

CHANNAKA-KORATA (RUDHA) BARRAGE

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SECTION -1
SALIENT FEATURES

1	Name of The Project	:	channaka-korata (Rudha) barrage
2	Type of Project (Irrigation Or Multipurpose)	:	Multipurpose
3	Location	:	Near Channaka village in Kelapur Tahsil of Yavatmal district in Maharashtra state & Korata village in Jainad Mandal of Adilabad district of Telangana State
3.1	River Basin		Godavari
	a) Name	:	Penganga
	b) Located in	:	Near Kelapur Tahsil of Yavatmal district in Maharashtra state & Jainad Mandal of Adilabad district of Telangana State
	i) State(s)	:	Telangana & Maharashtra
	ii) Countries (if international river)	:	N.A
3.2	River/ Tributary	:	Wardha in Godavari river basin
3.3	State(s)/District(s)/Taluka(s) or Tehsils in which the following are located:		
	a) Reservoir	:	Near Kelapur Tahsil of Yavatmal district in Maharashtra state & Jainad Mandal of Adilabad district of Telangana State
	b) Head work	:	Near Kelapur Tahsil of Yavatmal district in Maharashtra state & Jainad Mandal of Adilabad district of Telangana State
	c) Command Area	:	3 Mandals of Adilabad district in Telangana State
	d) Power house	:	Jainad Mandal of Adilabad district of Telangana State for Telanga Portion

3.4	Name of village near the Head works	:	Channaka village in Kelapur Tahsil of Yavatmal district in Maharashtra state & Korata village in Tamsi Mandal of Adilabad district of Telangana State
3.5	Location of Head works		
	a) Longitude	:	78° 31' 7.30" E
	b) Latitude	:	19° 49' 8.19" N
	c) Lies in Earthquake Zone No.	:	III
3.6	Project area reference to		
	a) Degree Sheets	:	56 I/5 & 56i/9 toposheet;
	b) Index Plan	:	Enclosed
3.7	Access to the Project		
	a) Airport	:	Nagpur at 180km away
	b) Rail Head	:	Adilabad at 18 km away
	c) Road Head	:	Near the site
	d) River port	:	Kakinada
	e) Sea Port	:	Mumbai , 800km
4	International/Interstate aspects of the project		Government of Maharashtra initially planned to construct 4 barrages on Penganga river at different locations on the down stream of Lower Penganga Dam to utilise 3.127 TMC out of the 9 TMC of water allocated to it by GWDT. Government of Maharashtra requested Government of Telangana to participate in these barrage schemes and take benefits out of them duly using the allocated share of Telangana below Lower Penganga dam site.
	a) Catchment area of the basin	:	19355.23 km ²
	b) State wise details of catchment area	:	Free catchment - 1338km ² Telangana - 191.45 km ² Maharashtra - 1146.52 km ²

	c) Submergence due to project		
	i) In the state	:	30.94 ha
	ii) In other states	:	0.63 ha (Maharashtra)
	iii) In other countries	:	Does not arise
	d) Water allocation for the state (if any)	:	1.2 TMC
	e) Water allocation for other states	:	0.3 TMC
	f) Committed utilization	:	Not Applicable
	Upstream Projects		58.51 Mcum
	vii) Projects completed	:	Not Applicable
	viii) Projects under construction	:	Not Applicable
	ix) Future Projects	:	NIL
	x) Any other	:	
	Downstream Projects	:	
	xi) Projects completed	:	
	xii) Projects under construction	:	
	xiii) Future Projects	:	
	xiv) Any other	:	
	g) Proposed utilization by the project		42.475Mcum(1.50TMC)- - 33.98Mcum(1.2 TMC) for Telangana & 8.495Mcum(0.30 TMC) for Maharashtra. The proposed command area of the barrage is 6680.16 ha (CCA) (5465.870 ha (CCA) for Telangana Portion & 1214.575 ha (CCA) for Maharashtra Portion)
	i) Irrigation	:	
	– Kharif	:	417.24 Ha.m
	– Rabi	:	508.01 Ha.m
	– Two seasonal	:	3171.21 Ha.m
	Total		4096.46 Ham
	ii) Water Supply	:	115.83 Ha m
	iii) Hydel (evaporation losses)	:	-
	iv) Thermal power	:	-
	v) Industrial	:	

	vi)	Gross annual utilization {sum of (i) to (v)}	:	4212.29 Ham
	h)	Minimum agreed/proposed flow in the river for maintaining ecology	:	10 cusecs
5		Estimated life of the project (years)	:	100 Years
6		Irrigation (ha.)		
	a)	Gross command area (GCA)	:	5967.55 Ha for Telangana portion 1798.38 Ha for Maharashtra portion
	b)	Culturable command area (CCA)	:	5465.8 Ha for Telangana portion 1214.57Ha for Maharashtra portion
	c)	Area under Irrigation (break up)	:	
	i)	Kharif	:	2672 Ha
	ii)	Rabi	:	1002 Ha (15% of CCA)
	iii)	Hot weather	:	
	iv)	Two seasonal	:	4008 Ha
	v)	Perennial	:	
	vi)	Gross irrigated area (GIA)**	:	7682 Ha
	vii)	Intensity of irrigation ($\frac{GIA}{CCA} \times 100\%$)	:	115%
	viii)	District(s) Benefited	:	Adilabad
7		Flood control	:	NA
8		Navigation	:	NA
9		Domestic	:	1.218Mcum
10		Project Performance		Period of simulation No. of failures
	a)	Irrigation	:	25 years
	b)	Power	:	- --
	c)	Flood Control	:	- --
	d)	Water Supply	:	- --
	e)	Navigation	:	- --
		• Deficit of more than 10% is considered as failure		

11	Hydrology		
11.1	Catchment	:	19355.23 km ²
11.1.1	Catchment area at head works site		
	a) Gross (Sq Km)	:	19355.23 km ²
	b) Intercepted (Sq Km)	:	222.526 Sq Km ²
	c) Unintercepted (Sq Km)		1338.1852 km ²
11.1.2	Catchment area classification according to mode of precipitation		
	a) Rain fed (sq Km)	:	1338.1852 km ²
	b) Snow fed (sq Km)	:	NIL
11.2	PRECIPITATION		
11.2.1	Catchment (DRAINAGE BASIN)	:	1338.1852 km ² (Telangana)

		Rainfall (weighted mm)		Snowfall (mm) Annual	
		Annual	Monsoon (June-Oct.)		
a)	Average	983	892	-	
b)	Maximum	1596	2012		
c)	Minimum	358	1541		
11.2.2	Command Area	:			
		Cropping Season			
		Annual	Kharif (June - October)	Rabi November - February	Hot (March)
a)	Average (mm)	1540.468	180.46	507.97	0
b)	ETo(mm)		600.39	311.11	0
11.3	Annual yield calculated at the proposed site (M.cum) :				
			Gross	Net	
	a) Maximum	:	930.28	930.28	
	b) Minimum	:	104	104	
	c) Average	:	462	462	
	d) Dependable	:	303.16	303.16	
11.4	Climate Data (Command)				

11.4.1			:		
Sl. No.	Name of station	Period of Record			
		From	To		
1	Adilabad	1967	2008		
11.4.2	Data (Mean Monthly)				
				Maximum	Minimum
	a) Air temp.(C)	:		48.5	4.6
	b) Humidity (per cent)	:		56	17
	c) Wind (day)	:		20.39	
	d) Water temperature(°C)	:		-	-
11.5	Seismic coefficients	:	0.060 (Horiz.)	0.02	0.03(Vert.)
11.6	Utilisation within the state (MCum)		N.A		
11.6.1	Water availability (State's share in case of interstate river)	:	N.A		
11.6.2	Committed Utilization		N.A		
11.6.3	Proposed utilization by the project	:			
	a) Irrigation	:			
	i. Kharif	:	-		
	ii. Rabi	:	-		
	iii. Hot Weather	:	-		
	iv. Perennials	:	-		
	Total	:	-		
	b) Water Supply	:	-		
11.7	Floods near the head work site	:	Not Available		
11.7.1	Historical-period of record	:	Not Available		
11.7.2	Observed-period of record	:	Not Available		
11.7.3	Estimated Flood				
	a) 50 year return period	:	13908.89 cumec		
	b) 100 year return period	:	16366.48 cumecs		
	c) 500 year return period	:	22293.33 cumecs		
	d) Standard project flood (Cumecs)				
	e) Maximum probable flood		16366.48 cumecs in		

	(Cumecs)		100years(PMF)
11.7.4	Design flood (Cumecs)		
	a) Dam		---
	b) Barrage	:	16366.48 cumecs
	c) Construction Diversion	:	Lift
	d) Flood Control Works (Freeboard)	:	N.A
11.7.5	River flows (minimum observed)		Not available
	a) Water level (El-m)	:	202.640m
	b) Discharge (cumecs)	:	-
	c) Months of nil flow, if any	:	Nil
12.	RESERVOIR		
12.1	Water levels (El-m)		
	a) Maximum Water Level (MWL)	:	+218.100
	b) Full Reservoir Level (FRL)	:	+213.000
	c) Minimum Draw Down Level (MDDL)	:	+203.00
	d) Outlet levels		
	i. Irrigation	:	-
	ii. Power	:	-
	iii. Others (Please specify) Scour Sluice	:	-
	e) Dead Storage Level	:	-
12.2	Free Board (m)	:	-
12.3	Wave Height (m)	:	-
12.4	Live storage (MCum)	:	23.309
12.5	Capacity (MCum)		
	a) Maximum Water Level (MWL)	:	
	b) Full Reservoir Level (FRL)	:	23.502
	c) Minimum Draw Down Level (MDDL)	:	0.193
	d) Dead Storage level	:	0.193
12.6	Flood absorption capacity (M cum)	:	-
12.7	Sedimentation (M. cum) and levels	:	

capacity(M.Cum)

		after 50years and 100 years		-
	a)	Above (MDDL)	:	-
	b)	Below (MDDL)	:	-
	c)	Encroachment of live storage %	:	-
12.8		Average monthly evaporation losses from the reservoir (M cum)	:	5.318 MCum
13		Submergence	:	0.63 Ha (Maharashtra) 11.09Ha(Telangana)
13.1		Land and property submerged	:	-
	a)	Villages affected (No.)		
	i.	Fully	:	NIL
	ii.	Partially	:	NIL
	b)	Land affected (ha.)	:	
	i.	Gross	:	NIL
	ii.	Culturable	:	
	iii.	Irrigated	:	
	iv.	Forest	:	NIL
	v.	Others (specify)	:	NIL
	c)	Buildings/houses (No.)	:	NIL
	i.	Private	:	NIL
	ii.	Community's	:	NIL
	iii.	Govt.	:	NIL
	d)	Wells (No.)	:	NIL
	e)	Road / rail (km)	:	NIL
	f)	Transmission lines (km.)	:	NIL
	g)	Any other	:	NIL
13.2		Submergence ratio (with reference to culturable command areas)	:	0.463%
13.3		Number of families/persons affected	:	-
			:	Families
			:	Persons
	a)	Scheduled Castes	:	Nil
	b)	Scheduled Tribes	:	-
	c)	Other Backwards	:	-

	d) Castes General	:	-	
13.4	Anticipated back water levels at important places along the periphery of the reservoir (500 Yrs Flood)	:	- Nil -	
14	Head Works	:	-	
14.1	Dam			
14.1.1	Embankment Dam(Approach bund)	:	-	
	a) Type of dam (Homogenous / Zoned /Rock- fill /Concrete faced)	:	-Homogeneous	
	b) Length of the dam at top (m)	:	-	
	i. Right Flank	:	837.50	
	ii. Left Flank	:	-	
	c. Top width (m)	:	6.00	
	d. Maximum Height above G.L. (m)	:	6.39	
	i. Right Flank	:	-	
	ii. Left Flank	:	-	
	e) Dyke(s)	:	-	
	i. Number	:	-	
	ii. Total length(m)	:	-	
	iii. Maximum height (m)	:	-	
	f) Type of cut off and maximum depth	:	-	
	(Upstream blanket/open trench/diaphragm/grout curtain/combination of alternatives)			
14.1.2	Masonry and Concrete Dam (Non-over flow section) :-			
	a) Type of Dam (Concrete)	:	-	
	b) EL of top (m)	:	-	
	c) EL of deepest foundation (m)	:	-	
	d) Length at top (m)	:	-	
	e) Length at the river bed (m)	:	-	
	f) Width at top (m)	:	-	
	g) Width at deepest bed level (m)	:	-	
	h) Maximum height above deepest foundation level (m)	:	-	

14.1.3	Spillway (overflow section)		
	a) Type of spillway	:	Broad crested weir
	(Ogee /chute/side Channel/tunnel/ syphon/any other type (specify)		
	b) Full reservoir level (EL-m)	:	+213.000
	c) Maximum water level (EL-m)	:	+218.100
	d) Length (m)	:	287.500
	e) Maximum height above the deepest foundation (m) : 6.0		
	f) Crest level (El-m)	:	+203.000
	g) Number of gates	:	20
	h) Type of gate	:	Vertical Gates
	i) Size of gate (m)	:	12 x10 M
	j) Maximum discharging capacity (cumec)	:	
	i. FRL	:	
	ii. MWL	:	16366.48 cumecs
	k) Flood lift (m)	:	
	l) Tail water level (EL-m)		
	i. Maximum	:	217.100
	ii. Minimum	:	-
	m) Type of energy dissipation arrangement	:	Stilling Basin
	<i>Note: - Similar details shall be furnished for subsidiary and auxiliary spillway, if any.</i>		
14.1.4	River sluice(s), Irrigation/Power outlet(s)	:	-
	a) Purpose	:	-
	b) Number	:	-
	c) Size (m)	:	-
	d) Sill level (El-m)	:	-
	e) Discharging capacity at (cumec)		
	Full reservoir level	:	-
	ii. Minimum draw down level	:	-
	f) Number of gates	:	-
	g) Type of gate	:	-
	h) Size of gate	:	-

	Canal System	:	-
15.1	Main Canal (Name)	:	main canal
15.1.1	Purpose of canal (Irrigation/Power/Navigation/Diversion/Water Supply/Multipurpose)	:	Irrigation
15.1.2	Type		
	a) Flow/lift	:	Lift followed by gravity
	b) Lined-unlined	:	Lined
	c) Discharging capacity of the channel upto which lining is proposed: Entire discharge	:	
	d) Type of lining	:	Concrete
15.1.3	Design data	:	
	a) Length (Km)	:	3.36 KM
	b) Full supply level at head/tail (El-m)	:	+281.8
	c) Full supply depth at head/tail (El-m)	:	1.80m
	d) Bed width at head/tail (El-m)		4.75m
	e) Side slope at head/tail (El-m)	:	1.5 to 1
	f) Bed slope (range)	:	1 in 4000 to 1 in 3000
	g) Maximum discharging capacity at head/tail (El-m)(m ³ /sec)	:	4.5 cumecs
	h) Total number of canal structures	:	830 structures (Telangana Portion upto Sub Distributories)
	i) Total assumed -head losses across the structure(m)	:	1.80
	j) Gross Command Area (ha)	:	7763 ha (Both states)
	k) Culturable Command area (ha)	:	6680 ha (Both states)
15.2	Efficiencies (percent)		
	i. Conveyance	:	70
	ii. Field application	:	65
16	Cropping Pattern		
16.1	Name of crop (Season-wise)		
	(1) Kharif		Percentage area CCA Existing Proposed
	Soybean		18% 30 %

	Jowar		5%	
	Red gram		9%	
	Tomato			5 %
	Brinjal			5 %
	(2) Rabi			
	Bengal gram		-	10 %
	cabbage		-	5 %
	(3) Two seasonal			
	Cotton		68%	60 %
<i>Note: - If there are different cropping patterns in different reaches of the canal, information for each reach shall be given separately.</i>				
17	Power requirement	:	8.44 MW	
18.	Construction facilities		N.A	
19.	Costs			
19.1	Cost of the project (Rs. Lakhs)	:	39916	
	Annual Cost (As per BC ratio Calculations)	:	5267.36	
20	Annual Benefits	:	8425.51	
21	B.C Ratio	:	1.60	

CHAPTER 1 INTRODUCTION

1.1 . Aim of the Project

The main aim of the project is to irrigate the left out ayacut of Lower Penganga project in Adilabad district by lifting water from the river Penganga from a point down stream of LPP Dam by constructing barrage at Channaka-Korata (Rudha).

The Lower Penganga project (LPP)

The Lower Penganga project is a joint project between the states of Maharashtra and Telangana on Penganga river. An understanding was reached between the states of Maharashtra and Andhra Pradesh (now Telangana) on 6th October 1975 to take up Lower Penganga Project as an inter-state joint project. Maharashtra Government prepared the Detailed Project Report for the joint project and submitted the same to Central Water Commission for clearance. The clearance from CWC is still awaited as of April 2016.

The net annual 75% dependable flows at Lower Penganga dam are assessed as 42.67TMC to be shared in the ratio of 88:12 between Maharashtra and Telangana, which makes the share of Maharashtra as 37.55 TMC and that of Telangana as 5.12 TMC. The Telangana share of water is proposed to be utilised for irrigating 19232 ha of land in the backward tribal areas of Adilabad district by gravity canals. The uplands in Adilabad district are not served by this gravity canal.

Thus the available alternatives to irrigate this left over ayacut is to plan lift irrigation schemes to allocated water to Telangana from downstream of LPP from Penganga river.

Godavari Water Dispute Tribunal (GWDT) allocation up to LPP and below LPP

Godavari Water Dispute Tribunal (GWDT) made the following allocation of water to the Penganga basin states at 75 % dependability.

Table 1.1: GWDT allocation up to LPP and below LPP

State	Allocation (annually at 75 % dependability)
Maharashtra	<p>A. The state of Maharashtra can use all the waters upto :</p> <ol style="list-style-type: none"> 1. Lower Penganga project site near Chikal Wardha subject to the condition that the Lower Penganga Project is taken up as a joint project. 2. Waghadi Project Dam site on the Waghadi River near village Yelbara. 3. Saikheda Dam on Khuni river near village Lingti.
	<p>B. In addition to the use of all the waters up to the point as specified above, the state of Maharashtra can use the waters of the rest of Penganga sub-basin 9 TMC (255 Mcum) for its existing, under construction and proposed schemes / projects each of which individually will not exceed an annual use of 1.5 TMC.</p>
AP (Now Telangana)	The State of AP (Now Telangana) can use all the remaining waters of the Penganga Sub-basin.

1.1.1. Description of works

The channaka-Korata (Rudha) irrigation project envisages construction of barrage across Penganga River on the downstream of Lower Penganga Dam near village channaka / Korata.

The major components of the channaka-Korata (Rudha) project are Barrage, Reservoir, Pump House, Pressure mains, Balancing Reservoir if any and Canal network.

1.2. Location Of Project Area

The channaka-Korata (Rudha) barrage is located on Penganga river near Channaka village in Kelapur Tahsil of Yavatmal district in Maharashtra state and Korata village in Tamsi Mandal of Adilabad district of Telangana State having following coordinates.

Longitude : 78° 31' 7.30" E

Latitude : 19° 49' 8.19" N

Index map showing the location of the barrage and project area is enclosed (Drawing No: AA/IRR/1774/ DPR/BAR/01).

1.3. Access

Road

The proposed barrage is approachable by road from Adilabad.

Adilabad – Borjiam (NH7)	-	8.50 km
Borjiam – Gimma	-	4.00 km
Gimma – Korata	-	5.00 km

Air

The nearest airport is Nagpur (180 km)

Rail

The nearest rail head is Adilabad in Adilabad district of Telangana.

14 . General Climatic Conditions of the State and the Project Area in Particular

Three distinct seasons prevail over the Penganga sub-basin: the rainy season from mid June to mid October, winter from mid October to February and summer from March to mid June.

The precipitation of the catchment area is mainly due to south-west monsoon and is from June to October. There are occasional post monsoon showers in December. There are frequent dry spells of a fortnight or more even during monsoon period. In early October, heavy showers are experienced some times. The average rainfall in the river valley is 1016 mm out of which 762 mm occurs in monsoon. The rainfall increases from west to east in the river valley.

The climate of the area is dry with large temperature variations. The maximum and minimum temperature in the valley so far recorded is 44.4°C and 15.6°C respectively.

Climate of Adilabad district (Project area)

The climate of the district is characterised by a hot summer and is generally dry except during the southwest monsoon season. The year may be divided into four

seasons. The cold season from December to February; summer from March to May; south-west monsoon season from June to September and post monsoon season from October and November.

1.5. General description of topography, physiography and Geology of the Area

The river Penganga originates near village Madha in Buldhana district at an altitude of 685.70m. The river flows mainly in south-eastern direction up to the upper Penganga dam site. From here it flows in southern direction for a short distance and again flows in south-eastern direction up to the Sahastrakunda fall from where it flows in a northern direction for some distance. From the point of confluence of its tributary Pus river, it flows in eastern direction up to Lower Penganga Dam site. From LPP Dam site, the river traverses in easterly direction till its confluence with Wardha River. The total length of river Penganga is 668.8km.

The Penganga catchment is feather shaped with length about twice the average width. Upper reaches of the basin lie on the plateau and is covered by forest in lower reaches.

The types of rocks that are found in the Penganga sub-basin are the Deccan trap, Gondwanas and Puranas. The ground water occurs in the soil cover, weathered mantle and in the highly jointed fractured zones of the hard rock. In the alluvium, the ground water is found in the basal portion containing gravel and coarse sand. The depth of ground water varies from 4.5m to 16.0m.

Topography, Physiography and Geology of Adilabad district.

The Sahayadri parvat or Satnala range traverses the district from the north-west to the south-east for about 281km. In this range, the Mahbubghat is the highest peak. In the eastern portion of the district, some hills and hillocks of minor importance are found.

In the geological history of the Peninsular India, the district of Adilabad has special significance in some of the areas. The Indian stratigraphy occurs in this district in addition to various types of geological formations. Important deposits of coal, limestone, iron ore and clays are also found besides several other minerals in the district.

1.6. Population

Data on Mandal-wise, village-wise population in the command area of the lift scheme (Barrage) are collected from the Mandal Revenue Officers concerned.

Table 1.2: Population in the command area under proposed barrage on Penganga in Adalibad District of Telangana State

S.No.	Mandal	Name	Population
Channakha – Korata (Rudha) Barrage			
1	Tamsi	Gunjala	876
2		Gollaghat	286
3		Tamsi (K)	908
4		Nipani	1788
5		Dabbakuchi	406
6		Bheempoor	1767
7		Wadgon	715
8		Khapperla	3148
9		Pippalkhoti	2876
10		Ghotkuri	1207
11	Adilabad	Jamdapur	1359
12	Jainad	Rampur Taraf	704
13		Guda	1279
14		Hathighat	21
		TOTAL	17340

1.7. Natural Resources

The present project is on the Penganga River. Penganga is an inter-state river and is a tributary of river Wardha in Godavari river basin. Its catchment area lies mostly in Maharashtra (93.5%) and part in Telangana (6.5%).

Telangana has drawn up sub-basin wise master plan for the use of Godavari water resources as per the GWDT tribunal award. The present planned utilizations are as per the agreement between Maharashtra and Telangana in accordance with the GWDT award.

1.7.1. The planned utilizations of Telangana

Following table shows the planned utilizations of different projects in Telangana on Penganga River Sub-basin (Unit: TMC)

Table 1.3 Utilization of Penganga River Sub -basins

	Name of the project	Existing	Ongoing	Future
Major	Lower Penganga	-	-	5.120
Medium	Satnala	2.048	-	-
	Mathadivagu	-	0.905	-
Minor		2.020	0.237	0.233
Sub- Total		4.068	1.142	5.352
Total				10.562

1.7.2. Present Level of Utilization of Land and Water Resources

At present the utilizations from the existing projects in Penganga sub-basin are as above irrigating an ayacut of 11457ha.

1.7.3. System Efficiency

Specific data in this regard from the existing projects in Adilabad district is not available. The following efficiencies are considered for calculating the Crop Water requirement.

1. Conveyance efficiency 70%
2. Field Efficiency 65%

1.8. Land Use and Socio Economic Aspects Including Tribal, Backward and Drought Areas etc.

Adilabad district is economically backward. The percentage of tribal population in the district is 16.74% of the total population and that of schedule castes is 18.54%. The rural population in the district is 73.47% consisting of mainly illiterate working class. The literacy rate of the district is 44.7%. The main occupation and source of livelihood of the people of Adilabad is agriculture. Even though the lands are fertile, the farmers depend on ill distributed and erratic rainfall with no dependable assured irrigation at all. Thus full benefit of the natural resources are not realized by the people so far.

The total Geographical area of the district is 1610500 Ha, out of which forest area is 43%, barren and uncultivated land is 3 %, land put to non agricultural uses is 4%, Current fallows is 7 %, Permanent pastures and other grazing lands is 1%, Other

fallow land is 4% , net area sown is 37% and land under miscellaneous tree crops & groves not included in net area sown is 1%.

1.9. History (Earlier Proposals)

Government of Maharashtra initially planned to construct 4 barrages on Penganga river at different locations on the downstream of Lower Penganga Dam to utilize 3.127 TMC out of the 9 TMC of water allocated to it by GWDT. Government of Maharashtra requested Government of Telangana to participate in these barrage schemes and take benefits out of them duly using the allocated share of Telangana below Lower Penganga dam site. The cost sharing of these barrages is proposed to be in the ratio of utilization of waters between the states of Maharashtra and Telangana. Subsequently meetings were held between the officers of the two states. As decided in the 3rd round of the Chief Engineers Level meeting, a Joint meeting has decided that Telangana Govt. will participate in 3 barrages out of the 4 barrages proposed by Maharashtra (1. Rajapet, 2.t Rudha, 3. Pimpard) below the Lower Penganga Project.

Table 1.3: The water availability and sharing from the 3 Barrages will be as follows:

Sl. No.	Bar- rage Loca- tion	Stor- age ca- pacity in TMC	Percentage of Sharing		Sharing of water in TMC		Ayacut in Ac	
			Telan- gana	Maharash- tra	Telan- gana	Maharash- tra	Telan- gana	Maharashtra
1	Rajapet	0.7	50	50	0.35	0.35	2500	2500
2	Rudha	1.5	80	20	1.2	0.3	13500	3000
3	Pim- pard	1.5	30	70	0.45	1.05	4500	10000

During the meeting held in the Chambers of Engineer-in-Chief (AW), I& CAD, Hyderabad on 10-10-2012, it was agreed that 2.00 TMC can be earmarked from 5.12 TMC unaccounted water below LPP for the use in AP (now Telangana State) in Penganga Basin (G7) under proposed barrages as there is no effect in water availability for the Project down below. (Letter enclosed as Appendix-1.1)

Governments vide Memo No. 25577/PW. IS/ 2013, dt. 15-07-2013 accorded permission to take up Barrage -1 at Rajapet and Barrage-3 at Pimpard by the state of Maharashtra and Barrage-2 at Rudha by the state of Telangana, (Letter enclosed as Appendix-1.2)

1.10. **Choice of Project**

On 30/03/2015, a Joint Inspection for finalization of location for Rudha Barrage was made by Superintending Engineer Yavatmal Irrigation Circle, Yavatmal & Superintending Engineer, Irrigation Circle (I & CADD), Nirmal. Joint inspection note is enclosed as Appendix-1.3.

Three alternatives were studied for the barrage near Rudha village at the following locations.

- Just upstream of the confluence of stream with Penganga
- Just downstream of the confluence of stream with Penganga
- Beyond Rudha village on the downstream.

Drawing showing these alternative alignments is enclosed (Drawing No:AA/IRR/1774/ DPR/BAR/02).

Considering the techno-economic factors as well as the local factors like submergence and LA issues, alternative 1 is favored. The alternative 1 was approved by CE/CDO during Joint Inspection held on 22-04-2015 (letter enclosed as Appendix – 1.4).

1.11. **Stages of Development**

Barrage on Penganga river at Channaka-Korata (Rudha)

As already explained above, Telangana Govt. is planning to construct the proposed barrage at channaka-korata (Rudha) for irrigating the left out ayacut of LPP situated in the uplands of Adilabad district.

1.12. **Fitment of the Scheme in Overall Development of the River Basin**

The proposed utilizations under the project will be within the frame work of GWDT award. The utilizations by Telangana are within the allocated waters to it and fit into the master plan for the overall development of sub-basin wise water resources in Godavari basin.

1.13. **Intimation to the other development authorities regarding this scheme.**

The development authorities concerned are aware of the scheme.

1.14. **Public announcement and Public hearing**

As the development authorities concerned are aware of the scheme, public and the farmers are happy about the construction of the barrage which was expressed several times during the interaction of the people with public representatives.

1.15. Interlinking of the scheme with neighboring schemes.

The other schemes on Penganga River adjacent to the present scheme are Lower Penganga project on the upstream of the present barrage.

The other significant schemes of Telangana in Penganga basin are Satnala project and Mathadivagu project, both are in Adilabad district. The present scheme excludes the command of these projects. However, some of the existing minor schemes will be integrated into the present scheme.

1.16. Interstate / International aspects

This project is a joint project of Maharashtra and Telangana, as per the agreement reached between these States on interstate river Penganga and as per the GWDT award.

No international aspects are involved.

1.17. Cost and Benefit of the Scheme

The B:C ratio for the joint project is 1.61 as per the as per the Draft Detailed Project Report.

1.18. Public cooperation and participation

The storage under this barrage will be limited to within the banks. The proposed barrage involves only 49 Acres of Private land in the submergence area in Telangana. It is proposed to construct protection wall along the Channaka village in Maharashtra under MWL condition. Public resolution was passed by the people of Channaka village to support the project. As such public cooperation and participation is assured.

1.19. Provision for domestic and industrial power supply

Provision of 1.218 M cum (0.043 TMC) of water is made for the drinking water supply for the en-route villages. No provision is made for industrial power supply.

CHAPTER 2

PHYSICAL FEATURES

2.1 Geographical Disposition

The channaka-Korata (Rudha) barrage is located on Penganga river near Channaka village in Kelapur Tahsil of Yavatmal district in Maharashtra state and Korata village in Tamsi Mandal of Adilabad district of Telangana State having following coordinates.

Longitude : 78° 31' 7.30" E

Latitude : 19° 49' 8.19" N

The free catchment area upto the project site is 133804.2 Ha. The Telangana portion of the works lie in the Adilabad district area.

2.2 Topography of the Basin, Reservoir and Command Area.

Basin

The Penganga catchment is feather shaped with length about twice the average width. Upper reaches of the basin lie on the plateau and is covered by forest in lower reaches. The terrain of the basin is a rolling terrain with natural slope of the ground and rock outcrops.

Command area

Adilabad district is situated between East longitudes 77° 47' to 80° 0" and North latitudes 18° 40' to 19° 56'. Telangana portion of the command lies entirely in Adilabad district. The command area is rolling and undulating. The Sahayadri parvat or Satnala range traverses the district from the north-west to the south-east for about 281km. In this range, the Mahbubghat is the highest peak. In the eastern portion of the district some hills and hillocks of minor importance are found.

2.3 Geology of the Basin, Reservoir and Command Area

Basin

The types of rocks that are found in the Penganga sub-basin are the Deccan trap, Gondwanas & Puranas. The ground water occurs in the soil cover,

weathered mantle and in the highly jointed fractured zones of the hard rock. In the alluvium, the ground water is found in the basal portion containing gravel and coarse sand. The depth of ground water varies from 4.5m to 16.0m.

Barrage site

The barrage site is located in sedimentary belt belonging to Penganga Group. Satnala shales are lithological type of the area which is sporadically exposed. At the proposed barrage site, the river bed is 175m wide and is 11m deep. The main river bed is occupied by pebbles boulders of basalt and limestone and Purple shale occurs as thin rock fragments. Maximum size of sub rounded boulder observed is 0.30 cum. They are loosely packed in coarse sand. These pebbles, boulders and rock fragments make up 75% of total bed loads of the river.

Command Area

In the geological history of the peninsular India, the district of Adilabad has special significance. The Indian stratigraphy occurs in this district in addition to various types of geological formations. Important deposits of coal, limestone, Manganese, iron ore and clays are also found besides several other minerals in the district.

CHAPTER 3

INTER STATE / INTERNATIONAL ASPECTS

3.0 Introduction

The Channaka-Korata Barrage project is the joint project of Maharashtra and Telangana, as per the agreement reached between these States on interstate river Penganga and as per the GWDT award.

No international aspects are involved.

3.1. State / Countries traversed by the river

Penganga is an inter-state river and is a tributary of river Wardha in Godavari river basin. The catchment area of the river lies mostly in Maharashtra (93.5%) and remaining in Telangana (6.5%). The Penganga sub basin lies between latitudes 19° 17' N to 20° 32' N and 75° 57' E to 79° 12' E.

3.2. Distribution of catchment in States

District wise breakup for the catchment area of Penganga sub basin is present in the following table.3.1.

State	District	Sub basin area (km ²)	% of the area of sub basin
Maharashtra	Akola	3060	12.83
	Buldana	2216	9.29
	Chanda	668	2.80
	Nanded	3124	13.10
	Parbhani	2952	12.38
	Yavatmal	10280	43.10
Telangana	Adilabad	1554	6.50
Total		23854	100

Catchment of 93.5% of Penganga River lies in the State of Maharashtra. As per the hydrological studies of Godavari basin carried out by WAPCOS considering data from 1941-42 to 1994-95, the 75% dependable annual yield of Penganga sub-basin is 3841 Mcum (135.64TMC). On catchment area proportion basis, the yields generated from catchment of each state are:

Maharashtra:	126.8 TMC
Telangana:	8.84 TMC

3.3. Interstate agreement

The barrage at channaka-korata (Rudha) is the joint project between the states of Maharashtra and Telangana on Penganga River independent of the joint Lower Penganga Project. An understanding was reached between the states of Maharashtra and Telangana to take up the barrages at Rajapet,. Channaka- Korata (Rudha) and Pimprod as an inter-state joint projects.

Government of Maharashtra initially planned to construct 4 barrages on Penganga River at different locations on the down stream of Lower Penganga Dam to utilise 3.127 TMC out of the 9 TMC of water allocated to it by GWDT. Government of Maharashtra requested Government of Telangana to participate in these barrage schemes and take benefits out of them duly using the allocated share of Telangana below Lower Penganga dam site. The cost sharing of these barrages is proposed to be in the ratio of utilization of waters between the states of Maharashtra and Telangana.

Subsequently, following meetings were held between the officials of the two states.

3rd round of the **Chief Engineers** Level interstate meeting, 24-01-2012 at Dr.MCR HRD Institute, Hyderabad (letter enclosed as Appendix – 1.6).

A Joint meeting of **Superintending Engineers** of Andhra pradesh (now Telangana) and Maharashtra States on 14.03.2012 at Nirmal (letter enclosed as Appendix – 1.5).

In the 2nd meeting, it has been decided that Telangana Government will participate in 3 barrages out of the 4 barrages proposed by Maharashtra at Rajapet, Channaka-Korata (Rudha) and Pimprod below the Lower Penganga Project. During the meeting held in the Chambers of Engineer-in-Chief (AW), I& CAD, Hyderabad on 10-10-2012 (letter enclosed as Appendix 1.1), it was agreed that 2.00 TMC can be earmarked from 5.12 TMC unaccounted water below LPP for the use in Andhra Pradesh (now Telangana State) in Penganga Basin (G7) under proposed barrages as there is no effect in water availability for the Project down below.

Table 2.2 : The water availability and sharing of ayacut and water for the 3 Barrages

Sl. No	Barrage Location	Storage capacity in TMC	Percentage of Sharing of cost		Sharing of water in TMC		Ayacut in Ac	
			Telangana	Maharashtra	Telangana	Maharashtra	Telangana	Maharashtra
1	Rajapet	0.7	50	50	0.35	0.35	2500	2500
2	Rudha	1.5	80	20	1.2	0.3	13500	3000
3	Pimprod	1.5	30	70	0.45	1.05	4500	10000

Governments vide Memo No. 25577/PW. IS/ 2013, dt. 15-07-2013 accorded permission to take up Barrage -1 at Rajapet and Barrage-3 at Pimprod by the state of Maharashtra and **Barrage-2 at channaka-korata (Rudha) by the state of Telangana .**

Government Memo No. 25577/PW. IS/ 2013, dt. 15-07-2013 (letter enclosed as Appendix 1.2).

3.3a. State / Countries traversed by the river

Penganga is an inter-state river and is a tributary of river Wardha in Godavari river basin. Its catchment area lies mostly in Maharashtra (93.5%) and remaining in Telangana (6.5%). The Penganga sub basin lies between latitudes 19 o 17' N to 20 o 32'N and 75 o 57 ' E to 79 o 12 ' E.

3.3. b Interstate adjudication

Godavari Water Dispute Tribunal (GWDT) made the following allocation of water to the basin states at 75 % dependability.

State	Allocation (annually at 75 % dependability)
Maharashtra	A. The state of Maharashtra can use all the waters upto : Lower Penganga project site near ChikalWardha subject to the condition that the Lower Penganga Project is taken up as a joint project. Waghadi Project Dam site on the Waghadi river near village Yelbara. Saikheda Dam on Khuni river near village Lingti.
	B. In addition to the use of all the waters up to the point as

	specified above, the state of Maharashtra can use from the waters of the rest of Penganga sub-basin 9 TMC.(255 M cum) for its existing, under construction and proposed schemes / projects each of which individually will not exceed an annual use of 1.5 TMC.
Telangana	The State of Telangana (now Telangana) can use all the remaining waters of the Penganga Sub-basin.

3.3.c *Interstate aspect submergence.*

No submergence of Private land or property is involved in Maharashtra as the storage is restricted to within the banks.

3.3.d *Any other aspects of the project involving Inter-state problems.*

A draft agreement in respect of the joint Rudha barrage Project between the States of Maharashtra and Telangana is prepared and is likely to be signed very soon. This agreement deals with all the aspects likely to be emerged during construction and Operation of the project.

3.3.e *Existing and sanctioned projects.*

Particulars of the existing and sanctioned projects pertaining to Telangana in Penganga basin are given in the following table.

	Name of the project	Existing	Ongoing	Future
Major	Lower Penganga			5.120
Medium	Satnala	2.048		
	Mathadivagu		0.905	
Minor		2.020	0.237	0.233
Sub-Total		4.068	1.142	5.352
Total				10.562

In addition to the above, lift schemes for lifting water from the proposed 3 barrages (including the Rudha barrage) on Penganga river below Lower Penganga Project for the purpose of drinking water supply to Adilabad town and irrigation of leftover ayacut in Adilabad district, are under proposal.

3.4 **Existing riparian use, quantum of water presently utilised, commitments for ongoing projects, plans for future development, balance share of the state/country and proposed utilisation by this project.**

As given above under Para 3.3.e

3.5 Whether operation and regulation of the project conform to the 'stipulation made in the Tribunal award/agreement and also the mechanism for such operation.

Yes. Operation and regulation of this project will be as per the stipulation made in the GWDT award and as per the agreement between the states of Telangana and Maharashtra.

3.6 In case of addition/alterations for existing project involving submergence in other states and additional utilization of water, concurrence of the concerned states is to be included.

Not applicable

3.7 Details regarding consumptive use of water in case of Hydro electric or Thermal Power Projects

Not applicable

CHAPTER 4 SURVEYS AND INVESTIGATIONS

4.0 General

The accuracy of the design of any scheme depends on the accuracy of field data. As such the survey has a greater importance in this kind of projects. Every effort was made to collect reliable data.

The objective of the proposed topographical surveys is to assess the topography of the project area, type of terrain, profile of alignment, ground features etc to enable planning, engineering and construction works.

Based on the information furnished in the tender document, initially a preliminary survey was conducted to study the general topographical conditions of the project stretch. In this survey, the neighboring villages under the stretch, location of different tanks, canals, power lines, pipe lines etc are studied; local enquiries were made to collect available information. Topo sheets and village maps of the project were collected.

Following are the various surveys undertaken.

4.1. Topographical Surveys

Relevant Topo maps of Survey of India were collected and Topographical features of the area studied which gave a preliminary idea of the river and command area. All the relevant topo sheets were joined together to get an overall picture of the project. The contours of the area were studied vis-a-vis the river levels and general command area levels. All the Survey requirements and scales of maps etc are according to the Central water Commission (CWC), Government of India. The project components were marked on topo sheets. Possible alternatives were explored on the map. Following series covers the Topo grid of the project area.

56 I/5	56 I/9	56 I/13
56 I/6	56 I/10	56 I/14

4.1.1 Reconnaissance Survey

Walk through surveys were conducted repeatedly to get the first hand information about the area. A reconnaissance survey is made at the river, proposed reservoir, possible Barrage axis, pump House and Command Area. All salient features of the area are noted during the reconnaissance survey. As such, the alignment marked on the toposheet was verified on the ground and found feasible ways to proceed with other surveys.

4.1.2 Reference Bench Mark

Height control has been established with respect to the GTS bench mark bearing value +225.300 m is located in Post Office at Gimma Village, Jainad Mandal.

4.1.3 Primary Control Points

Following the basic principle of surveying i.e., "to work from whole to part" a network of permanent primary control points have been established in the project area using auto levels and Dual frequency Global Positioning System (DGPS). Traversing was conducted between the DGPS points using Total Station.

4.1.4 Secondary Control Points

To facilitate the detailed survey of remote areas, which are not directly accessible from primary control GPS points, temporary secondary level control points have been established. Several such points were established during detailed survey depending upon the complexity of features and accessibility. Different arrangements were made for these temporary points like erection of a stone pillar wherever possible, marking on the rock where rock is exposed or driving a nail into the firm ground.

All the permanent and temporary reference points established above were also interconnected elevation wise. A double check leveling procedure has been followed to transfer the level of bench mark.

4.1.5 Detailed Topographical Survey

Survey was based on TM (WGS84) co-ordinate system. One pair of control points have been established in the Barrage site using DGPS and 16 pairs of control

points have been established in the Command area using DGPS. North south reference base line has been established to true North & East west lines has been established perpendicular to it. The control points have been established at an average of 4.0 to 5.0 km using DGPS and Traversing was carried out on control points using total station.

In the detailed survey, actual field data was collected duly covering the entire project area so as to prepare the scheme proposal in detail. This survey involved establishment of bench marks, collection of ground features and their levels. Following are the various activities covered under this survey.

Alternative studies for finalization of Barrage alignment

Annexure – Alternative site examined, are enclosed

Considering the techno-economic factors as well as the local factors like submergence and LA issues, alternative 1 is favored. The alternative 1 was approved by CE/CDO during Joint Inspection held on 22-04-2015 (letter enclosed as Appendix - 1.4).

Similarly canal alignment is marked in the combined toposheets. Various factors like optimum cutting and filling, commandability of ayacut, suitable locations for CM & CD works are taken into account before deciding on canal alignment. Detailed surveys are taken up for Barrage, canals, and command area. The detailed surveys comprise of the following activities.

4.1.6 Development of Plan

The overall plan of the project site indicating the streams, topographical features like cliffs, rock outcrops, mounds, ditches, was generated by taking coordinates using total station. Proposed alignment of barrage, approach bund, pump house, WCS, canals and distributories etc. are indicated in the plan.

4.1.7 Barrage Survey

The exact alignment of barrage, approach bund is fixed and detailed surveys carried out. The broad crested weir is located at the river portion and approach bund on right flank. The general arrangement drawing (GAD) enclosed.

4.1.8 Submergence area, Longitudinal and Cross sections of the proposed barrage

In order to generate the submergence area map, LS & CS of proposed barrage x, y and z coordinates of the following points are picked up using Total station with reference to the benchmarks.

1. Grid survey for submergence area at interval of 30m or less.
2. LS at every 25m along the Barrage alignment.
3. LS at every 25m along the Submergence area in Penganga River.
4. CS of the river on upstream and downstream.

4.1.9 Command Area Survey

An ayacut of 13500 acres is proposed to be irrigated under Channaka-Korata barrage in Telangana. This essentially includes collection of details for all features such as structures (buildings, tanks, towers etc.), monuments, places of worship, existing road and railway lines, streams, canals / rivers, tanks, utilities, electric and telephone installations, huts, fencing falling within the extent of survey. The detailed survey was carried out in a systematic way by covering all the details in the command area.

The entire command was surveyed with total station and contour plans are enclosed in AA/IRR/1774/DPR/BAR-2/09 and AA/IRR/1774/DPR/BAR-2/02. Alignment of main canal and distributaries are marked on this plan.

Main Canal

Longitudinal section of the canal is taken at 25m interval. Cross sections of the canal alignment are taken @ 50m interval extending 100 m on either side of the center line of the alignment for preparing the Strip Contour plan. Plan & Longitudinal are plotted giving the following details.

- Bed width
- Side slopes
- Full supply depth and free board
- Profiles of banks.
- Details of inspection and non-inspection paths

The Plan & Longitudinal Section plots are presented in Designs & Drawing volume IV (Part 2).

Canal Structures.

Block leveling of the area of the structure on 5m grid basis is carried out. Grid plan of the site with contours at 1m interval to cover an area up to 100m on either side of the center line of the canal.

- L.S and cross sections at 25m interval along the river and road crossings up to a length of 500m upstream and down stream are taken.
- Particulars of the cross drainage and Cross masonry structures are given in Designs & Drawings Volume IV (Part 1)
- The design details of the CM & CD works(for 10% of the total Structures for main canal) are given in the Designs & Drawings Volume IV (Part 1)

4.1.10 Standard observation procedure for traversing and staking using Total station

Aim: To provide planimetric and height control for subsequent survey exercise and to stake out points whose coordinates are known.

Instruments: Total Station and 50m long Fibre glass Tapes.

Observations:

- The work should start from a known station or a point whose coordinates are known.
- After setting instrument on a known station, telescope should be trained & targeted on to another known point, to get natural bearing.
- In case, the work starts from a GPS location, Total station should be set on one of the GPS points of the pair and the other GPS point of the pair should be taken as reference station for mutual bearing.
- The traverse line should have connection to one DT level at the beginning of the alignment and be connected to one more DT level at the end of the traverse.
- Offsets to pillars, should be restricted to 200m length only.
- Recording of point number in field observation book should be very clear and with no over writings.

- If needed, the figures should be cut neatly and the observations be recorded afresh. Each page of the field observation book must be completed in all respects in the field itself.

4.1.11 Computations:

- Computation of observations made during the traverse should be completed only after ensuring that all the observations are within tolerance limits.
- Traverse set up must be completed by running down the bearings and the corresponding distances, in the same sequence as that of the observation.
- Computation of coordinates and heights should also be completed in the same sequence.
- Closing error, if any, should be adjusted within the traverse legs as inversely proportional to their lengths.

4.1.12 Standard deviation of procedure for levelling

Aim: To provide height control for subsequent survey of cross sections of the canal, Plane Table Survey and contouring with 1m vertical interval.

Instruments: Auto levels, Aluminum levelling Staves and Iron brands.

Observations:

- Double tertiary levelling should be run along the banks of the canal.
- All level lines should start and close on the same point.
- In case, the level line is run from one BM to another, both the BMs should be visited, prior to the commencement of work.
- For DT levelling two sets of observations are to be taken at each of the instrument stations, disturbing the instrument between the observations. The difference between the two sets must agree within 0.003m and then the mean of the two sets is to be taken for reducing error.
- To avoid collimation error of the instrument, the instrument should always be kept at the center of forward and back staves.
- Maximum length of a shot should be restricted to 50m only.
- Observation during high winds and shimmering should be avoided.

- Staves should be kept on the iron brads and not on the ground directly. On the slopes of canal where it is not possible to put the iron brad, a small patch of firm ground may be levelled and the staff be put on it.
- To ensure that the same staff is kept on BMs, even number of stations should be made between the BMs.
- Spot heights should thrown as offsets, to a limiting distance of 50m.
- All the three wires should be read in quick succession and the mean of these should agree within 0.002m with the value of the central wire reading. Otherwise, the observation must be repeated.
- Always, the back staff is to be observed first.
- Accuracy should be within 0.025 multiplied by the square root of KX km square where K is the total distance in km of the level line for ST level line and 0.0125 multiplied by the square root of KX square for DT level lines.
- Bench marks should be made on permanent points with hard surface and should be painted with their elevation values.
- All the levels should be reduced in the field and accuracy should be ensured before closure of the work.
- While taking levels for the cross section of the canal all the levels should be taken in the line connecting the two BMs on either of the canal.
- While taking the levels under water, bed should be probed with staff till it touches firm surface and then should be held perfectly against the current.

Third extension piece of the staff is not be used at all.

EQUIPMENT USED

DGPS - 1 Set, DGPS 1200 Series

Total stations- 4 Sets

Leica TC 1800

Leica TRS1101

Leica TRS1202

Leica TS-02

Auto Levels

Sets of Pentax AFL 128 model

Sets of Pentax AL 240 model

Sets of Pentax AP 124 model

4.2 Other Surveys

4.2.1 Archaeological survey in the reservoir area.

There are no centrally protected monument / Archaeological site located in the proposed submergence area or along the canal alignment .

4.2.2 Mineral Survey

The mineral resources are not affected by the project.

4.2.3 Right of way surveys for the reservoirs

Due to formation of the proposed barrage across the Penganga river, survey of the existing causeways, existing highways etc, which are likely to be affected by submergence was undertaken. It has been found that, with the FRL of +213.00m as proposed no highway or road of importance are affected by the submergence.

4.2.4 Communication survey

No roads of importance are getting affected with the FRL fixed at +213.00m.

4.2.5 Drainage Survey

The topography of the command is sloping and can offer adequate drainage. Water logging of the command is not anticipated.

4.3 Geology Geo-technical Features and Seismicity.

These features are covered in detail in Volume III.

4.4 Foundation Investigation

Foundation Investigations are covered in detail in the Volume III.

4.5 Construction Material Investigation

Various construction materials like sand, aggregate, stone, borrow area soils, cement and steel are proposed to be obtained from the designated quarries. The samples of these materials will be got tested before doing detailed designs of the structures. For preliminary designs random samples are tested and values

taken. The quarry map is enclosed. Detailed investigation report is enclosed in Volume III.

4.7 Hydrological and Meteorological Investigations

Hydrological and Meteorological Investigations are covered in the next CHAPTER. Hydrology of the project is presented in Volume II.

CHAPTER – 5

HYDROLOGY

5.1. Hydro-logic Inputs to the project planning

The project is classified by storage as A-3 (with in the year storage). It is primarily classified as B-1 by use (Irrigation). Provision of drinking water supply is incidental and as such it can not be classified as B-2 (Multipurpose) by use.

Following are the requirement of inputs for the project.

For simulation studies

- Water inflows
- Lake evaporation
- Potential evapo-transpiration and rainfall
- Water quality inputs

The time unit for simulation studies can be monthly for such a storage reservoir.

The length of data for use in simulation studies for this project is 25 years.

For studies other than simulation

- Design Flood for the safety of the structure:
- Design Flood for diversion structure (cofferdam)
- Level at the Dam site
- Tail Water Rating Curve

5.1.1. Water inflows

The availability of water to Telangana at the barrage at Channaka-Korata(Channaka-Korata(Rudha)) can be assessed as per the allocation of GWDT according to which, the state of Maharashtra can use all the waters upto the following projects:

- Lower Penganga project site near ChikalWardha.
- Waghadi Project Dam site on the Waghadi river near village Yelbara.
- Saikheda Dam on Khuni river near village Lingti.

GWDT further allotted 9TMC of water annually to Maharashtra from Penganga below LPP subject to a maximum utilisation by Maharashtra of 1.5 TMC from each location below LPP.

Accordingly the yield need to be assessed from the free catchment below the above projects up to the project site and considering a total allocation of 9 TMC below LPP to Maharashtra. Accordingly the yield is assessed as given below.

5.2.1 Hydrological data

There are no Gauge and Discharge sites near the proposed barrages on Penganga. No project specific gauge and discharge data was observed for assessing the yields at the barrages. Central Water Commission maintains a regular gauge and discharge site on Penganga river on the upstream at Penganga bridge which is located on the upstream of the barrage at Channaka-Korata (Rudha).

5.2.2 Computation of yield, assessment of available water

There is no observed discharge data at the proposed barrage site to develop yield series and assessing the water availability. The possible alternative methods for estimating the yields at Channaka-Korata barrage are:

- Assessing the yield at barrage based on the yields at Lower Penganga Dam on prorata basis of catchment areas.
- Using Rainfall- Runoff relations for the Penganga sub basin based on the nearest Discharge observation point Penganga Bridge on Penganga.

5.2.3 Rainfall-runoff relation for Penganga basin

Detailed studies on the rainfall runoff relations for Penganga basin at Penganga Bridge made by the following agencies are available.

- Yavatmal Irrigation Circle, Govt. of Maharashtra for the yield studies for the DPR of Lower Penganga project.

- WAPCOS for the hydrological studies of Godavari basin for me&CAD department, Govt of Telangana.

5.2.4 Rainfall in the basin

WAPCOS have studied the rainfall data from 19 rain gauge stations in the Penganga sub basin in the context of hydrological studies of Godavari basin. The western most parts of Penganga sub basin receive relatively lowest rainfall, which gradually increases as one move to the eastern parts of the sub-basin.

The annual normal rainfall varies from 800 mm in the west to 1000 mm in the central part of the sub basin and 1300 mm in the extreme eastern part. Magnitude of dependable rainfall over the sub basin is highest over the extreme eastern parts and decreases gradually to the west.

The present study area falls in the extreme eastern part of the sub basin and experiences relatively higher rain fall.

The range of variation in the magnitude of rainfall is given in the following Table 5.1

Month	Level of dependability	Range of rainfall magnitude (East to West)
June	50	160-120
	75	100-70
	90	80-50
July	50	350-200
	75	250-140
	90	150-140
August	50	300-175
	75	200-100
	90	40-10
September	50	160-100
	75	100-60
	90	40-10
October	50	50-20
	75	10-0
	90	0

Water Resources Department, Maharashtra finalized the water availability studies for Lower Penganga Project based on observed rainfall data at 20 stations

in the catchment for the period 1967 to 2008 and observed G&D data at CWC G&D site at P.G. Bridge for the period 1970 to 2008. These studies have been approved by CWC. The monthly weighted rainfall data for the project and the corresponding flow data are presented in Annexure 5.1.

5.2.5 Rainfall-Runoff regression equations.

The regression equations developed in the above studies are given below.

For monsoon

$$Y = 0.6237 * X - 25.202 \text{ (Maharashtra Irrigation department)(Eq.1)}$$

$$Y = 0.7162 * X - 381.92; \text{ where } Y = \text{Runoff}; X = \text{Weighted Mean Rainfall.....(Eq2).}$$

For Non-Monsoon

3.37 % of monsoon flows (Maharashtra studies)

4.15 % of monsoon flows (WAPCOS study)

5.2.6 Yield at Channaka-Korata (Rudha) barrage

The water availability studies for Lower Penganga Project carried out by Maharashtra Irrigation department are based on the latest observed data and are more relevant to the yield calculations at the proposed barrage below Lower Penganga Dam.

The varacity of the yield calculations at each barrage is verified by reassessing the yields using the equation developed for Lower Penganga Dam (Eq.1). The water availability at the barrage site is reassessed. The weighted mean rainfall for the Penganga basin up to P.G. Bridge is considered as the weighted mean rainfall for the free catchment area of Rudha barrage.

The gross yield at Rudha has been assessed as 303.16MCM (10.71TMC)

The calculations are presented in Annexure 5.1.

5.3 75% DEPENDABLE FLOWS AT Channaka-Korata (Rudha) BARRAGE

From the yields thus assessed from free catchment, the net annual 75% dependable yields available to Telangana at Channaka-Korata (Rudha) barrage are assessed in the following table 5.2.

Table 5.2: Net annual 75% dependable yields available to Telanga at Channaka-Korata (Rudha) barrage

				Unit : TMC
Barrage	Gross flows	Existing utilisation by Maharashtra	Net flows available to Telangana	Remarks
Channaka - Korata (Rudha)	10.71	0.322	10.388	

The net annual 75% dependable yields available to Telangana for future use after accounting for the existing utilizations by Telangana at Channaka-Korata (Rudha) barrage are given in the following table 5.3.

Table 5.3: Net annual flows available for future use by Telangana

				Unit :TMC
Barrage at	Net flows available to Telangana	Existing utilisations by Telangana	Net annual flows available for future use by Telangana	Remarks
Channaka - Korata (Rudha)	10.388	1.744	8.644	

5.4 Monthly Net yield flow series Channaka-Korata (Rudha) barrage.

The 75% dependable net available monthly flows at Channaka-Korata (Rudha) are derived as follows.

- The gross flows available at Channaka-Korata (Rudha) from free catchment have been assessed using Rainfall-Runoff relations.
- From the above virgin flows the existing utilizations by Maharashtra & Telangana in Penganga basin upto Channaka-Korata (Rudha) barrage site have been subtracted.
- The resulting flow series after subtracting the existing utilizations (proportion to the LPP main canal demands) are the net flows available at Channaka-Korata (Rudha) barrage for planning utilizations from Channaka-Korata (Rudha) barrage.
- The 75% dependable net available flow series at Channaka-Korata (Rudha) are given in Annexure -5.1 & 5.2 respectively.

5.4.1 Lake evaporation

The meteorological observations at RARS, Jagtial used for estimation of Eto of Northern Telangana Agricultural zone .The average lake evaporation as per the working tables is 0.007 TMC.

Table 5.4: Mean meteorological observations at RARS, Jagtial used for estimation of ETo of Northern Telangana Agricultural zone

Month	Max.Temp 0 ^c	Min.Tem p 0 ^c	Humidit y %	RH max %	Wind km/day	Sunshin e Hours	ETo mm/day
JAN	30.01	14.49	58.57	76.46	51.97	7.55	3.74
FEB	32.53	16.76	54.06	71.99	74.13	8.34	4.92
MAR	36.22	19.67	48.42	64.76	84.12	8.12	6.06
APR	39.31	23.04	42.97	58.35	93.67	8.64	7.21
MAY	41.65	26.41	40.00	50.51	169.55	8.28	8.75
JUN	37.06	25.82	58.51	67.36	245.70	5.93	7.76
JUL	32.09	23.52	71.73	79.17	227.93	4.29	5.68
AUG	30.97	23.00	75.67	82.98	193.13	4.59	5.22
SEP	32.07	22.83	73.13	82.22	121.57	5.87	5.12
OCT	32.30	20.43	66.42	79.97	57.05	7.16	4.66
NOV	30.79	16.70	61.00	76.94	45.50	7.37	3.88
DEC	29.45	13.38	58.35	75.07	42.44	7.48	3.40
Year	33.70	20.50	59.07	72.15	117.23	6.97	5.53

5.4.2 Potential evapo-transpiration and rainfall

This aspect has been considered while working out crop water requirements and assessing irrigation demands under Irrigation Planning.

5.4.3 Simulation studies

Working tables are prepared for 25 years (1984 to 2008) using monthly inflows and demands. The area - capacity tables of the reservoir are used for the simulation studies.

Area Capacity Table

S.No	Elevation (m)	Area (Mm ²)	Capacity in M Cum	Capacity In Tmc
1	197	0.000	0.000	0.0000
2	198	0.002	0.001	0.0000
3	199	0.005	0.004	0.0001
4	200	0.014	0.013	0.0005
5	201	0.033	0.036	0.0013
6	202	0.067	0.084	0.0030
7	203	0.158	0.193	0.0068
8	204	0.363	0.447	0.0158
9	205	0.828	1.027	0.0363
10	206	1.322	2.092	0.0739
11	207	1.776	3.635	0.1284
10	208	2.349	5.691	0.2010
11	209	2.933	8.327	0.2941
12	210	3.424	11.502	0.4062
13	211	3.816	15.121	0.5340
14	212	4.169	19.112	0.6750
15	213	4.614	23.502	0.8299
16	214	5.473	28.540	1.0079
17	215	7.023	34.771	1.2279
18	216	7.677	42.119	1.4874
19	217	8.293	50.102	1.7693
20	218	8.893	58.693	2.0727
21	219	9.617	67.945	2.3995

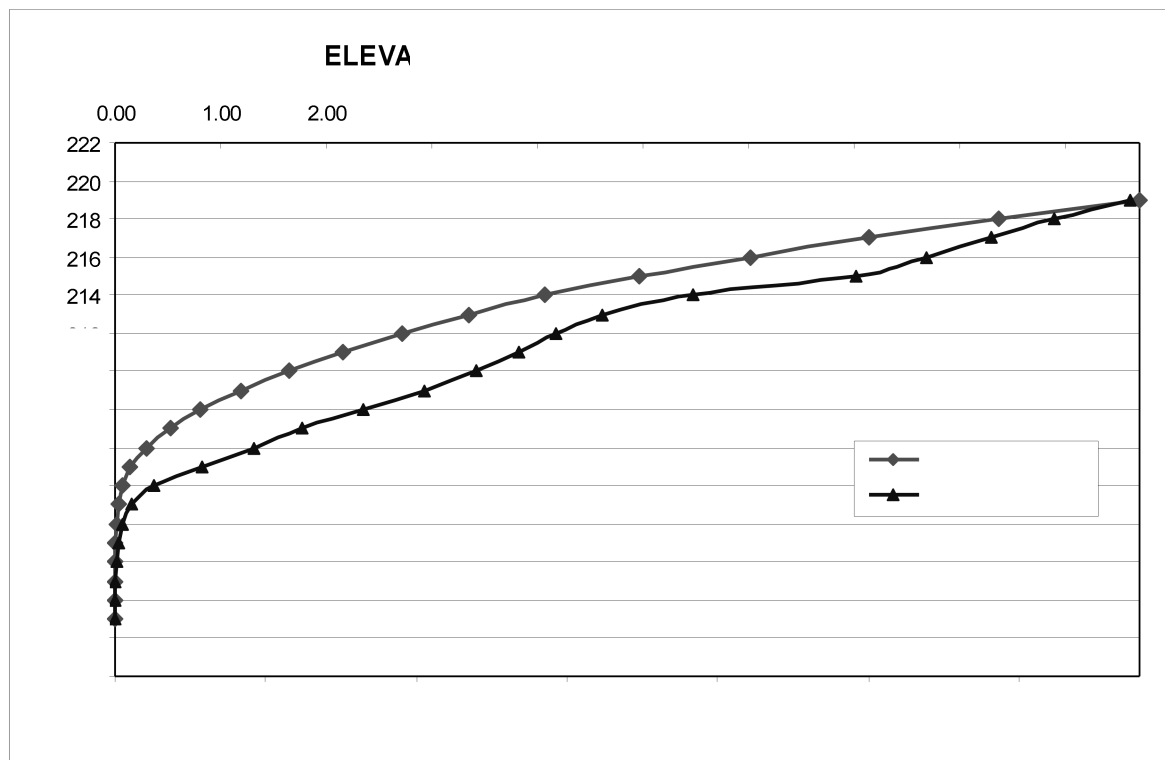


Fig: 5.1 Area- Capacity curve for Channaka-Korata Barrage

The FRL is considered as +213.000m with a capacity of 23.474 MCM. The summary of the working tables is given below table 5.5. The detailed calculations are presented in Annexure 5.3.

Summary Of Working Tables										
	FTL	+ 213.000	m					M.D.D.L	+ 203.000	m
	Capacity :	0.830	TMC					Capacity :	0.007	TMC
		23.500	MCM						0.191	MCM
S.No	Year	Start- ing Ca- pacity	Total In- flows	Total De- mand	Evapo- ration losses	Ending Capac- ity	Sur- plus	De- mands met	Deficit	
		TMC	TMC	TMC	TMC	TMC	TMC	TMC	TMC	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	1984	0.007	4.302	1.488	0.202	0.154	2.465	1.488	0.000	0.000
2	1985	0.154	8.956	1.488	0.210	0.187	7.226	1.488	0.000	0.000
3	1986	0.187	21.043	1.488	0.153	0.123	19.682	1.272	-0.216	14.513
4	1987	0.123	4.550	1.488	0.119	0.029	3.051	1.473	-0.015	1.002
5	1988	0.029	31.570	1.488	0.221	0.284	29.607	1.488	0.000	0.000
6	1989	0.284	16.972	1.488	0.148	0.083	15.753	1.272	-0.216	14.513

7	1990	0.083	21.717	1.488	0.214	0.226	19.873	1.488	0.000	0.000
8	1991	0.226	5.894	1.488	0.123	0.035	5.012	0.950	-0.537	36.123
9	1992	0.035	22.370	1.488	0.157	0.123	20.771	1.355	-0.132	8.894
10	1993	0.123	13.758	1.488	0.202	0.221	11.971	1.488	0.000	0.000
11	1994	0.221	18.992	1.488	0.210	0.236	17.279	1.488	0.000	0.000
12	1995	0.236	14.053	1.488	0.214	0.214	12.375	1.488	0.000	0.000
13	1996	0.214	15.061	1.488	0.200	0.221	13.366	1.488	0.000	0.000
14	1997	0.221	9.512	1.488	0.197	0.191	7.858	1.488	0.000	0.000
15	1998	0.191	10.822	1.488	0.153	0.059	9.313	1.488	0.000	0.000
16	1999	0.059	16.921	1.488	0.212	0.219	15.060	1.488	0.000	0.000
17	2000	0.219	10.073	1.488	0.129	0.059	9.153	0.950	-0.537	36.123
18	2001	0.059	16.192	1.488	0.209	0.220	14.335	1.488	0.000	0.000
19	2002	0.220	19.276	1.488	0.148	0.089	17.986	1.272	-0.216	14.513
20	2003	0.089	19.547	1.488	0.195	0.247	17.986	1.488	0.000	0.000
21	2004	0.247	10.018	1.488	0.209	0.247	8.134	1.488	0.000	0.000
22	2005	0.247	17.129	1.488	0.215	0.223	15.399	1.488	0.000	0.000
23	2006	0.223	32.446	1.488	0.226	0.314	30.641	1.488	0.000	0.000
24	2007	0.314	14.864	1.488	0.216	0.221	13.253	1.488	0.000	0.000
25	2008	0.221	16.012	1.488	0.214	0.233	14.299	1.488	0.000	0.000
			Average		0.188					

The minimum success rates for considering the project as viable as recommended by Planning Commission based on use of project are:

B-1 (Irrigation) : 75%

B-2 (Hydro Power) : 90%

B-3 (Water Supply) : Nearly 100%

Table 5.6: Performance of Channaka-Korata(Rudha) Lift Irrigation project

Sl.n	Description	Remarks
a	No. of years of simulation	25
b	Number of failure years to meet the demands	6
c	No of success years	19
d	% dependability	76 %

5.5. Hydrologic studies for design flood

5.5.1 Design flood for safety of structure

a. Criteria

The design flood can be defined as the maximum peak rate of runoff that occurs over a catchment due to a rainfall storm of given intensity and of various durations. A structure is to be designed to withstand this flood.

As per the IS code: 6966(Part 1)- 1989, For purposes of design of items other than freeboard, a design flood of 50 year frequency may normally suffice. In such cases where risks and hazards are involved, a review of this criteria based on site conditions may be necessary. For designing the free board, a minimum of 500 year frequency flood or the standard project flood may be desirable.

Floods of larger or smaller magnitude may be used if the hazard involved in the eventuality of a failure is particularly high or low. The relevant parameters to be considered in judging the hazard in addition to the size would be:

- i) Distance to and location of the human habitations on the downstream after considering the likely future developments.
- ii) Maximum hydraulic capacity of the downstream channel at a level at which catastrophic damage is not expected.

Table 5.7: Salient features of the Channaka-Korata(Rudha) barrage

Sl.no	Description	Level (m)
1	Average bed level	+201.645
2	Crest level	+203.000
3	FRL	+213.000

From the above discussion, 100yr frequency flood is to be adopted for the safety of the structure. The storage behind the dam is not much. It is unlikely, that

the damage caused on the down stream will be high in case of its failure, as the flood wave will be attenuated very soon. The design flood discharge for this project is calculated by the following method.

5.5.2 Frequency approach

Observed series of annual peak flows are available at CWC gauge and discharge site at Penganga Bridge on the upstream side of the project site. Frequency floods for different return periods have been assessed by applying proper frequency distribution to these peak flood series at P.G.Bridge. The 100yr frequency flood at the barrage site has been assessed by assuming an empirical formula equating discharge as a function of catchment area, ie; $Q = C*(\text{Root } A)$.

The 100 year return flood for the project is assessed as 16366.48 cumec.

The calculations are presented below.

INPUT OF THE VARIATE VALUES and FILE COMMUNICATION

Table 5.8: Annual Peak discharge at Pengang Bridge

S.No	Year	Dis-charge (Cumecs)	S.No	Year	Dis-charge (Cumecs)	S.No	Year	Discharge(Cumecs)
1	1965	1670	16	1980	4873	31	1995	6591
2	1966	4309	17	1981	4513	32	1996	2082
3	1967	2084	18	1982	1948	33	1997	528
4	1968	1748	19	1983	16000	34	1998	2192
5	1969	3188	20	1984	353	35	1999	4109
6	1970	5734	21	1985	2141	36	2000	4658
7	1971	1048	22	1986	6561	37	2001	4530
8	1972	3632	23	1987	741	38	2002	8702
9	1973	3552	24	1988	5970	39	2003	4118
10	1974	1142	25	1989	5591	40	2004	721
11	1975	5278	26	1990	5520	41	2005	7140

	5							
12	197 6	6137	27	1991	1125	42	2006	13881
13	197 7	3642	28	1992	4533	43	2007	2877
14	197 8	5410	29	1993	3676			
15	197 9	4130	30	1994	5334			

BASIC STATISTICS OF x and ln x

Description	x-stat	lnx-stat
mean =	4272.3720	8.0838
var =	.9778E+07	.6804
St.dev=	3127.0510	.8248
biasskew=	1.7883	-.7405
biaskurt=	7.4544	3.3253
skew =	1.9202	-.7951
kurt =	8.6045	3.8384

Table 5.9: Ranking of the data & the plotting positions

Rank	Value of x	Value of ln(x)	Plotting position (percent) according to WEIBULL
1	353	5.866	2.2727
2	528	6.269	4.5455
3	721	6.581	6.8182
4	741	6.608	9.0909
5	1048	6.955	11.3636
6	1125	7.026	13.6364
7	1142	7.041	15.9091
8	1670	7.421	18.1818
9	1748	7.466	20.4545
10	1948	7.575	22.7273
11	2082	7.641	25.0000
12	2084	7.642	27.2727
13	2141	7.669	29.5455
14	2192	7.693	31.8182
15	2877	7.965	34.0909
16	3188	8.067	36.3636

17	3552	8.175	38.6364
18	3632	8.198	40.9091
19	3642	8.200	43.1818
20	3676	8.210	45.4545
21	4109	8.321	47.7273
22	4118	8.323	50.0000
23	4130	8.326	52.2727
24	4309	8.368	54.5455
25	4513	8.415	56.8182
26	4530	8.418	59.0909
27	4533	8.419	61.3636
28	4658	8.446	63.6364
29	4873	8.491	65.9091
30	5278	8.571	68.1818
31	5334	8.582	70.4545
32	5410	8.596	72.7273
33	5520	8.616	75.0000
34	5591	8.629	77.2727
35	5734	8.654	79.5455
36	5970	8.695	81.8182
37	6137	8.722	84.0909
38	6561	8.789	86.3636
39	6591	8.793	88.6364
40	7140	8.873	90.9091
41	8702	9.071	93.1818
42	13881	9.538	95.4545
43	16000	9.680	97.7273

EVALUATION t-VALUE

one-tail Student t-value

degrees of freedom = 42 , level of significance= .9500

t - v a l u e = -.100T

Table 5.10: Pearson type III distribution

Return Period Years	Probab. Exc(p)	Non Probab. Exc (1-p)	Estimated Value (Cumeecs)
2	0.50	0.50	3280.967
5	0.20	0.80	6034.073
10	0.10	0.90	8207.091
20	0.05	0.95	10450.24
25	0.04	0.96	11186.53
50	0.02	0.98	13514.64
100	0.01	0.99	15902.88
500	0.00	1.00	21662.18

DESIGN FLOOD AT RUDHA		
CA upto PG Bridge	18441	sqkm
-do- upto Channaka-Korata barrage	19531.57	sqkm
25 yr flood upto PG Bridge	11187	cumecs
Equating $Q=C*\sqrt{A}$;		
11187= $C*18441$ and $C=11187/\sqrt{18441}$, C =	82.37993	
25 yr flood at Channaka-korata bar- rage	11513.04	cumec
100 yr flood upto PG Bridge	15903	cumec
Equating $Q=C*\sqrt{A}$;		
15903= $C*18441$ and $C=15903/\sqrt{18441}$, C =	117.1081	
100 yr flood at Channaka-korata bar- rage	16366.48	
500 yr flood upto PG Bridge	21662	cumec
Equating $Q=C*\sqrt{A}$;		
21662= $C*18441$ and $C=21662/\sqrt{18441}$, C =	159.5168	
500 yr flood at Rudha	22293.33	cumec

The design flood for a return period of 100 & 500 years is approved by CE, Hydrology, Telangana (Letter Enclosed as Appendix 1.7).

5.3.3 Design floods for flood control component

No storage for flood control is considered necessary in this project as no flood problems are anticipated in the downstream reaches.

5.3.4 Hydrological design of surface drainage

Flood control aspects are not contemplated in this project. The command area is not flood prone.

5.3.5 Design flood for planning construction and diversion arrangements

Construction of cofferdam is proposed for facilitating construction of the barrage. The construction of barrage will be throughout the year. A 25 year return flood is considered for the diversion arrangements.

The 25 year return flood is assessed as 11513 cumes.

5.3.6 Determination of flood levels for structures on river banks

The pump house will be located above MWL corresponding to 500 yr return flood.

5.3.7 Determination of outlet levels

The out let level for drawing water (MDDL) is fixed as +203.000.

5.3.7 Tailwater rating curves

The tail water rating curve up to the design flood value has been worked out by Standard Step Method. The actual x-sections of the river below the dam axis have been used for this purpose. Average coefficient of rugosity value is considered as 0.03 as per the profile and bed material of the river section. The tail water level corresponding to 100 yr return flood has been assessed as +217.100m. The tail water rating curve for 100 yr flood is given below fig 5.2. Tail water calculations are enclosed in Annexure 5.4.

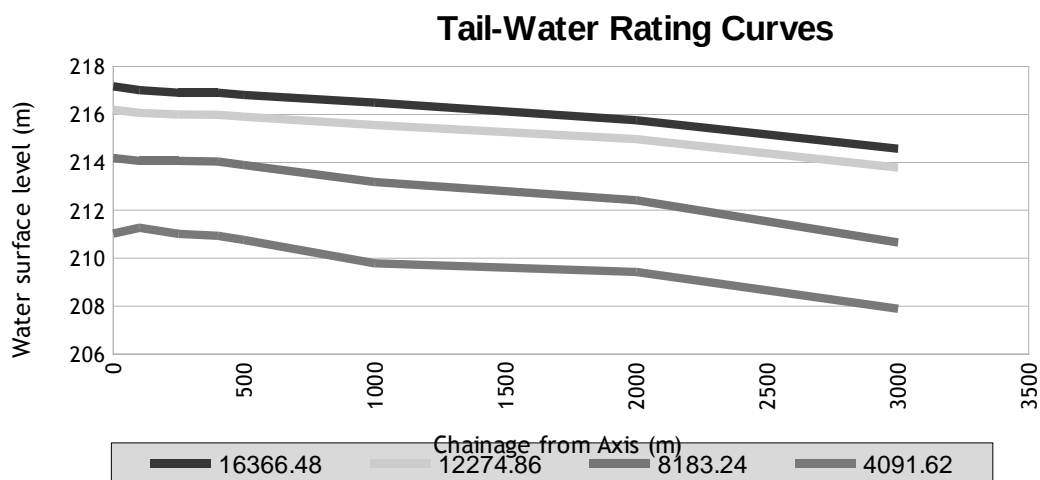


Figure: 5.2 Tail water Rating Curve

5.4. Effect of project development on hydrologic regime.

a. Impact on existing projects in the downstream of planned projects.

There will not be any impact with respect to water availability on the projects in the downstream, as the allocation to this project is made as per the overall planning for the basin. However the sedimentation concentration will be marginally reduced in the project in the downstream.

b. Effect on low flows

It is proposed to divert a maximum of 5.00 cumecs or less as per the requirement from stored water from the reservoir. The flow condition in the river before this project is dry during non monsoon. After construction of the reservoir and development of command, it is likely that the volume of low flows on the downstream reaches will increase due to regeneration etc. As such there will not be any adverse effect on low flows in the river.

c. Effect on Flood hydrograph

The flood hydrograph will be routed through the reservoir. The storage is by gates. The crest of the barrage structure will be almost near the river bed. During floods all the gates will be lifted and the outflows are not regulated. The incoming flood will pass over the crest. The effect of the project on river regime will be negligible during peak floods as the whole flood will pass over the spillway as it is without any moderation.

d. Effect on Total run off

The reservoir area is not considerable as it is located in a valley. The average annual evaporation losses will be about 0.25MCM only.

e. Effect on river hydraulics (Short and long terms)

The effect of the project on river regime will be negligible during peak floods as the whole flood will pass over the spillway as it is without any moderation.

f. Sedimentation

The trap efficiency of the reservoir will be negligible. The entire sediment is likely to flow down the river. The sediment concentration in the lower reaches will not be altered after the construction of the project. It is likely that slight aggradation may take place on the upstream and slight degradation may take place on the downstream.

g. Effect on Water quality

There will not be any effect on the water quality in the upstream. However on the downstream side there will be slight improvement in the physical water quality

parameters, since some of the sediment and organic matter will be trapped in the reservoir.

h. Effect on Water Demand

Demands for the water for this project are proposed based on the availability of yield and within the allocation of planning by the State Government. So, no problem is foreseen in respect of water demand either from upstream or downstream areas in future.

CHAPTER – 6

HYDRO - GEOLOGY

6.1 Introduction

In finally selecting the suitable alignment for Channaka- Korata barrage, geological conditions need to be addressed for individual sites, so as to avoid geologically unsafe site and select more suitable site Geologically and techno economic considerations which merits further studies. For this purpose, Geomorphological, Regional geology and site specific geology have been studied and evaluated.

6.2 Geomorphology

Geomorphology describes the land forms, their evolution, genetic relationship with Geology and influence of weathering and building agencies in carving present land forms.

In any project planning, study of the land forms for their maximum utilization is desirable. The Project area is predominantly undulatory, with sediplain terrain spreading towards south of the proposed sites and high hill ranges extending towards north and west.

The sediplain is developed over sedimentary rocks and with gentle easterly or northeasterly gradient of 3° to 15°. The hill ranges are classified, predominantly as denudational and structural hills with structures like mesas and buttes which are characteristic land forms of Deccan Trap (Basaltic) terrain

The site is drained by Penganga River and its tributaries. Penganga River flows in easterly direction with uniform gradient and width, suggesting a homogenous nature of underlying bed rock. However, further upstream and downstream reaches, it shows sinuous courses, here and there. The fluvial geomorphologic setup suggests that the river has attained maturity stage, Not much degradation of the river is noticed in the form of erosion of banks. However, deposition of bed loads is observed on the banks and on the concave side of the river curves. With increase in the accumulation of sediments the actual river course either has narrowed down or it has shifted its course at places.

Lower order streams have developed dendritic drainage pattern in the southern side of the area towards Adilabad, but with less density, suggesting uniform gradient and also less infiltration than run off through underlying imperious strata.

Towards north and west, dendritic, radial and parallel drainage pattern has developed in the resistant hill ranges.

Overall geomorphologic setup does not indicate any indirect evidence of adverse geological features in the area.

6.3 Regional Geology

Regional Geology gives a broad account of the overall stratigraphy, structural setup surrounding project site and helps in inferring and proper interpretation of geological setup and adverse structural features, if any, that may influence in selecting the site. Regional geology of the area is studied from published geological maps, reports and satellite imagery data of Geological Survey of India.

The broad geological set up of the area encompassing the site reveals that sedimentary rocks like lime stones, sandstones and shales occupy the central area, on either side of the Penganga river, which are flanked by igneous rocks like granite towards south and volcanic rocks like basalt towards north and west (Table 6.1).

Table 6.1: The general stratigraphic sequence of the area as established by GSI

Rock type / Lithology	Formation	Group/Super Group	Era
Alluvium, conglomerate			Recent
Basalt with inter trappean beds		Deccan Trap	Upper Carboniferous to Eocene
Infratrappean			Upper Carboniferous
Sandstones and Shales	Kamthi Talchir	Gondwana Super Group	Upper Carboniferous to permian
Sandstone/limestone/shale		Penganga Group	Upper Proterozoic
Pebbly sandstone/ Limestone		Pakhal Super Group	-do-
Dolerite dyke/ Quartz vein			Lower to middle proterozoic

Pink and Gray Granite		Peninsular Gneissic complex	Archaean
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Granites are exposed in and around Adilabad town, Basalts are exposed in Yavatmal district and western part on either side of state boundary. Gondwanas occur in North eastern part around kayar in Maharashtra.

Penganga group of rocks occur on either side of Penganga River. They are further sub divided into Pranahita sandstone, Chanda limestone and Satnala shale . The thickness of limestone is estimated to be 400m, whereas that of shales as 2000m. Lime stones are exposed in the western part and shales in the eastern part. They show regional trend varying from WNW-ESE to NW-SE. They are horizontally bedded or show dips varying from 3° to 15° towards north east.

A few faults are reported in the area, A fault trending N75° W- S 75°E in the granitic terrain ,located just north of Adilabad and a few NW -SE trending faults in Deccan Trap terrain, located towards west of the area close to state boundary.

6.4 Site Geology

In and around the site, Satnala shales belonging to Penganga Group are exposed sporadically and at the site in Penganga River they are reddish brown to pinkish in color. They are thin to medium thick bedded and are inter bedded with thin laminate of calcareous bands. They are horizontally bedded or show dips of 3° towards northeast.

Bedding joints are prominent discontinuities in this lithological unit. Apart from these a few joints trending along N 70° W-S 70° E, N W – S W and E - W are also observed at places in the area. Spacing of bedding joints vary from 10 to 50 cm. The spacing of other joints is not uniform and they are at random. The joints are tight as exposed.

At the barrage site, Satnala shales are exposed and there are no lithological variations from site to site. No adverse geological feature is observed at the proposed Barrage site. The barrage site fall in Seismic Zone II as per IS 1893 -2002. Geology Map is enclosed as Drawing No. AA/IRR/1774/DPR/BAR/9.

CHAPTER – 7

DESIGN FEATURES AND CRITERIA

7.1 Structure and layout

7.1.1 (a) Headworks - Site and Vicinity

The Rudha barrage is proposed on river Penganga which is a tributary to the river Wardha, near village Channaka in Kelapur Tahsil of Yavatmal district in Maharashtra and Korata village in Jainad Mandal of Adilabad district of Telangana. The river valley spreads over an area of 19531.57 Sq km up to barrage site. The average slope of the river in the vicinity of the barrage site is 1 in 637.

7.1.1 (b) Reasons for choice of the layout of the Project

All lands in the basin are fertile and suitable for Khariff and Rabi crops. All crops are rain fed with a few storage ponds. The occupation of the Inhabitants of the command area is agriculture. Due to erratic nature of rainfall, there is no assured irrigation. To overcome the above, channaka-Korata barrage is proposed. The project comprises of head works, Pump House, Canal network to supply assured water for crops, and drinking water.

7.1.1 (c) Type of Structure

The head works of the scheme comprise of broad crested weir and bank connections (abutments, returns, guide walls, guide walls & approach bund). The crest level of the barrage is proposed at +203.00m, while the average bed level of river is +201.645 and FRL of the barrage is restricted upto + 213.00m to avoid submergence. The barrage is constructed to store 23.502Mcm (0.829TMC) of water. The height of the crest above deepest foundation level will be about 6.00m.

7.1.1 (d) Layout of the dam

The layout plan showing the barrage, approach & guide bunds and roads connecting barrage to existing roads and bank connections have been decided as per the topographical features and soil/geological features and presented in the General Arrangement Drawing (GAD), which is enclosed.

7.1.2 Geology, seismicity and foundation

Covered in detailed in vol-III

(a) Geology of the entire project area.

To know the depth and nature of overburden, rock type and their physical conditions, total 9 numbers of exploratory bore holes were drilled. Out of this, 5 bore holes are along the centre line of barrage, 2 bore holes are in U/S and 2 bore holes are in D/S of barrage axis.

The barrage site is located in sedimentary belt belonging to Penganga Group. Satnala shales are lithological type of the area which is sporadically exposed. At the proposed barrage site, the river bed is 175m wide and is 11m deep. The main river bed is occupied by pebbles boulders of basalt and limestone and Purple shale occurs as thin rock fragments. Maximum size of sub rounded boulder observed is 0.30 cum. They are loosely packed in coarse sand. These pebbles, boulders and rock fragments make up 75% of total bed loads of the river.

A brief account of geology reach wise, along the alignment is given below:

Left bank is an undulatory to flat terrain with G.L varying from Rl.216.0 – 220.0 m and it is covered with dark silty clayey soils.

Reach from ch -25.91 – 0.00m forms left bank slope (near 1;1) with G.L varying from 216m slope. This slope is covered with silty soils and rock fragments but exposes bed rock between ch -5.0- 0.00 m. The bed rock is purple shale which shows dips of 3 – 5° degrees due north east.

River bed between Ch0.00and Ch. 122.189m is occupied by running water of about 1.5 to 2m deep.

The river bed portion between Ch.122.189- 151 m is covered with sand, pebbles, smooth angular fragments of different shapes and sizes.

Reach from 151 to 175m forms right bank slope with G.L's varying from R.L 203 TO 213 m and forms 1:1 slope and covered with silty soils mixed with pebbels rock fragments.

From ch 175 - 287.5m forms right bank with G.L's varying from R.L 213 to 217 m and is occupied by brown silty sandy /clay soils, forming a flat terrain

The shales as exposed in the left edge of the river are near horizontally bedded or show 2-3° dips towards north east or north. The strike of bedding makes an angle

of 60° with the barrage axis. At exposed surface they are thin to medium bedded with bedding thickness varying from 0.10 to 0.50 m. Thin laminae of calcareous bands occur with in these shales. The thickness of these laminae is about 2 to 3 mm. It shows weathering in the form of discolouration of the exposed surface and deposition of calcareous material along steepely dipping joint planes. The shale is splintary in nature and air slaking type, Normally shales show fissility and degree of fissility depending on compositional variation. Siliceous and calcareous shales are less fissile when compared to pure (argillaceous shales). Shales occurring at the site are calcareous in nature and hence less fissile .It is traversed by the following sets of joints.

TABLE -7.1 JOINT PATTERN

Joint set no.	Strike of joint	Dip and dip direction	Spacing and nature	remarks
1	NW-SE	2-5° due NE or Horizontal	0.05-0.50m, tight, planar, smooth or undulatory	Bedding joints, skew to dam alignment
2	E-W	Steeply dipping or 90°	Random, tight at some places filled with thin calcrete/calcareous material	Parallel to river course
3	NW-SE	30-90° due NE	Random, tight or 1 to 2mm opening filled with calcareous material. Planar, rough	Skew to axis

Of the above three sets of joints, bedding joints are prominent and they are tight or shows openness of 1 to 2mm.

7.1.3 Alternative studies carried out for selection of site

As discussed wide para 4.1.5

7.1.4 Choice of final layout of all major components of the project and reason details.

7.1.5 Design Flood and Sediment Studies

The design flood has been discussed in detail in CHAPTER 5. The maximum design flood to be adopted will be 16366.48 cumecs (100yr return flood). The yield has been worked out and given in CHAPTER 5. The net annual 75% dependable yield at head works out to 303.16 Mcum (10.71 TMC) after considering the planned upstream utilizations. The MDDL has been fixed as + 203.00 m.

7.1.7 River Diversion Arrangements

Coffer dams are proposed on u/s and d/s of the proposed site during construction activity.

7.1.8 Construction Materials

The samples from borrow areas for approach bund have been tested for c and ϕ values and engineering properties and permeability are evolved. The same have been used while designing the approach bund.

The source of material and their leads are enclosed with the data sheets and the same have been used for preparation of data and estimate of the barrage.

7.1.9 Model Studies

Model studies were conducted by TSERL(Telangana State Research Laboratory) (Report enclosed).

7.2 Barrage

7.2.1 Salient Features & Controlling Levels

- Hydrology:

- | | | |
|---------------------------|---|------------------|
| 1. 100 years return flood | : | 16366.480 cumecs |
| 2. Planned storage | : | 1.50 TMC |

- Barrage:

- | | | |
|--------------------------|---|----------------------------------|
| 1 Design Flood | : | 16366.480 cumecs |
| 2 Type | : | Barrage with vertical lift gates |
| 3 Lowest river bed level | : | +201.645 m |
| 4 Crest level of barrage | : | +203.000m |

- | | | | |
|----|----------------------------|---|-----------|
| 5 | Full Reservoir Level (FRL) | : | +213.000m |
| 6 | Maximum Water Level (MWL) | : | +218.10m |
| 7 | Tail Water Level | : | +217.100m |
| 8 | Length of barrage | : | 287.50 m |
| 9 | Length of each bay | : | 12.0 m |
| 10 | Energy dissipation length | : | 40.0 m |
- Piers:
 1. Thickness : 2.50 m
 2. Length : 14.850 m including cut waters
 3. No's. : 19
 - Gates:
 1. Type : Vertical Lift Gates
 2. Size : 12.0 x 10.0 m
 3. No's. : 20
 4. Hoist Bridge level : +231.60 m
 - Road Bridge:
 1. Carriageway width : 4.250 m
 2. Road Bridge top level : + 220.10 m
 3. Type : RCC T-Beam
 4. C/C span : 14.5m

7.2.2 Hydraulic Design

Fixation of Crest level

The lowest river bed level at barrage location is El. +201.645m and the crest level of barrage is fixed at El. +203.00m. The difference b/w crest level and river bed level is 1.355m.

7.2.3 Fixation of Barrage Bays

Maximum 100 years flood of 16366.480 cumecs is considered for design of barrage bays. Barrage of 287.50m long in between abutments with crest level at El. +203.00m has been proposed to pass the design flood with an afflux of 1.0 m above TWL (+217.10m) and MWL is El. +218.10m. The proposed barrage is consists of 20 bays of 12.0m width each with pier thickness of 2.5m and is capable of passing the estimated design flood even when two bays inoperative during the high floods. FRL of barrage is fixed at El. +213.00m to fulfill the peak requirements. Vertical Lift Gates in the barrage is provided from top of crest El. +203.00m to FRL +213.00m and they are spanning between the piers.

7.2.4 Overflow section Profile

As per the hydraulic requirements and techno economical considerations, Broad crested type of profile is proposed. Hydraulic design of barrage is done as per IS: 6966-1989. U/s glacis of 2:1 from crest level of barrage to u/s apron floor level +201.645m and below this it is vertical up to hard rock level. D/s glacis of 3:1 from crest level to d/s apron floor level of +197.60m. Crest width of 5.5m is provided as per the minimum clearances requirements for stop log and gate grooves.

Hard rock is available at El. +197.00m, hence the foundation of barrage is proposed at El. +197.00m. The excavated portion is backfilled with M15 grade concrete and top 1.5m thickness is glacis concrete with M20 grade excluding wearing coat of thickness 150 mm with M25 grade.

7.2.5 Energy Dissipation Arrangements

The energy dissipation arrangement for different flood discharges has been worked out based on IS: 4997-1962. The maximum length of basin worked out as 40m and basin floor level is +200.00m. The basin floor is proposed at El. +197.600 due to availability of hard rock at El. +197.0m, with apron thickness of 0.6m.

7.2.6 Design Assumptions

The following design parameters are adopted.

Unit weight of concrete : 2.40 t/m³

Unit weight of water	:	1.00 t/m ³
Saturated weight of earth	:	2.10 t/m ³
Angle of internal friction (ϕ)	:	30 deg.
Seismic Zone	:	II

7.2.7 Stability Analysis & Structural Design

7.2.7.1 Overflow Section

Stability analysis of Overflow section is carried out for different loading conditions and load combinations as per IS: 6512-1984. Seismic calculations were performed as per IS: 1893-1984. The maximum and minimum stresses were checked at foundation level. There is no tensile stresses were developed at base and the maximum & minimum stresses are within permissible limits. To take care of shrinkage and temperature stresses nominal reinforcement of 16mm dia. @ 250mm c/c is proposed in both ways on top.

The maximum and minimum stresses for various load combinations are shown in table below.

S. No.	Load Combination	Stresses (T/ Sq.m)	
		Max.	Min.
1	A	28.208	9.478
2	B	14.631	10.643
3	C	18.969	0.632
4	D	31.000	7.241
5	E	13.730	12.105

7.2.7.2 Intermediate Pier

Pier thickness is 2.5m and length is 14.85m. It is resting on overflow section of barrage. Hoist platform with rope drum hoist and gantry crane is proposed at El. +231.600m. Walkway platform is proposed on u/s of barrage at El. +220.1m for maintenance of stop logs. Single lane Road Bridge is proposed on d/s of barrage at El. +220.1m for vehicle movement.

Stability analysis of Intermediate Pier is carried out for different loading conditions as per IS: 13551-1992. Seismic calculations were performed as per IS: 1893- 1984. Piers are proposed with M20 grade concrete. The Longitudinal and Transverse stability of pier is checked at crest level +203.00m. There is no tensile stresses were developed at crest level and the maximum & minimum stresses are within permissible limits. Hence, the Minimum Vertical reinforcement of 20mm dia. @ 150mm c/c and Horizontal reinforcement of 16mm dia. @ 150mm c/c is proposed.

The maximum and minimum stresses for various load combinations are shown in table below.

S.No.	Analysis	Load Case	Stress (T/Sq.m)	
			Max.	Min.
1	Longitudinal	a. Without Seismic	96.255	25.004
		b. With Seismic	80.463	40.796
2	Transverse	With Seismic	97.960	33.793

7.2.7.3 Energy Dissipation Arrangement

Basin Floor is resting on hard rock, hence 600 mm thick apron slab with nominal reinforcement is provided on top. Concrete grade for basin slab is M20. Minimum reinforcement of 20mm dia. @ 300 c/c provided on top as per IS:4997-1987. To relive the uplift pressure, formed drain holes of 75mm dia. @ 3.0m c/c is provided in basin floor. To take care off uplift due to any choking condition of drains, 25mm dia. anchor rods @ 1.5m c/c 3.0m long is provided.

7.2.7.4 Left and Right side Abutments

Abutments are designed as RCC counterfort retaining walls for saturated earth pressure. Stability of retaining wall is carried out at the foundation level of El. +197.00m. Top of abutment is + 220.100m on either side of Hoist Platform. In hoist platform portion, the abutment top is +231.600m. Hard rock available at foundation level is Shale, hence max. Stress on foundation is limited to 50.0 T/Sq.m.

The maximum and minimum stresses for various load combinations are shown in table below.

S.No.	Structure	Stresses (T/Sq.m)	
		Max.	Min.
1	Abutment	48.785	42.228

7.2.7.5 U/S and D/S Guide Walls

U/S Guide walls

The top of Guide wall is provided at El. +220.10m i.e. 2.0m above MWL +218.100m. Foundation level is same as like abutment i.e. El. + 197.00. It is designed as a RCC counterfort retaining wall for saturated earth pressure.

The maximum and minimum stresses for various load combinations are shown in table below.

S.No.	Structure	Stresses (T/Sq.m)	
		Max.	Min.
1	Guide wall	49.90	40.90

D/S Guide walls

The top of Guide wall is proposed at El. +219.10m i.e. 2.0m above TWL +217.100m. Foundation level is same as like abutment i.e. El. + 197.00. It is designed as a RCC counterfort retaining wall for saturated earth pressure.

The maximum and minimum stresses for various load combinations are shown in table below.

S.No.	Structure	Stresses (T/Sq.m)	
		Max.	Min.

1	Guide wall	49.80	33.10
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7.2.7.6 Guide Bunds

Guide bunds are provided on u/s and d/s of barrage as per IS: 10751:1994. U/s Guide bunds are provided for a length of 290.0m and d/s guide bunds are provided for length of 72.50m.

7.2.7.7 Approach Bund

The maximum height of approach bund is 6.4 m. Earth dam is designed as Homogenous section with hearting zone with 1:1 slope with 2% extra moisture and a casing zone with slope 2:1 on D/S face and 2:1 on U/S face. The top width of the earth dam is kept as 6.00 m. Parapet on upstream side and guard stones on D/S on top of bund have been provided.

The Cut-off trench is taken 1.0m into the rock or continuous impervious strata. Grout -curtain in rock will be done in consultation with GSI, after the foundations for cut- off trenches are exposed. Key trenches are provided up to reach where the Ground levels are higher than FRL level.

In reaches where earth dam rests directly on rock, the foundation treatment consists of a key 1.0 m depth with bottom width of 4.0 m and the surface shall be treated for fractures and joints and transition zone provided wherever necessary.

The earth Dam is keyed with abutments of the Dam by means of core wall extending from abutment into the earth dam. The core wall is taken upto hard rock. Drainage arrangements shall be as per IS 9429 – 1999. The horizontal filters of 1000 mm shall be extended up to D/S rock toe.

Profile walls shall be provided at 30 m intervals for earth dam in line with revetment. The revetment shall be as per IS 8237 – 1985 reaffirmed – 1997 and rock toes are as per IS 9429- 1999.

Turfing shall be provided on D/S slope of earth bunds and chute drains at 45.0 m c/c shall be provided as shown in drawings and these are as per IS 8237 – 1985.

Tentative proposals for curtain grouting, consolidation grouting and drainage grouting have been provided. The curtain grouting depth is taken as $2/3 H + 8.0$. The consolidation grouting is taken as $H/4$. Depth of grouting may be modified if necessary in consultation with geologist after opening the foundation.

Temperature Control

For control of concrete cracking and development of high thermal stress, temperature control of concrete is necessary. This may be achieved by pre-cooling of aggregates to obtain desirable placement temperature of concrete. The concrete as deposited should have a temperature of not more than 15 to 21° c.

Water Stops at Transverse Contraction Joints

PVC (Polyvinyl Chloride) water stops are provided for transverse joints. The specifications to be followed are as per codes IS 12200 – 2001, IS 15058 – 2001 and IS 290 – 1901.

The design calculations for barrage, bank connections, earth dam as well as drawing are enclosed in Volume IV.

7.3 Opening through Dams

a) Galleries, adits, shafts, stair wells etc.,

Not applicable

b) Outlet(s)/sluice(s)

7.3.1 Pump House and Pressure mains

The crop water demand of Channaka-Korata(Rudha) Barrage was worked out. The peak demand of 4.47 cumecs was observed during September III decadal. The 4.5 cumecs of water for irrigation is proposed to be lifted from the barrage and delivered at elevated place and will be carried through gravity canals.

The Pump House is located at U/S of Barrage near Hattighat village, to lift 4.50 Cumecs of water from Barrage with LWL in the Jackwell as +204.670 to Delivery Cistern with El. +317.750. An approach channel 120 m long connects the fore bay of the pump House to the river bed level +204.00m. The static head is 113.08 m and total head including all losses workout to 123.00m. Vertical Turbine pumps (4 Nos) are proposed to lift the water through MS pressure mains of dia 1.60 m with a thickness of 18/16 mm having a length of 3.373km. The thickness of the MS pressure mains are finalized based on surge analysis and minimum thickness as per the IS Codes. The power required for lifting the water will be 7.68 MW.

The Motor floor level is kept at +220.00m with free board of nearly 2.0m from MWL. Ground levels at this location are greater than +220.0m locally. Hence,

level platform is created up to +220.0m and the drainage is diverted into the fore bay.

The Pump House, 23.025m x 9.80m, houses 4 Units of Vertical Turbine pumps/ motors. Capacity of each Pump is 1.92 MW. It is a semi underground type of pump House with sump floor level +202.370m (17.630m below motor floor level +220.0m).

Design

The main loads on the Substructure of the Pump House are Water pressure and uplift. It is an RCC structure in M- 25 Concrete. The foundation raft 750mm thick rests on hard natural rock strata. The RCC walls of the substructure along with internal strut beams and raft form a rigid box structure.

The Superstructure of the main Pump House is of RCC columns with brick walls and metallic sheet cladding. The roof consists of trusses and metallic sheeting. Superstructure houses 25 Tones Capacity EOT crane. The Switch gear and control equipment is housed in two storey RCC annexe building 30.055m x 6.510m.

The Substructure is Designed for the following load conditions

1. Construction / Fore bay empty

No water in the fore bay and External walls are subjected to water pressure.

2. Fore bay full and gates closed

Water pressures on the external walls and full uplift on raft.

Fore bay full and one gate closed and other open

Critical condition for the design of central wall (wall -4) is water on one side and no water on the other side.

Materials

Concrete is M-25 grade with MSA 40mm.

Reinforcement is HYSD Bars conforming to IS: 1786 of Grade Fe 415.

Permissible stresses:

The design is based on working stress method as per IS: 456 & IS: 3370 with stress in steel 150 N/mm².

Designs & drawings are enclosed in VOLUME IV.

7.4 CANALS

7.4.1 Description of canal system

As the command area is having undulating topography, the most of the canals including Main, distributory & sub distributory were proposed on the ridge of the area. This layout reduces cost of canals and the cross drainage works. Ayacut registers were prepared upto 40 ha chacks.

The main canal at head reach is designed for 4.50 cumecs and balance canals are designed as per the water requirement of the area. The detailed particulars along with the designs are enclosed in Volume IV. The design of CM & CD works for canal system are followed as per IS Codes, Manuals etc and same are enclosed.

7.4.2 Network of canal system:

Canal network is planned to supply water to all holdings under commendable area. It is also proposed to feed water to the existing ponds and provision is made towards drinking water supply.

7.4.3 Soil profile

Soils available in commendable area are BC soils which are suitable for growing the recommended crops with high productivity.

7.4.4 Evaluation of design Parameter

The canal is running almost in cutting except in some reaches. Wherever the canal is in embankment suitable soils are proposed for embankment.

7.4.5 Lining

Lining is provided upto 40ha chalk.

7.4.6 Cutoff statement showing the detail of the discharge required from tail to the head considering the irrigation requirement and transmission losses in the off taking channel.

MAIN CANAL							
REACH WISE HYDRAULIC PARTICULARS							
S.No	Description	Units	Reach - I	Reach - II	Reach -III	Reach -IV	Reach -V
			0 - 75 m	75 - 515 m	515 - 1685 m	1685 - 2850 m	2850 - 3360 m
1	Reach Ayacut	Ha	5494.2	1363.8	1304.9	2858.6	2479.2
2	a) Discharge Re-	Cumec	4.500	2.669	2.214	1.779	0.826

	quired	s					
	b) Discharge designed	Cumecs	4.530	2.735	2.251	1.785	0.868
3	Bed width	m	3.20	2.60	2.40	2.15	1.40
4	Full supply depth	m	1.20	1.00	0.90	0.80	0.65
5	Canal side slopes (in/out)	-	1.5 : 1/2 : 1	1.5 : 1/2 : 1	1.5 : 1/2 : 1	1.5 : 1/2 : 1	1.5 : 1/2 : 1
6	Bed fall	-	1 in 4000	1 in 4000	1 in 3500	1 in 3000	1 in 3000
7	Value of Rugosity	-	0.018	0.018	0.018	0.018	0.018
8	Free board(upto TBL)	m	0.60	0.50	0.50	0.50	0.30
9	Velocity	m/s	0.755	0.667	0.667	0.666	0.562
10	Critical Velocity Ratio		1.588	1.551	1.643	1.751	1.656
11	Top width of banks I/NI	m	6 m / 2.5 m	4 m / 2 m	4 m / 2 m	4 m / 2 m	4 m / 1.5 m
12	Thickness of lining	mm	60	60	60	60	60
13	Lining Free Board	m	0.45	0.35	0.35	0.35	0.15
14	Canal Bed Level	m	315.500	315.481	313.821	312.512	310.424

7.4.7 Design Discharge:

Water requirement is arrived with modified Penman method for each crop and total required discharge is arrived at considering all losses and also provision towards drinking water. For maximum required discharge, the canal section is designed.

7.4.8 Fixing the level of outlets:

Sill levels of outlets are fixed such that the off take channel can draw required discharge even at 3/4 F.S.L condition.

7.5 Canal structures

Cross masonry and cross drainage structures are proposed wherever required and the list of the structures along with details are enclosed in Volume IV (Part I).

7.6 Instrumentation

Not Applicable.

CHAPTER 8 RESERVOIR

8.1 Fixation of Storage and Reservoir Levels-Approach- Criteria

The storage and Reservoir levels are fixed based on water availability studies and crop water requirement studies. The levels are finalised after preparing working tables for 25 years.

8.1.1 Dead storage Level (EI-m): +203.00m

8.1.2 Low Water Level (Minimum draw down) (EI-m): +203.00m

8.1.3 Full Reservoir Level (EI-m) : +213.00m

8.1.4 Maximum Water Level (EI-m): +218.10m

8.1.5 Maximum Back Water Level at Full Reservoir Level and Maximum Water Level and its effect.

The FRL is +203.00m

The MWL is +218.10m

The maximum back water level extends upto about 23.93 km on the upstream side of the reservoir.

8.1.6 Any saddles present along the rim of the reservoir, how they are being tackled. Etc.

No significant saddles are present

8.2 Sedimentation data and studies

Sedimentation studies are not carried out since this is a barrage and storage capacity against crest is 0.194Mcum(0.007TMC) only.

8.3 Life of Reservoir in years with basis

Life of reservoir is taken as 100 years with full capacity as planned.

8.4 Capacities (Mcum)

8.4.1 Capacities (Mcum.)

Capacity at MDDL : 0.194 Mcum

Capacity at FRL : 23.502 Mcum

8.4.2 Storage (Mcum)

(a) Storage capacity is provided to meet the following requirement.

Irrigation requirement

Drinking water requirement (10%)

Evaporation losses

No separate allotment is made for power generation.

(i) Additional reservoir data

Bed level +201.645 m

Crest level. +203.00m

(ii) Hydrology

Details are given in hydrology Volume.

(iii) Diversion requirement

Requirements are as per crop water requirement and drinking water requirement. Details are given in hydrology Volume and irrigation planning chapter.

(iv) Return flow details

Return flows are not considered in the study.

(v) Minimum flow demands in the system.

(vi) Power details

The proposed project is basically an irrigation project.

(b) Annual Carry over capacity provided. If any, with basis. . Nil

(c) Gross annual utilisation and dependability (Mcum) for each use.

Gross annual utilisation 42.19 Mcum

For Irrigation 40.96 Mcum

For Drinking water purpose 1.23 Mcum

8.4.3 Water tight ness of the reservoir

No seepage is anticipated through the bed or through the foundation of the barrage as per the prevailing geological condition.

8.4.4 Annual Losses (Mcum) and basis

(a) Evaporation:

Average annual evaporation is 5.318 Mcum

(b) Seepage in the reservoir

No seepage losses are anticipated.

8.5 Effect on sub soil water table in the adjoining areas particularly downstream of the barrage.

Effect on sub soil water table in the adjoining areas will be nominal as the reservoir area is small.

8.6 Reservoir rim stability

As per the details given the geology chapter.

8.7 Area of submergence (ha) at: 31.552

8.7.1 Maximum Water Level

8.7.2 Full Reservoir Level: 11.09ha (Storage is within the banks only)

8.7.3 Submergence ratio(s) Submerged (cultivated) ArealCCA

$$= 11.09/6680*100 = 0.166 \%$$

8.8 Land Acquisition, property submerged and rehabilitation

8.8.1 Land Acquisition (ha)

(a) Quantum of land: 35.552 ha

(i) Up to Full Reservoir Level +213.00 = 11.09 ha

8.9 Recreation facilities

Not provided at DPR stage

8.10 Pisciculture

Pisciculture is considered in the reservoir area.

8.11 Need and recommendation for soil conservation measure in the catchments

There is no need for soil conservation measure in the catchments.

8.12 Any other relevant information: Nil

CHAPTER 9

IRRIGATION PLANNING

9.0 Introduction

The major source of irrigation in the district is through ground water (86.55%) followed by tanks and canals. During the year 2010-11, an area of 1,22,994 ha was gross irrigated of which 44,130 ha was irrigated more than once. The canals, tanks, tube wells, dugwells, lift irrigation schemes, other sources irrigated 12121, 1554, 33993, 15367, 934, and 975 ha respectively.

Two major irrigation projects (Capacity > 10000 Ha) namely Kaddam Narayanreddy Project and S.R.S Saraswati Canal (Sri Ramsagar Project-Left canal) with registered ayacut of 68500 and 35735 ha and Utilized ayacut of 50000 and 32735 ha respectively are major source of irrigation. The medium irrigation projects (Capacity > 2000-10000 Ha) like Vattivagu (Stage I and II), Satnala, Chalamala (NTR stage), Suddavagu, Ralivagu, Peddavgu, Gollavagu and Yerravagu with 71562 Ha registered ayacut and 48600 utilized ayacut are other sources of surface irrigation in the district. There are 675 minor irrigation tanks (>40-2000 ha irrigation capacity) and 1378 tanks below <40 ha capacity with 140746 ha and 42197 ha utilized ayacut.

9.1. Existing cropping pattern

9.1.1. Existing area under rainfed cultivation

9.1.1(a) :Rain fall during monsoon (Max, min and average)

The maximum, minimum and average rainfall received in three mandals command area during monsoon iperiod is 1038, 904 and 978 mm respectively (Table 9.1).

Table 9.1 : Rainfall received during monsoon and non monsoon periods in three mandals of command area

	Maximum, mm	Minimum, mm	Average, mm
Rainfall during monsoon (june – Sep)	1038	904	978
Rainfall during non- monsoon (Oct -May)	213	181	189

9.1.1(b) Rain fall during non- monsoon (Max, min and average)

The maximum, minimum and average rainfall received in three mandals command area during non- monsoon period is 213, 181 and 189 mm respectively

9.1.1(c): Area under rainfed cultivation:

The principal crops grown in the proposed command area are cotton followed by soybean, Redgram and Jowar purely under rainfed condition in an area of 8626 acres. On the other hand, the area for other crops is small.

9.1.2 Area under each crop

Agriculture is one of the most important sectors of the Adilabad district economy. The main / first agricultural season is normally referred to the growing cycle of temporary crops that are planted and harvested from June to Oct / Nov of the year known as Kharif and the Rabi - second agricultural season starts from Oct / Nov and continues up to March / April.

Cotton is the main commercial crop of the district and nearly 48.73 % of the net area sown is covered. Other principal crops are Soyabean, Jowar, Redgram, rice and maize in decreasing order. The commercial crops like cotton are grown mostly under rainfed and chilies, turmeric and groundnut are grown under irrigation. The total area under food grains is 211025 ha, out of which 146457 ha is under Khariff crop and 64568 ha is under Rabi crops.

In order to assess the existing cropping pattern and crop production system in the proposed barrage command area, the field level visits were made and interviewed the beneficiaries. The discussions were held with farmers, district agricultural and irrigation officers and also reviewed the information available in the form of publications. In three mandals of the proposed ayacut area of channaka-korata (Rudha) barrage, the crop area of the revenue villages was collected and the present cropping system was assessed. The principal crops grown in the proposed command area are cotton followed by soybean, Redgram and Jowar (Table 9.2) under rainfed condition. On the other hand, the area for other crops is small. There are no orchard crops, lakes and water bodies and lakes for aquatic farming under the proposed command. The cropping during rabi, hot weather seasons is negligible.

Table 9.2: Area (ha) sown under different crops during 2014-2015 under proposed Channaka-Korata(Rudha) barrage of Adilabad district, Telangana State

Barrage	Mandal	No of villages	Cropped area, Ha							
			Cot-ton	Soya bean	Jow ar	Red Gram	Black Gram	Green Gram	Padd y	Total
chan-naka-Korata (Rudha)	Adilabad	14	5850	1561	437	772	2	4	0	8626
	Jainad									
	Tamsi									

9.3 Soil Surveys

The basic purpose of Soil Survey is to obtain a clear understanding of the soils for their optimal utilisation consistent with the quality and potential. It enables organising and providing information on characteristics of the different soil classes and evaluate their utilisation potential from interpretative groups. Interpretative groupings thus serve evaluation of their potential and prediction of their behaviour under different management systems. It also indicates the degree of limitation for the sustained use of a soil under a specified system. The data obtained from soils survey is translated for several varied uses. Most commonly used interpretative are: Land capability classification and land irrigability classification.

Properties of soil may change after the introduction of irrigation system in the region due to the development of salinity, alkalinity, water logging etc. The soil survey therefore, be conducted during the planning stage of a project with particular emphasis to the suitability of soils for irrigation, reclamation, drainage and also in command areas where water is to be used for irrigation after impounding in a reservoir or running a canal.

Soil Surveys of the catchment and command areas helps in formulating measures for mitigating reservoir siltation, prevention of soil erosion and suggesting remedial measures for drainage and water logging problems. Further, soil surveys provides examination of the physical, chemical and engineering properties of the soil. From agricultural point of view the studies help in determining the availability of plant foods in the soils and the need for correcting the deficiencies.

Soil types (Traditional nomenclature):

The proposed command area of the Project, falls under North Telangana Agro climatic zone. In Adilabad district, red loamy soils are predominant which are followed by

black cotton soils. The soils of channaka-korata (Rudha) barrage command are rock lands followed by deep black soils and shallow black soils.

Table 9.3 : Area (ha) of different soil types in command area of the proposed barrage on Penganga in Adilabad Distict of Telangana state

Type	Channaka-Korata(Rudha)
Rock lands	5336
Shallow black soils	862
Deep black soils	1895
	58
Total	8150

9.3.1 Soil Capability Classification

Soil irrigability classes are useful to make grouping of soils according to their suitability for sustained use under irrigation.

The following factors have been taken into account in the classification of soils pertaining to the command area.

- (1) Consideration of erosion.
- (2) Consideration of slope of the land.
- (3) Development of soil such as Zonal (well developed) intra zonal (More or less developed) and a zonal (not well developed).
- (4) Soil series.
- (5) Type of soil.
- (6) Suitability of land use, whether suitable for agricultural purposes or not.
- (7) Suitability of soil for irrigation.

9.3.2 Land Capability Classification

Land capability classification is the grouping of soil map units to show the capability of the soils to produce field crops or to be put to other uses on sustained basis, based on the limitations of climate, problem of drainage, erosion and soil factors affecting the plant growth.

Soils suitable for agriculture are grouped under classes I to IV and soils not suitable for agricultural are grouped under classes V to VIII which are useful for pasture / forestry/ wildlife/ recreation.

In the three mandals where an area of 6680 ha is proposed to be irrigated under surface method are fertile soils and falls under class ii and III and iv lands and are suitable for cultivation.

9.4 Agroclimatic conditions

The proposed command area of barrage fall in Northern Telangana Agro climatic Zone of newly formed state of Telangana. The zonal Regional Research station is located at Jagtial in Karimnagar district where a fully fledged Meteorological station is in operation since 1982 and complete data set is available from 1989 to 2014.

On the other hand, at Adilabad an Agricultural Research station is located but complete meteorological data is not available. Considering the data availability, the rainfall which is available in complete form at Adilabad Research station and Temperature, Relative humidity, Wind Velocity and sunshine hours of RARS, Jagtial of the same agroclimatic zone was utilized for estimation of crop water requirements.

On considering terrain and climatic variations, the command area with respect to irrigation planning has been grouped into one zone. It may be worthwhile to mention here that variation in climatological parameters such as sunshine hours, relative humidity, maximum and minimum temperature over the area is much less.

Based on temperature and rainfall pattern, the proposed ayacut can be classified as subtropical and semiarid area.

Rain fall

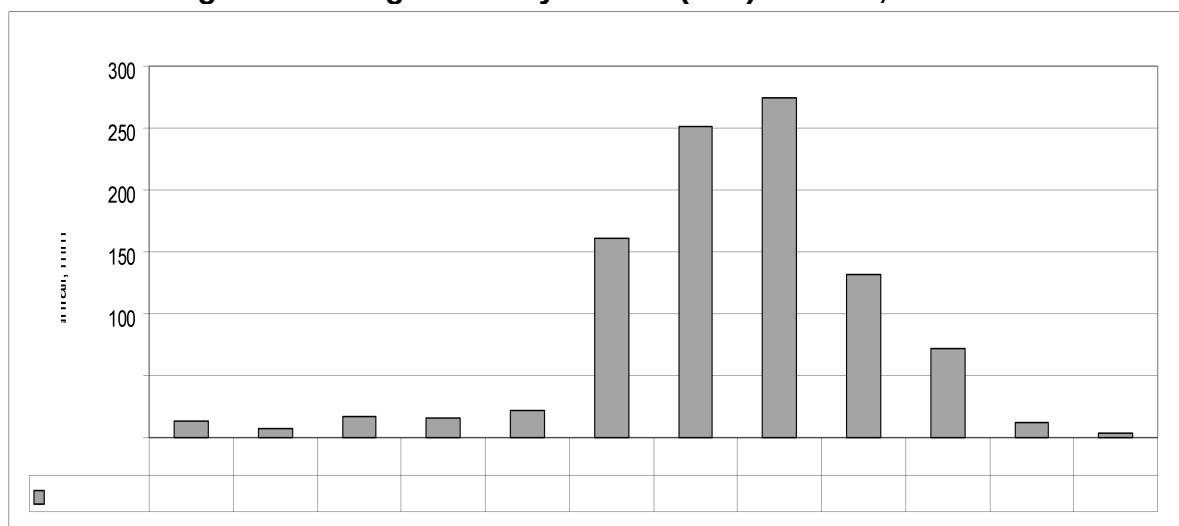
The proposed command area mandals receive annual high rainfall > 1000 mm, of which nearly 80% was received during South West monsoon (June-Sep) and about 10% was received during North east monsoon and rest during winter and hot weather period (Table 9.4).

Table 9.4: Season wise normal rainfall(mm) in four mandals of proposed barrages on Penganga in Adalibad District of Telangana State

Mandal	Rainfall in mm				
	South west	North east	Winter	Hot weather period	Total
Tamsi	904	135	13	27	1079
Adilabad	993	134	17	62	1206
Jainad	1038	109	23	49	1219
Average	978	126	17	46	1167
Adilabad Dist. average	984	117	17	40	1158

The average monthly rainfall of Adilabad is given in Fig. 9.1. The monthly year wise and average ten day decadal rainfall is presented in Annex 9.1 & 9.2 respectively.

Fig. 9.1: Average monthly rainfall (mm) at ARS, Adilabad



Temperature

The mean daily max temperature ranges from 29.5°C to 41.7 °C, while mean daily minimum temperature ranges from 13.4 to 26.4 °C. The temperatures were lowest in Dec and highest in May. In Dec the minimum temp was 13.4°C resulting in restriction of sowing of Rabi crops like groundnut (Fig. 9.2). However, during this period Bengal Gram can be grown successfully. The average daily max & min temperatures are presented in Annex 9.3.1 & 9.3.2 respectively.

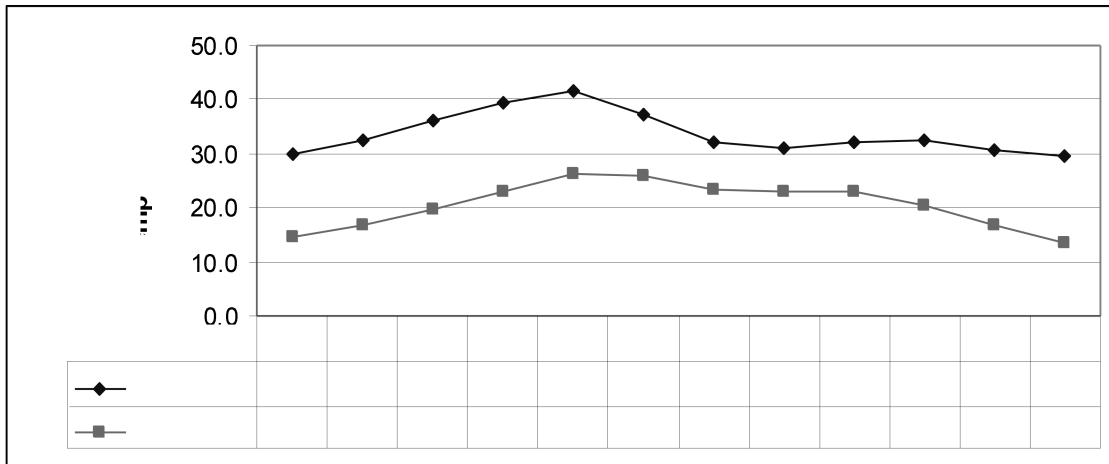
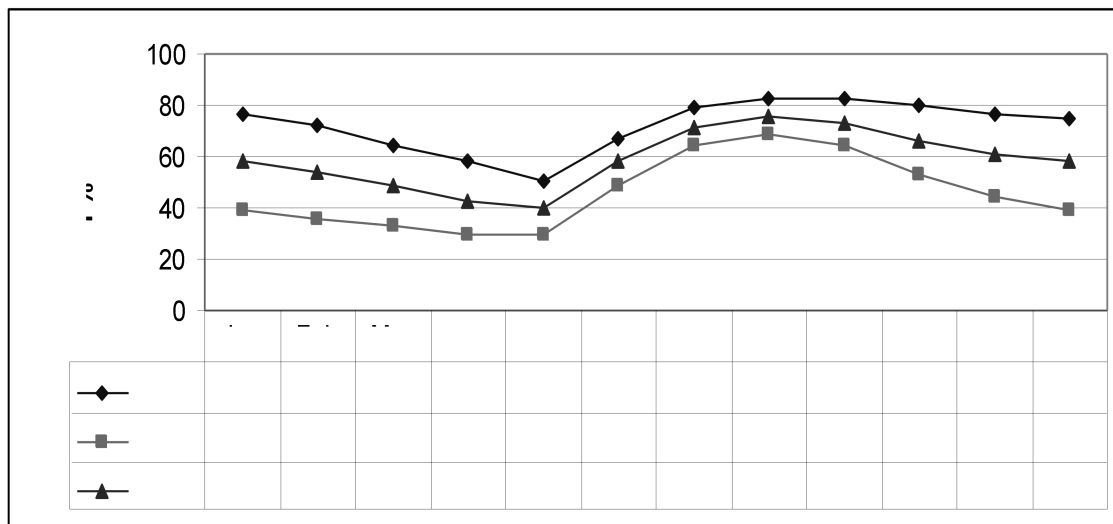


Fig. 9.2: Mean daily Max & Min Temperature in °C at RARS, Jagtial

Relative Humidity (RH)



The mean daily maximum relative Humidity (RH1) was highest during July to Oct (79-83%) and it was lowest in May (Fig 9.3). The average daily RH1, RH2 & mean Relative Humidity are presented in Annex 9.4.1,9.4.2 & 9.4.3 respectively.

Fig. 9.3: Mean daily Relative Humidity (RH1,RH2 & Mean) in % at RARS, Jagtial Sunshine Hours

The maximum sunshine hours of 8.64 hours/day were observed during April and minimum of 4.29 hrs/day were observed in July. The sunshine hrs ranged between 4.29 to 7.37 during kharif and 7.37 to 8.64 during Rabi/summer season (Fig.9.4).

The sunshine is not a limiting factor for crops grown in the command area of the proposed barrages. The average daily sunshine hours observed from 1989 to 2014 are presented in Annex 9.5.

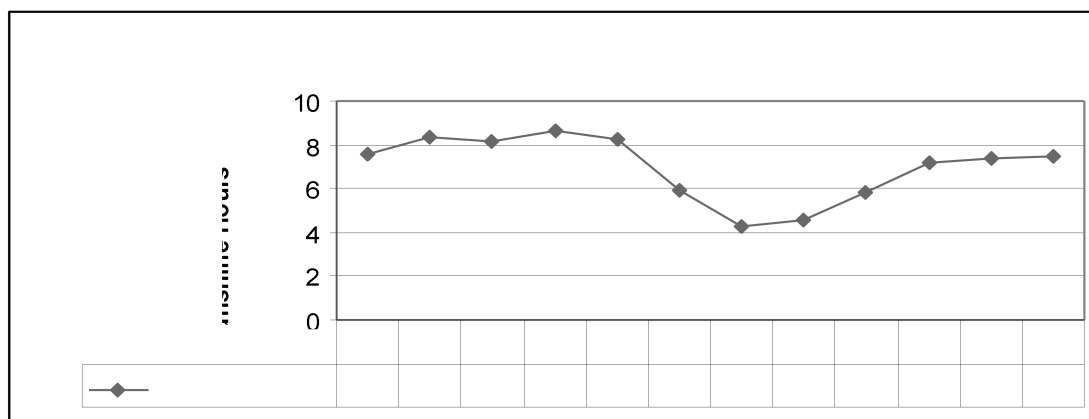


Fig. 9.4: Mean daily Sunshine Hours at RARS, Jagtial

Wind velocity

The wind velocity during Dec was observed as 1.77 km/hr and it ranged between 1.77 to 10.2 km/hr. Greater wind velocity of 10.2 km/hr was observed during June (Fig. 9.5). The average daily wind velocity is presented in Annex 9.6.

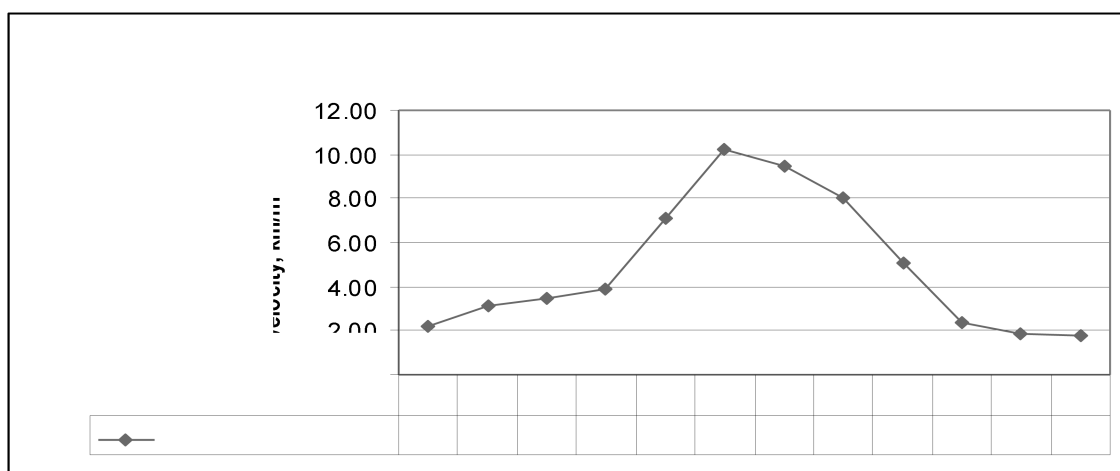


Fig. 9.5: Mean daily Wind Velocity(km/hr) at RARS, Jagtial

Evaporation

The mean daily evaporation was highest during May at 9.97 mm/day and lowest in December. The evaporation during July – January ranged between 3.11 to 4.41 mm/day. (Fig.9.6). The average daily Evaporation is presented in Annex 9.7.

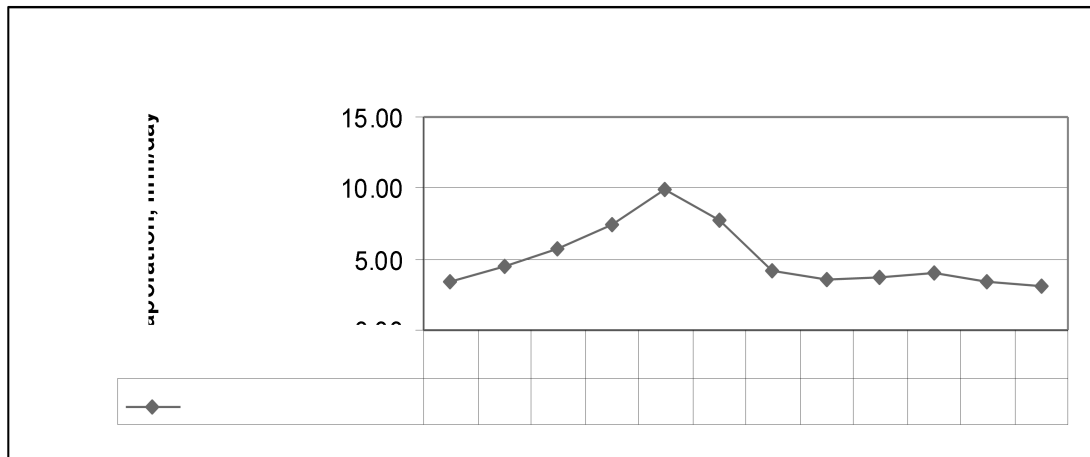


Fig. 9.6: Mean daily Evaporation (mm/day) at RARS, Jagtial

9.5 Proposed cropping system

The following crops have been identified for the command area, which suits the agro-climate, socio economic conditions and other factors (Table 9.6).

Under the existing irrigation scheme Satnala in Adilabad district which is near to the proposed barrages, cotton crop is being cultivated for two seasons with irrigation during mostly from post monsoon season from September onwards and continue to irrigate up to end of March. Further, Soybean crop is also grown during kharif under rainfed condition followed by Bengal gram under irrigation during Rabi.

The following crops are proposed to be grown under irrigated conditions in the command of the barrage on Penganga during kharif and Rabi with extent of area and crop calendar are given as under (Table 9.5 & 9.6).

1. LS Cotton (Two Seasonal)
2. Soybean – Bengal gram
3. Vegetables
 - a) Tomato – Cabbage
 - b) Brinjal - Cabbage

Potential Crops

Cotton

Cotton is the most important crop of the existing cropping pattern, which may continue to occupy almost the same area with little year-to-year variations. The optimum time for sowing cotton is from 10th June onwards following onset of rains. The crop stand of early-planted cotton is better than normal planted cotton. In cotton crop coverage increased very much in recent years and But cotton being shorter in duration, its early planting makes possible the timely planting of next season crop such as sesame.

Soybean

Soyabean crop is major crop grown in Adilabad district. It has been the experience that there is limitation of soil moisture at grain falling stage of the crop, particularly during the first week of September. It is, therefore, advisable to grow this crop with supplementary irrigation.

Bengal gram:

Vegetables: Tomato, Brinjal and Cabbage

Table 9.5: Proposed cropping pattern under the three barrages on River Penganga

S.no	Season	Crop Name	% of CCA
			channaka- Korata (Rudha)
A)	Kharif	Soyabean	30
		Tomato	5
		Brinjal	5
B)	Rabi	Bengal Gram	10
		Cabbage	5
C)	Two seasonal	LS Cotton	60

Table 9.6 :Crop calendar for proposed irrigation barrage on River Penganga in Adilabad district of Telangana state

Cropping System	Crop	Duration (Days)	Sowing time	Harvesting time	Remarks
LS Cotton	LS Cotton	185	11-Jun	12-Dec	-
Soya Bean-Bengal Gram	Soya Bean	105 (Main field)	15-Jun	27-Sept	-
	Bengal Gram	100	12-Oct	09-Jan	-
Tomato-Cabbage	Tomato	105 (Main field)	10-Jul	22-Oct	25 days nursery
	Cabbage	75 (Main field)	04-Nov	17-Jan	25 days nursery
Brinjal	Brinjal	125 (Main field)	11-Jun	13-Oct	25 days nursery

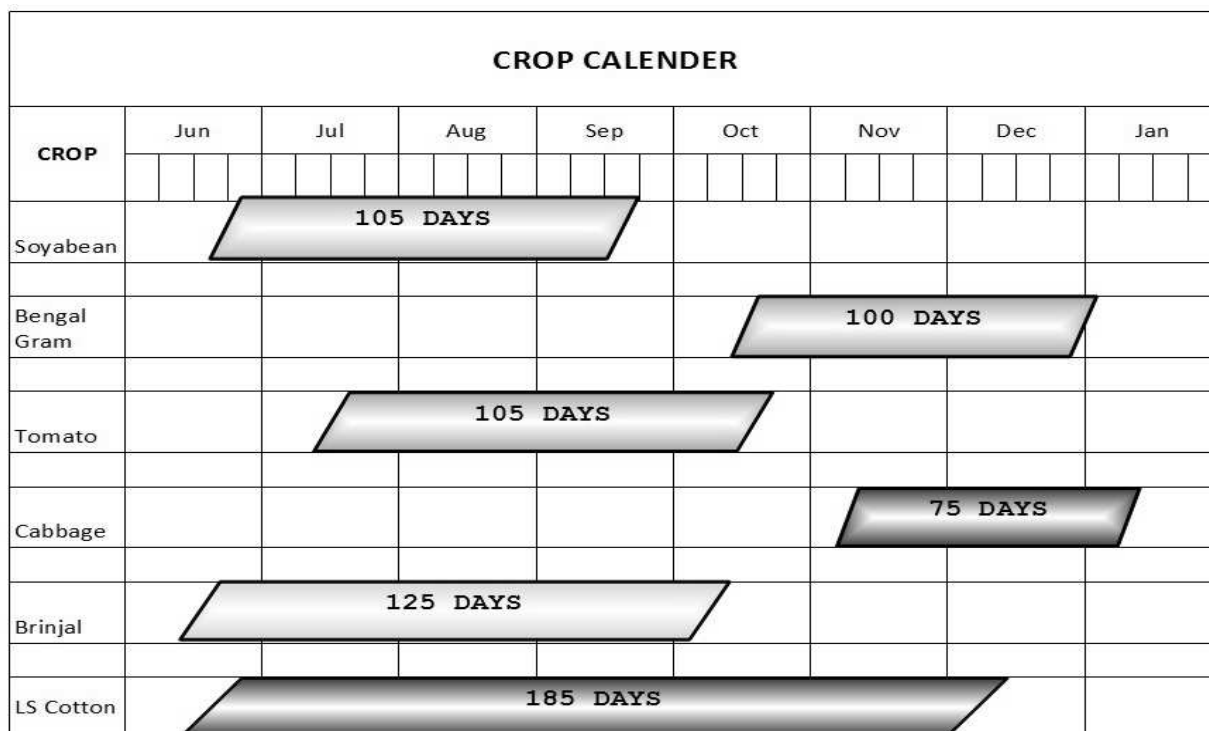


Figure: 9.7 Crop Calendar

9.6 Crop water requirements

Crop water requirement is defined as the depth of water needed to meet the water loss through evapotranspiration of crop growing in large fields under non-restricting soils, water and nutrient availability and achieving full production potential under the given growing environment.

The amount of water required to compensate the evapotranspiration loss from the cropped field is defined as crop water requirement. Although the values for

Crop evapotranspiration under standard conditions (ET_c) and crop water requirement are identical, crop water requirement refers to the amount of water that needs to be supplied, while crop evapotranspiration refers to the amount of water that is lost through evapotranspiration.

The success of this project depends on matching the water availability at river source with the quantum of water required for various crops in the command area for sustainable agricultural production. Keeping in view the above object, crop water requirements have been computed using Modified Penman's method.

The following are the main factors which play an important role in determining crop water requirements.

Climate or the ambient environment enveloping the plant determines the evaporative demand. For instance, in sunny and hot climate, crops need more water per day than in cloudy and cool climate,

Crops like banana and sugarcane having large leaf area need more water than crops having smaller leaf area like beans and wheat,

The crops which are fully grown need more water than crops that have just been planted and On the whole, surface climatology including temperature, sunshine duration, wind velocity relative humidity and rainfall has substantial effect.

Computing Crop Water Requirements

There are several methods for computing crop water requirements using climatological and physiological approaches. The most practical and comprehensive method for computing crop water requirements based on climatological approach is "**Modified Penman's method**", which has been used to compute crop water requirements.

Modified Penman Method

Based on the studies of the climate and measured grass evapotranspiration data from various research stations in the world, Dooren bas and Pruitt (1977) proposed a modified Penman's method for estimating reference crop evapotranspiration (ET_o) and gave tables for computations.

The procedure for computing crop water requirements is summarized below:

- Collection of climatological data.
- Computation of reference evapotranspiration (ET_o) based on two components viz: radiation term and aero dynamic term.
- Selection of crop coefficient K_c
- Determination of effective rain fall.
- Computation of crop water requirements and irrigation requirements for the proposed cropping pattern.

Crop water requirement is basically influenced by surface climatological data including temperature, sunshine duration, wind velocity, relative humidity and rainfall. The climatic data available from 1989 to 2014 at RARS, Jagtial were used for computing the ET_o(Table.9.7 and Annexure 9.8 to 9.10).

Table 9.7: Mean meteorological observations at RARS, Jagtial used for estimation of ET_o of Northern Telangana Agricultural zone

Month	Max.Tem p °C	Min.Tem °C	Humidity %	RH max %	Wind km/day	Sun- shine Hours	ET _o mm/day
JAN	30.01	14.49	58.57	76.46	51.97	7.55	3.74
FEB	32.53	16.76	54.06	71.99	74.13	8.34	4.92
MAR	36.22	19.67	48.42	64.76	84.12	8.12	6.06
APR	39.31	23.04	42.97	58.35	93.67	8.64	7.21
MAY	41.65	26.41	40.00	50.51	169.55	8.28	8.75
JUN	37.06	25.82	58.51	67.36	245.70	5.93	7.76
JUL	32.09	23.52	71.73	79.17	227.93	4.29	5.68
AUG	30.97	23.00	75.67	82.98	193.13	4.59	5.22
SEP	32.07	22.83	73.13	82.22	121.57	5.87	5.12
OCT	32.30	20.43	66.42	79.97	57.05	7.16	4.66
NOV	30.79	16.70	61.00	76.94	45.50	7.37	3.88
DEC	29.45	13.38	58.35	75.07	42.44	7.48	3.40
Year	33.70	20.50	59.07	72.15	117.23	6.97	5.53

Computation of reference Crop evapotranspiration (ET_c)

The crop water requirement (ET_c) was calculated using the relation

$$ET_c = ET_o \times K_c$$

Where,

ET_c = Crop evapotranspiration in mm/day. Actually ET_c is defined as crop water requirement or consumptive use of crop which is defined as the depth of water needed to meet the water loss through evapotranspiration (ET_{crop}) of a disease-free crop, growing in large fields under non-restricting soil conditions including soil water fertility and achieving full production potential under the given growing environment.

ET_o = Reference crop evapotranspiration in mm/day. ET_o represents the rate of evapotranspiration from an extended surface of 8 to 15 cm, green grass cover, actively growing, completely shading the ground and not short of water.

K_c = Crop co-efficient which varies with the crop genotype and growth stages. More explicitly it is the function of crop canopy coverage. The K_c of crop at younger age is lower than that at full maturity stage.

Kc values

The crop coefficient is the ratio of ET_c/ET_o . Where ET_c is the crop evapotranspiration of a crop and ET_o is the reference evapotranspiration of grass crop. K_c is defined as the canopy coverage factor, which is influenced by type of crop, growth stage of the crop, Climate, and surface moisture condition of the field. To determine the crop factor K_c the following parameters are to be considered Crop genotype i.e. type of crop as cereal, vegetables, pulses, fiber crop etc. Total growing period of each crop.

Crop growth stages

The total growing period of a crop is divided into four growth stages.

The initial growth stage: this is the period from sowing or transplanting when the crop covers about 10 % of the ground.

The crop development stage: this period starts at the end of the initial growth stage and lasts until the full ground cover has been reached (ground cover about 70-80 %).

The mid-season stage: this period starts at the end of the crop development stage and lasts until maturity; it includes flowering and grain setting.

The late season stage: this period starts at the end of the mid season stage and lasts until the last day of the harvest; it includes ripening.

In the present study the crop coefficient values for the crops under consideration as recommended by FAO have been used and Kc values are furnished in Table 9.8.

Table 9.8 : Growth periods (days) and crop coefficients (kc) of suggested crops under three barrages on Penganga in Adilabad district of Telangana state

Crop		Crop Development Stages			
		Initial	Develop-ment	Mid sea-son	Late season
LS Cotton	Length (Days)	30	50	60	45
(185 days)	Kc	0.45	----->>	1.15	0.68
Soya Bean	Length (Days)	20	25	40	20
(105 days)	Kc	0.35	----->>	1.08	0.75
Bengal Gram	Length (Days)	15	25	30	20
(90 days)	Kc	0.40	----->>	1.00	0.70
Tomato *	Length (Days)	20	30	35	20
Main field(105 days)	Kc	0.45	----->>	1.15	0.90
Cabbage *	Length (Days)	15	20	30	10
Main field(75 days)	Kc	0.45	----->>	1.05	0.95
Brinjal *	Length (Days)	25	35	40	25
Main field(125 days)	Kc	0.45	----->>	1.10	0.90

* Nursery of 25day old seedlings for transplanting in main field.

Effective rainfall

The growing crop does not utilize entire water received through rainfall in the field; a part of it may be lost by surface runoff, deep percolation or evaporation. Only a portion of heavy and high intensive rains can enter and be stored in the root zone. A part of stored water is utilized by crop to meet its evapotranspiration. In the present study, this is so called "effective rainfall" was computed using Table 10 of Technical series 2 "A Guide for Estimating Irrigation Water Requirements" published by Govt. of India, Ministry Of Irrigation. The ten day effective rainfall was computed in proportion to that of rain received in ten days which was calculated from the daily rainfall observed at ARS, Adilabad(Annexure 9.2).

Computation of crop water requirements and irrigation requirements

Crop water requirement (CWR) in practice is governed not only by the agro-climatic conditions (temperature, humidity, wind velocity and bright sunshine hours) and crop physiology i.e. crop coefficients (Kc values) but also by effective rooting depth and soil moisture condition i.e. water depletion level arising during the growth period. For design purposes, CWR is based on the assumption that no restrictive conditions arising out of soil on water stress would apply. The ETC was accordingly computed using Kc factor values for particular crops and the ETo values as computed by "Modified Penman's" method are summarized. The ETC for the proposed crops was calculated and presented in Annexures 9.11 to 9.16.

The net irrigation requirement has been computed by deducting effective rainfall from ETC. The effective rainfall has been calculated from the monthly average rainfall and monthly ETC values using Table-10 of Technical series -2 and adjusted proportional to the mean 10 day rainfall. The 10 daily gross irrigation requirements were computed adopting the following system efficiencies.

System efficiency takes into consideration the field efficiency, conveyance efficiency and operational efficiency. The field loss comprises seepage losses in field channels percolation losses beyond root zones and wastage of applied irrigation. Conveyance efficiency accounts for the losses in conveyance system from canal head to irrigation turnout and the operational losses result on account of slackness of management in responding to the changes in crop water requirements (as a result of rain fall in the command), etc.,

The following values of efficiency factors have been adopted.

Field Efficiency :	65 %
Conveyance Efficiency :	70 %
Overall Efficiency :	45.50 %

9.7 Water Planning

The total available water and ayacut for Telangana & Maharashtra for three barrages below Lower Penganga project were agreed to share as given below in Joint meeting of SE's of Andhra Pradesh and Maharashtra on LPP held on

14.03.2012 at Nirmal and 4th round of CE's level Inter state meeting on LPP on 04.09.2013 at Aurangabad .This water is to be fully utilised for irrigation and drinking water purposes of enroute villages.

As per the National Water Policy and guidelines of CWC, irrigation and multipurpose projects should invariably include a drinking water component, whenever there is no alternative source of drinking water. Drinking water needs of human beings and animals should be the first charge on any available water. In this regard guidelines are available in the following.

Guidelines on Provision for Drinking Water Supply Systems in Multipurpose and Irrigation Projects – issued by Central Water Commission.

Manual on Water supply and Treatment – brought out by Ministry of Urban Development.

9.7.1. Drinking Water Requirement

The drinking water requirement is for the villages enroute in the canal alignment in the project area. The quantity of water required for drinking purpose is assessed based on the population projected over the next 50 years after completion of the project.

Data on the population statistics of Adilabad district is collected for the census of 2011 from the Handbook of statistics, Adilabad district, published by the Chief Planning Officer, Adilabad.

Population projections are made for the year 2066 (50 years from 2016 the year when the project is expected to be commissioned). The average decade growth rate of population of Adilabad district as per the census records from 1901 to 2011 is 18.03%.

The per capita demand per day in case of rural areas is between 40 to 70 liters as per the CPHEEO guide lines. However, the per capita demand for this project is considered as 70 liters per day per person and filtration and other losses 25 and 5% respectively towards industrial requirement.

The drinking water requirements for the villages under the command area of Channaka-Korata (Rudha) barrage are 1.16 Mcm(0.04 TMC).

The detailed calculations is presented in Annexure 9.17 .

This requirement will be added to the peak requirement for irrigation including provision for rush irrigation for designing the canal capacity at the head.

9.7.2 Irrigation purpose

The total quantity of water required for irrigation and drinking purpose is 1.49 TMC excluding seepage losses. The requirement on 10 daily basis is given below.

Month/10 daily		Total Water requirement (Mcum)	Total Demand (Cumeecs)	Water Requirement (Mcum) for 13500 Ac)	Total Demand (Cumeecs) for 13500 Ac
June	I	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00
July	I	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00
Aug	I	0.00	0.00	0.00	0.00
	II	3.60	4.17	2.96	3.43
	III	0.96	1.01	0.80	0.84
Sept	I	0.64	0.74	0.54	0.62
	II	3.60	4.16	2.96	3.42
	III	4.71	5.45	3.86	4.47
Oct	I	3.29	3.80	2.70	3.13
	II	3.54	4.10	2.91	3.37
	III	4.34	4.57	3.57	3.75
Nov	I	3.62	4.19	2.97	3.44
	II	3.73	4.32	3.07	3.55
	III	3.61	4.18	2.97	3.43
Dec	I	3.00	3.47	2.47	2.85
	II	1.24	1.43	1.02	1.19
	III	0.87	0.91	0.72	0.76
Jan	I	0.79	0.91	0.66	0.76
	II	0.60	0.69	0.50	0.58
	III	0.00	0.00	0.00	0.00
Feb	I	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00

	III	0.00	0.00	0.00	0.00
March	I	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00
April	I	0.00	0.00	0.00	0.00
	II				
	III				
		42.12		34.68	

9.7.3 Availability of Water (Surface)

The net annual 75% dependable yields available to Telangana for future use after accounting for the existing utilizations by Telangana at Channaka-Korata (Rudha) barrage is 244.768 Mcum(8.644 TMC).

The proposed utilisation by Telangana under this project is 1.20 TMC annually.

9.7.4 Canal capacity

The demand at the canal head is arrived at considering all the requirements for peak irrigation & drinking water. The main canal for telangana is designed for a discharge of 4.5 Cumecs. The canal sections are designed as per the procedure given in the relevant BIS codes.

9.8 Command Area Drainage

9.8.1 Review of existing drainage system

(a) **The maximum intensity of rainfall over the command (SPS value)is given below.**

1 day 410mm

2 day 560mm

3 day 592mm

(Source: Generalised PMP Atlas for Godavari published by CWC)

(b) **Assessment of water logging, soil salinity and alkalinity**

From the local inquiry and field inspection, it is gathered that these problems do not exist in the command.

(c) **Identification of areas needing drainage**

No water logging problem is anticipated.

9.8.2 Type of drainage needed with proposals

Does not arise.

9.9 Water course / Field channels

Provision for water courses / field channels has been made at the rate of Rs.15000/- per acre as per the Telangana Government norms.

9.10 Water Management

9.10.1 Review and evaluation of existing system of operation and distribution

At present Water User Associations manage the water distribution at field level. The system is functioning satisfactorily.

9.10.2 Proposal for Participatory Irrigation Management

Participatory Irrigation Management is already in vogue through WUAs.

9.10.3 Scope of introduction of modern technology like sprinklers; drip irrigation etc. (generally for lift schemes)

Not contemplated in this report as irrigation in the present project is planned through gravity canal.

9.10.4 Existing practice of Dept. of Agriculture for popularising micro irrigation

Micro irrigation system is popularised through seminars, publicity and workshops. However at present the area irrigated in Adilabad by lift irrigation is virtually nil.

9.10.5 Facilities for Training the Operation and Maintenance-personnel at- different levels of management & farmers

Departmental infrastructure is available for this purpose. Govt. of Telangana invested large amounts under Neeru-Meeru program towards water conservation and water management program.

9.10.6 Existing extension activity & proposals for its improvement be described.

Does not arise.

9.11 Agricultural support services

Existing :- Does not arise.

Proposed :- Does not arise.

CHAPTER 10

COMMAND AREA

10.1 Command Area

10.1.1 Command Area Details

(a) Location

The Channaka-Korata barrage is planned on Penganga river to irrigate area in 14 villages of three mandals Tamsi, Adilabad and Jainad mandals of Adilabad district.

b) Classification of land

Present land use and Land cover

Adilabad district is economically backward. The percentage of tribal population in the district is 16.74% of the total population and that of schedule castes is 18.54%. The rural population in the district is 73.47% consisting of mainly illiterate working class and the literacy rate of the district is 44.7%. The main occupation and source of livelihood of the people of Adilabad is agriculture. Even though the lands are fertile, farmers depend on ill distributed and erratic rainfall with no dependable assured irrigation at all. Thus, full benefit of the natural resources is not realized by the people so far.

The total Geographical area of the district is 1610500 ha, out of which forest area is 43%, barren and uncultivated land is 3 %, land put to non agricultural uses is 4%, Current fallows is 7 %, Permanent pastures and other grazing lands is 1%, Other fallow land is 4%, net area sown is 37% and land under miscellaneous tree crops & groves not included in net area sown is 1%.

The geographical area of Adilabad district is 16105 sqkm and it consists of 52 mandals (an administrative unit with 15-20 villages). The agriculture and forests are the two important units of land utilization and the forests occupy about 689517 ha (42.8 % of total geographical area of the district) (Table 10.1). The gross cropped area during the year 2010-11 in the district is 664998 ha. The net area sown is 582886 ha, which is 41.3 % of total geographical area of the district.

Table 10.1 : Area (ha) under different land use & land cover in Adilabad Distict of Telangana state

Category	Area in ha
Total Geographical area	1610500
Forest	689517
Barren & uncultivated land	43920
Water logged	789
Social forestry	2346
Land under still water	9985
Other Land	47564
Land put to non agricultural uses	60684
Cultivable waste	14737
Permanent Pastures and other grazing lands	14234
Land under miscellaneous tree crops and groves not included in net area sown	8504
Other fallows	72109
Current fallows	123909
Net area sown	582886
Total cropped area	664998
Area sown more than once	82112

The land use of the three mandals which benefit from the proposed barrage indicate that of the 1,01,597 ha of geographical area net cropped area is 59920 and total cropped area is 62466 ha with a cropping intensity of 104 per cent (Table 10.2.).

Table 10.2. : Land use of mandals of proposed command area of Channaka-Korata(Rudha) barrage of Adilabad district, Telangana State (ha)

Category	Mandals			
	Tamsi	Adilabad	Jainad	Total
Geographical area	27728	45105	28764	101597
Forest area	2167	23264	708	26139
Bareen & uncultivated land	1428	184	841	2453
Social forests	45.00	81	91	217
Land under still water	24	20	146	190
Other Roads	2895	1510	1786	6191
Land put to non agricultural uses	2964	1611	2023	6598
Cultivable waste	283	1635	77	1995
Permanent Pastures and other glazing lands	488	0	845	1333
Other fallows	139	604	296	1039
Current fallows	0	1411	349	1760
Net area sown	20259	16396	23265	59920
				127234
Total cropped area	20549	16491	25426	62466

c) Gross command area, culturable command area

The land of the proposed command is culturable and there exists barren lands also. The land uses of the three mandals which benefit from the proposed barrage are given Table 10.3.

Table 10.3: Gross Command Area, Culturable command area (Ac)

Sl.no	Name of Mandal	GCA	CCA
1	Tamsi	14155	12937
2	Adilabad	292	282
3	Jainad	2161	2029

d) Size of land holding

In Adilabad district, there are 215788 marginal farmers (land <2.47 acres) and the total area are 246334 acres. Small farmers (land between 2.47-4.93 acres) are about 118305, semi-medium farmers (4.94-9.87 acres) are 88445, medium (9.88-24.7 acres) and large farmers (>24.71 acres) are 29012 and 2661 respectively. More than 85 per cent of holdings are small and marginal.

Most of the land is held by small and marginal farmers. In four mandals under the command, 36.97 and 30.91 percent of farmers are small (1-2 ha) and marginal (0-1 ha) holding 30.65 and 11.05 percent area respectively. On the other hand, 25.95 per cent farmers (2-4 ha) are holding 36.7 percent area. The large farmers (>4 ha) with 6.17 percent in number are holding an area of 21.6 per cent.

Table 10.4 : Land holding of barrage command area mandals

Sl. No	Size of Holding (ha)	Number			Total	% of total	Area (Ha)			Total	% of total
		Adilabad	Jainad	Tamsi			Adilabad	Jainad	Tamsi		
1	0.0 to 1.0	3658	4682	3665	12005	32.88	2215	3096	2125	7436	11.70
2	1.0-2.0	3180	4929	4871	12980	35.55	4570	7262	7101	18933	29.79
3	2.0 to 4.0	2730	3273	3291	9294	25.45	6804	8299	8075	23178	36.47
4	4 & above	724	916	596	2236	6.12	4463	5786	3751	14000	22.03
	Total	10292	13800	12423	36515	100	18052	24443	21052	63547	100

10.1.2 Climate of Command Area.

(a) Average annual Rainfall 1157mm

(b) Seasonal distribution

Monsoon 984mm

Non-monsoon 173mm

(c) Coefficient of variation

The coefficient of variation of rainfall over the sub-basin is generally of the order:

June 60%.

July 40-50%

August 50%

September 70 to 80%

October >100%

(d) Temperature

Maximum 41.1 o c

Minimum 9.4 o c

Average 25.3 o c

Evapo transpiration (ETO) – annual 1577mm

10.1.3 Irrigation

a) Present sources of irrigation in the command

Rainfall is the source of raising crops. However, there are few minor irrigation tanks in the three mandals of which 14 villages are supposed to receive water through the proposed barrage. Further, bore wells are the major source of irrigation in the area.

b) Method(s) of irrigation followed

Surface Irrigation methods are commonly followed in the command area. In wide row crops furrow method, close growing crops border strip method of irrigation is followed. In the recent past few sprinkler and drip method of irrigation is followed in high value crops like vegetables.

C) Status of land development for Irrigated Ares

- i) Condition of channels (lined/unlined): Unlined
- ii) Longitudinal slopes in the field: Natural ground
- iii) Status of field channels/drains: Unlined

Open channels are unlined and the water percolates deep into soil and the seepage water which drains through natural drains are available at lower reaches for irrigation.

(d) Assumed field application efficiency

Based on the performance of the existing projects the field application efficiency of 65 % was considered.

(e) Record of water logging, Salinity and Flooding

No records are available. However, from the local inquiry and field inspection, it is gathered that these problems do not exist in the command. From the local enquiry and field inspection, the problem of water logging / flooding does not exist. Further, the problem of salinity and ill drained condition may not crop up in the command area.

10.1.4 Socio-Economic Aspect

(a) Population major occupation(s) and income etc.

The major occupation of the population is farming and agricultural labor. About 74 % of the population lives in rural areas. The per capita income is very low. However, the average daily earning of coal worker is Rs.750/-

b). Population major occupation, income etc

The major occupation of the people live in villages is farming and agriculture labour. The per capita income is very low.

Table 10.5: Cultivators, Agricultural labourers and literacy in mandals of proposed command area of Channaka- Korata barrage of Adilabad district, Telangana State (ha), 2001 census

S.No	Mandal	Cultivators		Agriculture labourers		Literacy rate, % of population		
			% of total population		% of total population	SC	ST	All
1	Tamsi	8448	23	8306	23	46.79	43.91	48.93
2	Adilabad	9301	5	11643	7	60.74	47.26	67.48
3	Jainad	10823	24	11082	25	42.81	44.16	50.56

Beneficiaries

There are 3998 households in the proposed command area villages (Table 10. 6).

There are 3438 and 4187 SC and ST population in the command.

Table 10.6: Households, SC, ST, Male and female population of villages under proposed Pen ganga barrages, census 2011.

Barrage	No of house holds	Population				
		SC	ST	Male	Female	Total
Channaka-Korata	3998	3438	4187	7990	8058	

(c) Classification of farmers (marginal-small-medium-big)

Majority of the farmers are marginal and small (Table 10.4)

(d) Land tenure

Small and marginal farmers account for 33 and 36 per cent of land holdings (Table 10.4).

(e) Annual Income-average (Rs)

Category	Farm	Subsidiary sources	Total
Land less	Nil	20000 (labour)	20000

Marginal farmers (up to 2 acres)	25000	10000 (labour)	35000
Medium farmers (5 acres)	70000		70000
Big farmers (10 acres)	150000		150000

(f) Availability of agriculture labour and wages

About 74% of the people in Adilabad district live in rural areas. They are mostly agriculture workers. The average daily wage of agricultural worker is Rs. 200.

10.1.5 Infrastructure facilities

(a) Railways and roads (villages, district etc.)

Railways

There are 16 no of railway stations in Adilabad district with a track length of 219km in the district.

3. Highways

Length of roads in the district is given below.

National Highway 110km

4. R&B

State Highways 340km

Major district roads 844km

Other district roads 764km

iii) Zilla parishad 7355km

(all roads including district and village roads)

(b) Marketing facilities

There are a number of agriculture market committees in the district.

(c) Agro-industries

There are no agro industries in the three mandals. However, in Adilabad mandal there are tractor and other agriculture machinery shops are located. Further, seed, fertilizer and pesticides shops are also located in Adilabad and other mandal head quarters.

(d) Banks; credit societies etc.

There are a total of 22 banks functioning in Adilabad district. The average population per Bank branch is 5829000. The details of the banks is given below

Nationalised banks	9
Rural banks	4
Cooperative banks	1
Other banks	8

10.2 Topography and Soils

10.2.1 Topography and Relief

The terrain is generally undulating with a large forest cover. There are some hill ranges notable among them being Sahayadri. Gentle slope with undulating terrain topography exists in the command area.

Land slopes

Slope refers to indication of the land surface. It is defined by gradient, shape and length, which form integral part of soil as a natural body. The length and gradient of slope influence soil formation, proneness to erosion and effect on land use and development. The land is generally undulating with gentle slopes from west to east.

10.2.3 SOILS

Soil types (Traditional nomenclature):

The soils in the district are predominantly clay loams (Black cotton soils), sandy loams, sandy clay loams and red soils.

The soils of Rudha barrage are rock lands followed by deep black soils and shallow black soils (Table 10.7).

Table 10.7 : Area (ha) of different soil types in command area of proposed barrage

Type	Rudha
Rock lands	5336
Shallow black soils	862
Deep black soils	1895
Other	58
Total	8150

a) Origin

Black soils

b) Texture

Gravel : In Adilabad soil, only surface was gravelly with 25.7 % gravel while in Jainad soil the gravel content is <17% in different soil layers. The Surface is having only 5.9% gravel.

Sand: Sand content in Adilabad soils ranged from 20.2 % to 35.2 % in different soil layers. The sand content decreased with depth in Adilabad soils, while reverse trend was observed in Jainad soils.

Silt : It ranged from 10-15 % in adilabad soils and 5-15 % it different soil layers of Jainad.

Clay : Clay content ranged ranged from 49.8 % to 69.8 % in different soil layers of Adilabad and 49.9% to 59.9% in Jainad soils. Clay content increased with depth in Adilabad (49.8 % to 69.8 % upto 110+ cm). however, it decreased with increase in soil depth in Jainad soils.

Textural class: Adilabad and Jainad soils are clay soils

Table 10.8 : Particle size distribution of soils of Adilabad district

Location of	Depth	Gravel	Mechanical composition (%)	Textural
-------------	-------	--------	----------------------------	----------

the profile	(cm)	(%)	Sand	Silt	Clay	class
Adilabad	0-10	25.7	35.2	15	49.8	GC
	10-48	6.1	30.2	10	59.8	C
	48-79	16.9	20.2	15	64.8	C
	79-110	11.0	20.2	15	64.8	C
	110+	8.6	20.2	10	69.8	C
Jainad	0-10	5.9	25.2	15	59.8	C
	10-46	14.8	35.2	10	54.8	C
	46-95	16.8	40.2	5	54.8	C
	95-130	7.2	40.2	10	49.8	C

C – Clay; CL – clay loam; SCL – Sandy clay loam; SC – Sandy clay; SL – Sandy loam; LS – Loam sand, G – gravity.

Source: SPCRP, Annual report for 1997-98

c) Depth

d) Infiltration and drainability

Infiltration rate at 150' varied from 0.02 (Adilabad soil) to 0.09 cm/min (Jainad soil). The cumulative infiltration at 150' was 6.7 cm in Adilabad soils and 17.2 cm in jainad soils.

At Adilabad, the soils are deep and are moderately drained. Water table is at 80-100'. Big cracks of width 2 to 5 cm up to 1 m depth and fine cracks beyond 1 m depth were observed.

At Jainad, soils are deep and poorly drained occurring on plain. In this area, ground water level is improved because of Satmala Project. Water table is at 30'.

Table 10.9 : Infiltration rate and cumulative infiltration of soils of Adilabad district

Location of	Time in minutes
-------------	-----------------

the profile	5	10	30	60	90	120	150
Jainad	0.43	0.23	0.11	0.10	0.10	0.10	0.09
Adilabad	0.30	0.19	0.05	0.04	0.03	0.02	0.02
	Cumulative infiltration (cm)						
Jainad	2.15	3.30	6.50	8.50	11.60	14.50	17.20
Adilabad	1.50	2.48	3.48	4.68	5.58	6.18	6.78

Source: SPCRP, Annual report for 1997-98

Bulk density, saturated hydraulic conductivity (Ks)

Bulk density

Bulk density was 1.202 to 2.39 mg m⁻³ in surface layers of Adilabad and Jainad respectively. It increased with depth in Adilabad and decreased in soils layers of Jainad.

Particle density

It varied from 2.39 to 2.53 mg m⁻³ in different soil layers of Adilabad and jainad soils.

Saturated hydraulic conductivity (Ks)

There was large variation in Ks in different profiles and horizons. The Ks values ranged from as low as 0.07cm h⁻¹ in the bottom layer of Adilabad profile. It was high in plough layers of Adilabad and Jainad.

Table10.10 : Density, saturated hydraulic conductivity and water retention of soils of Adilabad district

Location of the profile	Depth (cm)	Bulk density (Mg m ⁻³)	Particle density (Mg m ⁻³)	Ks (cm hr ⁻¹)	Water content at saturation (% w/w)	Moisture retained at (% w/w)			Available water (% w/w)	Depth of available water (cm m ⁻¹ depth)
						0.1 bar	0.33 bar	15 bar		
Adilabad	0-10	1.202	2.51	3.30	3.30	26.38	22.65	11.58	11.07	16.34 High
	10-48	1.505	2.53	1.90	1.9	32.89	30.04	18.26	1.78	
	48-79	1.625	2.53	3.60	3.6	36.25	34.47	20.47	14.00	
	79-110	1.525	2.52	0.08	0.08	36.18	34.56	21.40	13.16	
	110+	1.361	2.55	0.07	0.07	36.17	33.65	22.87	10.78	
Jainad	0-10	1.320	2.39	3.62	3.62	39.54	36.65	22.94	13.71	20.01 very high
	10-46	1.403	2.42	0.30	0.30	36.04	34.56	20.74	13.82	
	46-95	1.590	2.40	0.30	0.30	35.28	33.51	19.96	13.75	
	95-130	1.663	2.43	-	-	25.03	21.03	14.83	6.2	

* cm/50 cm depth

Source: SPCRP, Annual report for 1997-98

e) Salinity

Physico-chemical properties

Horizon wise soil pH, EC and CEC data is given in Table 10.11 . Data on exchangeable cation and exchangeable sodium percentage is given in Table10.11.

Soil reaction (pH)

Soil pH was > 8 (slightly alkaline) in both Adilabad and Jainad soils. The pH with depth in profiles of Adilabad and Jainad increased. The soils were moderately alkaline in reaction.

Electrical conductivity

The electrical conductivity values ranged from 0.12 to 0.40 dS/ m in soil (+110cm depth) of Adilabad profile. While these values varied from 0. 38 to 0.69 dS/m in different soil layers of Jainad profile. No particular trend with depth was observed in profiles of Adilabad and Jainad soils.

Cation exchange capacity

CEC values ranged from 36.62 42.2 (c mol) (p+) kg⁻¹ soil). It increased with depth in adilabad, profile. CEC values of different layers in Jainad soil profile was around 41 to 43 (c mol) (p+) kg⁻¹ soil).

Table 10.11 : Physico-chemical properties of soils of Adilabad district

Location of profile	Depth (cm)	pH (1:2.5)	EC (d S/m)	CEC (c mol) (p+) kg ⁻¹ soil)
Adilabad	0-10	8.68	0.21	36.62
	10-48	8.78	0.12	40.96
	48-79	8.85	0.24	41.93
	79-110	8.97	0.40	42.20
	110+	9.16	0.22	42.37
Jainad	0-18	8.74	0.69	42.17
	18-46	8.82	0.40	43.45
	46-95	8.84	0.38	41.72
	95-130	8.88	0.41	42.14

Source: SPCRP, Annual report for 1997-98

f) Base exchange

Exchangeable cations

In Adilabad and Jainad soil profiles calcium was the dominating cation on the exchange followed by magnesium, sodium and potassium

Exchangeable sodium percentage (ESP)

The soils were non sodic and the ESP ranged between 0.43 and 5.42.

Table10.12: Exchangeable cations and exchangeable sodium percentage in soils of Adilabad district

Location of profile	Depth (cm)	Exchangeable cation (cmol (p+) / kg)				ESP
		Ca	Mg	Na	K	
Adilabad	0-10	25.29	9.83	0.29	0.79	0.79
	10-48	29.22	10.69	0.18	0.49	0.43
	48-79	29.49	11.21	0.40	0.47	0.95
	79-110	28.98	11.50	0.59	0.47	2.10
	110+	27.56	11.69	2.30	0.52	5.42
Jainad	0-18	31.27	9.02	0.37	1.16	0.80
	18-46	33.50	8.78	0.37	0.44	0.85
	46-95	30.89	9.86	0.33	0.27	0.79
	95-130	30.53	10.52	0.40	0.34	0.94

Source: SPCRP, Annual report for 1997-98

g) Fertility status

Data on organic carbon, N, P & K are given in Table 10. and micronutrients are given in Table 10. .

Organic carbon

The organic in the soil top layers was 1.09 to 1.19 % and it decreased with increase in soil depth both at Adilabad and Jainad. In general soils were with medium (0.5-0.75 %) organic carbon content.

Available nitrogen

Available nitrogen content was 156.8 and 210.1 kg / ha in the surface layers of Adilabad and Jainad respectively. Available nitrogen content decreased with depth.

Available phosphorus

The available phosphorus content of the top soil layer of Adilabad was 26.1 kg P_2O_5 / ha and it decreased with increase in soil depth. On the other hand, at Jainad, the available phosphorus content was lower than Adilabad profile and it was 19.8 kg /ha.

Available potassium

Available potassium content of the soil profile was higher at Jainad than that at Adilabad. It was high in surface soils and it decreased with depth. Available potassium contents steeply decreased in the surface horizon to lower horizons in Jainad profile.

Table 10.13 : Organic carbon and available nutrient content of soils of Adilabad district

Location of profile	Depth (cm)	Organic carbon (%)	Available nutrients (kg/ha)		
			N	P ₂ O ₅	K ₂ O
Adilabad	0-10	1.09	156.8	26.1	443.5
	10-48	0.81	150.5	19.8	398.6
	48-79	0.34	151.2	21.6	357.0
	79-110	0.88	188.1	12.6	346.2
	110+	0.51	87.8	10.8	340.8
Jainad	0-18	1.19	210.1	19.8	551.7
	18-46	0.95	169.3	9.0	454.4
	46-95	0.88	169.3	10.8	292.1
	95-130	0.62	150.5	10.8	259.6

Source: SPCRP, Annual report for 1997-98

Available Micronutrients

The data on available micronutrient contents of the soils are presented in Table 10.14. The available zinc, iron, copper and manganese contents ranged from 0.22 to 2.76; 2.16 to 9.04; 0.33 to 1.60; 11.18 to 49.58 ppm respectively.

Table 10.14 : Available micronutrients content of soils of Adilabad district

Location of profile	Depth (cm)	Available micronutrients content (ppm)			
		Zn	Fe	Cu	Mn
Adilabad	0-10	0.94	3.64	1.19	9.48
	10-48	0.32	4.78	1.04	6.26

Location of profile	Depth (cm)	Available micronutrients content (ppm)			
		Zn	Fe	Cu	Mn
	48-79	1.64	6.32	1.36	19.58
	79-110	0.24	2.16	1.01	11.18
	110+	2.76	4.34	1.27	14.68
Jainad	0-18	1.27	9.04	1.60	35.6
	18-46	0.29	4.64	0.98	49.58
	46-95	0.34	3.96	0.61	26.82
	95-130	0.22	3.56	0.33	12.3

Source: SPCRP, Annual report for 1997-98

It can be concluded that the pH in general is normal to very weakly alkaline. The total soluble salts in the soils are within the normal limit. The organic carbon content of soil is low to medium. The available P₂O₅ content in the soil is generally low. The K₂O content of the soil is generally medium to high.

10.3 Drainage – Density of natural drainage (km per sq km of command area.)

The most important river that drains the district is the river Godavari. The Penganga, Wardha and Pranahita are the other important rivers. Kadam river and Peddavagu river also drain the district. Besides these major rivers, small rivers like the Satnala, the Swarna vagu and the Sudha vagu also drain the district. Thus, the natural drainage network of the district is very dense.

The command area is having close network of village nalas draining in to Penganga . The soils of the command area are well drained with rolling terrain and topography having 1 - 5% slopes. Hence, the problem of drainage does not exist even after commissioning of lift irrigation project with irrigated dry crops in the proposed command area.

10.4 Agriculture

10.4.1. Cropping pattern followed

Crops are grown in two cropping seasons namely, Khariff (June to September) and Rabi (October to March). Cotton is the main commercial crop of the district occupying nearly 48.73 % of the net area sown. Other principal crops are soyabean, jowar, redgram, rice and maize in decreasing order. The commercial crops like cotton are grown mostly under rain-fed and chilies, turmeric and groundnut are grown under irrigation. The total area under food grains is 211025 ha, out of which 146457 ha are under khariff crop and 64568 ha is under rabi crops.

Table 10.15: Cropping pattern followed with average yield of 3 years irrigated and rain fed crops separately for each crop.

Kharif Crop	Rain Fed		Irrigation	
	Area , %	Yield (t/ha)	area %	Yield (t/ha)
(i) Paddy	5	2.5	95	3.0
(ii)Maize	100	3.7	-	
(iii)Cotton	80	0.55	20	
(iv)Red gram	100	0.53		
(v)Green gram	100	0.49		

10.4.2 Agriculture practices adopted-use of

(a) Improved implements and seeds

Farmers in the command area are habituated to use high yielding varieties of crops and improved bullock drawn and tractor drawn agriculture implements. Each village is having tractors for different primary and secondary tillage purposes. These tractors are also use for transportation purposes.

(b) Fertilizers, insecticides, pesticides, etc.

Farmers are using adequate quantities of fertilizers and pesticides in crop production. Number of fertilizer and pesticide shops are available at village/ mandal levels.

(c) Extension services.

Department of Agriculture, Horticulture, Animal husbandry, Sericulture, Marketing are actively involved in transfer of Technology at farmers level. However due to paucity of man power at mandal and village level the services are not up to the expectations of the farming community.

At present one agriculture officer is supposed to offer advice on crop production. However, in practice they are not positioned due to vacancies. Hence, there is a need to strengthen agricultural extension in the command area to get full benefit of irrigation.

However due to paucity of man power at mandal and village level the services are not up to the expectations of the farming community.

10.4.3: Farmer's attitude towards improved agricultural practices and willingness for payment of water cess to meet O&M expenses.

Farmers in the command area are highly responsive to the viable new agricultural technology and ready to adopt them on a large scale. They are eager to change the cropping pattern with the introduction of irrigation water. Water users associations have been formed at village level and are actively involved in management of community irrigation systems such as tanks. They are ready to pay the water tax to meet operation and maintenance expenditure.

10.4.4 Preparedness by State Irrigation/Agriculture Departments / WUAs/ Cooperatives to adopt improved farming system.

Once the water is made available Generally the farmers are prepared to adopt improved agriculture practices and all the departments will take necessary steps in implementing the required steps in improving the yield of crops and thereby the income of the farmers.

10.5.1. Physical problems (including hazards)

Land suitability assessment for irrigated dry crops:

Land suitability assessment for agriculture is meant to evaluate the ability of a piece of land to provide the optimal ecological requirements of selected crops. In other words, assessing the capability of land in enabling optimum crop development and maximum productivity. The land and soil parameters like land Characteristics, Temp, R. Humidity, Eff depth (cm), Texture class, drainage class, pH,

OC (%), N (%), are highly suitable for growing crops like cotton , soybean, Bengal gram, vegetables like Tomato, Brinjal and Cabbage. Further, there is no salinity, available water in the soil is more, the soil does not have stones hence are suitable for growing the recommended crops with high productivity. It can be concluded that the soils under the proposed irrigation scheme are suitable for irrigation development.

10.5.2 Financial problems

(a) *Socio-economic conditions*

The farmers in the command are poor with small and marginal land holdings. They need financial support for seeds and manures.

(b) *Availability of improved implements/machines and other inputs.*

Farmers in the command area are habituated to use improved bullock drawn and tractor drawn agriculture implements .

(c) *Credit facilities - Existing Cooperative structures/Number of primary agricultural societies in the area*

Public sector banks and co-operative banks are existing in the area.

(d) *Infrastructure facilities*

Seed supply centers, Agriculture marketing yards are established in the area.

(e) *Department of Agriculture and Soil Conservation's Plan for agricultural development with details of financial sharing.*

10.6 *Proposed Cropping pattern with justification based on land Irrigibility classification, agro-climatic conditions, developed irrigated cropping pattern in the adjoining projects/areas etc.*

Discussed in Chapter 9.

10.7 Land Development Works (proposals)

10.7.1 Area involved

(a) *Land leveling/shaping*

(b) *Field channels*

(c) *Field drainage*

(d) *Implementation of warabandi*

(e) *Reclamation of water logged areas.*

(f) *Farm roads*

No specific land development plans are proposed other than the canal system.

10.7.2 Measures proposed

No specific land development plans are proposed other than the canal system.

10.7.3 Agency responsible for survey planning and execution of land' development works. Availability of experienced agencies/contractors and their willingness to employ local population especially displaced persons.

No specific land development plans are proposed other than the canal system.

10.7.4 Cost estimates and cost per ha for land development.

No specific land development plans are proposed other than the canal system.

10.7.5 Financing arrangement for execution of works

Project will be completed with state funds only

10.7.6 Schedule for completion of land development

No specific land development plans are proposed other than the canal system.

10.7.7 Status of existing extension services, credit agencies, TCD 'farms etc. and location of inputs like seeds, fertilizers, insecticides, pesticides etc. depots and proposals for their strengthening if required with justification.

The existing extension services, credit agencies, TCD farms etc. and location of inputs like seeds fertilizers, insecticides, pesticides etc., need augmentation.

10.7.8. Conducting adaptive trails and demonstration on farmer's field.

The local research station of ANGRAU, Department of Agriculture and Horticulture and KVK's are jointly conducting adoptive trials and large scale demonstrations on various agro technologies developed in the farmers' field for their verification and improvement. However, there is a need to verify and test the technologies developed by the University through on farm demonstration in the newly developed ayacut for better adoption by the farming community.

10.7.9. Action Research Programme.

Irrigation water management being highly site specific and needs cooperation of all farmers in a distributory, the action research on a distributory basis is to be conducted on a pilot scale by PJTSAU in the farmers' field.

10.7.10 Participatory Irrigation Management

Being implemented through WUAs. The same will be extended to new command and participatory approach in integrated water management will be the main focus.

10.7.11 Training of

Senior level officers

Trainings to senior level officers will be imparted by national/ international institutes like WTC and IARI, New Delhi on recent advances in integrated water resource management.

Middle level officers and Farmers

The middle level officers and farmers' training is to be conducted at National and state level institutes on integrated water resource management.

10.8 Ayacut roads

The existing road network is adequate. No provision is made for new roads except inspection path along the bank of the main gravity canal.

10.9 Benefits

10.9.1. Crop-wise increase in yields per ha and total expected output from the command

GROSS VALUE OF PRODUCE - WITHOUT PROJECT

Sl.No	Crop	Area Ha	Area in Acres	Produce Kg per Acre	Total Produce in ton's	Price per Ton in Rs	Value of Produce in Lakhs	Cost of cultivation per Acre	Total cost Rs. In Lakhs	Net returns Of Produce (Rs Lakhs)	
1	a) COTTON	4543	68	11221	1000	11221	41000	4601	23600	2648.21	1952.49
2	a) SOYABEAN	1202	18	2969	400	1188	26000	309	9100	270.17	38.60
3	a) JOWAR	334	5	825	550	454	15700	71	8200	67.65	3.59
4	a) RED CHILLI	601	9	1484	250	371	44250	164	10250	152.16	12.06
	Total	6680		16500				5145		3138	2007

GROSS VALUE OF PRODUCE - WITH PROJECT

Sl.No	Season	Area Ha	Area in Acres	Produce Kg per Acre	Total Produce in ton's	Price per Ton in Rs	Value of Produce in Lakhs	Cost of cultivation per Acre	Total cost Rs. In Lakhs	Net returns Of Produce (Rs Lakhs)	
KHARIF											
1	SOYABEAN	2004	30	4950	1000	4950	26000	1287	10600	525	762
2	TOMATO	334	5	825	14000	11550	15000	1733	19600	162	1571
3	BRINJAL	334	5	825	14000	11550	12000	1386	19600	162	1224
RABI											
4	BENGGAL	668	10	1650	1000	1650	34250	565	8100	134	431
5	CABBAGE	334	5	825	6000	4950	8000	396	15100	125	271
Two Seasonal											
1	LS COTTON	4008	60	9900	2500	24749	41000	10147	39400	3901	6247
		7682		18975				15514		5007	10507

CHAPTER 11
FLOOD CONTROL

Not applicable.

CHAPTER 12 DRAINAGE

12.0 DRAINAGE

No drainage congestion / water logging / Salinity are anticipated.

12.1 Basin Characteristics

(a) Geological history/geology

(b) Physiography

(c) Existing Drainage lines

(d) Farm drainage

(e) Rainfall, its distribution over space and time (give 1, 2 and 3 days rainfall of 5 years frequency)

12.2 Investigation—Brief

(a) Water-table investigation and Artesian conditions, if any

Not warranted

(b) Soil surveys-texture and permeability

Not warranted

12.3 Cultivation practices

(a) Existing cultivation practices

Conventional practices only.

(b) Proposed cultivation practices

Modern practices can be gradually introduced.

12.4 Existing Drainage

Natural drainage system

12.5 Drainage deficiencies

No deficiency

12.6 Drainage requirements including alternative layout of drains, their capacities

Not required and hence not proposed

CHAPTER 13
POWER

Not applicable.

CHAPTER 14
NAVIGATION

Not applicable.

CHAPTER 15

CONSTRUCTION PROGRAMME AND MAN POWER AND PLANT PLANNING

15.1 Construction Programme

It is proposed to complete the work in 30 months duration and work Program in the form of bar chart is enclosed as Annexure-15.1.

15.2 Key materials Planning

15.2.1 Special Materials

- (a) Cement
- (b) Steel
 - (i) Structural
 - (ii) Plates
 - (iii) Bars & rounds
 - (iv) Special Steels, if any
- (c) Explosives
 - (i) Gelatin
 - (ii) Detonators
 - (iii) Fuse coil
 - (iv) Explosives-Ammonia Nitrate
- (d) Oils and Lubricants
 - (i) H.S.D. Oil
 - (ii) Petrol
 - (iii) Lubricants

Work is likely to be carried out through contractors. Hence, no planning of material is required at this stage.

15.2.2 Materials - Data

Material	Source	Mode of transportation	Distance from nearest Rly.stn to work site	Mode of handling
Cement	Manufacturers	Rail / Road	20 Km	Trucks
Steel	SAIL	Rail / Road	20 Km	Trucks
Explosives		Rail / Road	20 Km	Trucks
Oils and Lubricants	Oil Companies	Rail / Road	20 Km	Trucks

15.3 Construction power requirement & proposed supply arrangement

Power requirement for the construction is insignificant and will be drawn from the local power grid.

15.4 Plant/Equipment Planning

Work is likely to be taken up through Non - EPC procedure. Agency will take care of this aspect.

15.5 Man Power Planning

Required professional and Technical staff will be provided by the agency. The work is likely to be attached to a division of I & CAD department, under the control of a circle. The quality control circle of I & CAD department will monitor the quality aspects.

CHAPTER 16
FOREIGN EXCHANE ELEMENT

No foreign exchange is involved.

CHAPTER 17
ENVIRONMENT, ECOLOGY AND FOREST ASPECTS OF THE PROJECT

EIA aspects are covered separately in the EIA study report.

CHAPTER 18

ESTIMATE

18.1 The estimates are prepared as per the CWC publication "Guidelines for preparation of estimate for river valley projects". The Telangana Schedule of Rates for the year 2012-13 are followed.

18.2 Classification of Units

The project works are grouped into the following units:

Unit-I Head-Works including main dam and auxiliary dam, dykes spillway, outlet works, energy dissipation devices, barrages, weirs regulators including intake structures and diversion works.

Unit-II - Main canals, branches., and distribution system inclusive of all pucca works.

18.3 Accounts Heads

18.3.1 Minor Heads:

(i) Direct Charges

- (I) Works
- (II) Establishment
- (III) Tools and Plant
- (IV) Suspense.
- (V) Receipts and recoveries on capital account

(ii) Indirect Charges:

- a) capitalized value of abatement of land revenue, and
- b) Audit and account charges.

18.3.2 Detailed Sub-Heads under I-Works

- A- Preliminary
- B- Land
 - i) Acquisition & Compensation
 - ii) Rehabilitation and resettlement
- C- Works
- D- Regulators and measuring devices (for canals only)
- E- Falls (for canals only) .

- F- Cross drainage works (for canals only).
- G- Bridges (for canals only)
- H- EscTelanganaes (for canals only)
- 1- Navigation works
- J- Power Plant Civil Works
- K- Buildings
- L- i) Earthwork;
ii) Lining and
iii) Service Road
- M- Plantation
- N- Tanks and reservoirs
- 0- Miscellaneous
- P- Maintenance
- Q- Special T&P
- R- Communications.
- S- Power Plant and Electrical Mechanical system
- T- Water Supply Works
- U- Distributaries minors and sub-minors.
- V- Water courses
- W- Drainage (to be clubbed with Environment and ecology)
- X- Environment and ecology
- Y- Losses on stock

18.4 Abstract of cost

18.4.1 Detailed Abstract of Cost

The cost of various units are compiled in a tabular form according to the various accounts heads as below.

18.4.2 General Abstract of Cost

On the basis of the detailed abstract of cost as in Para 18.4.1 a general abstract of cost for the whole project is compiled by minor and detailed heads in the following table.

18.5 Preparation of estimates

18.6 Detailed estimate of costs

Above items 18.1 to 18.6 are presented in the detailed estimates volume.

18.7 II-Establishment

The work is likely to be taken up on non-EPC contract basis, a provision of 10 % of (I-works-B land) is considered in the estimate.

18.8 III – Tools & Plants

A provision of 1% of I-works is considered in the estimate.

18.9 IV - Suspense

Nil

18.10 V – Receipts and Recoveries on capital account

The provision under this head is 25% on inspection vehicles are considered.

18.11 Indirect charges

A provision of 1 % of I-works is provided under this head.

The classified abstract is given below

CLASSIFIED ABSTRACT

Sl.no	Description	Amount (Rs. In Lakhs)
I	Works	
A.	Preliminary (Annexure-1)	133
B.	Land (Annexure-2)	
	(i) Barrage including abutments, Road bridge Right and Left flanks, Guide bunds, Tie Bunds, Coffor Dam, Pump House, Pressure mains & delivery cistern etc.,	1015.0
	(ii) Canals	3568.13
	(iii) Maharashtra Bank Components	15.27
	(iv) Maharashtra portion	1108.18
C.	WORKS	
	Barrage including abutments, Road bridge, Approach bund, Guide bunds etc., (Annexure-3)	18309.68
D.	Regulator (Annexure-4)	33.80
E.	Falls (Annexure-5)	21.4
F.	C.D. Works (Annexure-6)	52.90

G.	Bridges	(Annexure-7)	9.50
H.	Escapes		NIL
I.	Off takes & DPs	(Annexure-8)	49.9
J	Pump House And Pressure Mains etc	(Annexure-9)	5645.21
K.	Buildings		
L.	Earth Work & Lining of Canals	(Annexure-10)	231
M.	Plantation	(Annexure-11)	4.00
N.	Tanks and Reservoirs.		NIL
Q.	Special T & P		10.00
R.	Communications.		100.00
S	Electro Mechanical works	(Annexure-12)	2025.60
U	Distributories and Minors	(Annexure-13)	1833.30
V	Field channels	(Annexure-14)	247.50
X.	Environment & Ecology		NIL
			34413.45
O.	Miscellaneous 4 % of I – works		1,376.54
P.	Maintenance 1% of I - work except A+B+O+M+Q+X+Y		285.60
Y.	Loss of Stock 0.25% fo I - work except A+B+O+M+P+Q+X		71.40
	Total of I-Works		36146.99
II	Establishment Charges @ 10 % on works less 'B' Land		3,044.04
III	T&P @ 1% on I-works.		361.47
V	Receipts and Recoveries.		
a)	15 % of the cost of Temporary buildings		0.00
b)	25 % of the cost of the inspection vehicles		2.50
	Total Cost of Direct charges		3408.01
VI	In direct Charges		
a)	Abutment of Land Revenue @ 5% of the cost of the Culturable land.		NIL
b)	Audit and accounts charges at 1% of I-works		361.47
	Total Cost of Indirect charges		361.47
	Total Cost of Direct and Indirect charges		3769.48
	Total Cost in lakhs		39916.47
	or say		39916.47

CHAPTER 19 FINANCIAL RESOURCES

19.0 FINANCIAL RESOURCES

- 19.1 Total resources of the state and their utilisation for developmental activities-- sector wise resources for the last five years – will be provided in Detailed Project Report Stage**
- 19.2 Present position of the scheme regarding its inclusion in the plan concurrence of the State Planning Finance Department - The G.O.R.T No.828 has been enclosed**
- 19.3 Provision for the sector/for the scheme in the plan. Irrigation -The above mentioned Go issues with the concurrence of Finance (W & P) Department vide their U.O No.7275/236/W&P/A1/2015, dated.18.11.2015.**
- 19.4 Central/foreign aid contemplated, if any. -Not Provided at DPR Stage**
- 19.5 Information on similar / related pending projects in the state, their status, stage/percentage of completion, percentage of expenditure incurred and average annual expenditure by the state on these projects put together year-wise during the Last 5 years. - Not Provided at DPR Stage**
- 19.6 Commitment on the work in progress in the plan and allocation available for starting new scheme. - Not Provided at DPR Stage**
- 19.7 Effect of inclusion of the scheme in the plan on the schedule of other works in progress budget staff etc. - Not Provided at DPR Stage**
- 19.8 Requirement of funds for the scheme and its yearly phasing as in project report - Not Provided at DPR Stage**
- 19.9 Adequate/strengthening of organisational set up for execution for all projects together as contemplated - Not Provided at DPR Stage**
- 19.10 Advance action proposal for starting the preliminaries of the project, if any. Not Provided at DPR Stage**

CHAPTER 20

BENEFIT - COST RATIO, FINANCIAL RETURN & INTERNAL RATE OF RETURN

B.C. RATIO

The B.C. Ratio for the joint project is 1.60

		Project Cost 399.16 Crores	
BENEFIT COST RATIO (BCR)		Prop. Command Area :6680 ha	
S.N o.	Description	Without Project	With Project
		Amount in Lakhs	
A.	GROSS RECEIPT		
1	Gross value of farm produce	5144.92	15513.72
2	Dung receipts (as 30% of the fodder expenditure)	0.00	0.00
3	Total (A) : Gross Receipt (1+2)	5144.92	15513.72
B	EXPENSES :		
1	Expenditure on seeds,manure & labour etc	3138.19	5006.80
2	Expenditure on manure etc		
3	Expenditure on hired labour (human and bullock)		
		Without Project	With Project
4	Fodder expenses	15% of Item A.1	10% of Item A.1
5	Depreciation on implements	2.7% of Item A.1	2.7% of Item A.1
6	Share and Cash rent	5% of Item A.1	3% of Item A.1
7	Land Revenue	2% of Item A.1	2% of Item A.1
8	Total (B) : Expenses (1 to 7)	3637.24	6201.36
C	NET VALUE OF PRODUCE		
1	Total Gross receipts (Total A.3)	5144.92	15513.72
2	Minus total expenses (Total B.8)	3637.24	6201.36
3	Net Value of Produce (C) : (1-2)	1507.68	9312.36
D	ANNUAL AGRICULTURAL BENEFITS		
1	Net value with project benefits by irrigation (C.3)		9312.36
2	Minus Net value without project by irrigation (C.3)		1507.68
3	Net Annual Benefits (D) : (1-2)		7804.68
E	Other net annual benefits due to aqua-culture including pisciculture, drinking & industrial water supply, hydro - power generation, animal husbandry, catchment area treatment chargeable to project, canal bank plantation, reservoir periphery afforestation		

	Drinking water supply (0.043 TMC or 12.18 lakh cums) as per CWC guidelines and Rs. 10 per KL		121.78
	Fisheries		
	Reservoir area (average of area at FRL & MDDL)	238.60 Ha	
		10000 per Ha	
	Rates as per fisheries Department		
	Benefits		23.86
	Animal Husbandry		
	No. of Cows	12000	
	Yield per cow per month	3960	
	Benefits		475.20
F	Total Net Annual Benefits (D.3 + E) in Lakhs		8425.51
G	ANNUAL COSTS :		
	Total cost of the project including Hydro power generation		39916.47
			39916.47
1	Interest on capital @ 10% estimated cost of the project		3991.65
2	Depreciation Cost		
	Civil works @ 1% of the cost of the project for 100 years life of the project.		181.28
	Rising main @ 3.33% on Rs.4766.98lakhs		158.74
	Pumping Machinery @ 8.33% on Rs.2025.6 lakhs		168.73
3	Annual operation and maintenance charges @ Rs.180 per ha of CCA 6680Ha.		12.02
4	Maintenance of the head works @ 1% of its cost (Barrage)		181.28
5	Power charges @ Rs. 2.36/kW for 8.44 MW		573.65
6	Total(G) : Annual Costs (1 to 5)		5267.36

BENEFIT COST RATIO = Annual Benefits / Annual Costs = 1.60