

**Government of Orissa  
Water Resources Department**



**Report of the High Level Technical Committee  
To Study Various Aspects of  
Water Usage for Hirakud Reservoir**

**August, 2007**

## ***Foreward***

Water is elixir of life. The history has shown us that great civilizations have developed along the rivers/water bodies and some of them have perished due to changing conditions of water availability at these sites. With the fast changing world environment, development needs and increase in population, both human and other living beings, water issues have assumed greater importance and are becoming more sensitive and complex. Though per capita water may be available, its skewed availability in space and time makes it necessary for adequate and appropriate planning for water resources development, conservation, sharing and management.

Orissa is one of the States endowed with ample surface and groundwater water resources in its river systems and the Mahanadi river basin contributes a large share of it. Hirakud is a major project of India started and commissioned after the country's independence and has served the aspirations of the people effectively and efficiently over the last fifty years. Irrigation achieved its full development within a short record time and the area benefited is much more than planned. Industrial development lagged behind in spite of the basin being rich in natural resources. Industrialization has picked up momentum and a number of industries are coming up now in the Ib and Bheden sub basins close to Hirakud reservoir, requiring water from the storage. Though this demand was anticipated in the project planning stage itself, no specific allocation was made for various uses. Flood control remained as the main purpose during monsoon and the reservoir is filled by 1<sup>st</sup> October every year, for meeting demands for irrigation, power generation, industrial needs, municipal water supply and ecological requirements during the post monsoon period.

Water was available in plenty and the irrigation use was unrestricted, leading to less efficiency in water use and consumption of more water. There is considerable scope for system improvement and efficiency, which will permit the water saved for other uses, particularly by the industries which require much less percentage of water compared to irrigation.

In order to have a fresh look into various aspects of water usage from Hirakud Reservoir, a High Level Technical Committee was constituted by the Government of Orissa. The Committee has studied the water availability at Hirakud objectively and analyzed present uses and the additional demands for industries. This report presents the outcome of the study along with suitable

recommendations as well as response on the Terms of Reference. We are sure that the report will be useful for understanding the current status of water availability and water use to be able to handle the issues raised, and promote better and efficient use of the available resources for the development of the region and the State at large.

The Hirakud dam project is truly a 'modern temple of India' as Hon'ble first Prime Minister of India Pandit Jawaharlal Nehru called it and it will continue to be a blessing to the people at large. The Committee wishes to record its appreciation for all the co-operation, assistance and hospitality extended by all concerned, particularly the contribution of the Water Resources Department of the Government of Orissa.

14.08.07

Bhubaneswar

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## **Acknowledgement**

The Chairman and Members of the High Level Technical Committee (HLTC) are grateful to the Government of Orissa for commissioning this study and availing the services of the members in the larger interest of the Project and optimal utilization of available water resource in Hirakud Dam Project. The Committee thanks the Hon'ble Chief Minister of Orissa and the Principal Secretary (Water Resources) for the time given for discussions, which were very useful in appreciating the problems and issues. The Committee wishes to record their appreciation for all the assistance given by the Officers of the Water Resources Department during discussions and supply of the required information/data. The Committee also wish to record their appreciation for the time given by the people's representatives, water users and stakeholders. Thanks are also due to all the officers who organized the meetings, logistics and hospitality.

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**August 2007**

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## *Abbreviations*

HLTC	- High Level Technical Committee
CGWB	- Central Ground Water Board
CWC	- Central Water Commission
DoWR	- Department of Water Resources
MAF	- Million Acre Feet
M cum	- Million cubic metres
BCM	- Billion Cubic Metres
ft.	- feet
mm	- millimeters
m	- metres
sq. km	- square kilometers
Ac	- Acres
ha	- hectare
Re	- Rupee
Rs	- Rupees

## CONVERSION TABLE

Multiply by	To Convert	To	For Opposite multiply by
<b>(a) Length</b>			
25.4	Inches	Milimeters	0.03937
0.3048	Feet	Meters	3.2808
1.6093	Mile	Kilometers	0.6213
<b>(b) Area</b>			
0.0929	Sq. feet	Sq. meter	10.764
6.4516	Sq. inch	Sq. centimeter	0.155
0.404686	Acre	Hectare	2.471
4047	Acre	Sq. meter	0.000247
2.590	Sq. mile	Sq. km	0.3861
640	Sq. mile	Acres	0.00156
<b>(c) Volume</b>			
0.0283	Cubic feet	Cubic meter	35.315
0.1233	Acre feet	Hectare meter	8.111
1233.0	Acre feet	Cubic meter	0.000811
43.560	Acre feet	Thousand cubic feet	0.0229
1233.0	MAF	M. cum	0.000811
1.9834	Cusec day	Acre feet	0.5042
86,39,686.40	Cusec day	Thousand cubic feet	0.01157
<b>(d) Miscellaneous</b>			
2830	Lakh Cusec	Cumec	2.2046
0.00283	Lakh Cusec	Million Cumec	353.35

## **1.0 INTRODUCTION**

### **1.1 General**

Water is the most precious and replenishable resource. Its development and management is of prime concern for any country or region. With the fast growing economic scenario, change in life styles, industrialization, urbanization and for other requirements such as ecology, the competing demand for water has increased many fold. Available supplies are under great duress as a result of high population growth, unsustainable consumption patterns, poor management practices, inadequate investment in infrastructure, lack of maintenance of systems and low efficiency in water use. Apart from quantity, quality of utilizable water is also deteriorating in the absence of adequate policy initiatives and constraints in implementation.

### **1.2 National and State Water Policy**

1.2.1 In order to guide and control the development and management of water, Government of India adopted the National Water Policy in the year 1988, which was subsequently modified in 2002 and has been circulated to all the States. Depending upon the resource availability, development pattern and priorities, the Government of Orissa formulated the State Water Policy in 1994 and revised in March 2007, taking into account all the emerging factors. It lays down principles for wise and judicious use of water for survival of life, welfare of human beings and sustained as well as balanced growth of the State. The State water plan has been formulated for a period covering up to 2051 when the population is expected to stabilize. Differing from the National Water Policy, the following priority for allocation of water has been adopted by the State:

- Drinking water and domestic use  
(human and animal consumption)
- Ecology
- Irrigation, agriculture and other related activities  
including fisheries
- Hydro power
- Industries including Agro Industries
- Navigation and other uses such as tourism

Any alteration in the above mentioned priorities will demand formulation of a new policy.

1.2.2 The hydrological unit of a basin has been considered as the unit for development and management of water resources, starting from primary watersheds to sub catchments and catchments integrated into sub-basins and basins. The salient features of the 11 major river basins of Orissa have been presented in the State Water Policy and that of Mahanadi basin are appended here as **Annex- A**.

### **1.3 General Water Resources of Orissa**

1.3.1 Orissa is one of the few States of the country endowed with abundant water resources in its network of rivers and streams (**Fig -1**). Annual rainfall varies from 1200 mm in the coastal plains to 1700 mm in the northern plateau with a long term annual average of the State of the order of 1452 mm. The 11 major river basins have substantial water resource, borne out by the fact that Orissa has 11% of the water resources of the country for supporting a population of only 4% (2001 census), while India has to sustain 16% population of the world with only 4% of the global water resource. The overall annual availability of free surface water in Orissa is about 120.40 BCM (82.84 BCM from its own territory). The total replenishable ground water of the State has been assessed (2001) at 21.011 BCM of which 12.607 BCM is safe and usable.

1.3.2 In terms of average per capita water availability (both surface and ground), the State has 3359 cum per year, as compared to national average of 1820 cu.m. With the projected future population of Orissa State, the per capita would reduce to 2218 cum in 2051, which is much above the water stressed condition of 1700 cum, and 1000 cum considered as water scarce condition. However, some smaller basins could reach water stressed condition due to higher population density and the skewed availability in space and time.

1.3.3 The Mahanadi is the largest and vital river basin (**Fig -2**) of the State. Out of the overall catchment of 1,41,134 sq. km, the River Mahanadi has 65,600 sq. km in Orissa, which is 42.15% of the geographical area of the State. Mahanadi annual flows account for 59.16 BCM (29.90 BCM from catchment in Orissa), about 49% of the total water availability, of which, the flows from outside flowing into the State is estimated to reduce by 8.1 BCM by 2051. The contribution of the Mahanadi, in terms of the potential of the State, is 43.80 BCM at 75% dependability. While three large dams were

planned in the basin, only Hirakud Dam Project has been constructed and commissioned in 1957, which is the first multipurpose Project of this magnitude in the post independence era of India.

1.3.4 Surface storages are essential component of development in view of the high variability in availability of water in space and time. Orissa has developed a storage of 16.16 BCM in projects (Major 14.86 BCM and medium 1.30 BCM and another 1.47 BCM will be added from ongoing projects. Out of this, Hirakud contributes about 50%, having a gross storage of 8.13 BCM (6.6 MAF), of which the live storage is 5.82 BCM (4.72 MAF). As such, the importance of Hirakud Dam Project and its proper management as a life line of Orissa needs no emphasis. Due to sedimentation over the period of 50 years, the live storage has reduced to 4.47 BCM (3.77 MAF), the loss being 20.12%.

1.3.5 The demand pattern for water from various sectors is changing rapidly. It is likely that the total water demand may increase to 84.463 BCM from the present usage of 55 BCM. Keeping in view the constraints of water availability, the variety/priority of uses, the sensitivity and complexity of water issues, water allocation needs to be addressed prudently. The present and projected future water requirement for all purposes has been assessed by the water resources department as given in **Table -1**.

**Table -1** Water requirement for different uses (in BCM) for Orissa

Uses	Year -2001			Year -2051		
	Surface	Ground	Total	Surface	Ground	Total
Domestic	0.798(1.97)	1.198	1.996 (3.63)	1.202 (1.87)	1.803	3.006 (3.56)
Agriculture	18.000 (44.4)	4.688	22.688 (41.25)	40.000 (62.4)	9.408	49.408 (58.5)
Industry	0.606 (1.50)	0.100	0.706 (1.28)	1.750 (2.73)	0.200	1.950 (2.31)
Environment	21.000 (51.8)	8.400	29.400 (53.5)	21.000 (32.7)	8.400	29.400 (34.8)
Others	0.100 (0.25)	0.100	0.200 (0.36)	0.200 (0.31)	0.200	0.400 (0.47)
Total	40.504 (100)	14.486	54.990 (100)	64.152 (100) (58.3)*	20.010 (38.1)*	84.463 (100) (53.59)*

\* Percentage by which present level of requirement gets increased by 2051.

Figures in brackets indicate percentage of the total

Taken from Annual Report 2006-2007, DoWR, Govt. of Orissa : Table 2.4

## **1.4 Constitution of High Level Technical Committee (HLTC)**

1.4.1 The Hirakud reservoir has been in operation effectively over the last fifty years for flood control, irrigation, power generation and other uses. With the availability of abundant basic natural resources in this region and the recent boom in industrialization, demand for water for industries from Hirakud reservoir has increased considerably. In order to study the various aspects of water usage from Hirakud reservoir, a High Level Technical Committee has been constituted by the Government of Orissa vide No.19692/WR, Irr-II HKW-11/07 dated 22.06.2007(**Annex- B**). The HLTC comprises of:

Er.R.Jeyaseelan, Retd. Chairman, CWC	- Chairman
Er.S.Patri, Retd. Chief Engineer, WR	- Member
Prof.K.C.Patra, NIT, Rourkela	- Member
Er.Sisir Rao, Chief Engineer, WR	- Member
EIC, WR	- Member, Convenor

However, Er.Sisir Rao, Chief Engineer, D&R did not participate as a member of the Committee since he retired from Government Service.

1.4.2 The Committee met three times during (i) 2<sup>nd</sup> to 4<sup>th</sup> July, 2007 (ii) 17<sup>th</sup> to 21<sup>st</sup> July, 2007 and (iii) 9<sup>th</sup> to 13<sup>th</sup> August, 07. The Committee visited the Project area accompanied by the officers of the Water Resources Department. All the relevant and available data were collected from the Project authorities and analyzed. Extensive discussions were held with the field officers of the Water Resources Department, State Directorate of Groundwater Survey and Investigations, Directorate of Agriculture, Central Ground Water Board and the Central Water Commission. Interactive sessions were held with the local bodies, legislators, stakeholders and water users. Brief of the three meetings of the Committee is attached as **Annex -C**.

## **2.0 GENERAL FEATURES OF THE PROJECT**

### **2.1 Brief History**

2.1.1 The Mahanadi, literally meaning the great river, is the largest river flowing through the State of Orissa. Devastating floods occurred frequently in the delta region crippling the economic development. After high floods in

1855, studies were initiated by Capt. Haris suggesting five dams for flood control, but were dropped as it did not meet adequately the irrigation and navigation benefits. After the high floods in 1937 Sri. M.Visveswaraya advised to take up detailed investigations for preparing plans for construction of storage dams for flood control and other uses. The recommendations of the Flood Advisory Committee (1938-42) were accepted in the Flood Conference of 1945 at Cuttack. Subsequently a proposal was made by CWINC (now CWC) in 1947, suggesting three dams i.e. at Hirakud, Tikarpara and Naraj, of which Hirakud was started in 1948 and inaugurated by Hon'ble Pandit Jawaharlal Nehru, the first Prime Minister of India on 13<sup>th</sup> Jan, 1957. Filling of the reservoir started in 1956. Power generation, flood control, domestic water supply and irrigation were started from 1957, irrigation achieving full potential by 1966.

## 2.2 Project Components

2.2.1 The Mahanadi river basin can be broadly classified into upland plateau, the central part flanked by eastern ghats and the delta area. Hirakud Dam is in the central zone. It comprises of 500 m. left and 648 m. right concrete spillways and power dam, connected by 3.65 Km. long main earth dam, 2298m on the right and 1353 m. on the left, five left dykes totaling 9.34 Km., right earthen dyke 10.76 Km. Outlet provisions include 40 sluices (3.658 m. x 6.20 m.) and 21 spillway spans (15.54 m. x6.10 m.) in the left concrete dam and, 24 sluices and 13 spillway spans on the right respectively. Three canals take off from the reservoir as below:

**Table -2** Hirakud project canals

	Length (Km)	Discharge (cumec/cusec)	Irrigation (Ha/Ac.)
Bargarh Canal	88	108.21/3818.5	1,33,539/3,30,048
Sambalpur Distributary		3.40/18.0	4,099/10,131
Sason Canal	22	17.84/614.0	21,468/53,058
<b>Total</b>		<b>129.45/4450.5</b>	<b>1,59,106/3,93,237</b>

2.2.2 The Project command area is served by the three canals. The project provides now irrigation up to 1,59,100 ha (3,93,295 Ac) in Kharif and

1,06,820 ha (2,64,012 Ac) in Rabi seasons against the designed ayacut of 1,53,750 ha (3,80,000 Ac) and 76,875 ha (1,90,000 Ac) respectively. The coverage under Rabi is 67% of the command area against 50% anticipated in the original design and 95% of the area covered with high yield variety paddy, which was to be limited to only 70% of Rabi area. Total water utilized for irrigation from October to May is, on an average, 1622 M.cum. (1.348 MAF). The command area is shown in **Fig -3**.

2.2.3 The dam toe power house has an installed capacity of 275.86 MW and another 72 MW at Chiplima at the end of the power channel, 22.4 km long. Salient features of the Hirakud Dam Project are given in **Annex- D**.

### 2.3 Existing reservoir operation

2.3.1 Hirakud Dam Project is primarily planned for flood control/management. The conservation storage of the reservoir is filled at the end of monsoon season for other uses. Since commissioning in 1957, it has performed satisfactorily in serving the different purposes as envisaged.

2.3.2 Flood control demands empty storage space to absorb the flood for regulated release, whereas, power generation and irrigation require the reservoir to be maintained at higher level. The joint use of the storage space between non-compatible demands is achieved by judicious selection and reservoir filling by the Rule Curve with some calculated risk. During monsoon months, appropriate lower reservoir levels are maintained with every effort taken to achieve a Full Reservoir Level by the end of September for maximizing the benefits during non-monsoon.

As per the original project report (1953), the reservoir was to be maintained at Dead Storage level to utilize the full live storage space for flood control up to 1<sup>st</sup> September and impoundment was to commence thereafter for filling up to full reservoir level by the end of October. Considering non-filling of the reservoir in a number of years for meeting the higher demand for irrigation and power generation, the filling schedule has been reviewed and revised from time to time based on the recommendations of different Committees set up by the Government. Current Rule Curve (**Fig -4**) followed since 1988 recommends upper and lower limits of levels within which the reservoir is to be maintained at particular periods of the monsoon, so that there is 90% chance of the reservoir getting filled up at the end of the monsoon. For flood control, inflow forecasts and pre-depletion are adopted

for getting more space for flood absorption. Above R.L. 625.00 ft the safety of the dam is prime consideration for operation of the reservoir.

For flood control, releases from the Hirakud are to be so regulated that the release combined with the runoff from the uncontrolled catchment below the dam remains within safe limit of 28,300 cumec (10.00 lakh cusec) at Naraj/ Mundali, the delta head of river Mahanadi. Chief Engineer and Basin Manager, Upper Mahanadi Basin, with headquarter at Burla, is in charge of operation of the reservoir. The project maintains gauging network both in upstream catchment and downstream basin to get information on rainfall and stream flow data on real time basis. Mahanadi Division of CWC at Burla also issues 24 hr forecast of average inflow into Hirakud reservoir. Using the operation model developed, the project authorities operate the sluices and the gates of the spillways.

In the pre-construction period, as per recorded data from 1868 to 1946, (in 79 years) there were 63 floods exceeding safe limit of 28,300 cumec (10.00 lakh cusec) at Naraj, which is nearly 8 floods in 10 years. In post Hirakud period, this has been reduced to nearly 3.30 floods in 10 years, which is substantially lower compared to pre-construction period. The dam enables excellent protection for floods of lesser magnitude.

2.3.3 The irrigation area served by the Hirakud Project is already given in para 2.2.2. In addition, water released from power generation is utilized to provide irrigation to Delta Stage-I and Stage-II area as given below.

Stage	Area of irrigation Ha (Ac)		Water requirement MCM (MAF)	
	Kharif	Rabi	Kharif	Rabi
Delta Stage-I	1,67,000 (4,12,800)	1,00,960 (2,49,573)	965 (0.78)	949 (0.77)
Delta Stage-II	1,36,000 (3,36,190)	67,622 (1,67,160)	786 (0.64)	636 (0.52)

2.3.4 With the original installation of 270 MW (including 24 x 3 = 72 MW at Chiplima), average annual power generation from the project was around 956 M.units (up to 1992), against the designed target of 1050 M.units. Now, with the addition of the 7<sup>th</sup> unit of 37.50 MW capacity, up gradation of the

two units of 37.50 MW to 49.50 MW and two units of 24.00 MW to 32.18 MW at the dam toe power house, the installed capacity has increased to 347.86 MW. The average annual power generation has gone up to around 1000 M.units. The stage-II powerhouse at Chiplima with 72 MW installed capacity is suffering from the problem of weed growth in the channel and chocking of trash racks leading to its failure, rendering only one unit in operation. The average generation from this powerhouse for the last five years is only around 10 MW. This needs attention on priority for a solution.

## 2.5 Municipal Water Supply

Municipal water supply during non-monsoon period is only a small component of 0.004 MAF to a few nearby towns only.

## 2.6 Industries

The actual water supply drawn by the industries from Hirakud reservoir and upstream is still very small, though sanctions have been issued so far is about 0.316 MAF and applications for another 0.183 MAF are pending.

## 3.0 Rainfall and Water Availability

### 3.1 Basin rainfall

3.1.1 State-wise catchment area distribution at different important locations such as at Hirakud, Naraj/Mundali and overall are given in **Table-3**.

**Table -3** Mahanadi River Basin : Distribution of catchment area (State-wise break up of catchment area)

State	Area in sq. km (sq. mile) and % of total	
	Catchment up to dam	Total Catchment
Chatisgarh	74,970 (28944) - 89.9	74,970 (74970) - 52.9
Madhya Pradesh	130 (50.2) - 0.1	130 (50.2) - 0.1
Maharashtra	250 (96) - 0.3	250 (96) - 0.2
Bihar	650 (251) - 0.8	650 (251) - 0.5
Orissa	7,400 (2857) - 8.8	65,600 (25329) - 46.3
Total	83400 (32200) - 100.0	141600 (54672) - 100.0

Major tributaries upstream of Hirakud are the Pari and Jonk on the right bank and the Seonath, Hasdeo, Mond and Ib on the left bank. The Ong, Tel, Suktel join downstream of Hirakud. Orissa is blessed with fairly good rainfall as indicated in para 1.3.1. When the original project report for Hirakud Reservoir was prepared in 1947, there were 23 rainfall stations above Sambalpur and 16 below. The mean annual rainfall above Sambalpur was 1381 mm (54.3”), the maximum and minimum being 1809 mm (71.21”) and 940 mm (37.02”) in the year 1902 and 1919 respectively. In the revised project report (1953), a total of 105 rain gauges were considered, out of which 66 were in the catchment above Sambalpur. Annual average, maximum and minimum rainfall over the Hirakud Catchment worked out to 1369 mm (53.9”), 1804 mm (71.03”) in 1919 and 889 mm (34.99”) in 1902 respectively considering 61 years data from 1891 to 1951 (**Table -4**).

**Table -4** Average monthly rainfall and runoff of Catchment above Hirakud  
(Pre-construction period – from revised project report -1953)

Month	Rainfall inches (cm)	Runoff MAF (MCM)	Mean monthly Temperature (deg. F)
January	0.548 (1.39)	0.223 (274)	68.31
February	1.027 (2.61)	0.204 (252)	72.54
March	0.754 (1.92)	0.150 (168)	80.85
April	0.700 (1.78)	0.121 (149)	88.63
May	0.755 (1.92)	0.094 (115)	93.74
June	7.968 (20.23)	1.156 (1426)	89.32
July	15.680 (39.82)	9.538 (11770)	82.10
August	15.198 (38.60)	15.215 (18775)	81.66
September	8.253 (20.96)	9.330 (11513)	82.69
October	2.275 (5.78)	2.519 (3108)	80.11
November	0.470 (1.19)	0.867 (1070)	72.46
December	0.166 (0.42)	0.338 (417)	67.72
Total (Monsoon) (June to September)	47.099 (119.63)	35.239 (43849)	
Total (Non monsoon) (Oct.to May)	6.695 (17.00)	4.416 (5449)	
Total Annual	53.794 (136.64)	39.755 (49058)	Average 74.01

Note:

1. Rainfall considered for 66 stations in catchments for the period 1891-1951(61 years)
2. Runoff series 1926 to 52 (27 years), out of which 1926 to June 1946 deduced from stage discharge curve of 1946 – 48 and rest actual observation.
3. Mean monthly temperature for Sambalpur for 1900 to 1952 (53 years)

Average monsoon (June to October) rainfall of Hirakud catchment in post Hirakud period is 1142 mm, which is about 90% of the total annual rainfall. Average monthly rainfall, runoff, irrigation, power and spill in the post Hirakud scenario are shown in **Table -5**. The monsoon sets in around mid June and recedes around the second week of October. The reservoir operation is to take into consideration rainfall variations in space and time to meet the conflicting requirements of flood control and the conservation storage.

**TABLE - 5 AVERAGE MONTHLY RAINFALL (U/S & D/S), RUNOFF, IRRIGATION, POWER AND SPILL- POST HIRAKUD FROM 1959-2006**

Month	Average monthly (U/S) rainfall in mm	Average monthly (D/S) rainfall in mm	Average monthly runoff in MAF	Average monthly Irrigation in MAF	Average monthly Power in MAF	Average monthly spill in MAF	Average monthly Evp. Loss in MAF
1	2	3	4	5	6	7	8
<b>January</b>	N.A.	N.A.	0.192	0.167	0.474	0.018	0.031
<b>February</b>	N.A.	N.A.	0.140	0.183	0.419	0.021	0.035
<b>March</b>	N.A.	N.A.	0.100	0.221	0.488	0.013	0.055
<b>April</b>	N.A.	N.A.	0.070	0.214	0.506	0.012	0.064
<b>May</b>	N.A.	N.A.	0.044	0.049	0.491	0.004	0.066
<b>June</b>	156.24	149.27	1.041	0.056	0.518	0.400	0.049
<b>July</b>	366.42	362.48	5.964	0.161	0.906	4.062	0.046
<b>August</b>	357.71	362.48	9.937	0.170	1.057	6.664	0.051
<b>September</b>	194.54	207.16	6.720	0.195	0.974	4.304	0.064
<b>October</b>	47.37	82.32	1.918	0.220	0.778	0.943	0.052
<b>November</b>	N.A.	N.A.	0.537	0.061	0.559	0.047	0.040
<b>December</b>	N.A.	N.A.	0.247	0.089	0.487	0.006	0.032
<b>Total</b>			<b>26.910</b>	<b>1.786</b>	<b>7.657</b>	<b>16.494</b>	<b>0.585</b>

3.1.2 The post-construction records available with the Hirakud Dam Authority show that the maximum monsoon rainfall over the catchment of the Mahanadi up to Hirakud is 1928.42 mm in 1961 and the minimum rainfall is 691.46 mm in 1979.

### 3.2 Surface water availability

3.2.1 The runoff from rainfall over the years has been shown in **Fig -5** and it varies between 54.78% (max. in 1961) to 17.95% (minimum in 2002). The

monsoon rainfall between 1959 and 2006 shows that the 75% dependable value of Mahanadi catchment up to Hirakud is 934.33 mm and runoff (inflow) at Hirakud is 298.51 mm (20.183 MAF). The rainfall – runoff ratio is 31.95% which is quite reasonable. Seventy five percent level of confidence is the standard adopted by the Government of India as success for water resources projects for irrigation purposes. Against this water available, the storage capacity of the reservoir is as given below, indicating that the reservoir could be full at the end of monsoon by suitable operation.

**Table – 6** Hirakud reservoir storage capacity

Storage capacity In MCM (MAF)	Original (1957)	Revised (2000)
Gross	8136 (6.60)	5896 (4.78)
Live	5818 (4.72)	4823 (3.91)
Dead	2318 (1.88)	1073 (0.87)

As per the available data, average annual runoff into the reservoir is 33,000 M.cum (27.00 MAF), which ranges from a maximum of 90,900 M.cum (73.63 MAF) in 1961 to a minimum of 11,330 M.cum (9.183 MAF) in 2000. Considering past 25 years 1982-83 to 2006-07, the average annual runoff of 25.317 MAF comprises average inflow of 21.715 MAF during the monsoon period and balance 3.602 MAF during non-monsoon period. The 75% dependable runoff for the non-monsoon period works out to 1.980 MAF. Reservoir filling at the end of Monsoon is shown in **Fig -8**. During this period, only in 6 years the reservoir was not filled up to Full Reservoir Level on account of maintaining the reservoir level as per recommended rule curve to facilitate flood control. However, only one year i.e. 2000-01 can be considered as significant non filling year as the reservoir level was down to 617.02 ft.

- 3.2.2 After commissioning of Hirakud Project, a number of major, medium and minor water resources projects have come up in the upper catchment leading to the changed inflow pattern at the dam site. Therefore, the inflow runoff series at the dam has been considered split up into two parts; (i) the initial 25 years up to 1982 and (ii) the later 25 years from 1982 to 2006 as given in **Tables -7 and -8**. The two segments of yield series give the following (**Table -9**) dependable inflow values.

**Table -9** Reservoir inflow dependability

Sl.No	Series From - To	Average inflow (MAF)		75% Dependable inflow (MAF)		90% Dependable inflow (MAF)	
		Monsoon	Non Monsoon	Monsoon	Non Monsoon	Monsoon	Non Monsoon
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	1982- 2006	21.715	3.601	16.468	1.980	12.381	1.562
2	1959- 1981	25.547	2.750	16.174	1.342	11.603	0.690
Percentage increase			23.65		32.22		55.80

The two series give nearly the same inflow values at 75% and 90% dependability in their monsoon total flows. However, the non-monsoon inflows (October – May) for the later 25 years (1982 – 2006) segment are observed to be higher than the corresponding previous segment values for the given dependability, perhaps due to changes in land use, some changes made in the reservoir elevation – capacity curves from time to time and increasing return flows from projects constructed upstream.

3.2.3 The reservoir Elevation Vs Capacity adopted since the year 2002 is shown in **Fig -9**. When compared with the revised live capacity of 3.77 MAF at FRL (630.0 ft.), the reservoir inflow to reservoir capacity ratio is very high (*over five times*) and therefore, there should not be any apprehension of short supply of water to fill the reservoir during monsoon months from June to September. Details of the inflow series at the dam for monsoon and non-monsoon months are included in **Tables -7 and 8**.

3.2.4 While there has been spill of water from Hirakud reservoir in the monsoon months during all the 50 years of the existence of the dam, the dependable inflows during non-monsoon months are critical for meeting the targeted water requirements from various sectors such as irrigation, hydropower generation, municipal water needs, industrial water supply, fishery, and other uses. Spill (sluices + flow over the crest) from the dam of 2.747 MAF was the minimum during the monsoon of 1979 and the maximum spill of 54.743 MAF occurred in 1961. The average spill over the last 50 years is 16.494 MAF. There has not been any year in the history of

the dam when spilling of water did not take place. As such, it is possible to fill the reservoir to Full Reservoir Level at the end of the monsoon every year by judicious operation.

3.2.5 By considering the reservoir to be full on 1<sup>st</sup> October, the water availability for use by various sectors such as irrigation, hydropower generation, domestic water supply, industrial use and others is the sum of the dam live storage plus the monthly inflows available at the dam site from October to May. Inflow into the reservoir is being calculated as the sum total of the outflow and the change in storage. The total outflow includes releases through sluices and over spillway crest, withdrawal for power generation, for irrigation through the three canals, withdrawal for other purposes and evaporation loss from the reservoir. Evaporation loss is computed from the average area of the reservoir and the average pan evaporation depth observed at the nearest meteorological observatory at Hirakud. Typical average pan evaporation rates observed are given in **Table -10**. Discharge through the sluices and over the spillways is computed from the formulae based on model study reports. Discharge for power is calculated from the power generation during the period considering the average head. Change in storage is calculated from the Area-Capacity curves/tables for the reservoir, which have been modified in 1988 and 2002 taking into consideration the results of sedimentation survey of the reservoir (**Fig -9**).

**TABLE – 10** Monthly Pan Evaporation  
(IMD Observatory at Hirakud Research Station)

Sl.No.	Month	Average Monthly Evaporation 1974 to 1995 ( 22 Years)	
		(mm)	(inches)
1	January	57.00	2.25
2	February	81.82	3.22
3	March	132.97	5.23
4	April	176.50	6.95
5	May	204.46	8.05
6	June	145.92	5.74
7	July	78.49	3.09
8	August	72.98	2.87
9	September	84.90	30.34
10	October	89.49	3.52
11	November	66.68	2.62
12	December	48.89	1.92
<b>Total</b>		<b>1240.10</b>	<b>48.80</b>

3.2.6 Considering the monsoon and non-monsoon inflow series from 1982 to 2006, water available at 75% dependability is 5.750 (3.770 + 1.980) MAF while that at 90% dependability is 4.941 (3.379 + 1.562) MAF during non-monsoon period from Oct. to May.

3.2.7 Reservoir sedimentation study was conducted by CWC by remote sensing technique in 1995. The Gross Storage and Live Storage of the reservoir were found to have reduced to 6,145 M.cum (4.98 MAF) and 4,934 M.cum (4.00 MAF) respectively. The average loss of gross, live and dead storages was computed to be 0.64%, 0.41% and 1.22% per annum respectively. At this rate of sedimentation, live storage capacity of the reservoir at present (2007) would be 4,647 M.cum (3.77 MAF). The loss in live storage in 50 years is 20.12%. The rate of loss of storage reduces with time compared with the initial years of observation.

### 3.3 Groundwater resource

3.3.1 Groundwater plays an important role in Agriculture sector in India. The Central Ground Water Board (CGWB) carried out an extensive assessment of the ground water resources in Hirakud Project command area in 1998 and brought out a detailed report of the study.

3.3.2 The data collected from 129 key observation wells show that water table in the command area varies between 0.80 m to 9.70 m below the ground surface during May and 0.30 m to 4.00 m below ground surface during November. The topography, infiltration from heavy rainfall, seepage from unlined canals, excessive use of irrigation water, very little development/use of groundwater, prevailing massive paddy cultivation by flooding are the major factors contributing to progressive development of water logging in the area. Water logging of any area is said to have occurred when the ground water table is less than 2.0 m below the ground surface. During pre-monsoon, the waterlogged area was observed to be 174 sq. km (17,400 ha) and 1494 sq. km (14,940 ha) during November '94. A study carried out by NRSA Hyderabad in April 2004 indicates 592 ha as surface water logged area with water table at 0 m. i.e., at the ground level. Long term behaviour of the water table indicates a generally rising trend in the command area. Ground water from shallow as well deep aquifers are generally fresh and suitable for drinking and irrigation purpose. (Para 3 at page ix – Ref: 5). It is pertinent to note that the streams and rivers in this area are effluent in nature

indicating very good groundwater recharge and release. There is no ground water quality problem in the Hirakud command area. The present position of the ground water availability and uses in the command area are given in **Table –11** below:

**Table -11** Groundwater resource in Hirakud command area

Sl. No	Utilisable GW Resources during Kharif (June to October)				Utilisable GW Resources during Rabi (November to May)			
	Available in MCM (MAF)	Present Draft in MCM (MAF)	Balance in MCM (MAF)	Percentage Utilisation	Available in MCM (MAF)	Present Draft in MCM (MAF)	Balance in MCM (MAF)	Percentage Utilisation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	508.44 (0.4122)	2.35 (0.0019)	506.09 (0.410)	0.46	764.44 (0.620)	4.25 (0.00344)	760.09 (0.6162)	0.56

3.3.3 In Hirakud command, development of ground water is feasible through dug wells as well as bore wells, the former being better suited for this area. Demand for water for 200% irrigation intensity can be met from surface water (90%) and supplementary use of ground water (10%). For meeting the additional demands of water, a total of 17,526 dug wells are required as assessed by CGWB. These should be constructed in the identified command area suitably. Conjunctive use of surface and ground water resources shall be planned to mitigate water logging and optimal use of water resources. Action for the development of shallow ground water has to be made for not only achieving sustainable irrigation system but also for overcoming the deleterious effects of rising water table and associated problems like water logging that leads to salinity and alkalinity. In the proposed conjunctive use plan 200% of crop intensity from the existing 170% is possible with changed cropping pattern, with Kharif and Rabi seasons almost at par with the cropping patterns envisaged in the original project report.

3.3.4 Apart from the Hirakud command, groundwater resource in the delta region is also relevant in view of the Stage –I and Stage –II irrigation. It is understood that substantial groundwater is available within 2m below ground level and nearly a third of the irrigated area is facing water logging and drainage congestion, necessitating consideration of conjunctive use of groundwater.

## 4.0 Flood Control and Water Use

### 4.1 Flood control

Though the Hirakud dam was planned for planned for flood control, the post-monsoon regulated releases from the reservoir fulfills the aspirations for irrigation, power development and other uses. Water use from Hirakud reservoir can be distinctly divided to two periods, Monsoon and Non-monsoon. During monsoon period, there is sufficient flow. The total live storage of the reservoir 4,647 M.cum (3.77.MAF) is only 17.40% of the average monsoon runoff of 26768 M.cum (21.715 MAF). The prevailing Rule Curve aims to fill up the reservoir in 90% of the years up to full reservoir level by 30<sup>th</sup> Sept. In the last 25 years the reservoir was not filled up in 6 years (20% cases). Except one year (2000-01), the deficit in storage was very marginal.

The storage available at the end of monsoon, along with the available runoff in the non-monsoon period is utilized for irrigation, power generation, industrial use and domestic water supply up to onset of next monsoon. Hirakud Coordination Committee, under the Chairmanship of the Commissioner cum Secretary to Govt. and the Dept of Water Resources decide each year the working table to be followed during the non-monsoon period considering the monsoon end storage available, anticipated inflow, probable evaporation loss, requirement for irrigation, power generation etc. Average utilization for power and irrigation during the monsoon period (June to September) is 3,947 M.cum (3.202 MAF) and 686.60 M.cum (0.557 MAF) respectively.

### 4.2 Irrigation

4.2.1 So far, the reservoir storage has been used extensively for irrigation and, the potential already developed and utilized is substantially more than the provisions made in the project report. Development of Irrigation is shown in **Fig -10** and the water supplied for irrigation over the years is shown in **Fig -11**. There is considerable deviation in the existing cropping pattern from the pattern envisaged in the Project Report, predominantly resorting to paddy cultivation over 98% of the area (**Table -12**). The quantum of water supplied is seen to be steadily on the rise for the same level of irrigated area indicating reduction in efficiency of water use.

**Table -12** Cropping pattern

Crop	As per Project Report		As Existing
	(1952)	% of CCA	% of CCA
<b>Kharif</b>			
1. Paddy	70		98
2. Sugarcane	10		1.3
3. Cotton	5		-
4. Other crops	15		0.7
<i>Total</i>	<i>100</i>		<i>100</i>
<b>Rabi</b>			
1. Paddy	33		60
2. Medium Rabi	8		3
3. Light Rabi	7		7
<i>Total</i>	<i>48</i>		<i>70</i>
<b>Grand Total</b>	<b>148</b>		<b>170</b>

4.2.2 The irrigated area has increased and paddy cultivation is much more than planned requiring higher water allocation. Moreover, it can be observed from **Tables -7 and -8** that the average withdrawal for irrigation for non monsoon period (considered from October to May) during the last 25 years has increased to 1.364 MAF against the average withdrawal of 1.25 MAF during 1967-68 to 1981-82 (after development of irrigation in full), which indicates over application of water.

4.2.3 Water released from the dam toe power house flows down to provide irrigation to 1,36,000 ha in Delta Stage –II and stabilization of irrigation to 1,67,000 ha of Delta Stage –I. Details of water requirement is given in para 2.3.3.

#### 4.3 Power generation

Power is generated at the dam toe power house with 272.87 MW installation and part of the water is taken through a canal for additional

power generation at Chiplima. While dam toe power house has been generating planned level of power, Chiplima is suffering due to weeds and failure of trash racks generating only about 15% of its capacity. Average withdrawal for power generation in non-monsoon period during the last 25 years is 4.547 MAF. This varies from 1.383MAF in the worst year 2000-01 to 6.507 MAF in 2003-04 depending upon available storage and the inflow during the non-monsoon period. Power generation over the years is depicted in **Fig -12**.

#### 4.4 Industry

4.4.1 It was contemplated in the project planning period that Hirakud Project would provide water and power for irrigation and industries all the year around. Irrigation developed much faster achieving the anticipated potential within a few years, but the pace of industrial development lagged behind, which is gaining momentum now in the global environment of industrialization. According to the procedure followed, application is made by the industries to the Water Resources Department and after due examination, permission is given for withdrawal of water under compliance of certain conditions. Water use for existing industries and pending applications are shown in **Table -13**.

4.4.2 As per the information received from the Engineer in Chief, Water Resources Orissa, as on date 15 industries have been permitted to draw 436.215 cusec (12.35 cumec) of water from Hirakud reservoir, which works out to utilization of 0.316 MAF per annum. Applications from five more industries, for withdrawal of 253.39 cusec (7.17 cumec), which works out 0.183 MAF are pending for consideration. The total demand thus is for utilization of 0.499 MAF per annum. It may be mentioned that vide letter no. 40345 dt. 26<sup>th</sup> Nov 90 (**Annex –E**) Dept of Irrigation, Govt. of Orissa had decided for utilization of 0.35 MAF of water for use of industries, thermal power plant etc. The present demand is higher than this. However, at present withdrawal from the reservoir for industrial use is just 75.20 cusec (2.13 cumec), which works out to utilization of only 0.0545 MAF per annum.

#### 4.5 Municipal water supply

Part of Sambalpur town, Burla town and Hirakud town are getting water for municipal supply from Hirakud reservoir through the existing outlets provided in the dam. Towns like Brajaraj Nagar and Belpahar

situated in the reservoir periphery also draw their municipal water demand from the Hirakud reservoir. Present use is about 0.006 MAF per annum, of which 0.004 MAF is drawn during non-monsoon period.

## **5.0 Water Requirement for Various Uses**

### **5.1 Municipal water supply**

Municipal water supply is a very small component of water use, being only 0.004 MAF during non-monsoon period (Oct. to May). Supply could be made from canal or from ground water resource which is not yet tapped.

### **5.2 Irrigation**

5.2.1 Irrigation requirement forms the major component of water use from the reservoir during the post-monsoon period, say from 1<sup>st</sup> October onwards. Generally the crop periods are from 15<sup>th</sup> June to 30<sup>th</sup> October for Kharif and 15<sup>th</sup> December to 30<sup>th</sup> April for Rabi with marginal possible shift of about 15 days on either side depending on the monsoon conditions and the post monsoon flows available. Progressive development of irrigation command is shown in **Fig-5** and **Tables -7 and -8**. The command area already developed and being served is about 1,59,100 ha (3,95,295 Ac) during Kharif (4.0% more) and 1,06,820 ha. (2,64,012 Ac) during Rabi (39% more), total being 2,65,920 ha (6,59,309 Ac), 15.57% more than the command originally planned for. Independent studies by NRSA (Ref-6) also confirmed the area coverage under Rabi in the year 2001-2002 to be 1,02,591 ha (2,53,502 Ac) and 1,15,481 ha (2,85,353 Ac) in the year 2006-07.

5.2.2 After 1<sup>st</sup> October, shortfall of water requirement over and above the reservoir inflows are drawn from the reservoir storage, generally built up to El.630.0 (FRL) by then. Water requirement for tail end one month of Kharif and full Rabi requirements would have to be duly provided for, which works out to 0.263 MAF for Kharif and 0.917 MAF for Rabi, total being 1.18 MAF. With improvement of efficiency and utilizing the untapped rich ground water resource this requirement could be managed with not more than 1.0 MAF from surface water. Any additional area to be brought under irrigation during Rabi could be taken up only with suitable crop diversification and development of groundwater.

5.2.3 The irrigated area in the delta region is 1,67,000 ha in stage -I and 1,36,000 ha in Stage -II, which requires about 1974 M.cum (1.59 MAF) of water during the period Oct. to May. Releases from the power generation is 3,693

M cum (3.001 MAF) after allowing projected diversion of 616.60 M cum (0.500 MAF) annually for industrial use. Average run-off available at Delta head as assessed from the run-off at Tikarpara site (Ref. 7) for the period Oct. to May works out to 9905 M cum (8.01 MAF). Lowest observed discharge at Tikarpara during 2003 – 2004 was 217 cumec. With 90% dependable discharge of 250 cumec, the run-off from Oct. to May works out to 5184 M.cum (4.20 MAF). Allowing diversion of 0.334 M cum (0.5 MAF) per annum for industrial use, the balance availability reduces to 4677 M cum (3.866 MAF), which is adequate to meet the requirements for irrigation, industrial and municipal supply in the downstream areas (**Annex -G**).

5.2.4 In view of the high groundwater table, drainage congestion and water logging problem in about a third of the irrigated area in the delta region, conjunctive use of groundwater needs to be considered.

### 5.3 Industry

The list of Industries already granted permission to draw water, actual water drawn on-date and Industries pending permission is contained in **Table -13**. As already stated, the reasonability of the water demanded by the Industries need to be checked up and confirmed by relevant department. Industries generally have over 80% regenerated water for reuse by recycling, which shall be made compulsory and, only consumptive use and evaporation loss needs to be drawn from the reservoir. Disposal of wastes, environmental safeguards, acceptable quality of any water returned to the reservoir shall be monitored by the Pollution Control Department/Concerned Agencies. Water actually drawn shall be charged at the rates fixed along with compensation for the loss of power generation on the water consumed during the period October to May. Abstract of present status of water requirement for industry is given in **Table -14**.

**Table -14** Total industrial requirement

	Water allocation		Water actually drawn	
	Cusec	MAF	Cusec	MAF
Industries granted permission	436.215	0.316	75.20	0.055
Industries pending allocation	253.390	0.183	-	-
Total	689.605	0.499*	-	0.055

\*Quantum of water to be actually supplied would come down on a review of the actual development status of the industry and corresponding water use. Future requirement could be reassessed every five years. In view of the very low water use at present, the industrial use may be limited to 0.500 MAF per annum until further review, say, after five years.

## 5.1 Power generation

5.4.1 The Project has delivered substantial power benefits since its commissioning which has been depicted in **Fig -12**. The targeted generation of power after addition and renovation of the units is about 1000 million units per annum. The releases from the power house along with the return flows from Hirakud command, contribution from the uncontrolled flows from the catchment downstream sustain the irrigation and other uses in the delta region.

5.4.2 Water use for industries was not explicitly allocated during the project report stage and this component of water has been available for power generation hitherto on account of slow industrial development. In view of this, the question of compensation for this power loss is being considered for appropriate compensation from the industries.

The recommendations made by Dr.A.N.Khosla (the then Chairman of CWINC) in June 1947 contained provision for water to industries. Eminent engineer M.S.Thirumalai Iyengar, the C.E. of the project stated in his paper presented "To the Nation" that '...one such in Orissa across river Mahanadi formulated and executed by the Central Government on behalf of the State is the Hirakud project that will provide water and power for irrigation and industries all the year round'.

## 6.0 Recommendations

### 6.1 General

6.1.1 Brief and specific study has been made of the rainfall and water availability in the Mahanadi River Basin, with particular reference to Hirakud Dam Project, to assess the existing water uses and possibility of providing water for other uses such as immediate additional demands for emerging industries in the vicinity of the Hirakud reservoir. The studies indicate that water is prima facie available to support the industrial

requirements up to 90% dependability, the quantum of water required for industrial use being a relatively smaller component. However, a detailed study could be taken up for projected water demand in the next, say, twenty five years for all sectors and plan for meeting the same.

- 6.1.2 There need not be any apprehensions regarding shortfall of availability of water for irrigation use. As a general practice irrigation projects are planned based on 75% dependability criteria, in which case the water available for other uses is substantial.
- 6.1.3 It is observed that the irrigation use is far (at least about 20%) in excess of its optimal requirements. It requires suitable implementation of command area development works and improvement of the water delivery systems to minimize losses to make water available to the tail end users. Proper water management practices and use of modern technologies can reduce the irrigation water requirement considerably.
- 6.1.4 Progressively water logging conditions are developing due to continued excessive application of surface water for irrigation by flooding, that makes it obligatory to deploy conjunctive use options in these areas to reclaim and minimize the cultivated area becoming more and more water logged. Over application of water may lead to deterioration of land fertility and reduction in crop productivity. In order to achieve optimal use of available water resources, both surface and ground water are to be used conjunctively to maximize agricultural production, with lesser water use. Crop diversification needs to be implemented to improve the productivity of land.
- 6.1.5 As stipulated by the Ministry of Water Resources, as a reforming State, at least the O & M expenditure shall be recovered by upward revision of the water charges for irrigation appropriately over a period of time. Maintenance of the water infrastructure is highly essential to maintain and operate the system efficiently,
- 6.1.6 While giving permission to industries for drawing water from the reservoir, adequate safeguards are to be incorporated. Return flows are generally high in industrial use, which could be over 80%. Zero based approach needs to be implemented by suitable recycling of water and only consumptively used and topping up of the balance requirement after recycling shall be drawn from the reservoir. In order to meet any exigencies

and unexpected stoppage of water due to non availability or for any other reason, the industries shall have a back up storage for at least fifteen days of its needs, and desirably for a month. Any water returned back into the reservoir must meet the water quality standards prescribed for the same. Pollution control board shall take adequate steps for monitoring the water quality and implementation of environmental safeguards.

6.1.7 Withdrawal of water now for industrial or other uses involves some loss of power. Quantum assessment of the power loss shall be made case by case and necessary recoveries made from the industries against the water drawn from the reservoirs.

6.1.8 The Hirakud Dam Project has been in operation for fifty years. Being the Golden Jubilee year, it would be worthwhile to take up/commission a specific study on the overall evaluation of the performance of the project, its socio economic and environmental impacts. This will be very useful in the planning of future projects using the lessons learned and to counter the projection of water resources development in an adverse manner or misinformation due to non availability of such supporting information and success stories from actual projects in operation.

## 6.2 Terms of reference

The terms of reference are given in the notification N0.19692/WR. Irr. II HKDW-11/07 Dtd 22.06.07 and the recommendations thereon are given below:

6.2.1 *To assess if water allocated to various industries which are already drawing water is adversely affecting Irrigation. Hearing of issues raised by different farmers Organisations.*

The List of Industries and the quantity of water allocated to them already, including the water drawn by them as of now, is given in **Table – 13**. It has been established that water is available and the problem is one of appropriate maintenance of the infrastructure for efficient use. The issues raised by various farmers Organizations fall into the category of inadequacy of the existing distribution system due to lack of maintenance and inability to carry the design discharges up to the tail enders. For example, it was stated that, after repair and rehabilitation work done on Sason canal system, the delivery capacity has improved substantially and the farmers are quite

satisfied. However, due to siltation in the leading/approach channel at intake, there is difficulty in drawing the design discharge, when the reservoir is below El.595 ft. This needs to be attended to on priority, or else the minimum draw down in the reservoir at the end of the season be limited to El.595 ft. and avoid drawing below. This will help in providing adequate water for start of cultivation in the event of delayed monsoon. It may be mentioned that power loss by raising the minimum drawdown level from El.590 ft to El.595.0 ft will be 32.40 M units, a loss of Rs.3.24 Cr per annum. Hence, it desirable to maintain the approach channel by timely excavation/restoration before start of the Monsoon, so that reservoir storage below El.595 ft. could also be gainfully utilized at least up to El.592 ft..

*6.2.2 To recommend intake points for various Industries in whose favour in principle/final water allocation has been made.*

It may not be desirable for the Department to suggest the intake location and the type. Certain guidelines could be given and the owners should come back with viable and economic proposals to the Department for necessary approval. The intake location should take into consideration the future sedimentation scenario. Construction of the structures should be in accordance with the design/drawing approved by the department. The project authorities shall exercise check on the implementation of the approved plan by the industries. The leading/approach channel excavated inside the reservoir, periodic desilting and maintenance of the structures etc shall be the responsibility of the industry for satisfactory functioning/operation of the system.

*6.2.3 To suggest technically feasible and practical ways by which industries drawing water for the reservoir can contribute to the creation of additional storage facilities in the reservoir/on the fringe of the reservoir.*

During the field visit, it was observed that there are potential sites for bunding the reservoir locally to allow filling up when the reservoir level reaches up to El.630.0 ft and hold the water during recession. One such possibility is construction of earth/masonry dam across one arm of Hirakud reservoir near the confluence point of Matwala nala with river Ib for storage. This aspect requires further detailed study.

Local depressions nearer to the industry could be explored for creating useful storages. Considerable amount of earth obtained from excavations

made for construction activities within the industry's area were seen to be dumped along the river banks, which was only reducing the flood spill area adversely. This material could be utilized for creating earthen bunds suitably designed for creating local storage near the Industry, for which adequate land shall be acquired by them.

- 6.2.4 *To suggest how much storage facilities of their own and for what period should be created by the industries to meet the dry season requirement which is a must for the industries.*

The industries could draw water up to a reservoir level of El.592.0 below which it may not be possible to draw water from the reservoir. The Industries should aim at creating a back up storage for about a month's minimum requirement during the dry season.

(In this context, it may be mentioned that for withdrawal of 1 cusec over a month, the storage would be 74,000 cum or 2.592 M cft, for which a land area of 7.41 Ac or 3.0 ha will be required for a depth of storage of 2.50 m.)

- 6.2.5 *To estimate Hydropower loss, if any, due to supply of water to various industries/otherwise.*

In any multipurpose project, water for industrial use would have formed a part of the water allocation in the Project Report stage itself and would have entailed water charges alone for industrial use. However, at this stage, it is being considered that the water that was available for power generation hitherto will not be available on diversion for industrial use hereafter and a demand for compensation has been made. It has been estimated that 1 cusec of water drawn for industrial use would involve a loss of 0.067 million units of power considering an average head during November to June, which will involve a loss of Rs. 67,000/= per annum at Re.1 per unit or Rs. 23.66 lakhs per annum per cumec of water.

- 6.2.6 *To study and either confirm or recommend revision of the share of water of Hirakud Reservoir earmarked for industries in 1990.*

An allocation of 0.350 MAF has been made for supply of water to Industries from the Hirakud Reservoir, vide.Lr.No.Irr-III-HKDW-6/90-40945 dt. 26.11.1990. Demand for water from Industries, as on date, has been given

in **Table -13**, as indicated by the Water Resources Department. Present demand has risen to 0.499 MAF per year and it is desirable to keep a provision for 0.5 MAF, keeping in view the need for accelerating industrial development, which is a very essential component of progress of the State. The momentum generated recently for making the best use of the naturally available resources by the industries in the Hirakud Reservoir area requires to be sustained and necessary assistance extended.

6.2.7 *To suggest additional conditions, if any, required to be imposed at the time of allocation of water to industries, besides those which are being currently imposed.*

The Copy of Lr. No.Irr.-II-WRC-32/07-12427/WR dt.18.04.2007 addressed to M/s Vedanta Alumina Limited and Memo No.Irr-II-Misc-1/2000-20563/WR dt.17.06.03 were available and the conditions given are prima facie meet the requirements. A general set of conditions has been compiled (**Annex-F**), which could be suitably modified to suit the requirements of each individual case for allocation of water.

6.2.8 *The Committee should hold extensive discussions with all the stake holders including Panipanchayat and give its considered opinion on the various view point expressed.*

A meeting was held with the farmers, legislators and others from the area on 20.06,07, when about 38 representatives were present. A brief of the presentations and suggestions made by them is given in **Annex-C**. A critical examination of the presentations made relate to local difficulties in getting the water at the right time due to deficiencies in the conveyance system and need for adequate maintenance measures. The cultivated area is substantially more (**Fig-10**) than the potential contemplated in the project report.