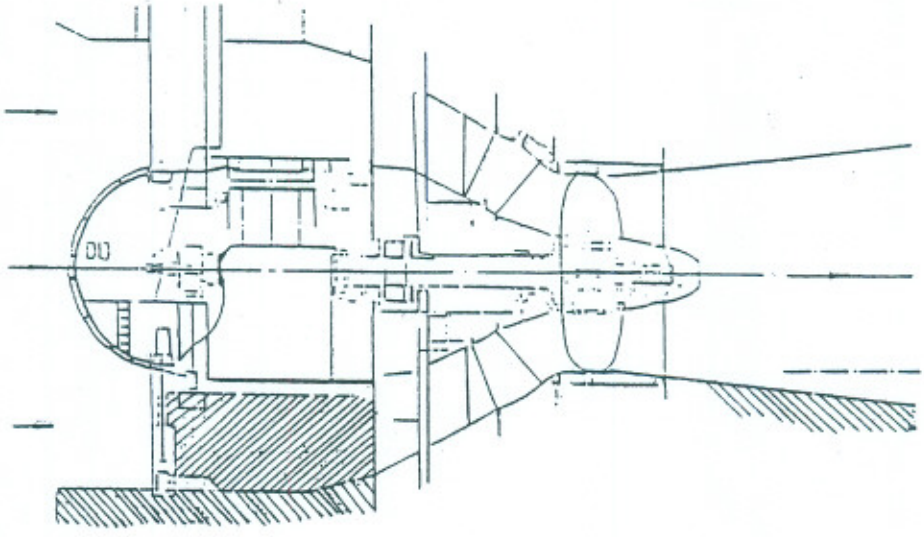
LAND ACQUISITION

Total land acquired for pond area ..... 98.052 acres
Compensation paid..... Rs. 7,32,83,000

CONTRACTUAL INFORMATION

Total Contract price..... Rs. 399/- million
Date of commencement..... 10th February 1967'
Date of Completion ..... 25th March 1971
Contractors ..... Societe Domez Enterprises Borie Coode & Partners, London

CHASHMA HYDROPOWER PROJECT



PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY

CHASHMA HYDRO POWER PROJECT

THE PROJECT

A low head hydel power station of 184 MW capacity consisting of 8 units of 23 MW each is ready for construction on the right side of Chashma Barrage on the Indus river utilizing available head 4 to 11.6 m.

The Chashma Barrage is located on the Indus river about 30 km South of the Mianwali Town and 11 km South-West of Kundian Railway Junction. The barrage was completed in 1971 as part of Indus Basin Treaty. From its left bank Chashma Jhelum Link Canal takes off which carried 615 m^3/s and on right bank is the intake of Paharpur Feeder Canal now named as Chashma Right Bank Canal with capacity of 142 m^3/s.

NEED FOR THE PROJECT

In order to meet over increasing requirement of power in the country WAPDA studied all available sources including sites for low head hydro elctric projects. Pakistan has network of existing barrages and canals on many of which there is enough water flowing downstream with sufficient head convertible power.

Elsewhere and particularly in Europe such sources have been successfully utilised for power generation specially on rivers Rhine and Rhone. Although the barrage in Pakistan have been in existence for quite some time but had not attracted the attention so far as low head hydro electric and generators are relatively expensive. However the studies conducted have established the feasibility of the barrage and major Civil Works structures already exist which are required to be constructed for power house.

Being most economical Chashma emerged as the first prospective site which has come to implementation stage and will have an installed capacity of 184 MW.

TRANSMISSION OF POWER

The power generated will be connected to the existing WAPDA grid and will require:

1- One double circuit line from Chashma Project to Wanbachran grid station covering a distance of 30 km.

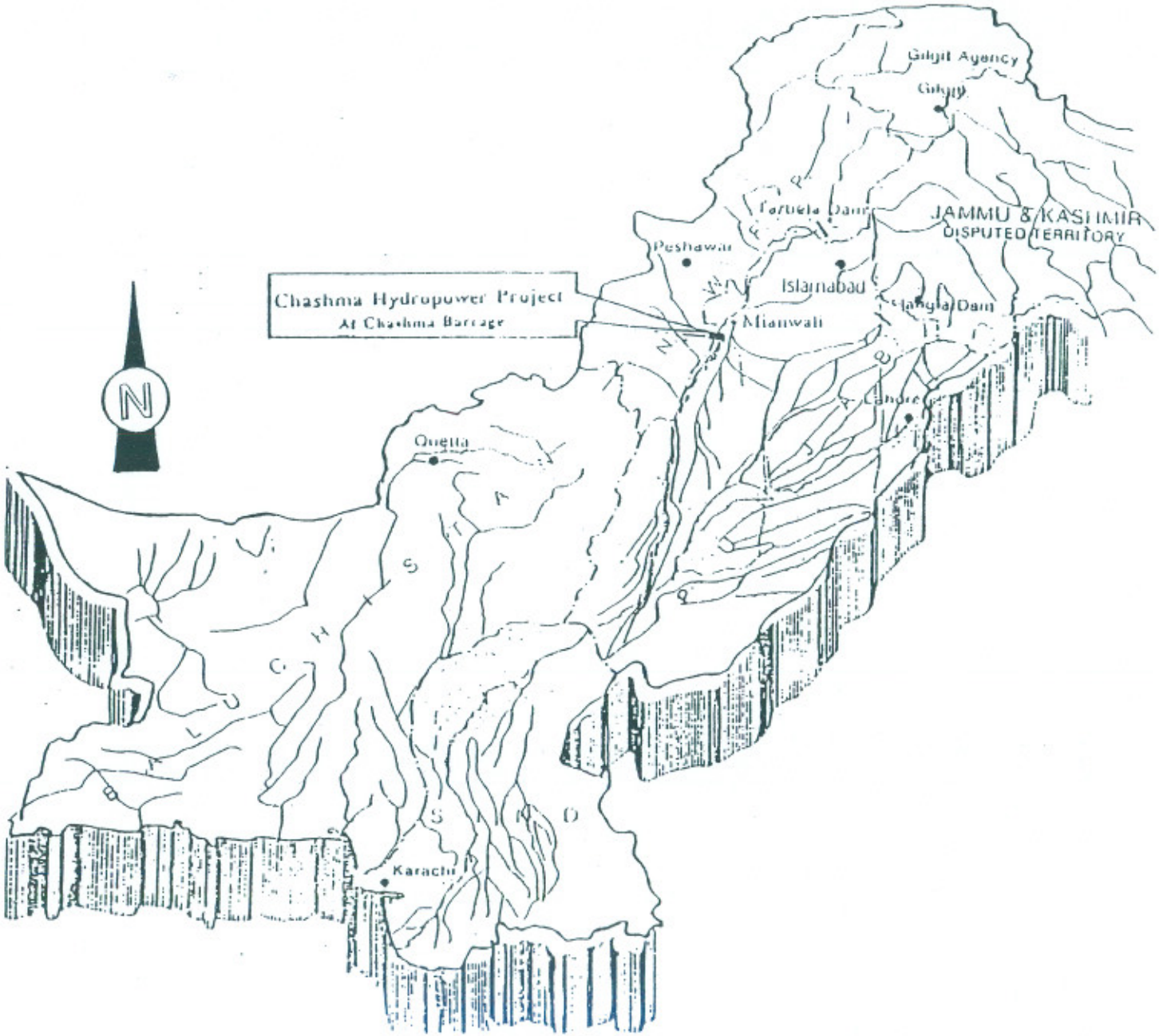
2- One double circuit line from Chashma Project tapped to the line between Wanbachran and Piplan having a length of 14 km.

ENVIRONMENTAL IMPACT

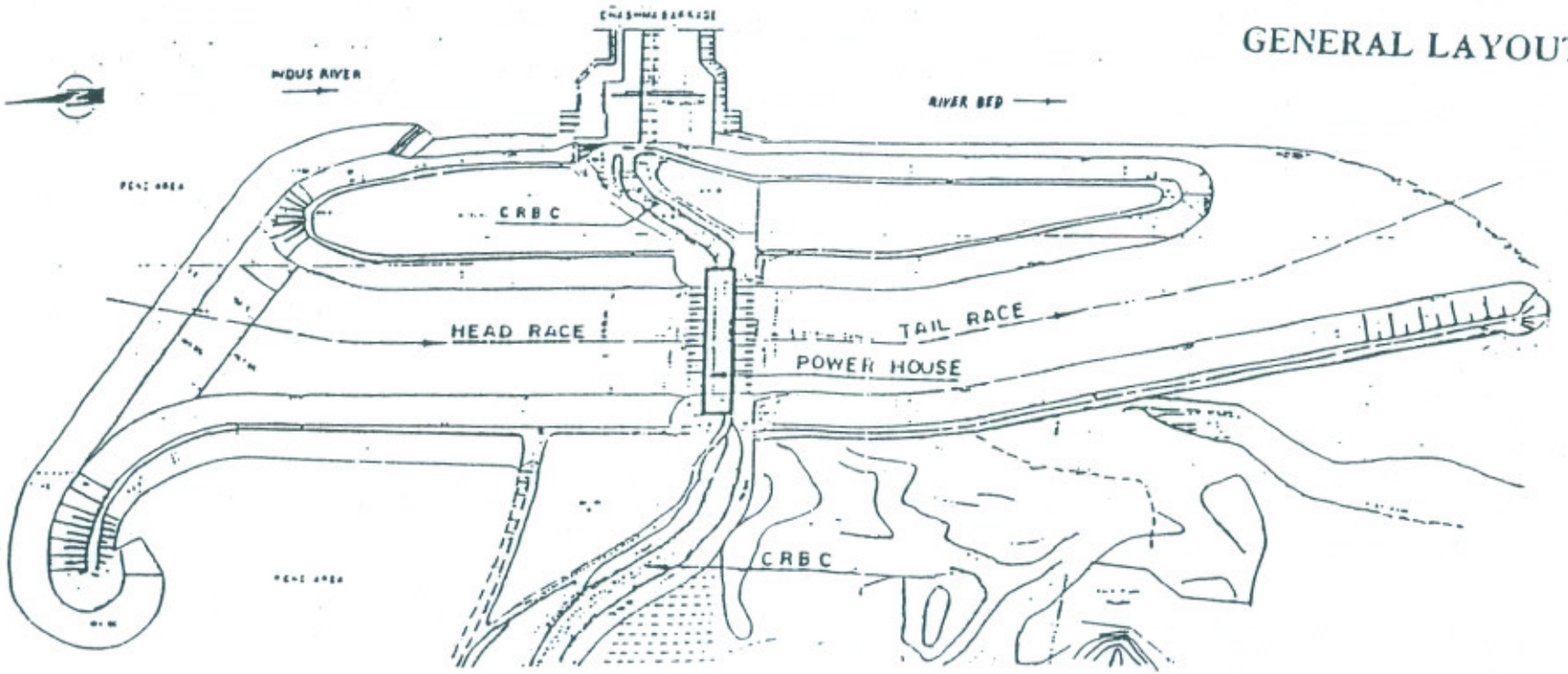
Significant environmental changes have already taken place due to the construction and operation of Chashma Barrage. The power plant therefore is unlikely to result in any significant change, as no change in operation of the reservoir is foreseen for power generation. The level of reservoir shall continue to be controlled for irrigation purposes as in the past.

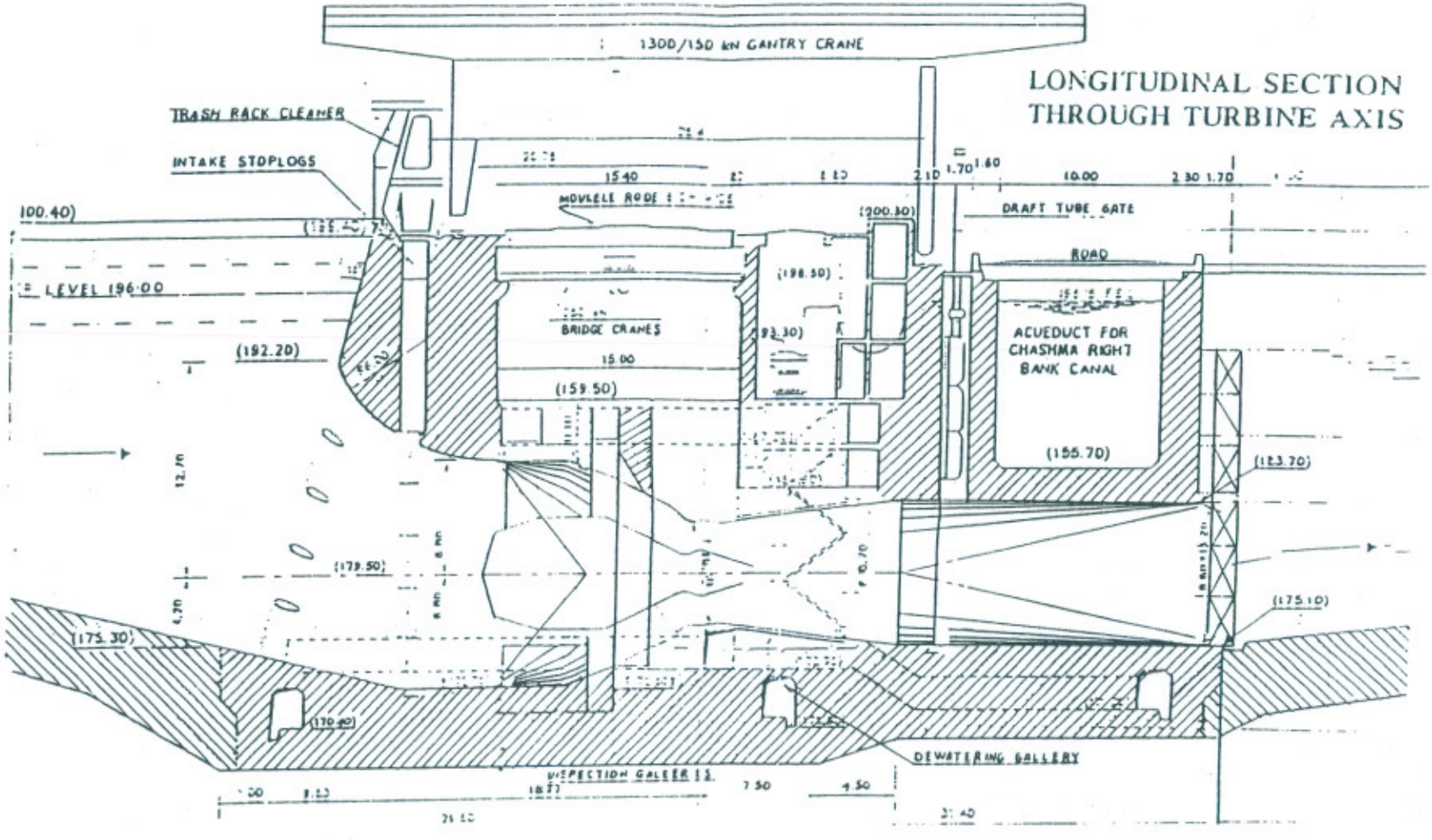
A fish ladder in addition to the existing bar one in the barrage shall be provided along the left side of the powerhouse to allow seasonal irrigation of fish.

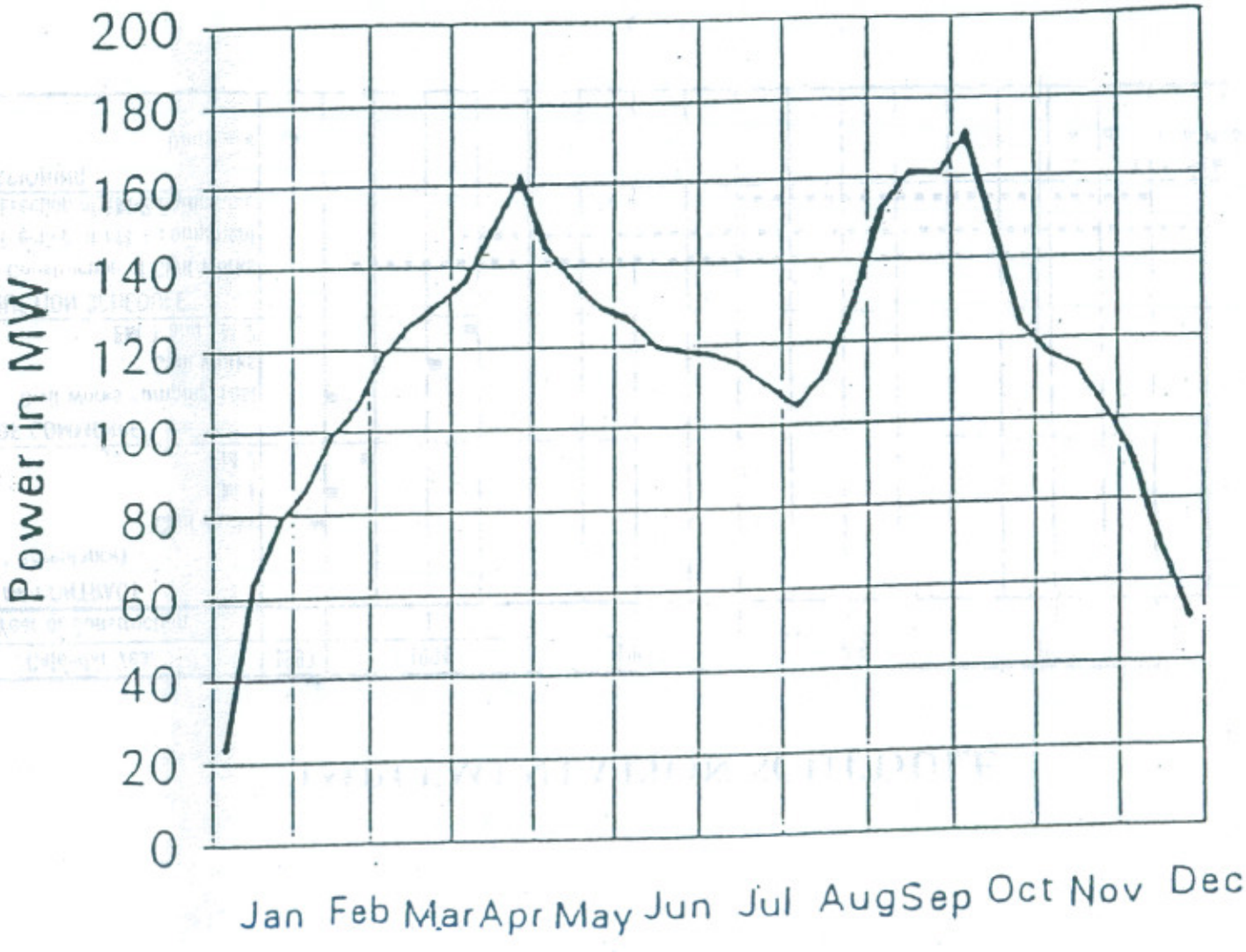
No significant changes in sedimentation pattern are expected


Gilgit Agency
Gilgit
Tarbela Dam
JAMMU & KASHMIR
DISPUTED TERRITORY
Peshawar
Islamabad
Chashma Hydropower Project
At Chashma Barrage
Mianwali
Jhelum Dam
Quetta
Karachi
N

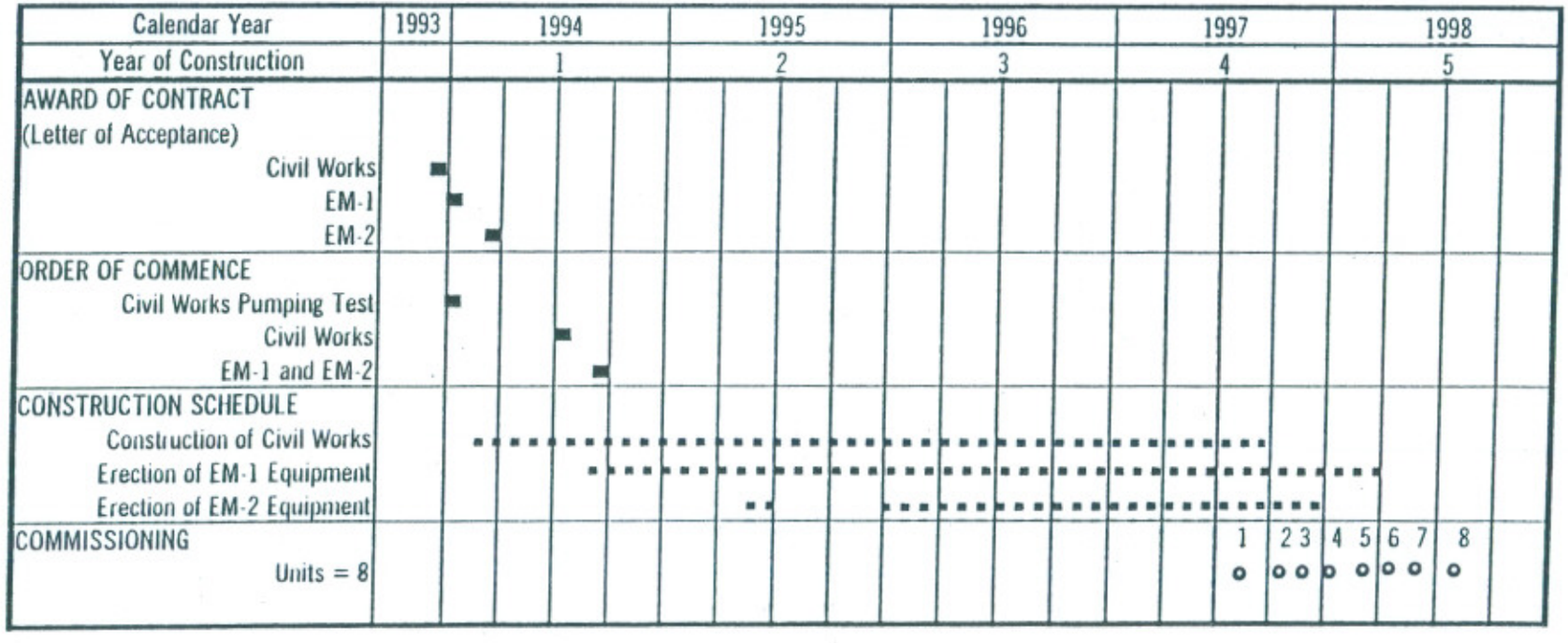
GENERAL LAYOUT




LONGITUDINAL SECTION
THROUGH TURBINE AXIS
1300/150 kN GANTRY CRANE
TRASH RACK CLEANER
INTAKE STOPLOGS
MOVABLE RODE
DRAFT TUBE GATE
ROAD
BRIDGE CRANES
15.00
ACUEDUCT FOR
CHASHMA RIGHT
BANK CANAL
LEVEL 196.00
100.40)
(192.20)
(159.50)
(198.50)
(200.30)
(155.70)
(183.70)
(179.50)
(175.30)
(175.10)
(170.40)
DEWATERING GALLERY
INSPECTION GALLERY
10.00
2.30
1.70
1.60
2.10
7.50
4.50


Power in MW
200
180
160
140
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

IMPLEMENTATION SCHEDULE



except that due to diversion of flow some change in operational rules of barrage gates may become necessary.

COST OF PROJECT

The Project Cost had been estimated at 10,557,30 millon of Ruprees on completion. This includes a Foreign Exchange portion of Rs. 6,152.79 million (U$ 204.89 million at 1 US$ = 30.0292 Rs. September, 1993 level).

BENEFIT

The Project will start giving benefit in the year 1997-98. The expected total energy generated annually is estimated at 1031 GWh. The revenues attributable to the project are calculated at 55% of generated energy. This ratio is based upon assets committed to power generation in the total power system, comprising of generation, transmission and distribution (55% : 22% : 25% adopted for 1993-94). The income is estimated on the basis of average sale price at Rs. 1.326/KWh in 1992-93 which has been escalated at 10% per annum to Rs. 2.135 upto year 1997-98 when the Project will start giving benefits. Based on these factors the estimated yearly revenues (at 1997-98 average sale) is Rs. 1.210 million.

In addition there are numerous non-quantifiable benefits such as saving of foreign exchange required to operate a thermal power station of equivalent capacity, boost in agriculture and industrial production, increase in incomes of farmers and workers and increase in government levies and taxes on increased production.

JOB OPPORTUNITIES

Job opportunities will come up during construction of the project and after completion of the project. A good number of staff will be appointed by WAPDA for its operation and maintenance. The categories of staff required for these two stage are as follows:-

Sr. No.		During Construction Nos.	During O&M Nos.
1.	Profession and Technical	250	48
2.	Administrative Executive and Managerial	10	11
3.	Clerical	80	46
4.	Supervisory	150	18
5.	Skilled	600	212
6.	Unskilled	1,800	180
7.	Total:	2,890	515

SALIENT FEATURES OF THE PROJECT

RESERVOIR (Existing)

	Maximum Pond Level	197.8m	(649 ft)
	Normal Pond Level	195.7m	(642 ft)
	Minimum Pond Level	194.2m	(637 ft)
POWER COMPLEX			
a.	Hydrological Data		
	Maximum Rated discharge	$2,000^3$/s	(70,630 cfs)
	Unit Discharge	$250m^3$/s	(8,829 cfs)
	Head Available	4.0 to 11.6m	(13 to 38 ft)
	Rated Head	8.35m	(27.4 ft)
b.	Head Race		
	Length	1,000m	(3,280 ft)
	Bed Width	136m	(446 ft)
	Side Slope	4:1	
c.	Tail Race		
	Length	1,200m	(3,937 ft)
	Bed Width	136m	(446 ft)
	Side Slope	4.1	
d.	Power House		
	Type	Semi- Outdoor	
	Length(Right to left Sides)	202m	(663 ft)
	Width (US-DS)	61m	(200 ft)
	Number of Units	8	
	Turbine:		
	type	Bulb type	
	Rated output	23 MW	
e.	Main Quantities		
	Excavation	$1,270,000m^3$	(45 million ft^3)
	Fill	$1,200,000m^3$	(42 million ft^3)
	Concrete	$306,000m^3$	(11 million ft^3)
	Cement	178,000t	
	Aggregate	440,000t	
	Reinforcement	15,800t	
	Stone	$654,000m^3$	(23 million ft^3)
	Geotextile	$952,000m^3$	(10 million ft^3)
	Dredging	$5,500,000m^3$	(194 million ft^3)
f.	Power Potential		
	Installed capacity	184MW	
	Average Annual Energy Output	1031GWh	

TRANSMISSION LINES (132 KV)

Length of the Two Double Circuit lines		
To Wanbanchran Grid Station	30Km	(18 miles)
To Wanbachran- Piplan Tee off Point	14 km	(9 miles)

COST OF THE PROJECT

Total	Rs.	10,557.30 million
Foreign	Rs.	6,152.79 million

CHASHMA RIGHT BANK IRRIGATION PROJECT STAGE -I

PROJECT AT A GLANCE

1. Name of Project ..... Chashma Right Bank Irrigation Project Stage -1
2. River Off- take ..... Indus (at Chashma Barrage)
3. Location District D.I.Khan (NWFP) and District Mianwali (Punjab)

4. **Main Canal**
   - **Length of Canal**
   - RD. 000 to RD. 260 ..... 52 miles
     - i) Unlined ..... 24 miles
     - ii) lined ..... 28 miles
   - **Discharge Capacity**
     - i) At Head (RD. 000) ..... 4,879 cusecs
     - ii) Water Requirement ..... 1,226 cusecs
     - iii) MWFP ..... 1,192 cusecs
     - iv) Punjab ..... 34 cusecs
   - **Structures**
     - i) Cross- Drainage Works ..... 18 Nos.
     - ii) X- regulators ..... 2 Nos.
     - iii) Escape Structures ..... 2 Nos.
     - iv) Bridges ..... 36 Nos.

5. **Distributaries**
   - i) Nos. ..... 13Nos.
   - ii) Length ..... 147 miles

6. **Cultural Command Area (CCA)**
   - i) Total ..... 150,000 acres
   - ii) NWFP ..... 146,000 acres
   - iii) Punjab ..... 4,000 acres

7. **Construction Schedule**
   - i) Commencement ..... July 1978
   - ii) Completion ..... December 1986

8. **Financial Status**
   - PC-I Cost ..... Rs. 2,481 million
   - ADB.s Share ..... 79% (US$ 32.00 million)
   - Government of Pakistan's Share ..... 12% (Rs. 1925.00 million)

9. **Cropping Intensity**
   - i) Before Commissioning 28%
   - ii) After Commissioning 84%
   - iii) Ultimate 150%

*Distribution System was handed over to PID NWFP during year 1990-91
O&M of Main Canal rests with WAPDA.

CHASHMA RIGHT BANK IRRIGATION PROJECT STAGE II

PROJECT AT A GLANCE

1. Name of Project ..... Chashma Right Bank Irrigation Project Stage -II
2. River Off- take ..... Indus (at Chashma Barrage)
3. Location ..... District D.I.Khan (NWFP)

4. **Main Canal**
   - **Length of Canal**
     RD. 260 to RD. 378 ..... 24 miles
     i) Unlined ..... miles
     ii) Lined ..... 24 miles
   - **Discharge Capacity**
     i) At Head (RD. 260) ..... 3,653 cusecs
     ii) Water Requirement ..... 800 cusecs
     iii) NWFP ..... 800 cusecs
     iv) Punjab ..... cusecs
   - **Structures**
     i) Cross- Drainage Works ..... 21 Nos.
     ii) X- regulators ..... 2 Nos.
     iii) Escape Structures ..... 1 Nos.
     iv) Bridges ..... 20 Nos.

5. **Distributaries**
   i) Nos. ..... 15 Nos.
   ii) Length ..... 105 miles

6. **Cultural Command Area (CCA)**
   i) Total ..... 94,000 acres
   ii) NWFP ..... 94,000 acres
   iii) Punjab ..... acres

7. **Construction Schedule**
   i) Commencement ..... August 1988
   ii) Completion ..... September, 1994

8. **Financial Status**
   PC-I Cost ..... Rs. 2,331 million
   ADB's Share ..... 79% (US$ 44.00 million)
   Government of Pakistan's Share ..... 21% (Rs. 1273.00 million)

9. **Cropping Intensity**
   i) Before Commissioning 28%
   ii) After Commissioning 84%
   iii) Ultimate 150%

*Distribution System was handed over to PID NWFP during year 1993-94
*O&M of Main Canal rests with WAPDA.

CHASHMA RIGHT BANK IRRIGATION PROJECT - STAGE - III

PROJECT AT A GLANCE

1. Name of Project ..... Chashma Right Bank Irrigation Project Stage-III
2. River Off-take ..... Indus (at Chashma Barrage)
3. Location ..... District D.I. Khan (NWFP) and District Mianwali (Punjab)

4. **Main Canal**
   - **Length of Canal** ..... 94 miles
     - i) NWFP (RD. 378 to RD 528) ..... 30 miles
     - ii) Punjab (RD. 528 to RD 851) ..... 64 miles
   - **Discharge Capacity**
     - i) At Head (RD. 378) ..... 2,853 cusecs
     - ii) Water Requirement ..... 2,853 cusecs
     - iii) NWFP ..... 1,053 cusecs
     - iv) Punjab ..... 1,800 cusecs
   - **Structures**
     - i) Cross-Drainage Works ..... 27 Nos.
     - ii) X-regulators ..... 16 Nos.
     - iii) Escape Structures ..... 4 Nos.
     - iv) Bridges ..... 33 + 2 Nos.
5. **Distributaries**
   - i) Nos. ..... 44 Nos.
     - a) NWFP ..... 13 Nos.
     - 2. Punjab ..... 31 Nos.
   - ii) Length ..... 414 miles
     - a) NWFP ..... 138 miles
     - b) Punjab ..... 276 miles

6. **Cultural Command Area (CCA)**
   - i) Total ..... 326,000 acres
   - ii) NWFP ..... 110,000 acres
   - iii) Punjab ..... 216,000 acres

7. **Construction Schedule**
   - i) Commencement ..... February, 1995
   - ii) Completion ..... February, 2002
8. **Financial Status**

PC-I Cost ..... Rs. 9058 million
ADB's Share ..... 65% (US$ 185.00 million)
Government of Pakistan's Share ..... 14% (Rs. 2292.00 million)
Expenditure (Incurred September 30, 1998) ..... (Rs. 3221 Million)
Contract-wise detail is annexed.

CONTRACT - WISE DETAIL

CHASHMA RIGHT BANK IRRIGATION PROJECT STAGE - III

1. **Contract No. 64**
   - a) Construction of Main Canal, Related Structures (RD, 385 + 425 to RD. 405 + 000) 4 miles
   - b) Flood Carrier Channel including affiliated structures ..... 4 miles
   - c) Off-take Structures (D-14 and D-15) ..... 2 miles
   - d) Cost
     - i) Estimated ..... Rs. 209 million
     - ii) Contract Price ..... Rs. 207 million
   - a) Dates of
     - i) Commencement ..... February 20, 1995
     - ii) Completion ..... December 15, 1995

   Contract has been completed.

2. **Contract No. 65**
   - a) Construction of Main Canal, Related structures (RD. 405 + 000 to RD 851 + 100) 90 miles
     - i) NWFP (RD. 405 + 000 to RD. 527 + 950) ..... 24 miles
     - ii) Punjab (RD. 527 + 950 to RD. 851 + 100) ..... 66 miles
   - b) Flood Carrier Channel including affiliated structures ..... 180 miles
   - c) Off-take Structures (D-16 and D-53) ..... 44 Nos.
     - i) NWFP ..... 13 Nos.
     - ii) Punjab ..... 31 Nos.
   - a) Cost
     - i) Estimated ..... Rs. 5,091 million
     - ii) Contract Price ..... Rs. 5,715 million
   - e) Date of
     - i) Commencement ..... September 27, 1997
     - ii) Completion (Scheduled) ..... February 26, 2002

   Work in Progress

3. **Contract No. 66 (Covers Distribution System in NWFP)**
   - a) Construction of Distributaries No. 14 to No. 23 and Appurtenant Structures ..... 138 miles
   - b) Cost
     - i) Estimated ..... Rs. 427 million
     - ii) Contract Price ..... Rs. 430 million
   - e) Date of
     - i) Commencement (Scheduled) ..... November 30, 1998
     - ii) Completion (Scheduled) ..... November 30 2001

   Award under process of approval.

4. **Contract No. 67 (Covers Distribution System in Punjab)**
   - a) Construction of Distributaries No. 24 to No. 36 and Appurtenant Structures ..... 141 miles
   - b) Cost
     - i) Estimated ..... Rs. 449 million
     - ii) Contract Price ..... Under Evaluation
   - c) Date of
     - i) Commencement (Scheduled) ..... February 26, 1998
     - ii) Completion (Scheduled) ..... February 26, 2002

   Tenders have been issued on 15-July 1998 and opened on 1st October 1998.

5. **Contract No. 66 (Covers Distribution System in Punjab)**
   - a) Construction of Distributaries No. 37 to No. 53 and Appurtenant Structures ..... 135 miles
   - b) Cost
     - i) Estimated ..... Rs. 480 million
     - ii) Contract Price ..... Tenders yet to be called.
   - c) date of
     - i) Commencement (Scheduled) ..... May 26, 1999
     - ii) Completion (Scheduled) ..... May 26, 2002

   Tender Documents have been finalized. ADB has advised that the issuance of the tenders should commensurate with the Bank's decision regarding shortfall of loan financing.

CHASHMA RIGHT BANK IRRIGATION PROJECT STAGE - III

CONTRACT NO. 65
SOME INFORMATIONS SUPPLIED BY THE INTERNATIONAL CONTRACTOR M/S TEKSER

Personnel List

As per September 1998

No.	Designation	Total Nos.
	TEKSER Personnel	
1.	Turkish Management	20
2.	Turkish Supervisors	72
3.	Pakistani Engineers	44
4.	Administrative	30
5.	Foremen	52
6.	Sub-Engineers	27
7.	Supervisor	13
8.	Skilled Labour	1277
9.	Indirect Services	152
Sub Total		1687
	Sub-Contractors Personnel	
1.	Civil Engineer	14
2.	Equipment Operator	310
3.	Labour	320
4.	Supervisor	18
5.	Surveyor	10
Sub Total:		672
Grand Total		2359

Equipment List

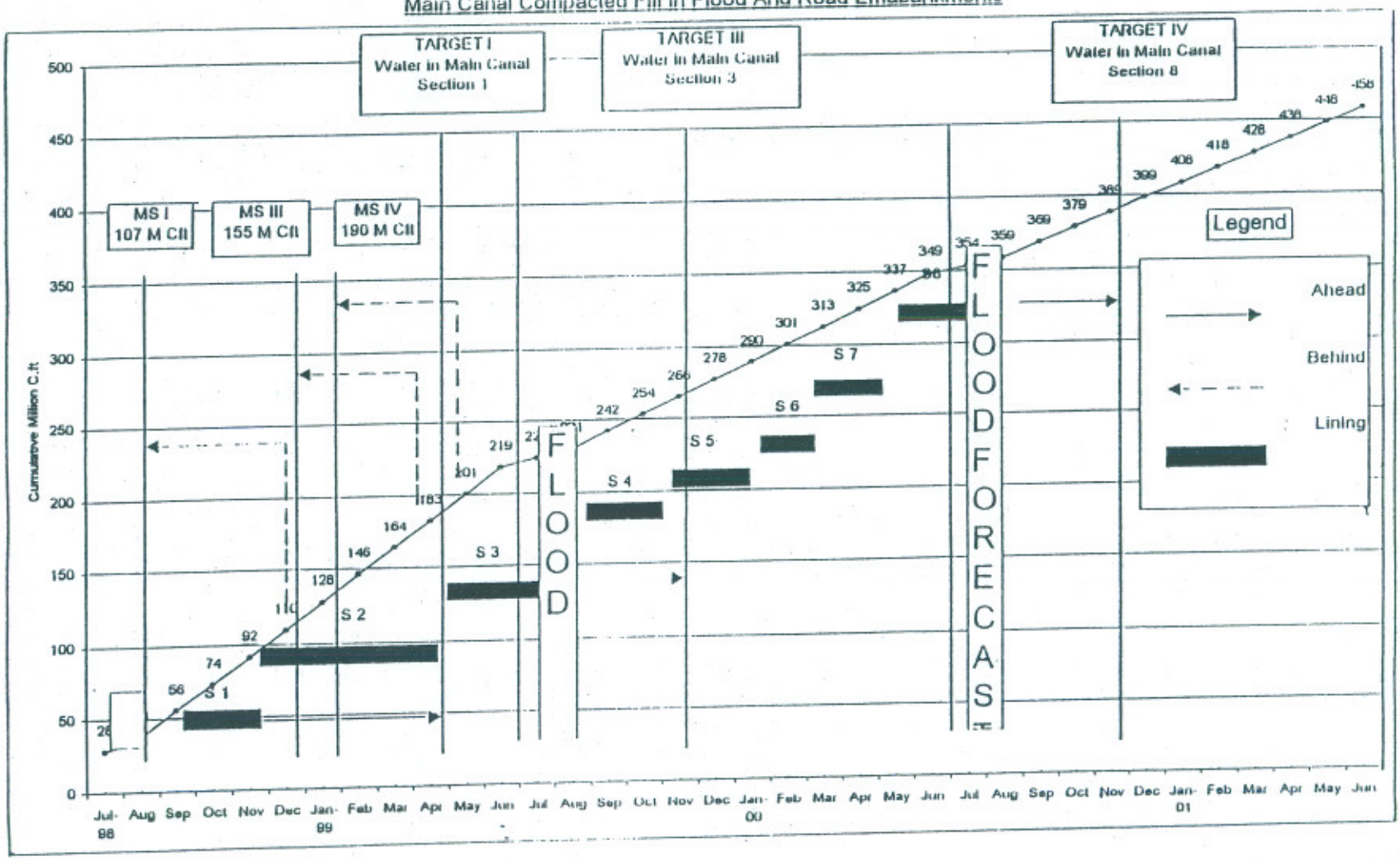
As per September 1998

No.	Description	Total Nos.
	TEKSER Equipment	
..1.	Backhoe Loader	2
..2.	Batch Plant	5
..3.	Bull Dozer	7
..4.	Cement Trailer	6
..5.	Compressor	12
..6.	Concrete Pump	5
..7.	Crusher Plant	3
..8.	Dump Truck	33
..9.	Excavator	9
.10.	Fork Lift	2
.11.	Fuel Tank	2
.12.	Generator	39
.13.	Grader	4
.14.	Lighting Tower	2
.15.	Low Bed Trailer	1
.16.	Maintenance Truck	3
.17.	Mobile Crane	2
.18.	Mobile Welding Machine	2
.19.	Scrapers	3
.20.	Telepoater	4
.21.	Tower Crane	4
.22.	Tractor	13
.23.	Transitmixer	20
.24.	Truck Crane	3
.25.	Vibratory Roller	11
.26.	Water Pump	20
.27.	Water Tank	15
.28.	Water Tanker	15
.29.	Well with Casing	4
.30.	Loader	9
Sub Total		260

No.	Description	Total Nos.
	Rental Equipment	
1.	Crane	2
2.	Dozer	3
3.	Excavator	1
4.	Grader	4
5.	Loader	3
6.	Tractor	24
7.	Water Bowzer	10
Sub Total		47
	Sub-contractors Equipment	
1.	Crane	2
2	D Trucks/Trolley	66
3.	Dozer	3
4.	Drilling Rigs	3
5.	Excavator	11
6.	Generators	1
7.	Grader	1
8.	Loader	9
9.	Precation Rigs	1
10.	Rollers	6
11.	Tractor	150
12.	Water Bowzer/Tankers	16
13.	Water Pump	10
Sub Total		279
	Light Vehicles	
1.	Commuter Van	2
2.	Jeep	8
3.	Jeep (Four Wheel Drive)	3
4.	Pick-up	27
5.	Sedan	3
6.	Large Bus	11
7.	Mini Bus	4
Sub Total		58
Grand Total		644

Chasma Right Bank Irrigation Project

Main Canal Compacted Fill in Flood And Road Emabankments



CRACKS IN BUILDING STRUCTURES

(A BRIEF ON LECTURE DELIVERED ON 25.2.98
BY ENGR. ABDUS SALAM, A FORMER SECRETARY, C & W DEPARTMENT, PUNJAB)

This lecture does not refer to structural cracks in buildings (which can be due to faulty design, bad workmanship or over loading), but refers to non structural cracking in buildings commonly constructed in this country. Such non-structural cracking can be due to one or more of the following causes:-

i) Moisture Movements.
ii) Thermal expansion and contraction.
iii) Elastic Shortening.
iv) Movement due to Creep.
v) Movement due to Chemical Re-action.
vi) Foundation Settlement.
vii) Cracking due to Vegetation.

Non structural cracks in buildings generally do not impair stability of buildings, but they are aesthetically un-pleasing; some times cause scare to the residents and with ingress of rain/ moisture, the internal finishes can be spoiled leading to expensive restoration. With little more attention and care at the design stage and during construction phase, their occurrence can be controlled or eliminated.

The public generally complain that old buildings constructed during pre-independence era performed much better then buildings being constructed during the present years. The old buildings do not show cracking, while in the modern buildings cracks can be seen a few months after completion. The working of present generation of engineers is being adversely commented upon. It is not realized that modern buildings are tall, have thin walls with high stresses, built in cement mortar with rapid pace of construction. As against this old structures were low in height, had thick walls, built generally in mud mortar, stresses were low and speed of construction was slow. The modern buildings are thus more crack prone.

This lecture aims to identify causes of non-structural cracking and advises necessary precautions to avoid occurrence of such cracks. These precautions do not entail additional cost and should pay dividend in better professional performance of our engineers in the construction of new buildings.

In case of some completed buildings, engineers are called upon to inspect cracks in various locations and are required to look into their causes and suggest remedial measures. For repairs and remedies to be effective, it is important that engineers should have proper understanding of various causes of cracking.This lecture highlights the likely causes and as mentioned above advises on better building practices.

Cracking is of different types. It can be straight, diagonal, map pattern or random and may be vertical or horizontal. The causes are varied as mentioned in para I above. The diagnosis and repairs of cracks in a completed building needs to be treated separately and are not covered in this short lecture, which mainly aims to create awareness among the engineers to devote little more attention both at the design stage and during construction phase of the buildings they are called upon to structurally design and execute at site.

The lecture is illustrated with slides and elaborates the causes of cracking and relevant precautions under the seven sub heads as listed in paral.

FROM CHAIN TO GPS

By Engr. A.W. Mir
G.M. (S&M), NESPAK.

The very basic activity of land surveying involves measurement of distances or dimensions of object and determination of position on the surface of earth. Right from the dawn of civilization man needed measurement of land for a variety of purposes both at the individual level and national level. The individuals needed to determine the extent or limit of their holdings, and the Rulers needed measurement of land for assessment and collection of revenue and also for military purposes. The early instrument of distance measurement was a length of rope with knots at equal spacing or length of pole with notches. Edmond Gunter (1581-1626), a mathematics professor at a College in England divided the 66 ft chain into 100 links of 7.92 inches each, and the famous much used Gunter Chain came into being. Any combination of its length and width could easily be converted into acres. It has been very popular in cadastral surveying up until this century. Early last century produced the Engineer's Chain (100 ft long), followed by steel tapes, steel bands of varying length, standardized metal rods, Invar Tapes or Wires etc.

Accurate distance measurement was very tedious task and limited to baseline measurements for triangulation networks. Long distances were measured indirectly through triangulation chains. The big leap forward in distance measurement came with the invention of Tellurometer produced by the South African scientists based on Radar principle and about the same time the Swedish scientists produced the Geodimeter which used light beam and a reflector. They were the first EDMs (Electronic Distance Measuring) to become available in the early sixties to surveyors. Long lines many kilometers long could be measured in matter of minutes to baseline measurement accuracy of 1:100.000 or better.

Triangulation networks were replaced by EDM traversing for establishing control networks over large areas. With the subsequent developments and refinements in the science of electronics, the short range EDMs were produced, one of the early ones being Wild DI 10. The theodolite mounted EDMs were merged within the electronic theodolite housing and used common optics, and thus electronic total station came into being, a compact angle and distance measuring instrument. All the EDM instruments require a stable base like a tripod or similar arrangement to sit on and at the other end a reflector or similar object to carry out the measurement. Reflectorless EDMs are already on the market plus Leica has produced a very useful hand held electronic tape called "DISTO". It makes short distance (20m) measurements using a laser beam, it is an extremely easy to use and light weight instrument which can fit a palm.

All these instruments have contributed a lot in revolutionizing the surveying techniques over the past 40 or so years. The process of measurement in every case require clear line of sight between the two ends of the line.

The real breakthrough has come about with the advent of Global Positioning System (GPS) technology. No other single invention in surveying instruments have brought about such a revolutionary change as the GPS technology. Position determination anywhere on the surface of the earth in any weather conditions or at any time of the day and night is no more a problem. The only requirement is the clear view to the sky.

Intervisibility is no more a necessity, one GPS instrument can be on one side of the hill and the second one on the other, completely hidden from the first one and we can still make measurements to geodetic accuracy.

The basic principle in the most simple terms behind this technology is the measurement of rangelines from the satellites in outer space to the GPS receiver, minimum of 4 satellites are needed to achieve the 3D fix. This technology is the off shoot of US Government Global Navigation System developed for the defense requirements.

The variety of GPS instruments is very varied and diversified, the price varies from 500 US $ of hand held single frequency unit to dual frequency unit casting 20,000 - 30,000 US dollars. Today, a plethora of GPS receivers are available on the market. The GPS World magazine in its January 97 issue listed more than 375 receivers from more than 60 manufacturers. For geodetic surveying work our choice of course is the duel frequency GPS. The main applications of GPS in Surveying/Engineering are;

1. establishing geodetic survey control on countrywide basis.
2. controlling flight lines of aircraft taking aerial photos.
3. ground control for photgrammetric mapping.
4. reconnaissance survey in un-mapped or poorly mapped regions.
5. survey control for conventional topo surveys.
6. spatial data collection for GIS work.
7. deformation survey for tectonic movement studies.
8. route surveys for highways, motorways, power lines, pipelines etc.

A very good example of 3D fixation in one of the most difficult field condition is that Mount Everest in 1992 carried out using Leica's GPS equipment and EDM's from Chinese and Nepalese sides of the mountain. The new agreed height of Mount Everest is 8846.10 meters as against the previous one of 8848 determined in 1954 and in 1975.

SURVEYING AND MAPPING PROFESSION IN PAKISTAN

By Engr.. A.W. Mir
G.M. (S&M) NESPAK

HISTORY

Surveying and Mapping (S&M) is a basic activity for all civil engineering projects right from feasibility stage through to detail design and execution and further beyond in many cases during operation and maintenance phase of the projects. Earlier civilizations e.g. Egyptians, Greeks and Romans had good knowledge of S&M. Ruins of the massive monuments built by these civilization are ample proof of their expertise in this science.

European nations made major contribution in the post renaissance period in the development of modern S&M as we know it today. Before the arrival of the British on sub-continent of India-Pakistan- Bangladesh, Hindu rulers and later the Muslims in particular the Mughals constructed many large structures which they could not have executed without good command of surveying. No research has been done to find out the method and tools used by the builders in the planning and setting out the works.

S&M ON THE SUB-CONTINENT

The British introduced the modern S&M science to this sub-continent and the establishment of survey control triangulation and levelling network followed by detailed mapping of such a large chunk of the earth, was indeed a great achievement of the time. The two major objectives were, mapping for military purposes and land revenue assessment and collection of the area under their control. This was followed by using the same information for development projects e.g. roads, water resources management schemes etc.

Advancing military column always had a survey party accompanying the force to survey and map the route and the adjoining areas. The art and science of map making was classified profession and only very trusted natives were trained in this field in that period. With the increased work load things of course changed and more and more local manpower was inducted in the Survey of India service. Secrecy of maps and their issue to person or agencies was always selective and needed clearance from the military and other Government offices. It was perhaps need of the time and justified then.

CREATION OF SURVEY OF PAKISTAN

With the creation of the country, Survey of Pakistan (SOP) came into being made up mainly of the Muslim Officers and technicians of the Survey of India (SOI) inherited all the rules and procedures of the British days and have religiously guarded and enforced them to-date, in particular pertaining to the secrecy of the Survey Control Data and Maps. In the present age of Satellite Imagery earth is like an open book for anyone with eyes in the sky to read e.g. our next door neighbour India has Satellite operational producing imagery with 5 meter resolution and this data is up for sale to the World. With the advent of Global

Positioning System (GPS) the secrecy of survey control data is also futile effort.

SURVEY EDUCATION

The education and training facilities in our country for this profession have not kept pace with the time. To-date there is not a single University with B.Sc. degree program in S&M and related disciplines. Polytechnics offer 300 hr. or one year diploma technician level course in surveying. The oldest institution being Rasul followed by Khewra Mining School. The facilities and syllabus offered to the students is so poor and outdated that the students who qualify from these schools can barely set up or use a simple levelling instrument. The result is that they need extensive on job training with the employer before they can be productive. SOP and army each have their own training schools for grooming their fresh recruits to their specific requirements.

The way to get out of this poor situation is to revise the syllabus to bring it in line with the present day needs equip the institutions offering survey & mapping courses with modern instruments including computer hardware and software for CAM. The one year course should be upgraded to two year level with more coverage of the subject matter. This would of course need better educated and trained teaching staff. Four years B.Sc. degree level courses be introduced at our engineering universities.

CONSULTANTS AND S&M

The largest of all training institutions in the profession been the Indus Basin water resources projects of the sixties and seventies. The foreign and local consulting engineering companies have all along contributed a lot towards the progress and development of the S&M profession by way of introducing state of the art instruments and techniques.

NESPAK has played a leading role in this regard by having a full fledge S&M Speciality group headed by a Professional Survey Engineer and a Charted Land Surveyor. They have made many firsts in the past twenty plus years in the way of acquiring state of the art instruments and techniques. The foremost achievement being the introduction of Computer Aided Mapping (CAM) technology through its in-house developed software in 1986.

CREATION OF PROFESSIONAL BODY

Leading individuals of the profession got together on August 21, 1995 and decided to form Society for Surveying and Geoinformation (SSG) to be the representative body of the profession of surveying, mapping and allied disciplines. It is hoped that it will be able to project and promote the profession and people engaged in this specialty of civil engineering.

DEVELOPMENT OF HYDRODYNAMIC FLOW MODELS OF INDUS BASIN AQUIFERS

By Dr. S. Khan, S. Gohar and A.N. Sial
NESPAK

ABSTRACT

According to the policy of Government of Pakistan deep SCARP tubewells are being transitioned and replaced with relatively shallow private/community tubewells. This change from deep to extensive shallow pumping has necessitated the development of groundwater models to study future response of aquifer for proper development and management considering groundwater quality and quantity implications. With the advancement of scientific knowledge in groundwater hydrology and revolution in computational techniques it is now possible to accurately evaluate the future impact of such transitions on the hydrodynamics of groundwater flow and solute transport by developing numerical models of subsurface systems. The groundwater regulation decisions of critical area can be taken only with the help of regional and local critical area groundwater models. This paper stresses the importance of correct representation of aquifer parameters, recharge and discharge process. The issues related to modelling of the groundwater resources of Pakistan are briefly discussed.

INTRODUCTION

According to the policy of Government of Pakistan deep SCARP tubewells are being transitioned and replaced with relatively shallow private/community tubewells. The ultimate objective of Government of Pakistan is to transfer the development and management of groundwater particularly in fresh groundwater areas to farmers by providing financial and technical assistance. In this regard two projects in Punjab and one project in Sindh has already been implemented and one project in Punjab is in progress (Punjab Private Sector Groundwater Development Project being implemented in SCARPs II, Shahpur, III(RP), IV and V-SKPP). The change from deep to extensive shallow pumping has necessitated the development of groundwater models to study future response of aquifer. Such studies will help in assessing the future hydrodynamics of groundwater flow and solute transport. These numerical models will provide sound base for:

- rational development and management of groundwater resources in Pakistan
- prevention of deterioration of groundwater quality due to lateral and vertical movement of high salinity groundwater underlying the central parts of doabs.

Intensive monitoring and assessment for rational exploitation of groundwater in these critical groundwater areas will be necessary:

- shallow groundwater which need intensive monitoring to provide adequate drainage facilities
- deep groundwater areas which meet controlled and rational exploitation
- areas lying close to the saline groundwater pockets/zones will

need intensive monitoring to keep a close watch on the chemical quality of groundwater

The groundwater regulation decisions of such areas can be taken only with the help of regional and local area groundwater models.

The accuracy of a subsurface numerical model depends on the correct representation of aquifer parameters, recharge and discharge processes. This can be achieved only if appropriated model codes are selected and rigorous procedures highlights the issues pertaining to the development of groundwater models of Indus basin aquifer while a case study in the development of groundwater flow and solute transport models can be found in Khan et al. 1998.

GROUNDWATER FLOW MODELS

The groundwater flow is governed by two well-known equations: Darcy's equation and the equation of conservation of mass. The combination of these two equations results in a partial differential equation (Rushton and Redshaw 1979)

$$\delta/\delta x(k_{xx}\,\delta h/\delta x)+\delta/\delta y(k_{yy}\,\delta h/\delta y)+\delta/\delta z(k_{zz}\,\delta h/\delta z)-q=S_s\,\delta h/\delta t$$

where

k_{xx}, k_{yy}, k_{zz} are values of hydraulic conductivities along x, y and z directions [L/T]

h is piezometeric head [L]

q is volumetric flux [L/T]

S_s is specific storage of the porous medium [1/L]

t is time [T]

For the solution of above partial differential equation there are two most popular approaches; finite difference and finite element methods. In the finite difference approach the partial differential equation is replaced by a finite difference equation satisfying the mass balance. Details of model codes developed on the basis of finite difference methods can be found Remson et al. (1971), Desai (1979), Rushton and Redshaw (1979), Mercer and Faust (1981), Wang and Anderson (1982) and MacDonald and Harbuagh (1984). The description of finite element models can be found in Remson et al. (1971), Pinder and Gray (1977), Mercer and Faust (1981) and Wang and Anderson (1982). These methods require the space to be divided into small finite sub-areas. The sub-areas formed are called nodal areas, as each of them have a node that connects it mathematically to its neighbors. The nodal areas, also referred to as cells, make it possible to replace the partial differential equation with a set of algebraic equations.

The modular three dimensional finite-difference groundwater flow model code developed by the United States Geological Survey (USGS) commonly known as MODFLOW can be used for the preparation of groundwater flow models of the Indus basin aquifers. The flow model can be linked with a solute transport model such as MT3D (Papadopulos and Associates 1996).

The purpose of this paper is to describe the selection criteria, data required and procedures adopted in the development of groundwater models while the numerical details can be found in the references.

Discretization

The model area should be divided into rectangular mesh intervals parallel and perpendicular to the principal axes of hydraulic conductivity. The size of the mesh used depends on the purpose of the model and variation of parameters. For regional flow models for studying water table response due to changes in recharge and discharge patterns, horizontal mesh sizes ranging from 500 to 2500 m can be used. In the vertical direction mesh

intervals based on the depth of pumping can be introduced to study the effect of stresses caused by different abstraction depths of tubewells. However, greater number of mesh intervals will increase the computational requirements. It is possible to study in more detail local areas within the regional flow models by developing zoomed area models with finer horizontal and vertical mesh intervals.

In the modelling terminology a stress period is defined as a period over which all the inflow and outflow components remain constant. The major components of the aquifer recharge and discharge i.e. recharge from canal irrigation system and discharge through public and private tubewells, mainly vary in accordance with the cropping season i.e. kharif and rabi. The kharif season approximately commences from April and lasts in September covering a period of six months (182 days). Rabi also covers a period of six months (182 days except for leap years i.e. 183 days) and extends from October to March next year. Data on groundwater levels are available for April, June and October, representing dry and wet cycles of the year. Hence, kharif and rabi seasons can be selected as stress periods with monthly or smaller computational time steps in the regional flow model. The total calibration period should include past 10-20 years depending upon the availability of data.

Model Boundaries

The hydrological boundaries of the models must be identified and properly represented in the models. The rivers and link canals can form the hydrological boundaries of the Indus basin models. In situations where the model boundaries are not located on rivers or link canals, water table contours for a number of years should be plotted and regional groundwater inflow or outflow from the area should be assessed and incorporated in the model as recharge or discharge wells.

Physical Processes to be Included in the Model

The groundwater flow model should be able to represent the following:

- o aquifer geometry and hydraulic parameters
- o recharge due to rainfall
- o seepage losses from rivers and canals
- o seepage losses from distributaries, minors, water courses and irrigated fields
- o discharge due to evapotranspiration
- o pumpage from wells
- o outflow to rivers and canals
- o flow to drains
- o changes in groundwater storage i.e. fluctuation in water table

Data Requirements of the Model

The aquifer parameters are time constant parameters while various recharge and discharge components are time dependent parameters. For model calibration time dependent data of 10-20 years must be collected.

Aquifer Parameters

The aquifer geometry and boundaries can be obtained from topographical maps of the area and review of available data on groundwater investigations in the past.

Surface elevation contours of the model area should be available preferably at a contour interval of 0.5 m or less.

Pumping test data and aquifer parameters i.e. lithological logs, hydraulic conductivity, storage coefficient and specific yield should be determined by analysing pumping tests. Various organisations including WASID (WAPDA) conducted field permeability tests during 1954-1960 (Ahmed and Chaudhry, 1988). These tests were analysed using Theis method which gives average value of lateral and horizontal permeability and

can not properly consider specific yield and vertical conductivity of the aquifer. Some researchers realised this shortcoming and tried to calculate vertical permeability and specific storage with Boulton (1963) and Bennet et al. (1964) methods (Ahmed and Chaudhry), 1988). However, these results may not be accurate and aquifer properties need to be re-assessed using curve matching techniques presented by Neuman (1975) or numerical model of Rathod and Rushton (1991).

Precipitation Data

Daily or monthly data for the calibration should be collected. Estimation of recharge from rainfall is a complex process since it depends upon a number of factors including antecedent moisture conditions from previous rainfall or irrigation, occurrence pattern of rainfall events, soil properties and topography. As cited by Ahmed and Chaudhry (1988) for different canal commands Maasland et al. (1963) has given different estimates of recharge as a percentage of rainfall in the 8 to 22% range. However estimates given by Maasland are very approximate due to a number of assumptions made. These recharge factors should be used with care after fields visits and rainfall-water table fluctuations sensitivity analysis.

Evapotranspiration Data

Groundwater is removed from aquifer due to evaporation and transpiration by plants, which is aided by capillary rise. The evapotranspiration process depends upon position of water table, type of vegetation, type of soil, sunlight, temperature, humidity and wind. A number of organisations including Irrigation Research Institute and WAPDA have conducted experimental studies by Lysimeters and consumptive use studies using Blaney-Criddle and modified Penman method to determine evapotranspiration and consumptive use of crops. These estimates of seasonal evaporation rates for different regions have been presented by Ahmed and Chaudhry (1988) as percent evaporation versus depth rate curves for sandy, silty and clayey soils. The evapotranspiration is maximum near the surface and reduces to less then 3 percent below 7-10 ft depth known as extinction depth. A detailed account of estimation of evapotranspiration of different crops can be found in FAO (1975).

River Data

The data on layout, cross-sections and monthly average discharge for the calibration period are needed to simulate the seepage from or flow towards the river depending the water levels in the aquifer and the river. This data can be obtained from the relevant Irrigation Departments and from flood studies of Federal Flood Commission.

Irrigation Network Data

Canals, Distributaries and Minors

The canals can be modelled as line sinks/sources or as areal recharge in the model. In order to simulate the recharge from canals, distributaries and minors data of longitudinal sections, present shape of cross-sections, material of bed and side of canal, actual flows during the calibration period and field seepage studies are needed.

Patten et al. (1963) developed empirical relationships for seepage

losses from canals based on 300 field measurements. These empirical relationships are result of regression analysis and include a wide scatter of observed data. The typical form of these empirical relationships is given below:

$$S = aQ^b$$

where S is seepage losses in cusecs per canal mile, Q is canal discharge in cusecs, a (0.03-0.06) and b (0.58-0.71) are regression coefficients for different doabs.

These relationships are very old and need to be updated by incorporating the later seepage losses measurement data of different canals.

Hunting (1966) has given estimates of seepage losses for different canals in Sindh ranging from 2-8 cusecs/million sq. ft. of the wetted perimeter. Tipton and Kalmbach (1967) have given estimates of seepage losses from link canals.

Siddique et al. (1977) have presented results of seepage loss studies in selected canals of Punjab. Recently studies by Yunis (1998) have shown that it is possible to determine seepage losses from canals by using numerical models. In these studies it is demonstrated that losses largely depend upon the water level in the canal hence it is very important to obtain the time data on the canal stages.

WATER COURSES AND FIELD LOSSES

The recharge from water courses and fields can be incorporated as areal recharge in the model. Maasland et al. (1963), Tipton and Kalmbach (1967), Hunting (1966) have assumed 10 to 20 percent water courses losses of the delivery at the head. However, there are other higher estimation of water course losses (40 percent of the delivery at head; Ahmed and Chaudhry, 1988). This situation warrants care in the estimates of seepage losses from water courses. It is suggested that all such estimates should be supported by the field surveys on the condition of water courses and underlying soils. Data of lining of water courses should also be consulted in these estimates.

Maasland et al. (1963) assumed 20 percent losses in the fields and 75 percent of these losses as recharge to water table while Tipton and Kalambach (1967) estimated that field losses are 22 percent and 85 percent of these recharges the groundwater.

Drains Data

Data on geometry and flow of existing and envisaged drains constructed for surface and subsurface drainage is also required.

Tubewell Data

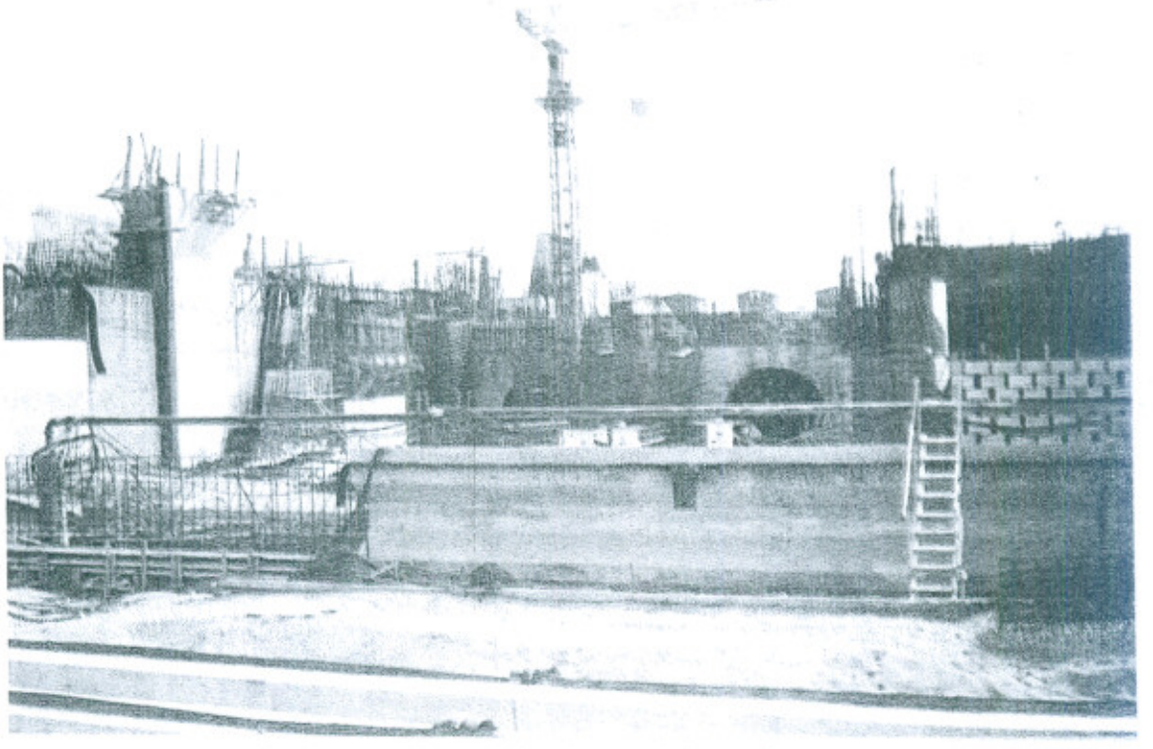
Data on the number, areal distribution, operation factor, depth of abstraction of the public and private tubewells is required to determine the stresses on the aquifer. Usually the data of public tubewells is available from related departments while the data of private tubewells has to be collected/updated by sample surveys. In order to assess the reliability of the tubewell pumpage data sensitivity analysis involving pumpage and water table fluctuations must be carried out before it can be used for the model development.

Water Level data

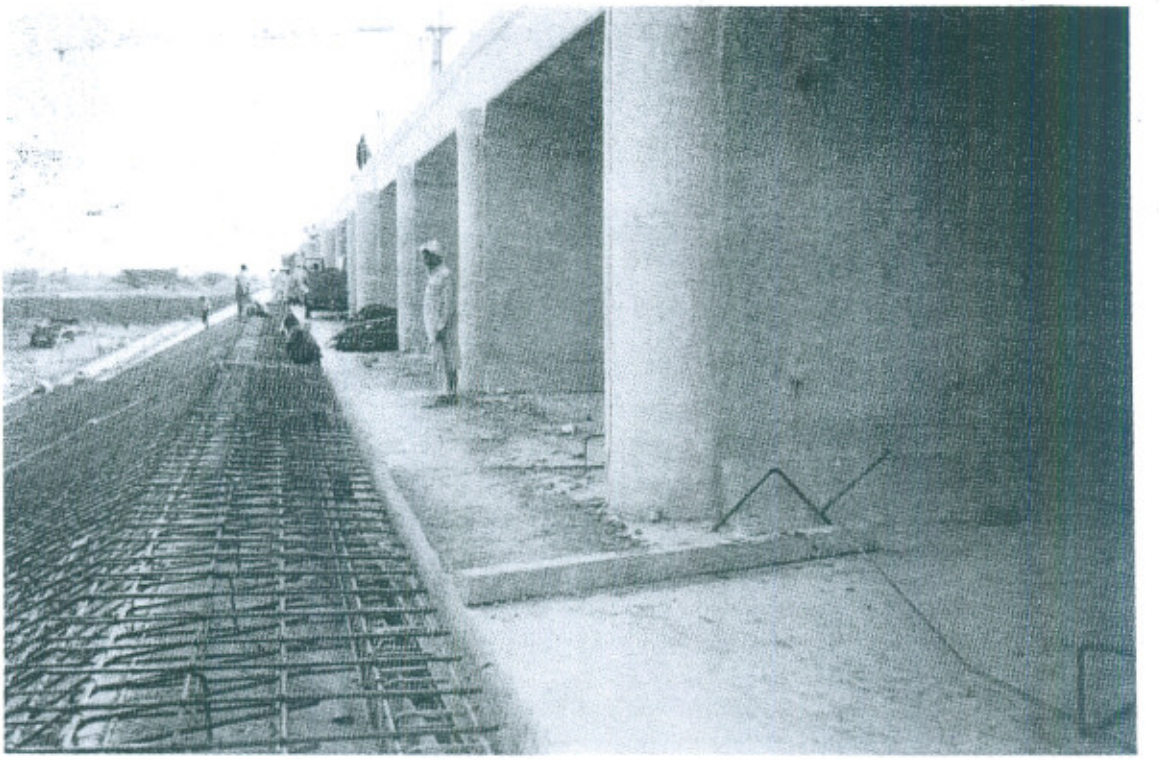
Records of depth to water table are available for June and October of each year from the SCARP Monitoring Organisation



A Downstream View of Chashma Barrage



An Upstream View of Chashma Hydro-Power Structure.
The Generator Housings are Conspicious



Downstream view of superpassage of Khad Waruki
showing Steel Fixation and preparation for Concrete
in Downstream Glacis at RD. 413-CRBC-III



Visiting delegates from PEC photographed at
Khad Waruki super-passage



PEC delegates group photograph with Power Units draft-tubes in the background at Chashma Hydro Power Station.



A group photograph of PEC delegates at Chashma Barrage at left bank upstream.



Another photograph of PEC delegates at Chashma Barrage at left bank upstream.

(SMO), WAPDA. This data is to be used for determining the initial conditions in the models and the calibration of the model parameters. Validation of water level data is essential in order to eliminate erroneous data by plotting water table contours and by comparing the water table response with other parameters like recharge due to rainfall and discharge from tubewells etc. Any data gaps must be identified and additional peizometric monitoring should be carried out for the proper calibration of models.

Modelling Process

Data Validation

As described in the previous section all the data should be checked for its consistency and for inter-relationship of different parameters.

Water balance studies

Area lumped water balance studies of recharge, discharge and storage components should be carried out for the entire calibration period to ensure that recharge and discharge considered are consistent with the areal storage change of aquifer. The water balance for each of the stress period (6-monthly intervals, kharif or rabi period) should satisfy the following mass conservation equation.

recharge-discharge + change in storage = 0

Calibration and Future Scenario Runs

The data is incorporated in the groundwater model and initial sensitivity runs are carried out to assess the impact of variation of aquifer parameters on water table response. The aquifer parameters are varied within the predetermined limits depending upon the quality of the data until computed aquifer responses match closely with the observed responses.

For the calibration purposes the model is run for calibration period by considering time dependent recharge and discharge data and without changing the aquifer parameters. If the computed water levels match closely with the observed water levels for all the stress periods the model has been properly calibrated. The calibrated model can be used to forecast the future response of the aquifer under changed pumping or recharge scenarios. The future scenarios can include replacement of deep public tubewells with relatively shallow private tubewells, increased pumping from the aquifer to meet enhanced cropping intensity, decrease in pumpage from the aquifer and effect of lining of canals.

Conclusions

It is concluded that in order to accurately assess the aquifer response due to changes in pumping or recharge patterns regional and critical area flow models need to be developed using the PC based computer software. The groundwater regulation decision of critical areas can be taken only with the help of regional and local area groundwater models. In the development of these models emphasis should be placed on the proper representation of physical processes and rigorous calibration procedures. The aquifer properties, recharge and discharge data should be carefully determined to simulate hydrology of complex Indus basin aquifers.

SOIL MAPPING OF FAISALABAD METROPOLITAN CITY

Engr. Muhammad Naeem Chughtai
Director, Building Research Station

In order to know the characteristics and the behaviour of soil under stress, the necessity for soil exploration can not be over emphasized in the construction of all types of structures. The stability and safety of any structure depends upon the support rendered to the structure by the soil strata on which it is placed. Soil exploration is a tool in the hands of an engineer not only for designing the structure but is also cost effective.

Building Research Station of Communication & Works Department Punjab, Lahore, has been rendering advices, since its creation, in the field of soil exploration for different sites both in the public as well as private sectors. The characteristics and behaviour of soils vary with place and with proportion of its constituents. However for a typical limited area, a general picture of the soil and geotechnical investigations/evaluation can be drawn and gathered in shape of maps, etc. for consultation of all concerned. This was the basic idea for the soil mapping of the districts in Punjab Province. Engineering practices are supported with proper guide lines in the form of local building codes, regulations and soil maps. Soil mapping is the time saver ready made device which provides information about sub surface data of the area mapped and is very helpful during planning, designing and feasibility studies of all types of Civil Engineering Projects as it gives information to predict foundation and excavation conditions, surface and ground water position, sub surface configuration of soil and sources of construction materials.

Building Research Station started work on soil mapping during 1996-97 for Faisalabad Metropolis. The work has been compiled and is being published shortly.

The strategic approach followed was to establish general geotechnical appraisal through preparation of sub surface maps at different depths, typical sub surface profiles/representative boring logs and tentative design recommendations and specifications. It involved data collection and data reduction analysis. The soil maps prepared for different depths and sub soil typical profiles clearly indicate the presence of typical alluvial deposits comprising of fine grained soils (CL, CL-ML, CL/ML, ML) overlying coarse grained formations (SM, SP-SM, SP). The variation of soil types with reference to depth and location has been depicted in the coloured soil maps, which will form a part of the publication of Building Research Station.

Effort has also been made to evaluate the tentative bearing pressures for different locations/areas of the city on the basis of simple geotechnical parameters available for a number of explored sites.

In the light of foregoing consideration, conclusions and recommendations have been made and summarized in tabulated form for ready reference. These results have been arrived at after detailed study and mathematical calculations involved in the research work and have not been depicted here as these are beyond the scope of this article.

Table "A" shows index properties of the soils encountered at different sites and at different depths with indications of minimum and maximum values gives the most important factors in determining the bearing pressure. Table "B" of soils i.e. the shearing strength parameters whereas table "C" contains the recommendations for foundation type with minimum depths and minimum width, corresponding to a typical structure.

TABLE - A
INDEX PROPERTIES

Index Properties	Common Range	Min. & Max. Values
Liquid Limit (LL)	28-30%	21-35%
Plastic Limit (PL)	18-22%	16-24%
Plasticity Index (PI)	07-12%	04-16%
N.M.C.	05-15%	01-29%
Bulk Unit Weight (□)	100-120 pcf.	89-129 pcf.

TABLE - B
SPT N-VALUE AND SHEAR STRENGTH PARAMETERS

Soil Type	Common range with max. & min. of N-value	Shear Strength parameters	Remarks
Fine Grain soil.	Common range 5 to 8 Min. = 3/blow/ft. Max. = 15	Unconfined compression strength qu = common range 0.75 to 0.9 tsf. Min. = 0.6 tsf. Max. = 1.2 tsf.	These values are highly susceptible to moisture change.
Coarse Grain Soil.	Common range 10 to 18 Min. = 10 Max. = 20	Angle of internal friction (Ø) Common range 30° - 32° Min. = 28° Max. = 36°	(Ø) has been estimated on the basis of correlation with SPT-N-values.

TABLE - C
RECOMMENDATIONS

Foundation Case	Description of Structures	Foundation Type	Minimum Depth (feet)	Minimum Width (feet)
Case-I	Lightly loaded 1 to 3 storeys residential buildings, no basement with load bearing wall and RC/RB roofing	Strip footing	3	3
Case-II	Moderately to heavily loaded multi-storey (4 or more storeys)	Footing for columns i.e. isolated	4 feet below NSL or 3 feet below FFL of	3

	commercial and industrial buildings of RC frame structures with or without basement.	combined stapes or continuous footings.	basement which ever is applicable	
Case-III	Extremely heavily loaded structures, major bridges flyovers, OHR, sensitive machine foundations.	i) Mat/Raft. ii) Piles	8 feet.	20 feet Dia 18

NOTE:

i) For Case-I structures, foundations may be designed by experienced geotechnical Engineer using the findings of this study. For critical sub soils conditions at site, however, detailed exploration is recommended prior to foundation design.

ii) For Case-II structures, the findings of this study may only be used for preliminary estimates/design and feasibility studies. For final designs, detailed geotechnical investigations are recommended.

iii) For Case-III, preliminary and detailed geotechnical investigation programmes are recommended.

iv) The recommendations of the study may be used for tentative site selection and preliminary estimation of Civil Engineer Work. However for small residential units, these may be used safely by experienced Geotechnical Engineer.

NATIONAL DEVELOPMENT CONSULTANTS (REGD.)

KEY DATA

Firm Name
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Engr. Ch. Ghulam Hussain, Partner
☎: 92-42 5860055
Language Proficiency :
English
DESCRIPTION
Established : 1977
Registered with Pakistan Engineering Council since 31 December 1977 under Serial No. CONSULT-71
Registered with Registrar of Firms on 12 December 1977 under Serial No. 876
Ownership:
Partnership
Personnel:

Civil Engineers	95
Agricultural Engineers/Agronomists	10
Electrical & Mechanical Engineers	4
Allied Professionals / Scientists	10
Hydrologist / Geologist	4
Social Organizers	26
Administration & Accounts	66
Technical Support Staff	35
Non-Technical Support Staff	165

NDC is a Member of the Association of Consulting Engineers , Pakistan (ACEP).

ACTIVITIES

National Development Consultants give central importance to serving the Clients through sound professional advice. A flexible approach is adopted to each new assignment and emphasis placed on close cooperation and team work with the Clients. This ensures the identification of appropriate technology, project development strategy and cost controls leading to a successful conclusion of the assignment. A commission in any of the civil engineering fields of activity may involve all or any of the services NDC offer, including

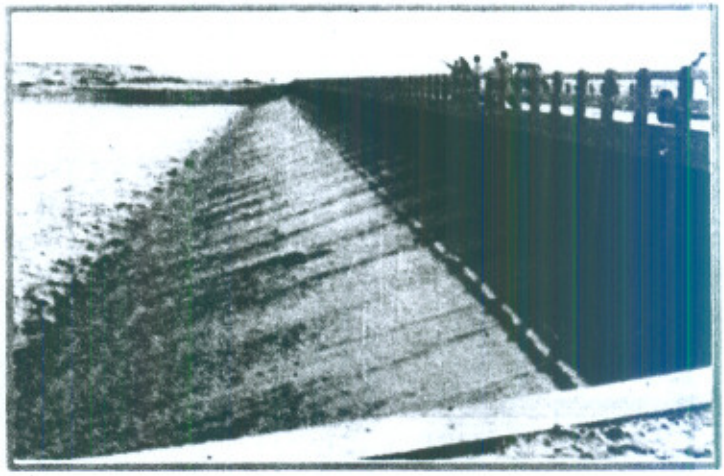
- Investigation & Planning
- Design
- Tender Stage Assistance
- Implementation
- Operation and Maintenance

FIELDS OF SPECIALIZATION:

- Irrigation and Hydraulics
- Agriculture
- Drainage and Groundwater Resources Development
- River Training and Flood Protection Works
- Surveys- Topographic and Socio-Economic
- Geo-Technical Investigations
- Physical Modelling of Hydraulic Structures
- Dams and Hydro-power
- Forestry and Rural Sociology
- Project Management and Construction Supervision
- Electrical and Mechanical Operations
- Roads and Bridges
- Environmental Engineering
- Tunnels
- Residential Buildings and Urban Development

TYPICAL PROJECTS

- Chashma Right Bank Irrigation Project Stage-III Client: WAPDA
- Pehur High Level Canal Project Client: Government of NWFP.
- Swabi Salinity Control and Reclamation Project Client: WAPDA
- Fordwah Eastern Sadiqia South Project Client: WAPDA
- Post Flood Rehabilitation and Protection Project Client: Government of Pakistan
- Marala Ravi Link Canal System Restoration and Improvement Project Client: Government of the Punjab
- Punjab Private Sector Groundwater Development Project Client: Government of the Punjab
- Remodelling Thal Canal Project Client: Government of the Punjab
- National Drainage Programme Client: WAPDA



A completed Superpassage in Operation on Chashma Right Bank Canal Stage-II (NWFP) Pakistan