

# Integrated Water Management Scheme — A Case Study of North Karanpura Super Thermal Power Project

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**Abstract:** North Karanpura Super Thermal Power Project (NKSTPP) with capacity of 3x660 MW is located in the Chatra District of Jharkhand, India. Water for North Karanpura STPP would require a sustained/continuous water supply from nearby available sources. Only available source in vicinity is river Garhi, which is rain fed and remains dry in non-monsoon periods. However, sufficient volume of Garhi river discharge, meeting the annual Plant demand of make-up water is available during the monsoon period. Initially, without Air Cooled Condensers (ACCs) total water required was about 55 MCM and to fulfill this huge water requirements of plant, dam of height 22.5 m and 1830 m length was envisaged. This required land acquisition to the tune of 5000 acres, including submergence of forest/fertile land and rehabilitation of some villages. To avoid the resettlement of villages and acquisition of forest/fertile land, an alternative scheme was worked out. In the present scheme, arrangement for lifting of water by pumping from river Garhi during monsoon period with storage facilities (raw water reservoir) in the plant area is envisaged. To reduce water requirement of power plant, power plant is now proposed with ACCs, thereby reducing water requirement to about 20 MCM. The present integrated scheme involves construction of a 6 m high and 121 m long barrage across river Garhi, with associated make up water pump house & pipeline of about 2.0 kms. length and raw water reservoir spread over 800 acres. The raw water reservoir inside the plant boundary has been designed to cater to the water requirements of non-monsoon period of nine months. During monsoon period of three months reservoir will store and also function as buffer & online supply to power plant. The low height barrage has been planned within the river regime and without acquiring any land. To avoid submergence of nearby Tandwa village and private fertile land on both sides of river even during flood peaks, the embankment as well as abutment wall of length of about 1.0 km. on both sides of banks has been provided. The Intake pump house has been provided at 100 m u/s of barrage for pumping the monsoon water from the river into raw water reservoir. The barrage control room building is planned to be constructed above the piers of the barrage. To avoid the seepage from the raw water reservoir 1 mm thick HDPE liner, geo-textile and 75 mm thick PCC at the bed and inside slopes of reservoir has been provided. The maximum height of reservoir embankment is 12.0 m and side slopes are 1V:2.5H. In this paper, integrated water management studies have been carried out for fulfilling the water requirement of North Karanpura STPP, thereby saving the resettlement of ten villages & about 220 nos. of families displaced and acquisition of about 5000 acres of fertile/forest land. This is a true example of sustainable development without using existing resources and using untapped monsoon flows.

**Key words:** North Karanpura, Garhi River, air cooled condensor, barrage, reservoir, guide bank

## 1. Introduction

For the development of backward areas of Chatra District of Jharkhand state, India, construction of North Karanpura Super Thermal Power Plant was conceived by Govt. of India way back in 1990. North Karanpura Super Thermal power Project (STPP) with installed

capacity of 3x660 MW was primarily guided by ample availability of coal from Tandwa block of North Karanpura coal fields as pit head thermal power plant. NTPC Limited (A Govt. of India Enterprises) was entrusted for implementing the proposed power project. Water for North Karanpura STPP would require a sustained/continuous water supply from nearby available sources. The project is envisaged with Flue Gas Desulphurization (FGD) system and Air Cooled Condensers (ACC). The total project area is about 2200

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acres. The ash disposal area and raw water reservoir area are 500 acres and 800 acres respectively. Three numbers steel flue reinforced concrete chimney of 275 m height shall be provided, catering to the three 660 MW units of the project. Layout Plan for the project has been developed taking into consideration various

aspects like available land & its shape, ground features & terrain, corridor for outgoing transmission lines, road approaches, prevailing wind direction, the water drawl and the associated pipe corridor. The layout of North Karanpura STPP is given below (Fig. 1) [3].

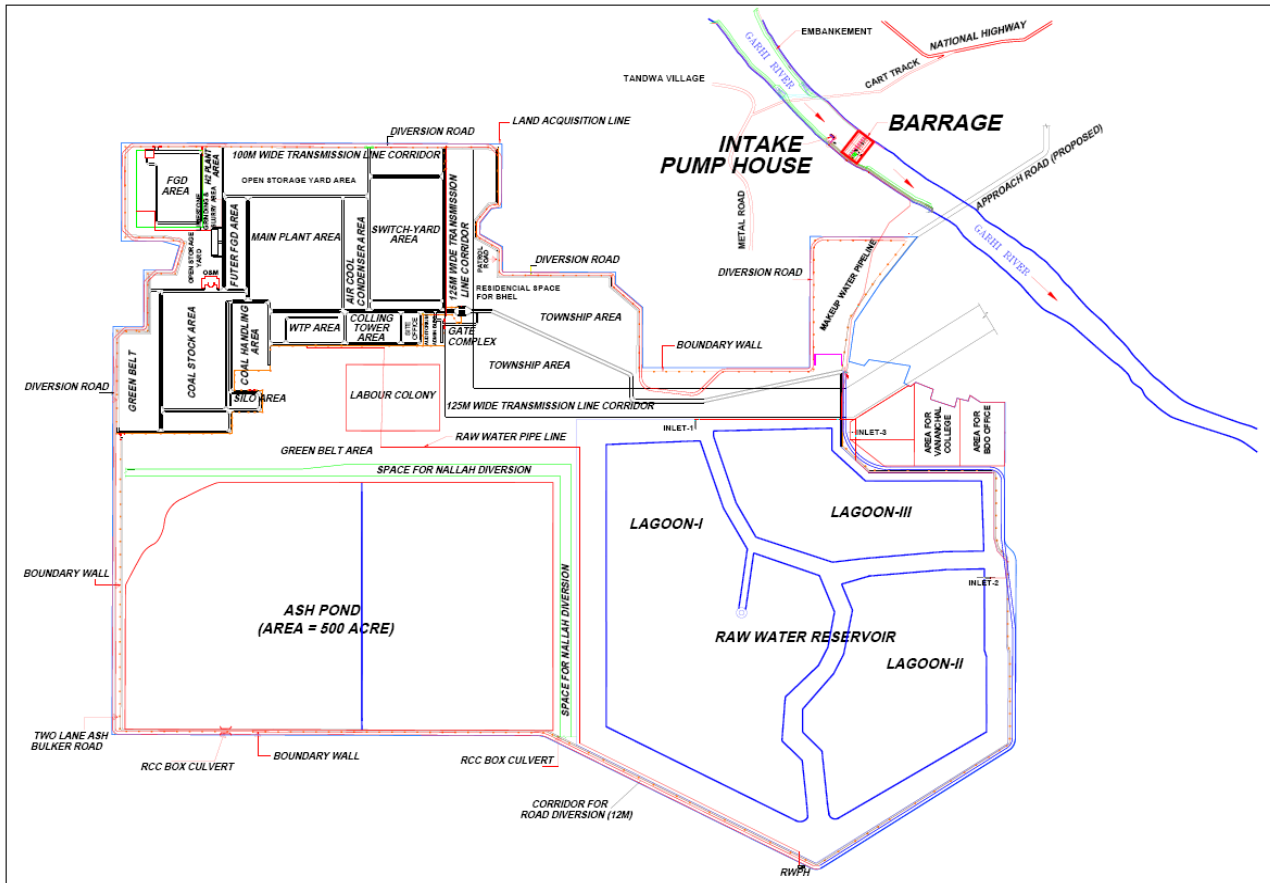


Fig. 1 Layout plan for North Karanpura super thermal power project.

## 2. Initial Proposal of Water Drawl Scheme

Initially, the power plant was planned to have closed cycle conventional condenser cooling and ash handling system with an estimated annual make up water requirement of about 55 MCM without ACC. The construction of 22.5 m Dam across Garhi river was envisaged to ensure a permanent source of water to meet the make-up water requirement throughout the operational period of the proposed thermal power plant. Garhi river is a tributary of Damodar river and is also known as Barki river in its upper reaches. The Damodar river and all its tributaries in the upper

Damodar river valley are non perennial and the flows are confined mostly to the rainy season, i.e., June 15th to end of September each year. After September each year, the flows in these rivers dwindle down and all the rivers become dry for a considerable period of time during the post monsoon period [2].

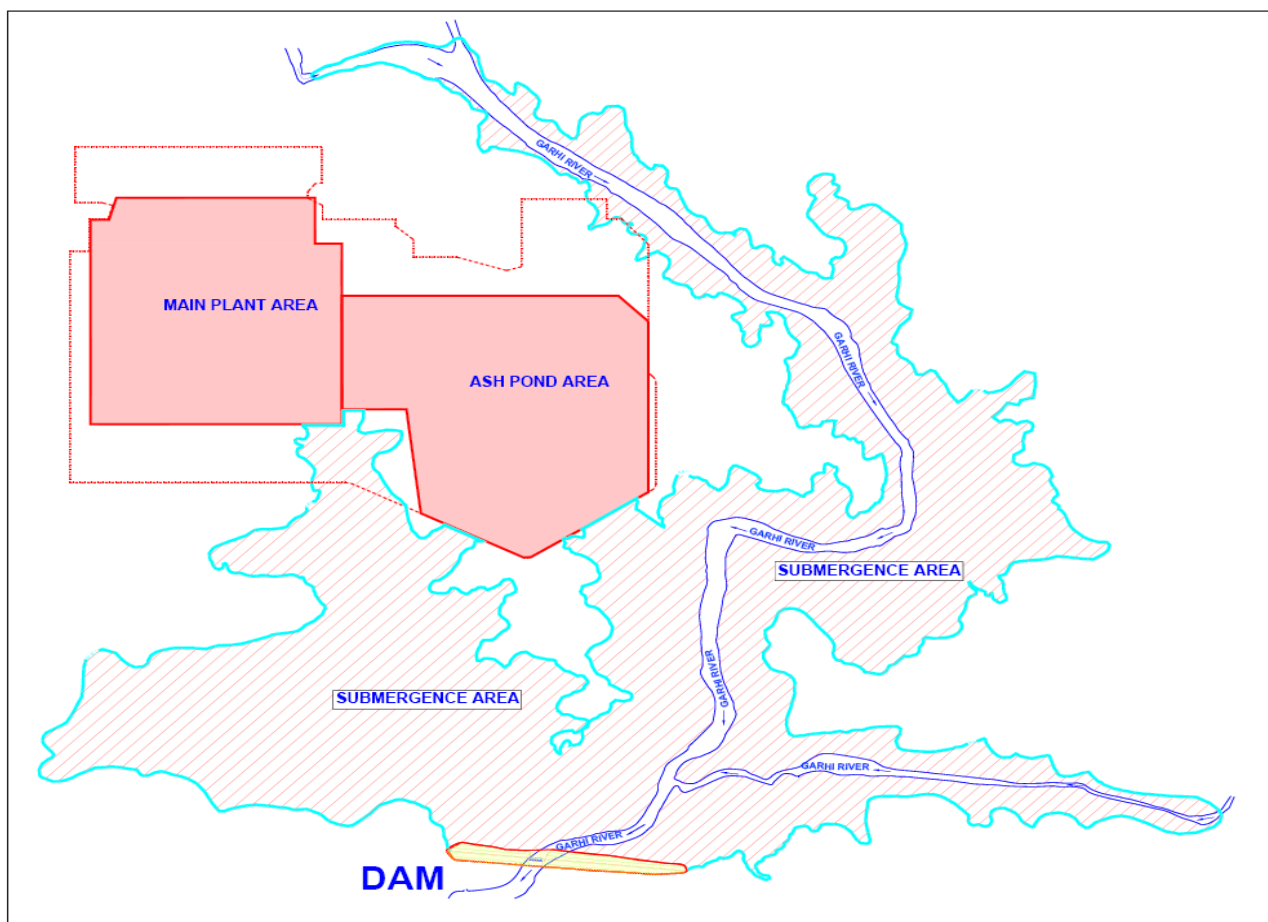
The annual water requirement for the Power Plant was 80 MCM including evaporation & other requirement and it is considered that sufficient flows would be available for 4 months in a year in the Garhi River to meet this requirement and for the remaining 8 months, water is required to be stored in the dam submergence reservoir. The main dam was envisaged

as a homogeneous type earth fill dam with a maximum height of about 22.5 m from the river bed level. The dam was designed with the central core filled with selected impervious material and the outer sides of semi-pervious or impervious material. A vertical chimney filter and a horizontal filter blanket along with a suitable toe drain arrangement was also proposed [2].

The length of the earth dam at the top level (El. 440 m) was 1650 m. The upstream slope is varying from 2.65:1 to 3.25:1 (H:V) and downstream slope is varying from 2.45:1 to 3:1. Provision of two nos. berms of five metre width and one no. berm of five metre width were proposed in U/S and downstream slope of the main dam respectively. The spillway structure would have a crest level of RL (+) 430.00 m above MSL and seven no. of bays of 12 m wide with 5.8 m high vertical lift gates. The Spillway was designed for

the probable maximum flood (PMF) of 4417 cumecs. Pump house for supplying water to the makeup water system was proposed to pump 100 cusecs of water from the reservoir. The pump house was proposed to be located about 585 m inside the reservoir over the intake well to ensure all season water flow within the pump sump. The pump house with 4 nos. vertical turbine pumps of 50 cusecs capacity each, was designed as a multi-unit pumping plant with echelon setting of pumps.

For construction of 22.5 m high dam, land acquisition to the tune of 5000 acres, including submergence of fertile/forest land and rehabilitation of 10 villages was required and rehabilitation of about 220 families was required. The layout along with Dam & its submergence for earlier proposal is given below as Fig. 2.



**Fig. 2** Layout of Earlier scheme with Dam.

### 3. Revision of Water Requirement of Plant

Initially, plant was envisaged with conventional water cooled condenser for the power plant and make up water requirement was substantially high, i.e., 55 MCM. It was very difficult to acquire the land for the construction of dam and its submergence area. Therefore, condenser cooling system was reviewed for the proposed power project and revised with ACC, by which the annual requirement of water reduced to 20 MCM.

### 4. Result: Evolvement of Integrated Scheme

Even after reduction of annual water requirement for plant to 20 MCM, it was very difficult to acquire the fertile/forest land as well as rehabilitation of villages. Besides, it was also an environmentally un-friendly option to disturb fertile agricultural land, cutting of forest and the village habitats. To avoid the resettlement of villages and acquisition of forest/fertile land, an alternative scheme was worked out. Low height diversion structure (barrage) on the Garhi river along with storage (raw water reservoir) inside the plant boundary was studied and detailed scheme was worked out. The layout of barrage along with raw water reservoir & make up water pipe line is given in Fig. 3.

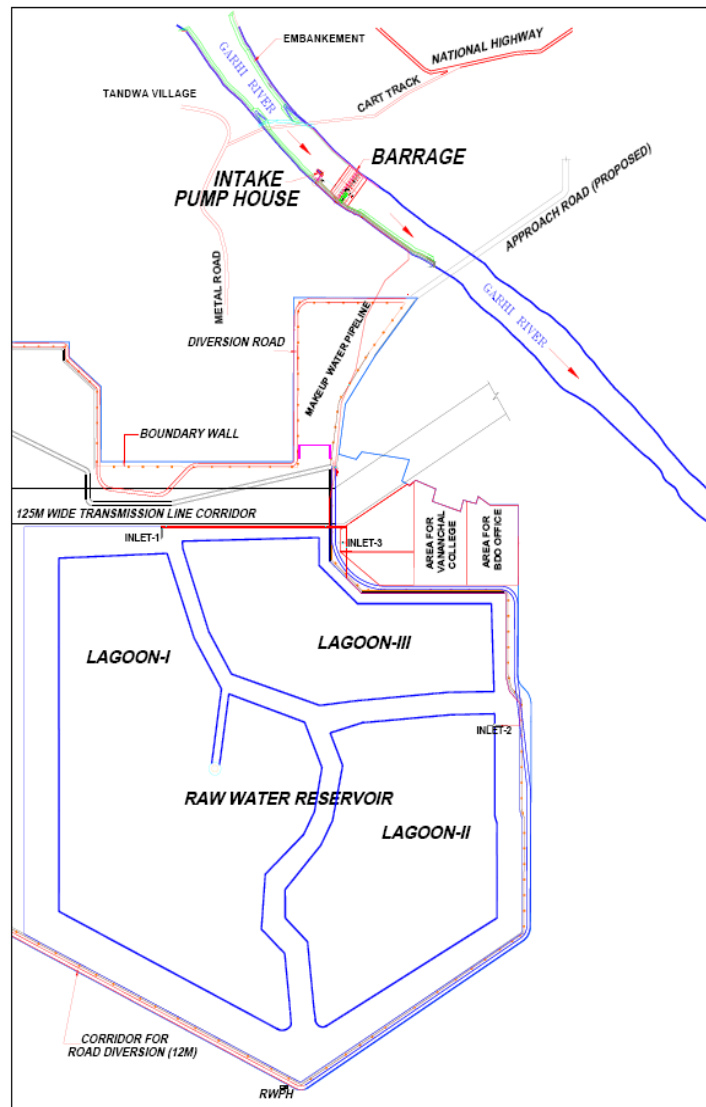


Fig. 3 Layout of water withdrawal integrated scheme.

The Cost comparison study between earlier proposal with Dam structure and integrated scheme has been carried out and given in Table 1.

The total cost of earlier Dam scheme was about INR 10,700 million, whereas for integrated scheme cost was about INR 5,200 million. Therefore, there is a saving of about INR 5,500 million with the implementation of integrated scheme instead of Dam scheme.

#### 4.1 Water Availability Studies

For the proposed project site, the proximate Gauge and Discharge (G & D) site is at Ramgarh maintained by Central Water commission (CWC). The daily discharge data for Ramgarh available for the period 1986 to 2015, is in ten daily form. Based on the available flow data there is wide variation of flow in the river. The catchment areas of Ramgarh and proposed diversion site are 3434 Km<sup>2</sup> and 346 Km<sup>2</sup> respectively. The 10-daily flow series has been developed based on above data. The annual runoff for the 90%, 75% & 50% dependable year are 126 MCM, 182 MCM & 276 MCM respectively at proposed barrage site. The design flood of 1800 cumecs and 1550 cumecs for 1 in 100 and 50 year return period respectively have been developed. The sediment rate of 1 mm/year have been adopted for the present study [4].

**Table 1 Approximate cost details of earlier proposal.**

S. No.	Description	Rate (INR)	Total (in million INR)
1	Submergence of 3300 acres private land	1.5 Million/Acre	4950
2	Pension for 3300 acres private land owners	3300/Acre/month	350
3	Afforestation cost for 1700 acres forest land		1150
4	Dam cost		4250
<b>TOTAL</b>			<b>INR 10,700 million</b>
<b>Cost details of the integrated scheme</b>			
1	Barrage package cost		960
2	Reservoir package cost		4250
<b>TOTAL</b>			<b>INR 5,200 million</b>

#### 4.2 Evolution of Barrage Structure

Study was for creating controlled condition of river flow by constructing gated barrage structure across river Garhi to regulate the river depth of flow, in accordance with the actual utilization flow depth requirement for pumping, as well as to facilitate river course sediment flushing. In the present case, the Garhi river is not perennial in nature, having braided river course with wide seasonal variation in river discharges. In present case, it is virtually without any considerable storage facility as the longitudinal river slope is limited to around 1 in 250 along with sediment laden flat river bed across. Garhi river is basically an alluvial river, where the river bed and banks are made of mobile sediment and/or soil. Thus suitable arrangement for flushing of deposited bed silt would be an essential requirement for the proposed diversion system.

The location of barrage has been finalized at d/s of Tandwa village on Garhi river considering the aspect of river morphology, proximity to plant area and mainly complete structure within the river regime and without acquiring any land. Due to flattening of river slope and river carrying certain amount silt during monsoon season, the bed of barrage is kept at river bed level at RL(+) 432.0 m to facilitate flushing of deposited silt at u/s of barrage. The FRL of barrage structure has been fixed as RL(+) 437.0 m using HEC-RAS software and 10 (ten) vertical gates are provided for controlling the river flow, as well as to facilitate passing of 1 in 50 year flood discharge. The top level of gates is kept at RL(+) 436.7 m corresponding to barrage sill level at RL(+) 432.0 m and ten number of bays of 9.5 m wide with 5.2 m high vertical lift gates with a rope drum hoist operating system. Basic purpose of the gate operation is to ensure requisite water level within the river to maintain submergence requirement of the pumping system. The barrage spillway bays will not be provided with stop log considering the purely seasonal status of Garhi river, which during the month of November to May in any year remains virtually dry and the public

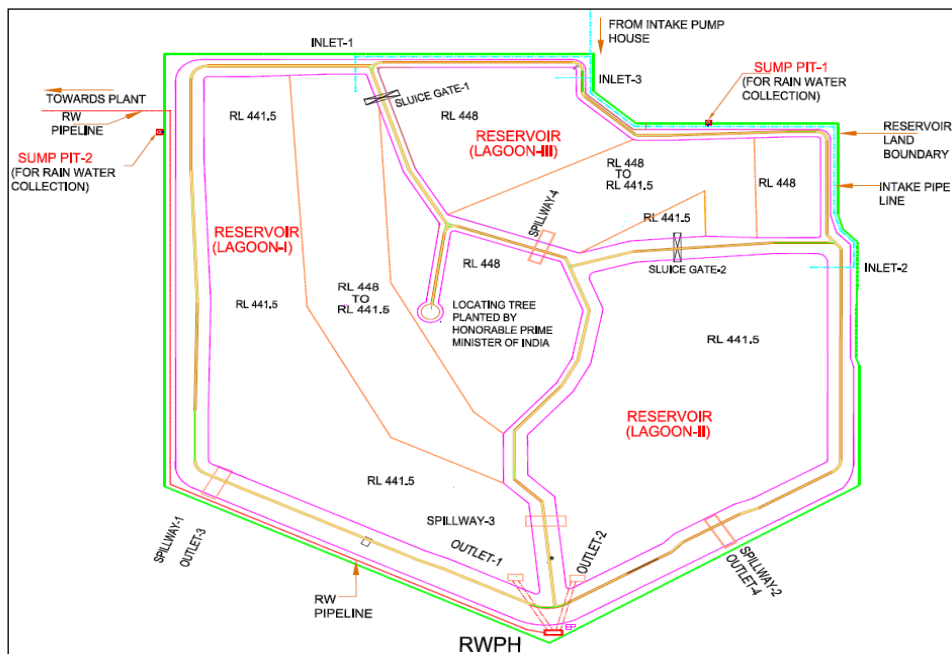


approach Bridge from the right bank to be built in the reservoir upto the Intake & structure which would be of 25 m length. The scheme shall comprise of six submersible pump sets installed in Pump house out of which five (5) pumps acting as main (working) and remaining 1 pump to act as standby. Rating of each pump shall be 3000 m<sup>3</sup>/hr so as to pump the water available in the river to make up water reservoir in 60 days. Rated dynamic head of 40 m (approx.) is envisaged.

#### 4.4 Evolution of Raw Water Reservoir

As the storage has not been envisaged at river end, it is necessary to store the water at the plant side. The raw water reservoir inside the plant boundary has been designed for storage of 18 MCM to cater the water requirements of non-monsoon period of nine months. During monsoon period of three months, reservoir will store and also function as buffer & online supply to power plant. The proposed Raw Water Reservoir, Raw Water Pump House and associated switchgear & control room facilities are located within the Plant's land acquisition boundary. The topography of the proposed Raw Water Reservoir area is undulating

terrain with levels varying from RL(+) 434.0 to RL(+) 458.0. Total area available for the reservoir is 800 acres approximately. The maximum height of reservoir embankment is 12.0 m from reservoir bed and side slopes are 1V:2.5H. Construction of water escape structure is also envisaged. Construction of spillways is envisaged for discharging excess rainwater from storage area to the existing drainage. To avoid the seepage from the raw water reservoir 1 mm thick HDPE liner and 75 mm thick PCC at the bed and inside slopes of reservoir has been provided [4]. The sand chimney, sand blanket as well as rock toe, toe drain and stone rip-rap for downstream slope protection works of dyke embankment has been provided. Construction of peripheral bituminous inspection road on the top of the embankment of the reservoir is also envisaged. The water from the river Garhi is proposed to be pumped in the raw water reservoir by providing 1600 mm diameter pipeline. The Layout and Typical cross section details are presented in Figs. 6 and 7 respectively. The Sump pit has been provided to collect the rainwater within plant boundary and pump to the reservoir. This rainwater which going to the river and then to sea has been tapped and utilized for running of plant.



**Fig. 6 Typical Layout of reservoir.**

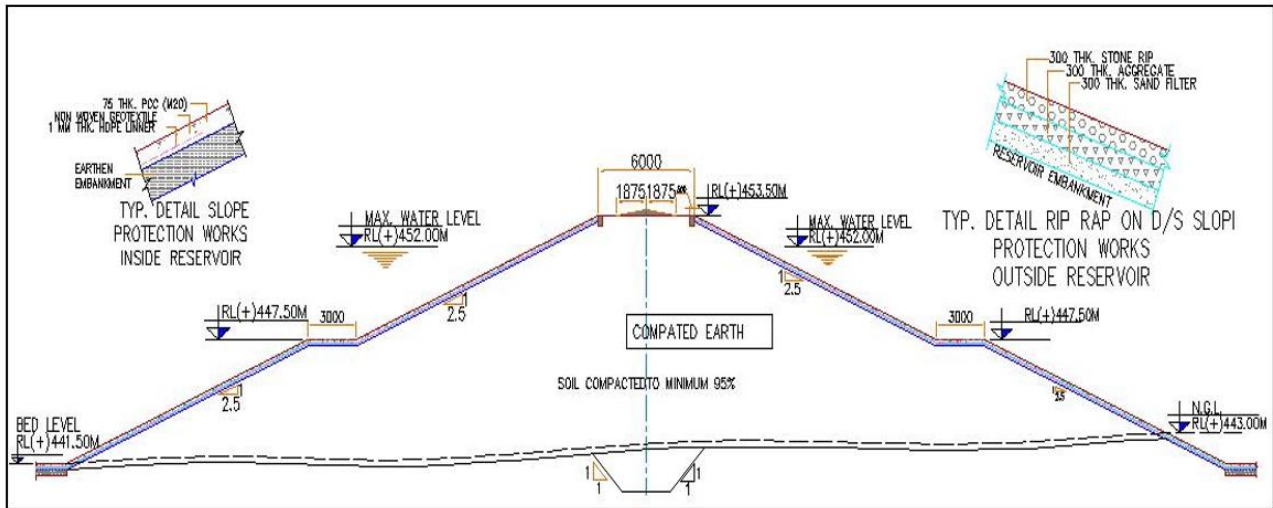


Fig. 7 Typical Cross section of reservoir embankment.

## 5. Conclusion

Initially, with conventional water based power plant cooling system, total water required was about 55 MCM. To fulfil this huge water requirement of power plant, dam of height 22.5 m & length of 1830 m was envisaged. This dam required land acquisition to the tune of 5000 acres, including submergence of fertile agricultural & forest land and rehabilitation of 10 villages comprising of about 220 families. As project authorities were unable to acquire this fertile/forest land and rehabilitate the villages for construction of dam on Garhi river, the project was getting delayed. It was also felt that such inundation of 5000 acres of fertile/forest land will disturb the ecological system of river, besides displacing the large nos. of villages. Therefore, to avoid the ecological disturbance of river, options were explored to reduce water requirement of power plant and to accommodate water facilities within the already acquired land for the power plant. Accordingly, integrated water management scheme, as detailed in the foregoing clauses was worked out, which included incorporation of Air Cooled Condensers (ACC), Low height Barrage within river regime and Raw Water Reservoir within the plant boundary. The new integrated water management scheme reduced water requirement to 20 MCM, thereby managing entire water scheme without any

additional land acquisition and rehabilitation of villages.

In the present study, without tapping the water from the existing reservoirs/storages, without acquiring any additional land & rehabilitation of any villages and using only about part of 90% dependable yield of the river during monsoon, a dependable scheme for water requirement of power plant has been worked out. The total cost of earlier Dam scheme was about INR 10,700 million, whereas for integrated scheme cost is expected to be about INR 5,200 million. The present scheme in addition to being environmental friendly also resulted in cost savings. This is a true example of sustainable development and smart scheme without using existing resources and using untapped monsoon flows.

## References

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- [5] Technical specifications for construction of 'Raw Water Reservoir' works for North Karanpura Super Thermal Power Project (3x660 MW).
- [6] Technical specifications for construction of barrage across Garhi river including intake water system equipment works for North Karanpura Super Thermal Power Project (3x660 MW).