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添付資料　XI

Detailed Project Report

BIHAR STATE POWER GENERATION COMPANY LIMITED

DETAILED PROJECT REPORT

OF

1 x 660 MW SUPER-CRITICAL COAL BASED TPS

AT BARAUNI, BIHAR (INDIA)

JUNE 2016

KYUSHU ELECTRIC POWER CO.,INC.

KYUSHU ELECTRIC POWER CO., INC. - JAPAN

BIHAR STATE POWER GENERATION COMPANY LIMITED

DETAILED PROJECT REPORT

FOR

1 x 660 MW BARAUNI TPS, UNIT # 10

EXTENSION PROJECT, BIHAR

<u>JUNE 2016</u>

Revision 2

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BIHAR STATE POWER GENERATION COMPANY LIMITED – 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

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SECTION 1

EXECUTIVE SUMMARY

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The basic objective of this detailed project report on Unit No. 10 of 1 x 660 MW is to describe the conceptual design, salient technical features, plant layout, fuel specifications, water intake scheme, ash disposal scheme, power evacuation scheme, environmental aspects, Operation & Maintenance (O&M) plan and project cost estimate. This report is prepared under the background of replacing an earlier proposed 1 x 250 MW subcritical power plant with 1 x 660 MW Super Critical (SC) unit. Three (3) project sites within the existing Barauni Thermal Power Station (BTPS) have been selected in the preliminary study i.e. planned site of Unit No.10 (originally 1 x 250 MW subcritical unit), the residential area and site in the south adjacent to Unit No. 8 & 9 to check the feasibility of setting up of an extension Unit No. 10.

The State of Bihar is located in the eastern part of India. The State of Bihar in recent years has attained a remarkable economic growth. The Gross Domestic Product (GDP) growth rate in the whole country during 2013 and 2014 was recorded at 6.9 % while it reached 8.82 % in Bihar.

Although India is in the midst of such rapid economic growth, the establishment of power infrastructures is not catching up the increasing power demand. During the period from April 2014 to March 2015, the country's peak demand was 147,815 MW, while peak supply was 144,788 MW, resulting in a supply deficit of 2.0 %. Demand for electric energy was 1,048,672 Million kWhr., while supply was 995,157 Million kWhr., which means supply deficit of 5.1%. However, for the State of Bihar during the period from April 2014 to March 2015, the peak demand was 2,994 MW, while peak supply was 2,874 MW, resulting in a supply deficit of 4.0 %. Demand for electric energy was 19,294 Million kWhr., while supply was 18,759 Million kWhr., which means supply deficit of 2.8 %.

In July 2012, a large-scale power blackout occurred in New Delhi and because of this the northern region of the country was left without electricity for almost two (2) days, and affecting the daily lives of more than 600 million people, which is more than half of the whole population. A power shortage has become a serious public concern in India. Unless new units are quickly planned and constructed, the deficit in power supply is expected to grow with continuing economic growth.

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Under these circumstances, the Government of India (GoI) has planned to add power generating capacity totaling 88 GW under the 12th National Power Plan. As a part of this plan, Bihar State Power Generation Company Limited (BSPGCL) envisaged to replace the obsolete Units No. 4 & 5 (2 x 50 MW) in BTPS with the development of new extension Unit No. 10 (1 x 250 MW). However, the GoI had examined the introduction of more efficient systems, leading to its reassessment of the original project structure i.e. construction of 1 x 250 MW subcritical unit as a substitute to Unit No. 4 & 5. After this reassessment, the GoI invited Japan Government to examine a possibility of constructing 1 x 660 MW SC unit instead of 1 x 250 MW subcritical unit. This detailed project report responds to this official request.

For this project, the river water will be drawn from the nearby the Ganga River which is at a distance of approximately 3.5 kms from the BTPS site. River water is proposed to be used for condenser cooling and other consumptive water requirements after suitable treatment. It is proposed to use Closed Cooling Water (CCW) system with an Induced Draft Cooling Towers (IDCT) as Main Circulating Water system. The normal plant water make-up requirement for the Unit No. 10 is estimated to be an approximately 1,600 m^3/hr., considering both the condenser cooling water and other consumptive water requirements. However, overall intake water system capacity for the extension unit is estimated to be designed for 2,140 m^3/hr. (21 cusec). The plant design concept is based on zero liquid discharge and hence no quantity of water will be returned to river.

The domestic coal will be used as main fuel and Light Diesel Oil (LDO) will be the secondary fuel. The coal will be transported from the allocated coal mine to the power station via an existing rail network at the west of BTPS, and onward transportation via railway branch track from station to the inside of BTPS. Gross Calorific Value (GCV) of the design coal is 3,300 kcal/kg while ash content is 44.6 % and the sulfur content is 0.3 %. Also, GCV of the worst coal is 3,100 kcal/kg with ash content of 40 %. As per coal consumption calculation, coal requirement of about 3.5 million tonnes per annum (MTPA) for worst coal will be required for 1 x 660 MW SC unit @ 85 % of Power Load Factor (PLF) (2 years average). As received basis the coal will be stored in the required nos. of coal silos after crushing. Therefore, for this extension unit of 660 MW SC unit when becomes fully operational, an additional 11,200 tonnes/day (TPD) of worst coal at Boiler Maximum Continuous Rating (BMCR) will be supplied via extending of the existing railway siding at BTPS.

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For Boiler start-up, LDO will be used not only for cold start-ups and low load but also for flame stability. LDO will be transported either as per existing scheme in road tankers or future planned railway tankers for the fuel oil transportation to the BTPS site. The unloading of LDO through an existing unloading and storage fuel oil facility of Unit No. 8 & 9 inside the BTPS site will be further modified to meet the future requirements of the Unit No. 10.

As per the MoEF notification [1], a new coal based power station should take requisite steps to ensure the utilization of fly ash up to 100 %, in a phased manner, within four (4) years from the date of commissioning. Therefore, it is proposed to provide dry fly ash extraction and storage system for fly ash utilization purposes. However, based on experience it may not be possible to utilize 100 % fly ash during the initial years of the Unit No. 10. Hence, High Concentrated Slurry Disposal (HCSD) system which disposes ash to an ash dyke / pond is also considered apart from the dry fly ash disposal facility. This HCSD system besides carrying larger volume of solid also uses less water comparing with Lean Slurry Disposal (LSD) System.

LSD system in the 75:25 ratio of the water to ash is considered for the wet ash disposal system of Bottom Ash (BA). This wet ash as well as High Concentrated slurry will be transported to the currently planned ash disposal area of 290 acres for Unit No. 6 to 9 as well as Unit No. 10. Ash generation from the Unit No. 10 is estimated as 1.45 MTPA and total ash generated from the Unit No. 6 to 9 and Unit No. 10 is about 3.36 MTPA.

Power generated in the plant will be suitably evacuated through 400 kV GIS switchyard which has been selected in view of space constraint. Construction power required will be arranged suitably from the nearest sub-station. Further aspects, such as power evacuation facilities, transmission system interconnection etc. will be suitably firmed-up by Bihar State Power Holding Company Limited (BSPHCL) / Bihar State Power Transmission Company Limited (BSPTCL) in the subsequent stages of the project based on load studies to be carried out.

The Boiler will be designed to generate an approximately 1,860 tonnes/hour (TPH) of main steam and 1,540 TPH of Reheater steam at 100 % Turbine Maximum Continuous Rating (TMCR) condition. Auxiliary steam supply as required for the start-ups of the Unit No. 10 will be fed / drawn from the existing Unit No. 8 & 9

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auxiliary steam header which is available at a pressure of 11 ata, hence no auxiliary boiler will be envisaged for the Unit No. 10. At the turbine inlet, the main steam parameters will be 245 bar (a) and 593 ^{o}C with feed water entering at the temperature of 295 ^{o}C, whereas the reheat parameters will be 53.2 bar (a), 351.2 ^{o}C and 48.9 bar (a), 593 ^{o}C at the High Pressure(HP) turbine outlet and Intermediate Pressure(IP) turbine inlet respectively. The Boiler will be provided with all standard auxiliary system such as Pulverizer, Flue Gas System and Electrostatic Precipitators (ESPs) etc.

The Steam Turbine will be of multi cylinders, tandem compound, single reheat, regenerative, condensing design with separate HP, IP and Low Pressure (LP) casings directly coupled with the Generator, and suitable for indoor installation. The unit will be designed to operate as a base load station. The Steam Turbine design will cover adequate provision for quick start-up and loading of the unit to full load at a fast rate. Apart from constant pressure operation, the Steam Turbine will also have the facility for sliding pressure operation. The Steam Turbine will be provided with suitable margins for Valve Widely Open (VWO) flow.

Regenerative feedwater heating system is envisaged for the Steam Turbine cycle to improve the plant efficiency. Typical feed water heating system with four (4) nos of LP heaters, one (1) no. of direct contact type deaerating heater and three (3) nos of HP heaters are foreseen for this type of unit. Other Steam Turbine auxiliary system such as HP / LP bypass system, Condenser Vacuum Pumps, Condensate Extraction Pumps (CEPs), Boiler Feedwater Pumps (BFPs) and Feed Water System etc. will also be provided.

Turbo-Generator will be hydrogen cooled 3-phase, 2-pole, horizontally mounted cylinder rotor type, directly driven by Steam Turbine and rated for 1 x 660 MW at 0.85 lagging to 0.95 leading power factor. The generation voltage is envisaged to be 20 - 27 kV as per manufacturer’s standard (i.e. original equipment manufacturer, OEM).

Balance of Plant (BOP) system complimenting the Boiler & the Steam Turbine Generator will be provided consisting of Coal Handling Plant (CHP), Ash Handling Plant (AHP), Compressed Air System, Heating, Ventilation & Air-Conditioning system (HVAC), Fire Detection & Protection System, Water Treatment Plant (WTP), Effluent Treatment Plant (ETP) etc.

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The electrical system will include the Generator Transformer, Unit Auxiliary Transformers, Bus Ducts, Middle Voltage (MV)/Low Voltage (LV) Switchgears, MV/LV Cables, Battery and Battery Chargers, Emergency Diesel Generator (EDG) Set, Plant Illumination, Plant Communication, below ground / above ground earthing etc.

To aid the operator in achieving safe and efficient operation of the unit, resulting in cost effective power generation with optimum fuel consumption and reduced emission levels, Distributed Control System (DCS) will be provided for the Unit No. 10. The design of Control & Instrumentation (C&I) system would be such as to permit on-line localization, isolation and rectification of fault in the minimum possible time. The Boiler, Steam Turbine and Generator along with associated auxiliaries will be controlled and monitored from the Central Control Room (CCR). The BOP and off-site facilities will be provided with Programmable Logic Controller (PLC) based control systems local to the equipment / system. The status monitoring will also be provided on the DCS.

Project cost estimates are made based on consultant's in-house data base and prevalent CERC guidelines. The fixed cost as well as variable cost of generation has been computed for the Unit No. 10 considering SC technology.

The estimated cost of the project is INR 6,788 Crores and the specific cost of the project is INR 10.29 Crores per MW.

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SECTION 2

INTRODUCTION

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2.1 Background

The basic objective of the planned development in the power sector in the country is to outpace the rapid rise in power demand with reasonable level of reliability to ensure faster economic growth. Rapid industrialization induced by the ongoing liberalization of the country's economic policy, continued stress on rural electrification with larger use of water pumps for irrigation purposes and increase in electricity utilization for transportation and household purposes have all contributed to the rise in the growth rate for the demand of power.

The GoI has planned a mission "**POWER TO ALL BY 2019**". Growth in economy and population has resulted in rise in the growth rate for demand of power. 90 % of total power installed in the State of Bihar is fossil fuel based thermal power. Present power shortage in the State of Bihar is anticipated to the tune of 15.3 % in terms of energy for the year 2014 - 15 [31] and therefore the Government of Bihar (GoB) has planned a massive capacity addition to cater for increase in demand.

The GoI, through the Ministry of Power and the State of Bihar, is targeting to secure a supply capacity of about 5,243 MW until 2015 - 16, to achieve its declared mission of 'power to all' and annual growth rate as of 9 - 10 %. In order to reduce the duration for setting up of the new power station, BSPGCL has planned the extension of existing BTPS. Accordingly, BSPGCL has proposed to augment the power generating capacity of BTPS where 2 x 110 MW & 2 x 250 MW units is in Renovation & Modernization / Life Extension (R&M/LE) and new installation stage, respectively.

BSPGCL had taken up the development of new power plants and hence construction of 2 x 250 MW rating units of sub-critical parameters due to retirement of old Unit No. 1, 2 & 3 (3 x 15 MW) under the 12th Five Year Plan at Barauni site.

The GoI has requested to check the feasibility to set up 1 x 660 MW unit which is more reliable with enhanced efficiency and application of SC technology. Thus, with optimized auxiliary power consumption the net capacity addition from this project will be in the range of 620 MW approximately (i.e. exported power to grid after taking account of auxiliary power consumption (in-house use) from gross power).

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Further, environmental consideration also leads to introduction of a highly efficient power generating machine, the SC coal fired thermal power plant of 1 x 660 MW instead of original envisaged subcritical technology.

For the main power block, 660 MW set with SC parameters is favored because of followings major advantages:

- Superior thermal efficiency
- Better heat rate, low fuel consumption, even though fragmentally high initial cost
- Commendable performance record of the above sets in India & abroad
- Reduction in emission like, CO_2, SO_2, NOx, SPM with application of SC technology
- Better performance capability at part load
- Quicker response to load variation

With the above considerations in mind, BSPGCL proposes to expand and develop an extension to BTPS i.e. Unit No. 10, brown field, river water based, domestic coal fired thermal power project with SC technology, configured as 1 x 660 MW unit at Barauni Village, in Begusarai district of Bihar.

2.2 Definitions

Project	:	1 x 660 MW Barauni TPS, Unit No. 10, Extension Project, Bihar
Owner	:	Bihar State Power Generation Company Limited (BSPGCL)
Power Purchaser	:	Entire Power will be consumed in the State of Bihar and purchased by North and South Bihar Power Distribution Company Limited

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2.3 Intent of Report

The scope of Kyushu Electric Power Co., Inc. consists of feasibility studies & preparation of a Detailed Project Report (DPR) for the 1 x 660 MW BTPS Unit No. 10, Extension Project, including the following:

- Survey of project site, collection of relevant data with respect to various infrastructure requirements & environmental aspects
- Preparation of site plans for finalization of layout
- Formulation of site selection reports
- Coal requirement and sources for using 100 % domestic coal
- River water requirement & its arrangement
- Design philosophy and system description
- Plant layout
- Power evacuation plan
- Plant O&M - manpower requirement
- Description of salient features of Mechanical, Electrical, Control & Instrumentation (C&I), and design considerations of Civil & Structure engineering works
- Environmental aspects
- Financial analysis including Return on Equity, Levelized tariff etc. with normative assumptions in line regulation set by state / central regulators for Tariff computation.
- Project Cost estimates covering detailed cost of development of project covering land costs, Civil, Electrical, C&I, and Mechanical & associate auxiliaries, Interest During Construction (IDC), Overheads etc.

2.4 Basis of Report

This DPR is based on data/documents provided by:

- Analytical reports by the Central Electricity Authority (CEA), Ministry of Power, the GoI and other authorities / agencies of the State of Bihar, available in the public domain.
- The data and documents provided by BSPGCL
- In-house data resources of Kyushu Electric Power Co., Inc.

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SECTION 3

OUTLINE OF BARAUNI THERMAL POWER STATION

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3.1 Outline of Barauni Thermal Power Station

BTPS is located in the Begusarai district on the north bank of the Ganga River, about 110 kms away from the east of Patna, the capital of State of Bihar.

Although infrastructure facilities such as oil refinery and fertilizer units is located within the vicinity of BTPS, however BTPS is deemed as a major work site for local residents of the area. Therefore, a small town was formed by the working staff of BTPS within the vicinity of the power plant, and BTPS is at the close distance from the National Highway Route 31 (NH-31).

Figure 3.1-1 Distant View of BTPS (Unit No. 1 to 7)

BTPS started in the middle of the 1960's as a coal fired thermal power plant owned by then undivided Bihar State Electricity Board (BSEB) now under BSPGCL. Then, it began commercial operation of units as declared in Table 3.1-1. Currently, Unit No. 6 & 7 are under R&M/LE stage and Unit No. 8 & 9 are under construction / installation stage. The outline of complete BTPS is as follows:

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Table 3.1-1 Outline of BTPS

Unit	Equipment Specification	Rated Output (MW)	Commencement of Commercial Operation	Present Situation	Manufacturer
No. 1	Coal Fired Subcritical Type Unit	15	January 26th, 1966	Retired	L&C Steinmüller
No. 2		15	January 16th, 1963		
No. 3		15	October 20th, 1963		
No. 4		50	November 9th, 1969	Retired	Polish
No. 5		50	December 1st, 1971		
No. 6		110	December 1st, 1984	R&M/LE [2] Ongoing	BHEL
No. 7		110	March 31st, 1985		
No. 8		250	2016 (Expected)	Under Construction	
No. 9		250	2016 (Expected)		

(i) Status of Unit No. 1 to 3 (3 x15 MW)

These units are already retired as a power plant, however the cooling tower and Steam Turbine building are left without being used, though parts of the power plant equipment such as chimney, Boilers and ESPs have already been removed.

Figure 3.1-2 Retired Unit No. 1, 2 & 3

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The most of the site area concerned with these units can be reused, so remaining facilities will be removed in case of future implementation of new plan.

(ii) Status of Unit No. 4 & 5 (2 x 50 MW)

Unit No. 4 & 5 are under shut-down due to environmental pollution problems that occurred in the year 1995 - 96. These units are also retired upon realization of unviability of conducting renovation & modernisation plan and hence not approved by CEA. Then, it was decided to construct new Unit No. 8 & 9. However, the Steam Turbine building and Boiler is left unused. Like Unit No.1 to 3, the most of the site area can be used and remaining facilities will be removed in case of future implementation of new plan.

Figure 3.1-3 Retired Unit No. 4 & 5

(iii) Status of Unit No. 6 & 7 (2 x 110 MW)

Unit No. 6 & 7 has been taken under R&M/LE work related activities by the Indian company M/s. BHEL for the life extension. The R&M/LE work for these units of 2 x 110 MW at BTPS, was scheduled to be completed by the end of May 2013 (Unit No. 7) & December 2013 (Unit No. 6) respectively, however, it has now been anticipated to be completed in the year 2015 for Unit No. 7 and three (3) months later for Unit No. 6. The benefits of R&M/LE of these units will accrue in the 12th Plan of the GoB.

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Figure 3.1-4 R&M/LE Status of Unit No. 7 (Boiler-Turbine-Generator Area)

(iv) Status of Coal Storage Yard & Coal Handling Plant

In BTPS, currently has railway network inside power plant premises for receiving coal and unloading of the same by the use of railway wagons. The coal storage capacity is secured in the coal storage yard by having digging type storage.

Also, due to enhancement / retrofitting of the old Unit No. 6 & 7, which is under R&M/LE, the existing coal facility cannot be used or available because this has not been used for long time and belt conveyors are too old thus sufficient maintenance is required before the operationalization of Unit No. 6 & 7.

Figure 3.1-5 Wagon Tipplers (Coal Unloading Equipment)

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Figure 3.1-6 Condition of Coal Storage Yard

Railway Line Inside BTPS

Conveyor & Transfer Point

Figure 3.1-7 Condition of Coal Handling Plant

(v) Status of Unit No. 8 & 9 (2 x 250 MW)

It was decided to construct Unit No. 8 & 9 upon retirement of Unit No. 4 & 5 due to high pollution problems occurred in the year 1995 - 96. The extension of the BTPS (2 x 250 MW) was estimated with capital expenses of 3,666 crores and the debt equity ratio of 70:30 has been considered. The Power Finance Corporation (PFC) and the Indian Finance Institution (IFI) would finance the debt and BSPGCL / GoB would arrange the equity [29]. The work is being done by M/s. BHEL as Orignal Equipment Manufacturer (OEM) on turnkey basis and project activity consultant or BSPGCL's consultant is M/s. STEAG Energy Services (India) Pvt Ltd.

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The Ganga River water scheme is under progress for BTPS plant and the water requirement for the consumptive uses at BTPS is to be met from the Ganga River. The Water Resources Department (WRD) and GoB has accorded the clearance for 60 cusecs for BTPS units (i.e. existing Unit No. 6 & 7, 2 x 110 MW & extension Unit No. 8 & 9, 2 x 250 MW) and approval from Central Water Commission (CWC) is accorded for 45 cusecs during lean period from January to May [29].

Figure 3.1-8 Construction of Unit No. 9 (Boiler-Turbine-Generator Area)

Support Structure – Coal Handling Plant

Figure 3.1-9 Construction of Coal handling Plant (Unit No. 8 & 9)

The Commercial Operation Date (COD) of Unit No. 8 & 9 are scheduled in the year 2016. And, 100 % power generated from these units to be utilized by the State of Bihar through BSPGCL.

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3.2 Past Operation Result of Barauni Thermal Power Station

Table 3.2-1 shows the operation results of BTPS. The operation results are currently available only for the fiscal years 2005 - 2010 because the R&M/LE of Unit No. 6 & 7 were started in the 2nd half of the fiscal year 2011.

Table 3.2-1 Operation Result of BTPS [4]

Fiscal Year	Installed Capacity (MW)	Program (GWhrs.)	Results (GWhrs.)	Achievement (%)	% of Last Year	Actual PLF (%)
April 2005 - March 2006	540	663	120.86	18.2	78.6	2.6
April 2006 - March 2007	540	600	37.25	6.2	30.8	0.8
April 2007 - March 2008	320	315	132.37	42.02	355.36	4.71
April 2008 - March 2009	320	578	102.94	17.81	77.77	3.67
April 2009 - March 2010	310	360	264.71	73.53	257.15	9.62
April 2010 - March 2011	310	310	220.44	71.11	83.28	8.12

As shown in Table 3.2-1, Power Load Factor of BTPS plant is less than 10 % for the said period indicates that this power station performance / usage could not be used as intended. The reason because the equipment utilization of Unit No. 6 & 7 during the concerned period was reduced and operating problems caused by the aging, since these units were built in the mid of 1980s.

Furthermore, actual amount of coal procured during the fiscal years 2005-10 was 50 % or less against the originally planned in almost all the fiscal years, refer to Table 3.2-2.

The data on power generation and the distribution of allocated coal indicate that the priority of operating Unit No. 6 & 7 of the BTPS plant after the fiscal year 2005 had been reduced considerably.

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Table 3.2-2 Coal Supply to BTPS by Eastern Coalfields Limited (ECL) [5]

Fiscal Year	Installed Capacity (MW)	Entitlement (x 1000 MTs)	Dispatch (x 1000 MTs)	Achievement (%)
2005 - 2006	220	330	162	49.1
2006 - 2007	220	420	42.72	10.2
2007 - 2008	220	345	99.60	28.9
2008 - 2009	210	360	67.59	18.8
2009 - 2010	210	340	314.61	92.5

3.3 Assessment Policy of Barauni Thermal Power Station

With aim at securing a supply capacity of 5,018 MW by 2016 - 17 in the State of Bihar from current 2,760 MW as on Jan 31st, 2015, and 9,306 MW by 2021 - 22 [7], there is need of an addition capacity about 6,546 MW by the end of 13th Plan. Therefore, aiming to secure a supply of addition capacity, for both India and the State of Bihar it is desired to advance the renewal of Unit No. 6 & 7 and newly installed Unit No. 8 & 9 of BTPS to be completed as per 12th Plan [6].

Also, speeding-up the construction of on-going projects in the State of Bihar including both state & central power utilities, the installed capacity by the end of 12th Plan (2016 - 17) would be of 5,110 MW.

But, there will be a gap of 4,196 MW by the end 13th Plan (2021 - 22). In order to secure the future requirements of the State of Bihar, it is desired to expand the capacity of BTPS while studying on the environmental consideration and the introduction of a highly efficient power generating machine, the construction of 1 x 660 MW SC coal fired unit has been examined for the future extension instead of an originally planned subcritical unit of 1 x 250 MW capacity.

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SECTION 4

JUSTIFICATION OF THE PROJECT

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4.1 Introduction

The National Electricity Policy 2012 [3] notified by the GoI lays down the following major objectives:

- Every house will have Access to Electricity within next five (5) years.
- Demand will have to be fully met by 2019. Energy and peaking shortages to be overcome and adequate spinning reserve (at least 5 %) to be ensured.
- Per capita energy consumption over 1,000 units by 2017 to be ensured.

Capacity addition in 12th year (2012 - 17) plan period has to fulfill the above said objectives.

The restricted Cumulative Annual Growth Rate (CAGR) in Electrical Energy Consumption (EEC) as recorded in the country for 10th & 11th plan ranges between 3 % and 5 %. The growth rate of EEC as forecast in the 17th Electric Power Survey (EPS) is about 10 % for the period till the end of 12th plan.

The present scenario has thus forced the GoI to lay special emphasis on accelerated rate of capacity addition and also maintaining cost of energy within reasonable limit.

The Unit No. 10 at BTPS in Begusarai District, the State of Bihar fits well in the present demand-supply scenario.

4.2 All India Power Scenario

Power Sector in India has evolved from controlled environment to competitive, market driven sector for providing power to meet demand to match the GDP growth envisaged after liberalization of Indian Economy in 1990s. The process of reforms continued and the Indian Electricity Act, 2003 ushered changes that simplified administrative procedures by integrating all aspects under Indian Electricity Act 1950, Electricity Supply Act, 1948 and Power Regulatory Commission Act of 1998 into single Act.

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The intent of Electricity Act was to drive competition as well as protecting the consumer's interest. The Indian Electricity Act essentially addressed on following features;

- Unbundling of Generation & Transmission segments of Power Sector
- De-Licensing of Thermal Power Generation
- Liberalization in captive Power Policy
- Open access to Transmission and Distribution Network
- Stringent penalties for Power Theft
- Transparent subsidy management
- Constitution of Appellate Tribunal
- Thrust on Rural Electrification

The Act provides legal framework to Generation, Transmission, Distribution, Trading and use of Electricity for the development of the sector including methodologies and measures for providing affordable and rationalization of Electricity Tariff, Environment concerns.

The Electricity Act provides open access in Transmission System thereby allowing bulk supply of power from Generators to Consumers. This facilitated trade of wholesale electricity to the consumers.

The planning commission now known as "Niti Aayog" had set capacity addition in 11th five (5) years plan ending March 2012 as 78,700 MW out of which thermal share was conceived as 59,693 MW. The achievement by Thermal Power Generation by the end of March 2012 was stood at 45,588 MW against 59,693 MW.

While working out the peak demand and energy requirement, due consideration has been made for efficiency measures and demand side management for planning generation studies. The load factor of 78 % for 12th Plan and 76 % for 13th Plan has been considered. Similarly, considering base case of 9 % GDP growth rate and elasticity ratio as 0.9 for 12th Plan and 0.8 for 13th Plan and also as per 18th EPS conducted by the CEA, the demand projection adopted for 12th and 13th Plans considering effect of Energy Conservation and Demand Side Management measures are as given in the below Table 4.2-1.

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Table 4.2-1 Demand adopted for Generation Planning Studies - base Case [7]

Plan/Year	Energy Requirement (BU)	Peak Demand (MW)
	9% GDP Growth rate (0.9/0.8 Elasticity in 12th / 13th Plan)	9% GDP Growth rate (0.9/0.8 Elasticity in 12th / 13th Plan)
2016 - 17 (12th Plan end)	1,404	1,97,686
2021 - 22 (13th Plan end)	1,993	2,89,667

The growth of installed capacity since 6th Plan up to end of March 2015 as per report published by CEA is indicated in the below Table 4.2-2 [27].

Table 4.2-2 Growth of Installed Capacity since 6th Plan [27]

Plan / Year	Thermal				Nuclear	Hydro	RES (MNRE)	Total
	Coal	Gas	Diesel	Total				
End of 6th Plan	26,310.83	541.50	177.37	27,029.70	1,095	14,460.02	0	42,584.72
End of 7th Plan	41,237.48	2,343.00	165.09	43,745.57	1,565	18,307.63	18.14	63,636.34
End of 8th Plan	54,154.48	6,561.90	293.9	61,010.28	2,225	21,658.08	902.01	85,795.37
End of 9th Plan	62,130.88	11,163.10	1,134.83	74,428.81	2,720	26,268.76	1,628.39	1,05,045.96
End of 10th Plan	71,121.38	13,691.71	1,201.75	86,014.84	3,900	34,653.77	7,760.6	1,32,329.21
End of 11th Plan	1,12,022.38	18,381.05	1,199.75	1,31,603.18	4,780	3,899.4	24,503.45	1,99,877.03
End of March 15	1,64,635.88	23,062.15	1,199.75	1,88,897.78	5,780	41,267.43	31,692.14	2,67,637.35

Note:

Renewable Energy Sources (RES)

Ministry of New and Renewable Energy (MNRE)

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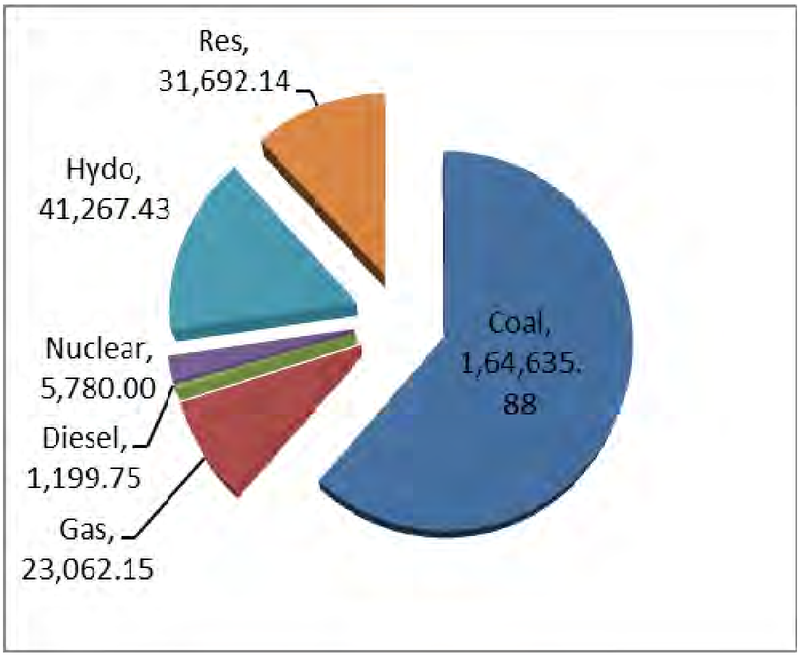
All India installed Generating installed capacity (MW) as on March 31st, 2015 as per the report published by CEA is indicated in Figure 4.2-1.

Figure 4.2-1 All India Generating Installed Capacity (MW) as on March 31st, 2015 [27]



Captive Generation Capacity in industries having demand of 1 MW and above, grid interactive (as on March 31st, 2013) is 40,726 MW.

The growth of Transmission sector since 6th plan is shown in Table 4.2-3 and the region wise Energy Requirement, Million Units (MU) and Peak Demand Requirement (MW) for 12th and 13th Plan is shown in Table 4.2-4.

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Table 4.2-3 Growth of Transmission Sector since 6th Plan [27]

Growth of Transmission Sector Since 6th Plan										
Transmission System Type	Voltage (kV) level	Unit	Ach. At the end of 6th Plan	Ach. At the end of 7th Plan	Ach. At the end of 8th Plan (as on 31.3.1997)	Ach. At the end of 9th Plan (as on 31.3.2002)	Ach. as on 31.03.2007 (End of 10th Plan)	Ach. as on 31.03.2012 (End of 11th Plan)	Ach. as on 31.3.2015	Target 31.03.2017 (End of 12th Plan)
AC Transmission Lines	765	CKM	0	0	0	1,160	2,184	5,250	18,644	32,250
	400	CKM	6,029	19,824	36,142	49,378	75,722	1,06,819	1,35,949	1,44,819
	220	CKM	46,005	59,631	79,600	96,993	1,14,629	1,35,980	1,49,412	1,70,980
	Total	CKM	52,034	79,455	1,15,742	1,47,531	1,92,535	2,48,049	3,04,005	3,48,049
HVDC		CKM	0	0	1,634	4,738	5,872	9,432	9,432	16,872
Total (AC+HVDC)		CKM	52,034	79,455	1,17,376	1,52,269	1,98,407	2,57,481	3,13,437	3,64,921
AC Substations Transformation Capacity	765	MVA	0	0	0	0	0	25,000	1,21,500	1,74,000
	400	MVA	9,330	21,580	40,865	60,380	92,942	1,51,027	1,92,422	1,96,027
	220	MVA	37,291	53,742	84,177	1,16,363	1,56,497	2,23,774	2,68,678	2,99,774
	Total AC	MVA	46,621	75,322	1,25,042	1,76,743	249439	3,99,801	5,82,600	6,69,801
HVDC		MW	0	0	0	5,200	8,200	9,750	13,500	22,500
AC+HVDC		MW	46,621	75,322	1,25,042	1,81,943	2,57,639	4,09,551	5,96,100	6,92,301
Inter-regional transmission Capacity		MW					14,050	27,750	46,450	65,550

In respect of Transmission Network Growth, the growth pattern of 400 kV and 765 kV picked up from 9th Plan (1997 - 2002) and the trend continues. By the end of 12th Plan ending on March 31st, 2017, the installed transmission line covering voltage level of 220 kV, 400 kV and 765 kV is expected to be 3,48,049 Circuit Kilometer (CKM). The High-Voltage Direct Current (HVDC) transmission line network will be around 16,872 CKM thus making combined CKM approximately 3,64,921 by March 2017.

Similarly, the transformation capacity at the end of March 2017 will be 6,69,801 MVA (AC) and 22,500 MW (HVDC).

In respect of potential of Power Generation and Demand Supply in different regions of the country, it is essential that sufficient power transfer capability for transfer of power from one zone to another zone be made. This aspect was given boost in the 10th Plan (2002 - 07) which was 14,050 MW by March 2007 and it is expected to be 65,550 MW by the end of 12th Plan.

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Table 4.2-4 Region wise summary of Energy Requirement and Peak Demand for 2016-17 and 2021-22 [7]

Region	Energy Requirement (MU)		Peak Demand (MW)	
	2016-17	2021-22	2016-17	2021-22
Northern Region	4,22,498	5,94,000	60,934	86,461
Western Region	3,94,188	5,39,310	62,015	86,054
Southern Region	3,57,826	5,10,786	57,221	82,199
Eastern Region	1,63,790	2,36,952	24,303	35,928
North-Eastern Region	16,154	23,244	2,966	4,056
Andaman & Nicobar	366	505	67	89
Lakshadeep	52	65	11	18
All India	**13,54,874**	**19,04,861**	**1,99,540**	**2,83,470**

The long term Projections for Energy Requirement and Peak Demand Requirement in India by the end of 14^{th} Plan (2026 - 27) region wise is indicated in Table 4.2-5.

Table 4.2-5 Long Term Projections for Year 2026-27 [7]

Region / Islands	Energy Requirement (BU)	Peak Demand (GW)
Northern Region	840.67	121.98
Western Region	757.32	120.62
Southern Region	727.91	118.76
Eastern Region	349.41	53.05
North-Eastern Region	33.95	6.17
A&N Island	0.71	0.125
Lakshadweep	0.08	0.023
All India	2,710	400.7

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4.3 Energy Requirement & Peak Load Availability

While working out the Energy requirement and Peak Load availability, assessment of power supply position in India during the year 2015 - 16 takes into account the power availability from various stations (Thermal, Hydro, and Nuclear) including the capacity addition during such period. The gross energy assessed as 1137.5 Billion Units from the power plants in operation, plants likely to be commissioned during the year and the plants considered for scheduled maintenance.

It is anticipated that during the year 2015 - 16, there would be energy shortage of 2.1 % and Peak Shortage of 2.6 % on all India basis. The Annual Energy requirement & Availability and Peak Demand & Availability in India are given below Table 4.3-1.

Table 4.3-1 Annual Energy Requirement & Availability and Peak Demand & Peak Availability in India for year 2015-16 [31]

Particulars	Energy (MU)	Peak (MW)
Requirement	11,62,423	1,56,862
Availability	11,38,346	1,52,754
Surplus (+) / Shortage (-)	- 24,077	- 4,108
Surplus (+) / Shortage (-) %	- 2.1	- 2.6

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Similarly, the anticipated Energy Requirement and Availability, Peak Demand and Peak Met and deficit for different regions is given below Table 4.3-2.

Table 4.3-2 Anticipated Energy Requirement & Availability, Peak Demand & Peak Met and Deficit for 2015-16 [31]

State / Region	Energy				Peak			
	Requirement	Availability	Surplus (+) / Deficit (-)		Demand	Met	Surplus (+) / Deficit (-)	
	(MU)	(MU)	(MU)	(%)	(MW)	(MW)	(MW)	(%)
Northern	3,55,794	3,54,540	- 1,254	- 0.4	54,329	54,137	- 192	- 0.4
Western	3,53,068	3,64,826	11,758	3.3	48,479	50,2542	1,775	3.7
Southern	3,13,248	2,77,979	- 35,269	- 11.3	43,630	35,011	- 8,619	- 19.8
Eastern	1,26,610	1,27,066	2,455	2.0	18,507	19,358	851	4.6
North-Eastern	15,703	13,934	- 1,768	- 11.3	2,650	2,544	- 106	- 4.0
All India	1,162,423	1,138,346	- 24,077	- 2.1	1,56,862	1,52,754	- 4,108	- 2.6

For Region wise, the Energy demand and supply, Peak Demand and Peak Met for year 2014 - 15 (up to February 2015) is given below Table 4.3-3.

Table 4.3-3 Region wise Energy Demand & Supply, Peak demand & Peak Met for year 2014-15 [31]

State / Region	Energy				Peak			
	Requirement	Availability	Surplus (+) / Deficit (-)		Demand	Met	Surplus (+) / Deficit (-)	
	(MU)	(MU)	(MU)	(%)	(MW)	(MW)	(MW)	(%)
Northern	3,32,453	3,11,589	- 20,864	- 6.3	51,977	47,642	- 4,335	- 8.3
Western	3,17,367	3,14,923	- 2,444	- 0.8	44,166	43,145	- 1,021	- 2.3
Southern	2,85,797	2,74,136	- 11,661	- 4.1	39,094	37,047	- 2,047	- 5.2
Eastern	1,19,082	1,17,155	- 1,927	- 1.6	17,040	16,932	- 108	- 0.6
North-Eastern	14,2243	12,982	- 1,242	- 8.7	2,528	2,202	- 326	- 12.9
All India	10,68,923	10,30,785	- 38,138	- 3.6	1,48,166	1,41,160	- 7,006	- 4.7

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In terms of Monthly Energy and Peak Demand, Availability and Shortage the details are given below during the year 2015-16, all India basis [31].

Figure 4.3-1 Peak: Demand vs. Availability

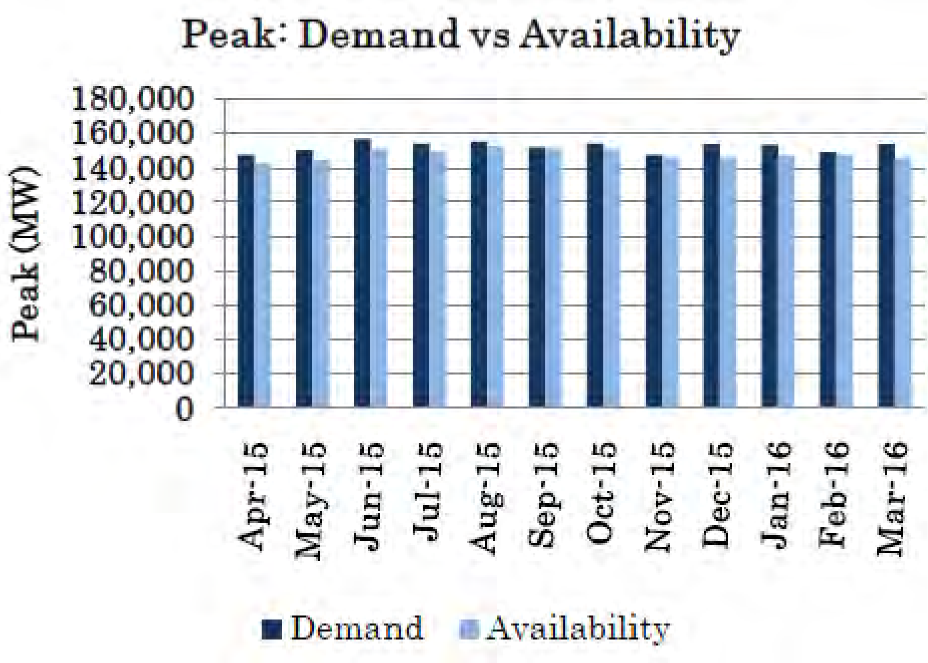
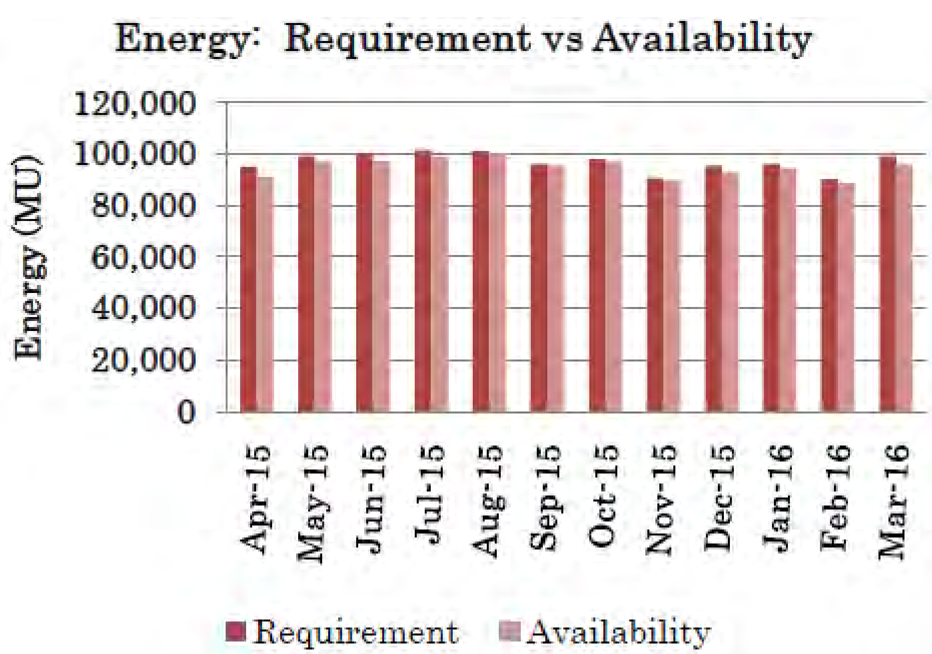


Figure 4.3-2 Energy: Requirement vs. Availability



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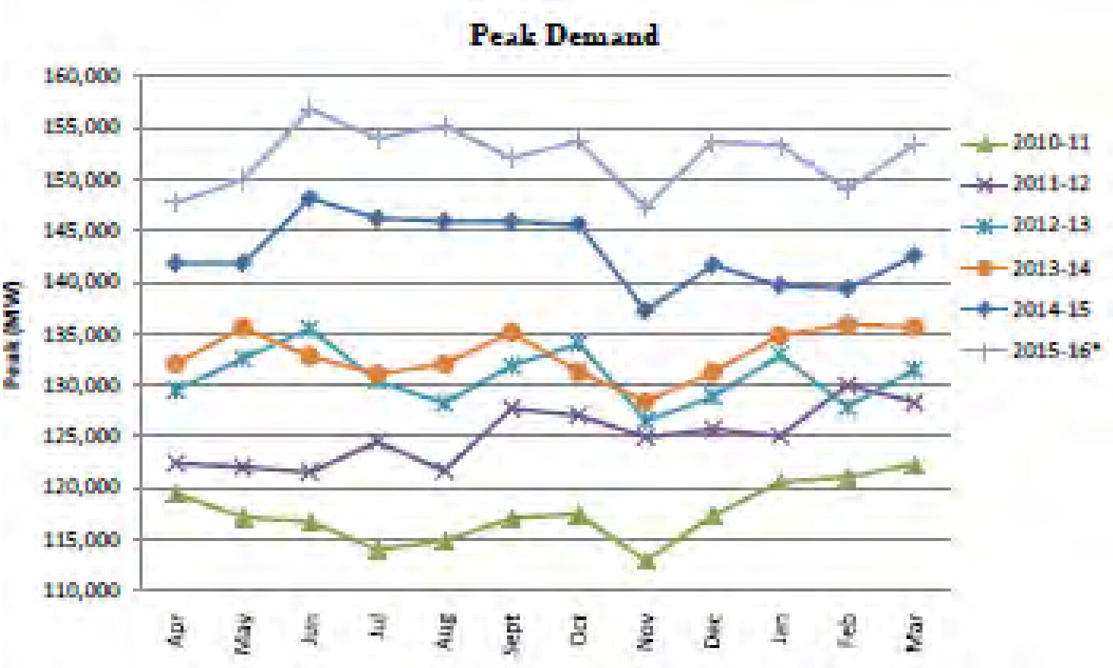
In respect of trends in Peak Demand & Energy Requirement on all India basis for period from April to March for years 2010 - 11, 2011 - 12, 2012 - 13, 2013 - 14, 2014 - 15 and 2015 - 16 (up to March 2016), there is substantial change between 2013 - 14 and 2014 - 15 [31].

Figure 4.3-3 Peak Demand



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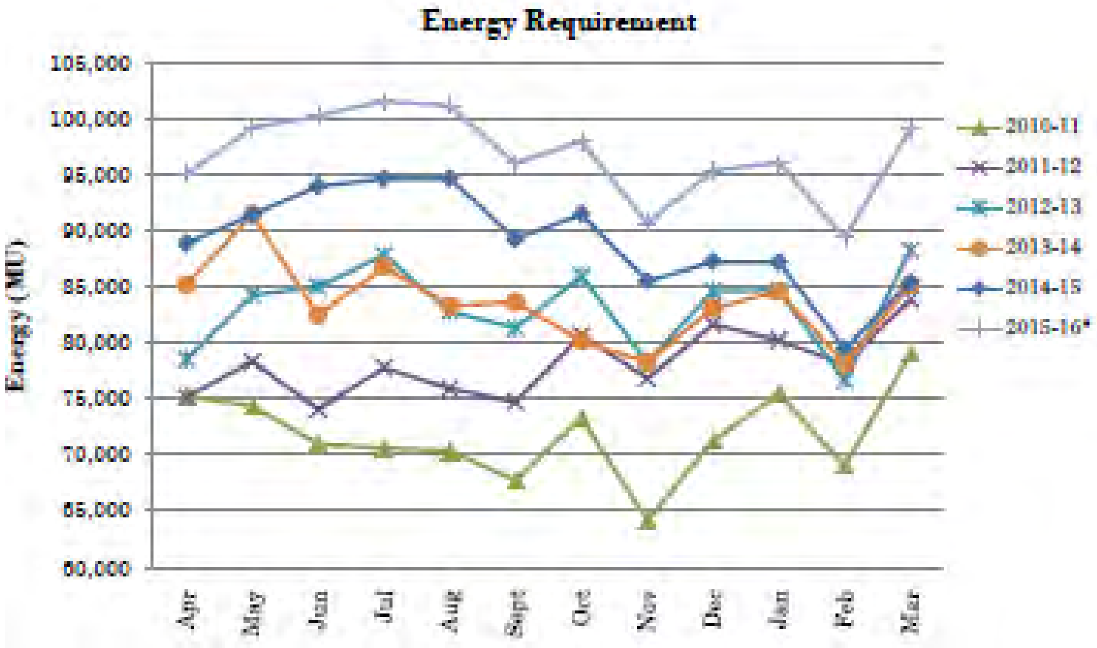
Similarly, for Energy Requirement follow the trend as per above.

Figure 4.3-4 Energy Requirement



* Anticipated

From the above analysis, it is observed that on all India basis it is expected a peak shortage of 2.6 % and energy shortage of 2.1 %. The peaking shortages prevailed in the Northern, Southern and North - Eastern Regions to the extent of 0.4 %, 19.8 % and 4.0 % respectively, however, the Eastern Region and Western Region showing a surplus energy to the extent of 4.6 % and 3.7 %, respectively.

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4.4 Eastern Region Power Scenario [31]

Eastern Region consists of the States such as Bihar, Jharkhand, Orissa, West Bengal and Sikkim as shown in Figure 4.4-1.

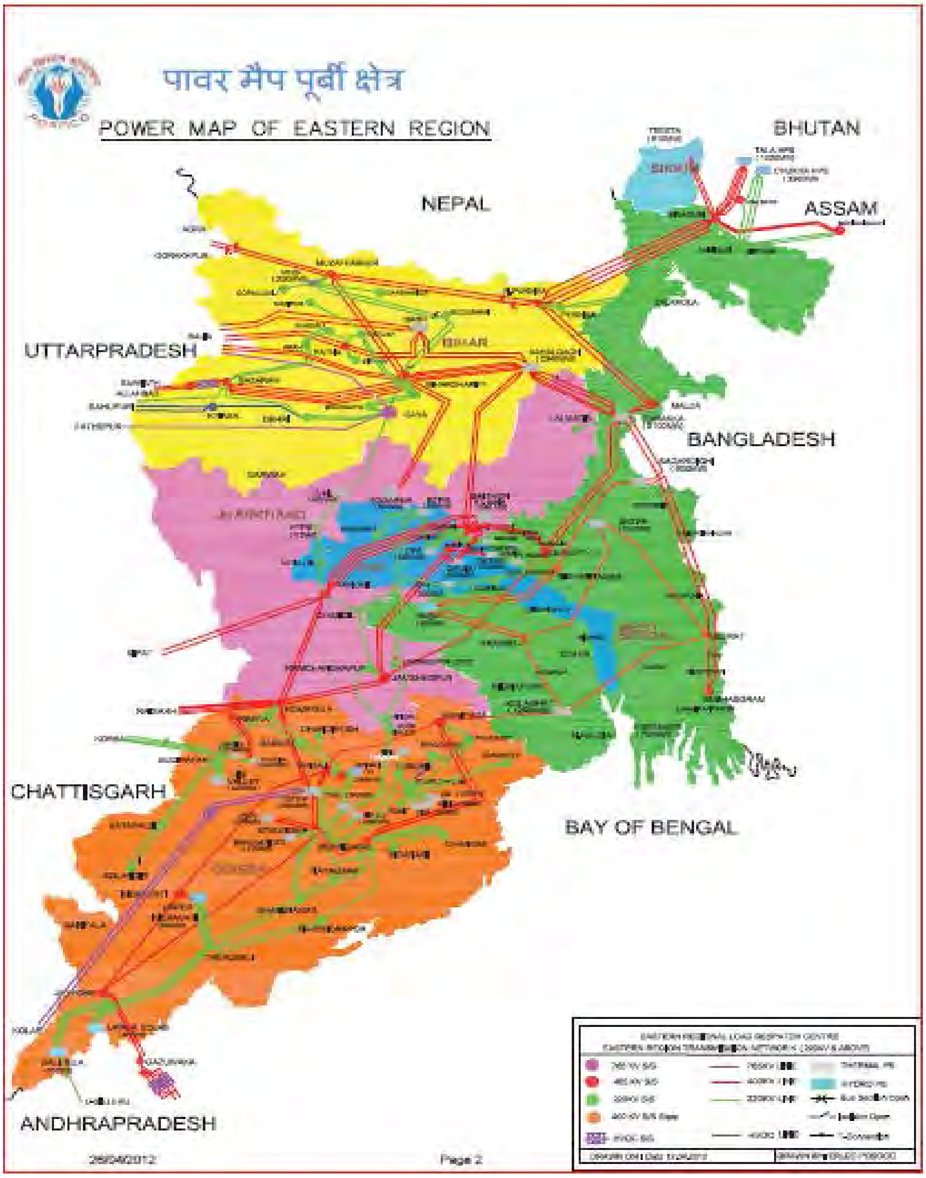

Figure 4.4-1 Eastern Region Grid Map

Based on the base case and Load generation balance report including the 18th EPS, the Peak Demand and Energy Requirement of each state for 12th Plan and 13th Plan is given in Table 4.4-1 & Table 4.4-2 [7], respectively.

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Table 4.4-1 Peak Electric Load Power Station Bus bars for Utilities only (MW) for Eastern Region period 2012-13 to 2021-22 covering 12th & 13th five year plans

State / Uts	12th Plan					13th Plan				
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Bihar	2,843	3,277	3,777	4,354	5,018	5,660	6,398	7,250	8,236	9,306
Jharkhand	3,452	3,727	4,010	4,301	4,616	4,948	5,262	5,598	5,957	6,341
Orissa	**4,397**	4,686	4,994	5,322	5,672	5,866	6,066	6,289	6,515	6,749
West Bengal	8,289	9,052	9,887	10,798	11,793	12,882	13,964	15,124	16,369	17,703
Sikkim	117	123	130	137	144	148	159	164	170	176
Eastern Region	**16,638**	**18,291**	**20,109**	**22,106**	**24,303**	**26,320**	**28,411**	**30,710**	**33,226**	**35,928**

Table 4.4-2 Energy Requirement at Power Station at Bus Bar for Utilities (MU)

State / Uts	12th Plan					13th Plan				
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Bihar	16,529	19,096	22,062	25,489	29,447	32,964	36,982	41,590	46,883	52,975
Jharkhand	21,309	22,844	24,407	25,990	27,691	29,592	31,381	33,287	35,318	37,482
Orissa	26,265	28,374	30,652	33,113	35,772	36,999	38,262	39,667	41,089	42,566
West Bengal	51,021	55,288	59,912	64,923	70,352	76,511	82,571	89,033	95,927	1,03,283
Sikkim	440	461	482	504	528	544	581	601	622	645
Eastern Region	**1,15,564**	**1,26,063**	**1,37,515**	**1,50,018**	**1,63,790**	**1,76,611**	**1,89,777**	**2,04,178**	**2,19,839**	**2,36,952**

From above, it is evident that State of Bihar needs to augment power generation approximate 2.46 times for Peak Demand and 2.4 times for Energy Requirement in respect of current level by 2022.

The data in respect of Eastern Region for Peak Demand and Energy Requirement vs. availability for the period from April 2015 to March 2016 (up to March 2016) is as per below [31].

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Figure 4.4-2 Peak: Demand vs. Availability

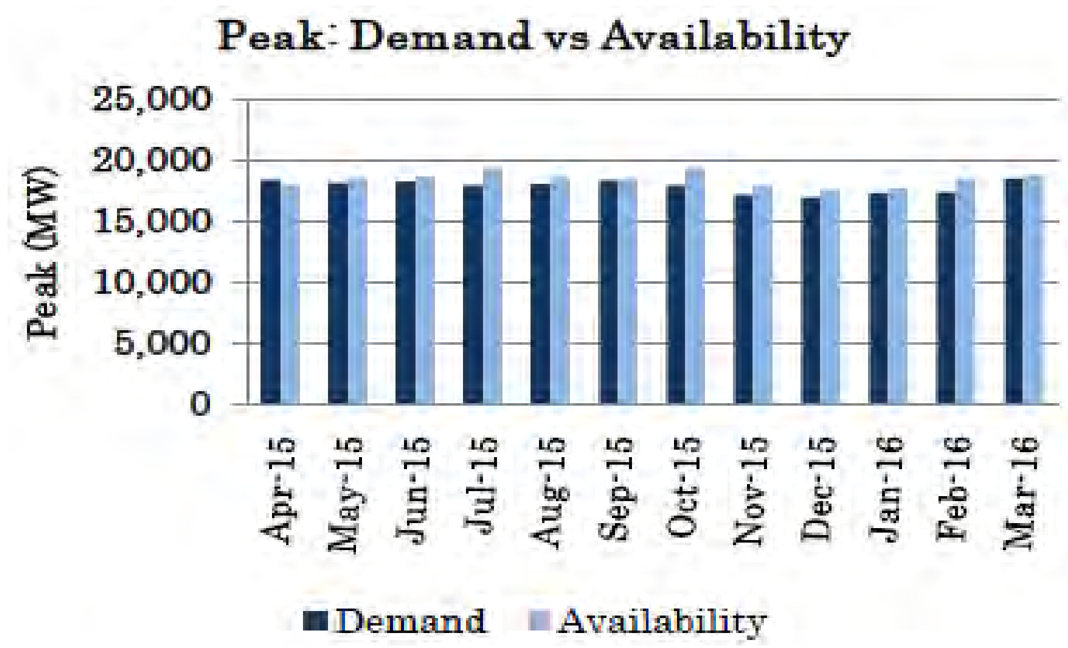
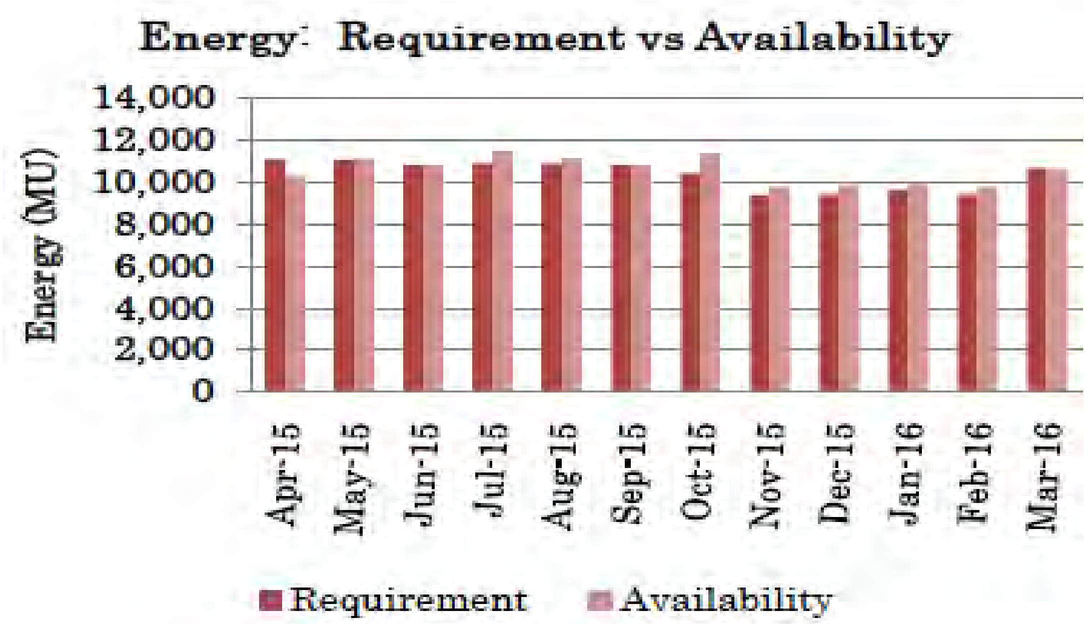


Figure 4.4-3 Energy: Requirement vs. Availability (Eastern Region)



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In respect of trends in Peak demand & Energy Requirement in Eastern region for the period from April to March for years 2010 - 11, 2011 - 12, 2012 - 13, 2013 - 14, 2014 - 15 and 2015 - 16 (up to March 2016), there is substantial change between 2013 - 14 and 2014 - 15 [31].

Figure 4.4-4 Pattern of Peak Demand in Eastern Region

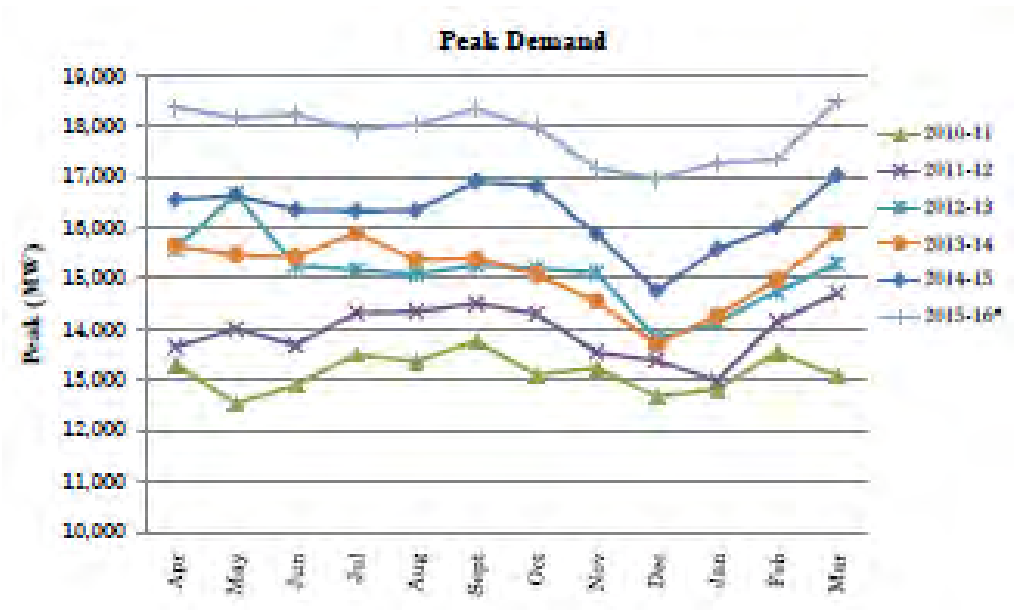
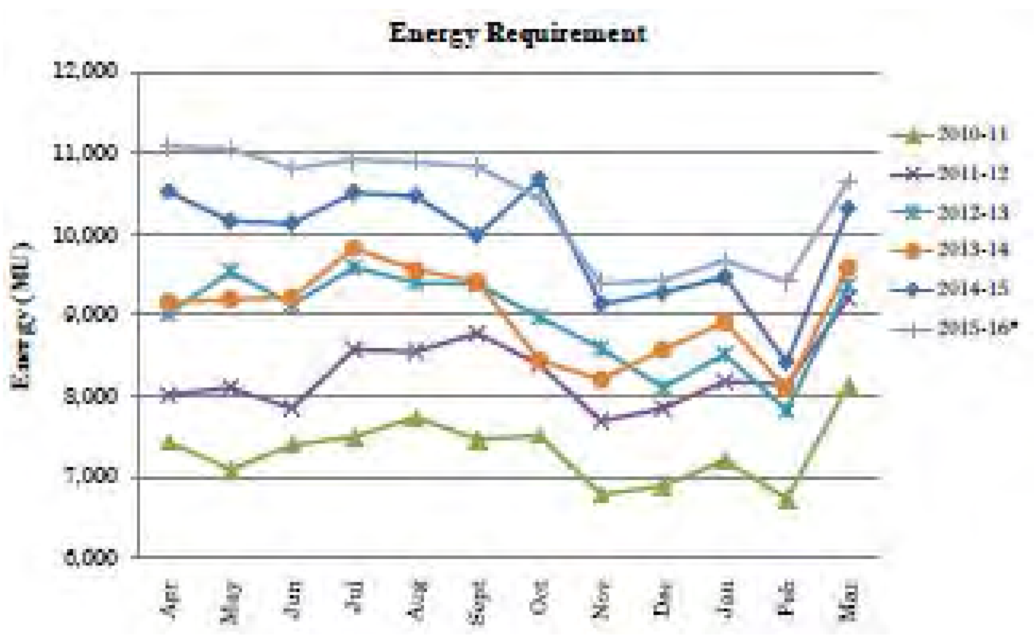


Figure 4.4-5 Pattern of Energy Requirement in Eastern Region



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4.5 Power Sector Scenario in State of Bihar [29]

BSEB was constituted on April 1st, 1958 under Section 5 of the Electricity (Supply) Act, 1948 and was involved in the management of Electricity Generation, Transmission, Distribution and related activities in the State of Bihar with effect from November 1st, 2012.

In 2012, under new "Bihar State Electricity Reforms Transfer Scheme", BSEB was unbundled into five (5) companies:

- Bihar State Power (Holding) Company Limited, (BSPHCL)
- Bihar State Power Transmission Company Limited, (BSPTCL)
- Bihar State Power Generation Company Limited, (BSPGCL)
- South Bihar Power Distribution Company Limited and,
- North Bihar Power Distribution Company Limited

A. Bihar State Power (Holding) Company Limited

The Company that will own shares of newly incorporated reorganized four (4) companies i.e. Bihar State Power Generation Company Limited, Bihar State Power Transmission Company Limited, South Bihar Power Distribution Company Limited, and North Bihar Power Distribution Company Limited.

B. Bihar State Power Generation Company Limited

The generating company which manages the Generation of Electricity as a separate undertakings of the GoB.

C. Bihar State Power Transmission Company Limited

The transmission company which manages the Transmission of electricity as a separate undertakings of the GoB.

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D. South Bihar Power Distribution Company Limited, North Bihar Power Distribution Company Limited

The South Bihar & North Bihar are the distribution companies, and responsible for the distribution of power within the State of Bihar.

E. Brief State Profile

The State of Bihar has been on the path of growth since the last few years. The developmental activities in the various sector has resulted in impressive growth rate of the state.

In the 11th plan period, against the all India growth rate of 7.94 %, the State of Bihar achieved a growth rate of 12.08 % at constant prices. It is observed that GDP growth relevant to year 2013 - 14, the range of 9 - 10 % has been seen with 2004 - 05 prices. There has been decline in primary sector especially the agriculture as the accessibility and availability of power was not adequate.

F. Twelfth Plan Objectives for Growth Trends

For ensuring the growth of power sector in line with 12th Plan, following objectives were drawn by the GoB:

- To plan for a 12 - 13 % growth rate for the State of Bihar, so that the state income can be closer to the per capita national income by the end of the 12th Plan
- To attempt for a high growth rate (7 %) in Agriculture and allied sectors by adopting the strategy of the Rainbow Revolution
- To develop infrastructure at a much higher pace
- Focus on industrialization
- To emphasize the development of the social sector further, particularly education and health
- To make a sustained effort for reduction in poverty
- To make a substantial increase in the income level of the lowest strata of society
- To make an attempt at equitable regional development

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G. Power Sector of Bihar

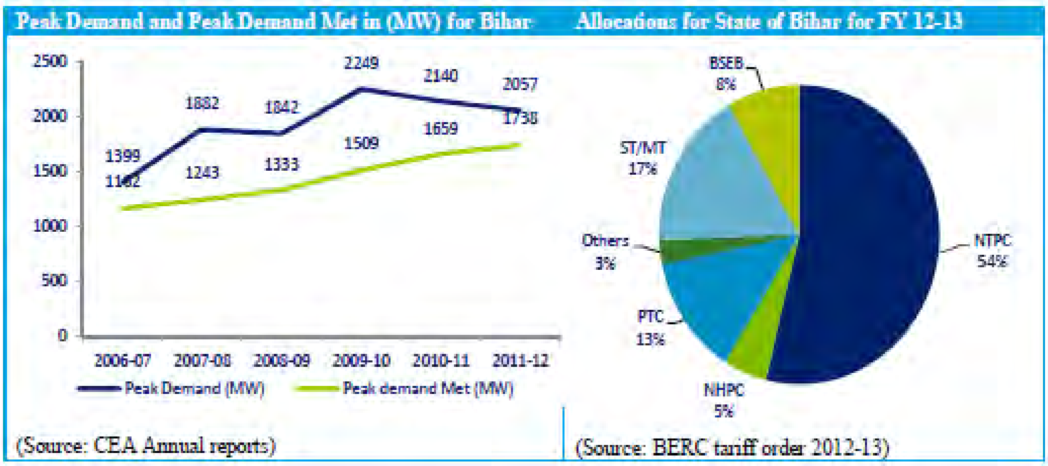
The State of Bihar has seen a high rate of growth particularly in the 11th plan. This is fuelled by developments in the secondary sector as well as growth in per-capita income. The state's per capita energy consumption at 160 units is well below the national average of 1,010 units (2014 - 15).

The sector in the state was managed by the erstwhile BSEB till November 1st, 2012. As per National Electricity Policy [7], the GoI wishes to provide power access to all by 2019, the per capita energy consumption to the level exceeding 1,000 units by 2019. In view of above policy, the State of Bihar needs to boost the Power Generation, Transmission & Distribution Sector to match the national level exceeding 1,000 units from current level of 160 units.

In the last six (6) years, the demand of the electricity in the State of Bihar has grown at a compounded annual growth rate of about 8 %. The gap between demand and supply was highest during 2009 - 10 at 32.9 % (720 MW, from CEA annual report). This gap has reduced in the year 2011 - 12 to 15.5 % owing to the allocations from the central sector.

The State of Bihar relies heavily on the allocations from the central sector to meet its demand. Besides the allocation from the Central Government (NTPC, NHPC and PTC) the state also has its own generation station now owned by BSPGCL.

Figure 4.5-1 Power Sector of Bihar



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As the demand increases, the state is ensuring availability of power for the consumers of the state by drawing out plans to augment its available capacity. Besides augmentation of the capacity in generation, the state is also working towards increasing the availability of transmission lines and improving the distribution network infrastructure. The state's transmission has received a loan from the GoI and Asian Development Bank to improve the network of the state. The distribution sector is also undergoing transformation with the help of centrally sponsored schemes like Restructured - Accelerated Power Development and Reforms Programme and Rajiv Gandhi Grameen Vidyutikaran Yojna.

Based on 18th EPS conducted by CEA, the Energy Requirement in MU and Peak Demand in MW by the end of 12th Plan (2012 - 17) will be as under [7].

Table 4.5-1 Energy Requirement (MU) and Peak Demand (MW) by end of 12th Plan (2012-17)

State/UTs	Energy Requirement by the end of 12th Plan in MU	Peak Demand by the end of 12th Plan in MW
Bihar	29,447	5,018

H. Profile of Generation in Bihar

Bihar grid, as on date, is totally dependent on central supply.

Power system in the State of Bihar is predominant by thermal power generation and the contribution of hydro power is only 10 %. The State of Bihar has only 491.1 MW of installed capacity, of which 440 MW is thermal and remaining 51.1 MW is hydro.

(i) Barauni Thermal Power Station, Barauni (BTPS)
(ii) Muzaffarpur Thermal Power Station (MTPS) JV with National Thermal Power Corporation (NTPC) now known as Kanti Bijlee Utpadan Nigam Limited
(iii) Koshi Hydel Power Station

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(i) Barauni Thermal Power Station, Barauni

BTPS is the only power station under state sector. The Barauni Thermal Power Plant was constructed in three (3) stages:

Stage – I: 2 x 15 MW (Unit No. 1, 2 & 3)

These units of stage – I are of L&C Steinmuller, West Germany make. One (1) with diesel and two (2) with coal base plant. These units have been declared obsolete long back due to uneconomical operation.

Stage – II: 2 x 50 MW (Unit No. 4 & 5)

These units of stage – II are coal based of Polish make and were under shut-down due to high emission problem since April 1996 and March 1995 respectively. Subsequently, the State Pollution Control Board (SPCB) made instruction to stop the units as the emission levels were exceeding the permissible limit in 1996. The CEA vide letter No. CEA/PLG/DMLF/St. Committee/545/510-549 dated on March 12th, 2012 had approved the retirement and subsequently these two (2) units were retired.

Stage – III: 2 x 110 MW (Unit No. 6 & 7)

These units of stage – III are coal based of BHEL make, the Unit No. 6 was commissioned on May 1st, 1983 and the Unit No. 7 was commissioned on March 31st, 1985. These units are under R&M/LE and it is expected that by 2015 - 16 the units will be put into operation.

Extension of BTPS (Unit No. 8 & 9)

To meet the continued power and energy demand in the state, BSPGCL proposed to augment the power generating capacity of BTPS by installing 2 x 250 MW plant alongside their existing units. Both the units are under construction / installation stage and expected to be commissioned in the year 2016.

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(ii) Muzaffarpur Thermal Power Station, Muzaffarpur (Now called Kanti Bijlee Utpadan Nigam Ltd (KBUNL)

Kanti Bijlee Utpadan Nigam Limited. (KBUNL) was incorporated as a wholly owned subsidiary of NTPC on September 8th, 2006 (MTPS was transferred to Joint Venture Company of BSEB and NTPC in the light of MoU signed on November 26th, 2005 vide notification no. 36 dated September 8th, 2006 of Energy Department, GoB).

The company was initially incorporated to take over Muzaffarpur Thermal Power Station (2 x 110 MW) by creating a subsidiary company named as "Vaishali Power Generating Company Limited" but later the company was rechristened as "Kanti Bijlee Utpadan Nigam Limited" on April 10th, 2008. Present, equity holding is of NTPC 64.57 % & erstwhile BSEB 35.43 % making it a subsidiary of NTPC under Union Ministry of Power. The entire power generated from the generating station, is supplied to the State of Bihar.

KBUNL has been constructed in following two (2) stages:

Stage – I: 2 x 110 MW (Unit No. 1 & 2)
Both the units are in operation (Unit No. 1, November 2013 & Unit No. 2 November 2014) after the R&M/LE work carried out by BHEL in 2013.

Stage - II: 2 x195 MW (Unit No. 3 & 4)
BHEL commissioned the first 195 MW unit on March 31st, 2015 and 2nd unit is now under advance stage of commissioning.

(iii) Koshi Hydel Power Station (KHPS)

Koshi Hydro Power Station (Kataiya) Birpur consisting of four (4) units of 4.8 MW each was commissioned during the year 1970 - 78. This project was handed over to Bihar State Hydroelectric Power Company Limited (BSHPCL) on November 16th, 2003 vide notification no. 11 dated June 26th, 2003 of Energy Department, the GoB and BSEB notification no. 46 dated July 31st, 2003.

BSHPCL is operating nine (9) nos. small hydroelectric projects. The list of the nine (9) projects are given in the below.

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- Eastern Gandak Canal HEP, Valmikinagar, 3 x 5 MW
- Sone Western Canal HEP, Dehri-on-sone, 4 x 1.65 MW
- Sone Eastern Canal HEP, Barun, 2 x 1.65 MW
- Kosi HEP, Birpur, 4 x 4.8 MW
- Agnoor SHP, 2 x 0.5 MW
- Dhelabagh SHP, 2 x 0.5 MW
- Nasriganj SHP, 2 x 0.5 MW
- Jainagara SHP, 2 x 0.5 MW
- Triveni SHP, 2 x 0.5 MW

Installed capacity of power utilities in MW located in the State of Bihar including the allocation of power share in joint & central sector utilities as on March 31st, 2015 is given in the below Table 4.5-2 [27].

Table 4.5-2 Installed capacity of utilities in MW in Bihar including allocation Power from Central Utilities as on January 31st, 2015

Ownership / Sector	Mode wise Break-up							Grand Total
	Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
	Coal	Gas	Diesel	Total				
State	210.00	0.00	0.00	210.00	0.00	0.00	70.70	280.70
Private	0.00	0.00	0.00	0.00	0.00	0.00	43.42	43.42
Central	2,306.24	0.00	0.00	2,306.24	0.00	129.43	0.00	2,435.67
Sub-Total	2,516.24	0.00	0.00	2,516.24	0.00	129.43	114.12	2,759.79

4.6 Bihar Projected Energy Requirement & Peak Demand

Based on Load generation Balance report by CEA, anticipated Peak Demand and Energy Requirement including the Peak Demand met and Availability of Energy for the period 2015 - 2016 (from April 2015 to March 2016) for the State of Bihar is shown in Figure 4.6-1. Based on this Figure, the Peak shortage on annual basis is 21.8 % and Energy shortage on annual basis is 4.7 % [31].

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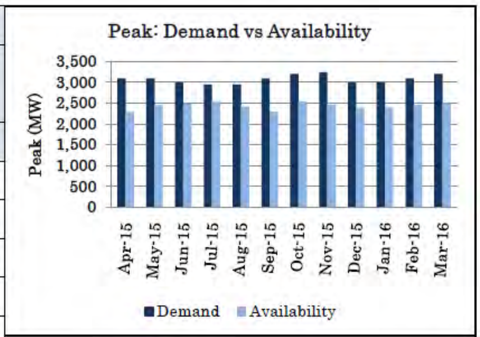
Month	Peak				Energy			
	Demand	Availability	Surplus(+)/ Deficit(-)		Requirement	Availability	Surplus(+)/ Deficit(-)	
	(MW)	(MW)	(MW)	(%)	(MU)	(MU)	(MU)	(%)
Apr-15	3,100	2,290	-810	-26.1	1,509	1,308	-201	-13.3
May-15	3,100	2,449	-651	-21.0	1,463	1,490	26	1.8
Jun-15	3,000	2,485	-515	-17.2	1,533	1,488	-45	-2.9
Jul-15	2,950	2,540	-410	-13.9	1,628	1,689	61	3.8
Aug-15	2,950	2,416	-534	-18.1	1,592	1,621	29	1.8
Sep-15	3,100	2,295	-805	-26.0	1,687	1,451	-235	-14.0
Oct-15	3,200	2,543	-657	-20.5	1,804	1,662	-142	-7.9
Nov-15	3,250	2,466	-784	-24.1	1,701	1,527	-174	-10.3
Dec-15	3,000	2,392	-608	-20.3	1,610	1,524	-86	-5.3
Jan-16	3,000	2,401	-599	-20.0	1,549	1,528	-21	-1.4
Feb-16	3,100	2,463	-637	-20.6	1,512	1,462	-50	-3.3
Mar-16	3,200	2,491	-709	-22.2	1,628	1,569	-59	-3.6
Annual	3,250	2,543	-707	-21.8	19,215	18,318	-897	-4.7



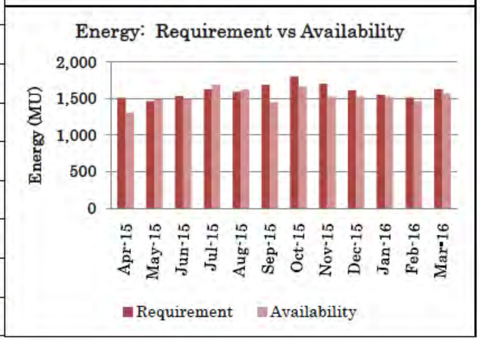


Figure 4.6-1 Anticipated month-wise power supply position for 2015-16

The Peak Electric Demand at Power Stations Bus Bars (Utilities Only) in MW for State of Bihar for the period 2012 - 13 to 2021 - 22 covering 12th and 13th five (5) years plans is given below [7];

Table 4.6-1 Peak electric Load at Power Station Bus Bars for Utilities (MW) for State of Bihar, Period 2012-13 to 2021-22 covering 12th & 13th five year plans

12th Five Year Plan 2012 to 2017					13th Five Year Plan 2017 to 2022				
2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**
2,843	3,277	3,777	4,354	5,018	5,660	6,398	7,250	8,236	9,306

Similarly for Energy requirement at Power Stations at Bus Bar for Utilities only in MUs for same period is given as below [7];

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Table 4.6-2 Peak electric Load at Power Station Bus Bars for Utilities (MU) for State of Bihar, Period 2012-13 to 2021-22 covering 12th & 13th five year plans

12th Five Year Plan 2012 to 2017					13th Five Year Plan 2017 to 2022				
2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**
16,529	19,096	22,062	25,489	29,447	32,964	36,982	41,590	46,883	52,975

Based on above, the projects planned for additional capacity as said in Clause 4.7, may not be adequate to meet the demand envisaged as per 18th EPS conducted by CEA.

However, it may be noted that the exact quantity of power (Peak Demand and Energy Requirement) may exceed these figures by 2022. This may be due to low accessibility by all consumers in the State of Bihar either due to reason of shortage of Generating Power, Lack of Transmission and Distribution Network to provide power to remote areas.

4.7 Bihar likely Capacity Addition in 12th and 13th Plan

Electric Generation Expansion Analysis System studies were carried out to assess the total capacity additional requirement during the 12th and 13th Plan to meet the demand within the confines of reliability criteria.

The list of coal based projects under construction for likely benefits the state of Bihar during 12th Plan (2012 - 17) by the central power utilities [7] are:

- Muzaffarpur (Kanti) TPP (Unit No. 3 & 4), 2 x 195 MW
- Barh Super TPP, Stage – I (Unit No. 1,2 & 3), 3 x 660 MW
- Barh Super TPP, Stage – II (Unit No. 1 & 2), 2 x 660 MW
- Nabinagar TPP (Unit No. 1, 2, 3 & 4), 4 x 250 MW

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4.8 Indian Grid & Its Management

The Indian Power system is divided into five (5) regional grids i.e. Northern, Eastern, Western, North Eastern and Southern region.

The total inter-regional capacity by the end of 11^{th} plan (2012) was about 27,750 MW which is expected to be enhanced to about 65,550 MW at the end of 12^{th} plan (2017).

The North Eastern and Eastern grids were connected in October 1991. In March 2003, Western Region and Eastern Region - North Eastern Region were interconnected. In August 2006, North and East grids were interconnected thereby four (4) regional grids Northern, Eastern, Western and North Eastern grids are synchronously connected forming central grid operating at one frequency. On December 31^{st}, 2013, Southern Region was also connected to Central Grid in Synchronous mode with the commissioning of 765 kV Raichur-Solapur Transmission line thereby achieving 'ONE NATION'-'ONE GRID'-'ONE FREQUENCY'.

At present, the Indian Grid comprises about 3,13,437 CKM of total AC + HVDC transmission lines at 800 / 765 kV, 400 kV, 220 kV & 132 kV EHV AC & +500 kV HVDC levels. Total Inter-regional power transfer capacity is 46,450 MW. Also the total AC substation transformation capacity is of about 5,82,600 MVA as on March 31^{st}, 2015 [27].

Power System Operation Corporation Limited (POSOCO) is responsible for the Grid Management Function (GMF). Unified Load Dispatch & Communication (ULDC) schemes have implemented to bring quality and economy in operation of power system besides improving data availability, visibility and transparency.

Grid management in India is carried out on regional basis. Each of the regions has a Regional Load Dispatch Centre (RLDC) which is the apex body as per the Electricity Act 2003 to ensure integrated operation of the power system in the concerned region.

These RLDC's are presently owned, managed and operated by the Central Transmission Utility (CTU), POWERGRID through its subsidiary POSOCO.

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RLDC is responsible for carrying out real time operations of grid control and dispatch of electricity within the region through secure and economic operation of the regional grid in accordance with the Grid Standards and Grid Code.

- Monitor grid operations
- Exercise supervision and control over the inter-state transmission system
- Optimum scheduling and dispatch of electricity within the region
- Keep track of the quantity of electricity transmitted the regional grid

National Load Dispatch Centre (NLDC) at Delhi, with back up at Kolkata, has been successfully commissioned on February 25th, 2009 for overall co-ordination.

4.9 Conclusion Justifying the Project

While referring to 18th EPS conducted by CEA and also Energy requirement of State of Bihar and Peak Demand by the end of 12th Plan (March 2017) and also by the end of 13th plan (March 2022), it is observed that installed capacity including allocation of power from central utilities need to be ramped up from current status of 2,760 MW to 5,018 MW by 2017 and to 9,306 MW by 2022.

Further to match the national level per capita energy consumption of more than 1,000 units by 2019, the State of Bihar has to boost generation from current level of per capita energy consumption of 160 units to national level exceeding 1,000. Considering above Peak Energy and Peak Demand assumed for March 2017 & March 2022, with current Peak shortage on annual basis of 21.8 % and Energy shortage on Annual basis of 4.7 %, the need of capacity addition to provide power for all by 2019 necessitate the establishment of the Unit No. 10 in addition to other planned capacity addition by the GoB as indicated in Clause 4.7 above.

Unit Size Selection

The basic criteria for selecting the unit size and configuration for the Unit No. 10 applying SC technology is as under:

- Cost of energy generated from the plant
- Steady load requirement

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- Plant efficiency
- Operating experience of set size
- Plant availability
- Plant Load Factor attainable
- Specific investment requirement
- Project timeframe and manpower requirement

The unit size of 1 x 660 MW is endowed with the following merits:

- Availability of proven technology
- High Plant efficiency
- Lower coal consumption
- Low environmental emission to match the Global standards
- Load variation capability
- Capability of grid to tolerate any outage

Therefore, considering above, the installation of the Unit No. 10 is justified from Peak Demand / Energy Requirement as well as rating and overall technology application point of view.

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SECTION 5

LOCATION AND SITE FEATURES

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5.1 Site Details

The selected project site is at Barauni and this area is in the Middle Ganga Plain, which mainly consists of three (3) Plains, Upper, Middle and Lower. This area is almost flat and having no undulation. BTPS is located about 3.5 kms from the left bank of the Ganga River.

The area nearby BTPS is usually flooded during the rainy season; therefore from the boundary of power plant area of Unit No. 8 to 10, a protection bund is to be constructed for the flood prevention around east, south side and some portion of the west side of the plant. The approach road from NH-31 to Main plant gate will also be protected. The high flood level at the water intake point is 43.22 m, therefore keeping approximately 2 m margin, the top level of the protection bund is planned as 45.5 m [8 & 12]. Designed ground elevation of Unit No.10 construction site is to be kept same as of Unit No. 8 & 9 where the power station site is at 45.0 m elevation [9].

5.2 Location & Accessibility

The project site is Barauni located in Begusarai District, the State of Bihar and can be approached from below mode of transportation. The details are summarized as below:

Road	:	NH-31 on the west of the power plant at 0.5 km away
Railroad	:	Hathidah station on Howrah-Patna route is about 3.5 kms Barauni station on Howrah-Muzzafarpur route is about 15 kms
Ship / Sea	:	at 430 kms Kolkata Port
Airport	:	at 110 kms Patna Airport
Latitude & Longitude	:	25°23'36"N & 86°1'26"E
City	:	Barauni, 10 kms
River	:	Ganga River, 3.5 kms
Altitude	:	45.0 m

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5.3 Climatic & Meteorological Data

The nearest meteorological station of Indian Meteorological Department is at Bhagalpur and refer to Appendix - V, Meteorological Data for the Climatological Table of this DPR.

This has been noticed that the area is having peculiar wind in the direction from east to west. The annual rain is about 1,119.1 mm with 80 % of precipitation occurred in the month from June to September. And, other meteorological feature which will form the design basis of the Unit No. 10 is as below:

Relative Humidity (average)	: 65 %
Maximum Relative Humidity	: 85 %
Minimum Relative Humidity	: 45 %
Highest Ambient Temperature	: 46.4 °C
Lowest Ambient Temperature	: 3.9 °C
Annual Rainfall (average)	: 1,255.2 mm
Maximum Precipitation (24 hours)	: 352.8 mm
Maximum Wind Speed	: 17 m/sec
Minimum Wind Pressure	: 991.9 hPa
Maximum Wind Pressure	: 1,013.1 hPa
Seismic Zone	: Zone IV (As per IS 1893, Part I, Edition 2002)

5.4 Land, Water & Construction Power Availability

Based on the preliminary survey results, total land for the project area is 680 acres, of which area for the Main Plant, Ash Pond & Slurry Pipeline, and Intake Water related facility is 370 acres, 290 acres and 20 acres respectively as shown in Table 5.4-1.

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For the main plant area (370 acres), the Unit No. 10 plant area required is 84 acres and remaining land (286 acres) is used for the existing 2 x 250 MW (i.e. Unit No. 8 & 9) main plant area and others such as green belt and rail track.

Leased land of 290 acres of ash pond, which is located at a distance of approximately 2.7 kms south east from the plant area of BTPS, will be used to dispose-off ash generated from the Unit No. 10. The ash pond will be shared among Unit No. 6 to 10.

Ash Slurry pipelines will be installed within a land secured by BSPGCL for Unit No. 8 & 9. This 50 m of Right of Way (ROW) acquired for Unit No. 8 & 9 project will also be used for the installation of ash slurry pipelines for Unit No. 10.

BTPS plant area including ash pond & water intake facility is shown in Figure 5.4-1 and plot plan for main plant area is provided in the drawing section of this DPR. Land requirement breakup for the Unit No. 10 and the land used for the existing Unit No. 8 &9 is summarized in below Table 5.4-1.

Table 5.4-1 Land Requirement, Area in acres

Sl. No.	Description	Area
A	**Main Plant Area**	**370**
A.1	**Proposed 1 x 660 MW plant area**	
	Main power plant including transformer yard	15
	Coal Silos & Handling systems	25
	Water System and related equipment	19
	Cooling Tower Area	10
	Switchyard (400 kV)	5
	Miscellaneous Plant facilities	5
	Road & Drains	5
	Total for A.1	**84**
A.2	**Existing 2 x 250 MW plant area**	
	Total for A.2	**166**
A.3	**Outside Plant**	
	Green area and laydown area	104
	Rail track area	16
	Total for A.3	**120**
B	**Ash pond and slurry pipelines**	**290**

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Sl. No.	Description	Area
C	**Water Intake Facility**	**20**
	River Water Sedimentation / Settling Basin	10
	River Intake pipeline	10
	GRAND TOTAL, A + B + C (rounded)	**680**

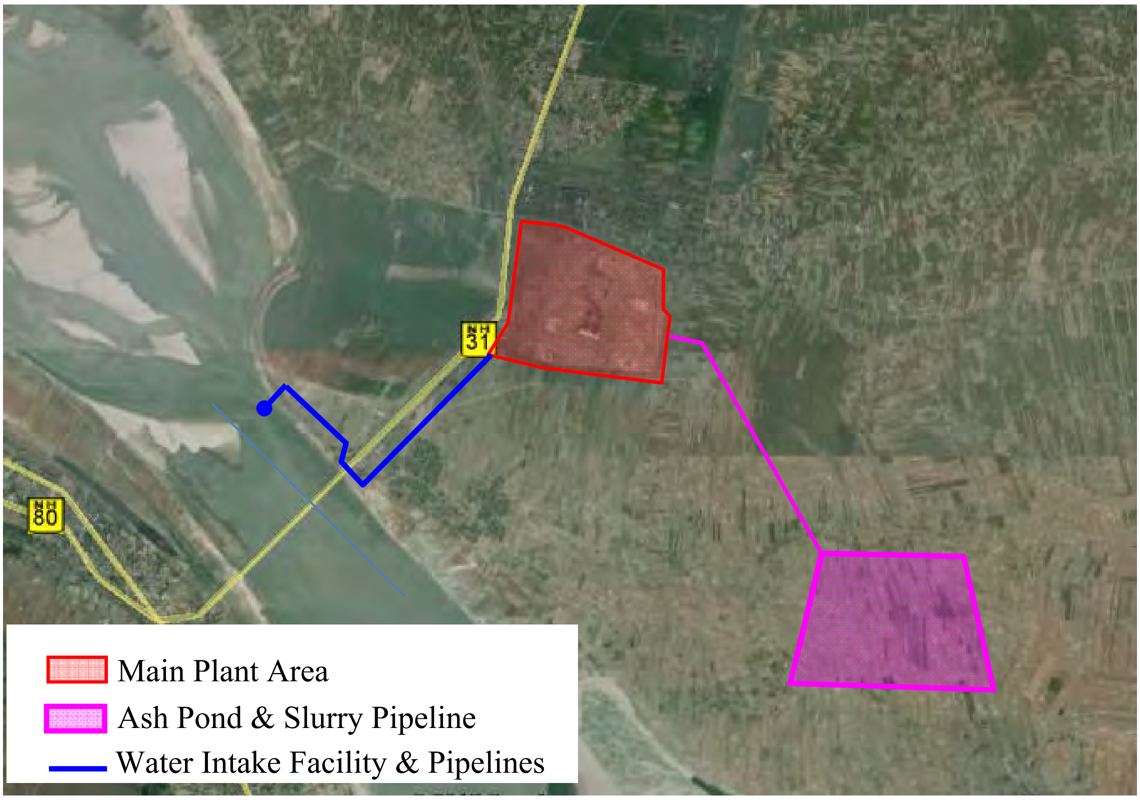

Figure 5.4-1 BTPS Plant Area

After evaluating the land area required from the plot plan with respects to land available, it was identified that ownership of subject land for ash pond is under judiciary negotiation. Although the high court rejected the plaintiffs' (local residents') demands on January 13, 2016, the land ownership issue has not yet been fully resolved and there is still a possibility that a lawsuit will be brought to a civil trial.

The river water would be the source of the plant raw water for the Unit No. 6 to 10 and will be used for condenser cooling and steam generation after pre-treatment followed thru demineralization process. The river water will be drawn from nearby the Ganga River.

The construction water will be suitably sourced from the nearby Unit No. 8 & 9 or from the bore well as alternative source of construction water, and / or a suitable

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pipeline scheme will be set-up to meet the demand during construction period.

It is estimated that construction water at about 450 m^3/day would be required, considering maximum concrete works per day, construction workmen requirements, dust suppression (to meet environmental stipulations) etc.

The nearest point for withdraw of construction power will be made from Unit No. 8 & 9. And, the necessary arrangements will be made after ensuring adequacy of power availability for the said purpose or requirement.

5.5 Fuel Sources & Transportation

The plant has been envisaged as a coal fired Thermal Power Plant. The type of fuel envisaged for the Unit No. 6 to 10 is domestic coal. Although the plant is based on domestic coal, in accordance with CEA technical guideline, up to 30 % of imported coal blending (i.e. 70 % Domestic & 30 % Imported) will be taken into main plant design.

The coal will be sourced either from the coal blocks or the coal linkage which will be allocated by the GoI. The specification of design coal is considered of Class / Grade “G14” domestic coal i.e. Gross Calorific Value (GCV), Ash & Sulfur content is as respectively 3,300 kcal/kg, 44.6 % & 0.3 %, for design coal and 3,100 kcal/kg, 40 % & 0 % for worst coal. For detailed coal characteristics & requirements, refer to Appendix - III, Typical Fuel Analysis & Requirements of this DPR.

The estimated coal requirement for the Unit No. 10 would be approximately 11,200 TPD considering worst coal at BMCR. The annual coal requirement at PLF of 85 % (2 years average) would be about 3.5 MTPA with the GCV of 3,100 kcal/kg based on worst coal.

Similarly, annual coal requirement for the Unit No. 10 has been assessed as 2.8 MTPA based on blended GCV of 3,855 kcal/kg with imported coal GCV of 5,617 kcal/kg & domestic coal GCV of 3,100 kcal/kg, unit heat rate 2,042 kcal/kWh & PLF of 85 %.

For domestic coal, coal would be transported by the Indian Railway System in bottom opening coal wagons (BOBRN – Bogie Open Bottom Rapid Discharge Type, refer to Figure 5.5-1) up to the BTPS site for the Unit No. 10.

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Imported coal will be sourced from foreign sources and transported from imported coal mines to nearest sea port by ship & from port to the site by Indian railway system.

Figure 5.5-1 BOBRN Hopper Wagon

For Unit No. 10, storage envisaged is the crushed coal for twenty (20) days considering total seven (7) nos. of coal storage silos duly complying with the requirements of the Ministry of Power [11].

LDO is the proposed secondary fuel for the Unit No. 10 start-up or low load operation and flame stabilization. It will be sourced from the nearest depots of the Government Agencies and supplied to BTPS site either by road tankers as per the existing fuel oil transportation scheme / philosophy or rail tankers.

Since LDO is the only start-up fuel and no HFO to be used for the Unit No. 10, therefore considering the fuel oil consumption of 1 x 660 MW unit, a new LDO storage tank of capacity 2,500 kL will be envisaged along with the transportation facilities by rail tankers of the Indian Railway System (Bogie POL Tank Wagon Type 'BTPN' or 'TOHC'). This new tank together with existing 2 x 250 kL tanks will be adequate to unload one (1) complete rake of LDO wagons.

The unloading of LDO through an existing unloading and storage fuel oil facility of Unit No. 8 & 9 inside the BTPS site will be further modified to meet the future requirements of the Unit No. 10.

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5.6 Power Evacuation

The electrical power generated is being planned to be transmitted to major load center at Patna, being large-scale consumption region of the State of Bihar. And, the transmission voltage will be determined depending on power system analysis. The connection point will, unless there is problem in system operation, be BSPTCL owned 400 kV substation viz. free from wheeling expenses charged by Power Grid. Also, provided that is should be operational on start of operation by BTPS (Figure 5.6-1).

From the result of power system analysis, Gaighat (new) substation is chosen as connection point, same being most cost effective out of all substations meeting the above requirements. Based on the result of power system study, twin D/C of Aluminium Conductor Steel Reinforced (ACSR) Moose is adopted. The construction plan of Gaighat (new) substation is incorporated in BSPHCL business plan and construction work for same is also progressing. Therefore, as evacuation point for BTPS, considering space requirement, it is necessary to create a well-organized plan for location finalizing and configuration of equipment at Gaighat (new) substation.

Gaighat (new) substation will be located at Bakhtiyarpur is in southern side of the Ganga River, whereas BTPS is located on the northern side of the Ganga River. Accordingly, transmission line from BTPS connecting to Gaighat (new) substation will be crossing the Ganga River. It is at a direct distance of about 50 kms from BTPS. However, transmission line length is assumed to be approximately 60 - 70 kms from BTPS.

Bakhtiyarpur region, being connected with capital region of Patna (district) through national highway i.e. NH-30, is anticipated as developing area with transportation facilities, therefore future power demand is foreseen to show upward trend. There are similar 400 kV class transmission lines existing nearby Bakhtiyarpur operating via Barh Power Station, however as the network is owned by Power Grid, the State of Bihar has to pay for receiving power using the Power Grid Network. Therefore, supplying power from Gaighat (new) substation to Bhakhtiyapur is considered to be economical.

At BTPS, Unit No. 10, 400 kV bus is connected to 220 kV bus of Unit No. 8 & 9 via ICT, it will be able to supply to Begusarai district etc. connected by 220 kV bus hence

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bringing supply stability for BTPS vicinity areas by contributing to Begusarai.

Figure 5.6-1 400 kV Transmission line route map

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SECTION 6

PROJECT INPUT REQUIREMENTS

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The basic requirements for setting up and operating a coal fired extension unit of 1 x 660 MW are:

- Availability of adequate land suitable for setting up the unit by utilizing the existing infrastructure to the extent possible
- Assured the availability of sufficient water of appropriate quality on year round basis
- Confirmed the supply of adequate fuel with effective transportation system to ensure the least delivered cost of fuel at the plant end
- Possibility of power evacuation to the grid at appropriate voltage levels
- Availability of construction water & construction power
- Availability of construction manpower
- Road and rail access, connectivity from airport, seaport etc.
- Availability of other infrastructural requirements

This section discusses the requirements vis-a-vis the availability within the stipulated time frame of the above features at the proposed BTPS site for a coal based power station.

6.1 Land

The land requirement for the coal based Thermal Power Plant can broadly be classified under the following major heads:

- Main Plant Area
- Ash Dyke / Pond & Slurry Pipelines
- Residential Township, Temporary Labor Colony
- Other land area requirements for infrastructure facilities such as rail access, river water intake system, intake water piping corridor, ash disposal pipe route, evacuation corridor, environmental requirements such as green belt etc.

As detailed under Section 5.0 of this DPR, eighty four (84) acres of land is available for the installation of 1 x 660 MW capacity coal based Thermal Power Station with SC steam parameters. This is based on the site features and land configuration, space required for Cooling Tower, coal received by the Indian Railways, CHP, Fuel Oil Handling System, 400 kV GIS Switchyard, WTP, Flue Gas Desulfurization (FGD), green belt as per Central Pollution Control Board (CPCB) / Ministry of Environment and Forests (MoEF) norms etc.

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The above land will be excluding the land required for disposal of ash generated from the Unit No. 10. Ash disposal will be in common ash dyke of Unit No. 6 to 10. For this purpose, sufficient ash dyke area will be required for the Unit No. 6 to 9 including Unit No. 10 throughout the operational life of thirty (30) years with 100 % ash utilization as per MoEF requirements, including area required for green belt, protection bund and peripheral road around the ash dyke.

It is expected that the BTPS personnel’s and required outstation staff (including specialized resources) will be suitably accommodated in the existing residential colony which will be upgraded without acquiring additional land. Additionally, Temporary Housing Facility / Labor Colony will be made available during construction phase, which will be located outside of the BTPS premises.

Additional land required for intake river water piping corridor, ash disposal pipe routing, power evacuation corridor etc. also will be arranged by BSPGCL as per Table 5.4-1.

6.2 Water

The BTPS site location being on the left bank of river in nature, therefore river water drawn from nearby the Ganga River, which is at a distance of 3.5 kms from the BTPS site, would be the reasonable source of water for various plant water based systems.

The river water will be used for Condenser Cooling in recirculation circuit. The water requirements for other plant consumptive use will also be met by this river water after suitable pre-treatment. A De-Mineralization (DM) plant of adequate capacity is envisaged to be set up for the said purposes and make the water fit to use in plant cycle. A suitable upstream treatment like Clarification will be done before the river water is fed to the DM plant. The fresh water requirement has been envisaged for the Unit No. 10, as Service Water & Potable Water. The plant water system will be constantly fed by the make-up water to compensate all losses including vents, drains etc. from the various systems, e.g. Cooling Tower blow-down, drift & evaporation losses, WTP rejects & effluents, CHP Dust Suppression System, HVAC, Fire Fighting, Cycle Blow-Down, AHP, FGD system, Potable & Service Water requirement etc.

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The proposed Water Balance Diagram (WBD) is attached in the drawing section of this DPR for with & without ash water recovery cases.

6.3 Fuel

Coal will be the primary fuel for the Unit No. 10 and LDO will be the secondary fuel for start-up or low load operation & flame stabilization in the furnace.

The Domestic coal of Class / Grade "G14" is considered for this Unit No. 10 which will be sourced from either coal blocks or the coal linkage allocated by the GoI.

The annual coal requirement of domestic coal for the Unit No. 10 is works out to be approximately 3.5 MTPA considering 85 % PLF (2 years average) based on worst coal basis and same is summarized in the below Table 6.3-1.

Table 6.3-1 Annual Coal Requirement

Sl. No.	Description	Unit	Value
1	Gross Unit Heat Rate for 660 MW	kcal/kWhr.	2,042
2	Gross Calorific Value of the Worst Coal	kcal/kg	3,100
3	Daily Coal requirement @ BMCR	TPD	11,200
4	Annual Coal requirement @ 85 % PLF	MTPA	3.5

For Boiler, LDO will be used for start-ups or low load and flame stabilization operation. LDO will be transported in either road tankers as per the existing fuel oil transportation scheme / philosophy or by future planned rail tankers by the Indian Railway System to the BTPS site. The unloading of LDO through an existing unloading and storage fuel oil facility of Unit No. 8 & 9 inside the BTPS site will be further modified to meet the future requirement of the Unit No. 10.

For the details of coal properties as received basis, LDO analysis is attached in the Appendix-III, Typical Fuel Analysis & Requirements of this DPR.

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6.4 Ash Generation & Disposal

(i) Ash Generation

Ash will be generated in two (2) forms i.e. BA & Fly Ash (FA). Considering an average ash content of 44.6 % in the design coal as per the typical fuel analysis & requirements, the total ash generated from the Unit No. 10 per day will be about 4,689 TPD at BMCR and same is summarized in the below Table 6.4-1.

Table 6.4-1 Ash Generation from 1 x 660 MW SC Unit

Sl. No.	Description	Unit	Based on Design Coal	Based on Worst Coal
1	Ash Content	%	44.6	40
2	Hourly Total Ash Generation	TPH	196	187
3	Daily Total Ash Generation @ BMCR	TPD	4,689	4,483
4	Annual Total Ash Generation @ 85 % PLF	MTPA	1.46	1.39

The total amount of annual ash to be generated from Unit No. 6 to 9 plus Unit No. 10 will be approximately 3.36 MTPA at PLF of 85 % based on design coal. Refer to below Table 6.4-2 for details of annual ash generation for each unit.

Table 6.4-2 Amount of Annual Ash Generation

(Unit: 10^3 tonnes)

Sl. No.	Unit	Annual Ash Generation	Source
1	Unit No. 6 & 7	635	Assumed, equivalent to ash generated from 1 x 250 MW
2	Unit No. 8 & 9	1,269	Results from interview / examine [13]
3	Unit No. 10	1,455	Estimated
	Total	3,359	

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(ii) Ash Disposal Scheme

As per MoEF notification [1], a new coal based power station should make plans for utilization of 100 % FA, in a phased manner, within four (4) years of its commissioning. Therefore, it is proposed to provide dry fly ash extraction, storage and disposal system for the ash utilization purposes. However, based on experience it may not be possible to utilize 100 % fly ash during the initial operation years of the Unit No. 10. So, a wet ash disposal system which disposes ash to ash dyke is also considered in addition of the dry ash disposal facility, so popularly known as HCSD system.

The lean slurry disposal system with 75:25 ratio of the water to ash is considered for the BA and HCSD system with 60:40 ratio of ash to water is considered for FA disposal system. Ash slurry FA & BA will be transported to the ash dyke through ash slurry pipelines, separately.

(iii) Ash Disposal Area

A new ash disposal area of capacity approximately 10 million m^3 common for Unit No. 6 to 9 plus Unit No. 10 has been planned in a land area of 290 acres (about 1.17 million m^2) situated at a distance of 2.5 kms south east from the main plant area. The ash disposal area is expected to be built before Unit No. 8 will start commercial operation in 2016.

According to Patna district records, this ash disposal area is owned by the GoB. Although the area is government land, some agricultural works has been recognized in the area. Therefore, necessary compensation will be provided for those who are engaged in the farming on this land.

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Table 6.4-3 Planning of Ash Disposal Area

Item	Area of Ash Disposal, Status of Land Acquisition, etc.	Remarks
Location	About 2.5 kms south east of plant area	
Lot Area	About 290 acres (about 1.17 million m^2)	Common ash dyke area for Unit No. 6 to 9 plus 10
Land Acquisition	Under possession of BSPGCL	Government's & Private land
Compensation	Compensation for the loss of livelihood	Compensation for farmers only

It is planned that the generated ash will be mixed with water so as to transport it in slurry form to the ash disposal area through an ash transport pipes.

Ash pond will be built during construction work of Unit No. 8 & 9 prior to Unit No.10 installation. Pre-cast tiles will be considered for the construction of ash dyke used for the disposal of ash generated from Unit No. 6 to 10 and the same will have two (2) lagoons with common overflow lagoon. It is planned that starter dyke will be constructed using excavated soil and subsequent raising of the dykes will be constructed using soil or deposited ash and inside the embankment will be filled with ash. Refer to Figure 6.4-1 for details of new ash disposal area.

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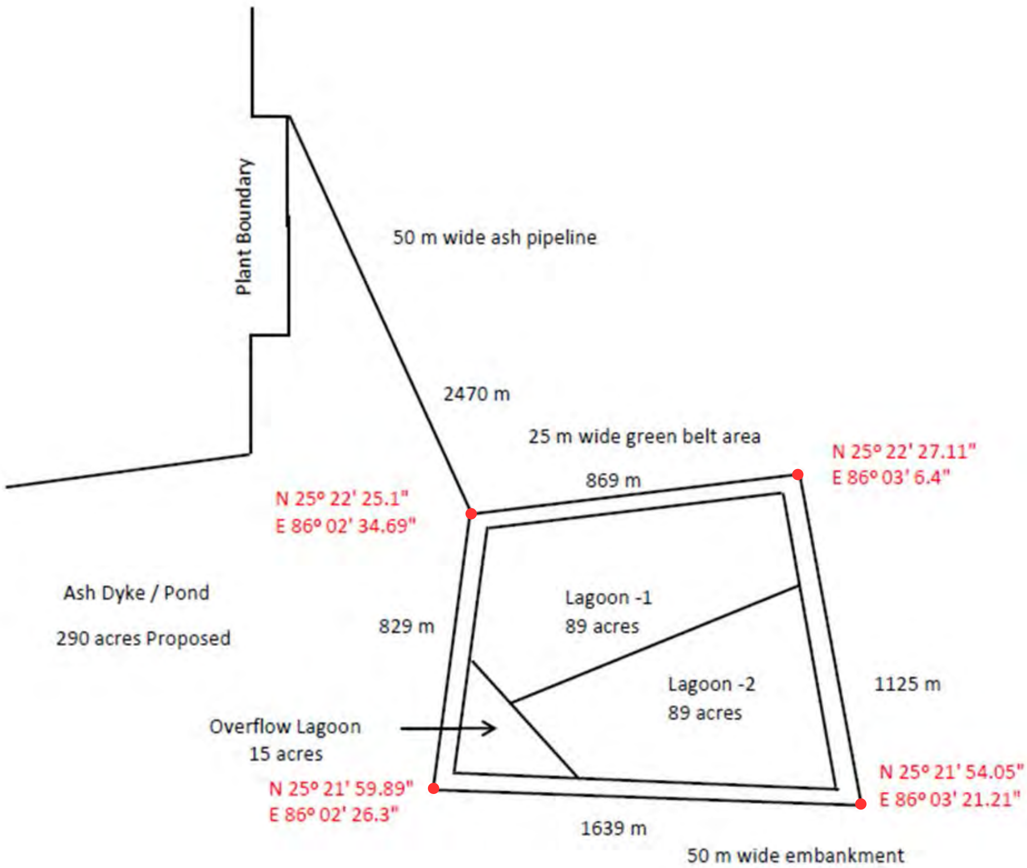

Figure 6.4-1 Details of New Ash Disposal Area

According to Environmental Impact Clearance (EC) for Unit No. 8 & 9 dated May 8 2014, MoEF requires that ash pond shall be lined with High Density Polyethylene (HDPE)/ Ligh Density Polyethylene (LDPE) lining or any other suitable impermeable media such that no leachate take place at any point of time. Based on the requirements, in the new ash disposal area for Unit No. 6 to 10, HDPE lining is planned to be provided at the bottom of the area to form an impervious layer and this eliminates any chance of possible leaching, if any.

(iv) Ash Utilization

The ash utilization is mandatory to be carried out at coal based thermal power plants that are emitting ash and it needs to be taken out as per MoEF guidelines. The important areas of ash utilization are indicated as per below:

- Building sector for use in bricks, blocks, tiles, cement, concrete, plaster,
- Land reclamation, filling low lying areas, raising ground levels,
- Roads, embankments, ash dykes, road blocks, kerb stones,

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- Agriculture and waste land area development.
- Hydro sector, Irrigation, drains, water supply & drainage, lining of rivers, tributaries, canals, minors, sub-minors,
- Mine filling,
- Industrial applications & high value areas,
- Roller compacted dams, pavements, roads,
- Special use for ash e.g. collecting cenospheres from floating ash.

BTPS would have well tied up program for ash utilization by end user agencies and dry fly ash collection, storage and making available dry fly ash to the end user agencies round the clock to agencies located outside of the BTPS plant premises, so that it forms a continuous process.

Also, BSPGCL will take necessary initiatives in the manufacturing of bricks, blocks, tiles, and substitute of clay for cement making etc. as convenient according to the usage anticipated either by their own efforts or by engaging private entrepreneurs to ensure ash utilization. It is reported that some 50,000 tonnes of fly ash generated from Unit No. 6 & 7 were used for brick materials in the year of 2011-12 at the BTPS site.

Considering all the five (5) units are in operation, the total amount of ash to be filled in the ash disposal area throughout thirty (30) years of operational life with conditions of utilization in Table 6.4-4 [1] is roughly estimated to be 12.8 million tonnes assuming that ash utilization is achieved as per MoEF guideline as shown in Table 6.4-5. In this case, the overall height of ash dyke will be approximately 18 m, as per CEA guideline [33].

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Table 6.4-4 Targets for Fly Ash Utilization for TPS Commissioned after Dated, November 3rd, 2009 as per MoEF requirements

Sl. No.	% Utilization of Fly Ash	Target Date
1	At least 50 % of fly ash generation	1 year from the date of commissioning
2	At least 70 % of fly ash generation	2 years from the date of commissioning
3	At least 90 % of fly ash generation	3 years from the date of commissioning
4	100 % of fly ash generation	4 years from the date of commissioning

Table 6.4-5 Amount of Ash to be filled in the Ash Disposal Area as per MoEF requirements (Unit: 10^3 tonnes)

Units		1st	2nd	3rd	4th	5th - 30th	Total
No. 6 & 7 (assumed)	BA	63	63	63	63	1,638	1,890
	FA	286	171	57	0	0	514
No. 8 & 9 [13]	BA	127	127	127	127	3,302	3,810
	FA	571	343	114	0	0	1,028
No. 10 (estimated)	BA	145	145	145	145	3,770	4,350
	FA	655	393	131	0	0	1,179
Total							**12,771**

Now, considering fly ash as substitute of clay in cement production, the consumption of fly ash is estimated about 1.2 MTPA, therefore, it is necessary to establish option other than cement material for 100 % utilization of fly ash of total amount from Unit No. 6 to 10 which will be about 3.36 MTPA as per above Table 6.4-2. According to the BTPS site survey, it is found that cement factories are also located in the neighboring states such as West Bengal, Jharkhand within 350 kms, a few cement factories within the State of Bihar within a distance of 300 kms from BTPS plant having annual production capacity of cement is more than one (1) million tonnes.

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Table 6.4-6 Details of Potential Cement plants for Ash Utilization (Unit: MTPA) [14]

Sl. No.	Name of Cement Plant	Location	District	Rail/Road Distance from BTPS Site	Present Installed Capacity
1	Kalyanpur Cement Ltd.	Banjari	Rohtas	270	1.00
2	Ultra Tech Cement Ltd.	Fatuha	Patna	98	2.00
3	Bangur Cement - A Unit of Shree Cement Ltd.	Aurangabad	Aurangabad	251	3.60
4	Ambuja Cements Ltd.	Farakka	Murshidabad	297	1.00
5	Birla Durga Hitech Cement	Durgapur	Burdwan	323	1.00
6	Lafarge India (P) Ltd.	Mejia	Bankura	309	1.00
7	Sindri Cement Works (ACC)	Sindri	Dhanbad	270	0.90
8	Jaypee Cement	Bakaro	Bakaro	294	2.10

Transport of dry fly ash from total five (5) units i.e. Unit No. 6 to 10 of about 9,745 TPD to cement factories is planned by either road and / or Indian Railway System as mode of transportation. Therefore, ash users have to come with trucks at the BTPS site outside of plant boundary for the ash collection, and it will be delivered to end users.

Alternatively, off-take of dry fly ash through Indian railway network inside plant boundary will be considered for the bulk transportation of fly ash to long distance end users or cement plants by installing two (2) nos. of dry ash storage silos on the railway track and each having capacity of 2,200 tonnes for total twenty four (24) hours of storage.

6.5 Other Infrastructure Facilities

Other infrastructure facilities are essential for timely implementation of the Unit No. 10 in a stipulated construction schedule of fifty two (52) months from the date of Notice to Proceed (NTP). The facilities which are considered essential during early stage of the construction are:

- Access roads
- Construction water and treated potable water
- Construction power

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- Temporary housing facility (labor colony) for the construction staff with water supply, electricity, community facilities viz. health care center, vehicular sheds,
- Ancillary or small scale industries to feed the new plant at project stage
- Local availability of skilled and unskilled manpower
- Telecommunication facility
- A few railway lines are already available to existing power station of BTPS, etc.

The nearest airport at Patna is at a distance of 110 kms. The shipyard / sea port facility at Kolkata at a distance of 430 kms may also be utilized for sea transportation of heavy equipment. The communication facilities viz. telephone, facsimile, internet etc. and other facilities already available in the existing BTPS site will have to be suitably extended for the timely implementation of the project. Amenities like market, hospitals, schools, college, entertainment, small scale industries to support construction of the Unit No. 10 available at Barauni and Begusarai.

The local villages can also be of assistances for workforce as needed to be deployed at the initial stages. To accommodate a large workforce during construction of the Unit No. 10 project, it is envisages that some housing facilities viz. temporary labor hutments may be developed / constructed along with necessary civil amenities. The facilities in the township will also be suitably utilized during construction phase of the Unit No. 10.

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SECTION 7

TECHNICAL FEASIBILITY

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This section describes the key aspects that need to be considered in determining the Technical Feasibility of locating and constructing a coal fired thermal power plant. The key aspects include land, water, fuel, steam cycle parameters, equipment sourcing and transportation of heavy equipment. This section compares the technological options available and proposes the most appropriate technology or equipment to be adopted for the Unit No. 10 at the BTPS site.

7.1 Site Selection & Land Availability

The selection of a suitable site for the establishment of Unit No. 10 depends primarily on availability of the following basic inputs:

- Land: Suitable & adequate land for constructing the various plant facilities
- Accessibility: Road, railway, seaport, airport for the transportation of plant and machinery
- Fuel: Availability and proximity to fuel source for supply of the Domestic Coal, and LDO in road tankers or in rail tankers of future planned Indian Railway System
- Water: Availability and proximity to the source, i.e. the Ganga River
- Power: Availability and proximity of power grid for the evacuation of generated power as well as withdrawal of start-up power
- Environmental aspects: Does not affect any sensitive environments around the vicinity of the BTPS site.

Site Selection

Based on the preliminary survey of BTPS, following three (3) sites were examined for the installation of the Unit No. 10 considering the ease of layout of plant facilities, ease of construction and the construction period. The areas where these construction sites can be located at BTPS are shown in the below Figure 7.1-1.

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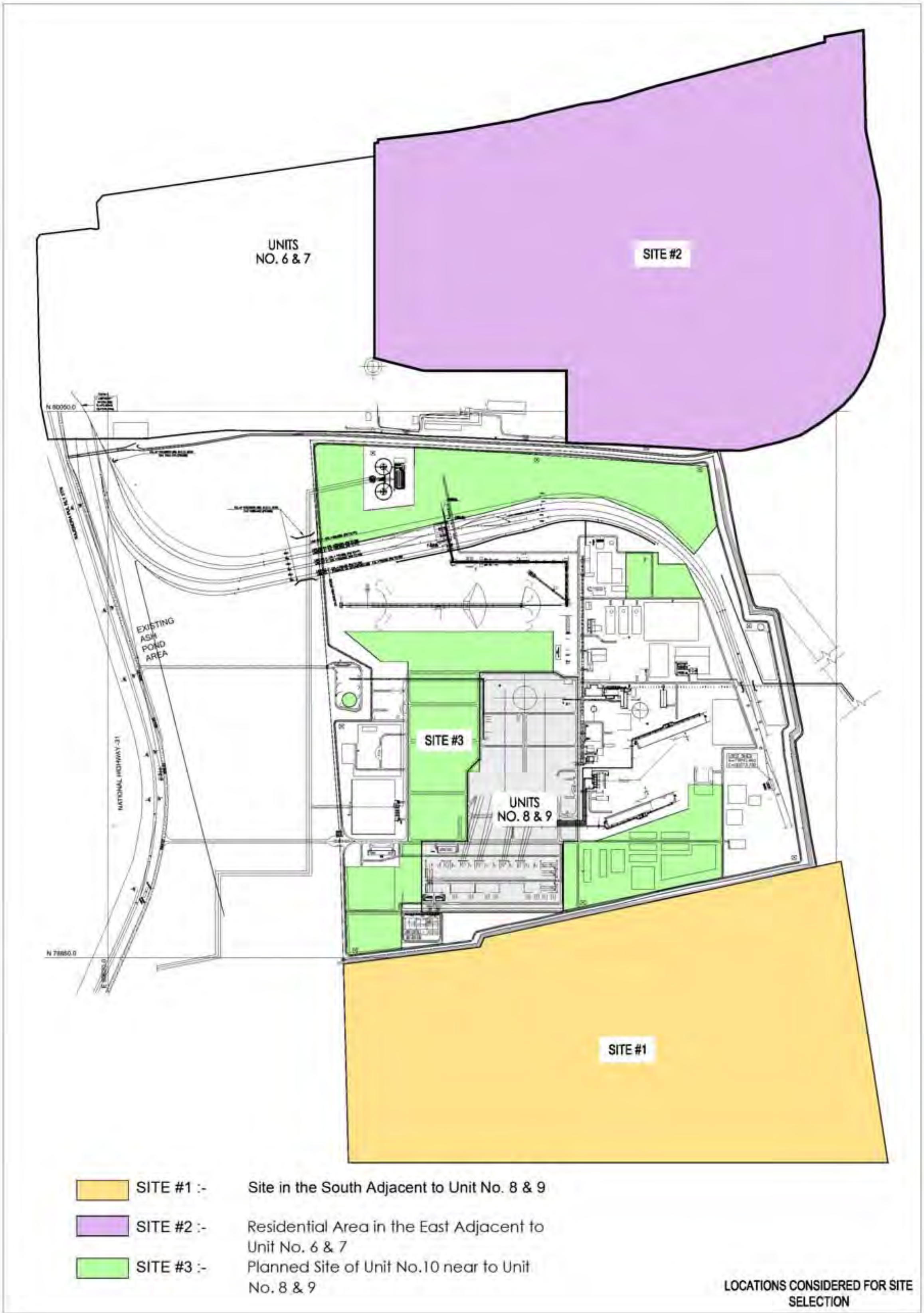

Figure 7.1-1 Site Location Map

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The below Table 7.1-1 listed a few advantages & disadvantages of all the three (3) potential sites as located within the BTPS premises.

Table 7.1-1 Evaluation Results of Installation Sites

Sl. No.	Examined Sites	Evaluation Results	
		Advantage	**Disadvantage**
1	**Site #1** (South side Adjacent to Unit No. 8 & 9)	•Large land area is available •Layout planning with adequate access for O&M is possible. •There is no need for existing plant/equipment removal. •The plant and facilities relative location and arrangement can be optimized. •No need to apply special facilities to mitigate lack of space. •Future expansion is possible.	•Acquisition of additional land is required by BSPGCL. •Additional railway siding is required for this area. •Private land acquisition is very difficult.
2	**Site # 2** (Residential Area in the East Adjacent to Unit No. 6 & 7)	•Large land area is available. •Layout planning with adequate access for O&M is possible. •There is no need for existing plant/equipment removal. •The plant and facilities relative location and arrangement can be optimized.	• Removal and leveling of residential buildings is required. • Rehabilitation of people living in the residential colony. • Additional railway siding is required for this area.

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Sl. No.	Examined Sites	Evaluation Results	
		Advantage	**Disadvantage**
3	**Site #3** (Previously planned Site of Unit No.10 (1x 250 MW) near to Unit No. 8 & 9)	•No need for equipment or residential colony removal / demolishing. •No need to acquire additional land. •Existing railway siding can be used. •No worries for rehabilitation of people living in the residential colony.	• Limited space for plant layout planning so special facilities such as coal silos have to be applied.

As a result of evaluation of different sites as shown in above Table 7.1-1, Site # 3 is selected considering the advantages mainly on account of no need to acquire land, no demolishing work and no rehabilitation of peoples.

The Site # 3 land will be used for locating the main plant facility inclusive of Boiler, ESP, Chimney, Steam Turbine, Transformer Yard and GIS Switchyard for the Unit No. 10. However, BOP like CHP, AHP, WTP and ETP will be located within the plant area based on space availability.

The land requirement for the construction of Unit No. 10 is as shown in Table 5.4-1 of Section 5.4, and land availability for each major area (i.e. inside / outside) including current status is shown in below Table 7.1-2.

Table 7.1-2 Land Availability

Sl. No.	Component	Acres	Current Status
1	Main Plant Area	84	Existing land Owned by BSPGCL
2	Ash Pond & Slurry Pipeline (common for Unit No. 6 to 10)	290	Mix of government and private land. The land is under the process of possession of BSPGCL for Unit No. 8 & 9.

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Sl. No.	Component	Acres	Current Status
3	Water Intake Facility (common for Unit No. 6 to 10)	20	Government land. Approximately seventeen (17) acres of land is under the possession of BSPGCL as required for onshore intake water facility and balance three (3) acres of land for ROW for intake water pipeline of Unit No. 10 is additionally required.

From above, it may be concluded that the land available is suitable and generally adequate for the Unit No. 10 with all the auxiliaries and accessories.

Major facilities required for constructing the Unit No. 10 at the proposed site location will be considered in the plot plan as per below criteria:

Coal storage

This will be done in silos having twenty (20) days storage capacity of coal requirements complying with the guidelines of Ministry of Power [11] for the coal mines located at a distance of less than 500 kms from the Unit No. 10. Coal silos will be located besides existing railway siding and coal unloading will be done with track hopper which will be planned on new rail track.

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Water Treatment and Cooling System

This system for the Unit No. 10 will be sourced from the Ganga River which is a perennial source adequate for the BTPS plant requirements. The raw water storage tanks with one (1) day capacity of the consumption of the Unit No. 10 will be provided. Water pre-treatment and DM water plant facilities are being considered accordingly. ETP will be installed on the basis of Zero Liquid Discharge (ZLD) for the Unit No. 10. Main Circulating Water system is based on CCW employing IDCT as described later in this Section.

Ash Handling System

This facility for BA will be through LSD System with provision for ash water recirculation and for FA will be through dry form as well as in HCSD System. Total three (3) nos., each of 1,500 tonnes capacity concrete ash silos will be provided for ash handling system i.e. dry fly ash - one (1) no., and HCSD silo - two (2) nos.

7.2 Water Availability

One of the features of the Unit No. 10 is to take advantage of round the year availability of water from nearby the Ganga River for the plant consumptive water requirements.

For Unit No. 10, the maximum water intake requirement is an approximately 2,140 m^3/hr. (21 cusec) which can be met by the Ganga River, if the additional water withdrawal rights are granted to BTPS.

7.2.1 Outline of Water Source and Water Intake Plan

Estimated amount of water required for each unit/phase and the permitted intake water withdrawal amount from the Ganga River were evaluated while finalizing the water intake plan.

Table 7.2-1 shows the amount of water required for each unit/phase, the permitted amount of water withdrawal from the Ganga River in the current plan and the required amount of intake water including the Unit No. 10 consumption.

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Table 7.2-1 Required Amount of Water from the Ganga River and Permitted Water Intake Amount in the Current Plan (Unit: cusec[*1])

Item	Phase-1 Unit No. 6 & 7 (2x110 MW)	Phase-2 Unit No. 8 & 9 (2x250 MW)	Phase-3 Unit No.10 (1x660 MW)	Total	Remarks
Max. required Amount of Raw Water	20	25	19	64	When there is No Recycling of ash water from ash pond
Min. required Amount of Raw Water	xx	xx	16	xx	When there is recycling of ash water from ash pond
Permitted Water Intake Amount	60 (plenty season) 45 (lean season)		-	60	Current Plan
Required Amount of Intake Water	22	28	21	71	Considering 10% loss at pre-sedimentation tank

*1: 1 cusec = 101.94 m^3/hr.

Previously, the plant consumptive water requirement such as Cooling Tower make-up water and process make-up water for the existing Unit No. 6 to 7 was taken from bore wells. However, during the construction of the Unit No. 8 & 9, it was considered to change the water source from the bore wells to the Ganga River for Unit No. 6 to 9. Water intake from the Ganga River is being first time implemented at BTPS.

The GoB is responsible for the management of the water intake from the Ganga River for BTPS. Since BTPS is a BSPGCL owned power plant, therefore, it will not be difficult to obtain approval for additional river water withdrawal from the WRD of the GoB even though the deficit between the required amount of water and the available amount is 26 cusec during lean season owing to the Unit No. 10 and de-silting losses of Phase-1 & 2.

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Although, the Ganga River is usually very muddy at the intake site and it becomes especially muddy for two (2) months in the rainy season, this problem will not be a big obstacle to construct the Unit No. 10 as the construction of additional De-Silting Basin (DSB) outside of the BTPS plant boundary will resolve this issue of incoming silts.

CCW system employing Cooling Tower of induced draft type will be selected for the Condenser cooling.

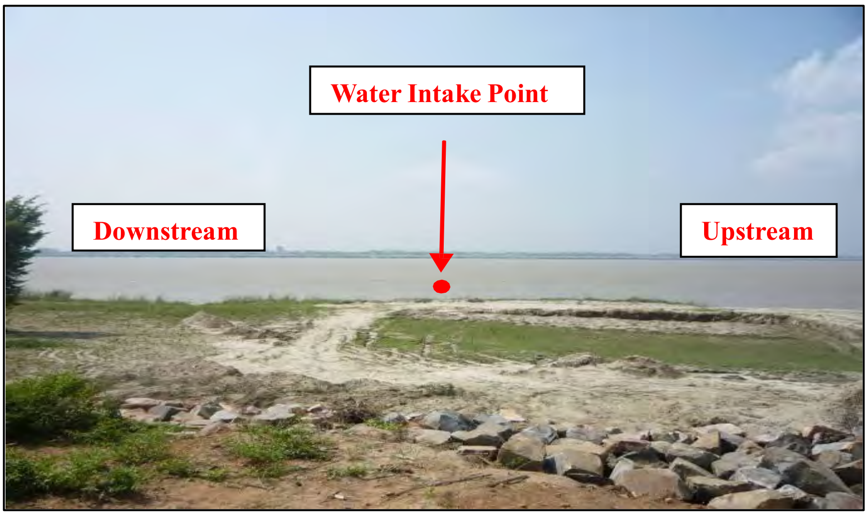

Figure 7.2-1 Water Intake Point at the Ganga River

Figure 7.2-2 Left Bank of the Ganga River (Downstream Side of Water Intake Point)

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7.2.2 Water Quality Evaluation

Table 7.2-2 shows the quality of raw water taken from the Ganga River [15].

Table 7.2-2 Quality of Raw Water from the Ganga River

(Unit: mg/L)

Sl. No.	Description	EIA / EMP Report [15]	DCPL – DPR [20]
1	pH	7.56 ~ 8.01	8
2	Turbidity (NTU)	57 ~ 82	702
3	Calcium Ion (Ca) / Hardness, $CaCO_3$ (DCPL)	34 ~ 42	76
4	Magnesium Ion (Mg) / Hardness, $CaCO_3$ (DCPL)	9.7 ~ 12	32
5	Sodium Ion / Hardness, $CaCO_3$ (DCPL)	-	24
6	Residual Chlorine	Nil	-
7	Mercury Ion, Hg	< 0.001	-
8	Chloride Ion, Cl	7.5 ~ 10	10
9	Sulphate Ion SO_4	14 ~ 19	-
10	Dissolved Silica, SiO_2	-	7.9
11	Iron, Fe	0.18 ~ 0.3	-
12	Total Hardness, $CaCO_3$	125 ~ 150	108
13	Alkalinity / M-alkalinity (HCO_3), $CaCO_3$ (DCPL)	105 ~ 120	104
14	P-alkalinity, as $CaCO_3$	-	0
15	Total Dissolved Solids	180 ~ 205	130
16	Arsenic Ion, As	< 0.01	-
17	Lead Ion, Pb	< 0.01	-
18	Zinc Ion, Zn	0.02 ~ 0.04	-
19	Chromium Ion, Cr^{6+}	< 0.01	-
20	Aluminium, Al^{+3}	0.05 ~ 0.07	-
21	Nitrate, NO_3^-	2 ~ 4	-
22	Fluoride, F^{-1}	0.2	-

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The raw water from the Ganga River has the following features.

- High turbidity, alkalinity ($CaCO_3$)
- Medium amount of positive ions / CATIONS such as calcium, magnesium, iron, and aluminium etc.
- Low amount of negative irons / ANIONS such as chloride, nitrate and fluoride etc.

Therefore, suitable WTP shall be provided for the Unit No. 10 to remove impurities from the river water and make it acceptable for use in the SC power plant. However, it is prudent to mention that certain impurities like chlorides, fluorides in the river water will be carried through to the condenser cooling water as it cannot be removed in the clarification process. Hence, appropriate material shall be selected for the condenser cooling water system to avoid chloride corrosion due to chloride deposition as it contents in the river water.

7.2.3 River Water Intake Structure

River water will be withdrawn from the Ganga River through an intake pump house. The options available for the river water pump house are listed below:

Onshore Pump House

In this option, under bed pipeline will be installed to carry intake water by gravity to the onshore pump house. This option will minimize the civil structure for pump house as compared to offshore construction thus it is an economical option. In this arrangement additional land is required on the shore & due to gravity flow or river water this arrangement will have sedimentation problem in the pipeline resulting in choking of pipelines and high silting in the pump chamber. Therefore, considering above sedimentation problem, the onshore pump house is not recommended.

Offshore Pump House

River water will be withdrawn from the Ganga River through a pump house suitably located in the river. This option has been agreed to implement for the river water intake pump house for the Unit No. 6 to 9.

Based on the earlier DPR for Supply of Ganga Water for Unit No. 6 to 9 [8], it is proposed to have offshore common river water intake pump house that will feed the required amount of river water to the BTPS plant including plant raw water

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requirements of all the units i.e. Unit No. 6 & 7 (Phase-1), Unit No. 8 & 9 (Phase-2) and the Unit No. 10 (Phase-3). The type and design of the river water intake structure (or river water pump house) as well as suitable intake point has been decided based on Hydro-graphic and Bathymetric studies, as carried out by accredited Agencies and/or Experts i.e. WAPCOS for Unit No. 6 to 9 [8].

The proposed design of river water intake pump house is having the limited space to accommodate the new pumps for the Unit No. 10 with similar pump configuration of 3 x 50 % as for Unit No. 6 to 9, thus additional installation for Unit No. 10 can be accomplished either by changing existing pump capacity & configuration of Unit No. 6 to 9 or developing a new and separate river water intake structure for Unit No. 10 with pumping configuration of 3 x 50 %.

The former will take advantage in no need of additional construction. Furthermore, the later will require additional land as well as approval. Considering as above, offshore pump house and its retrofit in existing pump arrangement is recommended.

It is therefore proposed to change the river water intake pump capacity & configuration from 3 x 50 % (Unit No. 6 & 7, each 1,275 m^3/hr.) and 3 x 50 % (Unit No. 8 & 9, each 1,275 m^3/hr.) to total 4 x 33 % (common for Unit No. 6 to 10, each of capacity 2,450 m^3/hr.). The revised configuration implies one (1) pump will operate for each phase, total three (3) pumps operating for BTPS with one (1) pump as common standby. Therefore, considering above pumping configuration it is proposed to construct a common raw water intake pump house for BTPS to install 4 x 33 % river water intake pumps, three (3) pumps will be installed for Unit No. 6 to 9 at present during the construction phase of Unit No. 8 & 9, while a space will be reserved for 4th pump to be installed during construction of the Unit No. 10. This arrangement will have optimized cost & land requirements as well as construction schedule of the Unit No. 10. Further, the transformer capacity and associated cable size will be considered with revised pump capacity in the electrical system design.
A common approach bridge will also be constructed for access to river water intake pump house for operation & maintenance and to install the intake pipelines up to the shore of Unit No. 6 to 10. The common approach bridge will have suitable walkway and car / rail arrangement for the movement of equipment.

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The pump pit depth will also be decided based on the amount of water intake & water quality such as turbidity, organisms (autotrophs such as plants, algae, or bacteria), and species etc.

Approval regarding construction of an intake water pump house in the Ganga River, approach bridge, onshore de-silted water pump house and onshore DSB including permission for withdrawal of river water for BTPS (Unit No. 6 to 10) to be obtained by BSPGCL from the competent authority.

To minimize the effect of silting, selection of water intake point is very important because of the drift in the Ganga River. However, DSB and regular de-silting methods will be envisaged in the design. For Unit No. 10, a DSB will be constructed at location beside to existing DSB of Unit No. 6 to 9.

The clear water make-up pumps will be arranged in the transverse direction of entry flow from the DSB. The pump configuration will be of 2 x 50 % for Phase-1 and Phase-2 each with common standby i.e. total of five (5) pumps will be installed / constructed for Unit No. 6 to 9 while space will be reserved for 3 x 50 % pumps as required for Unit No. 10.

Based on WAPCOS report the intake supply for Phase-3 Unit No.10 will be taken from the 33 kV Substation built for Phase-1 and 2 with extended bus at 33 kV level and further step down to 415 V with two (2) nos. 1,000 kVA auxiliary service transformer.

Hence, no separate 33 kV OHL is considered for Phase-3. The LV switchgear room will be common both for Phase-1 & 2 and Phase-3. Alternatively, as an optimization approach the present size of 1,600kVA auxiliary transformers planned for Phase-1 & 2 can be increased to 2,500 kVA with consideration of Phase-3 loads and thus 33 kV Switchyard bays for Phase-3 can be avoided.

7.2.4 Cooling Water Systems (Main Circulating Water System)

The water cooled Condenser is proposed to be used for the Unit No. 10 similar to Unit No. 6 to 9. The water cooled Condenser has the advantage of higher plant efficiency and less land area requirement as compared to Air Cooled Condenser (ACC). Since, in this project land area is very limited, ACC option is ruled out.

The cooling in case of water cooled Condenser is achieved either through a Once-through Cooling Water System or a CCW System employing IDCTs.

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Once Through Cooling Water System

The cooling water (i.e. river water) is withdrawal from the bank of the river and after de-silting, screening the clear water is supplied to the Condenser directly for cooling & condensing the steam exhausting from the Steam Turbine. The hot cooling water is then discharged back into the river simply. The temperature rise of the cooling water in this system is to be limited to 7 °C which is less than CCW system, as described below.

This results in large amount of cooling water requirement. The pumping system in this case is of large capacities thereby increasing the auxiliary power consumption. The environmental effect especially effect of the temperature rise of river water on aquatic life is a prime concern.

However, Cooling Tower and pre-treated water (i.e. clarified water) from the WTP is not necessary, The Once Through Cooling Water System is adopted on case to case basis depending on environmental sensitivity specially for seawater application where cooling water is available in abundance. Considering the above Once Through Cooling Water System, it is not recommended.

Closed Cooling Water (CCW) System

In this application, the river water is re-circulated in a closed system. The cooling water is pumped by Circulating Water Pumps from the Cooling Tower outlet to the Condenser where it picks up heat from the condensing steam and the hot water is led to the Cooling Tower where it is cooled by the ambient air flowing through the Cooling Tower by Induced Draft (ID) Fans.

The temperature rise of the cooling water in this system can be in the range of 9 - 10 °C which is more than the above Once Through Cooling Water System. Hence, it results in lesser cooling water flow through the system. Since the cooling at the Cooling Tower is by evaporation of some of the cooling water, make-up water to the cooling system is required on continuous basis.

Further, the make-up water has to be pre-treated (i.e. clarified water) in the WTP to reduce the concentration of impurities in the system, and dosing of chemicals are also required which otherwise would lead to scaling and corrosion. The Cooling Tower types may be IDCT or Natural Draft Cooling Tower (NDCT).

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Although, NDCT is a better choice due to lower operating cost, but considering lesser (rectangular) space requirement, lesser construction time and better performance in case of changing ambient conditions, IDCT is recommended to adopt for the Unit No. 10, which is same as of existing Unit No. 6 to 9.

A brief comparison between NDCT and IDCT is detailed in the below Table 7.2-3.

Table 7.2-3 Comparison in between NDCT & IDCT

Sl. No.	Description	Natural Draft Cooling Tower (NDCT)	Induced Draft Cooling Tower (IDCT)
1	Land / Space requirement (Acres)	3	2
2	Construction Schedule (Months)	25	20
3	Differential Auxiliary Power Consumption (kW)	0	2,500
4	Flexibility in Operation	No	Yes (spare cells available)
5	Effect of Ambient conditions and Cooling Load on Cooling Tower performance	Has some impact	Negligible
6	Installation Cost	More	Less
7	Operating Cost	Less	More

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7.3 Fuel Selection

7.3.1 Main Fuel

The Unit No. 10 has been identified will fire domestic coal as main fuel. The coal for BTPS is categorized as sub-bituminous coal as per Japan Industrial Standard or class / grade “G14” as per Indian coal classification, refer to below Table 7.3-2 [16].

Table 7.3-1 JIS Coal Classification (JIS M10002)

Classification		Gross Heating Value (Dry Ash Free Basis) (kcal/kg)	Fuel Ratio	Agglomerating Character
Grade of Coal	**Group**			
Anthracite Coal (A)	A_1	-	> 4	Non agglomerating
	A_2			
Bituminous Coal (B, C)	B_1	8,400	-	High agglomerating
	B_2		-	
	C	≥ 8,100 to < 8,400	-	agglomerating
Sub-Bituminous Coal (D, E)	D	≥ 7,800 to < 8,100	-	Low agglomerating
	E	≥ 7,300 to < 7,800	-	Non agglomerating
Lignite (F)	F_1	≥ 6,800 to < 7,300	-	Non agglomerating
	F_2	≥ 5,800 to < 6,800	-	

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Table 7.3-2 Indian Coal Classification [16]

Old Grading based on UHV Grade	New Grading Based on GCV	GCV, kcal/kg
A	G1	GCV exceeding 7,000
	G2	GCV between 6,701 and 7,000
	G3	GCV between 6,401 and 6,700
B	G4	GCV between 6,101 and 6,400
	G5	GCV between 5,801 and 6,100
C	G6	GCV between 5,501 and 5,800
D	G7	GCV between 5,201 and 5,500
	G8	GCV between 4,901 and 5,200
E	G9	GCV between 4,601 and 4,900
	G10	GCV between 4,301 and 4,600
F	G11	GCV between 4,001 and 4,300
	G12	GCV between 3,700 and 4,000
G	G13	GCV between 3,400 and 3,700
	G14	GCV between 3,101 and 3,400
Non-coking Coal Ungraded	G15	GCV between 2,801 and 3,100
	G16	GCV between 2,501 and 2,800
	G17	GCV between 2,201 and 2,500

Typically, domestic coals available are of class / grade “G14” with GCV on ARB, Ash & Sulfur content is around 3,300 kcal/kg, 44.6 % & 0.3 % for design coal, and 3,100 kcal/kg, 40 % & 0 % for worst coal, respectively.

Potential domestic coal blocks which will be allocated by the GoI through Ministry of Coal or purchase through fuel supply agreement as the case is considered for preparing this DPR. For Unit No. 8 &9, Eastern Coalfield Limited (ECL) has already issued Letter of Assurance to BSPGCL for supply of 1.53 MTPA of coal in GCV grade of G10 and above on tapering basis from its basket of mines, and Badam coal block having minerals reserves of 90.5 million tonnes of coal, which is scheduled to supply the coal in 2019.

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For Unit No. 10, although the coal will be sourced either from the coal blocks or the coal linkage, coal linkage is considered as primal option for securing domestic coal. For DPR study purpose, there are identified coal blocks within the proximity of the BTPS site and it will be sourced from the any one of the coal blocks likewise, Kerandari, Badam, Chatti Bariatu, Chati Bariatu (South), Pachwara North, Pachwara Central located in the state of Jharkhand.

Thus, the supply of domestic coal will be ensured by BSPGCL through the coal linkage application toward Ministry of Power / CEA / Ministry of Coal / CIL group (e.g. ECL, fully owned subsidiaries of Coal India Limited, Its coal mines are shown in Figure 7.3-1). In case coal blocks are allotted by the GoI same as Unit No. 8 & 9, such coal block will be developed by BSPGCL through an external agency for mining to ensure the supply of coal to the BTPS site.

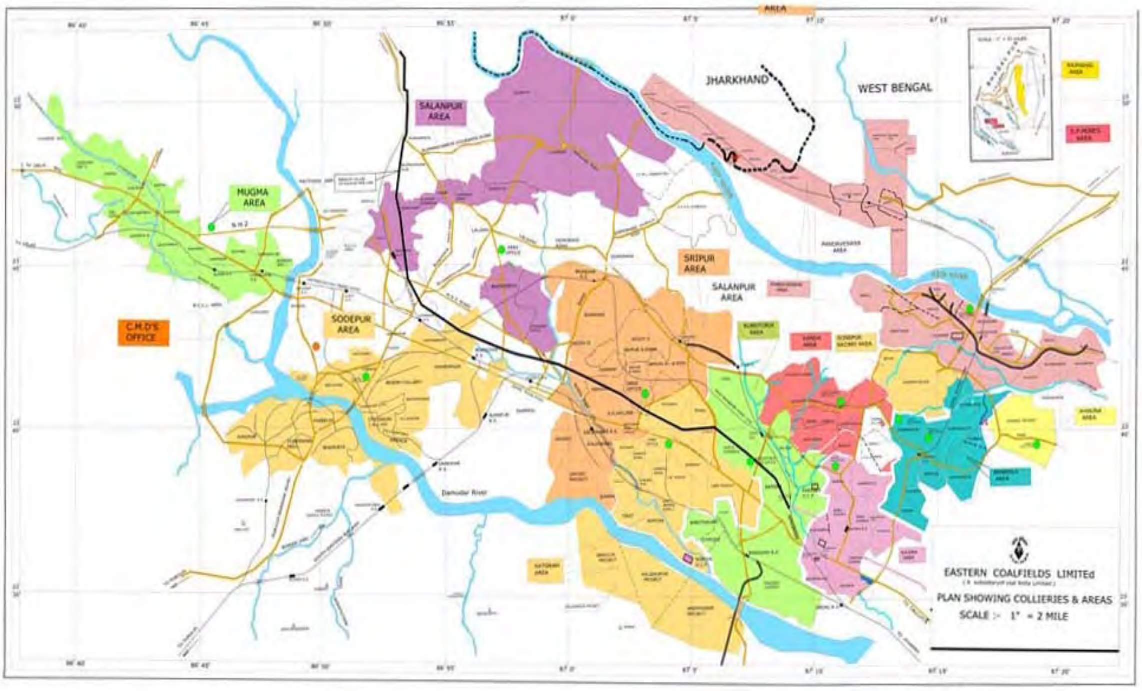

Figure 7.3-1 Geographic Location & Area leasehold by ECL Mining [17]

For coal analysis, refer to "Appendix – III Typical Fuel Analysis & Requirements" as attached with this DPR.

7.3.2 Start-up & Flame Stabilization Fuel

Start-up, warm up and low load operation will be carried out with LDO. Boiler will be so designed that oil firing for flame stabilization will not be required beyond

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40 % BMCR. LDO system would be used for Boiler start-up or low load and flame stabilization with coal firing, LDO system having load carrying capacity up to 30 % BMCR will be envisaged.

Ignition of LDO will be directly by high-energy arc igniters. LDO firing will be provided in at least one (1) burner elevation to facilitate a cold start-up of the Unit No. 10.

7.4 Steam Cycle Parameters Selection

The Unit No. 10 will adopt SC steam parameters to achieve higher efficiency and hence lower cost of generation. The review of parameters followed for unit of comparable sizes indicates that typically steam parameters in the following range have been adopted for the SC units.

Table 7.4-1 Boiler Parameters

Sl. No.	Parameters	Value
1	Pressure at superheater outlet	242 - 270 bar (a)
2	Temperature at superheater outlet	593 - 600 ^{0}C
3	Steam temperature at re-heater outlet	593 - 600 ^{0}C

The primary factors which govern the steam cycle selection are the efficiency, equipment cost and the fuel cost. With higher steam parameters, the investment cost goes up on account of increase in the cost of Boiler and Steam Turbine equipment. However, on account of higher plant efficiency, the incremental investment cost is recovered within the initial years of operation, if the PLF is maintained at higher value as planned.

The other major benefit of adopting higher steam cycle is the reduction in emissions (SPM, CO_2, SO_x, NO_x). Secondary benefits of higher steam cycle parameters are the reduction in the capacities of auxiliary systems such as Cooling Water, Coal and Ash Handling, thus some savings in the capital cost. The advancement in metallurgical research coupled with rising fuel cost have contributed to the migration of manufacturers and project developers to go for higher steam parameters.

In India, presently, there are many 660 MW SC thermal power plants in operation

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and / or under construction stage. And, based on the survey the following power plants were examined of upcoming similar capacity power projects based on supercritical technology and major among them are:

- 2 x 660 MW Raghunathpur Project of DVC, Purulia district, West Bengal
- 2 x 660 MW Meja TPS Project of MUNPL, Allahabad district, Uttar Pradesh
- 2 x 660 MW Suratgarh STPS stage V Project of RVUNL, Ganganager district, Rajasthan
- 3 x 660 MW Barh TPS Project of NTPC, Patna district, Bihar
- 2 x 685 MW TPS Project of GMR, Raipur district, Chhattisgarh

Keeping in view the current technological trends in the field of SC units, recent international power projects, the cost of coal (and its possible escalation during the plant life, number of manufacturers available in the world as well as predicted investment cost, following steam cycle parameters are selected for the Unit No. 10. As a result of further economical examination, SC parameters exceeding the conditions as shown in Table 7.4-2 will be a practical option for choosing final specification in future.

Table 7.4-2 Steam Cycle Parameters

Sl. No.	Parameters	Value
1	Main Steam Pressure	245 bar (a)
2	Main Steam Temperature	593 °C
3	Main Steam Flow Rate	1,860 TPH
4	Reheat Steam Pressure	48.9 bar (a)
5	Reheat Steam Temperature	593 °C
6	Reheat Steam Flow Rate	1,540 TPH
7	Feedwater Temperature	295 °C

The typical heat balance diagram with the above parameters at 100 % TMCR is attached with this DPR as Appendix - IV, Heat Balance Diagram.

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7.5 Material Selection

7.5.1 General

One of the prime catalysts in evolution of supercritical technology in power generation, with acceptable degree of reliability and availability is the advancements made in the metallurgical research over the past decades, resulting in superior high temperature withstanding materials.

While on one hand, research enabled identification of the many problems associated with existing SC units, which could be traced to failures related to metallurgy of components operating at high pressure & temperature environment, it also helped in development of new materials which could be used at more demanding operating conditions. The major issues related to the material compatibility with operating environment in respect of SC units are discussed below:

The Main Steam (MS), Reheat Steam (RHS) header and piping as well as HP & IP turbine components being heavy sections, apart from creep, thermal fatigue is also a major consideration. As the operating temperature increases, due to the fall in allowable stress levels, higher thickness is required to sustain the design pressure. Increase in thickness, increases the potential of thermal fatigue failure.

Ferritic materials containing varying proportion of Chromium (Cr), Molybdenum (Mo) with small quantities of Vanadium (V) and Niobium (Nb) were extensively used earlier for MS and RHS piping in view of their good / high temperature strength.

Recently, the most prominent material on this group has been ASTM A335 P91 and A213 T91. This is 9 % Cr steel containing 1 % Mo, 0.2 % V and traces of Niobium. However, the major drawback of ferritic steels is the vulnerability to oxidation at higher temperatures. Hence, even though from a creep standpoint, ferritic steels can be used up to 620 ^{o}C, oxidation susceptibility limits their use only up to about 600 ^{o}C.

However, recently further advancement has been made in the ferritic material development. First phase in this evolution were steels developed by optimization of Carbon (C), Molybdenum (Mo) and V as well as partial substitution of Tungsten (W) in place of Nb.

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The two (2) prominent alloys, thus developed, which are commercially available today, are:

- ASTM P122 (12Cr-MoVNbW)
- ASTM P92 / T92 (9Cr-0.5Mo-1.8WVNb)

ASTM P122 is a duplex 12 % Cr steel containing 2 % W and 1 % Cu along with other stabilizing elements like Mo, V and Nb. In addition to higher creep strength, it also has fairly good weldability.

ASTM P92 is 9 % Cr steel developed by partial substitution of W for Mo and has a higher creep resistance relative to P91. Both of these materials are approved by ASME. Most of these materials are compatible for pressures up to 340 bar and temperatures up to 620 ^{o}C.

7.5.2 Last Stage Blading (LSB) of LP Turbines

The main considerations in selection of materials for the LSBs are resistance to moisture and weight in view of their large diameter. These are normally made of either Titanium (Ti) based alloys or 12 % Cr steels.

7.5.3 Boiler Tubing

In case of tubing, apart from creep, fire side corrosion and steam side oxidation are the main considerations. Further, in respect of water wall tubing, the requirement of Post Welding Heat Treatment (PWHT) was another consideration. In respect of creep for tubes, the allowable stress needs to be seen at about 28 ^{o}C over and above the steam temperature.

7.5.4 Boiler Fire Side Corrosion

Fire side corrosion results from presence of molten sodium-potassium-iron tri-sulphates. In general, it has been found that the resistance to fire side corrosion increases proportionally to the increase in the Cr content in the steel.

For temperatures in the 600 ^{o}C region, since ferritic steel may not be compatible for combined resistance against creep as well as fire side corrosion, austenitic

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steels containing 20 % or more Cr may be applied / considered.

In general, it has been found that the weight loss on account of corrosion in respect of austenitic steels goes in a close band up to around 620 °C and fine distinction between the resistances of different grades becomes apparent only above 650 °C. Hence, up to around 620 °C, conventional stabilized stainless steels like SS316H, 347H or 321H can be used under moderately corrosive environment. For more corrosive coals, modified SS310 alloys like HR 3C (containing 25 % Cr) may be required.

7.5.5 Steam Side Oxidation

In SC units, the consequence of steam side oxidation becomes more severe in view of relatively high operating temperatures. With increasing thickness of the scale, heat transfer gets hindered resulting in increase in the outside metal temperature. If the situation gets aggravated further, the exfoliated scale can clog the tubes and can potentially reach the turbine and damage the blades.

7.5.6 Water Walls Corrosion

Water wall corrosion is caused by H_2S under reducing atmosphere around the burner. This is observed predominantly in those units where high sulfur (>1 %) fuel is burned and / or where staged combustion is used to bring down the NOx. In general, it has been found that low alloy steels are more susceptible to water wall corrosion.

7.5.7 Metal Temperature

Metal temperature has been another concern for water walls for boilers operating with steam temperatures close to 600 °C. It has been ascertained that generally, the mid wall temperatures tend to be about 100 to 125 °C less than the final superheater outlet temperature calling for alloy steel containing high Cr content for water wall application. However, these steels will require PWHT, which is difficult to carry out at site.

Some manufacturers have developed low alloy steels with adequate creep strength and which do not require PWHT.

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7.5.8 Cost Economics in Material Selection

While, the unit cost of materials compatible with demanding operating environment are higher, it can be found that the migration to better materials can actually reduce the cost, looking from a totalitarian angle. This is because, for materials with higher creep resistance, the thickness of section will be lower.

This can result in below likewise,

- Reduced weight
- Reduced handling cost
- Lower thermal stresses for cyclic loading
- Lower warm up / cooling periods during start-up / shut down respectively

7.6 Equipment Sourcing

Boilers and Steam Turbine Generators of the 660 MW rating SC units are being currently manufactured in India. However, some of the domestic power equipment manufacturing companies have also entered into collaboration with overseas suppliers for manufacturing of the same and have set up manufacturing facilities in the country.

The Generator Transformer (GT) of 660 MW rating is also manufactured in India. The control system for the SC unit is also sourced within the country.

All other remaining equipment is also sourced within the country. Nevertheless, a few equipment of the power plant would have to be sourced from the overseas manufacturers located in the countries likewise Japan, Europe and USA, if required.

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7.7 Transportation Logistics

Considering the construction phase of the Unit No. 10, the plant and machinery need to be brought to the project site by various means and modes of transportation.

Further, since the plant will use domestic coal, the same also needs to be transported to site on continuous basis. All major plant and machinery will be brought to the BTPS site via either railroad or in-land / road transportation however domestic coal will be brought to the project by railroad and unloaded inside the BTPS site.

Alternatively, equipment can also be shipped through other established nearby port located in Kolkata, West Bengal. Further, transportation from Kolkata port to BTPS site will be via the Ganga River, and if required then temporary jetty to be constructed nearby the BTPS site at bank of the Ganga River.

It is noted that not many bridges were constructed to span the Ganga River, which is a wider river, while transporting the material from the south bank to north bank. There is a bridge (the Rajendra Bridge) immediate vicinity of BTPS at a distance of 3.5 kms in southwest crossing the Ganga River. And, this bridge has been used for material transportation including major equipment for Unit No. 8 & 9. The below Figure 7.7-1 indicates the available bridges near BTPS.

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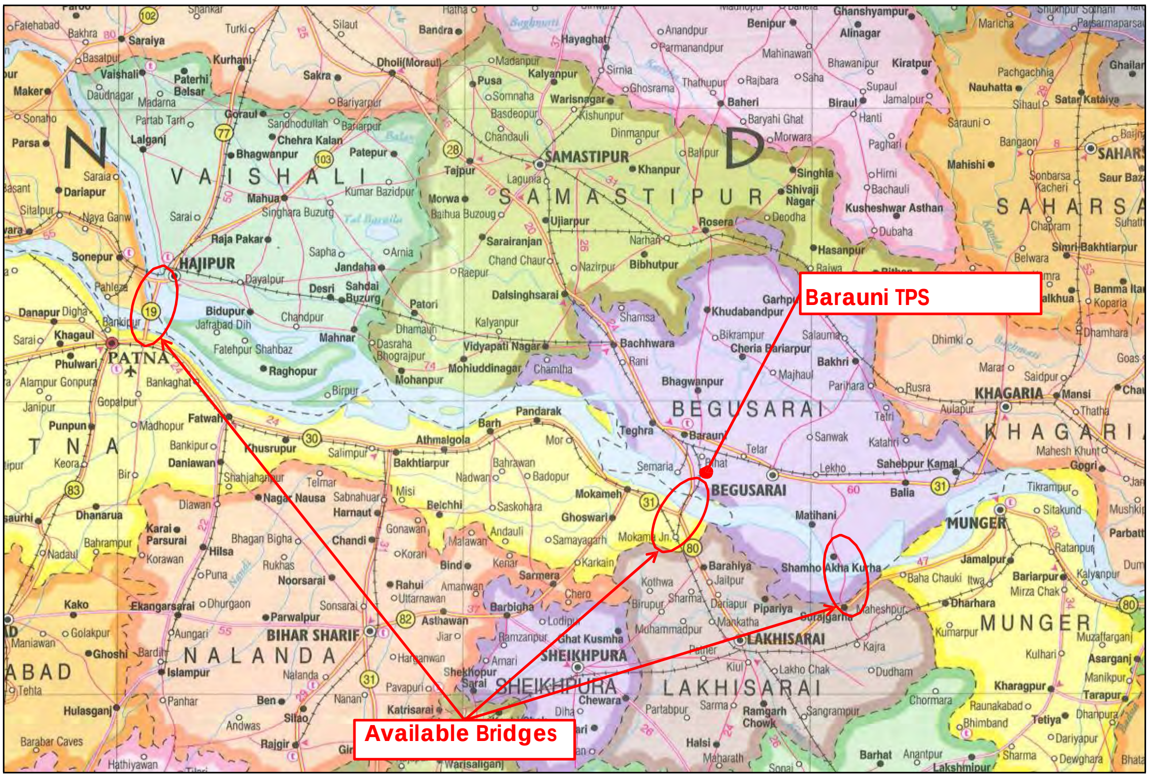

Figure 7.7-1 Available Bridges near BTPS

After completion of the new bridge of Munger Ganga Bridge, which is completed in 2016, the bridge is also expected to be used for transportation and the distance from Kolkata will be reduced to approximately 570 km. In addition to the Rajendra bridge, an another bridge spanning the Ganga River located at a distance of 140 kms named the Vikramshila Setu or bridge downstream of the Rajendra Bridge, also a bridge located in the capital city of Patna at a distance of 110 kms named the Mahatma Gandhi Setu or the Ganga Setu bridge upstream of the BTPS site.

(i) Precautions in equipment transport

The load bearing capacities and traffic conditions of roads and bridges should be checked before transporting machinery and equipment as shown below.

(ii) Load bearing capacities of roads and bridges in heavy equipment transport

As the power station site is located three km from the Ganga River, heavy equipment is supposed to be transported upstream on the river by barge. Of all the parts, the girder for the EOT crane at the turbine building, which measures 30

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meters by 3 meters by 1.5 meters, is the longest component. The girder is supposed to be transferred after disassembled, and it would be assembled on site. Refer to the following regulations and other standards applied to transporting heavy equipment (such as BTGs and transformers).

- Regulations on maximum loads
  Regulations of the Indian Roads Congress (IRC)
  IRC: S6 (2014), Standard Specifications and Code of Practice for Road Bridges Section II
- Regulations on transporting long objects
  IRC SP 37: Applies to the movement of over dimensional consignments (ODCs) that are being transported by car at low speed.
- Data gathered in earlier stage of projects
  The NTPC Barh (660 MW) project site is situated near the Barauni Site, so heavy and long items have been transported to the area. Heavy objects have been transported to the Meja Thermal Power Plant (2 x 660 MW), which is currently being built in the state of Uttar Pradesh, by barge on the Ganga River.
  In addition, Unit No. 8/9 of the BTPS are now under construction, so the condition of roads used for transporting have already been well developed.

(iii) Conditions of roads to be used

- Road conditions
  Conditions of roads (length, width, height and weight) to be used to be confirmed
- Possible obstacles in transportation routes
  The locations of the rail over bridge (ROB), small bridges, flyover roads (load bearing capacity), inclines, grade crossings, toll booths, signboards, traffic signs and other objects to be confirmed
- Traffic congestion
  Locations where traffic congestion frequently occurs due to obstacles and other reasons, the causes of traffic jams and countermeasures against them
- Survey on relevant government agencies
  Necessary permissions and offices of relevant government agencies (such as the Indian Railways, the MoP, the Ministry of Road Transport and Highways [MoRTH]) to be confirmed

Expected weights of main equipment of the 660 MW facility and relevant devices
The expected weights of heavy equipment to be used in this project are shown in

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Table 7.7-1

Table 7.7-1 Expected weights of heavy equipment

Heavy object	Weight (ton)
Single-piece ceiling girder (installed with crawler crane)	200
Modular ceiling girder (installed with strand jack) (Project example in India: NTPC Meja Thermal Power Project)	3,000-3,500
Total weight of pressure-resistant boiler parts	8,500
Total weight of steel structures and non-pressure resistant parts of boiler	19,500
Total weight of ESP, other auxiliary equipment	10,000
Total weight of rotating machines	4,000
Total weight of lagging materials	3,000
Total weight of major pipes for boiler and turbine	2,500

(iv) Transport of the heaviest object

Of all the components of equipment used in this project, the heaviest object per transportation unit is the generator, and the equipment will be transferred after the stator and the rotor are separated. Their weights and sizes are shown in Table 7.7-2.

Table 7.7-2 Expected weight and size of generator

Part	Category	Specifications
Generator stator	Cargo weight	About 340 t
	Package size	9,650 mm x 6,300 mm x 5,300 mm
Generator rotor	Cargo weight	About 89 t
	Package size	13,100 mm x 1,800 mm x 1,900 mm

On the other hand, in case the materials that are available from the neighboring

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states adjacent to the State of Bihar, will be transported to the BTPS site. The materials will be transported via using the Mahatma Gandhi Setu or the Rajendra Bridge.

Considering the features of the proposed Site#3 as mentioned in the Clause 7.1 of Section 7, it is concluded that it meets all the basic requirements for setting up of Unit No. 10 using domestic coal and with river water as the source of consumptive water. Further, with good connectivity to national highway (NH-31), rail network, essential logistics for the transportation of fuels (i.e. coal, oil) and other plant equipment is ensured. Therefore, it is considered that the site selection is suitable for establishment of the Unit No. 10.

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SECTION 8

POWER EVACUATION PLAN

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8.1 Load Flow & Grid Stability

The objective of the power evacuation study was to suggest technically feasible solution for evacuation of power from the Unit No. 10. The power evacuation study will include load flow studies and short circuit study. The load flow study will consider various loads - generation scenario and different contingency cases to establish the adequacy of proposed power evacuation system. The short circuit study will establish the fault levels at 400 kV bus. The data of power system study will be used for system design.

The power evacuation study was carried out for the year 2021 - 22 time frame, considering the network planning data available as on March 2015 and the State of Bihar peak load for the study year from CEA's 18th EPS demand. The various alternatives and network contingencies were also studied.

Based on the preliminary load flow contingency and short circuit studies carried out by PRDC, it is concluded that interconnection to proposed Gaighat (new) 400/220 kV substation with 400 kV Double Circuit (D/C) line (Twin ACSR Moose, 50 - 60 kms) is the suitable option for the power evacuation from Unit No. 10. Since construction of 400/220 kV substation in Gaighat (new) located at Bakhtiyarpur is yet in a planning stage, it is suggested to take up construction of both substation and evacuation lines from the BTPS site as composite scheme so as to match with the commissioning of the generation unit.

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SECTION 9

PLANT TECHNICAL FEATURES & DESIGN CONSIDERATIONS

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9.1 Mechanical Equipment & System Design

The proposed power generating unit will be of SC steam parameters employing once through type Pulverized Coal fired boiler considering 100 % domestic coal as a design basis. The domestic coal will be unloaded at the proposed plant site by railway networks. It is proposed to use river water for Condenser cooling with CCW system. Plant service water, potable water and DM water requirements will be met by treating river water suitably. Effluents generated from the power plant will be collected, treated and reused within plant premises to achieve the ZLD.

The BA will be collected in the wet form and FA in dry form. FA will be sent out for utilization (i.e. for road construction, back filling low lying areas, cement factories, bricks formation, etc.) and unutilized FA will be disposed to the ash dyke using HCSD system. FA will be stored in storage silos for the purpose of utilization. Unutilized fly ash will be converted into slurry form and will be disposed to the ash dyke along with BA, thus considered HCSD system for fly ash handling.

The switchyard will be located near the Steam Turbine and Generator (STG) building, from where the generated power will be evacuated at 400 kV level through suitable nos. of outgoing feeders.

The plant will be designed in compliance with applicable National and International Codes and Standards such as ASME, ASTM, DIN, BS, IEC, IEEE, IS, ISO, API, JIS etc. The plant will comply with all local statutory regulations & requirements, such as Indian Boiler Regulations, Indian Factories Act, Indian Electricity Act, Environmental Regulations, etc.

The key design parameters are tabulated in below Table 9.1-1.

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Table 9.1-1 Key Design Parameters

Sl. No.	Item		Data
1	Gross Output		660 MW (1 x 660 MW), 693 MW in case of emergency i.e. Valve Widely Open (VWO)
2	Performance	Plant Efficiency (Gross)	42 %
		Boiler Efficiency	87.7 %
		TG Gross Heat Rate	1791 kcal/kWhr
3	Fuel	Domestic Coal (Main)	3100 - 3300 kcal/kg (as received basis)
		Start-up fuel	LDO
4	Boiler	Boiler type	SC Once-through Pulverized Coal Fired Boiler, Opposed Firing / Tangential fired
		Steam Pressure & Temperature	(SH outlet) 255 bar (a), 596 °C (RH outlet) 50 bar (a), 596 °C
		Boiler MCR	≈ 2000 t/h
		Minimum Load	40 % BMCR (without oil support firing)
		Mill Arrangement	8 nos. (7+1)
5	AQCS (Air Quality Control System)		ESP, SCR, FGD
6	Steam Turbine	Type	Tandem Compound, 4 cylinders (HP+IP+LP(A)+LP(B))
		Turbine Throttle Condition	245 bar (a) / 593 °C / 593 °C
		Rotating Speed	3000 rpm
		Condenser Back Pressure	65 mm of Hg (A) (average)
		Rated quantity of MCW to condenser	71,000 m^3/hr.
		Temperature rise of MCW across condenser	9.0 °C
		Feedwater System	9 stages of feedwater heating incl. Deaerator i.e. 4 nos. LPH + Deaerator + 3 nos. HPH + Desuperheater
		BFP Configuration	2 x 50 % Turbine-Driven BFP + 1 x 30 % Motor-Driven BFP

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Sl. No.	Item		Data
7	Generator	Voltage / Capacity	20 - 27 kV / 780 MVA
		Power Factor	0.85 PF
8	Generator Transformer		3 nos. Single Phase 260 MVA,20 - 27 kV / 420 / √3 kV
9	Switchyard		400 kV GIS, Double Bus Scheme
10	Main Cooling System		IDCT with river water make-up
11	Chimney		Single flue RCC Chimney – 275 m height
12	Coal Handling System		2 stream conveying from track hopper to coal silos (1350 MT/hr. each) and from Coal Silo to Coal Bunkers (1200 TPH)
13	Plant Water System		2 stream Resin based DM water
14	Ash Evacuation		Bottom Ash (Lean Slurry) + Fly Ash (HCSD)
15	Ash Storage & Transportation		Two (2) nos. of Ash storage silos each of capacity 2,200 Tonnes

9.1.1 Steam Turbine & Auxiliaries

The Steam Turbine Generator (STG) will be rated for 660 MW at the 100 % TMCR condition. Steam Turbine will be provided with Cold Reheat (CRH) & Hot Reheat (HRH) system and regenerative feedwater heaters to achieve the best possible steam cycle efficiency. Salient technical details of steam turbine & auxiliaries are as below:

A. Turbine Proper

(i) Turbine General

The Steam Turbine equipment will have design and construction features with proven reliability and superior performance in a large number of units operating at comparable steam conditions. High reliability and high-sustained efficiency are achieved by the following design and construction features:

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- Standard block design
- Horizontal split casing
- High efficiency blade profile
- Proven blade fixture
- True centerline support of casings and nozzle diaphragms
- Solid rotor

(ii) Configuration of the Steam Turbine

The Steam Turbine will be a tandem-compound reheat unit with four (4)-flow LP exhaust, and such design and construction features are incorporated which have proved their reliability and efficiency in a large number of units operating at comparable steam conditions. The SC steam turbine consists of three (3) pressure sections i.e. HP casing, IP casing and four 4-flow LP sections.

Main steam passes through two (2) nos. combined Main Stop and Control Valves (MSV/CVs), enters the turbine at the bottom of the HP casing and flows toward the front standard side. When the load reaches above TMCR load, Over Load Valve (OLV) will be opened. The steam passing through the OLV will be admitted to the intermediate stage of the HP Turbine. After passing through the HP stages, the steam will be returned to the re-heater of the boiler. The reheated steam returns to the turbine through two (2) nos. Combined Reheat stop Valves and Intercept Valves (CRVs) at the IP turbine. The steam leaves the IP turbine through external crossover pipe that connects to the inlet of the LP turbines.

After passing through the LP stages, the steam will be exhausted downward into the condenser. The turbine is keyed at the centers of LP exhaust hoods to prevent axial movement and the turbine casings expand from these points. The front standard is free to slide in an axial direction as the turbine expands and contracts under operating conditions. The standards and LP casing are keyed to prevent transverse movement. To permit good sliding contact between the steel standard and foundation plate, oil impregnated bronze or cast iron pads are inserted between the two (2) and have sufficient area to provide a good bearing surface. Grease grooves are provided and these are connected to external grease fittings. The exhaust hood has a horizontal joint to permit inspection and maintenance. There is an inner exhaust hood that is supported in the outer hood by a few support pads, and is keyed to prevent axial or transverse movement.

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(iii) Casings

The HP, IP and LP casings have horizontal joints for ease of maintenance. These horizontal joints are accurately machined or hand scraped to obtain a full metal-to-metal contact and steam-tight joint.

The HP & IP section consists of double shell construction, which is made of casting alloy. HP & IP turbine casing is designed to minimize the possibility of steam leakage, reduce stress and minimize temperature gradient in both the inner and outer casings. There are two (2) main steam inlets on the lower half of casing, which provide more uniform heating of the casing and reduce distortion.

The inner casing is supported with four (4) shims in the outer casing and is fixed axially by faucet joint. The shims to secure correct vertical alignment of the inner casing have hardened surfaces to eliminate the wear which may result from the relative movement of the inner casing as it thermally expands and contracts. The inner casing is keyed to the upper and lower vertical centerlines which locate the casing transversely. This arrangement maintains accurate alignment between the stationary and rotary parts, as the casing expands and contracts under various operating conditions.

Each low-pressure section consists of 2-flow, low-pressure casing. The casing is made of steel plates welded and has separate inner casing, which is supported with four (4) support shims in the outer casing and keys to prevent vertical movement. The relief diaphragm and manholes are provided on the outer casing.

The design basis for parts subjected to high temperature is the reduction of thermal stresses by reduction of temperature differences and gradients.

(iv) Turbine Rotor

The Turbine has one (1) HP, one (1) IP rotor and two (2) LP rotors, which are uniformly and solidly fastened with coupling bolts. Rotors are supported by eight (8) journal bearings. The No. 1 & No. 2 bearings are in the HP rotor section, No. 3 & No. 4 bearings are in the IP rotor section, and No. 5 & No. 6, bearings are across the LP rotor (A), No. 7 & No. 8 bearings are across the LP rotor (B), in the LP hood section. Rotors are positioned in axial direction by the thrust bearing installed on the middle bearing pedestal between the HP, IP and LP section.

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The HP, IP rotor is made of 12 Cr / Cr-Mo-V welded alloy steel material having large high temperature and fatigue strength. The LP rotor is made of Ni-Cr-Mo-V steel having great resistance to low temperature brittleness.

Each rotor is forged from a solid alloy steel ingot and is machined to form shaft, wheels, bearing journals, thrust collar and coupling flanges. Prior to machining, ultrasonic tests, magnetic particle tests and various other tests are carried to assure that the forging meets the required physical and chemical properties. After the blades are assembled, the rotor is carefully balanced by the dynamic balance test. The balance weights are carefully fitted and securely fastened to the ports and/or grooves these are machined on a rotor.

(v)Turbine Blades

Turbine OEM (original equipment manufacturer) has many decades of experience designing turbine blades. Today, modern computers are used for precise calculations of wheel flexibility, twist effects and many other complex factors that determine proper blade design. Extensive calculations coupled with exhaustive development of testing programs make it possible to produce high efficiency, low vibration, and long life blades.

The blades are made from chrome-iron alloys that have excellent strength and fatigue properties as well as high resistance to steam corrosion and erosion. They are machined from solid stock, obtained either as bars or forging, and are dovetailed to the wheel rims using a tight machine fit. The radial spill strips are located above the turbine blade tips to limit steam leakage between the casing and blades.

Last stage blades are machined to axial curved entry dovetail at their lower portion, and fixed to rotors by keys. These are high efficiency transonic blades. They have high reliability and low vibration stresses due to flexible continuously coupled construction, in which all the blades are connected to each other.

(vi) Nozzle Diaphragms

The steam flow is directed into the blades at the proper angle and velocity by the nozzle diaphragm partitions. The nozzle profile, areas and angles of discharge are

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determined by various parameters such as, volume of steam to be passed, steam pressure drop across the nozzle, velocity of the adjacent blades, to enable the best performance.

The nozzle partitions are machined from solid chromium iron alloy and are incorporated into the diaphragm by welding or assembly process. This enables high strength to resist the pressure difference across the diaphragm.

(vii) Journal Bearings

All main bearings are pressure lubricated. To assure proper alignment of each main journal bearing at all times, the bearing design incorporates a self-alignment feature.

Pad type bearing or ellipse type bearing are selected according to the load of bearing. Pad type bearing has six (6) independent pads in one bearing; all of them are positioned to bearing ring with pivot and movable to follow the rotor alignment. Ellipse type bearing has spherical seat between bearing body and its ring, which also enable to obtain the freedom of movement.

Correct operating temperatures are maintained by oil supply unit, and the quantity of supply to each bearing is controlled by means of orifices in the oil feed pipes.

For ease of adjustment the bearing frame is equipped with shimmed pads that can be easily moved or replaced to obtain proper initial alignment. The bearings are lined with a carefully controlled, high quality tin base babbitt, which is secured to the bearing shell by dovetail anchorage. This helps to assure long service with a minimum of maintenance.

(viii) Thrust Bearing

The assembly consists of shoes, Base Ring, Leveling plate and Oil feed tube. The shoe bodies are low carbon steel with high tin content babbitt. The spherical support on the back of the shoe allows 360 degrees pivot. The shoe Supports are made of carbon tool steel.

Base ring holds the shoe and leveling plate in their operating positions. Base ring

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made of structural steel plate or forged steel. An oil inlet annulus located on the back of the base ring distributes oil to axial holes through the base ring outer wall and into the oil feed tube.

The leveling plates equalize the load of each shoe. The leveling plates working with the spherical shoe supports ensure that the thrust bearing face becomes perfectly aligned with rotating thrust collar.

(ix) Turning Gear

A turning device is used to turn the rotor at several rpm when starting, in order to evenly heat the rotor and reduce the possibility of distortion.

This device, mounted on the rear bearing casing (bearing No. 8), consists of an electric motor and a train of gears. A movable pinion to the gear casing engages with the ring gear on the coupling flange of the turbine rotor. Speed detector is provided at the front standard.

When steam is admitted to the turbine during operation of the turning device, the movable pinion will, by means of clash gear, immediately and permanently disengage without shock.

B. Principal Steam Valves

(i) Main Stop Valve (MSV)

This is a quick closing valve, which is tripped hydraulically to stop steam flow to turbine. It is supported separately from the turbine.

The valve is fully opened when oil pressure from the Electro Hydraulic Control (EHC) oil system is applied to the operating cylinder of the valve. It is fully closed when oil pressure is lost either by system initiated trip or turbine over speed.

There is a built-in steam strainer in the upper body to prevent ingress of large foreign materials. The operating cylinder and hydraulic mechanism are mounted on the valve. The valve body is made of alloy steel casting.

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(ii) Main Control Valve (CV)

Steam, after passing through the main stop valve, is admitted to main control valve before entering the HP turbine. These valves control the amount of steam passing to the turbine. It is opened and closed by actuator, and is controlled by digital EHC (D-EHC) system through turbine hydraulic system.

The valve is combined with main stop valve and so name implies as MSV/CV. The common body is made of alloy steel casting / forging.

(iii) Over Load Valve (OLV)

One (1) OLV is provided for Steam Turbine. OLV's inlet nozzle is connected from the combined MSV/CV and its outlet nozzle is connected with piping to the middle stage of the HP section which is a welded connection on the HP Turbine lower casing.

When the load is more than 101 % load, OLV will open so as to generate more output to maximum load by swallowing the additional steam flow. Thus, this kind of operation improves the efficiency with keeping the minimum MCV throttle at 101 % load. OLV is being controlled by EHC operation.

(iv) Combined Reheat Valve (CRV)

Two (2) nos. CRVs will be provided, those supply reheat steam to the IP section. As the name implies, the CRV consists of two (2) valves, the Intercept Valve (IV) and the Reheat Stop Valve (RSV), incorporated into one (1) valve casing. Although, they utilize a common valve casing, these valves provide entirely different functions.

The primary function of IV is pre-emergency protection. However, they also trip closed upon actuation of the emergency trip system. The second one is to control the steam flow during the turbine start-up and loading turbine bypass system. The RSV is provided to quickly shut-off the steam flow in the Reheater line in emergency conditions when steam turbine to be tripped.

Steam from the Reheater section of Boiler enters into the single inlet of each CRV casing, passing through the strainer, the opened IV and RSV, and going out through a double outlet connected directly to the IP turbine section.

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The inlet connection of the valve casing is welded directly to the hot reheat steam pipe, and the valve outlet are symmetrically connected to upper half (two (2) connections) and the lower half (two (2) connections) of the IP turbine shell. This arrangement results in positioning the CRV as close as possible to the turbine, thereby limiting the amount of uncontrolled reheat steam affects to the turbine over speeding under pre-emergency and emergency conditions (i.e. the steam volume between the valve outlet and turbine shell is limited to minimum).

C. Turbine Gland Steam System

Turbine gland steam system mainly consists of steam seal supply system (SSH) and steam packing exhaust system (SPE).

Before starting and at low load, seal steam is supplied from auxiliary steam system through feeding valve. At higher load, seal steam is supplied from high pressure gland leakage and brought to low pressure glands. Steam is cooled to appropriate temperature through gland steam pipe stretched in condenser by LP exhaust steam. Excess steam is discharged to LP heater 2 or Condenser through unloading valve. Gland packing exhaust steam, mixed with air is brought to gland steam condenser, where steam is condensed and heat is recovered. Air is extracted by blower (i.e. steam exhauster), which keeps exhaust line slightly lower pressure than atmosphere.

Exhaust hood spray system is also equipped with this turbine. During low load and when exhaust temperature is high, valve will automatically open and water from condensate line is sprayed into turbine exhaust hood.

D. Lubricating Oil System

Lube oil system consists of oil reservoir, 2 x 100 % AC motor driven pumps, 1 x 100 % emergency DC motor driven pump, 2 x 100 % plate type oil coolers, two (2) Main oil strainers and cooler transfer valve, etc. Temperature and pressure controlled oil passes through oil filters and distributed to each bearing. Return oil is collected to slightly sloped return pipe and led into the oil reservoir.

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E. Control System

(i) General

An EHC system controls the steam turbine by positioning the turbine's MSV/CV to meet operating conditions.

Turbine OEM's EHC systems have the great advantage of many years of successful operating experience gained through high-reliability automatic operation. The flexibility, quick response and complex logic capabilities of solid-state electronics are combined with high pressure hydraulic actuation to provide a significant degree of control and improved operation.

The unit's basic circuits for automatic operation such as automatic run-up, and speed matching for synchronizing, are equipped with the EHC system to implement highly advanced automation and easy interface with other systems.

(ii) High Pressure Control Fluid System

The turbine's high pressure fluid power unit is part of the hydraulic portion of the EHC system used to control turbine operation.

Control oil system is completely independent from lube oil system. The major components of the hydraulic power unit include:

- A fluid reservoir
- Two (2) completely independent and parallel pumping systems including filters
- Fluid coolers
- Accumulator

F. HP / LP Bypass System

The HP and LP bypass stations sized for 60 % of BMCR steam flow will be capable of meeting the following requirements:

- Quick startup of the steam generator from cold, warm & hot conditions
- Parallel operation of the bypass with turbine in the event of large load throw-off
- House load operation

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- Boiler Single operation

G. Protective Function

The following protective circuits and activation of the turbine emergency stop valves will be provided.

Table 9.1.1-1 List of Protective Circuits

Sl. No.	Item	Protective Circuits
1	Electrical over speed	2-out-of-3
2	Shaft vibration high	2-out-of-2
3	Thrust position abnormal	2-out-of-3
4	Lubricating oil pressure low	2-out-of-3
5	Main Oil Pump discharge oil pressure low	2-out-of-3
6	EHC control oil pressure low	2-out-of-3
7	LP exhaust steam temperature high	2-out-of-3
8	Condenser pressure high	2-out-of-3
9	Activation from electrical generator protection	2-out-of-3

H. Condensate Water System

(i) Surface Condenser

Surface condensing box type heat exchanger of dual pressure (HP & LP) type is proposed for extension unit of 1 x 660 MW, the Condenser shell is connected to the double flow LP turbine exhaust. Besides the steam exhausted by the LP turbine, miscellaneous recoverable steam drains flows from other heaters are directed to the condenser in order to be condensed by means of cooling water circulated by the Main Circulating Water (MCW) system. The Condenser is of two (2) single pass, divided water box type, dual pressure with an integral air cooling section. The Condenser consists of inlet and outlet Water Box, Hotwell, Tube Bundles and LP Turbine Bypass Dump Pipe. Cooling water flows inside tubes. The steam exiting the LP turbine condenses on the outer surface of the tubes and drips down to the Hotwell, where it is collected.

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The Hotwell has a capacity from NWL to LWL to collect condensate resulting from two (2) minutes of turbine operation at the design steam flow at VWO condition with 1 % make-up. Condenser tubes are arranged in two (2) different zones, these are condensing zone and air-cooling zone. Steam exhausted from the LP turbine is condensed in the condensing zone while the non-condensable gases are cooled in the air-cooling zone before being extracted out by the Vacuum Pumps.

De-aeration occurs inside the condenser where dissolved air is released from the bulk of water and removed out by the Vacuum Pumps along with in-leak air, if any. The condensate water is extracted from the Hotwell by the CEPs and pumped to the Deaerator.

Water boxes are divided into two (2) halves with separate inlet and outlet connections. These halves can be completely isolated from each other so that one half of the Condenser can be isolated on the cooling water side for inspection of the water box while the other half remains in operation.

The Hotwell level is normally maintained at the Normal Water Level (NWL) to ensure the Net Pump Suction Head (NPSH) required by the CEPs and to avoid flooding from the Condenser.

(ii) Condenser Vacuum System

2 x 100 % Liquid Ring Vacuum Pumps are provided in each pressure shell in order to remove non condensable gases from the Condenser.

During the hogging operation for the Condenser vacuum-up, all vacuum pumps will be operated for each shell. Vacuum pumps will be sized as per the recommendations of Heat Exchange Institute (HEI). Vacuum Pumps are located in the turbine hall at EL + 0 m level. The vacuum pump comprises of the condenser vacuum connection pipe with piston actuated main isolation valve at each vacuum pump suction. Each vacuum pump is provided with its own 1 x 100 % seal water tank, seal water pump (if required) and 1 x 100 % seal water cooler. Makeup to the seal water system is provided at the separator tank from the condensate water.

During initial startup, when the condenser is not under vacuum or inlet absolute pressure is greater than the set pressure of hogging operation then all pumps start in Hogging Mode. When the pressure at the inlet (Condenser) to the vacuum

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pump reaches below the set point of hogging operation then the standby selected vacuum pump stops and the main vacuum pumps operate on holding mode. In case the vacuum deteriorates due to unforeseen reasons then the standby vacuum pump starts again at the predetermined vacuum set point. Vacuum pump is controlled and monitored from the DCS.

(iii) Condensate Extraction Pump (CEP)

3 x 50 % Condensate Extraction Pumps (CEPs) are envisaged as per standard design concept. The CEP is a multi-stage canister type vertical pump.

The motor is mounted on the top of the pump (Level of motor may be below the GF level) and a single oil bath lubricated thrust bearing is provided in the upper side of the pump (outside the canister) which absorbs the thrust of both pump and motor.

Self-lubricated radial bearings are located in the pump shaft and first stage impeller. The mechanical seal flushing water is provided from the CEP discharge or inter-stage. The CEP is controlled from the DCS.

(iv) Condensate Polishing Unit (CPU)

Condensate Polishing Unit (CPU) consists of one (1) set of condensate polishing unit inside TG Building and an external regeneration system for the unit. CPU consists of three (3) service vessels of 33 % capacity each.

CPU is provided with an automatic bypass system for the condensate polisher on the condensate inlet and outlet headers with a control valve. In the event of excessive pressure drop between the condensate inlet and outlet headers or regeneration of service vessel this control valve will open automatically to bypass requisite quantity of condensate.

The CPU consists of 3 x 33 % exchanger vessels. An external regeneration facility is provided to regenerate the exhausted resins. The CPU vessel is located inside the STG building and regeneration facility is located outside the STG building. The condensate polishing plant reduces contaminants (impurities) that can appear in the condensate. CPU vessels will be spherical type design.

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The condensate polishing is done by Ion Exchange process with resins. The CPU vessels are loaded with CATION and ANION resins in Hydrogen (H+) and Hydroxyl (OH-) form. During service operation, the CATION impurities is exchanged with CATION resin of Hydrogen (H+) and ANION impurities are exchanged with ANION resin of Hydroxyl (OH-). In case of high pressure Differential across the exchanger vessel, the CPU will be isolated and bypass valve is opened to divert the condensate. Only one (1) vessel can be taken out for regeneration at a time.

On exhaustion of any exchanger vessel, the resin is transferred and regenerated in a common external regeneration area which is provided along with chemical preparation & dosing equipment, effluent disposal system and resin transfer piping arrangement. This facility extends from polishers in STG building to common regeneration facility and back.

During the regeneration process, the resin in the mixed bed polisher unit is fluidized first. Then it is transferred by hydro-pneumatic / hydraulic mode to the common regeneration plant by resin transfer pumps. After the transfer of resin from the vessel, it is refilled hydro-pneumatically / hydraulically with the regenerated resin held in a mixed resin storage vessel.

Acid (HCl) will be used for regeneration of CATION resin and alkali (NaOH) will be used for regeneration of ANION resin. Acid will be stored in the acid measuring tank and Alkali solution will be prepared in the alkali solution preparation tank.

During regeneration process, acid / alkali will be injected by using dosing pumps. In order to improve the regeneration efficiency, dilution water for alkali solution is preheated in hot water tank before sending it for solution preparation. Waste water generated during the regeneration process is finally discharged to the neutralization pit for neutralization.

(v) Chemical Treatment

The chemical dosing system for the main power cycle consists of Ammonia & Oxygen injection (Oxygenated Treatment (OT) / Combined Water Treatment (CWT)) during normal plant operation and Ammonia & Hydrazine injection (All Volatile Treatment (AVT)) during unit start-up period.

AVT operation is carried out for the pre-treatment of feedwater to initiate CWT or OT operation at normal plant load. OT operation period will be during normal load

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operation of the power plant after AVT operation. OT operation is carried out to protect the piping from corrosion and rusting under low pH condition.

Ammonia is injected continuously to maintain the average pH level between 9.2 and 9.6 (with target pH of 9.5) during AVT Operation and the average pH level between 8.0 and 8.5 (with Target pH of 8.5) during OT treatment. During OT treatment, controlled concentration of dissolved O_2 is maintained in the range of 30 to 150 ppb by dosing the oxygen (as O_2) while during AVT, feed rate of hydrazine (N_2H_4) will be two (2) times of the Dissolved Oxygen (DO_2) in the condensate water (DO_2 content in condenser outlet as per HEI is 15 ppb while acceptable DO_2 in feedwater is 7 ppb).

(vi) Gland Steam Condenser (GSC)

A horizontal, U-tube type Gland Steam Condenser (GSC) is located on the mezzanine floor of STG building. Escaping steam from the Steam Turbine gland sealing, moved by a gland exhauster blower is directed to the GSC's shell, where it is condensed while condensate is heated in its tubes. The GSC is fitted with a local pressure indicator and a condensate trap for separating condensate traces from the steam try to leaving the GSC back into the Condenser.

(vii) LP Heaters

One (1) x 100 % capacity, single shell LP Heater 1 and 2 are provided in series in the condenser neck. LP Heater 1 and 2 is built-in at the neck (upper transition zone) of the Condenser.

Additionally, one (1) train of 100 % capacity each, horizontal LP Heater 3 and LP Heater 4 connected in series, are provided. The LP Heaters 3 and 4 are located in turbine house at EL (+) 11.5 meters. All LP Heaters are horizontal, U-tube type and accessible from mezzanine floor EL (+) 11.5 meters. The condensate flows on the tube side and the extracted steam from the Steam Turbine condenses on the shell side of the tubes.

On condensate side, a full flow motorized individual bypass valve together with a motor operated inlet and outlet isolation valves are provided for LP Heater 3 & 4. A relief valve at each inlet of the LP Heaters protects the LP Heater tube side from overpressure due to heating from shell side during the LP Heater isolated condition.

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Heating steam for LP Heater 1 & 2 is bled from the LP turbine. Both the above extractions are uncontrolled and without any isolation valve and / or non-return valve. The LP Heater 3 & 4 each gets the heating steam from the LP turbine uncontrolled extraction No 5 and extraction No 6.

The drains from the higher heaters cascades to the next lower heater with an emergency drain line to the Condenser except LP Heater 1.

To improve cycle efficiency / heat rate 2 x 100 % drip pumps are used. Normal drip from the LP Heater 2 & 1 will come to drain tank where drip pump will take suction & drip pump will discharge water to main condensate line in between LP Heater 1 & 2.

(viii) Condensate Makeup Water System

The Condensate Makeup Water system is an indispensable system for plant operation and is aimed for supplying condensate make-up water to the Hotwell. Emergency make-up to the condenser will be provided from Condensate Storage Tank by 2 x 100 % Hotwell make-up pumps through make-up control station and Normal makeup via gravity in to Hotwell.

(ix) Condensate blow and Spill over System

The condensate water is dumped by the CEP discharge blow-down valve branched from condensate piping upstream of the CPU to the atmospheric flash tank drain header during the clean-up phase. This line has a motor operated isolation valve with a depressurization orifice element.

During normal operation, if the Condenser Hotwell level becomes high then surplus clean condensate spill over will be dumped to condensate storage tank so that condensate water can be reused as condensate make-up.

(x) Deaerator

1 x 100 % capacity horizontal, tray-spray type single deaerating vessel simultaneously acting as feedwater storage tank is provided and located at the Deaerator floor. The tank storage capacity is three (3) minutes from normal to low-low water level at VWO condition. After the condensate is directed through the LP Heaters, it is dumped into the Deaerator and is sprayed through nozzle as it falls

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through an internal arrangement of trays.

By splashing condensate water inside the Deaerator, the water is heated to the saturation temperature at its Deaerator internal pressure, and it is de-aerated from 15 ppb to below 7 ppb. During normal operation, both heating and de-aerating operations are performed with the No.4 extraction steam. However, during the plant start-up and/or turbine bypass operation, CRH steam and / or auxiliary steam is used for heating and de-aeration inside the Deaerator. The water level is maintained to ensure the required NPSH of BFP booster pump and to avoid flooding from the Deaerator.

(xi) LP Clean-up System

The LP Clean-up system is used at the time of plant start-up. Lines branched from each of the three (3) Deaerator down-comer pipes (one down-comer per Boiler Feedwater Pump (BFP)) form the LP clean-up line and which is fitted with a motorized isolation valve. At the other end, the LP clean-up line is connected to the Condenser / atmospheric flash tank.

I. Feedwater System

BFPs take feedwater from the Deaerator through an individual down-comer pipe and deliver the feedwater to the economizer through the HP Heaters 6A/6B, 7A/7B, 8A/8B and DeSuperHeater DSH-A/B.

HP turbine bypass spray water will be taken from downstream of feed control station and re-heater attemperation spray water from BFP inter-stage tap-off. Intermediate stage feedwater extraction from each BFP is fitted with one (1) no. isolation valve and one (1) no. non-return valve.

Each BFP is provided with individual minimum flow recirculation line. The BFP Recirculation lines are connected back to the Deaerator, each fitted with one (1) no. recirculation control valve (pneumatic actuator) and isolation valve. The feedwater is heated in two (2) trains of HP Heaters. Extraction steam from HP turbine is used to heat the feedwater through HP Heaters. The feedwater system is comprised by the following major equipment.

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- 2 x 50 % Turbine Driven Boiler Feedwater Pumps
- Booster Pump for each of 2 x 50 % TDBFPs and 1 x 30 % MDBFP
- 1 x 30 % Motor Driven Boiler Feedwater Pump with fluid coupling (MDBFP) for start-up purpose
- Two(2) train of High Pressure Heaters comprising of:
  - one (1) HP Heater 6A/6B
  - one (1) HP Heater 7A/7B
  - one (1) HP Heater 8A/8B
  - one (1) DeSuperHeater DSH-A/B
- Feed Regulating Station (FRS)

FRS comprises of 1 x 30 % modulating control valve and 1 x 100 % motorized operated gate valve with inching facility. Control valve will be in operation to control the feedwater flow to boiler during start-up condition up to 30 % load condition and during shutdown from 30 % load condition. Motorized gate valve will be in operation during normal operating condition from 30 % to full load condition. FRS will be installed at upstream of HP heaters train.

A flow measuring element, capable to transmit the signal to the DCS, is provided in the piping between the BFP suction line and discharge line of the BFP Booster Pump. A non-return valve and a motorized isolation valve are provided in each BFP discharge line.

The minimum flow recirculation line from the discharge line is branched upstream of the non-return valve. The discharge lines from each BFP are combined into the common BFP discharge header line delivering the feedwater to the HP Heaters train. The intermediate stage bleed-off lines from each BFP are also combined into the common line to supply the spray water to Reheater system.

Each of the BFPs booster pumps take suction independently from the Deaerator storage tank. Provision of oxygen scavenger, Ammonia (NH_3) and Oxygen dosing is made at each Booster pump suctions.

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(i) Turbine Driven BFP (TDBFP)

2 x 50 % TDBFPs, sized based on 10 % margin over feed flow corresponding to steam turbine VWO condition, with 1 % make-up, design condenser pressure and corresponding head and will take suction from the Deaerator. Variable speed steam turbine for each TDBFP is provided.

Main pump is connected to the drive turbine with suitable coupling and the booster pump with a gear box. Pumps will be located at EL (+) 0.0 meter.

Each TDBFP is a multi-stage, horizontal, barrel type, centrifugal type pump. The main pump and drive turbine are mounted in the same axis. An individual suction line is provided from the Deaerator fitted with suction isolation valve, and a suction strainer. The discharge line leaving each BFP Booster Pump is connected to their corresponding BFP.

Drive turbine of TDBFP will get normal motive steam from extraction No. 4 in the load range of 30 % to full load. During low unit load conditions or bypass operation, when the extraction steam pressure is inadequate, steam from CRH extraction will be used.

Admission valve for the BFP drive turbine will be operated from the governing system of the drive turbine. However, exhaust from each drive turbine is led individually to the condenser of the main steam turbine.

For thrust balancing of main pump, a balancing device is also provided. On either end the shaft stuffing box assembly is provided with mechanical seals and seal water coolers are also provided for the same.

BFP lube oil system is common with the drive turbine lube oil system for supply of lube oil to the pump bearings and the gear box. Each lube oil system consist of AC lube oil pumps, main and working oil cooler, filters, etc. The cooling water from the CCCW system is supplied to the lube oil coolers and the mechanical seal water coolers.

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(ii) Motor Driven BFP (MDBFP)

1 x 30 % capacity MDBFP is multi-stage, horizontal, barrel type, motor driven, centrifugal type pump located at the ground floor EL (+) 0.0 meter, for the plant start-up. Both booster pump and main pump are driven with a common motor.

BFP Booster Pump is of horizontal, single stage centrifugal type located at the ground floor. An individual suction line is provided from the Deaerator fitted with suction isolation valve, and a suction strainer. The discharge line leaving booster pump is connected to the corresponding main BFP suction side.

The main BFP is a barrel type multi-stage pump. The main BFP being of higher operating speed than the motor, a step up gear box and variable speed hydraulic coupling combination is used in between the motor and the main pump. For thrust balancing a balancing device is also provided.

On either end the shaft stuffing box assembly is provided with mechanical seals and seal water coolers are also provided for the same. MDBFP set has its own dedicated lube oil system for supply of lube oil to the pump bearings and the gear box. Each lube oil system consist of shaft driven pump, AC motor lube oil auxiliary pumps, main and working oil cooler, filters, etc. The Hydraulic coupling itself serves as a lube oil reservoir.

The cooling water from the CCCW system is supplied to the lube oil coolers and the mechanical seal coolers.

The booster pump is single stage constant speed type pump located on the other end of the motor driven by the same motor shaft at constant speed. The BFP and booster pump including the lube oil system is controlled by the DCS.

Feed pumps are provided with handling facility by means of overhead cranes presently and shown in the STG building drawings accordingly. However, alternatively, handling of pumps motors can be done by means of monorails and electric driven hoists.

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(iii) HP Heaters

HP heaters function is to increase feedwater temperature before entering into the boiler by using steam from IP and HP section extractions. HP Heaters system includes two streams of high pressure heaters where HPH-6A, HPH-7A, HPH-8A & DSH-A arranged in series in one train and HPH-6B, HPH-7B, HPH-8B & DSH-B arranged in series in the other train at feedwater pumps discharge side and both trains are arranged parallel to each other, therefore referred as 2 x 50 % HP heater configuration.

Alternatively, 1 x 100 % HP Heater configuration may be adopted. Feedwater flows on the tube side and the extracted steam from the steam turbine condenses on the shell side of the tubes.

HP Heaters will be bypassed in groups and each train is provided with three (3) way media operated group bypass valves.

The HP heater 6A/B gets the heating steam (through DSH) from IP section of the Turbine uncontrolled extraction No. 3 plus CV & OLV leak-off. The HP Heater 7A/B gets the heating steam from the CRH line. The HP Heater 8A/B gets the heating steam from the HP Turbine uncontrolled extraction No. 1 plus CV & OLV leak-off.

All the HP heaters have desuperheating, condensing and drain cooling zones.

(iv) 3-Way Bypass Valves for HP Heaters

3-way valves of type inlet cum bypass will be provided across each train of HP Heaters. During normal operation, 3-way valves direct the feedwater flow through the heater trains and bypass line is closed.

In the event of any damage to the heaters or tubes, the channel side of the feedwater heaters must be isolated quickly. Parallel to the heaters isolation process, a bypass circuit needs to be established across the heaters to keep up the continuous feedwater flow to the Boiler.

During Heaters isolation mode, the 3-way valves act as a bypass valves and direct the feedwater supply to the Boiler through bypass line thereby isolating the heaters from feedwater side.

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(v) Extraction Steam System

In the regenerative cycle, steam is extracted from the Steam Turbine at various stages and used to heat the condensate and feedwater. This results in higher cycle efficiency, as the temperature of the condensate and feedwater increases more efficiently. Steam is extracted at various stages in the HP, IP turbine and LP turbine to heat-up the condensate and feedwater to required temperatures and no. of extraction as indicated in below Table 9.1-3.

Table 9.1-3 Steam Extraction List

Item	Application
No.1 extraction from HP section	HP Heater 8A/8B feedwater heating
No.2 extraction from CRH	HP Heater 7A/7B feedwater heating, Deaerator pegging / heating steam & Auxiliary Steam PRDS
No.3 extraction from IP section	HP Heater 6A/6B feedwater heating (through DSH)
No.4 extraction from IP section	Deaerator pegging / heating steam, Auxiliary Steam Header & TDBFP motive steam
No.5 extraction from LP turbine	LP Heater 4 condensate water heating
No.6 extraction from LP turbine (A) & (B)	LP Heater 3 condensate water heating
No.7 extraction from LP turbine (B)	LP Heater 2 condensate water heating
No.8 extraction from LP turbine (A)	LP Heater 1 condensate water heating

Each steam line extraction to HP heaters is provided with Quick Closing Non Return Valve (QCNRV) as per OEM practice. QCNRVs and motorized isolation valve both are provided in each steam line extraction to heaters including LP Heaters 3 and 4. However, the same is not provided for LP Heater 1 and 2.

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(vi) Closed Cycle Cooling Water (CCCW) System

The DM water based Closed Cycle Cooling Water (CCCW) System is provided to transfer the heat from all the turbine auxiliaries' coolers then transferred to the Auxiliary Cooling Water System (ACW), which is comprised of the CCCW heat exchangers, CCCW pumps, make-up system, piping and chemical dosing (NaOH) system for CCCW system.

3 x 50 % duty CCCW pumps are provided, and the pumps are installed on the ground floor EL (+) 0.0 meter of STG building. CCCW heat exchangers are 3 x 50 % capacity of plate type construction i.e. Plate Heat Exchanger (PHE).

Passivated DM water in CCCW system is pumped by CCCW pumps through CCCW heat exchanger up to the turbine auxiliaries' coolers and return hot water from each cooler is discharged to the suction of the CCCW pumps. Hot water is cooled in CCCW heat exchanger by clarified water (from ACW system) passing through the secondary side of the CCCW heat exchanger.

2 x 100 % duty Auxiliary Cooling Water (ACW) Booster Pumps are provided on secondary side and are installed in the ground floor EL (+) 0.0 meter of STG Building.

2 x 100 % self-cleaning type strainers are also provided at ACW Pump discharge header to protect CCCW heat exchanger of PHE type.

(vii) Central Lube Oil Storage and Purification System

Central oil purification system comprising of dirty oil tank & clean oil tank, oil transfer / forwarding pumps, static coalescer type, piping etc. are considered.

A central oil storage system will be provided for transferring and storage of oil to facilitate maintenance and cleaning of the unit oil tank. The system will be complete with a dirty and a clean oil tank located outdoors, each of capacity as 110 % of the oil contained in the system of one (1) unit.

A coalescer oil conditioner will be provided for water and sludge removal from the lubricating oil.

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(viii) Condenser Online Tube Cleaning System

The Condenser Online Tube Cleaning System (COLTCS) will facilitate continuous cleaning of the inner side of condenser tubes while the unit is in operation. The online cleaning feature makes it most attractive proposition considering importance of the condenser tube cleaning on the performance of the generating unit and evident advantages thereof without requiring a shutdown.

The system will use sponge rubber balls which are slightly oversized than the internal diameter of the condenser tubes to be cleaned. The balls are injected into the MCW pipe just before the condenser inlet water box and are forced through the tubes by the available pressure drop across the inlet and outlet of the condenser.

A special screening device (ball separator) installed in the main cooling water outlet line downstream of the condenser separates these cleaning balls from the main cooling water flow. From this ball separator, the balls are extracted by a ball recirculation pump together with a small quantity of water and are injected back into the condenser inlet pipe through a ball collector vessel and injection pipes, thus making it a closed cycle.

The normal cleaning cycle will utilize cleaning balls charged in suitable quantities. However, in due course of time, certain deposits get hard enough to be removed by these normal cleaning balls and hence, it is normal practice to charge certain number of abrasive balls to clean such harder deposits. These abrasive balls will be charged at regular intervals.

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9.1.2 Boiler & Auxiliaries

The Boiler will be once-through, water tube, direct pulverized coal, opposed wall / corner or tangential fired, top supported, balanced draft furnace, single reheat, radiant, dry bottom type, suitable for outdoor installation. The gas path arrangement will be single pass (tower type) or two pass type.

A. Water and steam circuit

(i) Economizer

Feedwater is introduced into the Boiler through the economizer inlet header. The economizer is located in the convention pass. The heated feedwater then flows upwards through the economizer hanger tube elements to economizer outlet header. Transfer pipes extend from each end of the economizer outlet header and combine to a common, external, unheated transfer pipe which blends and directs the flow to the furnace to ensure uniform entrance conditions into the furnace evaporator.

(ii) Evaporator

The furnace circuit consists of a lower section with optimized wall tubes that extend up to a transition header located at an elevation below the furnace nose. Above this location, vertical smooth bore tubes extend up to the furnace roof and also form the furnace exit screen and part of the extended back pass side walls. Riser pipes from the furnace enclosure upper headers extended back pass and screen tubes are routed to a collection header from which the flow is directed to the vertical separator. The riser pipes are than connected to roof header, roof tubes from roof header form the furnace roof and these tubes further forms the second pass panels.

The furnace enclosure tube size and spacing were selected to provide a low mass flux to provide a “natural circulation” flow characteristic to accommodate radial heat absorption variations around the perimeter of the furnace. Tube sizes and spacing, membrane fin sizes, and materials are all selected to provide a long-term, trouble-free life in cycling and base load service.

The final evaporator zone that forms the furnace nose, screen tubes and part of the extended furnace wall is provided to act as buffer circuit to minimize tube

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temperature differentials between the furnace evaporator walls and the adjacent heat recovery area enclosure.

(iii) Superheater (SH)

From the back pass panel steam / water passes through the SH circuit which includes the divided back pass panel, low temperature SH located in back pass, the furnace platen SHs and the pendant finishing SH.

Spray water attemperators are positioned upstream of the primary SHs outlet header and the platen outlet header for initial rapid final main steam temperature control which is coordinated with the feedwater and firing rate controls.

(iv) Reheater (RH)

The cold Reheat steam is first heated in the Low temperature reheated located in the furnace back pass. The RH tubes extend to an intermediate header which provides mixing and pressure equalization to minimize temperature unbalances in the primary RH. The primary RH tubes then extend into the extended back pass wall to achieve the final reheat steam temperature.

Reheat steam temperature is controlled by the gas flow dampers located at the bottom of furnace back-pass or burner tilting mechanism. The distribution of RH surface between the Back pass front side and back pass rear side is selected to provide good steam temperature control response when the parallel pass dampers are adjusted.

A spray attemperator is provided in the inlet piping for transient conditions.

(v) Start-Up System

Before fuel can be fired in a once-through boiler, a minimum fluid mass flow rate must be established within the evaporator tubes that form the furnace enclosure to protect the tubes from overheating. This minimum flow is provided by a Boiler Recirculation Pump (BRP) that returns the heated water back to the boiler in a closed loop for maximum heat recovery.

During this start-up phase the boiler is controlled similar to a drum type unit by having in-line steam / water separators downstream of the evaporator to separate liquid and vapor phases. The load at which boiler control is switched from drum

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type control to a once-through mode is called the change-over load.

Separated water is drained to a water collecting vessel from which the water is pumped back to the economizer. To ensure that sub-cooled water enters the pump, a small amount of cold feedwater is piped to the pump inlet line. The design includes separators with one (1) no. water collecting vessel. The separator design is an optimized configuration developed to minimize pressure loss also vessel size. During initial firing, the inventory of water within the evaporator expands. Excess water is drained from the water collecting vessel to an atmospheric flash tank to maintain an acceptable water level within the water collecting vessel.

Provision will be there to start the Boiler without BRP. The condensate from water collection tank will be discharged to Boiler atmospheric flash tank which is further transferred to Condenser Hotwell through Condensate Transfer pumps.

B. Air and Flue Gas System

A balanced draft system will be provided which will consists of 2 x 50 % axial flow type Forced Draft (FD) Fans and 2 x 50 % axial flow type ID (Induced Draft) Fans and 2 x 50 % configuration Regenerative tri-sector rotary type Air Preheaters (RAPH) for the boiler plant.

2 x 50 % configurations of Steam Coil Air Preheaters (SCAPH) on secondary air system will be provided for start-up, low load operation or abnormal conditions when an increased air inlet temperature is considered desirable to minimize the cold end corrosion of RAPH.

Total flue gas flow downstream of RAPH will be bifurcated in two ducts. Each duct will connect to two (2) ESPs and one (1) ID Fan. Hence, two (2) streams of ID flow, means four (4) ESPs per boiler will be provided. Velocity of flue gas will be selected for minimum fly ash erosion and high availability of boiler.

C. LDO Firing System

LDO firing facility will be provided to cater boiler cold start-up, warm-up, hot start-up and flame stabilization under low load operation. Boiler will be so designed that

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it does not require the oil support for the flame stabilization beyond 40 % BMCR load with design coal.

D. Coal Burning System

The boiler and milling plant will be designed for satisfactory operation of boiler for the entire load range and range of coal specified. The burners and furnace combustion will be designed accordingly to suite the range of coal specified for stable flame. The coal burning system will comprise of coal mills of vertical spindle type bowl mills. The number of coal mills will be such that with one (1) coal mill out of operation / stand by at 100 % TMCR is attained with range of the coal.

Total eight (8) nos. mills will be provided, so that at TMCR and worst coal firing, one (1) mill is kept stand by with a loading of about 90 % for the operating mills.

Coal from raw coal bunkers will be fed into the mills by belt driven gravimetric coal feeders suitable for handling specified coal. There will be 2 x 50 % axial flow type Primary Air (PA) fans for drying and for transporting the pulverized coal from mills to burners.

E. Coal Bunkers

The capacity of series of bunkers should be normally sufficient to provide twelve (12) hours requirement at maximum mills operating capacity of the unit. The material used generally in the upper parts of the bunker will be of carbon steel plate and the area from where the cone formation starts will be of stainless steel plate (SS 316).

Each of the bunkers will be provided with level probes to indicate high, low, low-low levels in the control rooms and all local panels. Motor operated rack & pinion gates will be provided at bunker outlets. Coal chutes will be provided with poke holes and emptying bunker chute to be suitable for loading trucks at ground floor.

F. Soot Blowing System

Fully automatic, sequentially controlled, microprocessor based steam soot blowing system, complete with provision for individual operation of any soot blower pair,

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operation and facility to bypass any soot blower will be provided.

The system will have short retractable rotary wall blowers for the furnace and long retractable rotary blowers for the SH and RH.

G. Auxiliary Steam System

Boiler unit will be provided with two (2) nos. of auxiliary PRDS stations i.e. high capacity and low capacity PRDS taking their steam tap-offs from MS line and CRH line respectively.

The high capacity and low capacity auxiliary PRDS with adequate capacity will be designed suitably.

For the supply of auxiliary steam during initial start-ups, a necessary interconnection will be established with auxiliary steam header of Unit No. 8 & 9 to supply start-ups auxiliary steam requirements of the Unit No. 10.

Typically, steam parameters in the following range will be adopted for the auxiliary steam supply to match with existing Unit No. 8 & 9 auxiliary steam parameters.

Table 9.1-4 Auxiliary Steam Parameters

Sl. No.	Parameters	Value
1	Pressure at auxiliary steam header	11 ata
2	Steam Temperature	285 - 305 ^{0}C
3	Steam Flow Rate	60 TPH

H. Regenerative Air Pre-Heater (RAPH)

The Boiler will be equipped with 2 x 50 % sets of tri-sector RAPH. The RAPH will be provided with AC motor drive for normal operation and air motor drive for cooling during shut down in emergency.

Air pre-heater will be provided with rotor stand still sensors and fire sensing and protection system for the safety of the equipment. Soot blowers will be provided

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for on-load cleaning of air pre-heaters during start-up (oil firing).

The RAPH will be arranged so that the flue gas and air will flow through them in counter flow directions. To minimize the air leakage at the air and flue gas sides of the pre-heater, all seals will be designed so that they can be adjusted during operation.

I. Steam Coil Air Pre-Heater System (SCAPH)

To prevent the flue gas from cooling down to below dew point temperature, when ambient air temperature is very low (i.e. during winter season) and during fuel oil operation at start-up and / or low load operation.

One stage steam heated air pre-heater will be provided on the discharge side of the FD fans. The heat exchanger will be furnished with galvanized finned carbon steel tubes.

The capacity and surface of the SCAPH will be designed so that when operating under full load conditions and at lowest ambient air temperature the flue gas temperature at RAPH outlet can be maintained at least 10 ^{o}C above the flue gas dew point.

J. Elevators

One (1) no. passenger cum goods elevator will be provided for the Boiler.

The elevator includes all items/accessories including all electrical equipment, services etc. required to meet all design, installation, operation, safety, protection and other requirements as per the Indian standard.

K. Electrostatic Precipitator (ESP)

The ESPs will be of outdoor type and installed on the cold end side of RAPH.

The flue gas will be drawn from air preheater outlets of the balanced draft, pulverized coal fired Boiler and guided through adequately sized duct work into the two (2) nos. of independent ESP gas streams. Similarly, the flue gas after the

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ESPs will be led to the suction of the ID fans.

ESP is a physical process by which particulates suspended in a gas stream are electrically charged in a corona field. Three (3) aspects of the process are as follows:

- Charging the suspended particulates
- Collecting the particulates under influence of the electric field
- Removing the particulates from the collecting surfaces and discharge electrodes and transfer from the system

It is proposed to install high efficiency ESP having an efficiency that limits the outlet emission to ≤ 30 mg/Nm^3 while operating with one (1) field out of service condition at 100 % TMCR load using design coal.

ESPs will have at least six (6) gas streams, electrically isolated from each other as well as gas side and will be provided with gas tight dampers at inlets and outlets of each stream, so as to allow maintenance to be carried out safely on the faulty stream, while the unit is working. ESP will be provided with microprocessor based programmable type rapper control system and ESP management system to ensure safe and optimum operation of ESP.

ESP transformer rectifier sets will use high flash point oil as the cooling medium. The dust collection hoppers at all strategic locations will have a minimum storage capacity of eight (8) hours.

The hoppers will have heating arrangements to prevent ash sticking to the sloping sides and down pipes. Level indicators to indicate ash levels in the hoppers and trip ESP in case of high ash levels in the ash hoppers are also envisaged to ensure safety of ESP.

ESP will be equipped with microprocessor based control / Electrostatic Precipitator Integrated Controller or approved equal means to restrict the power consumption.

In most cases, ESP bidders would look for a field addition to improve the TT, or increase the cross Section of the ESP (Height, Number of Gas path) to reduce the Velocity of gas entering the ESP.

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L. Flue Gas Desulphurisation (FGD)

Wet Limestone based FGD system will be installed in and around the chimney area to limit the SO_x emissions to the atmosphere. FGD system will be installed, taking the suction from duct downstream of ID fan and feeding the desulphurised flue gases upstream of chimney with provision for bypassing the FGD system.

FGD system will be provided to limit the overall SO_2 release from chimney to the level of 100 mg/Nm^3. FGD system will be based on wet limestone slurry with in-situ forced oxidation to produce commercial grade gypsum. An absorber is provided for each of the two boiler ID fans. The flue gas from ID fans flows through the one inlet duct and the open-spray-tower absorber through a Gas - Gas Heater to the main flue gas duct when it mixes with the bypassed flue gas where temperature of final mixture of Flue gas increases to 80 ^oC.

The absorber is installed for the boiler to remove about 85 - 95% of the SO_2 in the flue gas. Clean gas from the absorber will be taken to the GGH through two stage mist eliminators. Treated and reheated flue gas from the absorber will be discharged through a 270 m high chimney.

Gypsum slurry produced in the absorber is concentrated by the gypsum dewatering system – hydrocyclone. The concentrated gypsum slurry underflow from the gypsum dewatering hydro cyclone is fed to a vacuum belt filter directly to produce commercial grade gypsum. The overflow from the gypsum dewatering hydro cyclone containing the unreacted limestone is returned to the absorber. The filtrate receiver water is sent to filtrate tank to make up for absorber & limestone preparation system.

The major design features for wet FGD are as follows:

- One wet FGD unit for the boiler plant.
- Absorption system consisting of a single loop spray tower / absorbing tower and also less number of the spray levels in operation
- Auxiliary plants consisting of reagent preparation, dewatering system, compressed air system, Oxidation system, water distribution etc.
- FGD Unit is equipped with a by-pass system at 100% sealing degree, to allow safe FGD maintenance operations and to manage the plant during normal operation, emergency, start-up and shut-down periods in safe conditions.

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- FGD Unit is equipped with a regenerative heat exchanger to re-heat the gases exiting the Boiler Plant at the required temperature.
- Redundancy is included for each component since the concept of redundancy is very important i.e. each mechanical equipment has a redundant equipment installed, that means the outage of an item do not compromise the operation on the FGD plant.
- The Wet FGD system is designed to achieve SO_x concentration @ outlet of FGD to the level of 100 mg/Nm^3 (dry, 6 % O2), which corresponds to 85 – 95 % SO_x removal efficiency.
- Wet FGD system is sized to minimize the use of raw water by using as much as possible the water coming from the cooling tower circuit.
- Wastewater from the wet FGD process will be collected and neutralized using lime and neutralized effluent will be pumped to Ash slurry sump. FGD waste water requires dedicated waste water treatment system as FGD wastewater poses a challenge to treat because of the following unique characteristics:
- High concentrations of TDS and TSS
- Super-saturation in sulfates
- High temperature
- High Chloride content
- Ammonia, from the ammonia slip for ESP conditioning and NOx control; and potentially nitrites and nitrates (if they're produced by the SCR or by the ammonia treatment)
- Miscellaneous regulated heavy metals and trace constituents (i.e., arsenic, mercury, selenium, boron, etc.) present that vary by coal type.

M. Selective Catalytic Reduction (SCR)

Nitrogen Oxides (NOx) is well known as one of the air pollutants in our atmosphere. Therefore, NOx removal technology has been getting more and more important to help preserve our environment all over the world. SCR technique is the most famous NOx reduction process. SCR is located in the gas stream between the boiler economizer outlet and the air pre-heater inlet. When the SCR is in operation, flue gas from the economizer sections passes through the SCR under positive pressure then through the air pre-heaters; however, when the SCR is not in operation, the flue gas bypasses the SCR system and flows directly to the air pre-heaters.

SCR system is designed to achieve NOx concentration at outlet of SCR to the level

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of 100 mg/Nm3 (dry, 6 % O2).

SCR is a dry process in which Ammonia (NH_3) in vapor form is injected into the flue gas upstream of a catalyst. The ammonia acts as a reducing agent and the NOx contained in the flue gas decomposes into nitrogen and water vapor in the presence of the SCR catalyst.

The ammonia system consists of ammonia storage tanks, vaporizers, dilution air blowers, and an ammonia flow control unit. The dilution air fans supply pressurized ambient air to dilute the ammonia to 5 % by volume at maximum ammonia consumption. The ammonia and air mixture is injected into the flue gas via the Ammonia Injection Grid.

The SCR process uses an ammonia reagent (NH_3) over a vanadium / titanium based catalyst to reduce NOx (primarily 95 % NO) according the following equation:

$4NO(g) + 4NH_3 (g) + O_2 (g) \qquad 4N_2 (g) + 6H_2O (g)$

$2NO_2(g) + 4NH_3 (g) + O_2 (g) \qquad 4N_2 (g) + 6H_2O (g)$

The process is effective within an approximate temperature ranging from 300 °C to 400 °C. Above 400 °C, catalytic sintering becomes prominent in lowering the NOx reduction performance. Below 300 °C, the susceptibility of ammonium bisulfate (NH_4HSO_4) formation on catalyst surfaces increases. The lower temperature limitation is dependent upon the amount of SO_3 in the flue gas.

An ammonia injection grid is situated upstream of the SCR reactor in a vertical run of ductwork. At this location, a diluted mixture of ammonia in air (6 % ammonia by volume in air) is uniformly injected into the flue gas stream through a network of pipes and nozzles. Multiple flow control zones ensure that a uniform distribution of ammonia can be achieved before entering the first catalyst layer. External flow control valves, installed in the piping between the manifold and the grid, enables the operator to bias the ammonia flow for off-design conditions.

The basic function of the ammonia injection controls is to supply the proper flow of ammonia to the system. This is based upon the NOx concentration at the inlet and outlet of the reactor, the gas flow entering and the molar ratio of NH_3/NOx. After a flue gas sample is analyzed for both inlet and outlet NOx, 4 - 20 milliamp signal from the plant's distributed control system (DCS) is used to properly position the

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ammonia flow control valve. If the outlet NOx concentration is still higher than the desired set point, the valve position is adjusted to increase the flow of ammonia to the system. Manual bypass valves are used in the event that the automatic valve fails or requires maintenance.

N. Mercury Control System

Mercury concentration and speciation will be changed across Air Pollution Control System (APCS) of the boiler plant. Some of the Hg in the flue gas is oxidized to Hg2+ in the SCR system. Large amounts of particulate-bound Hg are removed through ESP and small amounts of Hg is oxidized to Hg2+. It is expected that around 67 – 98% of Hg2+ in the flue gas is absorbed in the scrubber solution and retained in the FGD gypsum.

The distribution of mercury indicates significant amount of Hg removal by SCR, ESP and FGD systems. The average mercury removal efficiencies of the SCR+ESP+WFGD systems is around 74 % and balance of Hg in the flue gas is emitted to the atmosphere through stack, which is dominated by Hg.

Therefore, considering above and assumed average value of 0.14 g/tonne of mercury content in the domestic coal, we anticipate that co-benefit mercury removal APCS system (i.e. SCR + ESP + WFGD) will meets the proposed draft emission norms of MoEF published for Thermal Power Plants i.e. 0.03 mg/Nm3.

9.1.3 Plant Water Systems

The raw water required for the proposed power station is drawn from the Ganga River. The estimated maximum consumptive water requirement for proposed 1 x 660 MW Thermal power project is 21 cusec.

Refer to the attached plant water balance diagram for detailed estimation.

The location of the river water intake facility is located 3.5 kms away from the BTPS plant. One (1) number of intake well with 4 x 33 % capacity (three (3) working + one (1) standby) river water intake pumps for complete plant requirements (i.e. Unit No. 6 to 10) are provided at the Ganga River intake point to pump the required amount of raw water to the plant through Pre-Sedimentation Tank (PST) / de-silting basin. One (1) no. of PST / DSB with suitable capacity is provided near

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intake facility (i.e. onshore) for the proposed extension unit to reduce the suspended solids load into the plant. Clear water from the settling basin with help of 3 x 50 % clear water pumps will be pumped to raw water storage tank of twenty four (24) hours (i.e. one (1) day storage) capacity provided inside the plant boundary.

Pretreatment plant with clarification system is provided to produce the service water for the various applications as shown in plant water balance diagram.

Clarification plant will be designed for 120 % of the total calculated consumptive water requirement. Clarified water will be stored in clarified water storage tank. Suitable capacity filtration plant is provided to produce the potable water required for plant. Clarified water from clarification plant will be further treated in resin based DM plant to produce the DM water.

The DM plant will be sized to meet the heat cycle make-up at the rate of 1.5 % of the BMCR, make-up water for CCCW system, CPU regeneration & any other requirement envisaged. CATION & ANION exchangers will be designed for twenty (20) hours of operation cycle followed by four (4) hours regeneration period in a day of twenty four (24) hours. Mixed Bed will be regenerated after minimum 140 hours of operation.

The produced DM water will be stored in DM water storage tank and then pumped to cycle makeup and for other applications.

MCW system using IDCT will be adopted for the proposed extension unit of BTPS. Based on the raw water analysis report the Cycle of Concentration (COC) of 5 is adopted in IDCT.

A. Intake Water System

River Water Intake System is broadly divided into following facilities:

- Offshore facilities
- Onshore facilities

Whereas Offshore facilities are intake well cum river water pump house, approach bridge while Onshore facilities are PSTs / DSBs, clear water make-up sump & pump house, silting flushing pump house and make-up water rising main / pipelines up to

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the BTPS plant site including proposed extension unit of 1 x 660 MW, i.e. Unit No. 10.

(i) Offshore Facilities

It includes below listed facilities such as:

- Intake Jack-well
- Intake Water Pump House
- Intake Water Rising Mains (or Pipelines)
- Approach Bridge to Intake Water Pump House from the bank of the Ganga River (approximate 100 m)
- Mechanical Maintenance Bay, Control & Electrical Room

Intake Jack-well

The River water Intake Jack-well is proposed as an offshore structure oval in shape with circular ends for better structural stability and smooth flow around structure with overall inside dimension of 7.7 m (length) x 22.2 m (width).

The water flow entry into the Jack-well is along / parallel to the flow direction of the river. All the opening in the Jack-well wall for water flow entry are provided on river side of well..

Intake Water Pump House

The pump floor / operating level is kept more than 2 m above High Flood Level (HFL), i.e. EL (+) 45.5 m while pump motor floor is maintained at 4 m above pump floor level. Therefore, it is proposed to have double floor arrangement to keep motor & pump, motorized valve and other items at the different level for ease of operation & maintenance. Rails for maintenance are arranged at the centre of the intake water pump house. Local control panel (LCP) can be located at the motor floor.

The pumps are arranged in the transverse direction of entry flow and each pump is installed in separate sump. The pump configuration of 4 x 33 % (common for Unit 6 to 10, each of capacity 2,450 m^3/hr.) is considered for the complete plant wherein three (3) pumps will be installed / constructed for Unit No. 6 to 9 before operational phase while a space will be reserved for 4th pump as required for proposed extension Unit No. 10. This arrangement will have optimized cost & land requirements as well as construction schedule of the proposed extension Unit No. 10.

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These pumps provided in the pump house will draw the water at low water level of EL (+) 32.76 m and deliver water to PSD/ DSB at delivery level of EL (+) 45.50 m with exit head of approximate 1 m. Therefore, total head for the pumps will be approximate 16 m including losses in the intake water pipeline.

Typical Sizing data of the intake water pumps are as below:

Table 9.1-5 Design Data

Item	Data	
Construction Phase	Phase- 1 & 2 (Unit No. 6 to 9)	Phase- 3 (Unit No. 10)
Type	Vertical wet pit type	Vertical wet pit type
Configuration	3 x 33 %	1 x 33 %
No. of Working Pumps	2 nos.	1 no.
No. of standby Pumps	1 no.	1 no. (Existing)
Pump rated flow	2,450 m^3/hr.	2,450 m^3/hr.
Pump TDH	16 mWc	16 mWc

Recommended Material of Construction for intake water pumps are as below:

Table 9.1-6 Material of Construction

Item	Material of Construction
Suction Bell and Bowl	2 % Ni CI as per IS 210 Gr. FG 260
Column Pipe & Discharge Elbow	MS as per IS 2062 Gr. B with Epoxy Paint
Impeller	CF8M
Impeller Shaft, Line Shaft & Head Shaft	SS410
Line Shaft coupling	SS410
Shaft Sleeve	SS316

For the Jack-well layout, pump arrangement and other information refer to “General Arrangement of Intake Water System” in the drawing section with this DPR.

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Intake Water Sump (IWS)

Partition walls are provided for suction pipe of each pump from Jack-well floor level. This arrangement makes each pump to operate separately / independently. These pumps will also operate in parallel to each other as each sump is completely isolated from the adjacent sump.

Minimum Sump dimensions are based on HIS guidelines. Sump floor level is based on minimum submergence requirement as per HIS guideline and 1.5 m clearance for the silt accumulation.

Trash Rack & Gates

A coarse mesh Trash rack screens is to be provided at the entry of the Jack-well to restrict / prevent the entry of floating debris etc. into the Jack-well. These screens will be located on outer side of the Jack-well wall at 4 m before the entrance to pumps.

Gates will be provided for entry of water on the inside of the Jack-well wall. Operations of these Gates will be done from the pump operating floor level where operating wheels will be provided. These gates will be of sluice type with gear arrangements for operations.

The pump sump entry Gates & Coarse Trash racks are provided at two levels corresponding to the NWL & LWL. The gates will open only to the corresponding water levels and the gates at lower water level will be always closed while the water is always allowed to enter from the normal water level gates.

Two criterions are followed while deciding these level entries and operation of gates:

- The source for this project is surface flow water of river. In the surface water the dissolved oxygen content reduces with increase in the depth of water. Therefore, it is recommended to draw water from the upper layers of the flow i.e. NWL.
- The silt content of the river water increases towards the bed of the river. Therefore, to keep the silt content low in the intake water, it is recommended to allow intake water from the upper layers of the flow i.e. NWL.

Accordingly, the silt levels of the gates are decided as 1 m below corresponding LWL and NWL.

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Crane & Hoist

An Electrical Overhead Traveling (EOT) crane will be envisaged for maintenance of pump, motor and other misc. items during the construction stage of Phase-1 & 2 Intake water system.

Also, manual hoist is considered for maintenance of stop log gates, trash racks inside & outside the pump house.

Designated area for unloading of pump, motor and other parts is identified inside pump house. This maintenance area is accessible by rails from an approach bridge.

Intake Water Rising Mains (or Pipelines)

The discharge manifold will be aligned and designed for surface delivery, and located inside pump house.

The discharge manifold will be connected to the intake water rising mains made of mild steel material for Unit No. 6 to 9 & Unit No. 10, and it will run over the deck of bridge on both sides of the bridge. After the bridge it will be laid underground but above HFL, then will terminate into PST/DSB.

Pipe diameter of 950 NB for rising main pipeline is considered by allowing the water velocity of about 1.5 m/sec. And, total two (2) nos. of pipelines will be laid on chairs partially above ground and underground.

The external surface of pipe laid over ground chairs will be painted with epoxy paint as per IS 3589-2001, Annexure- B. However, pipelines laid underground will be externally wrapped by Tap coat as per IS 3589-2001 Annexure-D for protection against mechanical abrasion / corrosion / rusting due to soil & salinity or sub-soil water.

For the routing, dimension and other information refer to “General Arrangement of River Water Intake System” in the drawing section with this DPR.

Approach Bridge

The straight horizontal distance between the top of Protection Bund and Jack-well / Pump house is approximate 110 m. The ground in this length is steeply sloping towards river. An approach bridge is to be constructed to cover this distance.

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MS intake water rising mains / pipelines for Unit No. 6 to 9 & Unit No. 10 will run over the deck of bridge on both sides of the bridge. And, this is an approach bridge common for Unit No. 6 to 10.

Cable trays are also planned on the bridge superstructure. Handrail, lighting fixtures, warning signs is to be placed wherever required for the safety of operator.

An embedded rail track will be proposed on the river bank for plying trolleys carrying pumps and other accessories from the intake water pump house.

Maintenance Bay, Control Room & Switchgear Room

At the operating floor, space is reserved for local control panels. However, starter panel and MCC (switchgears) will be installed in a separate control room at onshore intake water facility.

Also, at the pump floor level, the maintenance bay for laying down the pump, motor and other items such as stop log gates and trash racks is considered.

(ii) Onshore Facilities

It includes the below listed facilities such as:

- PST/ DSB
- River (or Clear) Water Make-up Sump and Pumps & accessories and Pump house
- Silting Flushing Pumps and Pump house
- River (or Clear) Water Make-up Rising Mains (or Pipelines)
- River (or Clear) Water Pumps with Mechanical & Electrical Components.

And these facilities will require the land of approximate 107 m x 251 m for Phase -1 & 2 and Phase -3.

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Pre-sedimentation Tank (PST) / De-silting Basin (DSB)

As per the reference data of the Ganga River at Hathidah (during 1980 - 2008) by CWC noticed that considerable amount of suspended solids exists in the Ganga river and same is 2 g/lit as maximum at time of high flood.

Therefore, Sediment Analysis is required to be performed for grain size distribution and mineral composition in the Ganga Water thru accredited agencies / experts before finalizing the dimensions & design of PST.

A PST is the part of onshore intake water facility and install on bank of the Ganga River, to eliminate discrete particles of coarse size thru sediment reducing device / arrangement.

The open channel type gravity settling plane sedimentation tank of required dimensions is considered for BTPS (Unit No. 6 to 9). And, sludge cleaning by manual in addition to hydraulic system is envisaged at interval of once in ten (10) days and accordingly silt storage at bottom of the basin is to be planned.

It is proposed to provide one (1) common standby unit of pre-sedimentation basin to be used during maintenance / cleaning operation of working unit. The size of the standby unit will be the same as required for the working unit of BTPS (Unit No. 6 to 9).

Accordingly, total four (4) nos. of basins with common standby unit, each able to operate independently and feed to dedicated units of BTPS (Unit No. 6 to 10). And, it is to be designed for the detention time of four (4 hours at the sedimentation tank.

River (or Clear) Wate Pump House

The pump floor / operating level is kept about 1.6 m above High Water Level (HWL), i.e. EL (+) 46.10 m. Therefore, it is proposed to have single floor arrangement to keep motor and pump assembly, motorized valve and other items at the same level for ease of operation.

One side of pump operating floor is proposed to be utilized for service / maintenance bay and other side portion for keeping control panel, MCC / switchgear etc.

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The pumps are arranged in the transverse direction of entry flow from the PST/DSB. The pump configuration of 2 x 50 % for each Phase-1 and Phase-2 with common standby i.e. total of five (5) pumps will be installed / constructed for Unit No. 6 to 9 before operational phase while a space will be reserved for 3 x 50 % pumps as required for proposed extension Unit No. 10. This arrangement will have optimized cost & land requirements as well as construction schedule of the proposed extension Unit No. 10.

Clear water pumps are provided inside the pump house for unit No. 10 will draw the water at low water level of EL (+) 42 m and deliver water to the BTPS plant site at delivery level of EL (+) 82 m. Therefore, considering static head of the raw water storage tank, total head for the pumps will be approximate 50 m including losses in the river water pipeline.

Typical Sizing data's of the clear water pumps are as below:

Table 9.1-7 Design Data

Item	Data	
Construction Phase	Phase- 1 & 2 (Unit No. 6 to 9)	Phase-3 (Unit No. 10)
Type	Vertical wet pit type	Vertical wet pit type
Configuration	5 x 50 %	3 x 50 %
No. of Working Pumps	4 nos. (2 nos. per phase)	2 nos.
No. of standby Pumps	1 no.	1 no.
Pump rated flow	1,275 m^3/hr.	970 m^3/hr.
Pump TDH	23 mWc	50 mWc

Recommended Material of Construction for clear water pumps are as below:

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Table 9.1-8 Material of Construction

Item	Material of Construction
Suction Bell and Bowl	2% Ni CI as per IS 210 Gr. FG 260
Column Pipe & Discharge Elbow	MS as per IS 2062 Gr. B with Epoxy Paint
Impeller	CF8M
Impeller Shaft, Line Shaft & Head Shaft	SS410
Line Shaft coupling	SS410
Shaft Sleeve	SS316

Clear Water Sump

After the passage of water though PST/DSB, it overflows into Clear Water Sump (CWS). This clear water is further pumped by the pumps installed above the CWS inside pump house. This pumped water is transferred to water treatment system (for Phase-1) / raw water reservoir (for Phase-2) / raw water storage tank (for Phase-3) located inside the BTPS plant site by means of water pipelines of approximate 4.2 kms long, so called Clear Water Rising Mains (CWRM).

The system beyond PST/DSB is to be provided for discharge carrying capacity equal to plant water requirement of the respective phase at BTPS (for Unit No. 6 to 10), therefore, CWS and Clear Water Make-up Pumps (i.e. booster pumps) and water treatment facilities are to be designed for plant water requirement at BTPS.

CWS is required to be of one (1) hour storage capacity, which will be on and above low water level required for the operation of clear water make-up pumps. The width of CWS is maintained equal to the width of PST/DSB.

Trash Rack & Gates

A coarse mesh Trash rack screens is to be provided at entry of the CWS Pump house to restrict / prevent the entry of any unwanted material.

These screens will be provided for full opening size between first row of columns. It will be of fixed type, at distance of 5D (diameter of bell mouth opening, 0.7 m) equal to 3.5 m.

No entry gate provision is made in the CWS Pump house. It will have free overflow entry from the (PST/DSB).

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Crane & Hoist

An EOT crane will be envisaged for maintenance of pump, motor and other items during the construction stage of Phase-1 & 2 Intake water system.

Also, a manual hoist is considered for maintenance of trash racks beside the clear water pump house.

Designated area for unloading of pump, motor and other parts is identified inside clear water pump house. This maintenance area is accessible by road thus ramp is considered.

Silting Flushing Pump House

The purpose of silt flushing pumps is to dispose of the deposited silt from PST/DSB. The bottom of PST/DSB and water level in the river is not always sufficient to drain the sludge accumulated by the hydraulic system. Therefore, it is proposed to undertake the sludge cleaning by manual means at interval once in ten (10) days.

There is silting flushing pipe engraved only in the settling zone and inlet transition zone of PST/DSB. This is made of mild steel material and suitable perforated opening size at required spacing will be finalized for automatic silt flushing arrangement based on mathematical study by accredited agencies / experts.

Total four (4) nos. of silt flushing pipes of 300 NB is envisaged each from designated basin / tank up to inlet of flushing pumps inside the pump house. The pump house operating floor at EL (+) 40.25 m is decided based on flushing pipes from the tank / basin at EL (+) 41.20 m, same pump centerline.

Based on sediment concentration of 2 g/lit (2 kg/m^3) in the incoming design flow rate of 2,450 m^3/hr., flushing pump house is designed accordingly.

The flushing pump configuration of 1 x 100 % for each of designated de-silting basin, thus total four (4) nos. will be considered for the design of flushing pump house. And, installation is to be carried out phase wise, which means first three (3) pumps including spare pump will be installed during Unit No. 6 & 7 (Phase-1), Unit No. 8 & 9 (Phase-2) construction phase and 4th no. of pump during the proposed extension of 1 x 660 MW i.e. Unit No. 10 (Phase-3).

River (or Clear) Water Rising Mains (or Pipelines)

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The delivery of plant water will be sub surface delivery and will have separate manifold for Phase-1 & 2 (Unit No. 6 to 9) and Phase-3 (Unit No.10). These manifolds will be connected to the rising main pipelines. The rising main pipeline is two (2) nos. for each phase i.e. Unit No. 6 & 7 (Phase-1), Unit No. 8 & 9 (Phase-2) and Unit No. 10 (Phase-3).

The manifold and rising main pipes will be of mild steel material, and for its length in the pump house will be externally painted. From clear water pump house onwards the rising main pipelines are laid underground for its entire length up to the BTPS plant site.

The erection / installation of the CWRM will be carried out in phase wise and space provision will be kept for proposed extension unit of 1 x 660 MW, i.e. Unit No. 10.

Pipe diameter of 600 NB for rising main pipelines is considered separately for proposed extension unit no. 10 by having allowable velocity of about 1.0 m/sec. And, total two (2) nos. of pipelines for proposed Unit No. 10 will be laid underground for the entire length of approximate 4.2 kms except at crossing with IOCL pipelines.

Maintenance Bay, Control Room & Switchgear Room

At the operating floor, space is provided for local control panels, starter panels and MCC (switchgears) beside the clear water pump house within onshore intake water facility.

Also, at the floor level, the maintenance bay for laying down the pump, motor, other items, stop log gates and trash racks is considered.

B. Main Circulating Water System (MCW)

The plant will utilize clarified water for the Condenser cooling system (i.e. Closed Cooling Water system, CCW) in the closed cooling recirculation mode with IDCT having COC of 5.

Circulating water temperature is selected as 33 ^{o}C considering the ambient wet bulb temperature of 28.5 ^{o}C and minimum recirculation allowance of 0.5 ^{o}C.

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3 x 50 % configurations MCW Pumps for the proposed unit of 1 x 660 MW will be considered to supply cooling water to the surface condenser and auxiliary cooling water to ACW system with help of ACW Booster Pumps of 2 x 100 % capacity.

MCW Pump will feed the circulating water through side stream filters then treated through cooling water conditioning system.

The MCW Pumps will be of vertical turbine, constant speed, wet pit, mixed flow design and non-pull out type. The pump will be directly driven by a constant speed induction motor and will have a flanged discharge connection. The circulating water pump discharge piping will be complete with expansion joints and motorized butterfly valves.

One (1) no. of EOT crane will be considered including rails, rail fixing arrangement, stoppers and buffers etc. inside MCW Pump house for handling MCW Pumps, drives, discharge butterfly valves, rubber expansion joint etc.

Stop log gates are provided to isolate MCW Pump sump for the maintenance or repair jobs. The gates will be of welded construction, with rubber seals, guide shoes and lifting hooks. Stop log gates will provide leak tightness without jacking. Screens will be provided to prevent foreign material viz. debris etc. entering into the MCW Pump. The screens will always remain in position, under water, to stop objectionable large debris and floating matter. The MCW Pumps will be operated / controlled from the DCS.

C. Water Treatment Plant / System (WTP)

The Ganga River water will be pumped to plant raw water storage tank through pre-sedimentation / de-silting basin. The raw water will be pumped to raw water pretreatment plant by raw water transfer pumps.

The make-up water required for ash handling system will be pumped from raw water storage tank by AHP make-up pumps.

Clarification system along with suitable chemical dosing system will be provided in pretreatment plant to produce the clarified water. The produced clarified water will be stored in clarified water storage tank for further utilization for the following applications.

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- Cooling Tower Makeup
- Plant Service Water
- Feed to DM plant and Potable Water
- Feed to Firefighting Applications
- Seal Water for Ash Handling System
- Make water to HVAC applications
- APH / ESP Wash Water
- CHP Dust Suppression

The sludge coming from the clarification system will be routed to sludge sump by gravity and from sludge sump this will be pumped to sludge handling system by means of sludge transfer pumps. Sludge thickener and centrifuge will be provided to recover the water from the sludge.

The wet cake generated from the sludge handling system will be disposed-off suitably. The clear water from the sludge handling system will be routed to the stilling chamber.

The clarified water will be pumped to the DM plant to produce the DM water for plant cycle make-up, CCCW makeup and other miscellaneous uses.

The filtration system will be provided to reduce the total suspended solids. The plant potable water will be tapped from filtration plant i.e. discharge of dual media filters and stored in potable water storage tank for further distribution. The filtered water produced from the filtration plant will be taken to feed downstream Activated Carbon Filter (ACF) and CATION exchange unit. ACFs are provided in order to remove color, odor, organics etc.

The CATION exchange unit provided with CATION exchanger resin in regenerated form. The exchanger takes up all the CATION from water in exchange for hydrogen ions (H+) which it gives up. The CATION likewise Calcium (Ca), Magnesium (Mg) and Sodium (Na) etc. exist in the form of Chloride, Sulphate, Carbonate and Bicarbonate salts which get converted to their equivalent acids.

When the CATION exchanger is exhausted, it is regenerated with diluted acid. Outlet water from CATION exchanger is then passed through a degasser towers for removal of free CO_2.

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Degasser Tower (DGT) is a forced draft type atmospheric tower fitted internally with a top distributor and bottom collector. Polypropylene pall rings are charged in the tower. It is a vertical cylindrical vessel fitted with top & bottom distribution nozzles. Centrifugal type of air blowers will be provided for blowing high flow, low pressure air for degasification. Forced air by degasser blower is passed in counter current direction while the decationized water is sprayed from the top, thus removing the free CO_2 produced during splitting of alkaline salts. The decationized water from the DGT vessel is stored in a Degassed Water Storage Tank for further process. Degassed Water Transfer Pump will be further supplying the decationized and degassed water from Degassed Water Storage tank to ANION exchanger unit for further downstream process.

Decationized and degassed water will be passed through ANION exchanger unit for the removal of anion & silica impurities. The vessel will be charged with the ANION resins in regenerated form. The exchanger takes up the ANIONs, in water from ANION exchanger outlet is exchanged for hydroxide ions (OH-) which it gives up. When ANION exchanger is exhausted, it is regenerated with caustic soda to replenish the hydroxide ions. Mixed bed exchanger unit embodies a single column of strong acid CATION exchange resin and strong base ANION exchange resin mixed intimately together to take care of the slippages from CATION and ANION exchangers. Mixed bed unit are regenerated with acid and alkali but the ion exchange resins must be separated before the regeneration is performed / carried-out.

Bed separation is accomplished by back washing and this carries the heavier CATION resin sinks to the bottom. Two (2) completely separated and super imposed layers are thus formed, into which the acid solution, alkali solutions and rinse water are introduced through specially designed spreaders.

After regeneration, both the resins are remixed with compressed air. It is a vertical cylindrical vessel fitted with inlet header for uniform water distribution, bottom distribution plate with nozzles / strainer for water outlet as well as to prevent slippage of the resin. The header pipe works for acid /alkali fitted with nozzles / strainers for regeneration of the resin bed for CATION / ANION and vessel frontal pipe work with valves for normal & back wash, regeneration and rinse operation. All the piping inside the vessel is rubber lined for adequate thickness to prevent corrosion as well to safe guard the quality of water.

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The generated DM water from the mixed bed exchanger unit will be stored in DM water storage tank for further use. DM water storage tank will be sized suitably (24 hours) to store and meet the DM water requirements for plant cycle make-up.

Air blowers are provided for air scouring of the mixed bed exchanger unit. Acid measuring tanks and Caustic measuring tanks are provided to supply the diluted acid & caustic for regeneration of mixed bed CATION & ANION resin units. Bulk acid storage tank along with acid unloading pumps and bulk caustic storage tanks along with caustic unloading pumps are provided to store the acid & caustic required for DM plant. Acid and caustic will be routed from bulk tanks to respective measuring tanks by gravity.

The effluent / waste generated during the regeneration process from DM Plant will be routed to neutralization pit. The required amount of acid / alkali will be dosed to the neutralization pit to neutralize the effluent / waste. The neutralized effluent / waste will be pumped by means of neutralization effluent transfer pumps to central monitoring basin. The pretreatment plant and DM plant will be operated / controlled from dedicated Programmable Logic Controller (PLC) and required necessary signals exchanged in between WTP PLC & plant DCS.

D. Effluent Treatment Plant (ETP)

The function of the Effluent Treatment Plant (ETP) is to collect and treat effluent generated by various equipment of power plant to comply with applicable environmental regulations and / or CPCB.

The treatment consists of removing the oil, neutralization and removal of Total Suspended Solids (TSS) from the effluents generated at different locations in the proposed extension unit before treatment, reuse and further disposal.

The treated effluents will be reused for various applications within the plant premises in order to achieve the ZLD and also to minimize the fresh makeup water requirement. The various plant effluents are collected, treated and reused as per the following:

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(i) DM and CPU Regeneration Waste Water

DM plant and CPU regeneration waste will be generated based on periodic regeneration of resin beds by acid and /or alkali. It will contain high amount of dissolved solids and also will be acidic and / or alkaline based on the nature of requirements for the regeneration.

The regeneration waste comprising of acid, alkali and backwash water from the DM plant will be led to the neutralization pit through drain channels. The pH of neutralized waste is maintained in the range of 7.2 - 8.0. Once the pH level in the waste / effluent is achieved within desirable range the same will be pumped to the Central Monitoring Basin (CMB) for further treatment.

(ii) Cooling Tower Blow Down

Cooling Tower blow down is done to maintain the level of dissolved solids in the MCW. This effluent will contain dissolved solids and chemicals / biocides used for prevention of scale formation / corrosion / bio fouling. The whole of Cooling Tower blow down will be sent to the ash handling system as a makeup and excess Cooling Tower blow down if any will be routed to the CMB for further treatment.

(iii) Backwash Waste Water from Side Stream Filtration

Backwash waste from side stream filters will be collected in a pit and then transferred to the CMB for further treatment by means of backwash water transfer pumps.

(iv) Quenched Boiler Blow down Recycling System

Being a SC plant, boiler blow down will be occasional and ACW (i.e. clarified) water will be used for quenching of occasional boiler blow down. The quenched boiler blow down will be collected in boiler blow down drain pit / sump at around 60 ^{o}C temperature.

The water from the drain pit / sump will be pumped to the CMB for further reuse. The quenched boiler blow down drain pit / sump and quenched boiler blow down

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transfer sump pumps will be located near boiler house.

(v) Oil Handling Area Effluent & Service Oily Waste

The oily water run-off during rains and regular washing / cleaning, leakage and draining from fuel oil area will be treated in oily waste treatment system (API type). An underground retention pit will be provided to collect run-off water.

The treated water of oily waste retention pit will be directed to a common oily waste collection pit, which also receives service oily waste effluent from power house area and transformer yard area.

From the common oily waste collection pit, the oil contaminated effluent will be pumped to plate or tube type oil water separator (TPI type) for removal of free floating oil. The separated oil i.e. skimmed oil will be collected in a slopped oil storage tank and sludge will be collected in sludge pond, thus same will be disposed-off suitably. The treated water from oil water separator (TPI type) will be discharged / pumped finally into ash slurry sump.

The Oil Water Separator (OWS) of API & TPI type will be located in ETP area, and sludge & skimmed oil produced from OWS of API & TPI type will be disposed-off suitably. The major amount of oily effluent from the transformer yard area will be generated only during periods of rainfall. The rain water entering each of transformer pits containing small amount of oil and TSS will be led to the common oily waste water collection pit for further treatment.

Power house area effluent is generated from floor washings, leakages from bearing cooling systems, leakage from pumps, hydraulic couplings, oil leakage from oil burners etc. This effluent basically contains suspended solids, some oil and grease. Therefore, an underground retention pit will be provided to collect service oily waste from power house area. From retention pit, the waste will be transferred by pumps to common oily waste collection pit for further treatment.

(vi) Central Monitoring Basin (CMB)

All liquid effluents from the plant will be led to a CMB, which acts as an equalization basin. From CMB, wastewater will be pumped by means of central monitoring basin effluent transfer pumps to clarification system.

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ETP clarification system is provided with chemical dosing system to reduce the suspended solids and turbidity in the plant effluent. The clear water from ETP clarification system will be stored in ETP clarified water storage tank.

The sludge generated from high rate solid contact clarifier will be collected in a local sludge sump and finally pumped to ash slurry sump. The clear water from the ETP clarification system will be utilized for the applications like makeup water to AHP, CHP dust suppression, horticulture and gardening / green belt development.

The excess water from ETP clarified water storage tank will be pumped to Dual Media Filters (DMFs) for further treatment.

(vii) Dual Media Filters (DMF)

DMFs will be provided for filtration and removal of suspended particles which are carried in the clear water from the ETP clarified water storage tank. The filtered water produced from these filters will be taken to feed downstream Ultrafiltration streams.

(viii) Ultrafiltration (UF) System

The filtered water from the upstream DMFs is further screened to 100 microns using basket filters of 2 x 50 % configuration installed at the upstream of UF skid.

The UF system is provided to carry out filtration of suspended colloidal particles sizes of about 100 microns to 0.1 micron including organic macro-molecules and bio-organisms. The configuration of membrane will be of hollow fiber, cross flow, in-out / out-in type. The material of construction (MOC) of UF membranes will be Polyethersulfone (PES) / Polysulfone (PS) / Polyacrylonitrile (PAN) / Polyvinylidiene flouride (PVDF) hydrophilic in nature, which will attract water and repel oil which has escaped from prior pretreatment unit. Thus, it ensures the longevity of Reverse Osmosis (RO) membrane life due to decrease in fouling and leads to decreased chemical consumption in RO system. The product water from the UF membranes is stored in UF permeate water storage tank which will be used for downstream RO feed as well as UF backwashing.

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(ix) Reverse Osmosis (RO)

UF permeate water is pumped first through five (5) micron cartridge filters by RO feed pumps and then into the Effluent Recovery System Reverse Osmosis (ERS-RO) units for desalination through ERS-RO high pressure pumps.

2 x 50 % configurations of ERS-RO are envisaged in the ERS-RO system. The dosing of chemicals like anti scalant, sodium meta bisulphite and hydrochloric acid are envisaged on-line with the help of electronic dosing /metering pumps in the common discharge header line of cartridge filter feed pumps to control scaling of ERS-RO membranes and complete de-chlorination of UF permeate before feeding it to ERS-RO in order to have trouble free and efficient operation of the RO plant.

The permeate from ERS-RO will then be taken to ERS-RO permeate water storage tank through degasification system and then pumped as CT makeup to CT system / clarified water storage tank to minimize the fresh water requirement.

The ERS-RO reject water will be routed to ash slurry sump through ETP sludge pit. The ETP will be operated / controlled from dedicated PLC / LCP and required necessary signals exchanged in between ETP PLC & plant DCS.

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9.1.4 Coal Unloading, Transportation, Crushing and Feeding System

Coal will be linked from the Coal blocks which will be allocated by the GoI or purchase through fuel supply agreement as the case may be for preparing this detailed project report. The coal will be transported from coalfields by Indian Railway System in bottom opening (BOBR) coal wagons to project site.

The CHP will be designed to operate throughout the year with class / grade “G14” Indian domestic coal i.e. Gross GCV of 3,100 - 3,300 kcal/kg.

As per estimation, considering gross plant heat rate of 2,042 kcal/kWhr (i.e. 42 % of thermal efficiency) for 660 MW SC unit, the coal requirement for the plant works out at full load with GCV of worst coal as 3,100 kcal/kg will be about 3.5 MTPA.

For the detailed coal quality parameters and requirement refer to “Appendix-III, Typical Fuel Analysis & Requirements” of this DPR.

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CHP will be designed on the worst coal basis of daily requirement of 11,200 TPD. CHP system capacity is taken as 2 x 1,350 TPH (from track hopper to coal silo) based on coal receipt by rakes of coal with fifty nine (59) wagons and each wagon with maximum payload of sixty six (66) metric tonnes.

Coal of 300 mm size unloaded into the track hopper from coal rakes will be conveyed to crusher house for crushing to size less that 50 mm or as per requirement of the coal milling plant. From the outlet of the crusher house, the crushed coal is transferred and distributed to top of the coal silos through two (2) nos. of vertical conveyors each of rated capacity 1,350 TPH. The storage of coal in the coal silo's will be necessary to take care of any disruption in the transport system or in the coal mines due to which coal cannot be received on such days.

Suitable number of rail tracks appropriately interconnected with each other will be laid ahead & prior to the track hopper for handling / return of empty rakes.

CHP system will consist of two (2) fuel streams (1 operating + 1 standby) and each stream will have rated capacity of 1,200 TPH (from coal silo to bunker). The complete CHP equipment & systems will be designed for simultaneous operation of both the fuel streams in exigencies.

A. Crushed Coal Transfer (In between Unit No. 8 & 9 and Unit No. 10)

Additional provision will be made for bilateral coal flow between different units i.e. Coal of Unit No. 8 & 9 can also be used in proposed Unit No. 10 and vice versa. To meet such requirements of bilateral coal flow between Unit No. 10 and Unit No. 8 & 9, suitable connection will be made at Junction Tower JT-9 (of proposed unit No. 10) and JT-13 (of unit No. 8 & 9) as shown on the flow diagram for CHP and plot plant attached in the drawing section of this report. In this arrangement, coal conveying will be through conveyor BC-17A/B from JT-9 to JT-13 on conveyor no. BCN-6A/6B of existing Unit No. 8 & 9 for coal flow from Unit No. 10 and similarly for reverse i.e. Unit No. 8 & 9 to Unit No. 10, coal flow will be through conveyor No. 18A/B from JT-13 to JT-9 on conveyor BC-13A/B.

Since, the conveying capacity of existing Unit No. 8 & 9 belt conveyors BCN-6A/6B is 1,200 TPH as per Unit No. 8 & 9 drawing and while the same required for Unit No. 10 will be 1,050 TPH, therefore, due to higher capacity belt conveyors of Unit No. 8

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& 9, the capacity of the proposed Unit No.10 belt conveyors will also be selected as 1,200 TPH in the flow diagram.

Further, due to bilateral coal flow arrangement, additional modification work required on the coal handling plant of Unit No. 8 & 9 i.e. two (2) nos. of fixed tripper and one (1) no. of JT is also to be included on conveyor-BCN-6A & 6B of the existing Unit No. 8 & 9.

B. Uncrushed Coal Transfer (from Unit No. 8 & 9 to Unit No. 10)

Apart from above, additional coal flow arrangement from TP-2 of Unit No. 8 & 9 to Crusher House of Unit No. 10 is also to be considered to have a coal flow arrangement on the coal receiving side (i.e. uncrushed coal). In case, coal for Unit No. 10 is received through BOXN type of wagons due to non-availability of BOBR wagons with East-Central Railways, then existing Unit No. 8 & 9 coal unloading arrangement (i.e. Wagon Tippler) can be used to feed the uncrushed coal through Coal conveyor from TP-2 of Unit No. 8 & 9 to Crusher House of Unit No. 10, hence sharing of coal unloading facility is envisaged.

Two (2) nos. of conveyors will be connected from TP-2 of Unit No. 8 & 9 to Crusher House of Unit No.10.

C. Uncrushed Coal Transfer (from Unit No. 10 to Unit No. 8 & 9)

A connection will be made between Track Hopper of Unit No. 10 with Wagon Tippler of Unit No. 8 & 9 to unload and transfer the coal from Unit No. 10 to Unit No. 8 & 9 during non-availability of BOXN type coal wagons.

To share the unloading facilities of Unit No. 8 & 9 with Unit No. 10 and vice versa, modification will be required on TP-2, construction of additional JT-14, modification of Wagon Tippler complex of Unit No. 8 & 9 and addition of variable Speed control mechanism for Paddle Feeder to control the coal feed rate from Unit No. 10.

The CHP system envisaged will have track hopper system, coal crushing & screening system, crushed coal storage silo of twenty (20) days storage capacity & feeding system, bunker feeding arrangements etc. Coal Bunkers of the one (1) system will be operated although provision will be kept for both conveyors simultaneous operation.

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The Coal Bunkers (above the Pulverizer / feeders) will have aggregate twelve (12) hours of storage capacity. The bunkers will be steel cylindrical silos with conical bottom and lined with stainless plates to ensure smooth coal discharge from the Bunkers.

The CHP system will be complete with dust suppression / dust extraction system etc. to make the CHP system operation eco-friendly.

All chutes will be lined to ensure smooth flow & discharge of coal as well as to ensure longer operating life of chutes. All Junction Towers and crusher house will be provided with floor cleaning chutes.

CHP auxiliaries such as dust suppression / dust extraction system, on line for maintenance, sump pumps, vulcanizing machine, belt sealing arrangement, annunciation system etc. will be provided.

All associated electrical & instrumentation will be provided. And, for the details refer to coal handling system flow scheme in the drawing section of this detail project report.

9.1.5 Fuel Oil Handling System

LDO will be used as ignition / start-up fuel for the boiler during start-up and low load operation.

LDO will be used having a firing capacity equivalent to 30 % BMCR for start-up or low load operation. LDO will be fed / drawn from the proposed new LDO storage tank of 1 x 2,500 kL capacity with help of transfer pumps or pressuring pumps. The LDO will then be feed to boiler through LDO feeding system.

The LDO transfer pumps discharge lines will be provided with a recirculation line connecting back into the storage tanks. This having an automatic pressure control station to maintain the required supply pressure at the burners of the boilers.

LDO equipment and piping will be drained by gravity to drain oil tank which is located in the tank farm and / or pump house.
The oily water waste occurring during maintenance will be drained into the drain oil tank then transferred either to Oil Water Separator (OWS) of the proposed

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extension unit or OWS of the existing Unit No. 8 & 9.

9.1.6 Ash Handling Plant / System

AHP for the proposed 1 x 660 MW unit is designed on maximum ash generation at BMCR condition. All the parameters have been selected as per the guidelines of CEA and MoEF.

Following are the ash generation data at design and worst coal consumption at BMCR condition.

Table 9.1-9 Ash Generation corresponding to Coal Consumption at 100 % BMCR

Sl. No	Item	Unit	Quantity	
			Design Coal	Worst Coal
1	Design Coal Consumption at BMCR (Peak Hourly)	TPH	438	467
2	Maximum Ash Content	%	44.60	40.00
3	Ash Generation	TPH	196	187

Table 9.1-10 Detail Design Basis for Ash Handling System

Sl. No	Item	Unit	Quantity	Remark
1	Coal Consumption at BMCR	TPH	438	
2	Maximum Ash Content	%	44.60	
3	Ash Generation	TPH	196	
4	Bottom Ash Generation	25 %	50 (approximate)	Ash generation is based on CEA guideline
5	Economizer Ash Generation	5 %	10 (approximate)	
6	Regenerative Air Pre-Heater (RAPH) Ash Generation	5 %	10 (approximate)	
7	Fly Ash generation	90 %	176 (approximate)	

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Table 9.1-11 System Capacity

Sl. No	Item	Unit	Quantity	Remark
1	Bottom Ash + Economizer Ash	TPH	210 (approximate)	4 hours generation to be evacuated in 1.25 hours. (including 5 minutes of flushing & change over time)
2	Coarse Ash (APH Ash)	TPH	80	4 hours generation to be evacuated in 1/2 hour. (30 minutes)
3	Fly Ash	TPH	235	8 hours generation to be evacuated in 6 hours.
4	HCSD System	TPH	176	100 % generation of Fly Ash (1W+1S)
5	HCSD Silo (each)	tonnes	1,500	2 nos. Each having 8 hours of Effective Storage capacity.
6	Main Dry FA Silo – Road Transportation	tonnes	1,500	1 no., Each having 8 hours of Effective Storage capacity.
7	Alternate Dry FA Silo (each) - Railway cum Road Transportation	tonnes	2,200	2 Nos., Each having 12 hours of effective storage capacity.

A. Bottom Ash (BA) Handling System

Bottom Ash (BA) and economizer ash is envisaged to be collected in water impounded BA Hopper located below the Boiler. BA falls directly in the BA Hopper whereas economizer ash is led to the BA Hopper via flushing apparatus provided below respective economizer ash Hoppers.

Keeping in mind, the system operation and maintenance, effective storage capacity of BA Hopper is of five (5) hours generation of BA and economizer ash is envisaged.

Ash from BA Hopper is to be extracted periodically, twice in a shift of eight (8) hours and will be transported to the BA slurry sump via BA slurry transportation pipelines. Jet pumps are provided for BA extraction and transportation up to BA slurry sump.

RAPH ash collected in RAPH Hoppers will be led to one (1) RAPH ash receiving tank via flushing / educator apparatus provided below respective RAPH Hoppers.

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The RAPH tank will be emptied via jet pumps installed below the tank and the RAPH ash slurry will be led to the BA slurry sump via RAPH ash slurry pipeline.

BA slurry disposal pumps are provided to dispose-off BA, economizer ash and RAPH ash slurry collected in BA slurry sump to the ash disposal area via BA slurry disposal pipeline.

The BA Hopper will have three (3) sections, each section of the BA Hopper will be provided with two (2) nos. ash discharge gates, two (2) nos. double roll clinker grinders and two (2) nos. jet pumps complete with feed gate housings. One (1) set of equipment will be in operation during the ash removal operation with the other set as standby for each section of the hopper.

The overflow from BA Hopper will be collected in a tank called BA overflow tank having a minimum capacity of ten (10) minutes. The overflow water from the tank will be conveyed to settling tank followed by surge tank. The chemical dosing will be done in surge tank before the treated water is led by gravity to Ash Water Sump.

BA slurry of RAPH from discharge of slurry tank by jet pumps, will be transported to the ash slurry sump of BA Slurry Disposal Pump House.

BA Slurry Disposal Pump House will have two (2) nos. of compartments each serving for maximum flow of one (1) no. of streams of slurry disposal pumps. From the sump, the slurry will be continuously pumped to the disposal area by means of BA slurry pump sets and the disposal pipe lines. The ash slurry disposal system envisages two (2) nos. of identical streams each having series of ash slurry pumps connected to two (2) nos. independent ash slurry disposal pipe lines. Out of the two (2) nos. of pump streams with associated disposal pipe lines, one (1) no. will be working intermittently/continuously and another stream with associated disposal pipeline will always be available as standby.

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B. Fly Ash (FA) Storage, Extraction, Transportation and Disposal

The Fly Ash (FA) handling system will consist of two (2) stage conveying. First stage will be vacuum conveying system from the respective FA Hoppers to the Buffer Hoppers. And, the second stage conveying will be dense phase pressurized pneumatic conveying system from the Buffer Hoppers to dry FA silo.

The total ash removal system will be divided into six (6) nos. of parallel paths. In each path, clearing / scavenging of ash from Buffer Hoppers connected to common FA header will be done one after another. The shifting of ash clear / scavenge cycle from one hopper to the next will be automatic based on vacuum level.

Dry Fly Ash transportation (From Buffer Hopper to HCSD Silo or Main Dry Fly Ash Silo)
For second stage conveying, each buffer Hopper will be provided with two (2) nos. air lock tank or pump tank of adequate capacity, two (2) nos. (1W + 1S).

Six (6) nos. pressure conveying pipe lines for the unit will be provided. Out of six (6) pipe lines, three (3) lines will be working and the three (3) lines will act as standby, to continuously transport the dry fly ash (both coarse and fine) from Buffer Hoppers either to Main Dry FA silo or HCSD silos.

Transport of dry FA from the unit Buffer Hoppers to the Main dry FA silo (1 x 1,500 tonnes) located near plant boundary, alternatively to the Alternate dry FA silos (2 x 2,200 tonnes) located at railway siding facility nearby TH complex on separate railway track will be with the help of five (5) nos. (3W + 2S) Transport Air Compressors (TAC) suitably sized and designed to cater to the ash evacuation requirements of the unit.

The same set of TAC will also be used for transport of dry FA from the unit Buffer Hoppers to the HCSD silos.

Dry Fly Ash Storage System
For dry FA storage and road transportation, one (1) no. main storage silo is envisaged. It will have the minimum effective capacity of 1,500 tonnes.

For the main storage dry FA silo, four (4) nos. of outlets at the bottom will be provided. First outlet will be fitted with rotary feeder and hydromix conditioner for

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loading the conditioned ash into open trucks. Second outlet will be provided with telescopic / motor operated retractable chute, feeder valve and rotary feeder for loading the ash into closed tanker. Third and fourth connection at present will be blanked connections and will be provided with isolation valve, for the future provision such as disposal of conditioned ash to the open trucks or closed trucker / bulker for bulk disposal of dry fly ash for utilization purposes to cement plant etc.

For Alternate dry FA silo railway cum road transportation, two (2) nos. ash storage silos are envisaged. It will have capacity of 2,200 tonnes, each.

For Alternate dry FA silo, four (4) nos. of outlets at the bottom will be provided. First outlet will be fitted with rotary feeder and hydromix conditioner for loading the conditioned ash into open trucks. Second and third outlet will be provided with telescopic / motor operated retractable chute, feeder valve and rotary feeder for loading the ash into closed tanker and / or closed railway wagons for bulk disposal of dry FA for utilization purposes to cement plant etc. Fourth connection at present will be blanked connections and will be provided with isolation valve, for the future provision.

The dry FA silo will be fitted with bag filters and fans for cleaning the vent air before discharging into the atmosphere. The dry FA silo will be provided with a dedicated aeration system.

HCSD System

In the event that dry FA cannot be disposed-off through closed tankers, as a back-up HCSD system has been provided considering low water consumption and less land requirement for ash pond. With HCSD system the residual life of ash pond will also increase due to increase in slurry density.

Two (2) nos. of HCSD silos will be provided. Two (2) nos. of HCSD streams have been considered, out of which one (1) no. will be operating for the unit and another will always be available as standby. The capacity of each HCSD pump will be same as fly ash generation from the unit. FA from the respective HCSD silo will be fed to the HCSD system via a weighing system, rotary feeder with VFD, and an ash conditioner. In case of any trouble in the running HCSD stream, the standby HCSD stream will come into operation, hence no interruption in ash disposal system.

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Each HCSD system starting from Mixing Tanks / Agitator Retention Tanks (MT/ART) up to the ash dyke will be consist of charge pumps (if applicable), HCSD pumps and all other equipment, piping & valves etc., as per system design.

The Mixing Tanks / Agitator Retention Tanks (MT/ART) have agitators which prepare the High Concentration Slurry (HCS) of uniform and pumping mixture of ash and water. The mixer is provided with impellers fixed in a shaft and is driven by motor with gear-box arrangement. The HCS prepared in the ART will now be disposed-off by the HCSD pumps via a charge pump, which provides necessary boasting for the HCSD pumps. The HCSD pumps will be positive displacement diaphragm piston duplex/ triplex type. The pumps will have variable frequency drive and PLC based controlled diaphragm/ piston positioning system. The diaphragm piston pump at discharge will have pre-charged pulsation dampers to ensure a steady flow.

Typical comparison between HCSD and LSD system is shown in below Table 9.1-12.

Table 9.1-12 Comparison between High Concentration (HCSD) & Lean Slurry Disposal System (LSD)

Sl. No	Item	HCSD System	LSD System
1	Type of Pump	Positive Displacement	Horizontal Centrifugal
2	Slurry Concentration (Ash to Water Ratio)	High (60:40)	(30:70; in fly Ash case) & (25:75 in Bottom Ash Case)
3	Maximum particle size can handle	5 - 6 mm	20 - 25 mm
4	Slurry Disposal Distance	Long Distance can be covered. Single Pump can generate pressure more than 100 Kg/cm^2.	Low. As even series of pumps cannot exceed a certain pressure limit.
5	Water Consumption	Very Low	Very High
6	Power Consumption	Low	High
7	Slurry Velocity	Low (up to 1.9 m/s)	High (up to 2.8 m/s)
8	Wear Tear of pipe Lines	Low (due to low slurry velocity)	High
9	Size of Slurry disposal Pipe	Small (usually 150-200 NB)	Large (usually 350-450 NB)
10	Ash Dyke Area Requirement	Low	Very High

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Sl. No	Item	HCSD System	LSD System
11	Recovery Water System	No Recovery Water	Yes
12	Installation Cost	High	Low
13	Special Training	Required	Not Required

Conventional Lean Slurry Disposal System and Ash Water Recovery System have limitations / disadvantages on account of higher amount of water wastage / contamination, ground water pollution, potential for ash pond collapse, vast land required for ash dykes, higher costs for ash pond construction and higher power consumption. These limitations have led to the adoption of new environment friendly ash disposal technologies such as HCSD systems where less water consumption and less ash disposal area requirements are major advantages.

Accordingly, based on above mentioned major advantages, HCSD is considered in the design of ash handling system of proposed Unit No. 10.

9.1.7 Plant Instrument & Service Air System

For instrument air requirement of main plant and auxiliaries, air compressors of adequate capacity with air drying plants of same capacity will be provided. Suitably sized & configured Instrument air compressors along with its control system will be provided.

These compressors will be oil-free screw or reciprocating type provided with all accessories such as suction filters, inter-coolers, after coolers etc.

The air-drying plants will be capable of achieving a dew point of (-) 40 °C at atmospheric pressure. Individual air receiver will be provided near air compressor for the instrument air requirement of the plant in case of trip of air compressors.

Separate plant service air compressor will be provided to meet plant / service air requirements of the proposed unit. These air compressors will be of the same type and make as the instrument air compressors.

9.1.8 Fire Protection & Detection System

The fire detection, protection & Alarm system will be designed in line with the requirements of Tariff Advisory Committee of India / IS-3034 / NFPA. The following

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fire detection and protection systems are envisaged.

(i) Hydrant system for the extension unit including all the auxiliaries and buildings in the plant area. The system will be complete with piping, hydrants, valves, instrumentation, hoses, nozzles, hose boxes / stations etc.

(ii) Automatic high velocity water spray system for all transformers located in transformer yard and those of rating 10 MVA and above located within the boundary limits of plant, main and unit turbine oil tanks and purifier, lube oil piping (zoned) in turbine area, generator seal oil system, lube oil system for turbine driven boiler feed pumps, consisting of detectors, deluge valves, projectors, valves, piping, instrumentation etc.

(iii) Automatic medium velocity water spray system for cable vaults and cable galleries of main plant, switchyard control room, CHP control room and ESP control room consisting of smoke detectors, linear heat sensing cable detectors, deluge valves, isolation valves, piping, instrumentation, etc.

(iv) Automatic medium velocity water spray system for conveyors, galleries, transfer points and crusher house consisting of Quartzoid Bulb (QB) detectors, linear heat sensing cables, deluge valves, nozzles, piping, instrumentation, etc.

(v) Automatic medium velocity water spray system for un-insulated fuel oil tanks storing fuel oil having flash point 65 ^{o}C and below consisting of QB detectors, deluge valves, nozzles, piping, instrumentation, etc.

(vi) Foam injection system for fuel oil storage tanks consisting of foam concentrate tanks, foam pumps, in-line inductors, valves, piping & instrumentation etc.

(vii) For protection of control room, equipment room, computer room and other electrical and electronic equipment rooms, suitable clean agent system such as "Inergen" or "Argonite" system would be adopted.

(viii) Fire detection & Alarm system - A computerized, intelligent addressable type early warning system as per NFPA standards will be provided to cover the complete power plant with compatible detection systems

(ix) Portable and mobile extinguishers, such as pressurized water type, carbon-dioxide type, foam type, dry chemical powder type, will be located at strategic locations throughout the plant.

(x) Required fire tenders / engines of water type, DCP / foam type, trailer pump with fire jeep etc. will be provided in the fire station.

The clarified water will be used for supply of firewater.

Clarified water cum fire water pump house will be constructed to house horizontal

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firewater pumps in the pump house for hydrant and spray system and the same will be driven by electric motor and diesel engines as per TAC guidelines.

The water for foam system will be tapped off from the hydrant system pumps.

For the above firewater pumping station, automatic pressurization system consisting of jockey pumps will be provided. All necessary instrumentation & controls for the entire fire detection, alarm and protection system will be provided for safe operation of the system.

9.1.9 Air-Conditioning System

Air conditioning system will be provided for all those areas, which require close control of environment conditions and will cover the following areas:

- Central Control Room (CCR) consisting of control rooms, control equipment rooms, telecommunication rooms, microprocessor, computer and programmers rooms, data storage rooms, UPS rooms, instrumentation laboratory and steam & water analysis rooms (SWAS), conference room, shift charge engineer's room (if applicable), relay rooms. Control room will be air conditioned at around 20 - 24 ^{o}C, 50 - 60 % RH.
- ESP control room
- CHP control room and AHP control Room.
- Switchyard control room including Computer Rooms, PLCC room
- Required areas in Service / Facilities Building / Administration Building
- Water Treatment Plant / DM Plant / ETP control rooms, Water & Fuel Analysis (Chemical Laboratory) room, Instruments room
- Any other area, which contains control and instrumentation equipment requiring air conditioning or otherwise requires being air conditioned.

A central water cooled chilled water type air conditioning plant will be provided for air conditioning of CCR and its associated area as well as administration building and related facilities. The chilled water from the central plant will be pumped to various air-handling units catering each area or groups of areas.

For other areas, either package type air-conditioning unit or direct expansion type air conditioning unit will be provided as per requirement.

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9.1.10 Ventilation System

Ventilation system will be designed to supply fresh outdoor air and will be selected for maintaining inside conditions for those areas where close control of temperature is not required, but nevertheless have a stipulated maximum temperature.

The areas to be ventilated by Evaporative Cooling system are as follows:

- All floors and area of turbine hall (STG building) other than the areas which are air conditioned.
- Switchgear rooms and cable gallery areas of main plant.
- Non air conditioned area of ESP control room

The areas to be ventilated by Mechanical ventilation process (using roof extractors / supply air fans and / or exhaust fans) shall consist of the following:

(i) All the pump houses like fuel oil pressurizing pump house, fuel oil unloading pump house, MCW Pump house, Filtered water pump house, fire water pump house, Raw Water pump house, ash water pump house, Ash Slurry pump house, etc.
(ii) Battery rooms, lube oil purification room, non A/C areas of SWAS room
(iii) Switchgear Rooms/ MCC/ Battery rooms in various auxiliary buildings
(iv) Air Compressor House
(v) Ash Compressor House
(vi) Complete water treatment plant building facilities like PT, DM, Chlorination, CW treatment etc.
(vii) Air conditioning plant equipment areas
(viii) A/C Plant room, MCC room, Battery room etc. in service & administration building
(ix) Battery rooms of various remote I/O rooms
(x) EDG room
(xi) Elevator machine rooms
(xii) Transfer tower / Tunnel for CHP
(xiii) Crusher House / Bunker Bay
(xiv) All toilets & pantries (to be provided with propeller exhaust fan)
(xv) Any other areas which are not covered either by air conditioning system or by evaporative cooling system.

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Battery rooms, chemical stores and toilets will be provided with exhaust ventilation with thirty (30) air changes per hr. All other buildings / areas will be ventilated by mechanical ventilation process using combination of supply air fans and roof exhausters or wall mounted exhaust fans with air changes of 10 - 15 nos. per hour.

9.1.11 Cranes & Hoists

One (1) no. EOT crane of adequate capacity will be provided in the turbine hall to maintain the heaviest item of the steam turbine and generator equipment's except generator stator.

CW pump house, river water intake facility, water treatment, effluent treatment plant, hypo chlorination, and other facility requiring frequent handling of heavy loads will also be provided with EOT cranes of suitable capacity.

For handling other heavy equipment weighing above five (5) tonnes and above, electrical hoists with monorail beam arrangement of appropriate type and rating will be provided.

However, for lifting weights below five (5) tonnes will be handled with manual hoisting / chain block with monorail beam arrangement.

9.1.12 Hydrogen Generation Plant

A hydrogen generation plant of suitable capacity will be provided in order to make available hydrogen for filling up high-pressure hydrogen cylinders, which are required for generator initial fill up and regular makeup required for generator rotor cooling.

Hydrogen generation is accomplished by water electrolysis process. Two (2) nos. of hydrogen receivers will be provided. The plant will be designed as per the regulations of the Explosives Authority with all the required safety aspects, instrumentation control, including on-line hydrogen purity analyzer system and control panel etc.

9.1.13 Thermal Insulation

All equipment / pipes / ducts whose surface temperature is higher than 60 ^{o}C will

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be provided with thermal insulation for personnel protection and heat conservation.

The insulation material will be chemically inert, non-combustible and harmless. However, outer surface of the insulation will be covered with aluminum cladding of 22 BWG.

Materials and thickness of insulation will be selected so as to limit the surface temperature to 60 ^{o}C with an ambient temperature of 45 ^{o}C and wind velocity of 5 m/s.

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9.2 Electrical Equipment & System Design

9.2.1 General Electrical Requirement

The design concept of the electrical auxiliary system as a whole is based on the requirements for the safe and reliable operation of the plant with provision for easy maintenance. The design and performance requirements of equipment will be generally as per the latest Indian standards, International standards like IEC and Indian Electricity Rules.

All electrical equipment for the Unit No. 10 including 400 kV GIS equipment will be designed based on the following power supply conditions.

Table 9.2-1 Details of Power Supply

Sl. No.	Supply	Description	Variation	Load/System
1	Generation System	20-27 kV, 3-Phase, 3 wire, 50 Hz, Non-effectively earthed.	Voltage: ±5 % Frequency: (+) 3% and (-) 5% Combined volt. & freq.: 5 % absolute	Generator, isolated phase bus duct (Main run and tap off), etc.
2	Power Evacuation System	400 kV, 3-phase, 3 wire, 50 Hz, solidly earthed, Fault level :40 kA (rms) for 1 sec	Voltage: ± 5% Frequency: +3/- 5 % Combined volt. And freq.: 10 % absolute	Switchyard Equipment
3	11 kV System	11 kV, 3-phase, 3 wire, 50 Hz, Medium Resistance earthed, Fault level :40 kA (rms) for 1 sec	Voltage: ±10 % Frequency: ±5 % Combined volt. And freq.: 10% absolute	Motors rated above 1500 kW, LT Auxiliary transformers and HV switchgear.
4	3.3 kV System	3.3 kV, 3-phase, 3 wire, 50 Hz, Medium Resistance earthed, Fault level :40 kA (rms) for 1 sec	Voltage: ±10 % Frequency: ±5 % Combined volt. And freq.: 10% absolute	Motors rated 200 kW and above up to 1500 kW, LT Auxiliary transformers and MV switchgear.
5	LV (415 V) System	415 V, 3-phase, 4 wire, 50 Hz, solidly earthed, Fault level :50 kA (rms) for 1 sec	Voltage: ±10 % Frequency: ±5 % Combined volt. And freq.: 10 % absolute	Motors rated less than 200 kW, MCCs, ACDBs.

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Sl. No.	Supply	Description	Variation	Load/System
6	LV Emergency (415 V) System	415 V, 3-phase, 3 wire, 50 Hz, Fault level :50 kA (rms) for 1 sec	Voltage: ±10 % Frequency: ±5 % Combined volt. And freq.: 10 % absolute	Emergency Feeders.
7	LV (240 V) System	240 V, 1-phase, 2 wire, 50 Hz, solidly earthed, Fault level :50 kA (rms) for 1 sec	Voltage: ±10 % Frequency: ±5 % Combined volt. And freq.: 10 % absolute	Lighting, Space Heating of Motors and Panels, Motors up to 200 W, AC control circuits etc.
8	Uninterrupted AC supply System	240 V, 1-phase, 2 wire, 50 Hz, ungrounded system, 60 minute backup time.	Voltage: +/- 1 % Frequency: +/- 0.2 %	All control systems like DCS / PLC/ Microprocessor based systems, Critical equipment, Printers, Analysers, etc.
9	DC (220 V) System	220 V, 2 wire, Ungrounded system, 60 minute backup time. Fault level : 25 kA	Voltage:+10 / -15 %	All protection and control systems for all electrical system & equipment, critical lighting, emergency loads / seal oil pumps etc.
10	DC (48 V) System	48 V, 2 wire, Ungrounded system, Fault level : 25 kA	Voltage: +10 /- 15 %	PLCC system

For the purpose of design of equipment/system, an ambient temperature of 50 °C and relative humidity of 95 % will be considered. However, for equipment in air-conditioned areas, design ambient temperature will be 35 °C, if 2 x 100 % air conditioning system is provided. The outdoor equipment shall be designed to operate in a highly polluted environment. The electrical scheme for the project as conceived is shown in the key single line diagram & 400 kV switchyard single line diagram (GIS) and same is enclosed with this DPR in drawing section, “Typical Key Single Line Diagram”.

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9.2.2 Arrangement of Electrical System

The Generator will be connected to the LV winding of Generator Transformers (GTs) through Generator Circuit Breaker (GCB) by isolated phase bus ducts and the HV winding of the GT will be connected to the 400 kV GIS by overhead conductors.

GT will consist of three (3) nos. + one (1) no. as a spare single phase 260 MVA, 420 kV/√3 / 20 - 27 kV, transformer.

The 400 kV GIS is considered equipped with circuit breakers, isolators, current transformers, capacitive voltage transformers, wave traps, lightning arresters, ground mat, shield wire etc.

Two (2) nos, 3-phase, 55 MVA, 20 - 27/11.5 kV, Unit transformers have been envisaged to cater to total unit & station loads of 1 x 660 MW Unit.

Further, three (3) nos. + one (1) no. as a spare single phase, 105 MVA, 400 kV/√3 / 220 kV, Inter-Connecting Transformer (ICT) has been envisaged for connection with existing 220 kV Switchyard of Unit No. 8 & 9.

The Auxiliary loads including the station loads of unit will be supplied by its Unit Transformers (UTs). Two (2) nos. 11 kV Unit Switchgears have been envisaged for power distribution to various 11 kV motors, 11 kV Tie Feeders and downstream 3.3 kV & 415 V switchgears. Two (2) nos. 11 kV Station Switchgears fed from 11 kV Unit switchgear has been envisaged to cater to all station loads.

One (1) no. 3.3 kV Unit Auxiliary Switchgear fed from 2 x 100 % Unit Auxiliary Transformers (UAT) have been envisaged for power distribution to various 3.3 kV motors. Suitable numbers of 415 LV boards are provided for unit & station loads.

The power supply for various 11 kV unit/station auxiliary motors and auxiliary/service transformers for unit/station services will be fed from 11 kV Unit/Station Switchgears. For feeding 3.3 kV motors for unit services, 3.3 kV system has been envisaged through suitably rated 11/3.45 kV auxiliary/service transformers. Additionally 11/3.45 kV service transformers have been envisaged for each of CHP, AHP and Water system. Unit 3.3 kV switchgears will have 2 x 100 % incoming feeders, to be fed by 2 x 100 % auxiliary/service transformers.

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Oil filled/dry type, outdoor/indoor (as per application) LV auxiliary/service transformers of suitable ratings will be provided to meet the 415 V unit/station load requirements of the Unit No. 10. The transformers will be located at different load centers to feed the respective 415 LV boards in that area. All 415 V LV boards will have 2 x 100 % incoming feeders, to be fed by 2 x 100 % LV auxiliary/service transformers or feeders, and bus coupler to achieve maximum redundancy and reliability during operation.

Plant emergency power will be provided from Emergency Diesel Generator (EDG) set to take care of any emergency situation particularly in the case of grid failure condition. One (1) no. of 100 % capacity 415 V, 3 phase, 50 Hz EDG Set has been envisaged with automatic starting facility to restore the supply at respective 415 V Unit Emergency Switchgear for supplying emergency power required for safe shutdown of the unit.

The UTs will be sized to meet unit cum station auxiliary loads corresponding to the maximum continuous rating of the unit. The insulation level for the transformer windings, bushings and other insulators will be as given below:

Table 9.2-2 Insulation level for transformer Windings, Bushings and other Insulators

Nominal System Voltage (kV)	Highest System Voltage (kV)	Rated 1 Min Power Freq. Withstand Voltage (kV rms)	Rated Lightning Impulse Withstand Voltage (kV peak)
400	420	630	1425
11	12	28	75
3.3	3.6	10	40
0.415	0.433	3	-

The neutral point of Generator will be earthed through single-phase earthing transformer with a loading resistor, connected at its secondary side, to limit the earth fault current to about 5 to 10 amps. 11 kV and 3.3 kV systems will be low resistance earthed to limit the earth fault current to 600 Amps. 415 V systems will be solidly earthed. The DC system will be unearthed. 400 kV systems will also be solidly earthed. Neutral of EDG will be ungrounded.

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9.2.3 Generator, Generator auxiliaries & Excitation System

9.2.3.1 Generator

The Generator will generally comply with the requirements specified in IEC-60034.

Table 9.2-3 Key Technical Data of Generator

Item	Rating
Type	3 phase, rotating field, Indoor, cylindrical rotor, synchronous Generator
Number of poles of the Generator	2
Generator rated output	780 MVA
Generator rated voltage	20,000 V to 27,000 V
Generator rated current	22,517 Amps to 16,679 Amps
Generator short circuit ratio	Not less than 0.48
Generator rated power factor (lagging)	0.85
Generator capable power factor at rated kVA	0.85 lag ~ 1.0 ~ 0.95 lead
Generator rated frequency	50 Hz
Generator rated rotating speed	3,000 rpm
Generator cooling method	
1. Stator windings	DM Water
2. Phase connection ring	DM Water
3. Stator core & Rotor windings	Hydrogen
4. Bushing conductor	Hydrogen
Generator coolers inlet water temp	39 ^{o}C
Generator voltage variation	± 5 % continuously
Generator frequency variation continuous	- 5 % to + 3 %
Generator continuous V/Hz limit	105 %
Generator winding insulation class	Class F
Generator winding temp. rise at rated output & nominal operating condition	Within Class-B temperature rise
Reference standard	IEC 60034 series (Primary Code - IEC 60034-1-2010)
Generator gas displacement method	By using CO_2

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Item	Rating
Generator casing rated hydrogen gas pressure	0.52 MPa (g) (or 5.3 kg/cm^2(g))
Generator shaft seal oil nominal pressure	Approx. 0.57 MPa (g) (or 5.8 kg/cm^2(g))
Generator excitation	Static excitation through slip-ring / brush
Generator hydrogen gas consumption rate expected	30 m^3 / day
Number of Generator hydrogen gas coolers	4 sections
Generator available output kVA when one hydrogen gas cooler section out of service	0.66

The Generator neutral will be earthed through a single-phase earthing Transformer with a loading resistance, connected at its secondary side.

9.2.3.2 Generator auxiliaries

The Generator will have following auxiliaries:

Generator gas control system

The rotor and the stator core of the Generator are cooled by hydrogen gas. Hydrogen gas will be supplied from the station gas supply system.

During normal operation, the hydrogen gas pressure inside the Generator casing will be maintained automatically at rated gas pressure by the gas pressure regulator. During initial filling of hydrogen, the air inside the casing will be initially purged using carbon-dioxide gas through the purge line, after which the carbon-dioxide gas will be replaced with hydrogen, thus preventing the formation of an explosive mixture of hydrogen and air inside the Generator casing. Carbon-dioxide gas will also be supplied from the station gas supply system.

A continuous scavenging system will be used for the Generator as a method to maintain the hydrogen gas condition in the Generator casing.

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Generator shaft seal oil system

The hydrogen gas-cooled Generator will be fitted with a shaft sealing system to prevent hydrogen gas inside the Generator from leaking. The system consists of a main seal oil pump driven by AC motor, an emergency seal oil pump driven by DC motor, a pressure regulating valve, strainers, hydrogen detraining sections and a float trap.

The Turbine Generator's bearing lubrication oil will be used as the sealing oil, and will be fed to the Generator seal ring through a regulating valve.

Discharge pressure of the main seal oil pump will be monitored by a pressure switch, and in case that the pressure decreased below the limit, the emergency seal oil pump driven by DC motor will be started for back-up operation.

Generator stator cooling water system

The stator cooling water system will operate as an independent sub-loop of the turbine Generator cooling system with automatic regulation of the inlet pressure and Temperature of low conductivity water to cool the Generator stator windings.

The cooling water from the storage tank will flow through two (2) separate pipes to the respective cooling water pumps. Normally, either one (1) of the two (2) pumps will be in operation, with the other pump serving as a standby unit.

To monitor the system, instruments such as temperature elements, flow meters, pressure gauges, conductivity elements, etc. will be installed on the stator cooling water measuring rack or aux. panel. Low pressure condition and high temperature condition of the stator cooling water will lead to trip out the Generator.

9.2.3.3 Excitation System

A Potential-Source Controlled Rectifier excitation system will be provided. This system has a high performance, reliability, and response. Self-excitation of the Generator is provided by a static excitation system using a thyristor rectifier which converts the AC voltage from the Generator terminals through the excitation transformer into DC voltage.

The voltage regulator controls the output voltage of a thyristor rectifier. The resulting DC power is supplied to the Generator field. The excitation power is

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taken from the Generator terminal voltage through the excitation transformer. The AC voltage is controlled and rectified by a 3-phase full-wave controlled bridge, which consists of six legs, and is fed to the field winding of the Generator through the field circuit breaker .The output of the thyristor rectifier is controlled by gate pulses, which are generated in either of the two (2) master controllers and amplified by the pulse amplifier. A field discharge resistor is installed for fast discharge of the field energy.

9.2.4 Isolated Phase Bus Duct

The Generator will be connected to the LV winding of Generator Transformers (GTs) through GCB by isolated phase bus ducts, to Neutral earthing equipment through main run bus duct and to Unit Transformers, Voltage Transformers and Surge Protection Cubicles, excitation transformer through tap-off bus duct.

The bus duct will be of isolated phase, continuous type with high conductivity aluminum alloy conductor as per IS: 5082 in non-magnetic aluminium alloy enclosure. Lightning arresters and surge capacitors of proper rating will be located within Surge Protection Cubicles, which in turn will be located as close as possible to the Generator phase side terminals. The current transformers for measuring and protection purposes will be provided inside the enclosure of the bus duct.

The main run of bus duct from Generator to the GT Set will have a continuous current rating not less than the Generator output under VWO condition. Tap-off connection section for connection of each UT will be rated according to the final rating of the UT. Busduct rating used for delta connection of LV winding of GT will be $1/\sqrt{3}$ times rated current of Main Run. The maximum temperature of the bus conductors & connections and enclosure will be limited to 105 °C and 80 °C respectively.

A Generator neutral earthing cubicle housing the dry type Neutral earthing transformer and secondary loading resistor will be located near the neutral star point of the Generator.

The bus duct enclosure will be of welded construction. The bus ducts will be naturally cooled, dust tight and weather proof in construction. Bus duct pressurization arrangement using clean dry air will be provided. To avoid condensation of moisture inside bus duct during shut down of the Generator,

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suitable facility for blowing hot air inside the bus enclosure will be provided.

The short circuit rating of the main run of bus duct will correspond to higher of the fault current contributions from Generator or GT side while the tap-off bus ducts will be designed for sum of the fault contributions from Generator and Transformer side. The fault withstand time of the bus duct will depend upon the type of Generator excitation and de-excitation time of Generator.

9.2.5 Generator Transformer

GT connected to the Generator terminals through isolated phase bus duct will step up the Generator voltage to evacuation voltage of 400 kV. The high voltage side of the GT will be connected to the 400 kV GIS by means of overhead conductors. The GT will be designed to deliver the total output of the Generator in to the system and will be as per salient technical features given below.

Table 9.2-4 Details of Generator Transformer

Sl. No.	Item	Rating
1	Type	Three (3), single phase (420/ √3) / 20-27 kV two winding, OFAF/ODAF cooling
2	Rating per phase	260 MVA
3	Quantity	Three (3) + one (1) no. spare
4	No load voltage ratio	(420/ √3) / 20-27kV kV
5	Vector group	YNd11
6	Percentage impedance	15 % with ± 10 % tolerance (Preliminary value to be finalized based on system study)
7	Type of tap changer	Off –load on HV side
8	Tap range	±5 % in steps of 2.5 %
9	BIL (HV Winding)	1, 425 kV peak
10	Switching Impulse	1, 180 kV Peak
11	Chopped wave BIL	1, 570 kV Peak
12	Partial Discharge	Not more than 100 pc
13	Terminal connections:	
14	HV Side	HV side Terminals on bushings for overhead line connection.

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Sl. No.	Item	Rating
15	LV Side	Bushings with matching flanges for connection to IPBD.
16	Applicable standard	IS 2026
17	Temperature rise with an Ambient of 50 ºC	Oil -40 ºC Winding -45 ºC
18	Over-fluxing (V/f) withstand capability	110 % Continuous at all operating conditions 125 % for at least one minute 140 % for at least five seconds
19	Loading capability of the transformer	In accordance with IEC 354
20	Maximum Noise Level when energised at normal voltage and frequency with fans running	In accordance with NEMA TR-1

9.2.6 GIS Switchyard

9.2.6.1 General

A double bus 400 kV GIS Switchyard has been envisaged for evacuation of power generated from the Unit No. 10. This GIS will be located in an area separate from the main power house building and will be surrounded by a fence. This GIS will have the following bays:

- Generator Transformer Bay 1
- 400/220 kV ICT Bay 1
- Line Bays 2
- Bus coupler Bay 1

The GIS will have its own Control Building for control, protection and supervision of the equipment in 400 kV GIS. Separate room will be provided to accommodate batteries for 220 V DC System for control & supervision of the switchyard equipment and 48 V DC System for PLCC systems. Tariff Energy Meters will be provided in line with CEA regulations.

The 400 kV GIS will be designed based on the following parameters:

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Table 9.2-5 Details of GIS Switchyard

Parameters	Unit	Design Value
Nominal Voltage kV rms	kV rms.	400
Highest System Voltage kV rms	kV rms.	420
Lightning Impulse Voltage (Phase to earth & between phases)	kV peak	1,425
Lightning Impulse Voltage (Across isolating distance)	kV peak	1,425(+240)
Switching Impulse Voltage (Phase to Earth)	kV peak	1,050
Switching Impulse Voltage (Across isolating distance)	kV peak	900(+345)
PD level for GIS	Pico Coulomb	< 5
Power frequency withstand (for 1 min.) (Phase to earth & between phases)	kV rms.	650
Minimum Phase to Phase clearance (Across isolating distance)	kV rms.	815

9.2.6.2 Supervisory Control and Data Acquisition (SCADA) System

The SCADA system for the 400kV GIS will be IEC 61850-compliant and will include Bay Controllers, Numerical Protections Relays, Operator Workstations, Engineering Workstations and all other equipment required for proving the complete functionality.

The SCADA system will be suitable for full protection, control, metering, monitoring and communication functions of all the bays in the 400 kV GIS. The SCADA will be a computer-based system that will integrate independently operating subsystems, such as Bay Control Units, Bay Protection Units, Metering, and alarm annunciation, into a unified data acquisition, monitoring, protection and control system in the substation.

All systems comprising the SCADA will be state-of-the-art, based on industry standards, suitable for operation under electrical conditions present in the EHV substations, follow the latest engineering practice, and ensure long term compatibility requirements and continuity of equipment supply and safety of the operating staff.

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SCADA will have provision for interfacing with remote State Load Dispatch Centre through suitable redundant gateways with adequate number of ports along with modems for data sharing.

Real time monitoring of various electrical parameters like voltage, frequency, current, active power, reactive power etc. will be carried out by SCADA.

9.2.6.3 Power Line Carrier Communication (PLCC) Equipment

PLCC equipment has been envisaged to be installed at the 400 kV line feeders to provide for speech communication between the Unit No. 10 and different receiving substations. The PLCC system will also be used for tele-protection and tele-metering systems. The equipment will be designed to work on 48 V DC systems.

The PLCC system will be consistent with the system provided at the other end of the transmission lines. Proper co-ordination will be taken care of during specification / procurement stage.

9.2.7 Inter-Connecting Transformer (ICT)

Three (3) nos. + one (1) no. as a spare, single phase, 105 MVA, 400 kV/√3 / 220 kV, ICT has been envisaged for connection with existing 220 kV Switchyard of Unit No. 8 & 9. This will also provide flexibility and reliability in operation of BTPS during normal and contingency condition. The details will be as per salient technical features given below.

Table 9.2-6 Details of Interconnecting Transformer

Sl. No.	Item	Rating
1	Type	Three (3), single phase (400/ √3) / 220 kV two winding, OFAF/ODAF cooling
2	Rating per phase	105 MVA
3	Quantity	Three (3) + one (1) no. spare
4	No load voltage ratio	(400/ √3) / 220 kV
5	Vector group	Yna0d11
6	Percentage impedance	12.5 % with ± 10 % tolerance (Preliminary value to be finalized based on system study)

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Sl. No.	Item	Rating
7	Type of tap changer	OLTC
8	Tap range	±10 % in steps of 1.25 %
9	BIL (HV Winding)	1425 kV peak
10	Switching Impulse	1025 kV Peak
11	Partial Discharge	Not more than 100 pc
12	Terminal connections:	
13	HV Side	HV side Terminals on bushings for overhead line connection.
14	LV Side	Bushings with matching flanges for 220 kV cable connection with Cable sealing end.
15	Applicable standard	IS 2026 /IEC 60076
16	Temperature rise with an Ambient of 50 °C	Oil -50 °C Winding -55 °C
18	Over-fluxing (V/f) withstand capability	110 % Continuous at all operating conditions 125 % for at least one minute 140 % for at least five seconds
19	Loading capability of the transformer	In accordance with IEC 354
20	Maximum Noise Level when energised at normal voltage and frequency with fans running	In accordance with NEMA TR-1

9.2.8 Power System arrangement to auxiliaries

9.2.8.1 Generator Circuit Breaker (GCB)

GCB is provided between the Generator and the GT to derive start–up power for the station from 400 kV GIS through GTs. Unit transformers will be connected between the GCB and GTs through tap off bus duct. When the GCB is in open position, the start–up power required for unit will be derived through GTs and UTs.

GCB scheme has been adopted for this project due to following advantages.

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- Optimize the 400 kV GIS bay requirement as station transformer is not required in GCB scheme
- No fast changeover required during process faults in the unit, ensuring uninterrupted power to the plant during process faults.
- Fast clearance of faults in GTs and UTs.

9.2.8.2 Unit Transformers

For power supply to all unit auxiliaries, two (2) nos. oil filled, outdoor type, three phase Unit Transformers have been envisaged. These transformers will be directly connected to the Generator tap off Bus duct.

Each transformer will be rated for 55 MVA tentatively, 20 - 27/11.5 kV, Dyn1, 50 Hz, ONAN / ONAF / OFAF cooled and provided with On Load Tap Changer having range of ± 10 % of nominal voltage at 1.25 % per tap. The given ratings are tentative only; final ratings will be decided based on the detailed calculation and sizing of the equipment and actual loads.

On load taps have been proposed for the UTs so as to limit the operation of tap changing on the GT. The capacity of these transformers will be finalized during detail engineering stage and will be rated to meet the auxiliary loads of the unit at MCR condition, with due consideration to voltage regulation requirement.

9.2.8.3 11 kV and 3.3 kV Switchgear

For power supply to all Unit and common auxiliary loads, the following 11 kV and 3.3 kV Switchgear have been envisaged for the Unit No. 10, as shown in enclosed Electrical Single Line Diagram.

- Two (2) nos. 11 kV Unit Switchgear
- Two (2) nos. 11 kV Station Switchgear, each of them to be connected to respective 11 kV Unit Switchgear
  11 kV and 3.3 kV sub distribution for facilities like CHP, AHP, Intake pump house and other BOPs.

11 kV switchgear will supply power to the 11 kV motors rated above 1,500 kW such as BFP, CWP, ID, FD, PA fan motors, 11 kV / 3.45 kV auxiliary transformers and 11 kV/ 0.433 kV Service transformers required for feeding the Unit and Common system

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loads connected to the respective 3.3 kV and 415 V switchgear buses. 3.3 kV switchgears will mainly supply the 3.3 kV motor rated 200 kW & above up to 1,500 kW of Unit. 11 kV Unit and Station Switchgear are also proposed to be interconnected by 11 kV phase segregated bus ducts as shown in enclosed Electrical Single Line Diagram.

Auto fast changeover facility will be provided for the bus coupler of the 3.3 kV main plant switchgears along with a backup Manual closing of bus-coupler through check synchronizing relay.

The change over facility shall be designed to provide process continuity to the loads attached while transferring the source from one to another.

All 11 kV and 3.3 kV switchgear will be provided with positive safety electrical interlocking and bus bar / feeder earthing facilities for operational and personnel safety.

The Short circuit rating of MV (11 kV and 3.3 kV) switchgear will be 40 kA for 1 sec.

All 11 kV and 3.3 kV Switchgear will be of indoor, single front, metal clad, fully draw out type, sheet steel units, assembled to form a rigid, free standing, floor mounted structure with IP 4X degree of protection as a minimum. The material of bus bars will be aluminum alloy.

Vertical units will be assembled to form a continuous line up of panels with breaker. All Circuit Breakers (CBs) will be SF_6 or vacuum type having drawn out facilities. Where vacuum CBs or contactors backed up by High Rupturing Capacity (HRC) fuses are used for smaller rating motors, surge limiters will be installed on the cable side to limit switching over voltages to motors.

9.2.8.4 Segregated Phase Bus Ducts (SPBD) and Non-Segregated Phase Bus Ducts (NSPBD)

MV (11 kV and 3.3 kV) bus ducts will be metal enclosed, phase segregated and natural air cooled and LV (415 V) bus duct will be metal enclosed non-segregated type.

Segregated Phase Bus Duct (SPBD) and Non-Segregated Phase Bus Duct (NSPBD)

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will be rated for secondary side current of unit and secondary side current of LV auxiliary / service transformer at minimum tap rounded off to the next higher rating.

Rated voltage of the bus duct will be equal to the highest maximum continuous system voltage.

All buses and connections will be supported and braced to withstand stresses due to maximum short circuit current. Short circuit rating of MV (11 kV and 3.3 kV) bus duct will be 40 kA for 1 sec and of the LV (415 V) bus duct will be restricted to 50 kA for 1 sec.

9.2.8.5 Neutral Grounding Resistor (NGR)

The 11 kV & 3.3 kV systems neutral will be medium resistance earthed to limit the earth fault current to about 600 Amps for 10 seconds. Each Neutral grounding resistor unit will be air cooled and self-supporting type. The enclosure for outdoor installation will have a degree of protection of minimum with IP 33 degree of protection.

The resistor elements will be made of non-aging punched stainless steel or equivalent corrosion resistant material having high electrical resistivity and low temperature coefficient of resistant. All element connections will be bolted type to ensure stable resistance value throughout the working life of the unit.

9.2.8.6 415 LV Boards

415 V, 3-phase, 4-wire power for the 415 V auxiliaries would be obtained from 11 / 0.433 kV and 3.3 / 0.433 kV transformers. The system will be a solidly earthed system. For maximum reliability, duplicate power supplies with auto changeover facility would be provided for the essential power and Motor Control Centers (MCC).

All power and motor control centers will be compartmentalized and will be of single / double front construction. They will be of fully draw-out design with all circuit components mounted on a withdrawable sheet metal chassis. The CBs would be of air break type.
Motor starting will be direct-on-line.

All LV motors would be controlled by air break, electro-magnetic type contactors

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provided with ambient temperature compensated, time lagged, hand reset type thermal overload relays, having adjustable setting with built-in single phase preventer backed up by HRC fuses for protection against short circuits.

9.2.8.7 Plant DC System

To supply power to various unit / station emergency DC drives / loads, the following DC systems (one main and one standby) have been envisaged for the Unit No. 10:

- 2 x 100 % 220 V DC system with 220 V DC distribution board (DCDB) for main plant
- 2 x 100 % 220 V DC system with 220 V DC distribution board (DCDB) for CHP and adjacent area
- 2 x 100 % 220 V DC system with 220 V DC distribution board (DCDB) for 400 kV GIS
- 2 x 100 % 48 V DC system with common 48 V DC distribution board (DCDB) for PLCC

Battery

The batteries will be low maintenance lead acid positive plate type, or Ni-Cd type. Each battery will be rated for a backup period of sixty (60) minutes. The duty cycle of the battery during the one hour emergency period will determine battery capacity. The battery capacity will be determined during detailed engineering considering appropriate ageing factor, design margin, temperature correction factor etc.

Battery Chargers

2 x 100 % float cum boost chargers of suitable capacity will be provided.

The battery chargers will be of silicon, controlled rectifier type completely automatic and self-regulating type.

The float charger will be capable of floating the battery and at the same time supply the continuous DC load. The boost charger will be capable of charging the fully discharged battery to full charge in eight (8) hours.

DC Distribution Board (DCDB)

Each DCDB will receive power from its respective DC battery / battery charger.

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The arrangement will be as shown in the key single line diagram.

DCDB incomers will be provided with positive mechanical interlocking facility to ensure that different power supply sources will not operate in parallel to avoid fault level exceeding their designated capability.

Each DCDB will be of indoor, single front and non-draw-out type. These will be sheet metal enclosed, assembled to form a rigid, free-standing floor mounted structure. Vertical units will be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration will be provided. The degree of protection will be IP 52.

The DCDB will have short circuit ratings consistent with the available short circuit current.

9.2.8.8 Emergency Power Supply System

The emergency switchgear (415 V, 3-phase, 3-wire) feeds the important AC motors like turbine auxiliary lube oil pump (AC) and seal oil pump (AC). It also meets AC power requirements for essential services such as battery chargers, UPS, AC emergency lighting etc.

The normal source of power for this section is from the unit 415 V LV board. Since this section is feeding essential services, the reserve supply to this section will be arranged from the EDG. On under voltage on this bus section, as sensed by an under voltage relay connected to this bus section, the normal source breaker would be automatically tripped. Simultaneously start command would be given to the EDG. The reserve breaker would be closed manually after checking that EDG has developed its rated voltage and attained rated frequency. Voltage and frequency check relays would be provided for this purpose.
Return to normal source from the EDG would also be manual. During manual transfer to normal source, the normal source breaker will be closed after synchronization and the emergency supply breaker would be tripped.

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9.2.8.9 Motors

To feed power to various unit / station drives, the voltage rating for the motors will be as follows:

Below 0.2 kW	---	240 V, single phase
From 0.2 kW to 200 kW	---	415 V, 3-phase
200 kW to ≤ 1500 kW	---	3.3 kV, 3-phase
1500 kW and above	---	11 kV, 3-phase
DC Motors	---	220 V DC

All AC motors will be squirrel cage three / single phase induction motors. Lifts / Crane motors may be of slip ring type. DC motors will generally be of shunt / compound wound type rated for 220 V DC. All motors will be rated for continuous duty. Lifts / crane motors / valve actuators motors will be rated for intermittent duty. Inching type motors for regulating valves will be provided as per the requirement.

Motor enclosures will conform to the degree of protection IP 54 for indoor and IP 55 for outdoors. For hazardous areas, approved type of flameproof and increased safety enclosure will be provided. LV motors will be premium efficiency class IE 3, conforming to IS 12615, or IEC: 60034-30.

The motors will generally be of self-ventilated type totally enclosed fan cooled (TEFC). Alternatively for large motors, Closed Air Circuit Air Cooled (CACA) / Closed Air Circuit Water Cooled (CACW) / Totally Enclosed Tube Ventilated (TETV) type cooling arrangement will be adopted. 11 kV, 3.3 kV & 415 V motors will have Class F insulation with temperature rise limited to Class B.

9.2.8.10 Plant Illumination

The Plant Illumination System will provide illumination to all plant areas within the Unit No. 10. In addition, it will also provide emergency illumination to selected / critical areas during plant emergency conditions. The basic illumination system will include the following:

- Normal AC lighting system
- Emergency AC lighting system
- Emergency DC lighting system

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Normal AC lighting system

The plant lighting system includes the normal AC lighting and Emergency AC lighting, which contribute together 100 % lighting. The emergency AC lighting will provide about 20 % of the total AC lighting in selected areas. These lighting fixtures will be ON as long as normal AC supply is available. The plant illumination level at different areas of the Plant is specified according to the utility and operational requirement of the particular area. Generally, these are in accordance with IS 3646.

Power for normal AC lighting system in the main plant areas, transformer yards, 400 kV GIS, other ancillary areas will be supplied form 415 V, 50 Hz, 3- phase, 4 wire Main Lighting Distribution Boards (MLDBs). The power for these MLDBs will be obtained from the 415 V station switchgears (for main power house building) or other switchgear located in respective areas through suitable nos. of adequately rated 415/433 V dry type transformers for fault level reduction & isolation. Further distribution from MLDBs to lighting fixtures will be through Lighting Panels.

415 V, 63 A, 3-phase, 4-wire, 5-pin welding receptacles and 240 V, 5 / 15 A, 1-phase, 3-pin small power receptacles required for maintenance of the plant will be provided. These receptacles will be strategically distributed in the plant. The welding receptacles will be fed from 415 V MCC / ACDB and small power receptacles will be fed from lighting panels.

Emergency AC lighting system

The emergency AC lighting system will be provided by AC lighting fixtures which will be located at strategic areas throughout the main plant where lighting is required for emergency operation and / or maintenance and personal safety during loss of normal power. These lighting fixtures will be ON whether normal AC supply is available or not. This system will be designed for approximately 20 % of the necessary illumination level. This lighting system fed from EDG will not be provided for balance of plant area.

Power for emergency AC lighting system will be supplied form 415 V, 50 Hz, 4 wires Emergency Lighting Distribution Boards (ELDBs). The power for these ELDBs will be obtained from 415 V station switchgears when normal AC supply is available and from EDG set when normal AC supply is not available, through adequately rated 415 / 433 V dry type transformers.

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Emergency DC Lighting

The emergency DC lighting system will be provided by DC lighting fixtures which will be located at specific strategic areas where lighting is required at all times for emergency operation and personal safety / exit during loss of the AC power supply, e.g., Control room, exits / staircase of Power house building etc. These lighting fixtures will be fed from 220 V DC LDBs which in turn will be fed from DC Lighting Panels (DCLP).

The supply to the DC lighting panels will be automatically switched ON in case of loss of AC supply at station service switchgear as well as Emergency switch-gear. The DC supply will be automatically switched OFF after about three (3) minutes following the restoration of supply to normal AC or emergency AC lighting system.

Portable self-contained battery lighting fixture assemblies will be provided at escape routes of all electrical and control rooms of all decentralized buildings where no emergency AC / DC lighting system is available. These fixture assemblies will be rated for four (4) hours.

Lighting Fixtures

For indoor application, fluorescent / energy saving compact fluorescent fixtures are considered. For high bay areas and outdoor suitable high intensity discharge sodium vapor lighting fixtures will be used to suit the requirement and application. The lighting fixtures will be of industrial / decorative / recess mounted / corrosion proof type as per application. Aviation type fixture will be provided for the Chimney.

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9.2.9 Plant Communication System

The Plant Inter Communication System will be designed to provide quick and reliable communication between plant personnel as well as with the outside. The system will consist of Public Address System and Telephone system.

9.2.9.1 Public Address System

Public Address System (PAS) will be provided to issue instructions, calling and conversing with key operation. The system provides two (2) independent channels of communication namely page channel and party channel. The page channel will be used to make any announcement over the system loud speakers. The party channel will provide highly intelligible voice communication between two (2) or more stations without being heard over the loudspeakers.

9.2.9.2 EPABX (Electronic Private Automatic Branch Exchange) System

This system will have adequate number of push button type handset stations, central automatic telephone exchange, etc. The handsets in the control room would be provided with priority service facility to enable them to have immediate access to any handset even if it is already engaged.

Necessary interface with P&T telephone would be provided in EPABX system.

9.2.9.3 Walkie Talkies system

Walkie-talkie systems will be provided for mobile communications. These systems will be of particular use during commissioning stage as well as subsequently for convenience during maintenance.

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9.2.10 Cables

Power cables would be selected based on the following criteria.

- Short circuit current for given duration i.e. breaker fault clearing time
- Able to carry the load current continuously under specified laying & site condition
- Maximum voltage drop (running/starting) is restricted within permissible limit.
- Standardization of cable sizes to reduce inventory

The following types of cables would be used.

MV Power Cables

11/ 3.3 kV power cables will be 11 (UE) / 3.3 (UE) volt grade, single / multi core, 90 °C rating under normal running condition & 250 °C under short circuit condition, heavy duty with stranded annealed aluminium conductor, extruded semi-conducting conductor screen, cross-linked polyethylene (XLPE) insulation, extruded semi-conducting insulation screen, extruded PVC inner sheath, round wire armour (galvanized steel for multi-core and aluminium for single core) and extruded Flame Retardant Low Smoke (FRLS) PVC overall sheath. These cables will have phase identification color coding.

LV Power Cables

1.1 kV grade, single / multi core, 90 °C rating under normal running condition & 250 °C under short circuit condition, heavy duty with stranded copper / aluminium conductor, XLPE insulation, extruded PVC inner sheath, round wire armour (galvanized steel for multi-core and aluminium for single core) and extruded FRLS PVC overall sheath. These cables will have phase identification color coding.

For conductor cross section less than 10 mm^2, copper conductors will be used in place of Aluminium conductor.

LV Control Cables

1.1 kV grade, heavy duty, multi core, stranded copper conductor, PVC insulation, extruded PVC inner sheath, round wire galvanized steel armour and extruded FRLS PVC overall sheath. These cables will have phase identification colour coding. The size of the conductor will be 2.5 mm^2 or 1.5 mm^2. CT, PT and GIS control circuits will use 2.5 or 4 mm^2 copper conductor cables.

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All control cables will be armoured type.

Cables would be laid in fabricated steel ladder type or perforated type cable trays in the station and other auxiliary buildings. Between buildings, the cables would be laid in built-up trenches/ overhead cable racks. Cables to other plant areas located far off from the station building would be directly buried in soil or carried on overhead racks.

All buried power cables will be armoured type. Armoured cables will have galvanized steel wire armour for three core power cables and control cables and aluminium wire armour for single core power cables.

9.2.11 Earthing and lightning protection system

9.2.11.1 Design Criteria

The station earthing system will provide a safe environment for personnel and equipment in the event of earth faults or lightning strikes.

All major electrical equipment will be connected to the earth grid to provide a low resistance path to earth. For earth mat design, the size of the earthing conductor will be arrived, considering the maximum fault current for duration of 1 second and suitable corrosion factor. The spacing of the conductors will be such that the touch and step potential are within the limits of permissible values. The earthing resistance will be less than one (1) ohm. The earthing system will be designed for a life expectancy of at least thrity (30) years.

Design of earthing and lightning protection system will be carried out as per IEEE 80, IEEE 142, IS 3043 and IS 2309.

The Earthing requirement of a power station complex can be divided into the following two (2) main categories viz. System Earthing and Equipment Earthing.

9.2.11.2 System Earthing

The system earthing is adopted to facilitate earth fault relaying and to reduce the magnitude of transient over voltage. The system earthing involves primarily the earthing of the Generator and transformer neutrals.

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High resistance earthing is envisaged for Generator neutrals, which will be achieved through a distribution transformer shunted by a resistance in its secondary side to limit the earth fault current to about five (5) to ten (10) amperes. The transformer and resistor will be rated for five (5) minutes of operation.

To facilitate identification of earth fault and isolate faulty section from rest of the system with a minimum damage to the equipment / system, 11 kV and 3.3 kV systems have been envisaged to be low resistance earthed to limit the earth fault current between 600 Amps. The resistor will be rated for ten (10) seconds of operation.

Solidly earthed system has been envisaged for 415 V systems. The DC systems will be unearthed.

9.2.11.3 Equipment Earthing

The equipment earthing will be adopted to provide protection to personnel from potentials caused by earth fault and lightning discharges by providing a low resistance conducting path to the earth.

All metallic parts of equipment including structures, buildings, transmission towers, etc., supposed to be at earth potential would be connected to the earthing mat. Enclosure of all the electrical equipment as well as all cabinets / boxes / panels etc. shall be earthed by two separate and distinct earth connections. Metallic pipes, conduits, cable tray section etc. shall be bonded to ensure electrical continuity and earthed at regular intervals. All steel structures shall be duly earthed. Metallic sheaths & armour of all cables shall also be earthed.

9.2.11.4 Lightning Protection System

The lightning protection system will be installed as per IS 2309 (latest edition) for protecting the building / structures against lightning discharge. This will be achieved by providing lightning masts on chimney, powerhouse building, flood light towers etc. and connecting them with the earth grid. Over and above, the shielding wires and / or lightning masts will be used to safeguard the equipment of 400 kV GIS and transformer yard.

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9.2.12 Control Philosophy

9.2.12.1 Control Rooms

The following control rooms have been envisaged for the Unit No. 10:

- Central Control Room in Power House Building to take care of Boiler & Turbine auxiliaries.
- Control room near ESP area for ESP and its auxiliaries
- Control Building for 400 kV GIS
- Control Room for each of following BOP packages:
  - CHP
  - AHP
  - Clarified Water Pump House
  - DM Plant

9.2.12.2 Electrical Control Concept

The electrical power distribution for the plant will be as per the key single line diagram, attached in the drawing section of this detailed project report.

The complete control, indication, annunciation and supervision of the main plant electrical systems for the Unit No. 10 will be performed through main plant DCS. The control of the 400 kV GIS will be through SCADA, which has been described separately. Necessary 'On Line' dynamic graphics will be provided for 11 kV, 3.3 kV & 415 V systems. Necessary command signals, feedback signals and measurement signals will be wired up from the various equipment through transducers and interposing relays to the plant DCS system.

The measurements / indications available on the monitor of the plant DCS will include the followings:

- Current, voltage and power for each 11 kV / 3.3 kV / 415 V incomers
- Current for each HV motors, LV large motors and motors for important process
- Current for each outgoing feeder for each 11 kV / 3.3 kV / 415 V switchgears
- Voltage for each 11 kV / 3.3 kV / 415 V bus
- Voltage for DC system
- Voltage for UPS system
- EDG set parameters

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The status of the following will be monitored, on the plant DCS and/or SCADA system.

- Status (ON, OFF & Trip) of all 11 kV / 3.3 kV / 415 V circuit breakers (up to 415 V switchgear bus)
- Status (ON, OFF & Trip) of all motors operated through DCS
- Status (ON, OFF & Trip) of DC system
- Status (ON, OFF & Trip) of UPS system
- Operation of all protection relays for 11 kV / 3.3 kV / 415 V systems

The control of GCB will be configured in the main plant DCS. One (1) operator workstation of 400 kV GIS SCADA will be provided in the main plant control room to facilitate control of all GIS bays from main plant control room.

9.2.12.3 Control Panels with PLC

For balance of plant systems, the control of electrical breakers (11 kV / 3.3 kV / 415 V) will be implemented in respective PLC panels. No hard wired control panels are envisaged for electrical system in balance of plant area.

9.2.12.4 Synchronization Facility

For 400 kV circuit breakers, synchronization feature will generally be a built in function of bay control units. For main plant electrical breakers (11 kV / 3.3 kV / 415 V), a hardwired synchronizing panel with synchronizing relay, guard relay, voltmeters, frequency meters etc. will be provided. For synchronization of Generator Circuit Breaker (GCB), an auto synchronizer relay with facility to raise / lower the excitation and turbine speed will be provided.

9.2.13 Protection Systems

All electrical equipment will be protected against abnormal system conditions by means of numerical protection relays. All numerical relays will be IEC 61850 compliant.

All numerical relays, auxiliary relays and devices will be of types proven for the application. Numerical Relays will have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide the

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required sensitivity.

Numerical relays will be suitable for efficient and reliable operation of the protection scheme. The necessary auxiliary relays, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. will be provided. No control relay, which will trip the circuit breaker when the relay is de-energized, will be employed in the circuits. Except for event logging, alarm and annunciation type of non-trip functions, protective relay contact multiplier relay will be high speed relay only. Relays will be provided with self-reset contacts except for the trip lockout, which will have contacts with a manual reset feature.
Suitable measures will be provided to ensure that transients present in CT & VT connections due to extraneous sources in the EHV system do not cause damage to the numerical and other relays. CT saturation will not cause mal-operation of numerical relays.

Following major protections will be provided.

A. Transmission Lines

- Main-I: Numerical Distance protection scheme suitable for carrier aided protection
- Main-II: Numerical Distance protection scheme suitable for carrier aided protection and with a hardware platform different from that of the Main-I Protection or from a different manufacturer than Main-I
- Back Overcurrent & E/F Protection
- Overvoltage Protection
- Open Jumper Protection
- 1-phase auto reclose function

B. Generator / Unit Transformers

- Transformer Differential
- Overcurrent Protection (50/51)
- REF Protection
- Back Up Earth Fault Protection
- Winding Temperature Trip / Oil Temperature Trip / Buchholtz Trip

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C. Generator

- Generator Differential
- 100 % Stator Earth fault Protection (20 Hz Injection principle)
- Rotor Earth Fault Protection
- Loss of Excitation
- Pole Slipping Protection
- Thermal Overload Protection
- Over fluxing Protection
- Negative Sequence Protection
- Back Up Impedance Protection
- Reverse Power Protection
- Overvoltage Protection
- Over / Under Frequency Protection

9.2.14 Tariff Metering System

For tariff metering, energy meters complying with Availability Based Tariff (ABT) requirement will be provided. The location of tariff energy meters will be as per CEA regulations on installation and operation of meters. Accordingly, energy meters will be provided at following locations:

- Main & check meter for all outgoing feeders
- Standby meter for HV side of GT
- Main meter for HV side of ICTs
- Standby meter for LV side of ICT
- Energy accounting & audit meters for incoming feeder of 11 kV station switchgear
- Energy accounting & audit meters for LV side of UAT

Accuracy class of energy meters will be 0.2. All ABT type meters will be fed from current transformers with accuracy Class 0.2 and Capacitive Voltage Transformers (CVTs) / Voltage Transformers (VTs) of accuracy Class 0.2.

The main features of ABT compliant energy meters will be as follows:

(i) Will be microprocessor-based conforming to IEC 60687 / IEC 62052-11 / IEC 62053-22 / IS 14697

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(ii) Will carry out measurement of active energy (both import and export) and reactive energy (both import and export) by 3-phase, 4 wire principle suitable for balanced/ unbalanced 3 phase load.

(iii) Will have an accuracy of energy measurement of at least Class 0.2 for active energy and at least Class 0.5 for reactive energy according to IEC 60687, and will be connected to Class 0.2 CT cores and Class 0.2 VT windings.

(iv) The active and reactive energy will be directly computed in CT & VT primary ratings.

(v) The reactive energy will be recorded for each metering interval in four different registers as MVARh (lag) when active export, MVARh (lag) when active import, MVARh (lead) when active export, MVARh (lead) when active import.

9.2.15 Construction Power

For construction activities, power supply at 33 kV, 3-phase, 50 Hz will be made available at one point within power plant area.

The further distribution up to LV levels with required nos. of step down transformers and distribution switchgears / boards will be arranged by the electrical contractors during construction of the Unit No. 10 at the BTPS plant.

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9.3 Control & Instrumentation

9.3.1 Design Philosophy

The Control & Instrumentation (C&I) system of the plant will be designed to ensure safe, efficient and reliable operation of the plant under all regimes of operation in safe & most efficient manner, without invoking plant or system operational limits and to provide the quality of control to support the overall performance criteria.

The state of the art C&I system will minimize operator interventions required and would take pre-planned actions required in case of process drift or if unsafe trends or conditions develop in any regime of operation. The system should alert the operators as to any abnormal conditions or situations requiring manual intervention in a timely manner.

The general design philosophy for the C&I system will meet the following objectives.

- High level of automation
- Operational convenience, user friendliness
- Consideration of maintainability and accessibility
- Consideration of long-range economy and better spares management
- Remote monitoring and control with minimum no. of local operators

The design of the control systems and related equipment will adhere to the principle of "Fail Safe" Operation wherever safety of personnel/ plant equipment is involved. "Fail Safe" operation signifies that the loss of signal, loss of excitation or failure of any component will not cause a hazardous condition. However, it will also be ensured that occurrence of false trips are avoided/ minimized.

Centralized control/ operation have been envisaged from a common CCR. The entire operation/ control and monitoring under all regimes of operation i.e., start up, loading, normal operation, shutdown, emergencies etc. will be possible through Operator WorkStations (OWSs), keyboard/Mouse located at Unit Control Desk (UCD) supported by Large Video Screens (LVSs).

In line with the latest trend of control & monitoring, for centralized control & monitoring of the plant, the C&I system will be built around a DCS with functionally distributed multifunction controllers, suitable Human Machine Interface (HMI) devices and other required peripherals and hardware.

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The DCS will provide a comprehensive integrated control and monitoring system to operate, control and monitor the Boiler & auxiliaries, STG & auxiliaries and BOP systems including integrated control of all main plant equipment and auxiliaries with a hierarchically and functionally distributed structure.

For the Boiler & the STG dedicated integral control system viz. BMS/BPS & Digital control is envisaged.

Operation and Monitoring of Plant Electrical downstream System will be performed through DCS. Sequence of Event Recording system will be provided for recording and printing trip and causes of trip for quick diagnostic of fault and remedial action.

The control of BOP auxiliary packages like Mill reject system, CHP, AHP, WTP, and Compressed Air system etc. will be typically from respective Local Control rooms by means of PLC or manufacturer's standard control system. Redundant Software link will be provided between the offsite Package PLCs and main plant DCS for data exchange. Additionally the signals, critical in nature, will also be connected to main plant DCS by hardwired connection.

Plant abnormal conditions will be alarmed through the Operator Interface Units. Alarm printer will be provided to print out all alarms with time tagging and in the chronological order.

Where bus type communications are used for the actuators/electric –pneumatic converters interface, care will be taken to ensure appropriate functional distribution to prevent load losses due to bus failures.

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9.3.2 Operation & Performance

This will be specified under the following sub-headings.

(i) General

The Control System for the main equipment in the Power Cycle of the Power Generating Unit and control systems for offsite packages in the plant will be designed such that a centralized operation monitoring and control of the process and the equipment can be carried out from a central location - CCR.

Separate and independent Instrumentation and Control System has been envisaged for the Power Generating Unit in the plant. The entire plant control, operation and monitoring will be performed from HMI unit consisting of color graphic LCD (TFT) monitor/keyboard/Mouse located on the Unit Control Desk (UCD) in the CCR and through Large Video Screen (LVS) Hardwired trip push button stations will be provided on Unit Control Desk (UCD) to ensure fast and reliable tripping of the plant unit.

(ii) Load Cycle

The Process Control System will be designed to allow the unit to meet the specified generation load regimes:

The system will provide as a minimum the following capability for all load segments:

- Fully Automatic Operation from minimum load to MCR
- Load Following Capability
- Compliance to the respective Grid Code.

(iii) Runback Capability

When a unit is on load and a trip or abnormal condition is detected, the control system will take specific automatic run back actions in parallel to any possible trip functions, to place the unit and major components in a safe and stable operating state.

The control objective is to reach this lower energy state in a controlled manner

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and to remain in a controlled stable state. This requirement is necessary to enable adequate time for the operator to decide on further actions (e.g. re-start or total shutdown of the unit or the respective components of the unit.

(iv) Unit Islanding

The control system of the unit will be capable of tripping to house load and continue stable operation under unit islanded conditions. The unit will be islanded in all cases of network disturbances which would otherwise lead to unit shutdown.

(v) Standardisation

The control systems for the unit and the BOP will be standardized as far as possible, to ensure simpler operation and maintenance, as well as reduce life cycle management costs. The philosophy of standardization will include for such items as field instruments, DCS and PLC equipment, peripheral devices, networks etc.

9.3.3 Major Control and Instrumentation Systems

The major components of C&I system of the unit will comprise of the following:

- DCS
  - Boiler Control and Protection System as per manufacturer's standard design with interfacing with the plant DCS
  - Steam Turbine Generator Control and Protection System as per STG manufacturer's standard design with interfacing with the plant DCS
- Turbine Supervisory Instrumentation system for STG and BFP Turbine
- Vibration monitoring system for HT Drives
- Master and Slave Clock System
- Field Measuring Instruments
  - Transmitter, temperature element, Local gauges etc.
  - Flow Elements (Nozzle & Orifice)
  - Local Instrument Racks
- Steam and Water Analysis System (SWAS)
- Offsite Packaged control system
- Continuous Emission Monitoring System (CEMS)
- Ambient Air Quality Monitoring System (AAQMS)
- Close Circuit Television (CCTV) System

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- Uninterruptible Power Supply (UPS) 230 VAC System
- Final Control Elements
- Instrumentation & Special cables
- C&I Lab Instruments
- Instrumentation Installation material
- Grounding system

9.3.4 Distributed Control System (DCS)

An integrated functionally DCS from one general family of interchangeable multifunction hardware has been envisaged for the Unit.

DCS will consist of following basic functions / subsystems:

- Close Loop and Open Loop Control Systems, which include Interlock and Protection systems, Sequential Controls, Plant Automation features and Measurement Systems
- Operator Station (OPS) and Large Video Screen in CCR
- System Bus
- Historical Storage and Retrieval function
- Plant Performance Calculations System
- Sequence of Events Recording function Alarm Annunciation System
- Programming and maintenance station

DCS will be of open architecture type having high system availability and reliability. The general configuration of DCS is indicated in drawing section on this DPR as “DCS System Configuration Block Diagram”. The configuration diagram enclosed is only generic in nature and tentative.

The DCS will be of proven and latest configuration and will be provided with suitable soft connectivity like Ethernet/MODBUS TCP/IP communication so that it can be connected seamlessly with other systems. Data transmission speed will be sufficient to meet the response of the DCS.

Modular system design will be adopted to facilitate easy system expansion. It should be possible to remove or replace various modules on line. DCS will include online self-surveillance, monitoring and diagnostic facility so that a failure or

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malfunction can be diagnosed automatically DCS will be fault tolerant to provide safe operation under all plant disturbances and component failure.

The control and automation system, including plant protection systems, operator interface and information system will employ fully integrated modern distributed control system technology.

The system will employ a uniform approach across all plant areas with respect to design philosophy, hardware and software application, basic functional characteristics, system interfaces, documentation, standard function blocks and engineering systems and tools.

The control and automation system will be suitably designed to achieve the plant performance and safety requirements, and will be highly reliable, fail- safe, self-checking with comprehensive internal diagnostics. No single random fault in the entire automation and control system will cause a load loss, forced outage or unit trip, and no two (2) simultaneous faults will lead to or potentially cause damage to plant. Safety-related instrumentation and control will be designed with a fail safe mode. Fault in any of the sub system will be suitably alarmed in the DCS operator Interface units.

Adequate redundancy in processor, power supply and communication interfaces will be provided so that no single failure will jeopardize the functioning of the entire system. Fault in any of the sub system will be suitably alarmed in the DCS operator Interface units.

Measured data will be continuously checked for validity, whether used for operator information, for control, calculations or plant history. All signals have data quality attributes which will be carried forward to the control system, operator interface or information system.

Interfaces of the control and automation system to specialized equipment or standalone equipment will be standardized, based on internationally accepted norms. Provision for minimum 30 % reserve capacity in respect of processor Memory and minimum 40 % reserve capacity in respect of Networks will be included in the base design of the control and automation system and the system will be expandable for up to 20 % hardware and 30 % software without requiring redesign of the configuration.

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The control and automation system and the field measurement and actuator systems as well and its support systems, power supplies and data networks will be immune to electromagnetic interference, and will conform to internationally accepted standards for power plant.

The control and automation system and the field measurement and actuator systems will comply with Process Control Security Requirements, meeting international standard norms and requirements.

A. Closed Loop & Open Loop Control System

The control system along with its measurement system will perform functions of Closed Loop Control System (CLCS), Open Loop Control System (OLCS) including protection functions, measurement and monitoring of signals and alarm function.

The plant will be functionally subdivided into groups, subgroups and drive control levels. The main and hot stand by controllers will be identical in hardware and software implementation and there will be automatic and bump less switchover from main controller to hot standby controller in case of main controller failure and vice versa without resulting in any change in control status, Major protection systems of the plant including Furnace Safeguard and Supervisory System (FSSS) and Turbine Protection System (TPS) will be implemented through triple redundant Controllers based on three (3) input signals and three (3) input / output channel Protection Systems will be implemented through triple redundant sensors and input/output channels. Dual redundant sensors / transmitters will be provided for close loop control systems.

The control and automation system and the field measurement and actuator systems as well and its support systems, power suppliers and data networks will be immune to electromagnetic interference, and will conform to internationally accepted EMC standards for power plant. The control system along with its measurement system will perform functions of CLCS, OLCS including protection functions, measurement and monitoring of signals and alarm function.

The plant will be functionally subdivided into groups, subgroups and drive control levels. The CLCS, OLCS and protection system for different groups with its subgroups will be implemented through separate controllers. However, CLCS and

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OLCS of same group/ subgroup will be implemented through same controllers, which will have multifunctioning and multitasking facilities.

The Control and automation system and the field measurement and actuator systems as well and its support systems, power suppliers and data networks will be immune to electromagnetic interface.

The following major systems will be covered by the plant DCS for control and monitoring.

- Boiler auxiliaries system
- STG auxiliaries system
- Electrical System
- Interface with Boiler & TG integral control systems
- Interface with Plant Onsite & Offsite PLC's/LCP for centralised monitoring

B. Integral Control & Protection System

Boiler Control System:

The Burner Management System (BMS) will be designed to :

- Prevent any fuel firing unless a satisfactory purge sequence has first been completed. It is desirable to have an automated fuel oil leakage test also prior to firing.

- Prevent start-up of individual fuel firing equipment unless permissive interlocks have first been satisfied.

- Ensure right equipment sequencing during its start-up and shutdown.

- Provide equipment status feedback and annunciation to the unit operator.

- Provide flame monitoring when fuel-firing equipment is in service and effect a burner trip or master fuel trip upon warranted conditions.

- Continually monitor boiler conditions and actuate a Master Fuel Trip (MFT) during adverse operating conditions which could be hazardous to equipment and personnel.

- Provide all logic and safety interlocks in accordance with National Fire Protection Association (NFPA).

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- Allow the automatic start and stop of burners based on boiler load, on operator selected sequence.

The Boiler control system will include the following functional blocks.

- Furnace Safeguard and Supervisory with Flame Monitoring System (FSSS)
- Secondary Air Damper Control (SADC)
- Separator Level Control
- Auxiliary PRDS Control System
- Mill / Pulveriser Control System
- Coal Feeder Control System
- Boiler Auxiliaries Controls
- Electromagnetic Relief Valve control, Furnace Temperature Probe control and other miscellaneous control
- Air Heater Leakage Control System and Fire Detection System

(i) Boiler Protection System

The boiler protection system is integrated with the unit control and automation system and software communication (signal exchange) from and to it will be redundant. In the event of this interface not being able to handle time critical signals, they and other critical parameters will be hardwired.

The boiler protection system will be a fully electronic, fail safe multi-channel system. The protection system will accept plant protection input signals in a 2-o-o-3 (Two Out of Three), 1-o-o-2 (One out of Two) or 1-o-o-1 (One out of One) selection configuration, depending on the measurement loop installation constraints and criticality requirements. MFT will conform to NFPA requirement.

The boiler protection philosophy to be implemented is based on the respective required regulations. It is preferable to have redundant software communication link with the plant DCS and some of the critical signals for protection of the boiler will be hardwired to the plant DCS.

(ii) Steam Turbine Generator (STG) Control & Protection System

For Steam Turbine control and protection dedicated D-EHC system is envisaged.

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The control system will be as per OEM standard & proven practice. The controllers are provided in a triple redundant configuration. HMI station will provides the operator with a convenient control and monitoring interface to the EHC system.

The STG control system will typically include the following functions:

- Speed control & Load control, Initial Steam Pressure Regulator
- Automatic Turbine Start-up
- Turbine Protection Turbine Test Function
- Turbine Auxiliaries Control System

(iii) BOP and Auxiliary Control System

Control, Interlock, Protection, Start-up and Shutdown of major auxiliaries and balance of plant equipment and drives are implemented through this group.

(iv) Electrical Systems Operation and Monitoring

Operation and Monitoring of Plant Electrical system will be performed through DCS.

C. Human Machine Interface (HMI)

The entire plant control, operation and monitoring will be performed from HMI in central control room consisting of color graphic LCD (TFT) monitor/keyboard/Mouse located on the Unit Control Desk (UCD) in the CCR and through Large Video Screen (LVS). Color & monochrome Laser Printers, hard copiers etc. will be provided for generation of logs, reports and miscellaneous printouts.

Control and monitoring of plant through Operator Station will be performed through different displays which will include Process and Instrumentation mimic displays, control displays, bar graph displays, X-Y and X-T displays, alarm displays and messages, operator guide displays, system status displays etc. Logs, summaries and reports will be displayed and will be printed on the printers.

A comprehensive and integrated alarm handling system will be employed, which clearly distinguishes between different alarm types. Alarm information will not be lost or inaccessible whilst navigating through displays, and alarm presentation will dynamically provide the operator with information matched to the current

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situation and its criticality.

D. Data Communication

Different subsystems of the DCS are interconnected through redundant bus communication system. This includes redundant data Bus, redundant Plant Data Highway and other applicable bus subsystems. The communication bus system will be in hot redundant configuration with no loss of data or loss of configuration in case of failure of one bus.

All the subsystems will be connected to the data bus and plant data highway through hot redundant communication controllers.

LAN and network components in redundant configuration will be envisaged to provide information exchange of plant DCS with plant management and administration facilities, wherein, the office PCs is connected to the LAN.

Open Architecture based DCS with Global Database and intelligent distributed configuration has been envisaged. It will be capable of handshaking with any third party system following standard protocol. The primary objective will be Centralized Monitoring, presentation & report of data for information and analysis of the entire plant. Main Data Highway will be high-speed dual redundant type with a bus speed of minimum 100 MB/sec or higher. Communication link between DCS and control system of other plant areas such as AHP, CHP, DM plant, Instrument Air & Process Air Plant will be redundant. The communication link between DCS and all other plant sections of the main plant will be redundant. All the Controllers will be connected to a common high-speed data highway for global distribution and access of data. Any data will be available at any point of the network as and when required. The Control System will be modular, expandable and flexible so that expansion of the system is possible by adding extra stations on the data highway.

Comprehensive self-diagnostic features have been envisaged to facilitate easy fault location and detection of hardware and software while the unit is in operation.

E. Historical Storage and Retrieval (HSR) System

The function of HSR system is to store historical plant data as for information on

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DCS. Operators can see the stored data on the display of each Operator station in the CCR. HSR system will collect and store data and parameters including trends, alarms and events from DCS database periodically and transfer to external removable storage device for long term storage and retrieval.

F. Performance Calculation

Plant Performance Calculations and other complex computations will be envisaged by automatically retrieving data from plant data highways. Facility to display all data related to Performance Calculations will be provided on HMI. Performance Calculation will be based on ASME Performance Test Code for the SG, TG and other equipment in the plant. Performance Calculation Package will use high level language to carry out Class I calculations for detecting and alarming unit malfunctions and class II calculations to determine performance of individual equipment and overall unit.

G. Sequence of Event Recorder (SER)

High Resolution SER system will be in built with the plant DCS SOE records will be displayed from any of the DCS Operator stations. Status change of all SER inputs will be time tagged within 1 ms. SER report will include a list of unit/major equipment trip and cause of trip in chronological order and will include points, which initiated SER collection.

H. Alarm Annunciation System

The central alarm system will be a part of the functions performed by the DCS. Alarm List displays current state of alarm condition and abnormal Tag condition in chronological order in a window of list. The operator can filter alarm from level or category Alarms will be given when important plant values exceed their limits or when abnormal operating conditions occur in the plant.

The alarms will be displayed on all the DCS Operator Stations and will be printed on printer chronologically.

I. Hart Management System

Dedicated standalone PC based Hart Management System (HMS) will be provided for centralized configuration, maintenance, diagnostic and record

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keeping of all electronic smart transmitters. Transmitter signals will be wired parallel to DCS control system and Hart modules of HMS, which will be connected to PC through suitable communication modules. Complete diagnostic, record keeping, calibration and configuration, event and log reports, historical database records of all transmitters will be possible from the HMS.

J. DCS Programming Station

Engineering workstation facilities will be provided as an integral part of the respective control and automation systems. Engineering station will be provided for configuration/ tuning/ structuring of control system and program development/ modification of HMI. Engineering station will be located in Programmers Room. The system will allow structuring I reconfiguration/ modification of control loops/logics, change in system configuration and tuning parameters, program development/modification in Operator Interface Units and similar engineering, diagnostic and maintenance functions from full graphic displays using familiar and conventional functional blocks from Engineering and Diagnostic Work Stations. All changes and modifications to application software will be made using the engineering workstation. All tuning constants will be parameterized and can be altered on line without disturbances to the control system or to the plant.

Diagnostic and system maintenance facilities will be provided on the engineering work station, to obtain the error logs etc.

The system provides a comprehensive database management system and interface for the engineer to view optimize and organize configuration data.

The system will be fully protected from possibilities of data corruption, external changes, computer viruses and software corruption. Feature to access the actual controller logics (online) from the each of the Operator station in CCR will be available.

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9.3.5 Turbine Supervisory Instrumentation System for STG & BFP Turbine

Turbine Supervisory Instrumentation for the steam turbines for the STG and the TDBFP will be complete with Sensors, Amplifiers, Special Cables and monitors with all necessary equipment and accessories. Bearing Vibrations, Axial Shift, Eccentricity, Differential Expansion, Thrust position etc., will be some of the important measurements for the Steam Turbine. The measurement items will be as per Turbine OEM standard and proven practice.

PC based vibration monitoring system will be provided, which will be knowledge based with the capability of dynamic data analysis and provides complete information about machines. The vibration monitoring system will be provided with necessary interfaces with DCS for centralized monitoring purpose.

9.3.6 Vibration Monitoring System for HT Drives

The Vibration Monitoring System will be provided for all HT Drives like ID Fans, FD Fans, PA Fans, TDBFP, CEP, CW Pumps etc. The System will be complete with Vibration Sensors, Amplifiers, and Special Cables etc. with all necessary equipment and accessories.

The vibration monitoring system will be provided with necessary interfaces with DCS for centralized monitoring purpose.

9.3.7 Master and Slave Clock System

Master and Slave Clock System in redundant configuration would be provided in order to maintain uniform timing throughout for the various plant facilities and also for time synchronization between various digital systems including DCS, and other PLC based systems of the plant.

The system will include master clock and slave clock display units spread all over the Plant. The GPS receiving System will be complete with Antenna and other electronic devices.

In the event of non-availability of GPS Pulses, the time synchronizing pulse from the Master Clock itself will be utilized for time synchronization of the plant DCS with

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other Systems.

9.3.8 Field Measuring Instruments

Smart transmitters having 4 - 20 mA DC signal output with superimposed digital signal conforming to Hart or any other internationally accepted protocol will be used for measurements, having high degree of accuracy and reliability.

Signal transmission from primary sensors or converters to DCS would be in current mode and the signal range will be 4 - 20 mA DC, 2-wire type. Temperature signals will be connected to DCS or transferred through temperature transmitter.

RTD & Thermocouple will be used for Temperature measurement. All temperature elements will be duplex and will be in sheath tube and thermo-wells of suitable material. For high temperature applications, noble- metal thermocouple in Incoloy sheath and thermo-well will be used. Thermocouples will be mineral insula ted type.

Flow nozzles will be utilized for measurement of steam flow, Feedwater flow, SH & RH attemperator flow and BFP recirculation flow.

For fuel oil flow measurements, Coriolis type mass flow meters with an accuracy of +1- 0.5 % of FSD will be used. For Cooling Water flow measurement, Ultra sonic I Impact Head Type flow measurement system will be used.

Aerofoil / Venturi type sensors will be used for Combustion Air flow measurements. Airflow measurements used in the combustion process will be reliable and accurate. The impulse lines for air flow measurement and furnace pressure should be designed to eliminate blockages that could lead to incorrect flow or pressure measurements. Orifice plate will be used for all other flow measurements.

Level switches for separator and drain pots of steam lines will be of conductivity probe type. All other level switches will be of external chamber float / displacer type as per application.

Level Transmitters for vacuum service will be of guided wave radar or differential tressure type. All other level transmitters will be of differential pressure type with pressure and temperature correction, as required.

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Flue gas oxygen measurement will be carried out by in situ Zirconium oxide type sensor which will be provided at the Economizer outlets and Air Heater outlet.

The transmitters and switch devices will be grouped together and will be placed in different local instrument enclosures in open and dust prone areas and in local instrument racks in covered areas at suitable locations. Measurement gauges will be provided locally.
Transmitters required to serve multiple receivers will be arranged so that disconnecting, shorting or grounding of one receiver device will not have any perceptible influence on any other consumer point of the same signal nor will change the transmitter calibration.

Local Indicating gauges will be provided for local monitoring of process parameters.

All field mounted instrumentation items will be of IP 65 protection class. Uniformity in make and type of instruments will be followed in similar applications.

Equipment for special applications such as fail safe, protection applications and hazardous locations, will be based on the specific requirements for the application.

Where bus type communications are used for the field measuring device interface, care should be taken to ensure appropriate functional distribution to prevent load losses due to bus failures.

9.3.9 Steam & Water Analysis System (SWAS)

Recognizing the importance of water chemistry in the power plant operations, a centralized comprehensive Steam and Water Analysis System (SWAS) will be provided for continuous on line monitoring of water and steam purity in the plant cycle. Measurements of Conductivity, pH, Hydrazine, Dissolved Oxygen, Silica, Sodium and Phosphate will be provided.

SWAS will consist of Sample Conditioning Panel (Wet Panel) and Analyzers Panel (Dry Panel) located in air-conditioned SWAS room.

Sample Conditioning Panel will contain sample filtering, secondary sample cooling and temperature control, pressure reduction and control, flow rate control,

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necessary instruments required for sample conditioning and monitoring.

Primary sample coolers and high-pressure reduction units will be located in field. Provision of grab samples will be provided in Sample Conditioning Panel.

The Analyzer Panel will consist of process analyzers and monitors. Analyzer panel will house alarms in local control panel with provision for repeat alarms in CCR. The signal from the analyzers will be hooked up with the plant main DCS.

Following Table 9.3-1 provides a guideline for analysis of Samples taken from different streams:

Table 9.3-1 Types of Analysers envisaged in SWAS

Sl. No.	Item	Analyser
1	Make up water	Specific Conductivity
2	Hotwell Condensate	Specific Conductivity (Both sides 8 nos.)
3	CEP Discharge	Specific Conductivity
		Cation Conductivity
		Sodium
		Dissolved Oxygen
4	Condensate Polisher outlet	Specific Conductivity
		Cation Conductivity
		Sodium
		Silica
5	Deaerator Outlet	Dissolved Oxygen
6	Feedwater at economizer inlet	Dissolved Oxygen
		Specific Conductivity
		Cation Conductivity
		pH
		Sodium
7	Separator drain	Cation Conductivity
8	Separator outlet steam at LTSH inlet	Cation Conductivity

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Sl. No.	Item	Analyser
9	Main steam outlet	Cation Conductivity
		Sodium
		Silica
10	Reheated Steam	Cation Conductivity
11	Closed Circuit CW	Specific Conductivity
12	Condensate Cooling water	Specific Conductivity

9.3.10 Off Site Packaged Control System

The control, interlock, protection and start I stop operation for the off site package like DM plant, CHP, AHP, Instrument and Service Air Compressor Plant, Fuel Oil Handling System etc. will be carried out from the respective PLC and manufacturer's proprietary Local Control Systems.

Redundant software links will be provided between these PLC based control systems and DCS so that full operation, Monitoring of the off site packages are possible from the CCR through DCS operator Interface units.

PLC based control systems with have hot redundant CPU, memory, power supply and communication modules for these off site packages. These PLCs will be interfaced with DCS through redundant software links based on Dual Optical Fiber Communication (OFC). Necessary ports / converters will be provided at both ends.

For redundant PLC based control system for offsite packages, alarm annunciation will be carried out in the PLC system and to be displayed in the Operator Station (OPS) of the respective PLC based systems. Conventional Hardwired alarm system will be provided where LCD (TFT) based OPS is not provided.

9.3.11 Continuous Emission Monitoring System

Continuous Emissions Monitoring System (CEMS) for monitoring of flue gas emissions from the Stacks of the plant will be provided, which will consist of the following analyzer Instruments:

- SO_2/NOx Analyser
- CO Analyser

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- CO_2 Analyser
- Flue gas Flow Meter
- Flue gas temperature measurement
- Stack Opacity Monitor
- Mercury Analyser

CEMS will be complete with flue gas sample extraction and conditioning and analyzing system. PC based Emissions Monitoring System with 21" Color Graphic LCD/TFT monitor with keyboard, mouse along with laser jet printer.

A software link will be provided to hook up the Emission Monitoring System to the plant DCS.

9.3.12 Ambient Air Quality Monitoring System (AAQMS)

Ambient air quality will be monitored for concentration levels of selected gaseous pollutants at different locations within the power station boundary and adjoining areas as per the ambient air quality monitoring guidelines of central and state regulatory agencies like MoEF, CPCB and SPCB prevailing during contract execution phase.

AAQMS system including the analyzers being supplied will meet all applicable requirements/ guidelines of relevant central & state regulatory agencies like MoEF, central and state pollution control boards etc. or of US EPA.

AAQMS will include monitoring of the following pollutant gases/parameters:

- Sulphur dioxide (SO_2)
- Oxides of nitrogen (NO_x)
- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Suspended particulate matter (PM10)
- Suspended particulate matter (PM2.5)-respiratory
- Total suspended particulate
- Ozone (O_3)
- Mercury Analyser - at one location only

AAQMS for each plant location will be fixed type, self-contained “station”. Apart

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from Centralized AAQMS data acquisition system, total four (4) nos. such stations will be provided at the min. one (1) no “station” will be located at the “Up wind” direction path. Balance three (3) nos. ‘stations’ will be located at different plant locations considering the factors like downwind direction, sensitive receptor, population etc. the exact location of the monitoring stations will be decided in consultation with owner and regulatory agencies during project implementation phase.

9.3.13 Closed Circuit Television System (CCTV)

Closed Circuit Television System (CCTV) with all equipment and accessories will be provided for the purpose of online surveillance of plant area & equipment and displaying that information at DCS Monitors Also, cameras will be installed at the Main Gate and other common auxiliary plants. The system will allow to record & hold camera images for a minimum period of thirty (30) days.

The CCTV System will be complete with Fixed & PTZ cameras, Video Display Units, Digital Server based Video Manager, Video Streamer, Optical fiber network cables, Network hard ware.

9.3.14 Uninterruptible Power Supply System

Uninterrupted & regulated Power Supply system (UPS) is envisaged to meet the electric power requirements of various C&I systems.

UPS system in redundant configuration will comprise of 2 x 100 % redundant inverters, 2 x 100 % redundant chargers, single battery set, static switches, bypass transformer and voltage stabilizer, manual bypass switches and AC distribution board etc.

The 230 V, 50 Hz, AC load will be supplied by both the 100 % capacity inverters working in parallel each at 50 % load in synchronization with each other with equal load sharing. One (1) no. maintenance free Lead - Acid / Nickel Cadmium type battery set will be provided. The battery will be rated for a minimum period of one (1) hour. A stand by AC power source with bypass transformer and static voltage stabilizer unit with manual bypass switch will be provided as a back up to the inverters. One (1) main AC distribution board will be provided with sub-AC distribution boards as required to supply AC power to different loads.

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9.3.15 Final Control Elements

In general, control valves, dampers and other final control elements would be of pneumatic ally operated type except for HP / LP bypass valves, which will be of hydraulic operated type and Fan / Pump flow / speed control devices will be operated by electric / hydraulic actuating mechanisms. Control valves will have wide range of controllability, less noise and have adequate fail safe feature. Electric to pneumatic converters will be provided for pneumatically operated final control elements to interface with the DCS. Each final control element will be provided with Electro pneumatic positioners with inbuilt position transmitter of 4 - 20 mA output, air lock relay, air filter regulator, hand wheel, limit switches, solenoid valve's and other accessories in accordance with the system requirements. In case of control signal or pneumatic supply failure, the final control element should go to fail safe position.

For special applications such as hazardous areas, actuators/electric-pneumatic converters will be selected based on specific application requirements. Where bus type communications are used for the actuators/electric –pneumatic converters interface, care will be taken to ensure appropriate functional distribution to prevent load losses due to bus failures.

The control valve sizing will be suitable for obtaining maximum operating conditions with valve opening at approximately 80 % of total travel. Valves will be open not less than approximately 10 % of full opening for minimum flow condition and will be capable of handling at least 120 % of the required maximum flow at full open condition.

The valve outlet velocity will not exceed 8 m/s for liquid services, 150 m/s for steam services and 50 % of sonic velocity for flashing services by selecting proper body size and Trim for the required CV.

Maximum permissible Noise level will be 85 dB(A) approximately from 1 m from the control valve. Control valves will be provided with minimum ANSI Leakage Class-IV except for critical applications for which leakage class will be V / VI as per application.

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9.3.16 Instrumentation & Special Cables

Instrumentation Cables

Instrumentation Cables include twisted and shielded copper cables, thermocouple extension cables, Triad cables, prefabricated cables and other special cables required for control and instrumentation systems. Instrumentation cables including both prefabricated and non-prefabricated cables will be of Flame Retardant Low Smoke type, PVC overall sheathed with 600 V rating or higher and suitable for continuous operation at 70 ^{o}C minimum except for high temperature resistant Teflon insulated cables suitable for a continuous operation at 205 ^{o}C minimum. Thermocouple extension cables will be of 16 AWG. Single and two pair copper cables will be of 1.5 mm^2 size whereas cables of higher pair will be 0.5 mm^2 size. Thermocouple extension cables and pair cables used for analogue signals will be twisted, individual pair shielded and overall shielded and cables used for binary signals will be twisted and overall shielded.

Instrumentation Interconnection Philosophy

The cable interconnection philosophy to be considered will be such that extensive grouping of signals by large scale use of field mounted Group Junction Boxes (JBs) at strategic locations (where large concentration of signals are available, e.g. Instruments, valves limit & torque switches, switchgear) is done and consequently cable with higher number of pairs are extensively used. Internal wiring in factory pre-wired electronic equipment cabinets may be installed according to the OEM's standard as to wire size and method of termination or internal equipment.

9.3.17 C&I Lab Instruments

All accessories and any necessary additional tools as required for proper maintenance and calibration of all supplied C&I devices/systems will be provided. All the electronic items will be microprocessor based and will have the data logging facility for keeping calibration/maintenance records with proper communication facility for downloading these data on the Lab work station. The calibration standards of all equipment furnished under this subsection will be traceable to National Bureau of Standards, USA or NPL, India or to the applicable standards existing in the country where the equipment is manufactured.

The maintenance & calibration equipment will be for Owner’s use for normal operation & maintenance of the plant.

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9.3.18 Instrument Installation Material

All required installation hardware including impulse pipes, tubes, valves, manifolds, fittings, cable trays, holders, angles and conduits etc. required for proper installation and interconnection of instrumentation and control systems will be provided. All materials and installation thereof will conform to the latest editions of American National Standard code for pressure piping, ANSI B 31.1, ANSI 816.11, ASME Boiler and Pressure Vessel codes, IBR and other applicable ASME, ANSI and local Standards.

9.3.19 Environmental Conditions

Instruments, devices and equipment for location in outdoors/ indoor/ air-conditioned areas will be designed to suit the environmental conditions indicated below and will be suitable for continuous operation in the operating environment of a coal fired utility station and also during periods of air conditioning failure without any loss of function, or departure from the specification requirements covered under this specification.

9.3.20 Grounding System

All panels, desks, cabinets will be provided with a continuous bare copper ground bus. The ground bus will be bolted to the panel structure. Shields of instrumentation cables will be grounded on panel side. The system ground will be isolated from the panel ground with suitable isolators or as per manufacture standard practice.

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9.4 Civil Works

9.4.1 Architectural Planning

The structures and buildings will be developed architecturally economic, environmental friendly, energy efficient and with clearly defined boundaries locally available materials will be used as far as finishes are concerned and will be environmental friendly and energy efficient system. The overall view will be pleasing to the surroundings.

The overall impact of the buildings will be one of aesthetically unified architectural compositions having a comprehendible scale, blending tonal values with the surroundings and taking full consideration of the climatic conditions, and the building orientation.

All buildings and structures will be architecturally treated in such a way so as to be in complete harmony with the main plant building, surrounding structures and environment. Due considerations will be given to landscape design, and interior design. All finishes for floors, walls, ceiling, structural elements, partitions for offices and industrial areas will be suitable for their aesthetics, durability and functional requirements and will include the latest building material & technology.

All public buildings will be designed on the principles of providing barrier free environment for physically disabled persons.

9.4.2 Land Profile and Development

As the power plant site of Unit No. 10 has already been prepared for the extension project of Unit No. 8 to 9 and is almost flat, the topographical survey is not conducted for Unit No. 10 separately. However, the bore log at different point in the whole plant of Unit No. 10 shows the same existing ground level i.e. Elevation Level (EL) (+) 45.5 m.
The designated ground level for Unit No. 8 & 9 is set EL (+) 45.0 m, in comparison to the HFL at the water intake point in the Ganga River as EL (+) 43.22 m. The grade level of Unit No. 10 will be considered as EL(+) 45.0 m similar to Unit No. 8 & 9. As per the site visit and geotechnical report of the Main plant area for Unit No. 10 (refer to Annexure-II), the existing ground level is almost flat at EL (+) 45.5 m. Hence nominal cutting will be required to achieve the Finished Ground Level (FGL) for open areas.

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As per the topographic survey of the ash pond area for Unit No. 10, the level of the existing ground varies from EL (+) 40.5 m to Maximum EL (+) 42.0 m. The cut and fill of the inside area of the ash pond will be done during the construction period of Unit No. 8 to 9.

The contour of the water intake area shows almost flat land with level difference from EL (+)38.0 m to EL (+) 38.5 m in the land considered for onshore facilities of Unit No. 6 to 10 (Refer to Annexure-I for the topographic survey report). The designated ground level for common DSB for Unit No. 6 to 10 is set EL (+) 45.5 m , with consideration for the HFL 43.22 m and the crest level of river bank. The DSB site will be prepared during the construction period of Unit No. 6 to 9 water intake facilities.

As the proposed plant is staggered in the existing plant site, there will be possibility of dismantling, modification, rerouting of existing facilities. The same will be carried out as per the requirement.

9.4.3 Foundation Design Philosophy

The geographical investigations have been carried out for Unit No.10 main plant area, ash pond area and river water intake area. The borehole investigations are conducted six (6) nos. for main plant area, eight (8) nos. for ash pond area and three (3) nos. for river water intake area. The main plant area of Unit No.10 is located within the facilities of Unit No. 8 & 9. The detailed geotechnical investigation of the Unit No. 8 & 9 is already conducted. However, to ascertain the soil characteristics of Unit No. 10 area, six (6) nos. of bore holes being tested in Unit No. 10 area. The soil profiles for three (3) areas of geotechnical investigation are described below.

(i) Power Plant Area

The land of Unit No.10 main plant area consists of a surficial fill of fly ash is underlain by sandy silt / clayey silt to about 5 - 7.5 m depth. Silty sand / fine sand is then encountered to the final explored depth of 40 m. The stratigraphy at site may be divided into three (3) generalized strata as described below:

Stratum – I (Loose to medium dense fly ash): A loose surficial fill of fly ash is present all over the site to about 4.0-4.5 m depth {EL (+) 41.5 – (+) 41.0 m}. Standard

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Penetration Test (SPT) values in the fly ash range from six (6) to ten (10) indicating loose to medium dense conditions.

Stratum – II (Loose sandy silt / firm clayey silt): Below Stratum-I, loose sandy silt / firm clayey silt is encountered to about 5.0-7.5 m depth {EL (+) 40.5- (+) 38.0}. However, at the Chimney location (P-2), sandy silt / clayey silt layer extends to about 12.0 m depth {EL (+) 33.5 m). SPT values in this stratum range from five (5) to nine (9).

Stratum – III (medium dense to very dense silty fine sand / fine sand): Stratum-III consists of medium dense to very dense silty fine sand / fine sand to the maximum explored depth of 40 m {EL (+)5.5 m}. SPT values in this stratum range from twenty (20) to sixty six (66) to about 19 - 23 m depth {EL (+) 26.5- (+) 22.5 m}. Below this, refusal (N >100) is encountered.

The soil profiles are similar to the detailed geotechnical investigations carried out for Unit No. 8 & 9 as expected. The soil properties and Foundation type recommendation are mentioned in below Table.

Table 9.4-1 Soil Properties & Foundation type recommendation (Main plant area)

Structure	Borehole No.	Foundation Type	Remarks
Coal Silo	Bore Hole Point (BH-P)-1	Raft Foundation Reinforced Cement Concrete (RCC) Bored Cast In-situ Piles	• Fill is met to 4.0 m depth. • Open and raft foundation area feasible at 5.0 m depth. • Alternatively RCC bored piles with cut off level at 1.5~2.0 m depth may be provided.
Chimney	BH-P-2	RCC Bored Cast In-situ Piles	• Fill is met to 4.0 m depth and low SPT values to about 11 m depth. • Open and raft foundation are not feasible. • RCC bored piles with cut off level at 1.5 - 2.0 m depth may be provided.
Boiler	BH-P-3	RCC Bored Cast In-situ Piles	• Fill is met to 4.5 m depth and liquefy to about 13.5 m depth. • Open and raft foundation are not feasible. • RCC bored piles with cut off level at 1.5 - 2.0 m depth may be provided.

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Structure	Borehole No.	Foundation Type	Remarks
Generator	BH-P-4	RCC Bored Cast In-situ Piles	• Fill is met to 4.5 m depth and low SPT values to about 8.5 m depth. • Open and raft foundation are not feasible. • RCC bored piles with cut off level at 1.5 - 2.0 m depth may be provided.
Generator Transformer	BH-P-5	RCC Bored Cast In-situ Piles	• Fill is met to 4.5 m depth and low SPT values to about 7.0 m depth. • Open and raft foundation are not feasible. • RCC bored piles with cut off level at 1.5 - 2.0 m depth may be provided.
Raw Water Storage Tank	BH-P-6	Raft Foundation	• Fill is met to 4.5 m depth and low SPT values to about 6.0 m depth. • Open and raft foundation are feasible at 6.5 m depth. • Alternatively, RCC bored piles with cut off level at 1.5 - 2.0 m depth may be provided.
		RCC Bored Cast In-situ Piles	

Table 9.4-2 Recommended Allowable bearing pressure (Main plant area)

Structure	Depth, m	Recommended Net Allowable Bearing Pressure, T/m²					
		Isolated Footing			Raft Foundations		
		Total Settlement, mm					
		≤ 12.5	≤ 25	≤ 40	≤ 25	≤ 40	≤ 75
Coal Silo	5.0	5.2	10.3	16.5	10.9	17.5	32.8
	6.0	7.5	15.0	24.0	15.6	25.0	46.9
Raw Water Storage Tank	6.5	5.8	11.6	18.5	12.2	19.5	36.6
	7.5	8.1	16.3	26.0	16.6	26.5	49.7

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Table 9.4-3 Recommended Pile capacity (Main plant area)

Structure	Pile Diameter (mm)	Pile length below cut-off level (m)	Recommended Pile capacity (MT)		
			Compression	Pullout	Lateral
Boiler Area	550	26	105	54	9
	600	26	126	63	9.8
Other plant area	550	26	114	60	9
	600	26	135	69	9.8

As per the recommendation of the geotechnical investigation report, isolated & raft foundation may be possible for some areas of main plant at higher depth. Soil improvement may be done to improve the soil characteristics to allow the foundations for small structures on isolated/raft foundation. The heavier foundations will be resting on the in situ piles of required diameter as per the recommendation of the pile capacity and the loading.

As per the field geotechnical report, there is liquefaction potential between 10.0 to 13.5 m depth in the Boiler area for Unit No. 10. The counter measures proposed for the liquefactions are as below.

- Use of soil compaction methodology using stone piles similar to Unit No. 8 & 9.
- Other soil improvement methods such as deep mixing stabilization method using cement or lime, chemical grouting method, etc..
- Pore water pressure blocking methods such as drain method, diaphragm wall method, wtc.

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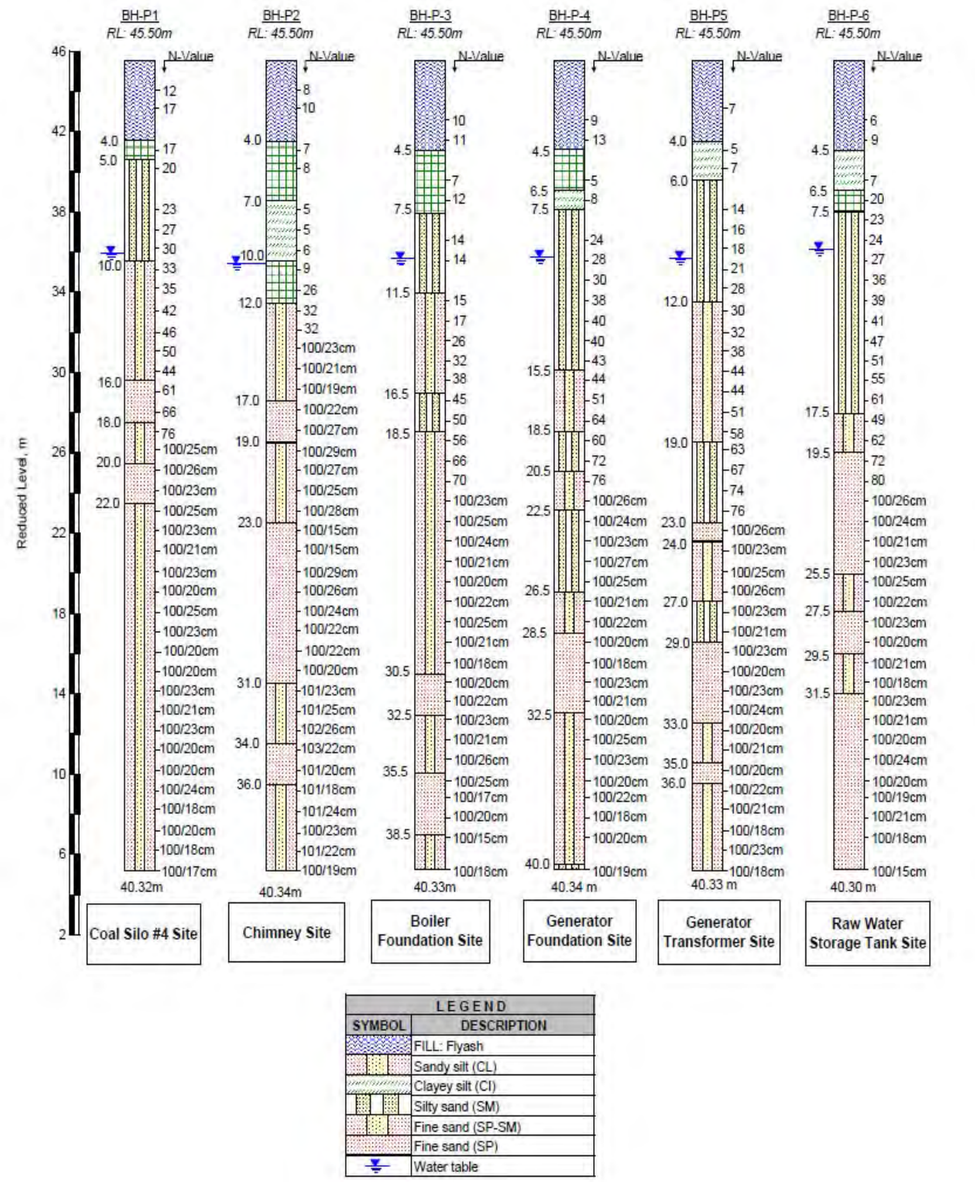

Summary of Borehole Profiles

Figure 9.4-1 General Soil Profile (Main Plant Area)

(ii) Ash Pond Area

The natural soils at the ash pond site consist of sandy silt from ground level to 0.5-2.0 m depth. This is underlain by silty fine sand/ fine sand to the maximum explored depth of 20 m. The stratigraphy at site may be divided into two (2) generalized strata as described below:

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Stratum – I (Sandy silt): A medium dense surficial sandy silt layer is present all over the site to about 0.5-2.0 m depth {EL (+) 39.9 – (+) 42.2 m}.

Stratum – II (Medium dense to very dense silty fine sand / fine sand): Stratum-II consists of loose to very dense silty fine sand / fine sand to the maximum explored depth of 20 m. The field SPT values generally range from 10 to 19 to about 4 m depth {EL (+) 33.7 m} and 20 to 30 to 8 m depth {EL (+) 33.7 m}. Below this, SPT values range from 26 to 42 to about 12 m depth {EL (+) 29.7 m}. SPT values then range from 36 to 58 to 16 m depth {EL (+) 25.7 m}. In the underlying soils, the SPT values range from 51 to refusal (N>100) to the final explored depth of 20 m {EL (+) 21.7 m}.

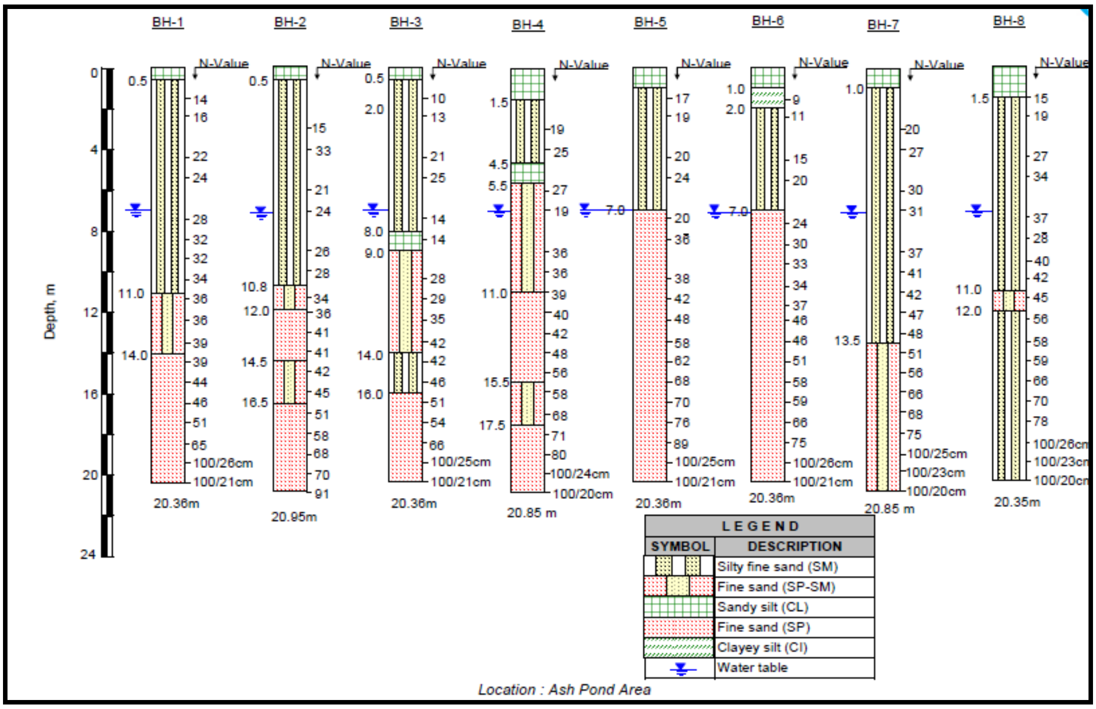

Figure 9.4-2 General Soil Profile (Ash Pond area)

Recommended Net allowable bearing Pressures for the foundation system in the ash pond area are as per below Table.

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Table 9.4-4 Recommended Allowable bearing pressure (Ash Pond area)

Foundation Embedment Depth below EGL (m)	Recommended Net Allowable Bearing Pressure (t/m^2)	
	Total Settlement ≤ 25 mm	Total Settlement ≤ 40 mm
1.5	9.0	14.4
3.0	13.0	20.8

The structures in ash pond area like recovery water pump house etc. will be constructed on isolated/raft foundation.

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(iii) Water Intake Area

The stratigraphy at site may be divided into two (2) generalized strata as described below.

Stratum – I (Stiff to firm clayey silt): A stiff to firm surficial clayey silt layer is present all over the site to about 1.0 - 1.5 m depth {EL (+) 36.7 - 37.8 m}.

Stratum – II (Loose to very dense silty fine sand / fine sand): Stratum-II consists of loose to very dense silty fine sand / fine sand to the maximum explored depth of 50 m {EL (-) 12.0 m}. SPT values in this stratum range from 5 to 16 to about 13 - 15 m depth {EL (+) 23.2 - 25.2 m}, indicating loose to medium dense soil conditions. SPT values range from 28 to 66 to about 26.5 m depth {EL (+) 11.7 m}. Below this, SPT values in this stratum range from 70 to 100+)refusal) to about 30 m depth {EL (+) 8.2 m}. Below this, refusal (N >100) is encountered.

Based on the field data of three (3) completed boreholes, groundwater was met at 3.0 - 3.1 m depth during the period of our field investigation (July 2015). Fluctuations may occur in the measured water levels due to seasonal variations in rainfall and surface evaporation rates as well as flow of water in the Ganga River.

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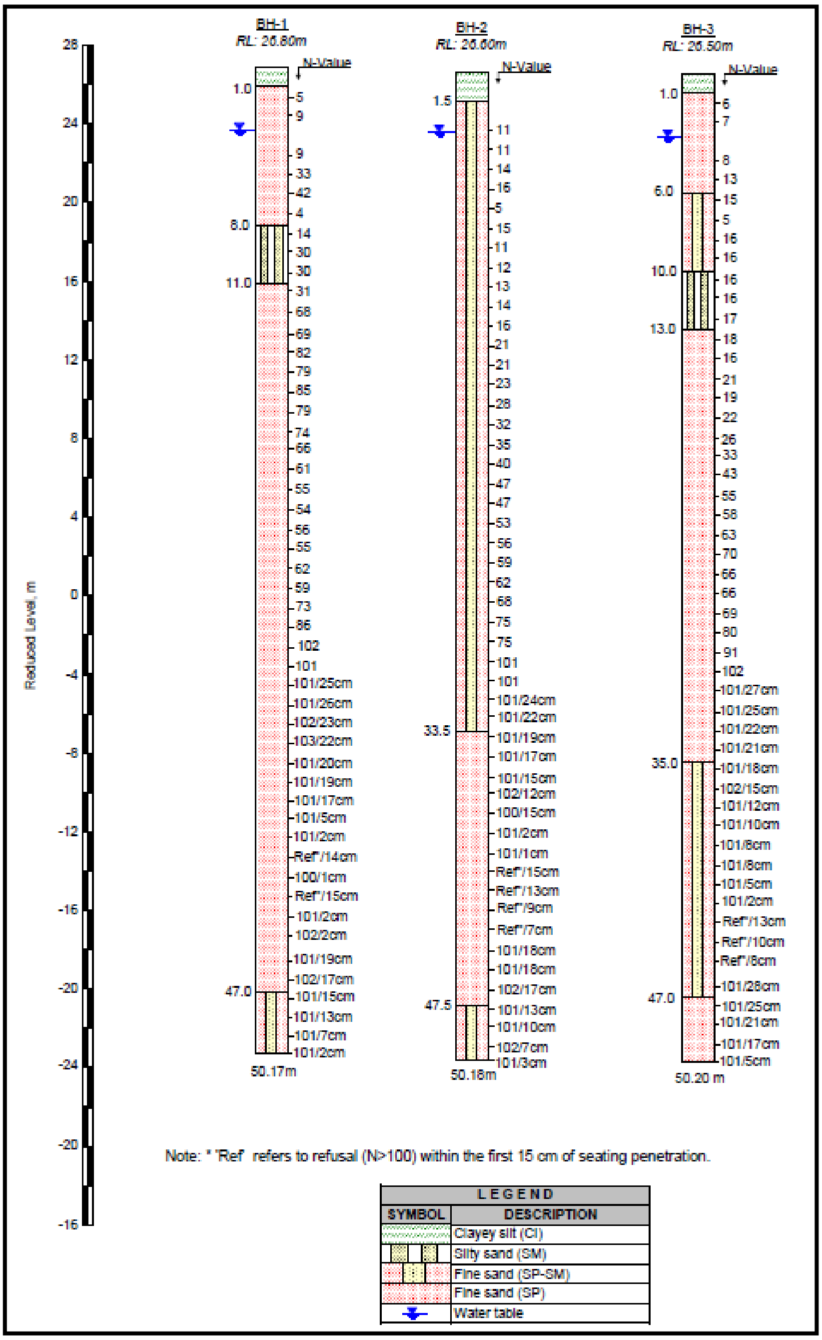

Figure 9.4-3 General Soil Profile (Water Intake area)

Recommended Gross allowable bearing Pressures for the foundation system in the Water Intake area are as per below Table 9.4-5.

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Table 9.4-5 Recommended Allowable bearing pressure (Water Intake Area)

Well Diameter (m)	Depth of Well Tip (m)	EL of the Well Tip (m)	Recommended Gross Bearing Pressure (t/m²)
8.0	30.0	EL -3.5 m	115.0
	32.0	EL -5.5 m	123.0
	35.0	EL -8.5 m	140.0
10.0	30.0	EL -3.5 m	99.0
	32.0	EL -5.5 m	108.0
	35.0	EL -8.5 m	125.0

The structures on the bank of the river will be constructed on isolated foundation / raft foundation based on the allowable bearing capacity estimation as per the field SPT value.

9.4.4 Civil Design Consideration

Design of civil works will be in accordance with the relevant Indian Standards. Design loading will take into consideration the following loads, as applicable:

- Dead Loads
- Live load/Imposed loads
- Wind Load
- Seismic Load
- Earth Pressure
- Temperature
- Water Pressure
- Dynamic Loads
- Test Loads
- Construction Loads
- Crane Load
- Mono-rail Load
- Special Loads

Imposed loads considered will be as determined by Code of Practice (e.g.: IS: 875-1987-reaffirmed 1997) or as per the requirement of plant design. Plant loading, lay-down, construction and maintenance loading will be as per the load data

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supplied by the respective plant/equipment manufacturers. Design and detailing will also take due account of locally available materials, such as bricks, aggregate, reinforcement, etc.

The load combination in the design will be as per relevant Indian standard. The serviceability and strength design consideration as per Indian standard will be followed. Pressure releasing valves will be used for the water retaining deep tank like structures to counter huge buoyancy force.

9.4.5 Steam Turbine Building

The building will be multi span framed structures consisting of structural steel columns, beams and trusses. This will be braced in longitudinal direction and moment resistant in transverse direction. Majorly Pile foundations will be considered for the building. The side cladding is considered to be of brick masonry and galvanized permanently color coated sandwiched insulated profiled sheet. Main power house building will comprise turbine floor, mezzanine floors, Deaerator floor, and various facilities such as unit control room, control equipment room, MCC/ switchgear rooms, SWAS room, battery rooms, cable vaults, air handling unit rooms etc.

All platforms and floors will be supported on structural steel. Central Control Room (CCR) will be located in BC Bay & CD Bay. The roof system will consist of a structural steel truss for the entire bay width. Wherever applicable the roof will consist of insulated sandwich panel and will be supported on structural steel purlins.

The purlins in turn will be supported on turbine bay roof truss top chord at regular intervals. If RCC roof is to be provided as per owner’s specification, the water proofing will be provided as per requirement for RCC roofs. The architectural finishes of the STG and control building will be as per the owner technical specification with environmental friendly material and color combination

9.4.6 Boiler, Steam Turbine and Generator Foundation

The boiler foundation will be raft/Isolated foundation resting mostly on pile as per the recommendation of the geotechnical investigation report. Tie beams will be considered to transfer the shear at foundation level (if required). The foundation will be isolated from the machine and other miscellaneous foundations.

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The Steam Turbine and Generator foundation will be a raft foundation resting on piles with a top deck supported on the RCC columns. The design of foundation will be as per relevant IS codes. The provisions of International Organization of Standardization (ISO) 10816 (part- 1 & 2), ISO 1940 (part-1) will also be considered in checking the dynamic characteristics of the foundation.

There will be an intermediate floor approximately at the mezzanine floor level. The top deck is meant for supporting the main equipment. This will be a table top type foundation supporting the vibrating machinery like HP/IP/LP turbines and Generator and will be isolated from the building at all the levels including the foundations. The amplitudes and the vibrations of the foundation will be kept well within the permissible limits stipulated by the machine manufacturer or as per the provisions of the ISO 10816.

The other dynamic foundations like Fans, Mills will be designed and constructed as per the code requirement and the manufacturers' criteria.

9.4.7 Chimney

The Chimney for the said project will be RCC construction with single steel flue of 275 m height. The grade of concrete for the Chimney shell & other super structure and foundation will be as per Indian standard Codes. The Chimney flues will be of mild steel/ corrosion resistant steel with resin bonded wool type insulation.

The portion of the liner projecting above the chimney roof, however, will be constructed of shaped acid resisting bricks. Brick liner will be protected by a reinforced concrete mini-shell also constructed from the roof slab. Suitable expansion joints will be provided between the steel and the brick liner. Internal platforms will be provided for enabling access to various elevations of the stack and to provide support to the steel flue. There will be sufficient working space around the flues. External platforms will also be provided. The external portion of the wind shield will be coated with alternate bands of red and white colors to meet the aviation safety requirements. The mini-shells and the top few meters of the internal surface of the windshield will be painted for acid and heat protection with bituminous paint. Provisions for ventilation and rack & pinion type elevator, stairs will be made in the Chimney.

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Arrangement will be made for the flue gas measuring instruments. The provisions for access inside, flue duct support, roof water proofing, earthing, lightening protection, aviation warning etc. will be made as per the specification requirement.

The analysis and design of the Chimney will be done as per the relevant Indian as well as international approved codes.

9.4.8 Transformer Area

The transformer foundations will be of RCC type raft/pile foundations with transformer supporting pedestals at the centre and an oil pit all around to collect oil / firefighting water in case of spillage. Common oil pit, connected by pipe network with all the transformer oil pits inside transformer yard will be planned to take care of the disposal of the collected oily water.

RCC Fire walls of adequate height are considered to be provided between the transformers and outside. For erection and maintenance purpose of the transformers, rails will be provided extending from each transformer foundation pedestal. The paving in transformer yard and fencing around the yard will be provided as per the specification requirement.

9.4.9 Gas Insulated Switchgear (GIS) and Control Building

The GIS building will be provided to house the GIS assembly. The foundations and GIS control room will be constructed as per the layout requirement. Outside GIS building auxiliary equipment foundations considered e.g. foundations for isolator, current transformer, line arrester, electromagnetic voltage transformer, capacitive voltage transformer, wave trap and Bus post insulator equipment. Isolated footings for each equipment will be considered resting on soil or pile as per the requirement. For the design of footing, short circuit forces will be considered wherever applicable. Complete switchyard area is considered to have gravel filling. Chain link fence will be provided as per the requirement.

Switchyard gantry tower foundations are considered will be of open type combined raft foundations resting on soil / appropriate engineered fill material / pile as per requirement. Each tower-leg will be supported on individual pedestals, which will in turn be internally connected through tie beams below ground level.

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For design of gantry tower foundations, appropriate load combinations, as stipulated in IS codes, will be followed to take care of the effect of wind load, short circuit load, wire snapping load etc.

The reactor foundations are considered to be of open type RCC raft foundations with reactors placed on pedestal at the center and an oil pit all around to collect oil / firefighting water in case of spillage. For erection and maintenance purpose, rails will be considered connecting each reactor foundation pedestal with the nearest road network. The oil pits will be provided with oil resistant paint and a localized gravel fill has been considered in each pit.

9.4.10 Raw Water Storage Tank

The raw water from the Ganga River will pass through the DSB and the clear water will be conveyed to plant by underground laid pipes. The water in the main plant area will be stored in the raw water storage tank. The foundations for the tanks will be on pile/raft as per the requirement.

9.4.11 Air Compressor Building

The air compressor building will be RCC/structural steel framed structure with side cladding with brick and permanently color coated metal sheets. The building will house the instrument and service air compressors with associated auxiliaries and rooms for control equipment and switchgear. The architectural finishes will be provided as per the requirement.

9.4.12 Emergency Diesel Generator Building

EDG building will be structural steel/RCC framed structure. The foundation considered to be open/pile foundation. Interior and exterior finish schedule will be as per the specification requirement. The provision for the trenches, equipment handling will be provided as per the Electrical requirements.

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9.4.13 Coal Handling System

(i) Track Hopper

The unloading of the coals from the wagons will be made through track hopper system. The railway track connecting existing system will be made as per the requirement. The Civil works will follow the general arrangement of the mechanical equipment. All arrangement of the inserts, embedment will be made along with the foundation for the equipment with finishes as per the specification.

(ii) Transfer Points

All Transfer Point /Junction Tower will be provided with RCC foundation with steel frame and RCC floor/roof. The side cladding system will be combination of brick cladding and permanently color coated metal sheeting. All external staircases will be provided with permanently color coated metal sheeting. Steel doors, louvers window and staircase will be provided for access and ventilation. Open/pile foundations are envisaged for column foundations.

(iii) Crusher House

The Crusher house will be of Structural steel framed structure with cladding consists of brick wall and permanently color coated metal sheeting. The floors & roof will be RCC supported on deck plate subsequently supported on the structural beam system. The foundations for the Crushers will be provided with Vibration Isolation System (VIS) arrangement or deck foundation system as per the specification requirement. The doors, windows, equipment handling facilities will be provided as per the requirement. The foundation for the crusher house will be on raft/pile foundation as per the requirement.

(iv) Coal Storage Silo

Due to space constraints of the plant site, the crushed coals will be stored in RCC / prestressed concrete overhead coal storage silo. The access, platforms, handrails etc. will be provided from the operational point of view. Inserts, embedment will be provided for the fixing of the mechanical accessories to the RCC structures. The foundation for the silo will be on raft or isolated foundation resting on piles as per the requirement.

(v) Conveyor Galleries

Conveyor galleries will be of structural steel with trestles at regular intervals. These

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will have permanently color coated steel sheets as side & roof cladding. Provision for lighting and ventilation will be made along the galleries. Open/pile foundations have been envisaged for trestle foundations.

(vi) CHP Control Room, Pump House

The auxiliary buildings such as CHP Control Room, Pump House will be RCC construction with brick cladding. The architectural finishes will be as per the specification. The doors, windows will be provided as per the requirements.

9.4.14 Ash Handling System

AHP system will comprise of BA and FA handling systems, ash slurry pump house, ash water pump house, HCSD Pump House, ash pipe supports including pipe racks, pipe trenches, culverts, ash pond etc. The major structures are described in brief below.

(i) Bottom Ash Hopper foundation & Trenches

Bottom ash hopper foundation & trenches will be provided to extract the bottom ash to ash slurry tank. Inserts will be provided to fix the conveyance system to the RCC structure.

(ii) Ash Slurry Pump House

Ash Slurry Pump House will be of RCC construction for housing the ash slurry pumps. The ash slurry sump with gratings will be adjacent to the building. The facilities for equipment maintenance will be provided in the building.

(iii) High Concentrated Slurry Disposal Silo

Two (2) nos. of HCSD RCC Silo will be provided for fly ash collection in wet form and transported to ash pond through HCSD Pumps in case of the non-utilization of the dry form ash and emergencies of failure. The access, platforms, hand railing will be provided as per the safety requirement.

(iv) High Concentrated Slurry Disposal Pump House & Control Room

HCSD Pump house will be of RCC construction for housing the HCSD Pumps. The facilities for equipment maintenance will be provided in the building. The control room will be equipped with local control panels for the operation of HCSD Pumps

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(v) Dry Ash Silo & Dry Ash Silo Utility Building

One (1) no. of Dry Ash Silo will be provided for dry form fly ash disposal system. The foundation for the silo will be raft/ pile foundation as per the requirement. The facilities for the dry fly ash collection through bottom chute to the trucks will be made. All inserts/embedment will be provided for fixing of electro mechanical fixtures. The Dry ash Silo utility building will be RCC construction to house the fluidizing blowers and other equipment as per the system requirement.

(vi) Ash Water Tank & Pump House

Ash Water tank and adjoining Ash Water Pump House will be RCC/steel framed structure to house the Ash Water Pumps. The finishes, embedment, access platforms will be considered during the building construction.

(vii) Ash Pipe racks, pedestals, trenches & culverts

Ash slurry disposal pipe lines will be routed on overhead trestles within plant area. Pipe lines will be routed supporting on pedestals up to ash disposal area beyond plant boundary. For crossing of the pipe line with nallahs, canals etc. (if applicable), pipe will be laid through RCC box culverts/bridges. Access road for the ash pond for the Unit No. 8 to 9 will be considered for maintenance purpose.

(viii) Ash Handling Plant Control Room

AHP Control Room will be RCC construction. There will be separate floor for cable spreader room. Switchgear and control room will be provided in the building. Provision for the transformer foundation will be provided as per the electrical requirement.

(ix) Ash Pond

There will be a common ash pond for the proposed Unit No. 10 along with Unit No. 6 to 9. And, this ash pond land should be selected considering design life of thirty (30) years with 100 % fly ash utilization as per CEA’s requirement as shown in Section 6.4.

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The common ash pond will be constructed during Unit No. 8 & 9. The garlanding of the ash slurry piping for Unit No.10 will be done along the periphery of the ash dike. The other facilities of the common ash pond like access roads along periphery of ash dike, green belt, decantation lagoon etc. will be shared by Unit No.10.

(x) Ash Water Recovery System

The ash water decanted in the ash pond will be transported to the plant area for treatment and subsequently re-circulated to ash water treatment system with recirculation pipes. The common Ash Water Recovery Pump House will be constructed in the ash pond area during construction of Unit No. 8 & 9. The treatment system will be constructed in the main plant area separately.

9.4.15 Fuel Oil System

Fuel Oil Forwarding Pump House

Fuel Oil (LDO) Forwarding Pump House will be RCC/structural steel framed building with brick cladding. A separate maintenance bay and Control room will also be provided in this pump house. The foundations for the pumps, auxiliaries will be provided as per the requirement. The finishes and the equipment handling facilities for maintenance purpose will be provided.

9.4.16 Water Intake System

The Raw water required for the proposed plant will be drawn from the Ganga River. There will be common intake jack well for Unit No. 6 to 10 with due consideration of the water drawn capacity requirements of the plant.

The common intake water pump house for Unit No. 6 to 10 above the jackwell will be Steel framed structure and will house the intake water pumps. The maintenance of the pumps, screens, gates will be done with the overhead crane/monorail arrangements as required.

The common approach bridge from the jackwell to the land area will be constructed during Unit No. 6 to 9 projects and will be supporting the river water pipelines (intake water rising mains) along with electrical cable supports. Walkway

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will be provided to reach the pump house. The rails will be supported on the approach bridge to access the maintenance bay for equipment maintenance.

The water from the Ganga River will be stored in a common DSB for Unit No. 6 to 10 to remove the silt from river water and clear water can be pumped to the plant area. The DSB will have a common standby sedimentation unit for Unit No. 6 to 10.

The clear water after DSB will be pumped to the main plant area by the clear water pumps housed in the common Clear Water Pump House for Unit No. 6 to 10. The clear water pipelines (clear water rising mains) will be buried along the route parallel to the pipes of Unit No. 6 to 9. The river bank crossing and other road crossing will be provided with RCC encasement of the pipes.

Other auxiliary facilities related to water intake systems like silt flushing, electrical system etc. will be provided as per the system requirement.

9.4.17 Water Treatment System

The water from the raw water storage tank will be transferred to the pre-treatment system with cascade aerator and clarifiers to generate clarified water and filters for further purifying the water for potable purpose. The Civil structures required for the system along with pump houses, electrical & control buildings, pits, trenches will be constructed as per the system requirement.

The Clarified water will be pumped to the DM plant to generate demineralized water. The DM plant along with all foundations, dykes, trenches, will be provided as per the requirement.

The architectural finishes as per system requirement like lining, chemical resistant paint, water proofing, acid resistance bricks etc. will be used in the construction as per specification requirement.

9.4.18 Cooling Water Pump House

Cooling Water (CW) Pump House for housing Circulating Water Pumps will be provided. Separate bays will be provided for each pump by providing intermediate dividing piers / walls of RCC between the pumps. The sub-structure of CW Pump Houses including their fore bays will be of RCC construction.

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The sump for CW Pump House will be designed as non-cracked section. Removable trash rack and stop logs including their handling arrangement during operation and maintenance will be provided. CW Pump House will be provided with a separate maintenance bay for maintenance of the various equipment and an electrical switchgear room.

The recirculation water system will be provided by IDCT similar to the other units. The civil construction as well as the electromechanical construction for IDCT will be as per the system design.

9.4.19 Non-Plant Building

Major non plant buildings like Service Building, Work Shop, security office, Canteen, Fire Station, Weigh Bridge, Main Gate etc. will be considered from the existing Unit No. 8 & 9.

Hydrogen Generation Plant

The building will be RCC construction with roof with water proofing. The cladding will be with brick. The internal and external finishes will be as per the specification requirement. The lighting and ventilation of the building will be taken into consideration in planning.

9.4.20 Roads

The roads of the existing Unit No. 8 & 9 will be mostly used for connectivity. However, any modification or newly construction of the roads will be done as per the requirement.

Double Lane Roads

The major roads connecting main plant area and internal roads in main plant area will be double lane roads with raised foot paths on both sides of the road. The divider will be provided as per the requirement. The type of road construction will be either flexible pavement type or rigid pavement type.

Single Lane Roads

All access roads to all buildings/facilities/structures will be single lane roads with

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hard shoulder on both sides of roads. The roads will be mostly of flexible bitumen road. The roads will be designed and constructed as per the latest IRC codes recommendation.

9.4.21 Plant and Storm Water Drainage

Drains will be constructed on both sides of double lane and single lane roads and on one side of patrolling road. The storm water drain from the Unit No. 10 area will be collected and connected to the drains of the Unit No. 8 & 9 storm water drains and subsequently collected at the storm water collection pit under scope of Unit No. 8 & 9.

The discharge of the storm water for the whole plant, after collection at the storm water collection pit, will be in the scope of Unit No. 8 & 9 constructions.

All drains will be of RCC open rectangular section. However, it will be closed at required location for the passage. The invert level of the drains will be designed considering the invert level of the drains of Unit No. 8 & 9.

9.4.22 Effluent Treatment Plant

Effluent Treatment Plant/ system will be provided to maintain the standards of Industrial Waste. A CMB of RCC construction will be provided to collect all the plant effluents. The effluents (oil waste, chemical waste) will be further treated in ETP. The civil structure required for the ETP will be provided as per the system requirement.

9.4.23 Sewerage System

The sewage generated at remote places will be treated / disposed considering package septic system with soak pit. For the plant area centralized sewage treatment system will be followed. The sewerage generated at different places will be collected and transferred by gravity or pumping system to the Sewage treatment plane and further treated. The treated water will be used for gardening purpose or other requirement.

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SECTION 10

ENVIRONMENT ASPECTS

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10.1 Introduction

A comprehensive Environment Impact Assessment (EIA) study is to be conducted to assess the existing baseline environmental conditions and impact of the Unit No. 10 on the environment. Based on the studies, an Environmental Management Plan (EMP) will be prepared. The EIA study report is a prerequisite towards obtaining clearances from MoEF and Local Pollution Control Boards. The Unit No. 10 could contribute to the following types of environmental pollution:

- Atmospheric Pollution
- Solid & Liquid Waste Water Discharge Pollution
- Thermal Pollution
- Noise Pollution

The Unit No. 10 will be provided with necessary systems and equipment to achieve all applicable environmental regulations. The plant has been envisaged with the following features, which would help in reducing emissions and effluents discharges into the surrounding environment.

- SC steam parameters, resulting in higher efficiency - thereby leading to lesser fuel (coal) consumption and consequently reduced atmospheric pollutants (SPM, SO_2, NOx, and CO_2) as emission is linked to global warming.
- As once through technology is selected for the Boilers, Blow Down would be eliminated and make up water requirement becomes minimal. The consumptive water requirement for the plant is thereby reduced.
- FGD and SCR is envisaged to limit SO2 and NOx emission to meet new air emission standards in India.
- Domestic coal has been envisaged for the plant.
- High efficiency ESPs has been envisaged to limit the particulate emissions to less than 30 mg/Nm^3.
- 275 m tall single flue chimney is envisaged for the Unit No. 10 in line with the MoEF guidelines [23], which will help in dispersion of air borne emissions over larger area and thus reducing the impact of the power plant on ground level concentrations.
- CCW system with IDCT is envisaged, thus reducing significantly the water requirement for the BTPS plant. River water is envisaged for Condenser cooling and for other equipment cooling water requirements of the Unit No. 10.

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- Ash pond water will be re-circulated and discharge is not envisaged from the Unit No. 10. This will not only prevent contamination of natural water bodies within the vicinity of BTPS, but also help in reducing the fresh water requirement for the Unit No. 10.
- ZLD schemes have been envisaged for Unit No. 10. All effluents from Unit No. 10 will be treated, recycled and reused within the BTPS premises to achieve the ZLD.
- Dust Extraction and Dust Suppression Systems have been envisaged in the CHP.

10.2 Pollution Control Measures

Various aspects of the environmental impact due to the Unit No. 10 are discussed below.

10.2.1 Air Pollution

The proposed plant will be designed to meet with the new emission standard in India.
High efficiency ESPs will be installed, upstream of the flue gas discharge into the atmosphere, to control the emission of ash particles. The ESPs would be designed to limit the particulate emission to less than 30 mg/Nm^3 at 100 % BMCR conditions for firing range of coal specified.

FGD will be installed to control the emission of SOx. The FGD would be designed to limit SOx emission to less than 100mg/Nm^3. In addition, SCR will be installed to control the emission of NOx. The SCR would be designed to limit NOx emission to less than 100 mg/Nm^3.

To ensure safe and optimum operation of the ESPs, each stream of precipitator would be supervised and monitored by a separate microprocessor based rapper control EP Management System (EPMS).

In order to meet the guidelines of CPCB as well as that of SPCB for SO_2 emission, the Stack / Chimney of 275 m height has been envisaged as per below Table 10.2-1. The Chimney would be provided with personnel access for regular monitoring of stack emissions.

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Table 10.2-1 Thermal Power Plant Stack Height Limits [23]

(Unit: m)

Sl. No.	Generating Capacity	Stack Height
1	500 MW and above	275
2	200 /210 MW and above to less than 500 MW	220
3	Less than 200/210 MW	$H = 14(Q)^{0.3}$ H= Stack Height, meters Q =Emission rate of SO_2, kg/hr.

For the control of fugitive dust emission within and around the CHP, dust extraction and suppression systems will be provided. Dust suppression system will be installed at all transfer points in the CHP. Dust extraction system would be provided in the Crusher House, Coal Silo, as well as in Coal Bunkers. However, dust suppression systems will be provided for transfer point / junction towers, track hopper complex.

During the construction phase, no significant impact on air quality is expected. However, fugitive dust emission and NOx level may temporarily increase in the immediate vicinity of the construction site due to soil excavation and vehicular movement respectively. Such impacts will be confined to the construction site.

These will be minimized by sprinkling water and proper maintenance of vehicles. A green belt is recommended to be developed all around the BTPS periphery, to minimize dust nuisance outside the BTPS boundary.

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10.2.2 Water Pollution

Water will be drawn from the Ganga River to meet the plant (including Unit No. 10) condenser cooling and other consumptive water requirements.

Effluents streams emanating from the Unit No. 10, during operational phase will be treated individually based on the effluent quality. Various effluents from the Unit No. 10 will be collected in a CMB for monitoring.

The effluent from CMB will be treated in ETP and treated effluents will be recycled and reused within Unit No. 10 & the BTPS premises for the various applications as shown in the “Water Balance Diagram” to achieve the ZLD is attached in the drawing section of this DPR.

Therefore, there will be no impact on the water pollution.

10.2.3 Noise Pollution

The plant is expected to cause noise level increase within the surroundings due to operation of Unit No. 10 & associated machinery. Necessary noise control and abatement measures will be adopted to contain the noise level from Unit No. 10 during detailed engineering, construction and operation phases to a maximum of 85 dB(A) as per the requirement of OSHA (Occupational Safety and Health Administration) Standards.

The major sources of noise during the construction phase would be vehicular traffic, construction equipment like bull dozers, scrapers, concrete mixers, cranes, generators, pumps, compressors, rock drills, pneumatic tools, saws, vibrators, etc. The operation of above said equipment will generate noise levels ranging between 75 & 90 dB(A).

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10.3 Solid Waste Management

BTPS, being coal-fired power station, would generate coarse as well as fine ash. All efforts will be made to utilize the fly ash for various purposes. Ash Management Plan will be developed for 100 % utilization of fly ash within the time period prescribed by MoEF. The unused ash, till such time, would be disposed in the existing ash pond of Unit No. 6 to 9 outside the BTPS premises.

Chemical sludge from pre-treatment plant will be treated in sludge handling system. Sludge handling systems is equipped with thickener and centrifuge. The wet cake generated from the sludge handling system will be disposed suitably. The clear water from the sludge handling system i.e. thickener & centrifuge will be routed back to pre-treatment plant i.e. clarifier to minimize the fresh water requirement of Unit No. 10.

Oil sludge generated from OWS will be collected in sludge trolleys or drums and disposed suitably.

Sludge generated from the sewage treatment plant will be treated in package septic system with soak pit, and wet cake will be used as manure. Clear water from the sewage treatment plant system will be used for gardening purpose and / or other requirement.

10.3.1 Afforestation and Green Belt Development

Afforestation in the BTPS area is planned to comply with MoEF guidelines, which would also improve the overall aesthetics of BTPS. Equipment layout areas would be progressively brought under green-belt development as the project progresses.

10.4 Pollution Mitigation Measures

The primary impact on the environment due to installation of Unit No. 10 arises from the release of atmospheric pollutants (through flue gas) into ambient air - caused by combustion of fuel in the Boiler and discharge of chemicals and effluents from other plant systems & processes, through wastewater.

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A well-defined environmental monitoring programme will be provided with trained and qualified staff for monitoring the ambient air as well as stack flue gas quality to ensure that the quality of effluents are maintained within the prescribed limits. The stack / chimney will be provided with CEMS to monitor the SPM, CO, NOx and SO_2 constituents in the flue gas. The plant effluents will be periodically analyzed on a weekly basis so that the effluents are maintained within the permissible levels of the pollution control board regulations.

10.5 Environment Impact Assessment Studies

EIA studies have been commissioned and collection of baseline data is in progress by the environmental consultant. EIA report will be prepared to identify the impact of the Unit No. 10 on the flora, fauna, human inhabitations, etc. in the surrounding area and prescribe mitigation measures.

The objective of the EIA will be to establish the baseline environmental status of the study area for purpose of environmental monitoring, collect available secondary data, identify various existing pollution loads due to industrial and domestic activities in the ambient zone, identify pollution levels that may arise due to establishment of the Unit No. 10, predict & evaluate the impacts on environmental attributes due to the Unit No. 10 using scientifically developed EIA methodologies, prepare the EMP outlining measures for improving the environmental quality, identify critical environmental attributes to be regularly monitored and formulate a Post-Project Monitoring Programme in compliance with prevalent statutory guidelines.

The success of any EIA study will primarily depend on the accuracy of assessing the baseline environmental situation prior to superimposing the predicted result on the ambient situation to arrive at the post project scenario.

To determine the magnitude of significant potential impacts and ensue that environmental considerations are given adequate weightage in the design of the Unit No. 10, preliminary environmental screening will be carried out, based on available secondary data and supplemented by regular field visits.

In EIA study, cumulative impact shall be considered, including effects on ambient conditions such as the incremental contribution of pollutant and effects on water resource due to other water uses. As for air, the key other contributor to airshed

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degradation will be the emission from Unit No.6 to 9 of BTPS. Therefore, air dispersion modeling shall be conducted considering the emission from these units. Cumulative impact on water resource will consider a water used for not only Unit No.6 to 9 but also for other water uses of upstream and downstream of the project area including irrigation and industrial activities.

The environmental attributes which will be studied are, ambient air quality (PM_{10}, $PM_{2.5}$, SO_2, NO_x, HC, CO), meteorology (wind speed, temperature, relative humidity, rainfall, water quality), ecology (flora & fauna), noise levels, soil characteristics (pH, total acidity, nitrates, potassium) land use and socio-economic aspects.

EIA report will elaborate the assessment of the environmental scenario around the reposed BTPS, with regard to the main environmental attributes viz., air, water, soil, noise and socio-economic conditions.

10.6 Ash Utilization

Utilization of ash by the coal based power plants is as a thrust area of activities in environmental safeguarding. All possible measures will be undertaken to maximize utilization of ash produced. In Unit No. 10, various means of ash utilization will be explored. Supply of ash to cement plants in the nearby region, for manufacture of cement will be taken up as a priority area. Towards this objective the following are actions proposed to be taken-up:

- In order to supply quality ash to users requiring only dry FA, such as, manufacturers of cement, concrete and allied products, etc. BSPGCL will be providing systems and facilities for 100 % extraction of dry FA along with storage and unloading facilities.

- BSPGCL will encourage entrepreneurs in the area to set-up units for manufacture of ash based products, such as FA Bricks, Light Weight Aggregates, Cellular Concrete products etc. BSPGCL will provide all possible infrastructure facilities to this effect.

- BSPGCL will encourage utilization of ash based products in all its construction activities.

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10.7 Environmental Standards

The environmental standards as prescribed by MoEF and CPCB is as per below.

A. Effluent Disposal Limits

The Environmental (Protection) Rules (EPR), 1986 issued by MoEF - Schedule-I, stipulates the following limits for effluent disposal and same will be applied for Unit No. 10.

Table 10.7-1 Limits for Effluent Disposal [23]

Sl. No.	Industry	Parameters	Standards
THERMAL POWER PLANTS			Maximum limiting concentration, milligrams per litre (except for pH and temperature)
1	Condenser cooling water (Once Through Cooling System)	pH	6.5 - 8.5
		Temperature	Not more than 5 °C higher than the intake water temperature
		Free Available Chlorine	0.5
2	Boiler blowdown	Suspended solids	100
		Oil and Greases	20
		Copper (total)	1.0
3	Cooling Tower blowdown	Free available chlorine	0.5
		Zinc	1.0
		Chromium (total)	0.2
		Phosphate	5.0
		Other corrosion inhibiting material	Limit to be established on case by case basis by CPCB in case of Union territories and State Board in case of States.

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Sl. No.	Industry	Parameters	Standards
4	Ash pond Effluent	pH	6.5 - 8.5
		Suspended Solids	100
		Oil and Grease	20

Article 3 (1) of the EPR, 1986 also stipulates standards for liquid effluents discharged from thermal power plants in India. Meanwhile, in the International Finance Corporation (IFC) Environmental, Health and Safety (EHS) Guidelines, site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classifications as described in the IFC General EHS Guidelines.

Table 10.7-2 Comparison of Effluents Standards for Thermal Power Station
(All units: mg/L, except for pH and Temperature)

Description	EPR [25]	IFC EHS Guidelines [26]	Remarks
pH	6.5 - 8.5 *1,4	6 - 9	
Suspended Solids	100 *2, 4	50	
Oil and Grease	20 *2, 4	10	
Free Available Chorine	0.5 *1, 3	0.2	Standards in India only include free chlorine.
Chromium (Cr)	0.2 *3	0.5	
Copper (Cu)	1.0 *2	0.5	
Iron (Fe)	1.0 *2	1.0	
Zinc (Zn)	1.0 *3	1.0	
Lead (Pb)	- +	0.5	
Cadmium (Cd)	- +	0.1	
Mercury (Hg)	- +	0.005	
Arsenic (As)	- +	0.5	
3-Phosphate (PO_4)	5.0	-	

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Description	EPR [25]	IFC EHS Guidelines [26]	Remarks
Temperature [°C]	5	Evaluated in EIA	

*1: Condenser cooling water (once through higher cooling system)

*2: Boiler blow downs

*3: Cooling tower blow down

*4: Ash pond effluent

+: Limit to be established on case by case basis by CPCB in case of Union territories and SPCB in case of States.

B. National Ambient Air Quality Standards (AAQS)

As per notification by CPCB dated November 18th, 2009, for the ambient air quality, the permitted limits of ground level concentrations of pollutants considering Industrial, Residential, Sensitive areas is furnished in below Table 10.7-3, and same to be complied for the Unit No. 10.

Table 10.7-3 National Ambient Air Quality Standards [24]
(Unit: µg/m³)

Pollutant	Time Weight average	Concentration in Ambient Air	
		Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)
Sulfur Dioxide (SO_2)	Annual *1	50	20
	24 hours *2	80	80
Nitrogen Dioxide (NO_2)	Annual *1	40	30
	24 hours *2	80	80
Particulate Matter, (size less than 10 µm) or PM_{10}	Annual *1	60	60
	24 hours *2	100	100
Particulate Matter, (size less than 2.5 µm) or $PM_{2.5}$	Annual *1	40	40
	24 hours *2	60	60
Ozone (O_3)	8 hours *2	100	100
	1 hour *2	180	180

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Pollutant	Time Weight average	Concentration in Ambient Air	
		Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)
Lead (Pb)	Annual *1	0.5	0.5
	24 hours *2	1.0	1.0
Carbon Monoxide (CO)	8 hours *2	2	2
	1 hour *2	4	4
Ammonia (NH_3)	Annual *1	100	100
	24 hours *2	400	400
Benzene (C_6H_6)	Annual *1	5	5
Benzo, (a) Pyrene (BaP) - particulate phase only	Annual *1	1	1
Arsenic (As)	Annual *1	6	6
Nickel (Ni)	Annual *1	20	20

*1: Annual arithmetic mean of minimum 104 measurements in a year at particular site taken twice a week twenty four (24) hourly at uniform intervals.

*2: Twenty four (24) hourly or eight (8) hourly or one (1) hourly monitor values, as applicable, will be complied with 98 % of the time in a year. 2 % of the time, they may exceed the limits but not on two (2) consecutive days of monitoring.

Note:
Whenever and wherever monitoring results on two (2) consecutive days of monitoring exceed the limits specified above for the respective category, it will be considered adequate reason to institute regular or continuous monitoring and further investigation.

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C. Ambient Noise Standards

CPCB notifies the AAQS in respect of noise is given in the below Table 10.7-4.

Table 10.7-4 Ambient Noise Standard [25] (Unit: dB (A) Leq.)

Area Code	Category of Area	Limiting Value	
		Day Time	Night Time
(A)	Industrial Area	75	70
(B)	Commercial Area	65	55
(C)	Residential Area	55	45
(D)	Silence Zone	50	40

Note:

- Daytime is reckoned in between 6 am and 9 pm.
- Nighttime is reckoned in between 9 pm and 6 am.
- Silence zone is defined as areas up to 100 meters around such premises as hospitals, education institutions and courts. Silence zone are to be declared by the competent Authority.

  Use of vehicular horns, loudspeakers and detonating of crackers shall be banned in these zones.

- Mixed categories of area should be declared as one (1) of the four (4) above-mentioned categories by the competent authority (and the corresponding standard shall be applied.)

All the equipment within the power plant would be designed / operated to have the noise level not exceeding 85 dB(A) measured at a distance of 1.5 m from the equipment. Also, all the measures would be taken to limit the noise levels at the plant boundary within the stipulated limits.

Article 3 (1) of the EPR, 1986 also stipulates Ambient Air Quality Standards (AAQS) in respect of noise in India. The IFC EHS Guidelines also regulates noise as a general aspect in the general section, because noise is similar to other large industrial facilities.

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Table 10.7-5 Comparison of Noise Standards

Time	EPR*1 [25]	IFC EHS Guidelines (General)*2 [26]
Daytime	75	70
Nighttime	70	70

*1: Daytime (6 am to 9 om), Nighttime (9 pm to 6 am)

*2: Daytime (7 am to 10 pm), Nighttime (10 pm to 7 am)

As per the above norms, the standard for IFC EHS guidelines – which is more stringent, thus will be applied for Unit No. 10.

D. Emission Standards as per Indian Regulations

As per notification by MoEF act 1986 and Rules & regulations notified by CPCB in June 2010, 6th Edition, the emission limits are as follows:

Table 10.7-6 Thermal Power Plant Emission Standards [23]
(Unit: mg/Nm³)

Sl. No.	Pollutant	Limiting Value
1	Particulate matter (PM)	350 (< 210 MW size)
		150 (≥ 210 MW size)
2	Sulfur Dioxide (SO_2)	No Regulation
3	Oxide of Nitrogen (NOx)	No Regulation
4	Mercury (Hg)	No Regulation

Depending upon the requirement of local situations, such as protected area, the SPCB and other implementing agencies under the EPR, 1986 is prescribed a limit of 150 mg/Nm^3 & 350 mg/Nm^3 based on generation capacity.

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New emission standard for coal-based power plants were notified by MoEF and are as per below:

Table 10.7-7 New emission standard for Coal based Power Plants [27]
(Unit: mg/Nm³)

Sl. No.	Pollutants	Limiting Value		
		Units installed before Dec. 31, 2003 (i)	Units installed after 2003 to Dec. 31, 2016 (i)	Units installed after Jan. 1, 2017 (ii)
1	PM	100	50	30
2	SO_2	600 (< 500 MW size) 200 (≥ 500 MW size)	200 (≥ 500 MW size)	100
3	NOx	600	300	100
4	Mercury (Hg)	- (< 500 MW size) 0.03 (≥ 500 MW size)	0.03	0.03

Note:

(i) Thermal Power Plants (i.e. Units) shall meet the limits within two (2) years from the date of notification.

(ii) Thermal Power Plants (i.e. Units) which have been accorded environmental clearance and are under construction.

Above draft notifications which the central government proposes to issue under the EPR, 1986 (29 of 1986), is published for the information of the public likely to be affected thereby after the expiry of a period of thirty (30) days from the date on which this draft has been made available to the public.

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E. Emission Standards Comparison

The Comparison of Indian Emission Standards with International standards is as per below Table 10.7-8.

Table 10.7-8 Emission Standards Comparison (Unit: mg/Nm³)

Pollutant	Environment Rules as per MoEF [23]	IFC EHS Guidelines as per IFC Standards for Boiler emissions– Solid Fuels (Plant ≥ 600 MWth) [26]	
		NDA (**)	DA (**)
SO_2 (*)	100	200 ~ 850	200
NOx (*)	100	510 (***)	200
Particulate Matter, PM (*)	30	50	30
Mercury	0.03	-	-

(*) - To be measured at the outlet of the stack when fired with design / worst coal from 50 % to 100 % BMCR.

(**) - The current flue gas emissions on dry flue gas with 6 % of O_2 content in a non-NDA and DA (i.e. poor air quality) based on design / worst coal.

(***) - Or up to 1,100 if volatile matter (VM) of fuel < 10 %

NDA: non-degraded air shed (NDA) means, no or few pollution existing at site.

DA: degraded air shed (DA) means, significant pollution already existing at site. ‘Degraded Air shed’ shall refer to Air shed within which the ambient air quality standards have been infringed (as set out within the AAQS).

‘Air sheds’ shall refer to a geographic area that, due to topography, meteorology, and climate, shares the same air;

Note:

Evaluation of the baseline air shed quality (e.g., DA or NDA) is the result of EIA report of the project.

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Monitoring of the flue gas for emission levels will be as per below Table 10.7-9.

Table 10.7-9 Flue Gas Emissions Monitoring [26]

Sl. No.	Parameters	Typical Air Emission Monitoring Parameters	
		Emission Monitoring	Stack Emission Testing
1	SO_2	Continuous	Annual
2	NOx	Continuous	
3	Particulate Matter, PM	Continuous or Indicative	
4	Heavy Metals	N/A	

The predicted values of the SO_2 & NOx are described in the below Table 10.7-10, and comparing against the standard for IFC EHS guidelines - Solid Fuels (Plant ≥ 600 MWth), these values are within for NDA but above DA and also the new standard for coal based thermal power plant as prescribed by MoEF. Therefore, the result of EIA report for the Unit No. 10 project to limit the flue gas emission of SO_2, NOx, Particulate matter, and Mercury (Hg) will decide the applicable norms after evaluation of the baseline air quality.

Table 10.7-10 Emission Standards Comparison with Predicted Values (Unit: mg/Nm^3)

Pollutant	IFC EHS Guidelines – Solid Fuels (Plant ≥ 600 MWth) Table 10.7-8		MoEF new standard Unit after Jan 1, 2017 Table 10.7-7	Predicted Values for 1 x 660 MW, Unit No. 10	
	NDA	DA		Design Coal	Worst Coal
SO_2	200 - 850	200	100	Less than 100	
NOx	510	200	100	Less than 100	
Particulate Matter (PM)	50	30	30	Less than 30	

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SECTION 11

ANTICIPATED PERFORMANCES

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11.1 Power Output

A. 100 % Turbine MCR Load - 660 MW (measured at Generator terminals)

This output of 660 MW will be reached:

- At 0 % make-up
- condenser vacuum of 65 mmHg (average)
- Steam conditions as described in Clause 7.4

B. Valve Widely Open (VWO) - 693 MW (measured at Generator terminals)

This output of 693 MW will be reached:

- At 1 % make-up
- Condenser vacuum of 65 mmHg (average)
- Steam conditions as described in Clause 7.4

11.2 Plant Auxiliary Power Consumption

For continuous operation at rated output conditions – 36,200 kW
This is at 100 % TMCR Condition and at following conditions:

- At 0 % make up
- Condenser vacuum of 65 mmHg (average)
- Steam conditions as described in Clause 7.4

11.3 Turbine Cycle Heat Rate

Turbine Cycle Heat Rate at 100 % TMCR load at Generator terminals for continuous operation at rated output conditions - 1,791 kcal/kWhr.

- For steam conditions refer as described in Clause 7.4
- Turbine performance will be as per PTC 6.0, alternative method.

11.4 Boiler Efficiency

Boiler efficiency at TMCR condition and zero make-up, referred to the design coal GCV at design ambient conditions of 25 °C, 67 % RH is assessed according to ASME PTC 4 latest edition (i.e. 2008) and using the heat losses method.

Boiler Efficiency = 87.7 % on GCV basis for design coal firing.

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11.5 Gross Unit Heat Rate

Tests for Turbine Cycle Heat Rate and Boiler efficiency will be conducted simultaneously but independently and Gross Unit Heat Rate is to be computed as follows:

$$\text{Gross Unit Heat Rate} = \frac{\text{Turbine Cycle HeatRate (100\% TMCR)}}{\text{Boiler Efficiency (100\% TMCR)}}$$

Gross Unit Heat Rate in kcal/kWhr., under rated steam condition at 65 mmHg (average) Condenser pressure with zero make-up at 660 MW unit load (i.e. 100 % of rated load) firing design coal – 2,042 kcal/kWhr.

11.6 Flue Gas Emission

The result of EIA report for the Unit No. 10 project to limit the flue gas emission of SO_2, NOx, Particulate matter, and Mercury (Hg) will decide the applicable norm after evaluation of the baseline air quality.

Table 11.6-1 Emission Standards Comparison with Predicted Values (Unit: mg/Nm^3)

Pollutant	IFC EHS Guidelines – Solid Fuels (Plant ≥ 600 MWth) [23]		MoEF New Standard Unit after Jan 1, 2017 [22]
	NDA (**)	DA (**)	
SO_2 (*)	200 - 850	200	100
NO_x (*)	510 (***)	200	100
Particulate Matter, PM (*)	50	30	30
Mercury (Hg) (*)	-	-	0.03

(*) - To be measured at the outlet of the stack when fired with design / worst coal from 50 % to 100 % BMCR.

(**) – The current flue gas emissions on dry flue gas with 6 % of O_2 content in a NDA and DA (poor air quality) based on design / worst coal.

(***) - Or up to 1,100 if volatile matter (VM) of fuel < 10 %

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Note:

Evaluation of the baseline air shed quality (e.g., DA or NDA) is the result of EIA report of the Project.

Monitoring of the Flue gas for emission levels will be as per below Table 11.6-2.

Table 11.6-2 Flue Gas Emissions Monitoring

Sl. No.	Parameters	Typical Air Emission Monitoring Parameters	
		Emission Monitoring	Stack Emission Testing
1	SO_2 concentration (*)	Continuous	Annual
2	NO_x concentration (*)	Continuous	
3	Particulate Matter	Continuous or Indicative	
4	Heavy Metals	N/A	

11.7 Effluent Quality Level

The permissible liquid effluent quality before being discharged from BTPS premises / complex will mandatorily meet the requirement as per below Table 11.7-1.

Table 11.7-1 Effluent Quality Level [23]

Sl. No.	Industry	Parameters	Standards
THERMAL POWER PLANTS			Maximum limiting concentration, milligrams per litre (except for pH and temperature)
1	Boiler Blowdown	Suspended solids	100
		Oil and Greases	20
		Copper (total)	1.0
2	Cooling tower blowdown	Free available chlorine	0.5
		Zinc	1.0
		Chromium (total)	0.2

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Sl. No.	Industry	Parameters	Standards
		Phosphate	5.0
		Other corrosion inhibiting material	Limit to be established on case by case basis by Central Board in case of Union territories and State Board in case of States.
3	Ash pond effluent	pH	6.5 - 8.5
		Suspended Solids	100
		Oil and Grease	20

11.8 Noise Level

The noise emitted from its equipment of Unit No. 10 does not exceed the following values given in the below Table 11.8-1.

Table 11.8-1 Noise Level

Sl. No.	Description	Limiting Values
1	Plant and / or noise sources completely enclosed within buildings or rooms which are normally accessible or in which maintenance and repair work will be carried out during normal operation, at a distance of 1.5 m from the building	≤ 85 dB(A)
2	On the boundary of Plant for normal operation	≤ 70 dB(A)
3	In the control rooms	≤ 55 dB(A)
4	In the computer rooms	≤ 65 dB(A)

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SECTION 12

PERMITS & CLEARANCES

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The GoI, at the central level and the State Governments, at the local level, have established legal, policy guidelines and regulatory frameworks for the setting up of electricity generating stations. Accordingly, certain clearances and approvals are required to be obtained from different government bodies and statutory agencies at various stages of development and operation phases of the Unit No. 10 project. These clearances are classified into two (2) broad categories known as statutory and non-statutory clearances.

12.1 Statutory Clearances

The following are the general Statutory Clearances required to be obtained:

Table 12.1-1 List of Statutory Clearances

Sl. No.	Description	Reference
1	Cost Estimation Project involving Capital exceeding limit	GoB, BSPGCL
2	Techno-Economic Clearance - Water Availability - Economic Output - Transmission Line & System - Reasonableness of Scheme - Site Location, optimum use of fuel resources, distance from load centre, transport facilities & environmental clearances	BERC / GoB
3	Water Availability	WRD - GoB Central Water Commission (CWC)
4	Consent to Establish and Consent to Operate	SPCB
5	Environmental Clearances	MoEF
6	Civil Aviation Clearances for Chimney Height	Airport Authority of India (AAI)

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12.2 Non-Statutory Clearances

The following are the general Non-Statutory Clearances required to be obtained:

Table 12.2-1 List of Non - Statutory Clearances

<table>
<tr><th>Sl. No.</th><th colspan="2">Description</th><th>Reference</th></tr>
<tr><td>1</td><td colspan="2">Land availability</td><td>GoB</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Fuel Linkages</td><td>Oil</td><td>Ministry of Petroleum & Natural Gas</td></tr>
<tr><td>Coal</td><td>Standing Linkage Committee (Long Term) - Ministry of Power,
Ministry of Coal</td></tr>
<tr><td>3</td><td colspan="2">Financing</td><td>GoB
Ministry of Finance - GoI</td></tr>
<tr><td>4</td><td colspan="2">Transportation of Fuel</td><td>Ministry of Coal
Ministry Petroleum & Natural Gas
Ministry of Railways</td></tr>
<tr><td>5</td><td colspan="2">Approval for Private Railway Siding</td><td>Ministry of Railways</td></tr>
</table>

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12.3 Other Clearances

The following are other project clearances required to be obtained:

Table 12.3-1 List of Other Clearances

Sl. No.	Description	Authority
1	Sanction of Construction Power	Office of Chief Engineer / DISCOM, BSPGCL
2	Permission to use ground water	WRD - GoB
3	Boiler and other pressure parts including pipes and valves - Design aspects and inspection before light up	The Chief Inspector of Boilers, Bihar
4	License for construction labor pursuant to Section 7 of the Contract Labor (Regulation and Abolition) Act, 1970	Labor Department - GoB
5	Collection, Storage and Disposal of Water, Site Clearance, Safe Report and Safety Audit	SPCB
6	Consent of the Commissioner of Explosives for possession and use of explosives for the purpose of blasting, if any	District Authority / Chief Controller of Explosives - Department of Explosives
7	Oil – Design / Installation	District Authority / Chief Controller of Explosives - Department of Explosives

Other clearances are also required to be obtained from the GoB / concerned agency by the EPC contractor assisted by BSPGCL. This will include permits and licenses such as Indian Boiler Regulation approval, permission of Chief Electrical Inspector for electrical installation, Import license, labor license, approval form Chief Inspector of Factory, Chief Controller of Explosive, ROW for raw water pipeline etc. as required during the detail design engineering and construction phases of the Unit No. 10.

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SECTION 13

CLEAN DEVELOPMENT MECHANISM (CDM)

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The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) came into force on February 26th, 2005 and is now fully operational. Most of the industrialized countries have committed to reducing their aggregate emissions by 5.2 % below 1992 levels during the first commitment period (2008 to 2012), the United States and Australia have so far declined ratifying the protocol. To make the process cost effective, the protocol established the following three (3) flexible mechanisms:

- Joint Implementation (JI) among developed countries
- Clean Development Mechanism (CDM) for use between developing and developed countries
- Carbon trading among developed countries

The CDM encourages investments in the projects that provide a sustainable development in the developing countries, while at the same time limiting the GreenHouse Gas (GHG) emissions. Under CDM, legal entities in the developed countries can invest in the projects in the developing countries that reduce GHG emissions. Once certified, these emission reductions can be used to meet the commitments made by the developed countries under the protocol.

Of the above three (3) mechanisms, only the CDM is applicable to developing countries.

GHG emissions defined under the protocol are:

- Carbon dioxide (CO_2),
- Methane (CH_4),
- Nitrous Oxide (N_2O),
- Hydro fluorocarbons (HFCs),
- Per fluorocarbons (PFCs), and
- Sulfur Hexafluoride (SF_6)

Certified Emission Reductions (CERs) are the credits issued by UNFCCC to the developing countries loosely called carbon credits, under the CDM. CERs can be purchased by the developed nations to meet their emission reduction targets. One (1) carbon credit is equivalent to one (1) tonne reduction of CO_2 or its corresponding GHG. The carbon credits earned on CDM certified projects, by developing countries, can be encashed in the international market - though

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trading is permitted only among the developed countries. The prices of carbon credits are presently (as in December 2008) ruling around Euro fourteen (14) per ton - the peak was about Euro twenty (20), during September 2008.

UNFCCC accredits certain CDM Auditors, throughout the world, for the project registration and advising on issue of carbon credits. It monitors the activities of such Auditors by spot checks and other means, to ensure conformities under the process.

Although, there are no immediate targets for the developing countries, it can be seen as an additional source of foreign direct investment into national mitigation projects, which would contribute to a sustainable development and decrease in worldwide GHG emission levels.

13.1 Introduction

India's economic growth is mainly based on energy from the fossil fuels, such as coal & lignite, and therefore has considerable potential in reducing its GHG emissions as well as in CDM participation. CDM projects starting after January 1st, 2000 are eligible to earn CERs. However, the modalities and procedures of the CDM may be too complex to exploit / achieve its full benefit. It is reported that India's quantum of unsold CERs is about fourty two (42) million, which accounts for more than 40 % of the world’s unsold CERs.

India is a party to the UNFCCC as well as the Kyoto Protocol, which is ratified in August 2002 and India has established a designated national authority which is designated as the ‘National CDM Authority' and consists of nine (9) members. The MoEF is the nodal ministry for climate change & the CDM is chaired by its Secretary. Climate change is an important consideration in India’s national plan and millennium development goals.

13.2 Selection of Technology

Power generation based on higher efficiency technologies such as supercritical / ultra-supercritical technology, Integrated Gasification Combined Cycle (IGCC) and R&M/LE of old thermal power plants. Co-generation along with renewable energy sources are some of the potential candidates for CDM in the power sector.

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13.3 Baseline Scenario

Establishing a 'baseline scenario (commonly referred to as baseline) is the crucial part of designing a CDM project activity. It sets the 'base' from which the amount of total GHG emission reductions and credits is calculated. The baseline scenario describes the current level of GHG emissions prior to introducing the proposed CDM project activity. In India, CEA in co-operation with GTZ-CDM, India has compiled a data base for all grid-connected thermal power stations within the country.

13.4 CDM for the Project

Emission reduction from CDM projects in the power sector are calculated based on net electricity generated from the project and the difference between the emissions factors (in tonnes CO_2/MWhr.) of the baseline and the project activity. The baseline emission factor reflects the carbon intensity of the displaced amount of grid electricity. This baseline emission factor can be derived from the CO_2 database provided by CEA in its web portal.

Presently, the CDM Executive board has approved the consolidated methodology ACM0013 ver.1.0 for new grid connected fossil fuel based power plant using less GHG intensive technology. The following criteria need to be fulfilled:

- The project activity is the construction and operation of a new fossil fuel-fired grid connected electricity generation plant that uses a more efficient power generation technology that would otherwise be used with the given fossil fuel.
- The project activity is not a co-generation power plant
- Data on fuel consumption & electricity generation is available
- Identified baseline is more than 50 % of total generation by utilities in the geographical area.

This ACM0013 methodology is applicable to new upcoming supercritical technology based power plants. The above conditions are fulfilled for the Unit No. 10 project. However, these will be explored during detailed engineering and application for CDM project registration will be made.

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SECTION 14

PROJECT IMPLEMENTATION
& MONITORING

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The project will be implemented by BSPGCL which will assume overall responsibility for the implementation of the project, covering all fronts of activities as well as conflict resolution, drawing necessary expertise and support from Implementation Consultants / Owner's Engineer / Project Management Consultant on a continuous basis. BSPGCL will establish Project Management Systems for close monitoring of the Project for cost, quality, schedule and environment.

14.1 Project Schedule

Proposed Unit No. 10 will be considered to be commissioned in fifty two (52) months from Notice to Proceed (NTP), which is reckoned on achievement of financial closure and award of EPC contract. The implementation schedule is attached with this DPR, refer to drawing section.

14.2 Project Management

The major phases of the project during its implementation are classified under the following heads:

- Planning & Contract Packaging
- Design, Engineering, Tendering & Contract award
- Manufacturing, Inspection and Expediting
- Construction/Erection and Commissioning
- Operation & Maintenance and Manpower Training & Placement
- Quality Management and Safety-Health-Environment Management

During construction phase, a team of engineers headed by Project Site Manager of BSPGCL supported by Implementation Consultant's Site Manager and other Engineers will supervise the activities of the EPC Contractor(s). Specialists for each of the main / critical equipment / system will supervise the respective areas. The methodology adopted for executing the project is as detailed below.

14.3 Planning PhaseContract Packaging

BSPGCL may implement the this extension project under either a single EPC Contract or maximum two packages divided as BTG Package and BOP Package.

The initial site development and enabling works will be carried out by BSPGCL

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through local contractors. Indicative scope of the packages envisaged is as below:

A. Single EPC Package

The single EPC Package option would consists of all Plant systems including BTG & Auxiliaries, power cycle equipment's including BFPs, CEPs, Regenerative feedwater heating system i.e. LP & HP Heaters, Deaerator, HP Piping, HP & LP Bypass Systems, Station C&I and related electrical systems and BOP consisting of electrical systems like Switchyard, HT & LT Transformers, offsite packages like coal handling system, coal unloading and transportation system including raw water supply system, and condenser cooling water system, ash handling system, DM plant, miscellaneous pumps, piping and systems; and civil, structural and architectural work of the plant including civil works for BTG equipment, BOP equipment, all buildings in the plant, Chimney, Cooling towers etc.

EPC Contractor will establish a comprehensive reporting structure, which broadly encompasses the following:

- Management Reports - Progress Reports, Exception Reports, etc.
- Inspection and test Program - Manufacturer's shop and site
- Site Safety, Health and Environment
- Statutory Permits, Approvals & Clearances

B. Two EPC Packages:

In case of two (2) EPC Package contracting, the packages would be divided as follows:

- BTG Package - Boiler, Steam Turbine Generator & all associated auxiliaries including DCS and C&I systems
- Civil works and BOP systems - all other systems not covered under the BTG package

Preliminary enabling works will be carried out by BSPGCL, through local contractors. This will include roads, boundary wall and Guard's house, construction power and water.

The EPC Contract Packages and the enabling works packages will be developed before finalization of the Master Network Programme of the project to ensure that the master network heads are developed in accordance with the list of the contract packages for better monitoring.

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14.3.2 Master Project Implementation Schedule - Master Network

The Master Network identifies the key milestone dates for each package in the area of engineering, procurement, manufacturing, dispatch, construction, erection, testing & commissioning. The Master Network, which is the overall schedule of the project implementation, will be finalized in consultation with the EPC Contractor, Owner's Engineer (Implementation Engineering Consultant) and other contractors. The date of order of the main plant equipment will be the zero date of the Master Network.

Owner's Engineer will prepare the Master Schedule (L-1) for the project at the start of the project. Major Contractors will generate L-2/L-3 Schedules for its scope of works, and secure Owner’s approval of the same, adhering to major milestones indicated in the L-1 Schedule. Contractors will furnish a monthly progress report to the Owner reflecting the scheduled dates, progress made in different activities as weighted percentage separately for Engineering, Procurement and Construction and cumulative progress. Contractors will also highlight any delays /stalling of works and would be expected to make recovery or 'catch-up' plans, in such instances. Owner's Engineer will closely monitor all project timelines for strict compliance with overall project schedule.

14.3.3 Owner's Engineer/Consultant

BSPGCL will appoint a reputed Engineering Consultant as its Owner's Engineer to assist them throughout the development of the Project, from preparation of Request for Price Quotation for the EPC Contractor till handing over of the Plant by the EPC Contractor.

The objectives of the Consultant will be to assist BSPGCL in its implementation of the Project. The Consultant shall endeavor to carry out all the services in a satisfactory manner in order to ensure the successful completion of the Project with the quality, cost and schedule planned originally. The objective of the consulting services is to achieve the efficient and proper preparation and implementation of the Project through the following works:

- Basic Design
- Detailed Design
- Tender Assistance
- Construction Supervision
- Facilitation of implementation of Environmental Management Plan and

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Environmental Monitoring

- Technology Transfer

From the point of construction of SC parameters' boiler and its fixed facilities, the Consultant is expected to have plenty of experience in SC units not only in India but other countries.

The Consultant would engage multidisciplinary experienced engineering teams at its Home offices to undertake the various tasks related to the engineering, design, project implementation/management and monitoring. Apart from this, it would also provide necessary engineering back up support during construction, installation and commissioning at site. The drawings and documents generated by the EPC Contractor(s) would be reviewed and checked / approved by the Owner's Engineer to ensure the following:

- Compliance to the contract requirements
- Compliance to the various local / statutory authorities
- Correct design and technology as per technical specifications
- Seamless interfacing amongst various systems / equipment / sub-contractors
- Technical Transfer to O&M staff during operation & maintenance phase

Further, Owner's Engineer will also be involved in shop inspection of various critical equipment / components in line with the agreed project quality assurance plan, ensuring field engineering / construction quality and ensuring that the EPC Contractors meet all guaranteed parameters during performance testing of the unit.

14.4 Tendering, Contracts & Engineering Phase

14.4.1 Engineering, Planning, Monitoring & Control

The basic engineering issues initiated during the DPR stage will be addressed in a more focused manner during this phase.

The engineering services plan and the schedule of the project engineering activities, within the time frame specified for the engineering milestones will be finalized in the Master Network. The engineering schedule at Level-2 accordingly will show the dates for data availability, tender drawing release, specification release, bid evaluation and construction drawing release etc. The schedule drawn up by each engineering discipline will also take into consideration the assistance from the Owner's Engineer or other external agencies that can be

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advantageously supplemented to the internal resources of BSPGCL depending on the complexity of an equipment system, the need for inducing latest available technology, the large quantum of engineering work etc. The engineering manpower resources will then allocated depending upon the priorities in the schedule of each engineering discipline.

Departmental reviews will be conducted by BSPGCL's Project Coordinator/ Owner's Engineer to evaluate the work actually performed vis-a-vis detailed schedules. Corrective action within the scope of the disciplined heads will be identified and the plans updated. The engineering status appraisal for the heads of different engineering disciplines is then reviewed to check the various areas of specification release, bid evaluation, drawing releases etc. against target schedule dates. If any delay is expected to affect the schedule of other centers, corrective action to rectify the situation will be initiated.

14.4.2 Contracts Planning, Monitoring & Control

Based on the key event dates identified in the Master network, detailed plan for pre-award activities up to award of contract will be finalized and monitored vigorously.

When the EPC contracts are awarded, detailed schedule in the form of networks will be tied-up with the Contractor to clearly establish the Owner's obligation and Contractor's responsibilities. The Owner's inputs in terms of land availability, construction power/water availability, civil fronts readiness etc., while that of the contractor's, in terms of drawing submission, manufacture, supply, transportation, erection & commissioning etc. will be clearly brought out in the schedule. Monthly progress reports are generated for monitoring & tracking purposes.

14.5 Manufacturing, Inspection & Expediting Phase

14.5.1 Inspection & Expediting

On behalf of BSPGCL project coordinator, Expediting-visits conducted by Owner's Engineer will be made periodically to the works of equipment suppliers for inspection and ensuring that works progresses as per schedules. This will be done in coordination with EPC contractor. The manufacturing & quality plans finalized at the time of contract award will be utilized by the inspectors / expeditors for monitoring the manufacturing & quality status. Specified reports at regular intervals

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shall be submitted highlighting the areas of schedule variations, if any, their likely impact on delivery schedules, any recommendations for improvement etc.

14.5.2 Quality Assurance

The EPC Contractors will follow a comprehensive Quality Assurance and Control Programme developed by BSPGCL / Owner's Engineer for entire project. The quality control and assurance activities would be supervised by the BSPGCL / Owner's Engineer and / or through the appointed offsite approved agencies for shop as well as field activities.

Before the award of the EPC contract the QA Dept. will finalize a mutually acceptable inspection schedule and detailed quality plan. In the post contract stage, the inspection reports generated by the inspectors will be reviewed to evaluate the quality status with respect to the specified levels and necessary coordination of all actions required to ensure the achievement of the planned quality levels. The quality plans after discussions and finalization with the EPC Contractor will form a part of the contract.

14.6 Construction & Commissioning Phase

14.6.1 Construction Planning, Monitoring & Control

Site activities will start progressively with the award of EPC Packages. Based on the Master Network Schedule (L-1 network) prepared during the award of the EPC Contract, L-2 networks are finalized, keeping in view the interface events required to be realized. The Owner's Execution Group including Owner's Engineer at site will begin interactions with the EPC Contractor after receipt of Letter of Award for establishment of the site office. Based on the L-2 network the Execution Group will initiate securing of required drawings in sequence for continuous progress of works at site.

14.6.2 Project Review Team meeting

A project review team headed by the project head with members from various departments of BSPGCL/ Owner's Engineer and site will be constituted to review the progress of project on a monthly basis. This will be chaired by the project head and attended by different departments of Head Office and Site Offices of BSPGCL. The meetings will review both pre-award and post-award progress of the EPC packages.

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In the pre-award review, the progress in award of EPC Packages will be discussed and corrective measures identified for any delays.

In the post-award period common problems such as non-availability of desired drawings for construction activities, drawing approval, clarifications, non-receipt of material from various vendors, clearance of fronts etc. will be analyzed. Interface problems among various project agencies will also reviewed.
Budgetary review will also be carried out during this meeting and shortfall, if any, is identified and responsibility fixed for corrective action.

14.7 Operation & Maintenance (O&M) Phase

On completion of erection & commissioning of the plant, the operation & maintenance functions would be fully taken over by the O&M team of BSPGCL, which will be deployed from the pre-commissioning stages itself. BSPGCL is presently operating units of up to 2 x 110 MW capacities and will also be operating upcoming 2 x 250 MW units. However, the proposed unit is planned to be the one with 660 MW SC capacity, accordingly, the technology transfer will be implemented by the Consultants who internationally experienced in the same projects as the proposed units to facilitate the O&M team of BSPGCL appropriately operate and maintenance the units.

The EPC Contractor will provide three (3) Warranty Engineers, one (1) for Boiler, one(1) for turbine Generator and one (1) for Control & Instrumentation, who will be available at site till completion of warranty period to guide and assist BSPGCL's O&M team in the O&M of the units. These services will be part of EPC Contract.

The plant is envisaged to have high level of automation to minimize manual intervention. It is estimated that about 600 staff including engineers & supervisory will be required for operation and routine maintenance. Major maintenance works will be contracted out to specialized agencies.

14.7.1 Operation Philosophy

14.7.1.1 Overall Requirement

In the construction of O&M system, the consistent Quality Control, or Total Quality Management (TQM) system based on the records of each step through basic EPC

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design, construction, trial run, to performance tests is demanded. In the selection of the consulting services in the proposed units, the Japanese-consulting firms who have long experience in performing TQM from 1990s could be at the dominant position from this point.

The station will be basically designed to operate as a base load station. The design of the plant will provide for the following;

- Capability of rapid unloading from full load to no-load controlled conditions in the minimum possible time.
- Capability to achieve full load within the shortest possible time after synchronization, subsequent to an overnight shutdown.
- The main plant, auxiliaries and associated systems & controls will be designed to permit house load operation, without shutting down the unit in the event of sudden loss of load due to tripping of transmission lines or other grid disturbances.
- The main plant control systems will be designed to permit participation in load frequency control in the event of system disturbances.

14.7.1.2 Design for High Unit Availability

High availability of the unit and associated auxiliaries is one of the main O&M objectives for ensuring high PLF and low partial loading. These objectives will be achieved by involving the O&M personnel in basic design concepts with the focus on the following:

- Use of equipment and systems of design performance and high availability which has been fully established by a considerable record of successful operation for similar service conditions in coal fired utility stations.
- Use of only proven design concepts and conservative designs.
- Special consideration for ease of maintenance while selecting equipment and finalizing location and layout plans.
- Strict implementation of quality assurance norms during design, manufacture as well as installation and commissioning stage.
- Strict compliance with approved pre-commissioning and commissioning procedures as well as standard checklists forming a part of commissioning documents for the project.

14.7.1.3 Sizing of Critical Equipment- Margins & Redundancy/Standby

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Adequate margins will be provided while sizing all important auxiliaries and sub-systems, during detailed engineering, to ensure operation of the unit at full rated capacity under the worst conditions and taking into consideration normal wear & tear.

14.7.1.4 Design for Efficient Operation

The basic & detailed engineering of the project will be carried out so as to ensure achievement of high standards of operational performance especially with respect to the following key indices:

- Low auxiliary power consumption
- Low make-up water consumption
- No oil support above 40 % BMCR operation with any combination of mills
- Optimum efficiency and heat rates for the unit and sub-systems

Provision will be made for accurate and reliable measurement of coal receipt, coal consumption per unit, oil receipt & consumption per unit, total DM water production and make-up water consumption, flue gas oxygen content etc. These values will be fed to the Data Acquisition System and daily reports regarding receipt, consumption and stock position will be prepared.

Adequate provision of sequence controls, safety interlocks protection automatic modulating controls and operator guidance messages through suitable display methods will be made to assist the operators in safe and efficient operation of the units.

Provision will be made for on-line performance calculations for the unit and major sub-systems in the Data Acquisition System. Online display of heat rate penalties due to deviation of key parameters from design values will be provided.

14.7.1.5 Operation Performance Management System (OPMS)

The operation of the plant will be optimized by implementation of OPMS. This system will clearly define the responsibilities of all key O&M personnel including the shift-in-charge. The OPMS will also cover a system of daily reporting to BSPGCL Corporate Office and monthly O&M review meetings.

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14.7.2 Maintenance Philosophy

14.7.2.1 Maintenance Management System

The maintenance of the plant will be carried out as per the maintenance management system of BSPGCL presently being followed in all its operating plants. This system aims at maximizing the availability of the generating unit while ensuring minimum maintenance cost and safety of plant & personnel.

The maintenance management system covers organizational structures, preventive maintenance schedules, detailed work specifications covering all maintenance jobs, permit-to-work system, long term maintenance planning, safety aspects etc.

14.7.2.2 Spare Parts Management System

The primary objective of the spare part management system will be to ensure timely availability of proper spare parts for efficient maintenance of the plant without excessive build-up of non-moving inventory. The spare parts management system will cover the following aspects:

- Proper codification/identification & retrieval of all spares & consumables
- Proper storage & protection
- Spare parts indenting and procurement policy
- Criteria for ordering of mandatory & recommended spares
- Judicious fixing of inventory levels and spare part ordering based on experience of similar units or other benchmarks.
- Development of indigenous sources/in house capability for imported spare parts.
- Development of more than one source wherever applicable.

14.7.2.3 Special Tools & Tackles

The EPC Contracts will include the provision of supply of special tools & tackles, wherever required, for installation, commissioning, and maintenance of the plant & equipment. These will be handed over to the O&M department at the appropriate time after commissioning of the unit.

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14.7.3 Manpower Training

The proposed 660 MW unit with SC steam parameters being relatively new technology, the O&M personnel will be imparted training at the manufacturer's works and at Project site. Suitable training schedule accepted by BSPGCL / Owner's Engineer will be developed for this purpose and will be included in the scope of EPC Contract.

Adequate emphasis will be given to training of O&M personnel so that required skills in various specialized disciplines are created in the shortest possible time. It is important to ensure that all Engineers designated for O&M of the unit are posted at least twelve months prior to commissioning so that they become fully familiar with the plant equipment & systems. This will be achieved by:

- Making available equipment supplier O&M manuals & drawings
- Involvement of O&M personnel in pre-commissioning & commissioning activities
- Well-documented maintenance management system
- Training at manufacturer's works in specialized areas
- Simulator Training, where such facility exists

14.7.4 Availability of O&M Manuals

The EPC contracts will include provision for supply of sufficient copies of detailed O&M manuals for distribution to the different user departments of BSPGCL.

The draft O&M manuals will be prepared by the EPC Contractor and submitted to the project group of BSPGCL, for review by itself/Owner's Engineer to ensure completeness and comprehensive coverage of all plant systems.

Final O&M manuals will be made available to all concerned at least six (6) months prior to the commissioning date of unit to avoid problems in preparation of commissioning documents as well as proper installation & commissioning of equipment.

14.8 Quality Management System

To establish, document, implement, maintain and continually improve the Quality Management System (QMS) in EPC stage as per accordance with ISO 9001: 2000.

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QMS as per ISO 9001:2000

Sr. VP along with HOD's and MR/AMR for implementing, maintaining, and continually improving the system.

MR/ AMR along with the Task Force for establishing and facilitating implementation & maintenance of the system.

14.8.1 Establishment of Quality Management System

A QMS as per ISO 9001: 2000 (IS/ISO 9001: 2000) has been established, documented, and implemented in EPC stage. This has been done to ensure that:

- All EPC services provided are consistent with the objectives
- The services meet the requirements of clients as well as applicable statutory and regulatory requirements,
- The system is effective in prevention of non-conformities, and
- Customer satisfaction is enhanced through continual improvement of the system and processes.

The QMS as per ISO 9001: 2000 (IS/ISO 9001: 2000) has been documented in a combined set of documents called Quality Manual and Procedure Manual.

14.8.2 Scope of Quality Management System

The EPC Contractor undertakes EPC projects in the energy sector for customers from Government as well as public & private sector.

The responsibility for successful completion of the projects is with EPC Contractor, as per the specific contract / agreement with the internal or external customer.

The scope of the QMS, as documented in this Quality Manual in accordance with the standard ISO 9001: 2000 is: "Engineering, Procurement, Supply, Construction, Erection and Commissioning of Generation, Transmission, Distribution and Infrastructure Projects in Power Sector."

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14.8.3 Permissible Exclusion

The permissible exclusions of the QMS will be as per Clause 1.2 of ISO 9001 2000 standard.

14.8.4 Implementation and Maintenance of QMS

The QMS in EPC stage is maintained to ensure its effectiveness. Efforts are made to continually improve the effectiveness of the system.

All Heads of Departments (HODs) and concerned personnel are responsible for the implementation of the system in their areas.

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14.8.5 Processes

The various processes of the QMS have been identified by EPC contractor. The sequence and interaction of one process with another and the interaction of one function (sub process) with another function (sub process) of the same process has been clearly identified and relevant details given in Procedure Manual, the flow chart and in the respective procedures in the Procedure Manual.

Each process is verified and approved. Acceptance criteria and methods for ensuring the effective operation and control of these processes at appropriate stages are stated in the contract, QAP, relevant IS or other standards and the procedures.

Inputs and output for each process have been clearly defined in Process Manual and in the procedures.

Necessary resources and information needed to support the execution and monitoring of these processes are provided. These resources are reviewed and augmented wherever required generally on need basis.

14.8.6 Monitoring, Measurement and Improvement

All activities are monitored at appropriate points/stages through collection of appropriate data and review. Evaluation and analysis of this data is carried out to identify problems, make corrections, and take appropriate corrective actions & preventive actions leading to continual Improvement.

Continual Improvement of QMS is an important part of the QMS at EPC stage by the contractor.

Appropriate records and documents are maintained.

The effectiveness of the QMS is monitored by MR/AMR and reviewed in the Management Review Meeting by ED.

14.8.7 Outsourced Processes

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For all processes out-sourced partly or fully, adequate control is exercised over the process to ensure conformity of product/service with requirements. This is identified in the Procedure Manual e.g. engineering, construction, site erection, security, labor, transportation, AMC, etc.

This control is exercised in all cases as given in Procedure Manual.

14.8.8 Statutory and Regulatory Requirements

The statutory and regulatory requirements applicable to the activities of EPC Contractor are identified by the respective departments, actions taken to fulfill them and monitored.

EPC Contractor is committed to implement all the legal requirements and as well as the circulars/instructions of Corporate Management.

14.9 Environment, Health and Safety Management (EHS)

To create an environment of safety of all personnel & protection of assets including plant, equipment and infrastructure in all works executed or under execution in order to prevent any kind of accident or incident and near miss.

All activities at EPC Contractor offices and at l site offices, EHS being physically executed at each site.

The Safety Officer along with Chief Construction Manager at each site, HOD Administration at Noida Offices, HOD EHS for technical guidance, adherence to statutory & regulatory requirements, monitoring and prevention.

14.9.1 Definition

Safety: Safety is freedom from unacceptable risk of harm. (Safety is freedom from accidents and freedom from the fear of accidents)

Accident: An undesired event giving rise to death, ill health, injury, damage or other loss. (Accident is an unplanned unexpected event which causes interference to work, or results in injury or damage to property and\or to

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environment.)

Incident: Event that gave rise to an accident or had the potential to lead to an accident.

Reportable Accident: All accidents where the injured person is unfit for more than forty eight (48) hours.

Fatal: Death resulting from an accident

LTA (Lost Time Accident): An injury causing

- Disablement of an injured person beyond forty eight (48) hours including the days of accident and reporting to work back which also includes Sundays & holidays
- Immediate loss of any part of the body or any limb or part thereof
- Crushed or serious injury to any part of the body due to which loss of the same is obvious
- Any injury, which is likely to prove fatal
- Unconsciousness due to accident
- Severe burns or scalds due to chemicals, steam or any other cause

Dangerous Occurrences

- Collapse or failure of lifting appliances, hoist, conveyors etc.
- Collapse or subsidence of soil, any wall, floor, gallery etc.
- Collapse of transmission towers, pipeline, bridges etc.
- Explosion of receiver, vessel etc.
- Fire & explosion
- Spillage or leakage of hazardous substances
- Collapse, capsizing, toppling or collision of transport equipment
- Leakage or release of harmful toxic gases at the construction site
- Failure of lifting appliance, loose gear, hoist or building and other construction work machinery, transport equipment etc.

Minor Injury: An injury, which requires medical treatment, causing any disablement of injured person from work less than forty eight (48) hours and the person resumes site duty within forty eight (48) hours after receiving an injury.

Near – Miss Occurrence: An incident where no ill health, injury, damage, other loss occurs is referred to as Near Miss. The term incidents include Near-Misses. These are

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incidents/ occurrences wherein a serious accident has not happened but could have happened or could happen, if the unsafe situation/ act continues, or it did not happen due to absence of a factor which could have resulted in the serious accident.

Major Fire: A fire would be considered as major fire if it meets at least one of the following criteria:

- If the duration of fire is more than fifteen (15) minutes and/ or if there is a plant shut down because of the fire,
- If the fire cause fatalities,
- If the cost /loss of property exceeds 5 lakhs,
- If it is an explosion / blowout,

Minor fire: Any fire not falling in any of the criteria of major fire but having direct loss due to that fire would be deemed to be a minor fire.

Hazard: Source or situation with potential for harm in terms of human injury or ill health, damage to property, damage to the work place environment or combination of these.

Risk: Combination of the likelihood and consequence(s) of a specified hazardous event occurring.

14.9.2 Objective

The objective of Safety management is to effectively eliminate occurrences of accident at all working places and to provide a safe working environment for the personnel as well as the plant & equipment.

The specific Safety Objectives are:

- To achieve zero accidents
- To increase awareness
- To identify unsafe act and unsafe conditions

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It needs to be remembered that:

- Both unsafe acts and unsafe conditions need to be avoided, much more the accidents.
- Accident does not happen by its own. There will be combination of number of reasons leading to the accident.
- The accident happens due to unsafe condition or unsafe act or combination of both. If these two are eliminated chances of happening of an accident become rare.

It is mandatory to strictly comply with the legislation and regulations related to safety and health, enacted for protecting the employees from Industrial accidents.

Safety is freedom from accidents and freedom from the fear of accidents

14.9.3 Organization

14.9.3.1 Organization Structure

To maintain high availability of Unit No. 10 at BTPS, each and every group in its Organization will cooperate so as to manage troubles such as fuel shortage, equipment failure and so on. Figure 14.9-1 shows the proposed Organization for Unit No. 10.

The Organization is basically classified into two (2) sections, namely Administration and Technical. The latter consists of four (4) group as listed below.

- Administration Group
- Inventory Group
- Finance and Human Resource Group

The former consists of three (3) groups as listed below.

- Plant Operation Group
  - a) Performance Management Team
  - b) Fuel/Ash Management Team
  - c) Operation Shiftwork Team
- CHP Group
- Maintenance Group
  - a) Maintenance Planning Team
  - b) Mechanical Maintenance Team

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c) Electrical and C&I Maintenance Team
d) Civil Maintenance Team

Coal Handling operation, Fire Fighting and Security Services are to be outsourced as same as at Unit No. 6 & 7 and No. 8 & 9.

Organization Hierarchy

To clarify where the responsibility and authority lie is considerably important for stable and reliable plant operation. Therefore, organization of Unit No. 10 requires on additional position of Deputy General Manager above Superintendent in both Administration and Technical Sections.

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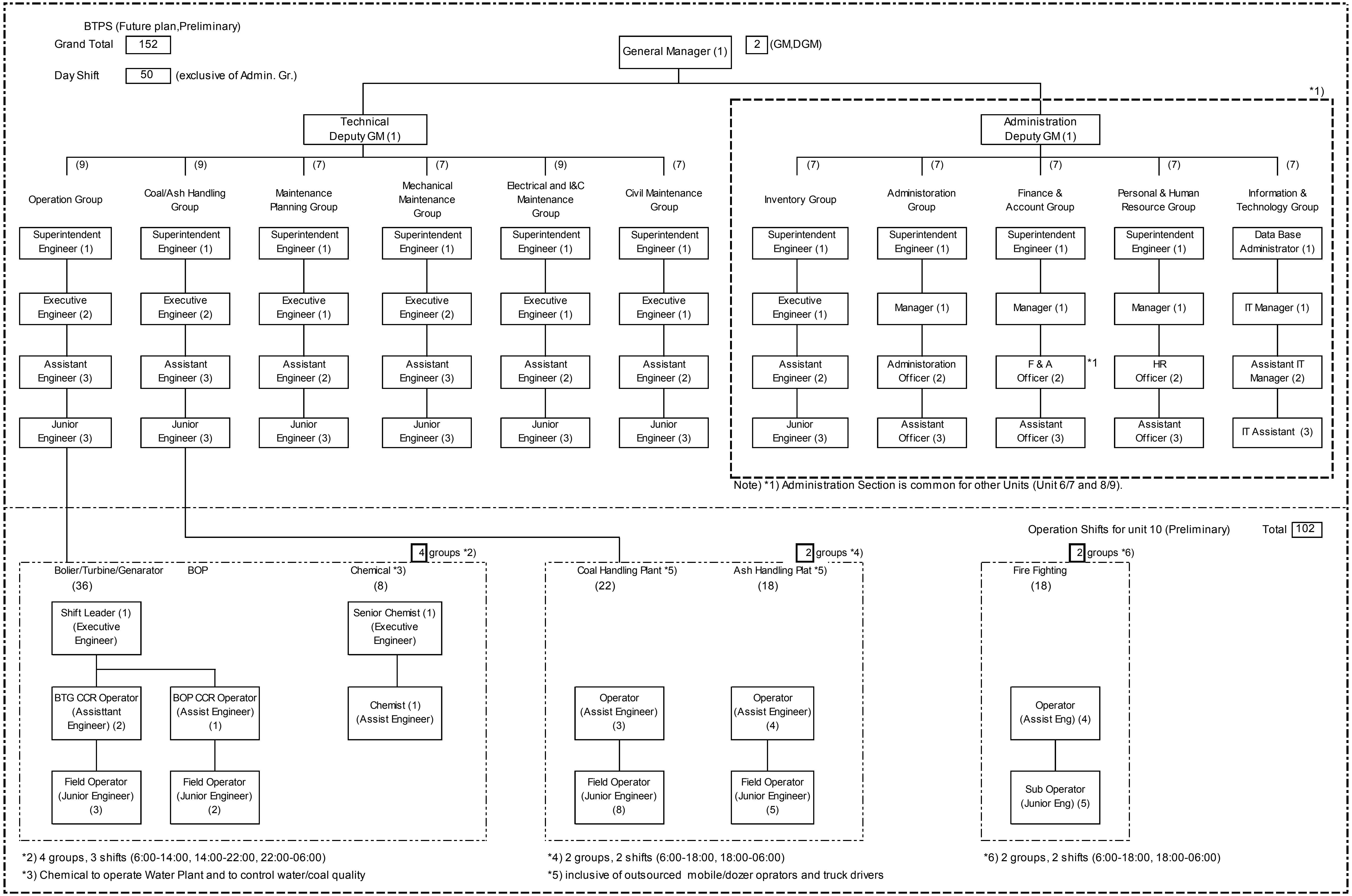

Figure 14.9-1 Proposed O&M Organization of BTPS

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14.9.3.2 EHS Management

A central EHS Cell/Department has been set up at Noida office to coordinate all Environment, Health and Safety activities at offices and site.

The role of the EHS Cell is to implement the Safety Systems and Processes, Integrated Management System (IMS), CSR (Corporate Social Responsibility) and R&R activities for the EPC projects at our sites.

As a part of this planning, adequate number of personnel's will be attached to the EHS Cell. At each site, Safety Officers will be nominated.

14.9.4 Safety Control Plan

A Safety Control Plan is developed for the construction of the various units at each project site. Its aim is to define the approach to Safety Management. The primary purpose of this plan is to provide a guideline for preventing any accidents that may injure workers or damage property to the owner and EPC Contractor at the construction site.

It is mandatory for all, including contractors and their personnel, everybody will abide by all safety rules and other regulations imposed at the site by the laws of the country and the provisions of applicable laws, rules and regulations.
Identify the specific site conditions: location, monsoon rains from July to September, which creates poor site and road conditions due to intermittent heavy rain, thunderstorms, etc.

As the site work is of a fast track nature and involves many activities, the need for effective traffic controls is extremely important. The site speed limit will be 25 km/hr. and there will be traffic restrictions applied on the job for activities such as movement of wide or heavy loads. The Safety Officer will provide guidance to the staff for the control of vehicular movement on site and the Construction staff will monitor compliance.

Safety Committee: Organize a Safety Committee at each site consisting of Construction Manager, Safety Officer and representative of Major Contractors.

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14.9.5 Roles & Responsibilities

Safety Committee: The role of the Safety Committee will be to:

- Monitor and ensure the operation of safety norms, rules & regulations in proper manner
- Direct, coordinate and orient the safety activities
- Promulgate the spread of policy, objectives, rules and regulations
- Look for defects, and identify risky conditions
- Perform a thorough investigation of all accidents and review the recommendations to avoid any repetition
- Site safety inspection will be conducted by members subsequent to holding a meeting and inspection will be discussed at the meeting.

Safety Officer: The Safety Officer will:

- Coordinate and assist in organizing periodical Safety Committee Meeting
- To ensure that the workers likely to be exposed to hazardous chemicals/ materials have access to appropriate Material Safety Data Sheets (MSDS) wherever applicable, and provide necessary mitigation measures
- Coordinate the safety activities between the owner and the contractor
- To ensure that all critical equipment, tools & tackles etc. have a valid Statutory test Certificate and are in good condition before use
- Review and approve the subcontractor's safety procedures, advice and recommend any corrective actions necessary
- To ensure that workers have proper training for their job assignments, including use of appropriate Protective Personal Equipment (PPE) and First Aid and also Fire Fighting Equipment
- Be familiar with State and Statutory Legislation and BSPGCL/Consultant Site Safety Rules and Guidelines
- To report each incident and/or injury in accordance with established procedures and assist in investigation
- To conduct daily inspections to ensure compliance with safety standards, codes, regulations, rules and orders applicable to the work concerned
- To arrange daily tool box talk and regular site safety meetings and maintain records
- To develop methods and display banners/ posters to inculcate safety consciousness

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- To attend training and ensure participation of his workers for training as per schedule arranged by BSPGCL/Consultant and keeps himself updated
- Attend all BSPGCL/Consultant Safety meetings as required
- Advice promptly for the corrective action when any unsafe conditions or violations is observed & exercise authority to stop work in case of any danger
- Maintain the published safety literature, safety regulations, codes and other communications. Advise management of compliance and conditions requiring attention
- Check on the use of all types of personal protective equipment, evaluate effectiveness and suggest improvements of good housekeeping at site

Construction Manager: The role of construction Manager is:

- To implement safe methods and practices, deploy appropriate machinery, tools & tackles, experienced supervisory personnel and skilled work force etc. required for execution
- To prepare a comprehensive and documented plan for implementation, monitoring and reporting of Health, Safety and Environment (HSE) and implement the same after it's approved
- To nominate qualified & trained Safety Officers reporting to the site-in-charge, for supervision, co-ordination and liaison for the implementation of the safety plan
- To arrange suitable facilities in liaison with BSPGCL for drinking water, toilets, lighting etc. as applicable as per Laws / Legislation at site and also arrange for Workmen Compensation Insurance, Third party liability insurance, registration under ESI/PF Act etc. as applicable
- To arrange for protection equipment as per the advice of BSPGCL.
- To ensure that its employees have completed appropriate health & safety training as per the requirement of BSPGCL/Consultants. The records should be maintained and produced for verification as required
- To comply with all the security arrangements of owner
- To ensure that plant and equipment used at site are correctly registered, controlled and maintained in sound working condition
- To ensure availability of first Aid boxes and first Aid trained attendant
- To ensure that all incidents including near misses are reported to all concerned immediately
- Attend all safety meetings with BSPGCL/Consultant
- Inspect job site regularly and enforce all general safety rules and regulations at

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site

- Responsible for the prevention of accidents at his site
- Report accidents and near miss accidents and help in its investigation as per the BSPGCL's requirement
- Ensure that all persons working under him are properly instructed on safe and proper working procedures
- Advice prompt corrective action to supervisors and workers when any unsafe condition or violation observed
- Use only tested lifting tools and tackles
- Conduct daily tool box talk with foreman/supervisor at respective area to maintain good housekeeping
- Follow the work permit system at site
- Ensure proper personal protective equipment are being used for the job
- Assist the safety officer in conducting accident investigation involving his workers
- Stop work in case of imminent danger to man, machine or material and resume work only after corrective measures have been initiated
- Ensure that work statement made and safety precautions implemented before start of work

Task Performers: All Task Performers are required:

- To perform work safely as per the job requirement and instructions
- To inform all concerned regarding unsafe condition
- To wear PPE as stipulated and necessary for the job
- To inform promptly to their supervisor regarding all work related incidents resulting in personal injury, illness and or property damage
- To take all necessary and appropriate safety precautions to protect themselves, other personnel and the environment

14.9.6 Corrective Action

Whenever any unsafe condition/ practices are detected, these are reported to Package In charge or Safety Officer. The serious occurrences are recorded as non-conformity in format as approved on project.

Immediately make corrections and take corrective action. The record in the same format as approved on project.

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If anybody fails to heed the instruction or neglects precautions described in the work permit, Safety Officer will issue a letter or instruction for corrective action. The unsafe work will be stopped and the work will not be allowed to commence until corrective action has been taken.

14.9.7 Daily Inspection

Safety Officer / Package Engineer conduct daily safety inspection and record all observations.

During this inspection, special focus will be on:

- Vehicles and equipment: Speed limit at the site controlled according to site and road condition, but must not exceed maximum 25 km/hr.
- Refueling equipment with the engine running is prohibited.
- Alcoholic drinks and drugs will not be used or allowed on the site at any time. Anyone who is found under the influence of, or in possession of, alcohol or drugs will be removed immediately from the site and refused future access.
- Smoking is not allowed in stores and other specific confined areas like tank, vessel, column, barrel, pipeline, furnace, manhole pits, heat exchanger shell open from one end, excavation more than 1.5 m (if depth is more than width), AC ducting system and other similar enclosure which may have gases or vapors harmful to persons.
- Safety signs are displayed and followed.
- No one removes any safety chain, barrier, tag or sign unless so directed by the proper authority.
- Head protection: All required work force uses safety helmet. Ensure that the Safety helmet is not altered or holes punched in hat. (Remember Head injuries are not to be taken lightly)
- Eye and face protection: All welders are using suitable equipment. E.g. Industrial grade safety glasses (with shield)
- Hand protection: Use of hand gloves depending upon the material or equipment being handled. (Gloves should not be used near moving machinery)
- Foot protection: All concerned work force to wear safety shoe/Gum boot. (Workers wearing sandals or barefooted are not allowed inside the project premises).
- Safety belts (or harness), Lifelines and lanyards: Have to be worn while working

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above ground level or platform level to protect worker from falls. This equipment needs to be inspected daily by a supervisor. Life lines are to be secured above the point of operation to an anchorage or structural member.

- Accident prevention signs and tags: When hazardous work is to be performed, the appropriate signs and symbols have to been put before start of work and have been removed or covered promptly when the hazards no longer exist.
- Caution signs are used to warn against potential hazards or to caution against unsafe practices. Accident prevention tags are used as a temporary means of warning workers of an existing hazard, such as defective tools, equipment, etc., until the defective equipment is repaired or removed.
- Warning barricades: Warning barricades are erected before work begins or when specific hazard identified (in some situations a rigid guardrail needed). Warning barricades are erected and maintained at least 1 m from the edge of an excavation or opening. When emergency happens, all the persons on site should evacuate the working place.
- All personnel must know where fire extinguishers are kept. All inflammable materials are stored in properly barricaded areas. Accumulation of trash, oily rags, combustible materials and similar fire hazards of any nature is not permitted.
- All welding and cutting torches have to be equipped with flame valve, flash back arrester and gauges.
- All alleyways, driveways, road, stairway, ladder and transformers will be kept cleared of hazardous material and equipment.
- Refueling of petrol and diesel equipment is done only in prescribed areas and with approved equipment.
- Workers will take all measures to minimize spills and to clean up immediately spills that may accidentally occur. Refueling equipment with the engine running is prohibited.
- There must be a fire extinguisher easily accessible for each welding, cutting, burning or any other hot work operation.
- First Aid facilities on the site with ambulance or any other vehicle are always available at site while any work is being done.
- Safe practices are observed during pressure testing since this can be a hazardous procedure.
- Handling of chemicals: Storage of chemicals in appropriate containers with proper labels.
- No outsiders near hazardous construction area without permission.
- No climbing / working allowed without proper safety belt above 2 m height.

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- Nobody should stand under suspended loads.
- No debris obstacles allowed on the road and passages.
- Nobody should walk on pipelines or false ceiling.
- Good housekeeping should be maintained at worksite.
- Only certified equipment/ machine are being used.
- Construction work outside plant premises or the area specifically exempted inside refinery premises, work permit's will be obtained for the following jobs:
- All required precautions are taken in case of Radiography.
- No work is being done on lice electrical installations without shut down /work permit.
- Road cutting / blockade does not block traffic.

14.9.8 Common Hazards

Excavation:

- Fall of materials
- Collapse/ sliding of walls
- Fall of persons
- Underground electrical cables & pipes

Concreting shuttering and Backfilling

- Fall of persons/ material.
- Crushing of parts of body
- Electric shock
- People hit by moving objects

Erection of equipment:

- Fall of materials / Persons
- Hit against existing object
- Hit by moving objects
- Loose soil
- Failure of lifting M/c Tool & Tackles
- Collapse of nearby excavations

Fabrication and welding:

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- Electric Shock
- Fall of Materials / Person
- Exposure to UV & IR radiations
- Flying of hot particles
- Fire
- Short circuit

Radiography:

- Exposure to radiations
- Fall of persons

Hydro test:

- Sudden release of pressure
- Fall of materials / Persons
- Fire
- Insulation of pipe
- Fall of materials / Persons

Painting:

- Inhalation of paint mist
- Fall of persons / materials

14.9.9 Skills and Training

Induction Training: All the workers are given safety induction training by Contractor/Safety Officer prior to engaging them at site. E.g. Helpers, Masons, Bar binders, Riggers, Fitters, Welders; Electricians, Drivers, Office boy, Gas Cutter, Khalasi, Supervisors, Grinder, Painter, etc.

Safety Tool Box Talks: Daily 5 – 15 minute Safety Tool Box talks will be given to all the workers by concern site engineers.

Safety Training: The safety training forms part of EPC overall training plan which is targeted at achieving competency in safety though up-gradation of knowledge,

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skills and attitude towards safety.

14.9.10 Emergency Procedures

- Separate area will be identified as emergency assembly point and its board will be displayed at site.
- All important telephone numbers in case of emergency will be displayed at site.
- Display of safety poster
- Emergency drill will be explained to all site employees.

The Corporate Construction and Erection Safety Manual (Vol–I) will be implemented at the site.

14.10 Environment Management

To ensure environment protection as a result of site activities and to obtain appropriate environment clearances for the project from the regulatory authorities

All environment related issues at projects being physically executed at each site. Applicable to all the locations & projects of EPC

Safety Officer along with Chief Construction Manager at each site, HOD Administration at Noida Offices, HOD EHS for technical guidance, adherence to statutory & regulatory requirements, monitoring and prevention.

14.10.1 Definition

Environment: Surroundings in which EPC operates including air, water, land, natural resources, flora, fauna, humans and their interrelation

Environmental Aspect: Element of an EPC's activities or products or services that can interact with the environment

Environmental Impact: Any change to the environment, whether adverse or beneficial, wholly or partially resulting from EPC's environmental aspects

Environmental Management System: Part of EPC's management system used to

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develop and implement its environmental policy and manage its environmental aspects.

Environmental Objective: Overall environmental goal, consistent with the environmental policy that EPC sets itself to achieve

Environmental Performance: Measurable results of EPC's management of its environmental aspects

Prevention of pollution: Use of processes, practices, techniques, materials, products, services or energy to avoid , reduce, or control the creation, emission or discharge of any type of pollutant or waste, in order to reduce adverse environmental impacts

Significant Environmental Aspects: Those environmental aspects that have or can have significant impact(s) on the environment

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14.10.2 Specific Requirement

Following are the specific requirements for Construction Work;

- Environmental Clearances by the concerned Pollution Control Board
- Adherence to legal norms regarding emissions, discharges and waste disposal affecting land, water & air
- Noise levels of construction work and fully operational plant at full load to be within statutory levels
- Testing of air for emissions and ground water discharges for contamination to be carried out periodically

14.10.3 Planning

Planning for environment is done at engineering stage.

Equipment selection is done based on the environmental requirements.

Clearances from SPCB are taken to avoid any hassles at a later date.

14.10.4 Environmental Management during Construction, Erection & Commissioning

All actions are to be taken to demonstrate the strong commitment of EPC Contractor for Environment.

The most important part is adherence to legal requirements.

Identify the activities, products, services (direct/indirect) which are likely to have an adverse effect on environment.

Take positive measures towards protection of environment like:

- Generating green belt within the premises
- Strict control on tree felling
- Rain harvesting
- Neutralizing the chemicals before discharge

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- Recycling of water
- Avoid spillage of chemicals and fuels
- Control emissions from DG sets.
- Any used oil or liquid waste will not be disposed directly to the ground, pit or storm drain. Disposal of these materials will only be in properly labeled containers.
- Chemical and Other Effluents properly disposed
- Cleaning liquid of pipes disposed-off properly
- Lubricant Waste/ Engine oils properly disposed
- Waste from Canteen, offices, sanitation etc. disposed properly
- Disposal of surplus earth, stripping materials
- Oily rags and combustible materials done properly
- Green belt protection
- Hygienic conditions at labor camps O.K.
- Proper sanitation at site, office and labor camps
- Measures for dealing with illness
- Availability of Potable drinking water for workmen & staff
- Provision of crutches for children

Plan and conduct periodical tests of air, water, discharges, and noise.

14.10.5 Training

Conduct training to concerned persons on environmental aspects.

Arrange lectures from specialists.

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SECTION 15

FINANCIAL ANALYSIS OF THE PROJECT

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15.1 Project Cost Estimates & Financial Analysis

In this section, the project cost estimate has been worked out and fixed cost as well as variable cost of generation has been computed for the Unit No. 10 in order to assess overall financial viability of the Unit No. 10 project. For this purpose, a comprehensive financial model has been set up based on CERC guidelines 2014, representing a complete simulation of the project cost with regard to technical and financial aspects.

15.1.1 Basis of Cost Estimates

The project cost has been worked out based on the following assumptions

15.1.2 Assumptions of Hard Cost Input

The cost estimate for the Unit No. 10 has been worked out on the basis of the following assumptions:

- One (1) unit of 660 MW gross capacity, operating with SC steam parameters is considered.

- The entire project is proposed to be executed by dividing into one (1) or two (2) major packages viz. BTG Package, BOP Package (including civil works). Site development and enabling works will be carried out by BSPGCL through Contractors.

- The cost of BOP equipment, auxiliaries and services has been estimated from data available for similar items of other ongoing projects in India.

- The cost of general civil and architectural works of the plant has been estimated based on similar works of other ongoing projects in India. The cost of piling has been considered based upon the detailed soil investigation & geo-technical investigation as available for Unit No. 10 at the time of preparation of this DPR.

- The completion schedule is considered as fifty two (52) months from the date of NTP.

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15.1.3 Assumptions of Soft Cost Input

- Interest During Construction (IDC) is calculated based on fifty two (52) months of the construction period, adopting 8 % per year as interest rate. It should be noted that despite the fact that JICA YEN loan will be available at the rate of 1.4 % per year, JICA loan will be only extended to the GoI. Hence, the interest rate for sub-loan from the GoB will be determined by it, considering forex hedging costs to INR from JPY. It should be also noted that JICA YEN Loan provides currency conversion option, with which the borrower is able to change the currency of repayment from JPY to USD, which might result in lower forex hedging costs.

- Finance charge is calculated based on the JICA's policy that front end fee will be imposed by 0.2 % of the commitment amount, but the rate of 0.1 % will retroactively be applied instead of 0.2 % in the event that all disbursement is completed within the original disbursement period.

- Taxes and duties have been considered prevailing as on date, as below.

Table 15.1-1 Applicable Taxes and Duties

Description	Parameter	Application
Import Duty	23.42 %	On imported goods (custom duty, countervailing duty, special additional duty, education tax)
Excise Duty	12.5 %	On domestic production of goods
Central Sales Tax	2 %	On domestic goods sold interstate
Service Tax	14.5 %	On local services (engineering, erection and commissioning)
Labor Cess	1 %	On employers of building and construction workers
VAT	5 %	On goods sold within state

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15.2 Project Cost Break Up

On the basis of the assumptions discussed above, the estimated cost of Civil Works, Plant & Equipment and Intake System Including Initial Spares, Taxes & Duties an Erection, Testing & Commissioning is INR 5,210 Crores. Adding physical contingency, overhead construction charges, pre-operative expenses before financing and IDC, amount to INR 5,972 Crores. Financing expenses and IDC add INR 810 Crores, bringing the total financing requirement to INR 6,788 Crores. The specific cost of the project is INR 10.29 Crores per MW. A summary of the break-up of the project cost is indicated in the below Table 15.2-1.

Table 15.2-1 Project Cost Break-up

Sl. No.	Description	Cost in Crores
1	Civil Works	939
2	Boiler Island	980
3	Turbine Generator Island	528
4	Balance of Plant (BOP)	992
4.1	Mechanical	770
4.2	Electrical	222
5	Raw Water Intake Pump House & Intake Line	60
6	Railway Siding	33
7	Initial Spares	178
8	Total Plant and Equipment	2,771
9	Total Plant and Equipment (Including Civil Works) sum of item 1 & 8	3,711
10	Taxes & Duties	575
11	Erection, Testing & Commissioning	245
12	FGD, SCR & FGD with Taxes and Duties	679
Total Direct & Indirect Costs		**5,210**
13	Physical Contingency (3 % of Total Costs above)	156
14	Overhead Construction Charges	57
15	Pre-Operative Expenses (R&R, Accommodation, Margin Money for WC, etc.)	549
16	Finance Charges	6
Total Project Cost Excluding IDC		**5,978**
17	Interest During Construction	810
Total Project Cost Including IDC		**6,788**

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15.3 Phasing of Expenditure

- Phasing of expenditures or funds (withdrawal of debt and equity) has been estimated from data available for similar items of other ongoing projects in India.

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15.4 Tariff Calculation

15.4.1 Financial Input Assumptions

The following are the financial assumption in below Table 15.4-1.

Table 15.4-1 Financial Input Assumption for Tariff Calculation

Sl. No.	Particulars		Assumptions
1	Project capital structure	Total project cost	6,788 Crores
		Interest during construction	810 Crores
		Cost/MW	10.29 Crores
		Debt Equity ratio	85:15
2	Technical operating parameters	Plant Load Factor	85 %
		Auxiliary consumption of electricity generated	5.25 %
		Gross unit heat rate	2,250 kcal/kWhr.
		Gross calorific value of domestic coal	4,450 kcal/kg
		Specific consumption of coal	0.51 kg/kWhr.
3	Financial parameters	Interest rate	8 %/year [JICA JPY loan: 1.4 %/year]
		Payment period	25 years [JICA JPY loan: 30 years]
4	Operational parameters	Domestic coal cost	3,800 INR/ton
		O&M expenses	11.69 lakhs/MW (Escalation 6.29 %/year)
		Depreciation	25 years for depreciation calculation as per CERC

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Note:

- Gross unit heat rate of 2,250 kcal/kWhr is in accordance with the CERC guideline year 2014 and used for tariff calculation purpose although the figure is different from the gross unit heat rate mentioned in Section 6, 11 and other sections of this DPR.
- Auxiliary Power Consumption of 5.25 % is in accordance with the CERC guideline year 2014 and used for tariff calculation purpose although the figure is different from the auxiliary Power consumption mentioned in Section 11 of this DPR.

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15.4.2 Tariff

In accordance with CERC guidelines, the annual tariff is computed as a two (2) part tariff comprising a fixed charge per kWhr. and a variable charge per kWhr. for net generation. The economic plant life has been taken as twenty five (25) years for tariff calculation.

The estimated capital cost (including IDC) has been taken as Rs. 6,788 Crores. The total Levelized tariff has been arrived as INR 4.32/kWhr (fixed cost: INR 2.14/kWhr, variable cost: INR 2.17/kWhr). The first year tariff works out to INR 4.59/kWhr (fixed cost: INR 2.42/kWhr, variable cost: INR 2.17/kWhr).

The total project cost and tariff described above have a room for reduction through detailed design of technical aspects and subject to the terms & conditions of borrowing debt.

A. Fixed Charge

The Fixed Charge covers the following items:

- Depreciation
- Return on Equity
- Interest on Term Loan
- Interest on Working Capital
- O&M Expenses
- Tax on Income

B. Variable Charge

The Variable Charge covers the following items:

- Primary Fuel Cost
- Secondary Fuel Cost

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LIST OF APPENDICES

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LIST OF APPENDICES

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Appendix - I

SITE LOCATION MAP

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Figure I-1 SATELLITE PICTURE OF BARAUNI TPS, BIHAR

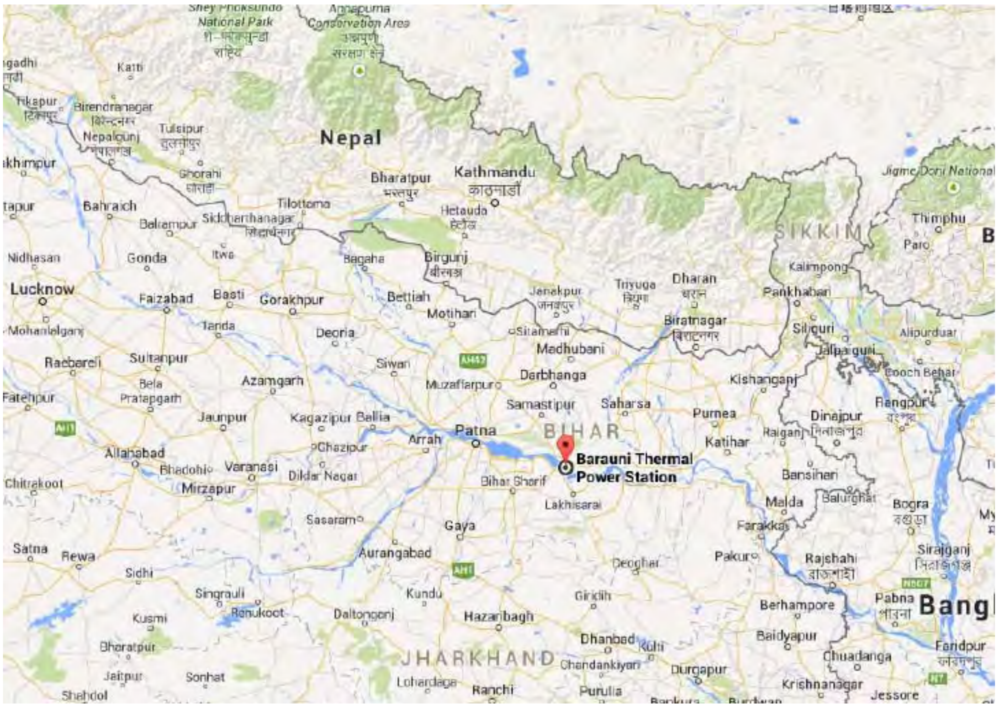

Figure I-2 LOCATION MAP OF BARAUNI TPS, BIHAR

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Appendix - II

VICINITY MAP

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Figure II-1 Existing Barauni Oil Refinery, Bihar

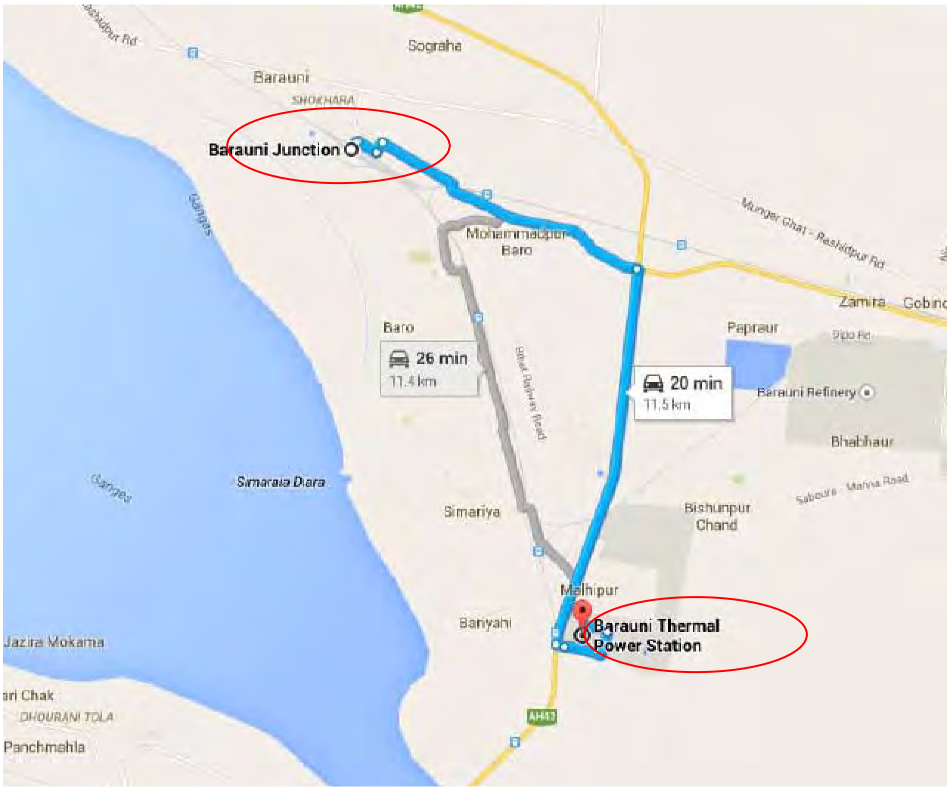

Figure II-2 Exiting Railway Station, Barauni, Bihar

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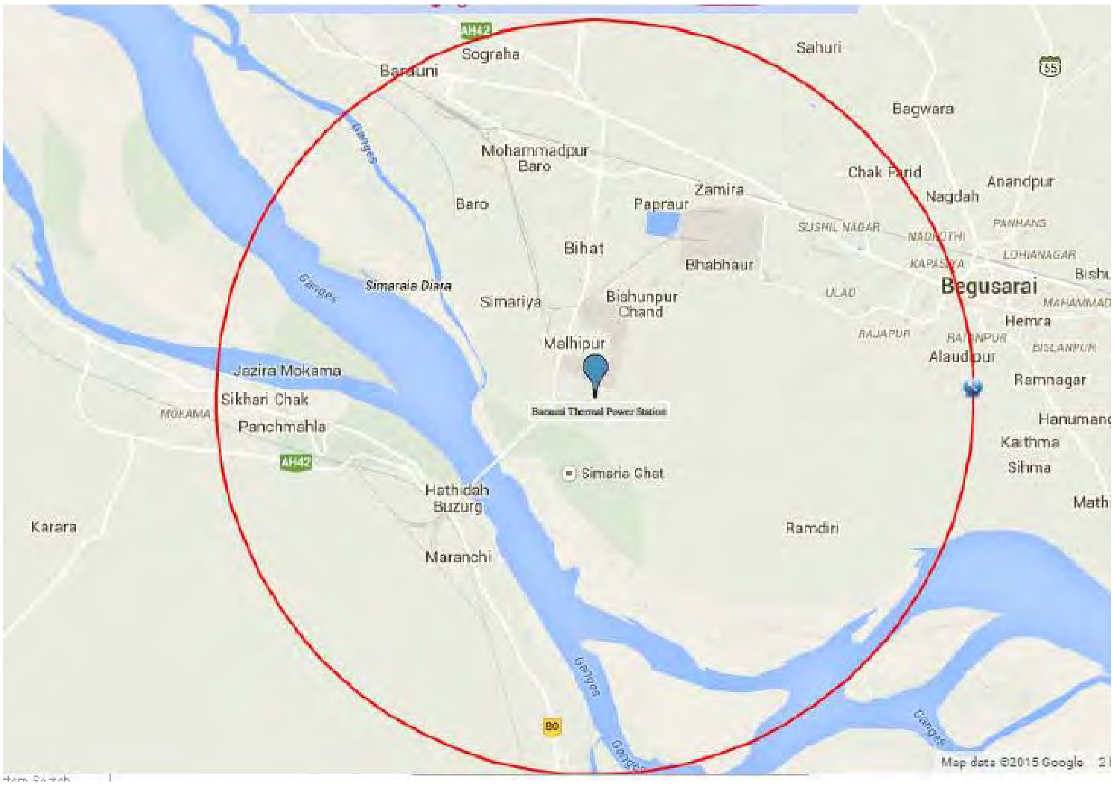

Figure II-3 10 km Radius Topographical Map Showing Project Location

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Appendix - III

TYPICAL FUEL ANALYSIS
&
REQUIREMENTS

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Fuel Data:

- Domestic coal shall be used in this power project.
- For boiler start up, Light-up and flame stabilization LDO would be used.
- LDO system capacity shall be of 30 % BMCR.
- The range of Gross Calorific Value (GCV) of the coal is in the range of 3,100 to 3,300 kcal/kg.
- The Coal and Fuel Oil analysis is as per below Table III-1 and 3.

(i) Coal Analysis (As Received basis)

Table III-1 Coal Analysis (as received basis, ARB)

Item		Unit	Design	Worst	Remarks
Gross Calorific Value		kcal/kg	3,300	3,100	As received
Proximate Analysis	Fixed carbon	%	29.7	29.4	As received
	Volatile matter	%	17.7	20.6	
	Ash	%	44.6	40.0	
	Total Combined Moisture	%	8.0	10.0	
Ultimate Analysis	Carbon	%	34.69	34.66	
	Hydrogen	%	2.43	2.26	
	Sulphur	%	0.3	0.00	
	Oxygen	%	9.27	12.33	
	Nitrogen	%	0.71	0.75	

Note:

These properties as indicated above are same as coal being used and sourced from the "Detailed Project Report for 2 x 250 MW Coal Based Extension, TPS at Barauni District Begusarai in Bihar" (Unit No. 8 & 9). The above coal characteristic shall also be used / applied for the design of the proposed extension unit of 1 x 660 MW, which will be subjected to final acceptance of BSPGCL.

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(ii) Coal Consumption / Requirements

Table III-2 Annual Coal Requirements

Sl. No.	Item	Unit	Value
1	Gross Unit heat rate for 660 MW	kcal/kWhr.	2,042
2	Gross calorific value of the worst coal	kcal/kg	3,100
3	Daily Coal requirement @ BMCR	TPD	11,200
4	Annual Coal requirement @ 85 % PLF	MTPA	3.5

The annual requirement of domestic coal for the extension unit works out to approximately in million tonnes per annum (MTPA), considering 85 % PLF (2 years average) based on worst coal (as received basis). Indian domestic coal of specification as mentioned in Table III-1 is considered for this proposed extension unit.

Note:

- The source of coal blocks which shall be allocated by GoI or purchase through fuel supply agreement yet to finalize and assumed the same as the case with Unit No. 8 & 9.
- Unit heat rate is estimated as per following formulae while estimating the coal requirements:

$$\text{Gross Unit heat rate} = \frac{\text{Turbine Cycle HeatRate (100\% TMCR)}}{\text{Boiler Efficiency (100\% TMCR)}}$$

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(iii) Light Diesel Oil (LDO) Analysis

Table III-3 Light Diesel Oil (LDO) Analysis

Item	Unit	Value
Specification		IS-1460 (Latest Revision)
Acidity, Inorganic	-	Nil
Ash content (max.)	% by mass	0.02
Carbon residue (Rams bottom) on whole sample (max.)	% by mass	1.5
Pour Point (max.)		
a) Winter	^{o}C	12
b) Summer	^{o}C	18
Flash point (Pensky Martens) (min.)	^{o}C	66
Kinematic Viscosity at 38 ^{o}C	cSt	2.5 to 15.7
Sediment (max.)	% by mass	0.1
Water Content (max.)	% by volume	0.25
Total Sulphur Content (max.)	% by mass	1.8
GCV (Approximate)	kcal/kg	10,000
Density at 15 ^{o}C	kg/m^3	850

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(iv) **Light Diesel Oil (LDO) Requirements**

Table III-4 Light Diesel Oil (LDO) Requirements

Sl. No.	Item		Units	Value
1	Oil Consumption (Max.)		KLPH	52.5
2	PLF		%	85
3	Plant Shut-down for Maintenance (2 years average)		days	50
4	Total no. of starts for Fuel Oil requirement (per year)	Cold	nos.	3
		Warm	nos.	6
		Hot	nos.	15
5	Fuel Oil requirement		KLPA	2030

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Appendix - IV

HEAT BALANCE DIAGRAM

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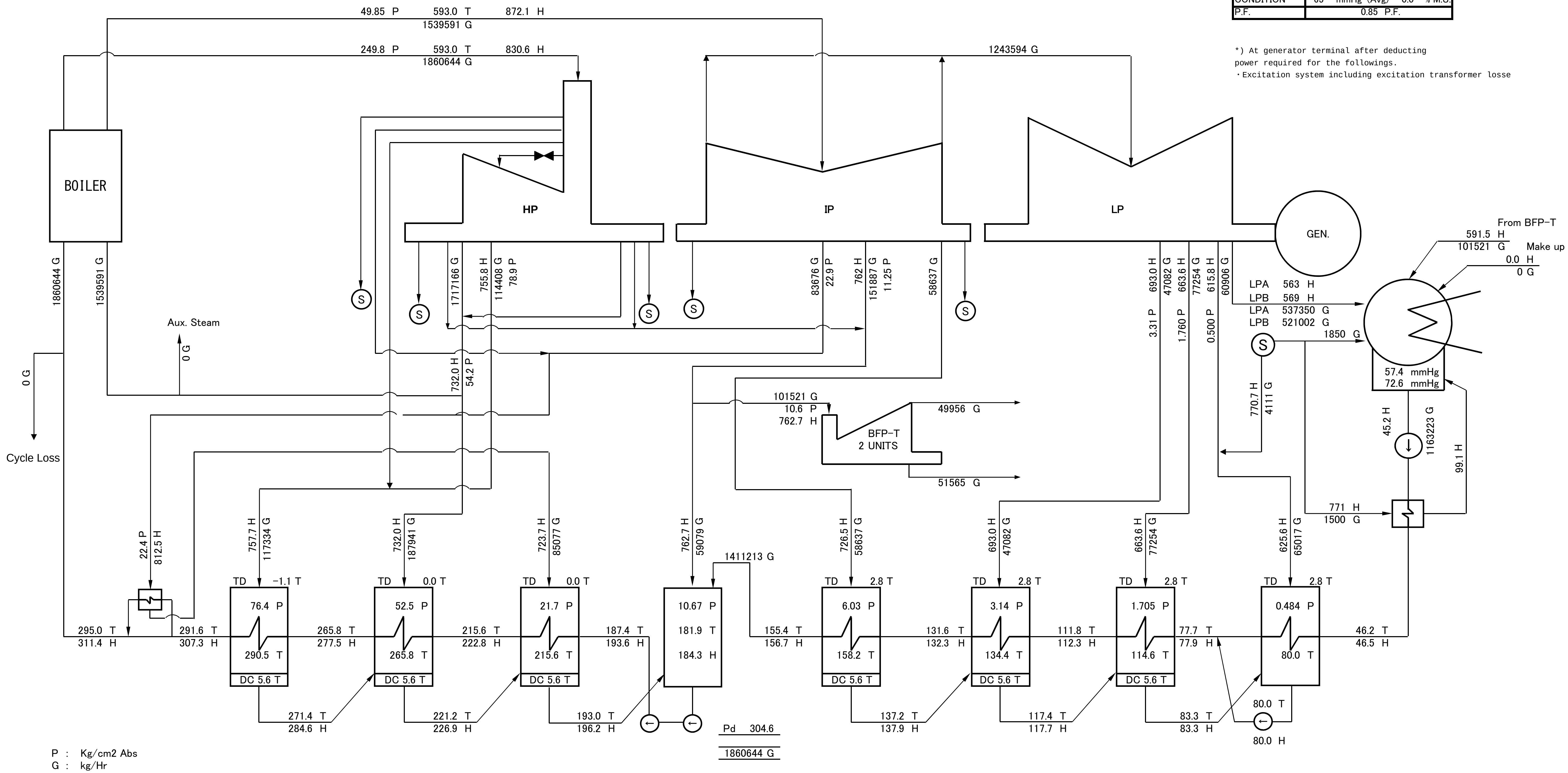
LOAD	100% TMCR
GEN. OUTPUT	660000 kW(*
CONDITION	65 mmHg (Avg) 0.0 % M.U.
P.F.	0.85 P.F.

*) At generator terminal after deducting
power required for the followings.
・Excitation system including excitation transformer losse



P : Kg/cm2 Abs
G : kg/Hr
T : deg. C
H : kcal/kg

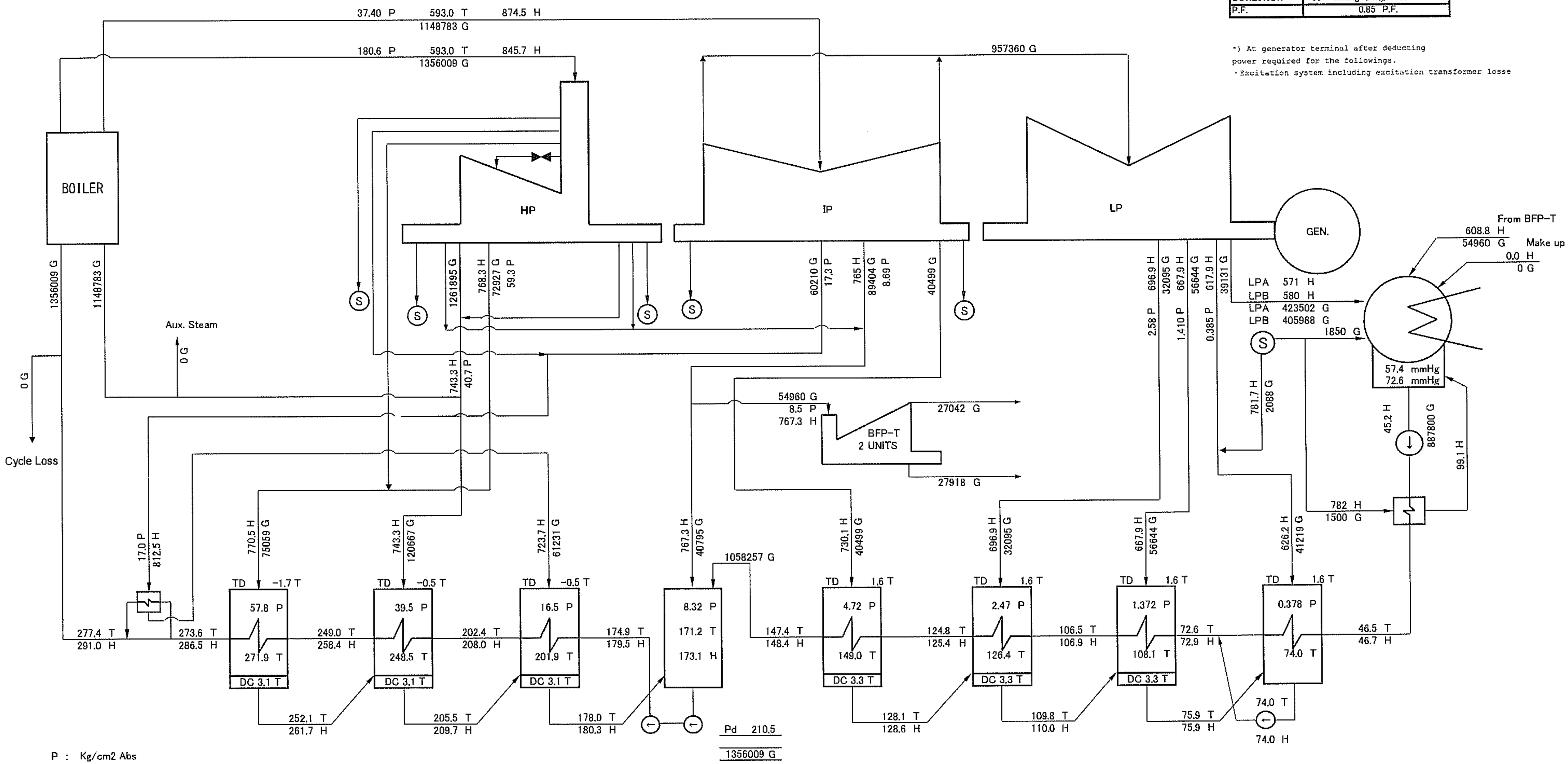
Note: (S) is a representation of the steam seal system

FOR DETAILED PROJECT REPORT

APPROVED BY	Y.O.	Kyushu 660 MW	660000 KW REHEAT TURBINE
CHECKED BY	A.M.		HEAT BALANCE DIAGRAM
DESIGNED BY	A.V.		

LOAD	75% TMCR
GEN. OUTPUT	495000 kW(*
CONDITION	65 mmHg (Avg) 0.0 % M.U.
P.F.	0.85 P.F.

*) At generator terminal after deducting power required for the followings.
・Excitation system including excitation transformer losse



P : Kg/cm2 Abs
G : kg/Hr
T : deg. C
H : kcal/kg

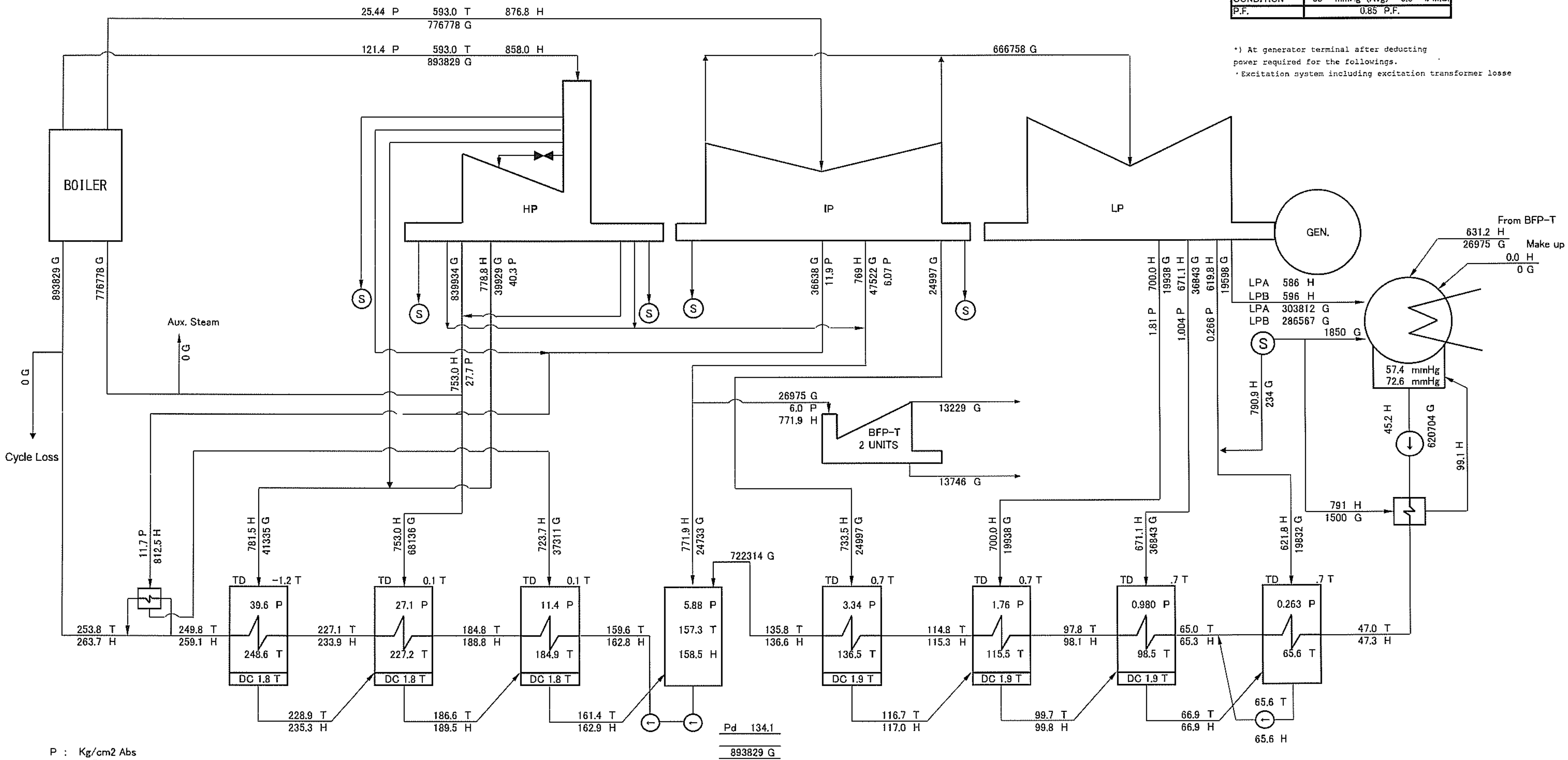
Note: (S) is a representation of the steam seal system

FOR DETAILED PROJECT REPORT

APPROVED BY	Y.O.	Kyushu 660 MW	660000 KW REHEAT TURBINE
CHECKED BY	A.M.		HEAT BALANCE DIAGRAM
DESIGNED BY	A.V.		

LOAD	50% TMCR
GEN. OUTPUT	330000 kW (*
CONDITION	65 mmHg (Avg) 0.0 % M.U.
P.F.	0.85 P.F.

*) At generator terminal after deducting power required for the followings.
・Excitation system including excitation transformer losse



P : Kg/cm2 Abs
G : kg/Hr
T : deg. C
H : kcal/kg

Note: (S) is a representation of the steam seal system

FOR DETAILED PROJECT REPORT

APPROVED BY	Y.O.	Kyushu 660 MW	660000 KW REHEAT TURBINE
CHECKED BY	A.M.		HEAT BALANCE DIAGRAM
DESIGNED BY	A.V.		

Appendix - V

METEOROLOGICAL DATA

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Station: Bhagalpur

1971-1999

Month			Mean Temperature						Extremes				Humidity		Cloud Amounts		Rainfall						
		Station Level Pressure	Dry Bulb	Wet Bulb	Daily Max	Daily Min.	Highest in the Month	Lowest in the Month	Highest	Date and Year	Lowest	Date and Year	Relative Humidity	Vapour Pressure	All Clouds	Low Clouds	Monthly Total	No. of Rainy Days	Total in Wettest Month with Year	Total in Driest Month with Year	Heaviest Fall in 24 hours	Date and Year	Mean Wind Speed
		hPa	°C	°C	°C	°C	°C	°C	°C		°C		%	hPa	Oktas of sky		mm		mm	mm	mm		kmph
Jan	I	1012.6	14.9	13.2	24.6	12.2	28.2	9.0	31.9	25	6.4	15	81	13.9	1.6	0.6	13.7	1	120.4	0	91.2	10	3.1
	II	1009.1	20.1	16.6						1982		1983	68	16.2	1.6	0.5			1959			1957	
Feb	I	1010.2	18	15.1	27.7	14.5	32.4	10.4	35.8	26	5	3	72	15.0	1.7	0.5	13.5	1.5	41.2	0	26.7	14	4.1
	II	1006.5	23.3	18.5						1981		1990	58	17.2	1.7	0.5			1972			1972	
Mar	I	1006.7	23.8	18.9	33.8	19.6	39.1	14.9	42.6	27	10.8	10	62	18.2	1.5	0.5	10.9	1.1	39.9	0	27.9	30	4.7
	II	1002.4	29.8	21.7						1988		1979	47	19.7	1.7	0.4			1993			1998	
Apr	I	1002.7	28.4	23	37.8	23.7	42.1	19.7	45.3	30	13.1	2	62	23.9	2.1	0.9	20.8	1.8	212.4	0	172	22	5.6
	II	997.9	34.3	24.7						1980		1990	45	23.7	2	0.7			1971			1971	
May	I	999.7	29.4	25.3	37.6	24.9	42.6	20.5	46.4	28	14.5	13	71	29.2	3.4	2	68.7	4.8	228.3	0	70.3	29	6
	II	995.2	34.1	26.5						1982		1978	55	28.8	2.8	1.5			1999			1960	
Jun	I	995.5	30	27	36.2	26.6	41.9	23.2	46	7	19.5	16	78	33.2	5.3	3.2	211.9	9.5	675.6	44.8	181.5	25	5.2
	II	991.9	32.6	27.7						1982		1968	69	33.1	5.5	3.2			1984	1967		1984	
Jul	I	995.6	28.9	26.9	33.3	26.4	37.3	24	42.3	6	22.4	12	85	33.9	6.7	4.2	315.4	14.5	502.2	47.7	147.5	9	4.2
	II	992.5	30.5	27.5						1982		1980	79	34.3	6.6	4			1997	1972		1969	
Aug	I	997.0	29.1	27	33.2	26.4	36.8	23.9	39.7	11	20.1	21	84	34.1	6.3	3.9	272.1	12.4	815.4	74.8	237.2	1	4.4
	II	993.8	30.5	27.5						1986		1989	79	34.3	6.4	3.8			1987	1964		1987	
Sep	I	1001.3	28.6	26.5	33.2	26	36.7	23.5	38.6	24	21.7	27	84	32.9	5.5	3.3	221.2	10.1	743.9	44.7	352.8	25	3.8
	II	997.8	29.9	26.8						1982		1956	77	32.6	5.8	3.4			1960	1994		1965	
Oct	I	1006.6	26.8	24.2	32.8	23.5	35.6	19.8	40	19	16.1	31	79	28.3	2.7	1.5	90.4	3.7	346.9	0.5	196	20	2.8
	II	1002.9	29	25						1981		1954	71	28.5	3	1.7			1986	1981		1987	
Nov	I	1010.6	22.6	19.5	30.4	18.4	33.2	14.4	37.4	15	11.1	29	74	20.4	1.4	0.5	6.8	0.7	51.1	0	37.1	2	2.4
	II	1007.0	25.6	21.3						1981		1952	67	22.1	1.6	0.5			1993			1956	
Dec	I	1013.1	16.9	14.8	26.1	13.4	29.2	10.2	32.2	4	3.9	31	78	15.1	1.2	0.3	9.5	0.8	49.7	0	32.8	11	2.8
	II	1009.4	21.2	17.6						1981		1990	68	17.4	1.3	0.3			1991			1981	
Annual Total Or Mean	I	1004.4	24.7	21.5	32.3	21.3	43.6	8.6	46.4	28	3.9	31	76	24.7	3.2	1.8	1255.2	61.8	2205.3	602.1	352.8	25	4.1
	II	1000.6	28.4	23.4					5	1982	12	1990	65	25.6	3.3	1.7			1987	1966	9	1965	
Number of Years	I																						
	II	25	25	25	24	24	24	24	56		56		25	25	25	25	30	30	50	50	51		24

Note: 1) Above Climatological Normals (1971-1999), Govt. of India Ministry of Earth Sciences India Meteorological Department.

2) Lat. 25° 14' N, Long. 86° 57' E, Height above MSL 49 m

Station: Bhagalpur
1971-1999

Month		Weather						Wind Speed				% Wind Direction								
		PPT 0.3 mm or more	Hail	Thunder	Fog	Dust Storm	Squall	62 or More	20-61	1-19	0	N	NE	E	SE	S	SW	W	NW	CALM
		No. of Days With						No. of Days with Wind Speed, kmph				% No. of Days Wind From								
Jan	I	1.7	0	0.4	2.3	0.1	0	0	0	19	12	2	2	3	2	11	20	14	4	42
	II							0	0	18	13	3	2	3	1	0	11	23	13	44
Feb	I	2	0	0.6	0.3	0.1	0	0	0	21	7	2	3	4	3	12	26	18	28	27
	II							0	0	19	9	4	3	3	1	2	9	33	14	31
Mar	I	2	0	1.3	0.1	0.2	0.1	0	0	25	6	2	7	10	2	9	25	18	5	22
	II							0	0	23	8	6	5	6	1	2	7	29	19	25
Apr	I	2.7	0	2.3	0.1	1.3	0.3	0	1	25	4	2	13	30	10	8	10	10	3	14
	II							0	1	25	4	9	13	23	5	1	3	16	18	12
May	I	6.3	0	5.8	0	1	0.3	0	1	27	3	2	18	42	13	6	3	3	2	11
	II							0	1	27	3	6	20	39	10	3	2	2	6	10
Jun	I	11.2	0	6.7	0.1	0.3	0.1	0	0	26	4	2	10	40	18	8	4	3	1	14
	II							0	1	24	5	4	14	40	14	5	2	2	2	17
Jul	I	19.2	0.2	8.6	0	0	0	0	0	23	8	1	4	26	18	10	5	5	1	30
	II							0	0	22	9	1	7	33	14	7	4	3	2	29
Aug	I	16.3	0	8.7	0	0	0	0	0	25	6	2	5	33	19	9	6	3	2	21
	II							0	0	24	7	2	7	35	15	6	3	6	3	23
Sep	I	12.9	0	7.5	0	0	0	0	0	23	7	3	7	27	14	8	9	5	2	25
	II							0	0	22	8	3	7	26	12	6	6	7	4	29
Oct	I	5.6	0	3	0.2	0	0	0	0	19	12	2	6	15	6	10	10	7	3	41
	II							0	0	15	16	4	6	12	4	3	5	8	8	50
Nov	I	0.9	0	0.2	0.4	0.1	0	0	0	14	16	3	4	7	3	7	11	8	6	51
	II							0	0	11	19	3	3	6	0	1	6	9	7	65
Dec	I	1	0	0.1	0.5	0	0	0	0	17	14	3	1	2	1	8	20	12	4	49
	II							0	0	14	17	2	2	2	1	1	12	18	8	54
Annual Total	I	81.8	0.3	45	4.1	3.1	0.7	1	3	262	99	2	7	20	9	9	12	9	3	29
	II							0	4	245	116	4	7	19	7	3	6	13	9	32
Number of Years	I																			
	II	24						26				26								

Note: 1) Above Climatological Normals (1971-1999), Govt. of India Ministry of Earth Sciences India Meteorological Department.

2) Lat. 25° 14' N, Long. 86° 57' E, Height above MSL 49 m

Station: Bhagalpur
1971-1999

Month		Total cloud					Low Cloud						Visibility				
		0	T-2	3-5	6-7	8	0	7-2	3-5	6-7	8	Fog 8	< 1 km	1-4 kms	4-10 kms	10-20 kms	>20 kms
		No. of Days with All Cloud Amount "Oktas"					No. of Days with Low Cloud Amount "Oktas"						No. of Days with Visibility				
Jan	I	20	3	3	3	2	27	1	2	1	0	0	2.3	11.2	17.1	0.4	0
	II	20	4	4	2	1	26	2	2	1	0	0	0	7.1	21	2.8	0
Feb	I	17	3	4	3	1	24	2	2	0	0	0	0.4	8.1	18	1.5	0
	II	16	4	4	3	1	23	2	3	0	0	0	0	6.2	17	4.7	0
Mar	I	20	3	4	3	1	26	2	3	0	0	0	0	1.4	23.9	5.6	0.1
	II	18	4	4	4	1	26	3	2	0	0	0	0.1	6.9	20.2	3.7	0.2
Apr	I	16	4	4	5	1	22	3	4	1	0	0	0	6.2	20.4	3.4	0
	II	15	5	5	4	1	21	5	4	0	0	0	0.2	7.6	19.2	2.8	0.2
May	I	11	4	6	7	3	15	8	8	3	1	0	0	5.9	20	5	0.1
	II	12	6	7	5	1	15	4	7	1	0	0	0	7.2	18.8	5	0.1
Jun	I	3	2	6	14	5	7	3	14	5	1	0	0	5.3	19.3	5.4	0.1
	II	2	2	7	14	5	5	6	15	4	0	0	0	5.4	18.3	5.9	0.3
Jul	I	0	0	4	17	19	1	3	20	7	0	0	0	6.4	19.2	5.4	0
	II	0	0	4	19	8	0	4	22	5	0	0	0.1	6.2	17.8	6.7	0.2
Aug	I	0	0	6	19	6	1	4	21	5	0	0	0.1	5.3	19	6	0.7
	II	0	0	5	21	5	0	5	23	3	0	0	0	5.3	17.5	7.3	0.8
Sep	I	1	2	7	15	5	4	4	16	5	0	0	0	5.5	18.1	6.3	0.2
	II	0	2	7	16	5	2	7	18	3	0	0	0	5.4	18.2	6.3	0.1
Oct	I	14	5	5	5	2	18	5	6	2	0	0	0.1	6.6	20.1	4.2	0
	II	10	7	7	5	2	12	9	8	2	0	0	0	7	19.7	4.2	0
Nov	I	18	4	4	3	1	25	2	2	1	0	0	0.1	9	19.2	1.8	0
	II	16	6	5	2	1	23	4	3	0	0	0	0	7.8	19	3.2	0
Dec	I	23	2	3	2	1	29	1	1	0	0	0	0.7	11.1	18.8	0.3	0
	II	20	4	4	2	1	28	2	1	0	0	0	0	8.8	19.5	2.7	0
Annual Total Or Mean	I	152	33	56	86	38	205	36	90	31	3	0	3.7	86.9	230.4	43	1
	II	129	45	65	94	32	185	55	104	20	1	0	0.6	80.8	226.3	55.4	1.9
Number of Years	I																
	II	26					26						26				

Note: 1) Above Climatological Normals (1971-1999), Govt. of India Ministry of Earth Sciences India Meteorological Department.

2) Lat. 25° 14' N, Long. 86° 57' E, Height above MSL 49 m

Appendix - VI

RAW WATER ANALYSIS
&
REQUIREMENTS

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The following raw water analysis is considered for designing the plant water treatment system, as sourced from the Ganga River.

Table VI - 1 Detailed Raw Water Analysis [35]

Sl. No.	Item	Unit	Value
1	pH	-	8.90
2	Dissolved Oxygen	mg/l	7.5
3	Chloride	mg/l	58
4	Calcium	mg/l	51.20
5	Magnesium	mg/l	17.01
6	COD	mg/l	58
7	BOD	mg/l	3
8	Total Solids	mg/l	694.40
9	Volatile Total Solids	mg/l	117.98
10	Suspended Solids	mg/l	64.43
11	Volatile Suspended Solids	mg/l	28.30
12	Settable Solids	mg/l	1.90
13	Total Dissolved Solids	mg/l	237
14	Turbidity	NTU	12
15	Oils / Hydrocarbon	mg/l	6.5
16	Phenols	mg/l	0.010
17	Ammonia	mg/l	0.210
18	Nitrate	mg/l	0.80
19	Nitrite	mg/l	6.67
20	Phosphate as phosphorus	mg/l	0.09
21	Flurides	mg/l	0.69
22	Iron	mg/l	0.29
23	Coliform	MPN	1,405
24	Faecal Coliform	-	175
25	Faecal Streptococcus	-	1,600
26	Total Organic Carbon	mg/l	5.30
27	Total Inorganic Carbon	mg/l	28
28	Total Nitrogen	mg/l	4.08
29	Total Organic	mg/l	3.03
30	Inorganic Nitrogen	mg/l	2.78
31	DDT	mg/l	0.001
32	Bromide	mg/l	2.10
33	Cadmium	mg/l	0.960
34	Chromium	mg/l	0.055

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Sl. No.	Item	Unit	Value
35	Copper	mg/l	1.40
36	Lead	mg/l	0.120
37	Mercury	mg/l	0.56
38	Nickel	mg/l	0.230
39	Zinc	mg/l	2.0
40	Toxicant vs. Toxicity	-	Negative
41	Boron	mg/l	1.87
42	Sodium	mg/l	28
43	Color	-	Light Brown
44	Total Chromium	ppb	68
45	Total Colloidal Silica	ppb	980

Note:

These properties as indicated in the above table are same as raw water being used for Unit No. 8 & 9, and taken from BHEL reference document “Design Memorandum for Pre-treatment Plant, 2 x 250 MW BTPS Unit 8 & 9, Doc. No. PE-DC-374-158-A001” [35]

The above raw water analysis shall also be used / applied for the design of the proposed extension unit of 1 x 660 MW, which will be subjected to final acceptance of BSPGCL.

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Table VI - 2 Summary of Plant Water Requirements for 1 x 660 MW unit

Sl. No.	Item	Unit	Case - 1	Case - 2	Case - 3	Case - 4
1	Total CW make-up	m^3/hr.	1468	1468	1468	1468
2	Service Water	m^3/hr.	160	160	160	160
3	DM Plant Feed	m^3/hr.	55	55	55	55
4	Make-up Water for PT Plant	m^3/hr.	1679	1631	1686	1531
5	Raw Water make-up to Ash Water Sump	m^3/hr.	152	0	34	0
6	Total River Water at raw water tank	m^3/hr.	1840	1640	1730	1540
7	Total River Water at raw water tank	cusec	≈ 18	≈ 16	≈ 17	≈ 15
8	System losses in de-silting at sedimentation basin @10%	Cusec	≈ 1.8	≈ 1.6	≈ 1.7	≈ 1.5
9	Raw water intake water requirement	Cusec	19.8	17.6	18.7	16.5
10	Raw water intake design capacity considering margin	Cusec	21			

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Case - 1: Wet Bottom Ash (BA) + Wet Fly Ash (FA) by HCSD system, and without recovery from the Ash Pond

Bottom Ash (BA) is disposed by Lean Slurry System & Fly Ash (FA) by HCSD System (during initial phase of Unit No. 10 i.e. COD+3M). It is expected that ash water recirculation system of the Unit No. 10 will become functional after three (3) months of Unit No. 10 operation. Hence, during the initial dyke filling there will not be any recovery of water at all from the Ash Pond.

Case - 2: Wet Bottom Ash (BA) + Wet Fly Ash (FA) by HCSD system, and with recovery (70 %) from the Ash Pond

Bottom Ash (BA) is disposed by Lean Slurry System & Fly Ash (FA) by HCSD System (after three (3) months of Unit No. 10 operation from COD). As the Unit No. 10 operating duration increases, ash water recirculation system of the Unit No. 10 will become functional. As per the CEA standard guideline 70 % of water (which is delivered through Lean Slurry System) can be recovered. In this case HCSD system never contributes to recovery system.

Case - 3: Wet Bottom Ash (BA) + Dry Fly Ash (FA) system, and without recovery from the Ash Pond

Bottom Ash (BA) is disposed by Lean Slurry System & Fly Ash (FA) by Dry System (during initial phase of Unit No. 10 i.e. COD+3M). It is expected that ash water recirculation system of the Unit No. 10 will become functional after three (3) months of Unit No. 10 operation. Hence during the initial Dyke filling there will not be any recovery of water at all from the Ash pond.

Case - 4: Wet Bottom Ash (BA) + Dry Fly Ash (FA) system, and with recovery (70 %) from the Ash Pond

Bottom Ash (BA) is disposed by Lean Slurry System & Fly Ash (FA) by Dry System (after three (3) months of Unit No. 10 operation from COD). As the Unit No. 10 operating duration increases, ash water recirculation system of the Unit No. 10 will become functional. As per the CEA standard guideline 70 % of water (which is delivered through lean slurry system) can be recovered.

The above indicated in the table are taken from W B D of proposed extension Unit No. 10, and refer to “List of Drawing” Section of this DPR.

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Appendix - VII

STATE GRID MAP

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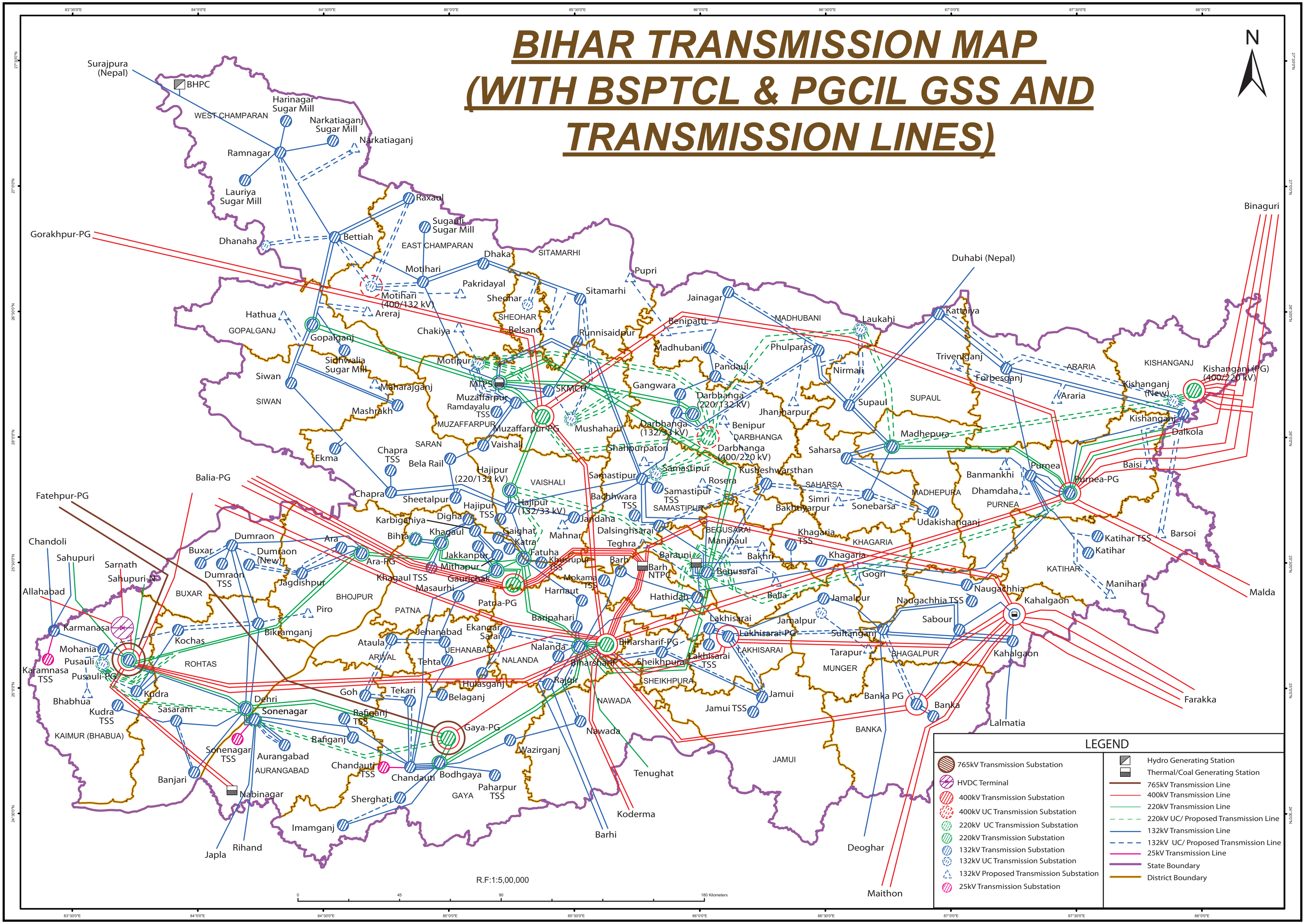
BIHAR TRANSMISSION MAP (WITH BSPTCL & PGCIL GSS AND TRANSMISSION LINES)



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The following is the listed source from where the data is extracted and referred in this DPR.

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[15] Data of the Ganga River comes from results of interview Data from the Environment Impact Assessment (EIA) & Environmental Management Plant (EMP) Report for 2 x 250 MW Barauni (Extension) Thermal Power Project, November 2013.

[16] Coal Directory of India, 2011-12, Coal Statistics, Government of India, Ministry of Coal, Coal Controller's Organization, Kolkata

[17] http://www.easterncoal.gov.in/corporate.html

[18] C.E. Testing Company Pvt. Ltd., Geotechnical Investigation Work For 2 x 250 MW Units at Barauni TPS, PH-II Bihar Part I – BTG Area, (October 2011)

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[19] Indian Meteorological Department (Ministry of Earth Sciences, Govt. of India), http://www.imd.gov.in/doc/climateimp.pdf

[20] DPR for 2 x 250 MW Coal Based Extension TPS at Barauni, District Begusarai in Bihar, prepared by DCPL.

[21] Prepared by JICA Study Team based upon ERLDC Power Grid Map with modification of related transmission system plans

[22] The Gazette of India: Extraordinary, [Part III, Sec.3, Sub-section (i)], GoI, Ministry of Environment, Forest and Climate Change Notification, http://www.moef.nic.in/sites/default/files/draft%20Notification%20forinviting%20the%20public%20comments%20for%20the%20Coal%20BTPP.pdf

[23] MoEF, Environmental (Protection) Rules, Amendment Rules, 2015

[24] MoEF / CPCB, notification S.O. 384 (April 1994) / S.O. 935 (October 1998)

[25] MoEF, Environmental (Protection) Rules, Schedule - III (1986)

[26] IFC, EHS Guidelines (Thermal Power Plants) (December 2008)

[27] Executive Summary, Power Sector March 2015, Issued by GoI, Ministry of Power, CEA New Delhi

[28] CEA, Review of progress of Thermal Power Projects under execution in the Country, 150th Quarterly Review (Jan to March, 2015)

[29] Generation Business Plan, Business plan for the State of Bihar Power Generating Company for Control Period from FY 2013-14 to FY 2015-16

[30] CEA, Standard Technical Features of BTG system for supercritical 660/800 MW Thermal Units

[31] Load Generation, Balance Report 2015-16 from GoI, Ministry of Power, CEA.

[32] Annual Report (2013-14) on The Working of State Power Utilities & Electricity Department, (Power & Energy Division) Planning Commission, GoI, February' 2014.

[33] CEA, Report on the Land Requirement of Thermal Power Stations, GoI (Ministry of Power), CEA, December 2007.

[34] CERC guideline (No.L-7/145(160)/2008-CERC, January 2009).

[35] CEA, Advisory issued by CEA for Design of new boilers for Blend Ration of 30:70 (or higher) imported/high GCV coal: indigenous coal http:// www.cea.nic.in/reports/articles/thermal advisory_blended_coal.pdf

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LIST OF DRAWINGS

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LIST OF DRAWINGS

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1. PLOT PLAN

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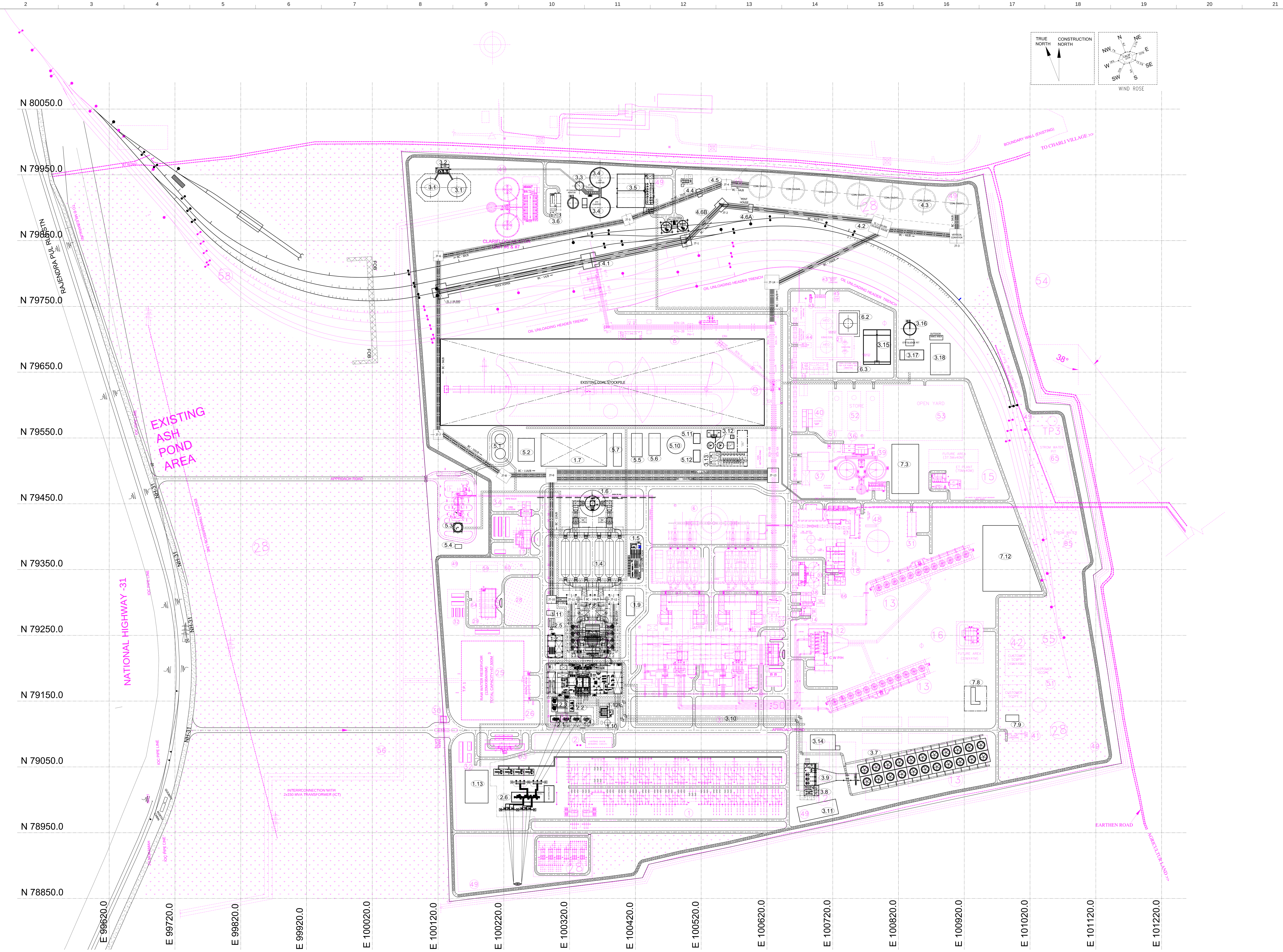

SL.NO.	BUILDING/STRUCTURE DESCRIPTION	SIZE OF STRUCTURE	CAPACITY	REMARKS
1.0	**POWER BLOCK AREA**			
1.1	TG BUILDING	115 M x 46 M	-	
1.2	TG CENTERAL CONTROL ROOM BUILDING	43 M x 23 M	-	
1.3	BOILER, MILLS, FD/PA FANS	92 M x 76 M		
1.4	ESP	69 M x 95M	-	
1.5	ESP CONTROL ROOM	52 M x 15 M	-	
1.6	CHIMNEY	275 M HEIGHT	-	
1.7	SPACE FOR FGD	50M x 100M	-	
1.8	MILL REJECT SILO	DIA 4.5M	-	
1.9	PLANT AIR COMPRESSOR BUILDING & MILL REJECT COMPRESSORS	30 M 12M	-	
1.10	CONDENSATE STORAGE TANK & PUMP AREA	DIA 10M x 11M	800 CuM	
1.11	FIRE WATER BOOSTER PUMP HOUSE	12 M x 7 M	-	
1.12	CLEAN & DIRTY LUB OIL TANK AREA	20 M x 16 M	-	
1.13	CPU REGENERATION PLANT	50 M x 35 M	-	
2.0	**SWITCHYARD & TRANSFORMER YARD AREA**			
2.1	GENERATOR TRANSFORMER & FOUNDATION	16 M x 11 M	-	
2.2	UNIT AUXILIARY TRANSFORMER & FOUNDATION	8 M x 6 M	-	
2.3	UNIT TRANSFORMER & FOUNDATION	11 M x 9 M	-	
2.4	SPARE GT & FOUNDATION	16 M x 11 M	-	
2.5	EMERGENCY DG SET	12 M x 10 M	-	
2.6	GIS SWITCH YARD & CONTROL BUILDING	74 M x 54 M	-	
3.0	**WATER SYSTEM**			
3.1	RAW WATER STORAGE TANKS (2 NOS)	DIA 28 M x 37 m ht	22000 Cu M	
3.2	RAW WATER PUMP HOUSE	40 M x 10 M	-	
3.3	CASCADE AERATOR & FOUNDATION	DIA.14 M	-	
3.4	RAW WATER CLARIFIER	DIA 30 M	-	
3.5	CLARIFIED WATER RESERVOIR & PUMP HOUSE (2 COMPT)	55 M x 25 M (EACH)	2 x 4600 Cu M	
3.6	CHEMICAL HOUSE AND ELECTRICAL & CONTROL ROOM	37 M x 16 M	-	
3.7	INDUCED DRAFT COOLING TOWER	200 M x 36 M	-	
3.8	CW PUMP HOUSE & ELECTRICAL ROOM	55 M x 25 M	-	
3.9	FOREBAY & CHANNEL	-	-	
3.10	CW CONDUITS	-	-	
3.11	CW SIDE STREAM FILTRATION PLANT	60 M x 23 M	-	
3.12	DM WATER STORAGE TANKS (2 NOS)	DIA. 9 M x 10 M ht	2 x 600 Cu M	
3.13	DM PLANT AREA	70 M x 50 M	2 X 60 CuM/Hr	
3.14	CHLORINATION PLANT	38 M x 23 M	-	
3.15	ETP- COMMON MONITORING BASIN (2 COMPT)	40 M X 20 M (EACH)	2 x 2600 Cu M	
3.16	ETP- CLARIFIER	DIA 18 M	-	
3.17	ETP- STORAGE TANK	29 M x 15 M	1300 Cu M	
3.18	EFFLUENT RECYCLING SYSTEM (ERS) BUILDING & PUMP AREA	36 M x 17 M	-	
4.0	**COAL HANDLING PLANT**			
4.1	TRACK HOPPER	260 M x 22 M	4000 Tons	
4.2	CRUSHER HOUSE	30 M x 20 M	-	
4.3	COAL SILO (7 NOS)	DIA 33 M x 48 M HT	33000 Tons	
4.4	CHP MCC / CONTROL ROOM	18 M x 12 M	-	
4.5	JUNCTION TOWER	VARIES	-	
4.6	PENT HOUSE (A & B)	12.5 M x 7 M	-	
55	LOCO SHED			EXISTING
5.0	**ASH HANDLING PLANT**			
5.1	HCSD SILO (2 NOS)	DIA 16 M x 28 M ht	1500 TON	
5.2	HCSD PUMP HOUSE & MCC ROOM	35 M x 25 M	-	
5.3	DRY ASH SILO (1 NO)	DIA 16 M x 28 M ht	1500 TON	
5.4	DRY ASH SILO UTILITY BUILDING	10 M x 6 M	-	
5.5	ASH SLURRY PUMP HOUSE	35 M x 16 M	-	
5.6	ASH WATER TANK & PUMP HOUSE	33 M x 17 M	-	
5.7	AHP COMPRESSORS & VACUUM PUMP BUILDING	50 M x 12 M	-	
5.8	ASH POND	290 ACRES	-	EXISTING
5.9	ASH WATER RECOVERY PUMP HOUSE	13 M x 7 M	-	IN ASH POND AREA
5.10	ASH WATER CLARIFIER	DIA. 27 M	750 Cu M/Hr.	
5.11	CHEMICAL HOUSE FOR AWRS	18 M x 10 M	-	
5.12	CLARIFIED WATER STORAGE TANK FOR AWRS	15 M x 10 M	-	
6.0	**FUEL OIL SYSTEM**			
21	HFO TANKS (2 NOS)		3000 CuM	EXISTING
	LDO TANKS (2 NOS)		250 CuM	EXISTING
6.2	LDO TANK (1 NO)		2500 CuM	
6.3	HFO & LDO FORWARDING PUMP HOUSE	32 M x 20 M	-	
7.0	**NON-PLANT BUILDING**			
20	SERVICE BUILDING			EXISTING
31	WORKSHOP			EXISTING
7.3	STORES			
17	CANTEEN			EXISTING
34	FIRE STATION			EXISTING
63	WEIGH BRIDGE			EXISTING
7.9	SEWAGE TREATMENT PLANT	20 M x 10 M	-	
7.10	H2 GENERATION PLANT	63 M x 37 M	2 x 6 NM3/Hr.	
50	RAIN WATER HARVESTING FACILITY			EXISTING
7.12	OPEN YARD			
32	PARKING SPACE			EXISTING
-	MAIN GATE			EXISTING
30	TIME OFFICE & SECURITY OFFICE			EXISTING
49	WATCH TOWER			EXISTING

REFERENCE CLIENT CAD DATA

DRAWING NO.	REV. NO
PE-DG-374-100-M001	R07 (20.02.2014)
RITES/KOL/BTPS/ BARAUNI-000/13	- (NOVEMBER, 2013)

NOTES ;-

1. GRIDS SHOWN ARE IN METERS.
2. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE INDICATED
3. ALL BUILDING & STRUCTURE SIZES AND LOCATION ARE TENTATIVE SHALL BE CONFIRMED DURING DETAIL ENGINEERING.
4. LAYDOWN, STORAGE, PRE-ASSEMBLY AREA SHALL BE LOCATED OUTSIDE PLANT BOUNDARY.

LEGENDS

EXISTING PLANT FACILITIES
PROPOSED 1X660MW PLANT FACILITIES
EXISTING ROAD AND BOUNDARY WALL
GREEN AREA
PIPE RACK
PIPE SLEEPER

FOR DETAILED PROJECT REPORT

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

REVISIONS	
REV. NO.	–
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APPROVED BY	–
CHECKED BY	–
REVISED BY	–
CONTENTS	–

DRAWING SCALE: NTS
UNITS: MM

APPROVED BY	CHECKED BY
– 18/08/2015	– 18/08/2015
DESIGNED BY	DRAWN BY
– 18/08/2015	– 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

TITLE: PLOT PLAN

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO. 1/1

REV.NO. 0

A0 (841mm x 1189mm)

2. WATER BALANCE DIAGRAM

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Sr. No.	Parameters	Data	Unit	Basis / Remarks
1	BMCR	1995	TPH	HMBD
2	Heat cycle makeup	1.5% of BMCR	%	As per standard industry practise; followed by NTPC also
3	Condenser cooling water flow rate	71000	m^3/hr	HMBD
4	BTG + BOP Auxiliaries cooling water flow rate	4500	m^3/hr	Reference Project of same capacity
5	Cold water temperature	33	°C	HMBD
6	Hot water temperature	42	°C	HMBD
7	Cooling tower range	9	°C	Sr. No. (6) - (5)
8	Design ambient wet bulb temperature	28.5	°C	Site meteorological data
9	Recirculation Allowance	0.5	°C	Reference Project of same capacity
10	Design inlet wet bulb temperature	29	°C	Sr. No. (8) + (9)
11	Cooling tower approach	4	°C	Sr. No. (10) - (5)
12	Annual mean relative humidity	52	%	Site meteorological data
13	Maximum flow rate per cell of cooling tower	4000	m^3/hr	Based on maximum fan dia (10 m) commonly available with all cooling tower vendors and their recommendations
14	No. of working cells in cooling tower	20	Nos.	Based on criteria specified in Sr. No. 13
15	No. of standby cells for single air inlet cell of cooling tower	2	Nos.	CEA Guidelines (Page 6-8)
16	Storage capacity of DM water storage tank	24	hr	CEA Guidelines (Page 5-23)
17	Side stream filtration flow rate	2% of CW + ACW flow	%	CEA Guidelines (Page 6-6)

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UNITS: N/A

APPROVED BY: – 18/08/2015
CHECKED BY: – 18/08/2015
DESIGNED BY: – 18/08/2015
DRAWN BY: – 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

TITLE: FLOW DIAGRAM FOR PLANT WATER WATER BALANCE DIAGRAM

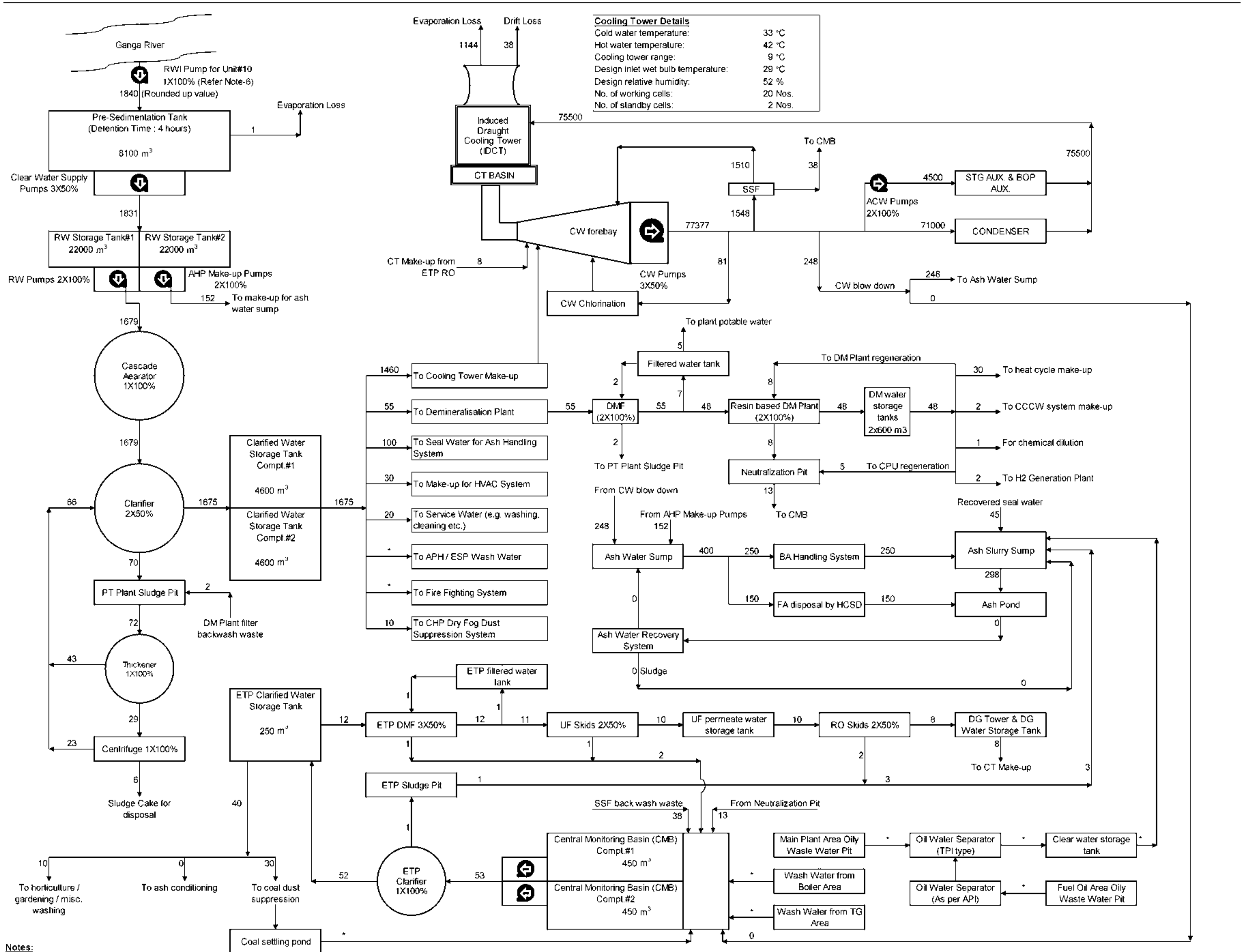
PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO.

1/5

REV.NO. 0

A1 (594mm x 841mm)



Notes:

1) This WBD is for 1X660 MW requirement.
2) All flow rates are in m3/hr.
3) * indicates intermittent flow rate and hence not considered for water balance.
4) Case-1: Wet BA + Wet FA by HCSD System without recovery from Ash Pond.
5) Cycle of concentration (COC) considered for CW System is 5.
6) Total 4 pumps will be installed at RWI Pump House. One Pump is common for Unit # 6 & 7. Second Pump is common for Unit # 8 & 9. Third Pump is dedicated to Unit # 10 and Fourth Pump is common standby for all units (Unit # 6 to 10).

Legends:				
RWI : River Water Intake	PT : Pre-Treatment	BOP : Balance of Plant	DMF : Dual Media Filter	API : American Petroleum Institute
RW : Raw Water	DM : Demineralisation	CW : Circulating Water	UF : Ultra Filtration	BA : Bottom Ash
AHP : Ash Handling Plant	ETP : Effluent Treatment Plant	ACW : Aux. Cooling Water	RO : Reverse Osmosis	FA : Fly Ash
CPU : Condensate Polishing Unit	CT : Cooling Tower	DG : Degassed	HCSD : High Concentrated Slurry Disposal	
CHP : Coal Handling Plant	STG : Steam Turbine & Generator	SSF : Side Stream Filtration	TPI : Tilted Plate Interceptor	CCCW : Closed Cycle Cooling Water

FOR DETAILED PROJECT REPORT

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PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

APPROVED BY: – 18/08/2015
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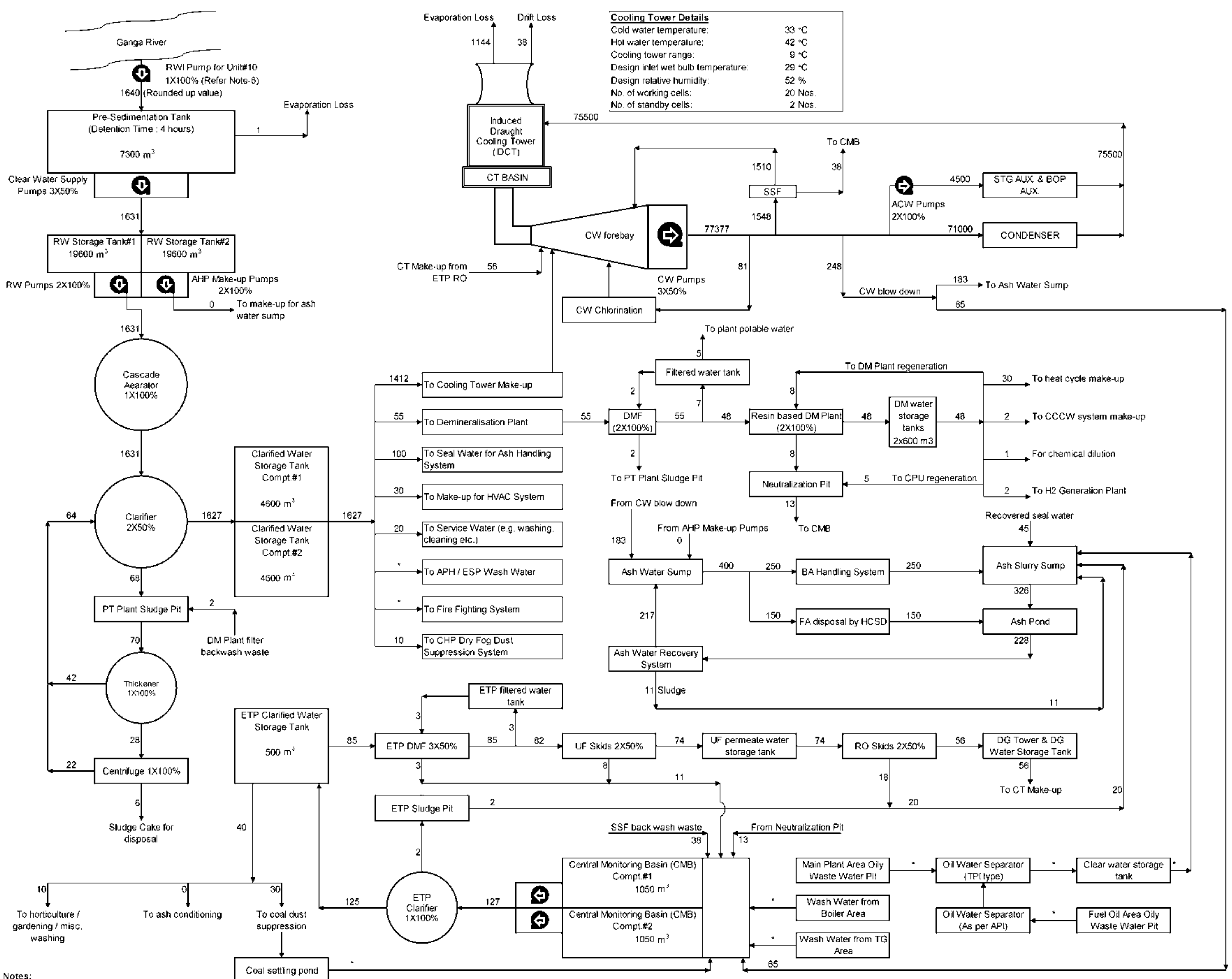
DESIGNED BY: – 18/08/2015
DRAWN BY: – 18/08/2015
DRAWING SCALE: NTS
UNITS: N/A

REV. NO. / DATE / APPROVED BY / CHECKED BY / REVISED BY / CONTENTS — REVISIONS

KYUSHU ELECTRIC POWER CO., INC.

DWG. NO. 2/5 REV.NO. 0

A1 (594mm x 841mm)



Notes:

1) This WBD is for 1X660 MW requirement.
2) All flow rates are in m3/hr.
3) * indicates intermittent flow rate and hence not considered for water balance.
4) Case-2: Wet BA + Wet FA by HCSD System with recovery (70%) from Ash Pond.
5) Cycle of concentration (COC) considered for CW System is 5.
6) Total 4 pumps will be installed at RWI Pump House. One Pump is common for Unit # 6 & 7, Second Pump is common for Unit # 8 & 9, Third Pump is dedicated to Unit # 10 and Fourth Pump is common standby for all units (Unit # 6 to 10).

Legends:

RWI : River Water Intake	PT : Pre-Treatment	BOP : Balance of Plant	DMF : Dual Media Filter	API : American Petroleum Institute
RW : Raw Water	DM : Demineralisation	CW : Circulating Water	UF : Ultra Filtration	BA : Bottom Ash
AHP : Ash Handling Plant	ETP : Effluent Treatment Plant	ACW : Aux. Cooling Water	RO : Reverse Osmosis	FA : Fly Ash
CHP : Coal Handling Plant	CPU : Condensate Polishing Unit	CT : Cooling Tower	DG : Degassed	HCSD : High Concentrated Slurry Disposal
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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: FLOW DIAGRAM FOR PLANT WATER WATER BALANCE DIAGRAM

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

APPROVED BY	18/08/2015
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DESIGNED BY	18/08/2015
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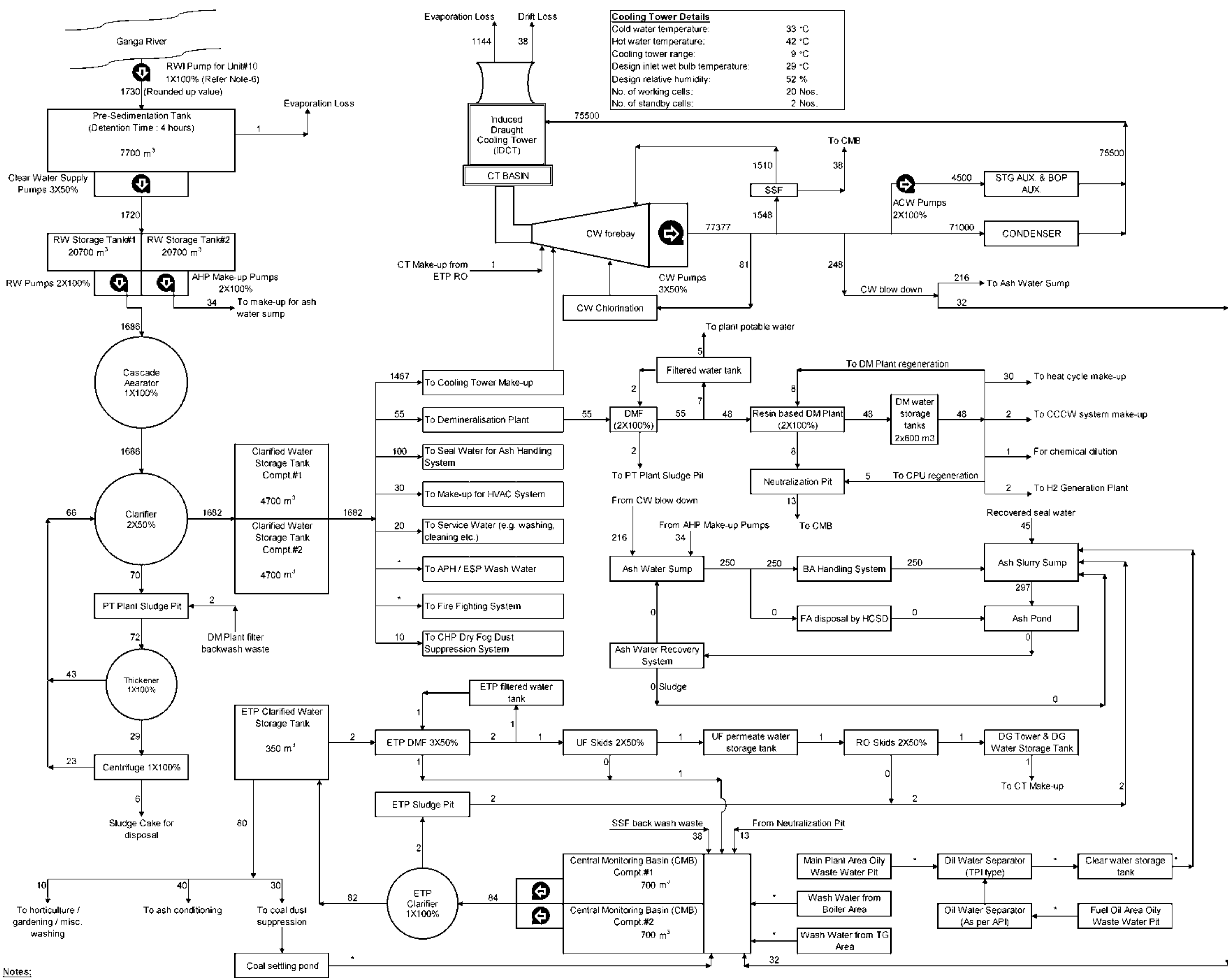
DRAWING SCALE	NTS
UNITS	N/A

KYUSHU ELECTRIC POWER CO., INC.

DWG. NO. 3/5 REV.NO. 0

A1 (594mm x 841mm)



Cooling Tower Details	
Cold water temperature:	33 °C
Hot water temperature:	42 °C
Cooling tower range:	9 °C
Design inlet wet bulb temperature:	29 °C
Design relative humidity:	52 %
No. of working cells:	20 Nos.
No. of standby cells:	2 Nos.

Notes:

1) This WBD is for 1X660 MW requirement.
2) All flow rates are in m3/hr.
3) * indicates intermittent flow rate and hence not considered for water balance.
4) Case-3: Wet BA + Dry FA System without recovery from Ash Pond.
5) Cycle of concentration (COC) considered for CW System is 5.
6) Total 4 pumps will be installed at RWI Pump House. One Pump is common for Unit # 6 & 7, Second Pump is common for Unit # 8 & 9. Third Pump is dedicated to Unit # 10 and Fourth Pump is common standby for all units (Unit # 6 to 10).

Legends:				
RWI : River Water Intake	PT : Pre-Treatment	BOP : Balance of Plant	DMF : Dual Media Filter	API : American Petroleum Institute
RW : Raw Water	DM : Demineralisation	CW : Circulating Water	UF : Ultra Filtration	BA : Bottom Ash
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CHECKED BY	– 18/08/2015
DESIGNED BY	– 18/08/2015
DRAWN BY	– 18/08/2015
DRAWING SCALE	NTS
UNITS	N/A
TITLE	FLOW DIAGRAM FOR PLANT WATER WATER BALANCE DIAGRAM
PROJECT	1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR
DWG. NO.	4/5
REV.NO.	0
	KYUSHU ELECTRIC POWER CO., INC.

REV. NO. | DATE | APPROVED BY | CHECKED BY | REVISED BY | CONTENTS | REVISIONS

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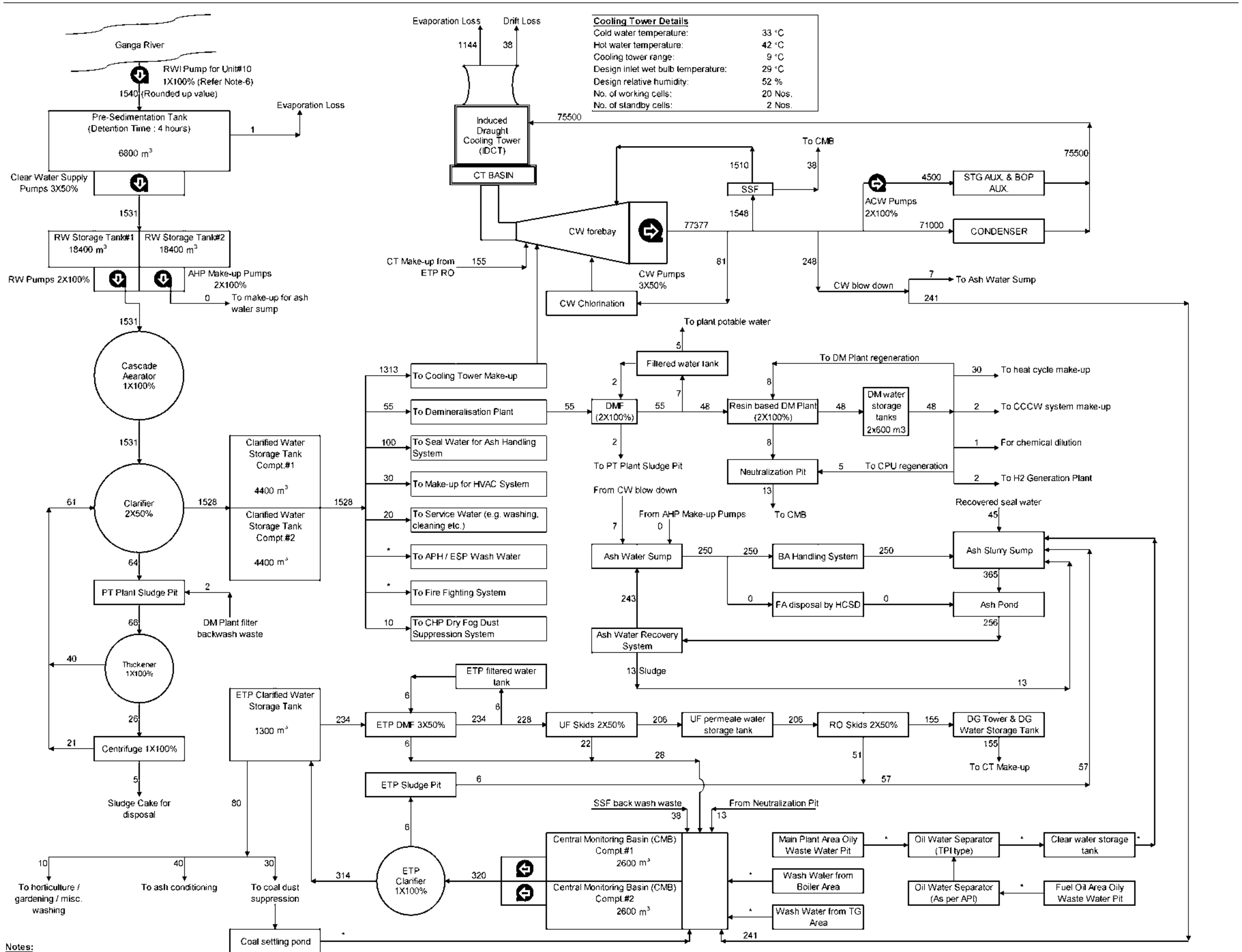

Cooling Tower Details	
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Notes:

1) This WBD is for 1X660 MW requirement.
2) All flow rates are in m3/hr.
3) * indicates intermittent flow rate and hence not considered for water balance.
4) Case-4: Wet BA + Dry FA System with recovery (70%) from Ash Pond.
5) Cycle of concentration (COC) considered for CW System is 5.
6) Total 4 pumps will be installed at RWI Pump House. One Pump is common for Unit # 6 & 7, Second Pump is common for Unit # 8 & 9, Third Pump is dedicated to Unit # 10 and Fourth Pump is common standby for all units (Unit # 6 to 10).

Legends:				
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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: FLOW DIAGRAM FOR PLANT WATER WATER BALANCE DIAGRAM

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DRAWING SCALE: NTS
UNITS: N/A
APPROVED BY: – 18/08/2015
CHECKED BY: – 18/08/2015
DESIGNED BY: – 18/08/2015
DRAWN BY: – 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

REV. NO. 0

A1 (594mm x 841mm)

3. PLANT FLOW DIAGRAM

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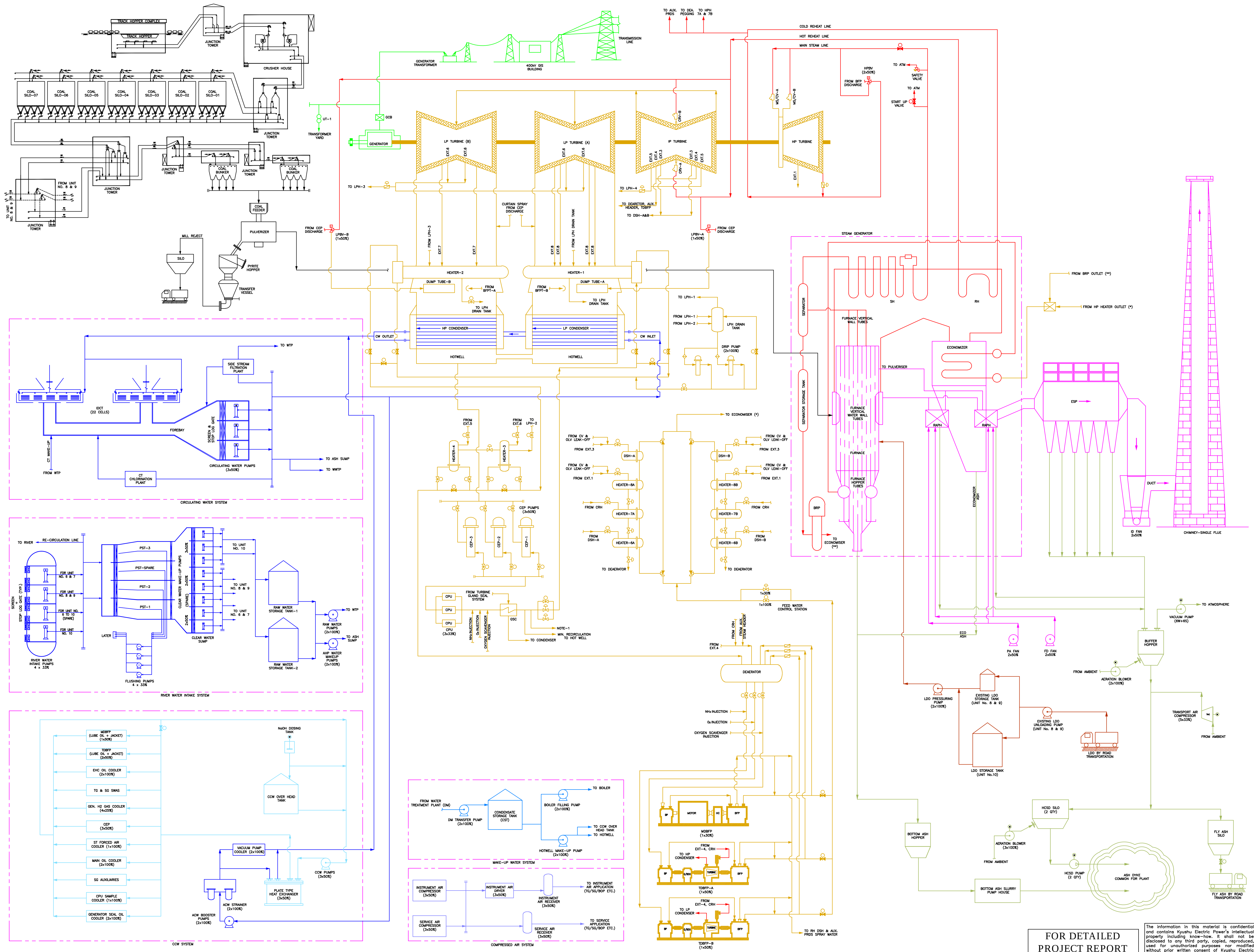

1. CRITICAL STEAM LINES & AUX STEAM SYSTEM
2. TURBINE CYCLE EQUIPMENTS & LINES
3. CIRCULATING WATER SYSTEM
4. MAKE-UP WATER SYSTEM
5. CLOSED COOLING WATER SYSTEM
6. BOILER & FLUE SYSTEM
7. ASH HANDLING SYSTEM
8. COAL HANDLING SYSTEM
9. FUEL OIL SYSTEM
10. POWER EVACUATION SYSTEM
11. COMPRESSED AIR SYSTEM

LEGENDS:

AUX.	–	AUXILIARY
ACW	–	AUXILIARY COOLING WATER
BP	–	BOOSTER PUMP
BRP	–	BOILER RECIRCULATION PUMP
BFP	–	BOILER FEED PUMP
CST	–	CONDENSATE STORAGE TANK
CPU	–	CONDENSATE POLISHING UNIT
CEP	–	CONDENSATE EXTRACTION PUMP
CCW	–	CLOSED COOLING WATER
CRH	–	COLD REHEAT
CRV	–	COLD REHEAT VALVE
CW	–	CIRCULATING WATER
DSH	–	DE-SUPERHEATER
DEA.	–	DEAERATOR
ESP	–	ELECTROSTATIC PRECIPITATOR
EXT.	–	EXTRACTION
FD	–	FORCED DRAFT
GSC	–	GLAND STEAM CONDENSER
GCB	–	GENERATOR CIRCUIT BREAKER
HP	–	HIGH PRESSURE
HPBV	–	HIGH PRESSURE BYPASS VALVE
HCSD	–	HIGH CONCENTRATED SLURRY DISPOSAL
HPH	–	HIGH PRESSURE HEATER
IDCT	–	INDUCED DRAFT COOLING TOWER
ID	–	INDUCED DRAFT
LPH	–	LOW PRESSURE HEATER
LP	–	LOW PRESSURE
LPBV	–	LOW PRESSURE BYPASS VALVE
MS/CV	–	MAIN STEAM STOP/CONTROL VALVE
MDBFP	–	MOTOR DRIVEN BOILER FEED PUMP
PLANT	–	2x110 MW + 2x250 MW + 1x660 MW
PA	–	PRIMARY AIR
PRDS	–	PRESSURE REDUCING & DE-SUPERHEATING
PST	–	PRE-SEDIMENTATION TANK
RH	–	REHEATER
RAPH	–	REGENERATIVE AIR PREHEATER
S	–	STANDBY
ST	–	STEAM TURBINE
SH	–	SUPERHEATER
TDBFP	–	TURBINE DRIVEN BOILER FEED PUMP
UT	–	UNIT TRANSFORMER
UNIT	–	1x660 MW
W	–	WORKING
WTP	–	WATER TREATMENT PLANT
WWTP	–	WASTE WATER TREATMENT PLANT

NOTE:

1. DEAERATOR FILLING, BOILER FILLING, TO AUX. STEAM PRDS, LP TURBINE BYPASS SPRAY.

FOR DETAILED PROJECT REPORT

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: PLANT FLOW DIAGRAM

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

REV. NO.	–
DATE	–
APPROVED BY	–
CHECKED BY	–
REVISED BY	–
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REVISIONS

DRAWING SCALE: NTS

UNITS: N/A

APPROVED BY	CHECKED BY
– 01/10/2015	– 01/10/2015
DESIGNED BY	**DRAWN BY**
– 01/10/2015	– 01/10/2015

KYUSHU ELECTRIC POWER CO., INC.

DWG. NO.

1/1

REV.NO. 0

A1 (594mm x 841mm)

4. FLOW DIAGRAM FOR COAL HANDLING PLANT

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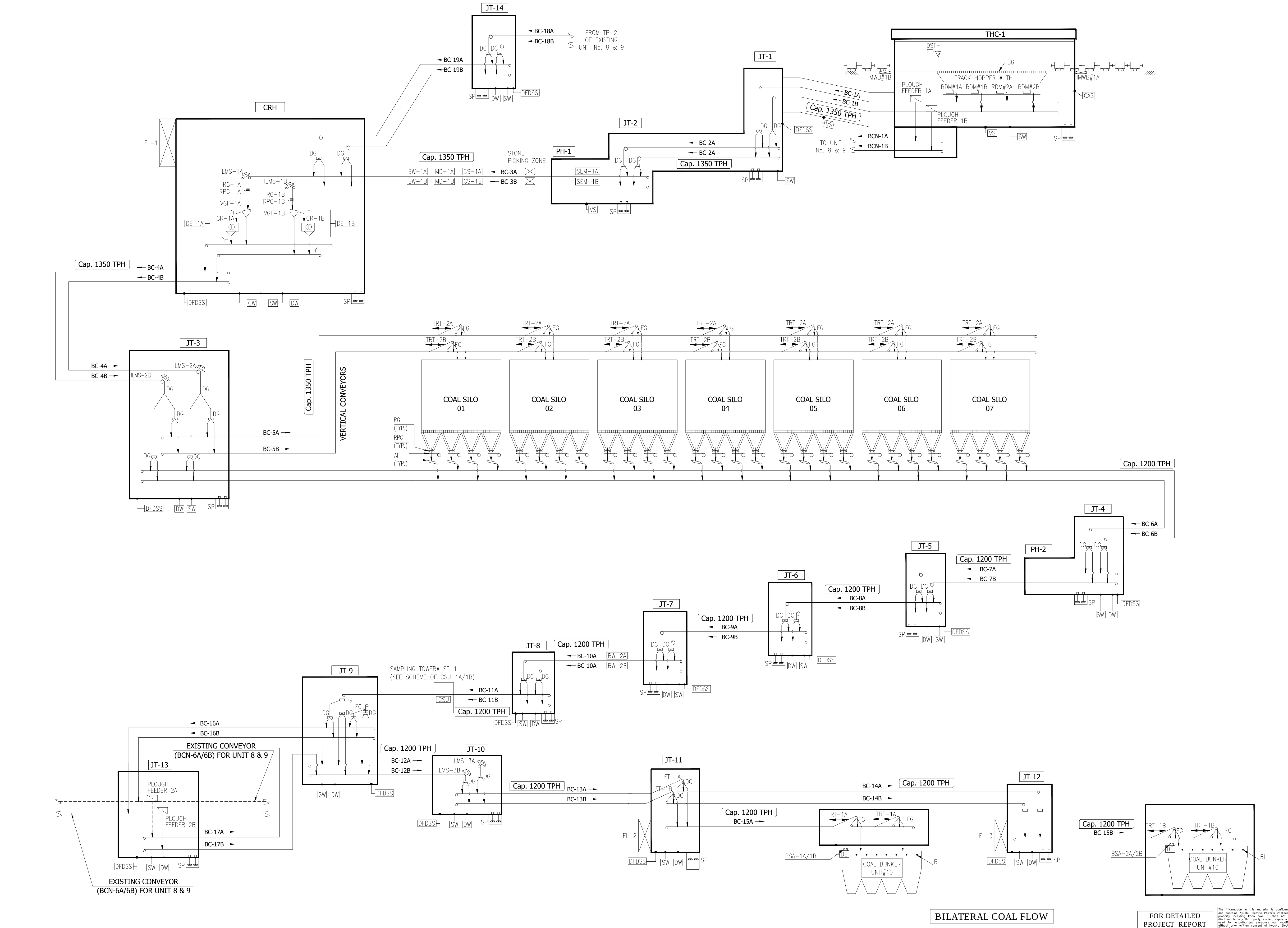


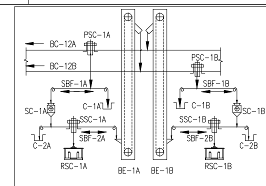
BILATERAL COAL FLOW

NOTES ;-

1. THE TECHNICAL PARAMETERS AS SHOWN SHALL BE FINALIZED DURING BASIC ENGINEERING.
2. BHEL DRAWING NO. IS-1-FL-660-100-M002 FLOW DIAGRAM OF CHP FOR UNIT NO. 8 & 9.

LEGENDS

AF	APRON FEEDER
BC	BELT CONVEYOR
BG	BAR GRID
BSA	BELT SEALING ARRANGEMENT
BLI	BUNKER LEVEL INDICATOR
CRH	CRUSHER HOUSE
CR	CRUSHER WITH BY-PASS FACILITY
CS	COAL SCOOPER
CSU	COAL SAMPLING SYSTEM
CCS	CRUSHED COAL STOCKPILE
CAS	COMPRESSED AIR SYSTEM FOR THC-1
CW	COOLING WATER
DFDSS	DRY FOG TYPE DUST SUPPRESSION SYSTEM
DF	DRIBBLE FEEDER
DST	DUST SUPPRESSION FOR TRACK HOPPER
DG	DIVERTOR GATE
DE	DUST EXTRACTION SYSTEM
DSPW	DUST SUPPRESSION SYSTEM FOR TIPPLER HOPPER
DW	DRINKING WATER
DS	DUST SUPPRESSION
EL	PASSENGER CUM GOODS ELEVATOR
EOT	CRANE
FT	FIXED TRIPPER
FG	FLAP GATE
ILMS	INLINE MAGNETIC SEPERATOR
IMWB	IN MOTION WEIGHT BRIDGE
JT	JUNCTION TOWER
MD	METAL DETECTOR
PH	PENT HOUSE
PSS	PRE SPRAY SYSTEM
PWDS	PLAIN WATER DUST SUPPRESSION SYSTEM FOR COAL STOCK PILES
RDM	ROTARY DISCHARGE MACHINE (PADDLE FEEDER)
RHC	RECLAIM HOPPER COMPLEX
RG	ROD GATE
RPG	RACK & PINION GATE
RBF	REVERSIBLE BELT FEEDER
SAC	SIDE ARM CHARGER
SP	SUMP PUMP
SR	STACKER CUM RECLAIMER MACHINE (BUCKET WHEEL TYPE)
SEM	SUSPENDED ELECTROMAGNET
SW	SERVICE WATER
THC	TRACK HOPPER COMPLEX
TH	TRACK HOPPER
TBC	TRIPPER BELT CONVEYOR
TRT	TRAVELING TRIPPER
VF	VIBRATING FEEDER
VGF	VIBRATING GRIZZLY FEEDER
VS	VENTILATION SYSTEM FOR TUNNEL / UNDER GROUND PORTION OF TRANSFER TOWER / HOPPER ET
WB	WEIGH BRIDGE
YBC	YARD BELT CONVEYOR



ITEM NO.	DESCRIPTION	REMARKS
PSC-1A/1B	PRIMARY SAMPLER	HAMMER TYPE
SBF-1A/1B	PRIMARY SAMPLE BELT FEEDER	REVERSIBLE TYPE
SC-1A/1B	SAMPLE CRUSHER	HAMMER MILL TYPE/EQU
SBF-2A/2B	SECONDARY SAMPLE BELT FEEDER	REVERSIBLE TYPE
SSC-1A/1B	SECONDARY SAMPLER	HAMMER TYPE
RSC-1A/1B	ROTARY SAMPLE COLLECTOR	TO COLLECT FINAL SAMP
BE-1A/1B	REJECTS BUCKET ELEVATOR	BELT TYPE
C-1A/1B	CAN FOR PRIMARY SAMPLE	--
C-2A/2B	CAN FOR SECONDARY SAMPLE	--

FLOW DIAGRAM FOR SAMPLING SYSTEM # CSU-1A/CSU-1B

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

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DRAWING SCALE: NTS	APPROVED BY: – 01/10/2015	CHECKED BY: – 01/10/2015
UNITS: N/A	DESIGNED BY: – 01/10/2015	DRAWN BY: – 01/10/2015

KYUSHU ELECTRIC POWER CO., INC.

TITLE: FLOW DIAGRAM FOR COAL HANDLING PLANT

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO.

1/1

REV.NO. 0

A0 (841mm x 1189mm)

5. FLOW DIAGRAM FOR ASH HANDLING PLANT

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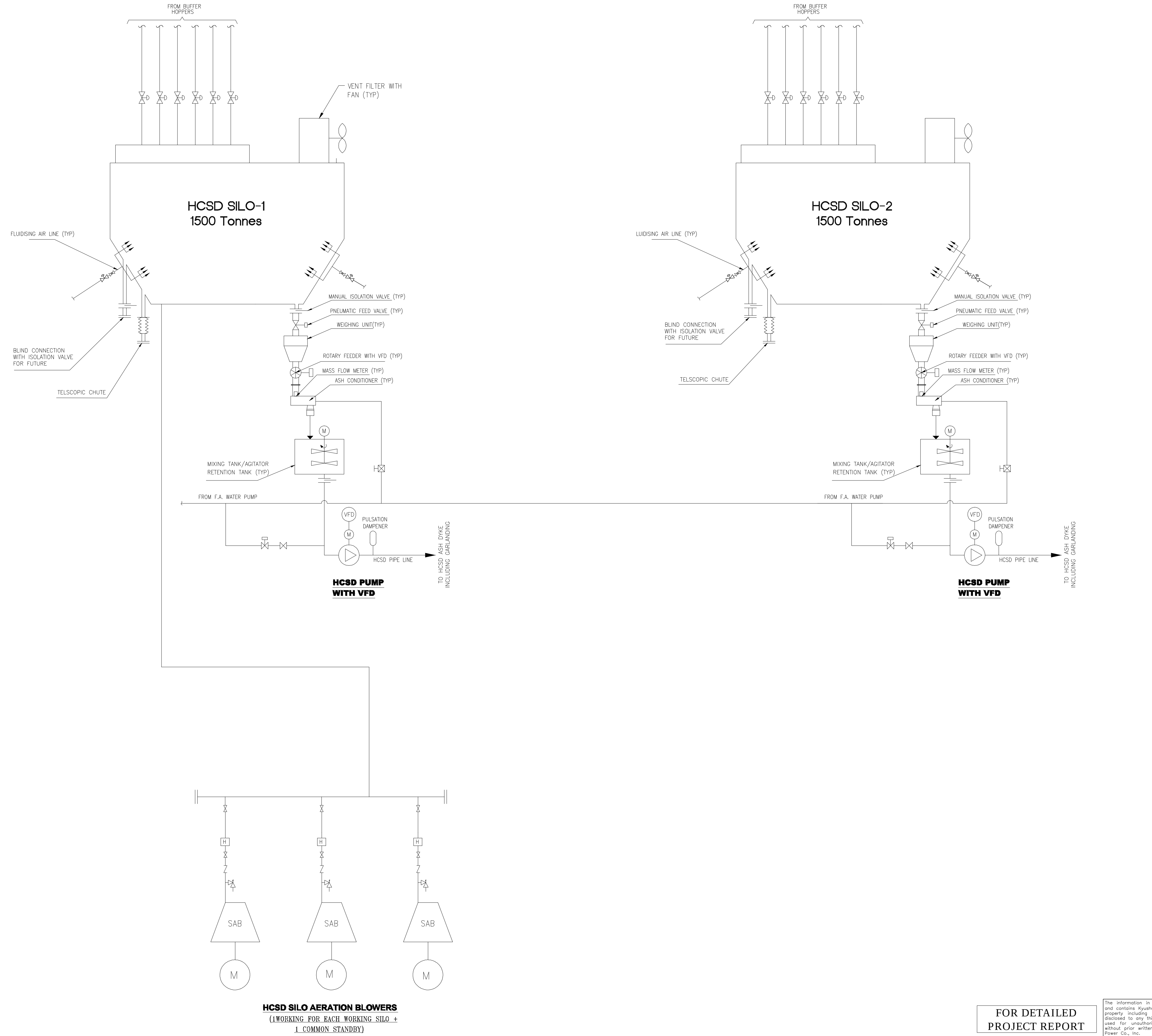

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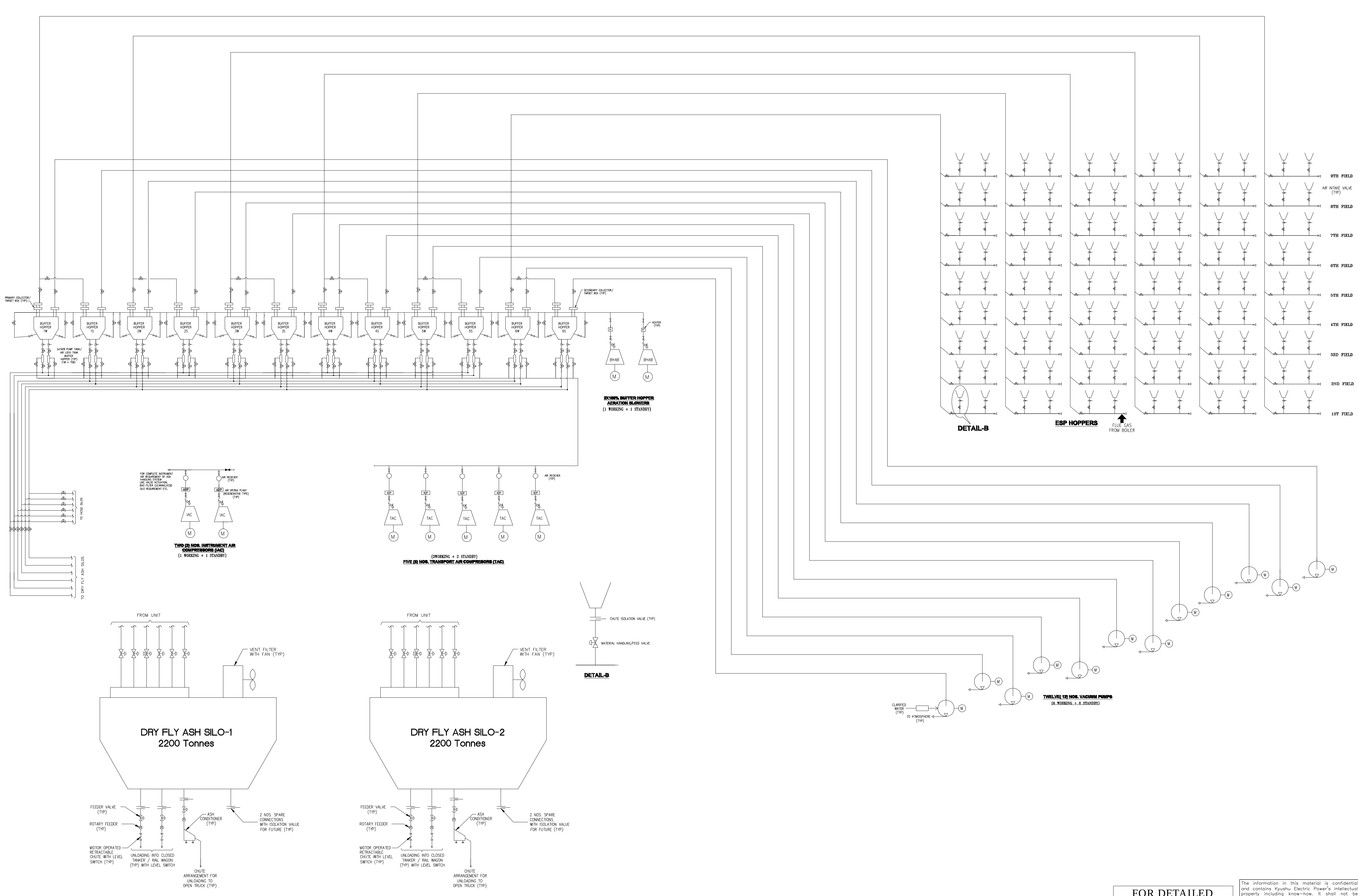
–	DATE				
–	APPROVED BY	UNITS: N/A	DESIGNED BY: – 01/10/2015	DRAWN BY: – 01/10/2015	PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR
–	CHECKED BY				
–	REVISED BY	REVISIONS			
–	CONTENTS	KYUSHU ELECTRIC POWER CO., INC.			DWG. NO. 1/1 REV.NO. 0

A1 (594mm x 841mm)



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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: **FLOW DIAGRAM FOR FLY ASH HANDLING SYSTEM**

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

REV. NO.	–
DATE	–
APPROVED BY	–
CHECKED BY	–
REVISED BY	–
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DRAWING SCALE	NTS
UNITS	N/A
APPROVED BY	– 01/10/2015
CHECKED BY	– 01/10/2015
DESIGNED BY	– 01/10/2015
DRAWN BY	– 01/10/2015

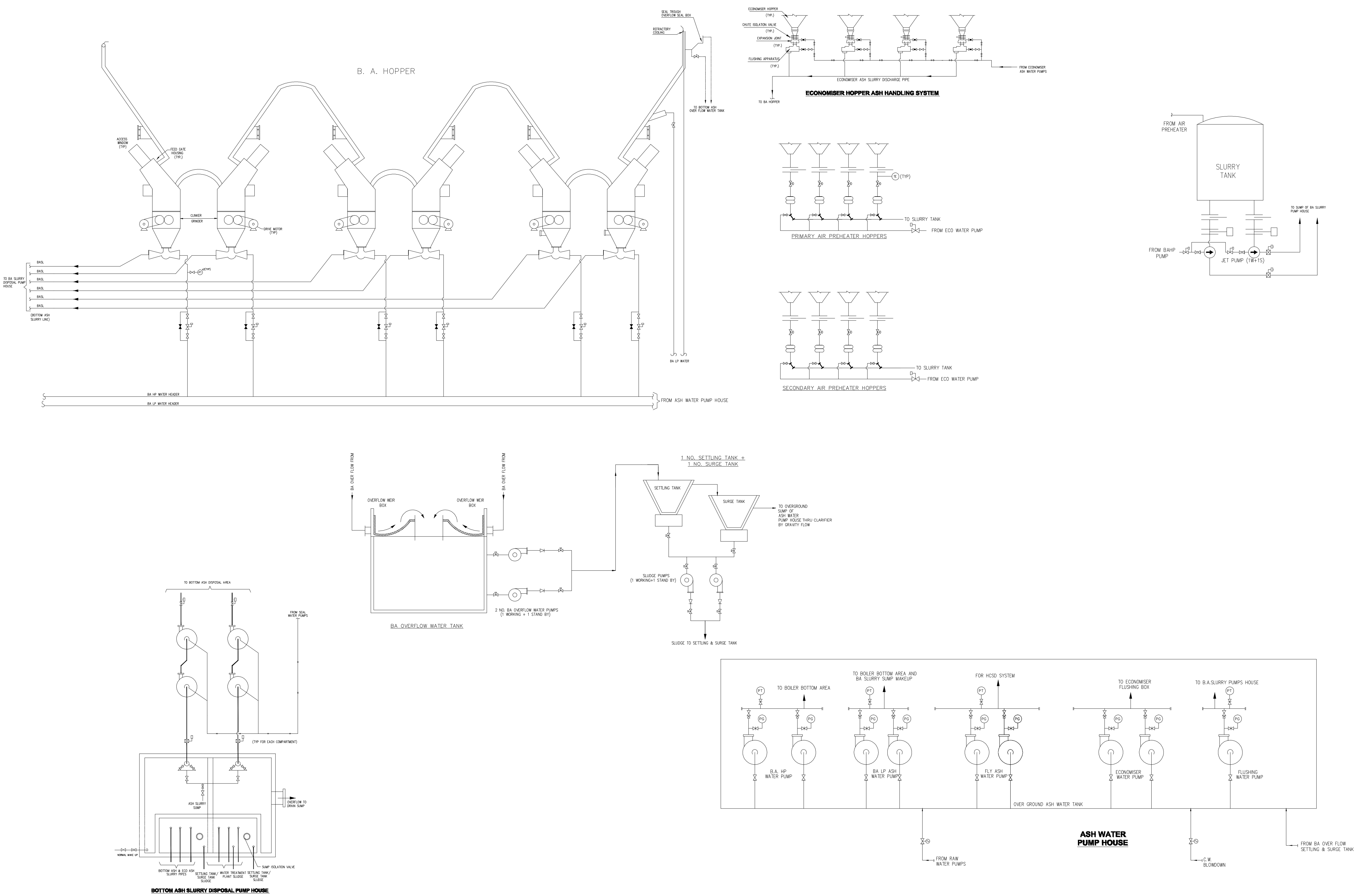
KYUSHU ELECTRIC POWER CO., INC.

DWG. NO.

REV.NO. 0

1/1

A1 (594mm x 841mm)



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APPROVED BY	–	DESIGNED BY – 09/09/2015	DRAWN BY – 09/09/2015
CHECKED BY	–	UNITS N/A	
REVISED BY	–		
CONTENTS	–	KYUSHU ELECTRIC POWER CO., INC.	

REVISIONS

TITLE: FLOW DIAGRAM FOR BOTTOM ASH HANDLING SYSTEM

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO. 1/1 REV.NO. 0

A1 (594mm x 841mm)

6. FLOW DIAGRAM FOR FUEL OIL HANDLING SYSTEM

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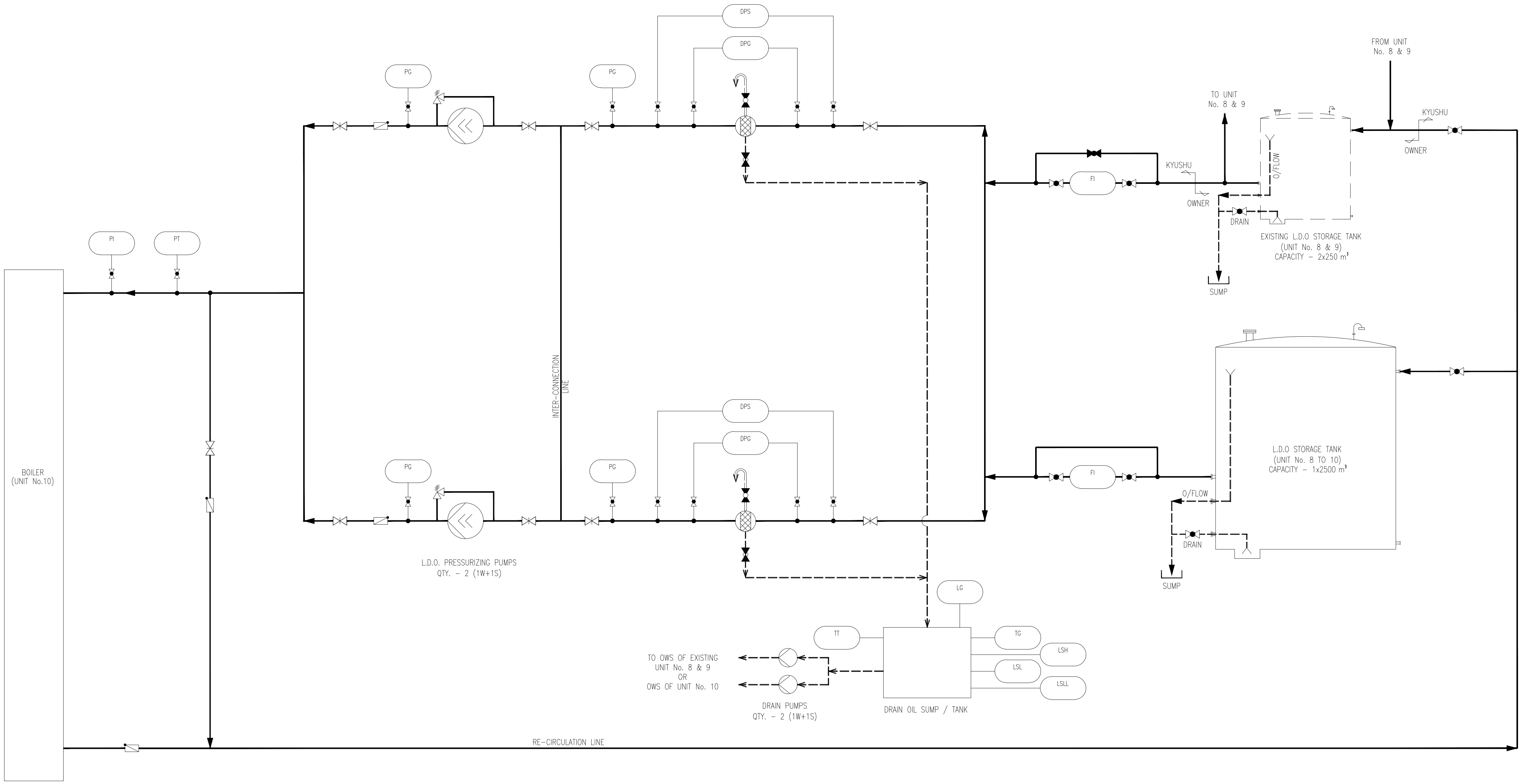

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APPROVED BY	–	DESIGNED BY – 01/10/2015	DRAWN BY – 01/10/2015
CHECKED BY	–	UNITS N/A	
REVISED BY	–		
CONTENTS	–	KYUSHU ELECTRIC POWER CO., INC.	

REVISIONS

TITLE: FLOW DIAGRAM FOR LIGHT DIESEL OIL TRANSFER SYSTEM

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO. 1/1

REV.NO. 0

A1 (594mm x 841mm)

7. FLOW DIAGRAM FOR COMPRESSED AIR SYSTEM

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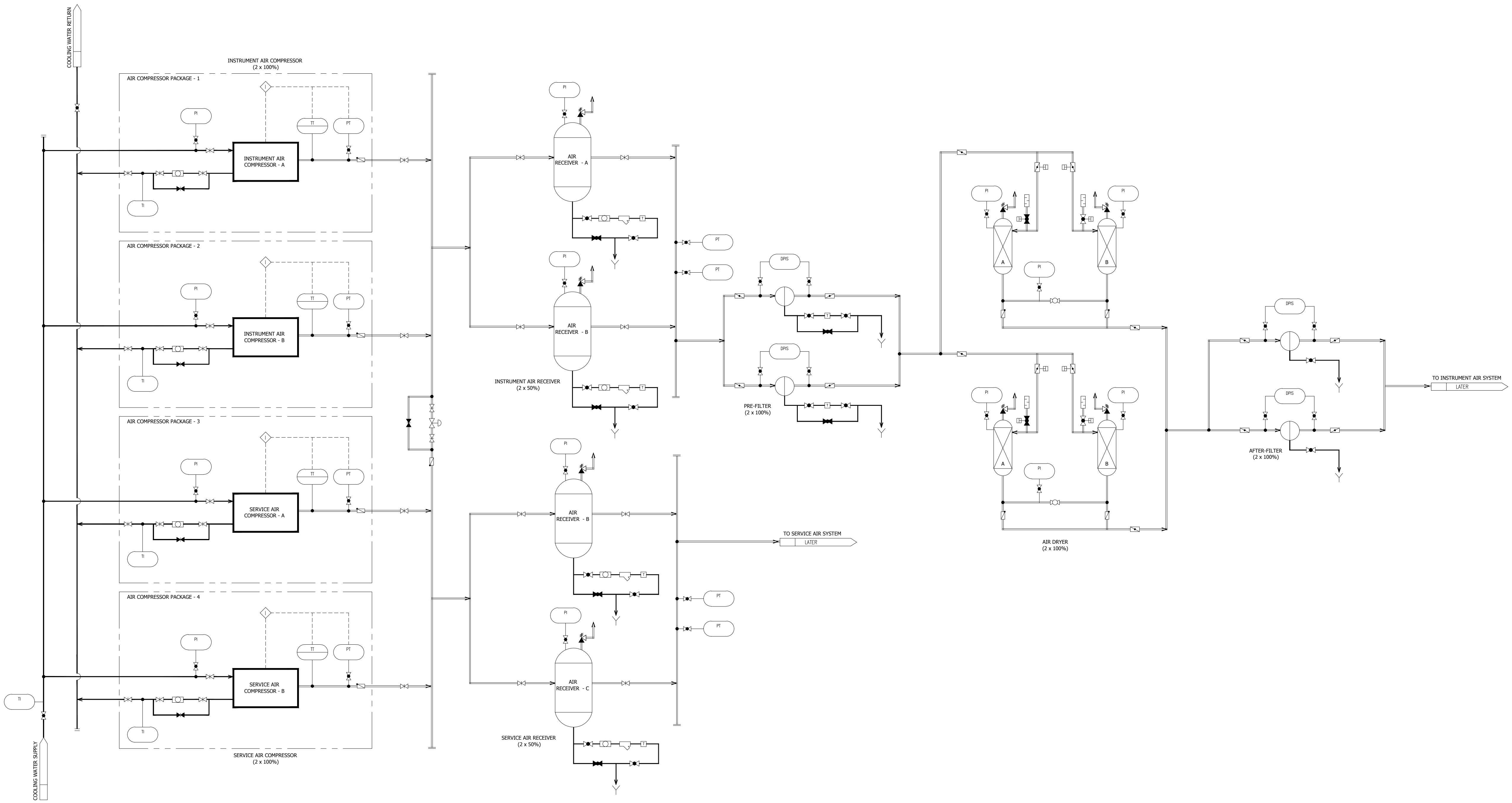

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: FLOW DIAGRAM FOR COMPRESSED AIR SYATEM

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

APPROVED BY	– 18/08/2015
CHECKED BY	– 18/08/2015
DESIGNED BY	– 18/08/2015
DRAWN BY	– 18/08/2015
DRAWING SCALE	NTS
UNITS	N/A

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KYUSHU ELECTRIC POWER CO., INC.

DWG. NO. 1/1 REV.NO. 0

A1 (594mm x 841mm)

8. FLOW DIAGRAM FROM RIVER WATER SUPPLY SYSTEM

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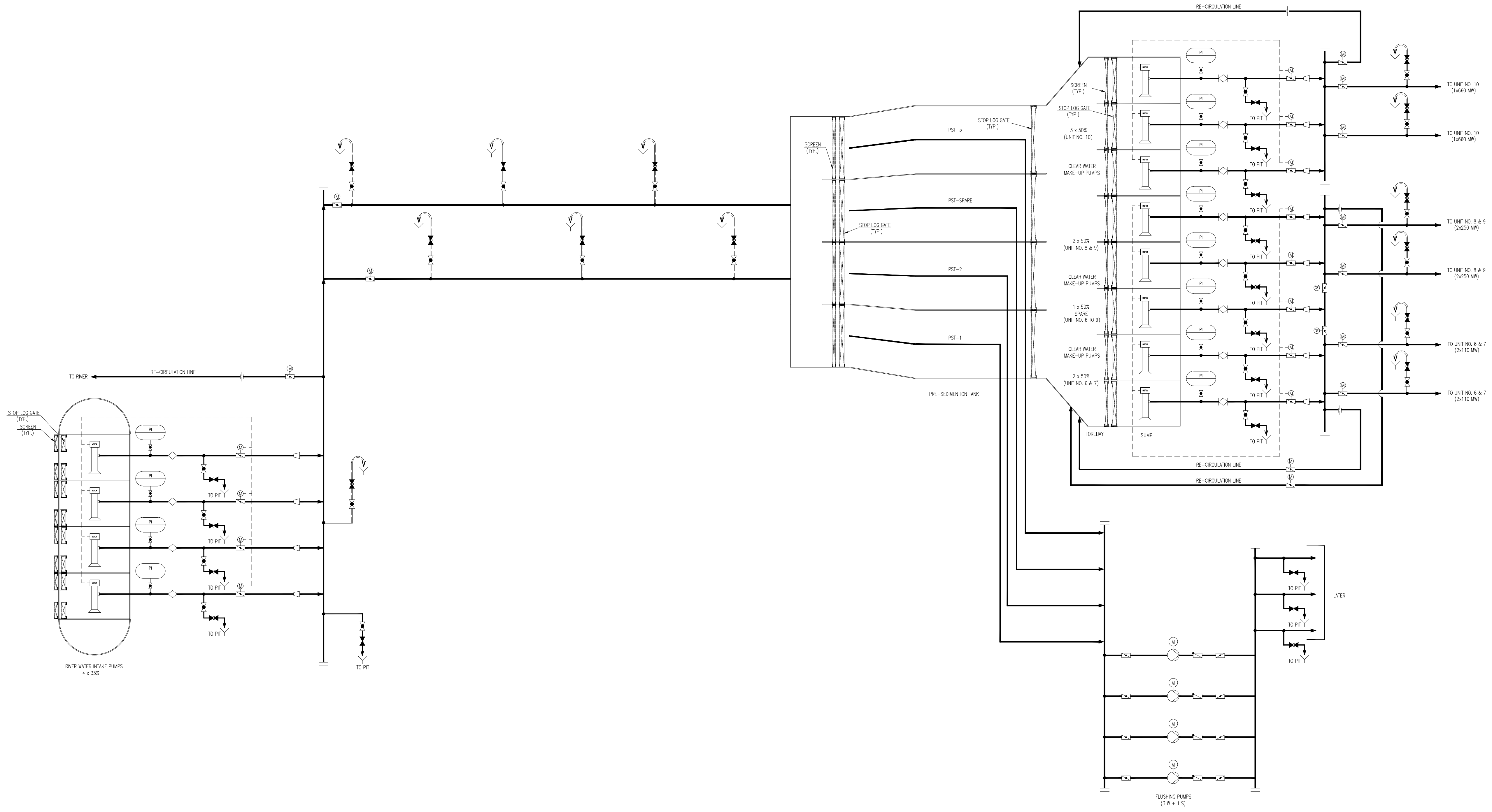

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DRAWING SCALE	NTS
UNITS	N/A
APPROVED BY	– 18/08/2015
CHECKED BY	– 18/08/2015
DESIGNED BY	– 18/08/2015
DRAWN BY	– 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: **FLOW DIAGRAM FOR RIVER WATER SUPPLY SYSTEM**

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO. 1/1

REV.NO. 0

A1 (594mm x 841mm)

9.FLOW DIAGRAM FOR PLANT WATER SYSTEM

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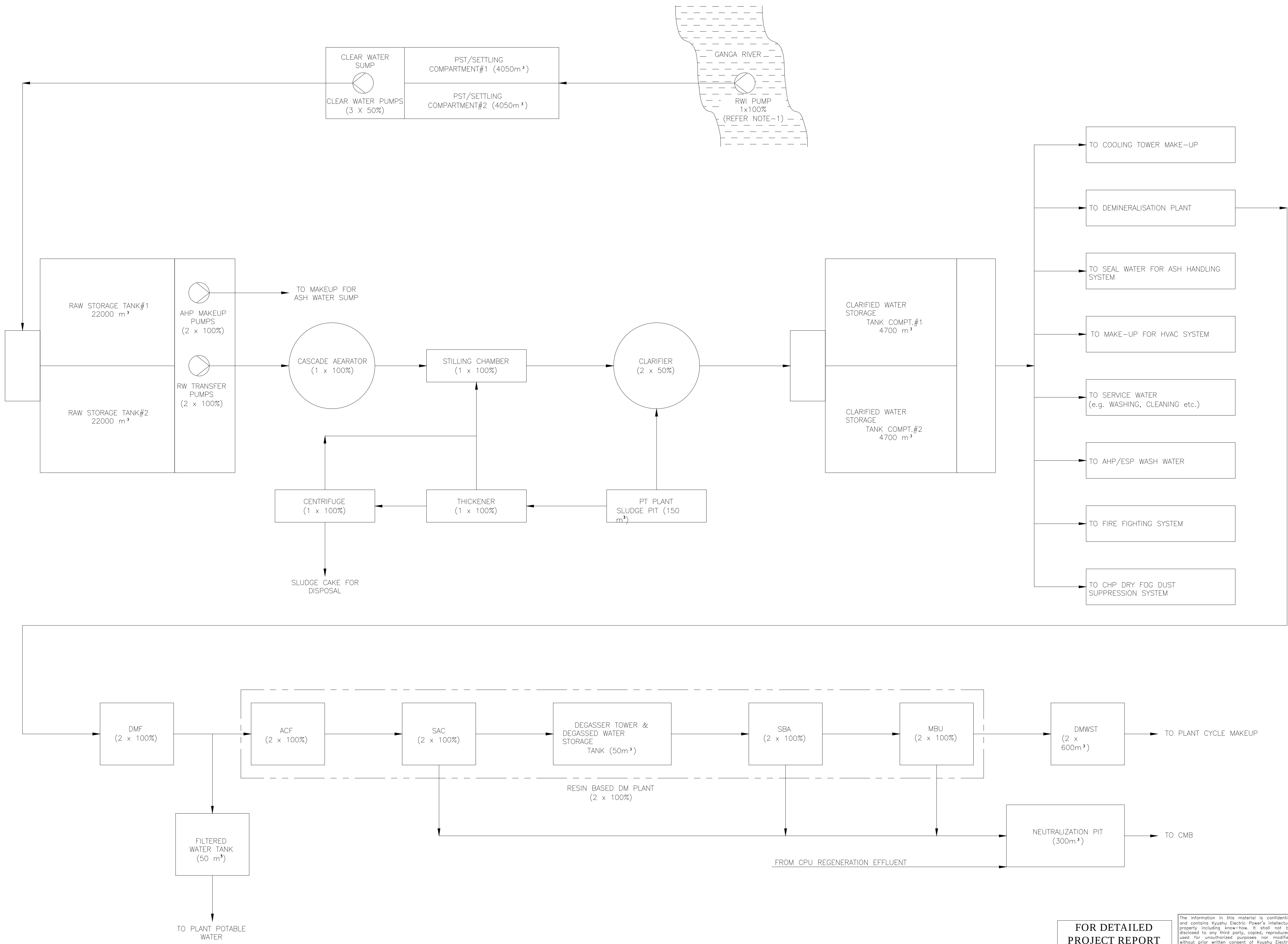

LEGENDS:

ACF	–	ACTIVATED CARBON FILTER
AHP	–	ASH HANDLING PLANT
APH	–	AIR PRE–HEATER
CHP	–	COAL HANDLING PLANT
CPU	–	CONDENSATE POLISHING UNIT
CMB	–	CENTRAL MONITORING BASIN
DMF	–	DUAL MEDIA FILTER
DMWST	–	DM WATER STORAGE TANK
DM	–	DEMINERALIZED
ESP	–	ELECTROSTATIC PRECIPITATOR
HVAC	–	HEAT VENTILATION AIR CONDITIONING
MBU	–	MIXED BED UNIT
PT	–	PRE–TREATMENT
PST	–	PRE–SEDIMENTATION TANK
RW	–	RAW WATER
RWI	–	RIVER WATER INTAKE
SAC	–	STRONG ACID CATION
SBA	–	STRONG BASE ANION

NOTE–1:

TOTAL FOUR PUMPS WILL BE INSTALLED AT RWI PUMP HOUSE.
ONE PUMP IS COMMON FOR UNIT # 6 & 7.
SECOND PUMP IS COMMON FOR UNIT # 8 & 9.
THIRD PUMP IS DEDICATED FOR UNIT # 10 AND
FOURTH PUMP IS COMMON STANDBY FOR ALL UNITS (UNIT # 6 TO 10).

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

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REVISIONS

DRAWING SCALE: NTS	APPROVED BY: – 18/08/2015	CHECKED BY: – 18/08/2015
UNITS: N/A	DESIGNED BY: – 18/08/2015	DRAWN BY: – 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

TITLE: **FLOW DIAGRAM FOR PLANT WATER SYSTEM**

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO. 1/1 REV.NO. 0

A1 (594mm x 841mm)

10. FLOW DIAGRAM FOR EFFLUENT TREATMENT PLANT

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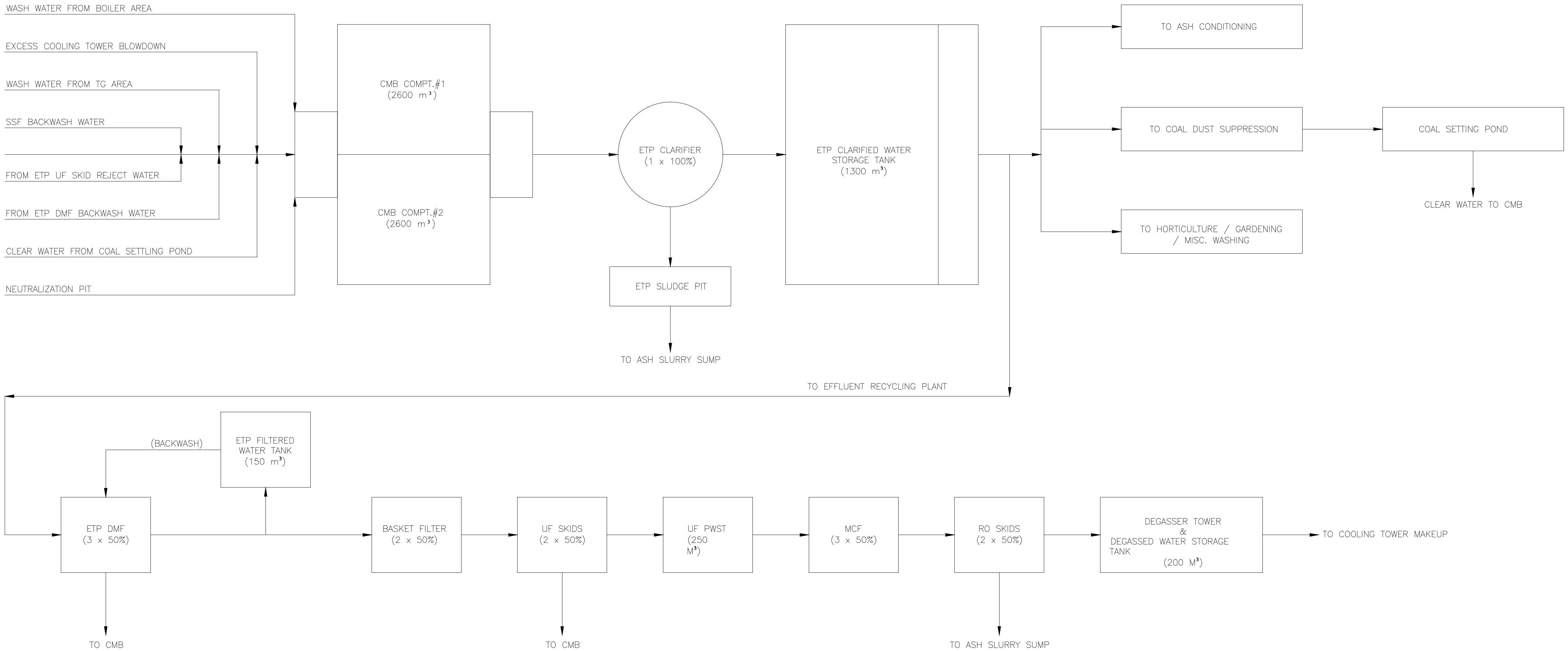
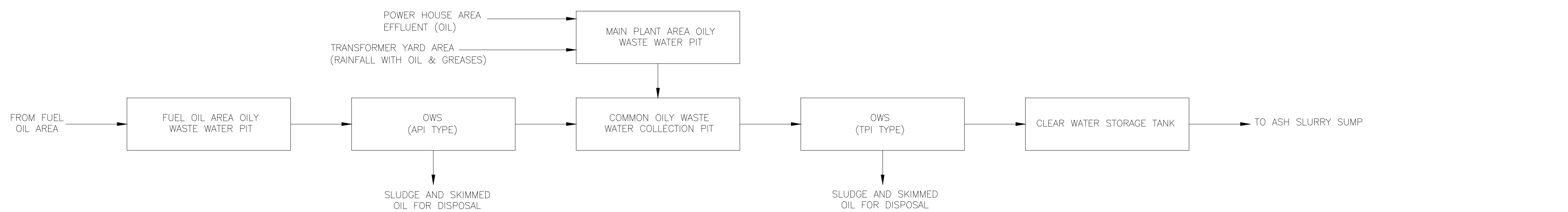


LEGENDS:

API	–	AMERICAN PETROLEUM INSTITUTE
CMB	–	CENTRAL MONITORING BASIN
CPU	–	CONDENSATE POLISHING UNIT
DMF	–	DUAL MEDIA FILTER
DG	–	DEGASSED
ETP	–	EFFLUENT TREATMENT PLANT
MCF	–	MICRON CARTRIDGE FILTER
OWS	–	OILY WATER SEPARATOR
PWST	–	PERMEATE WATER STORAGE TANK
RO	–	REVERSE OSMOSIS
SSF	–	SIDE STREAM FILTER
TPI	–	TILTED PLATE INTERCEPTOR
UF	–	ULTRA FILTRATION

OILY WASTE WATER TREATMENT SYSTEM:



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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

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REVISIONS

DRAWING SCALE: NTS
UNITS: N/A

APPROVED BY: – 18/08/2015
CHECKED BY: – 18/08/2015
DESIGNED BY: – 18/08/2015
DRAWN BY: – 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

TITLE: **FLOW DIAGRAM FOR EFFLUENT TREATMENT PLANT**

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO. 1/1

REV.NO. 0

A1 (594mm x 841mm)

11. FLOW DIAGRAM FOR FIRE DETECTION & PROTECTION SYSTEM

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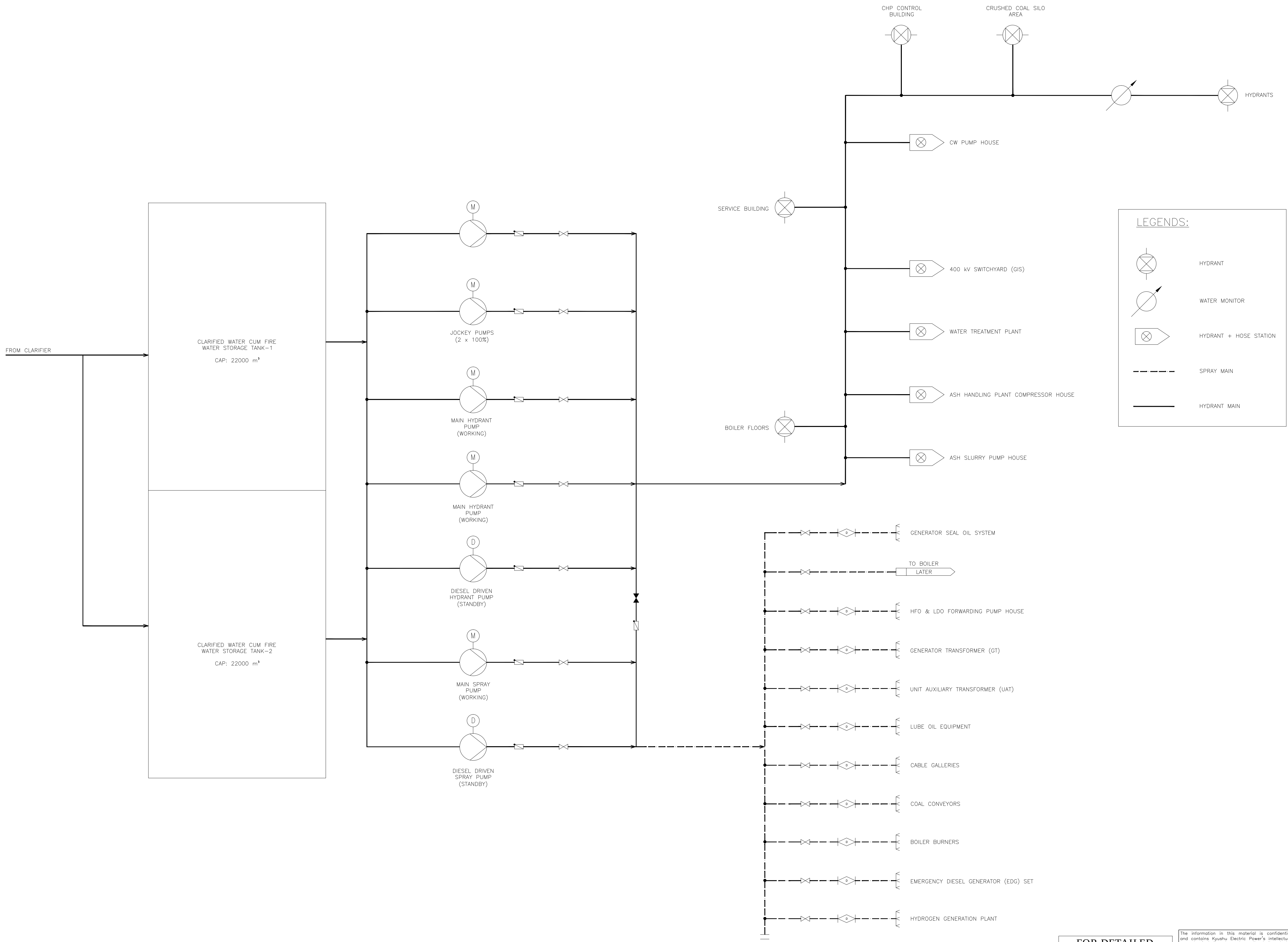

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UNITS: N/A

APPROVED BY	CHECKED BY
– 18/08/2015	– 18/08/2015
DESIGNED BY	**DRAWN BY**
– 18/08/2015	– 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

TITLE: **FLOW SCHEME FOR FIRE FIGHTING SYSTEM**

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO.

1/1

REV.NO. 0

A1 (594mm x 841mm)

12. BUILDING GA OF STG & AUXILIARIES

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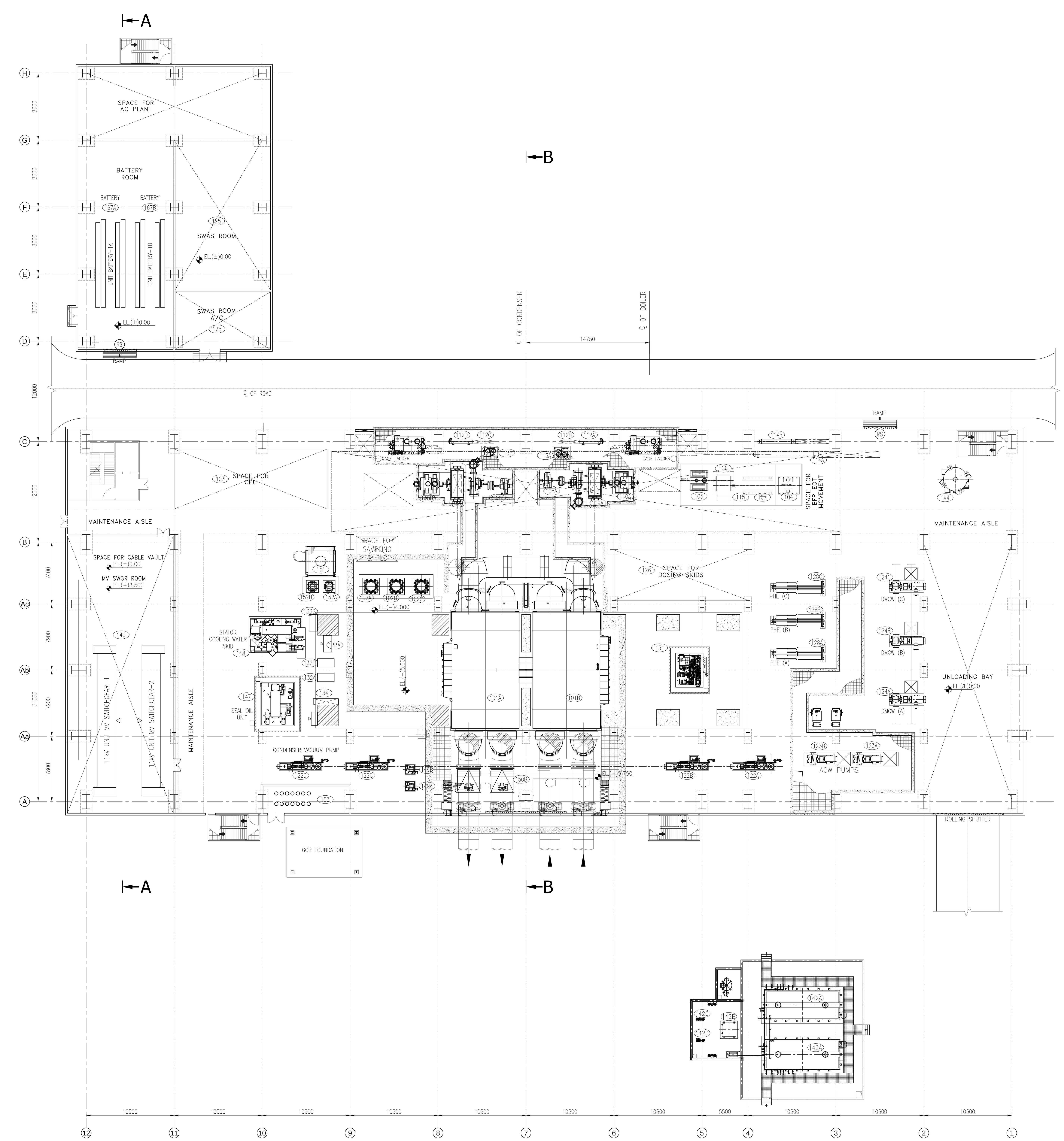

UNIT#10

GROUND FLOOR PLAN AT (FL+0.00M)

NORTH

TRUE NORTH

KEY PLAN

NOTES ;-
1. ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE INDICATED
2. ALL EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.
3. FACING CHIMNEY FROM LEFT TO RIGHT AND FROM ROW A TO C EQUIPMENT MARKING IS IN ORDER OF A, B, C
4. EL (±)0.000M CORRESPONDS TO FINISHED FLOOR LEVEL OF ST BUILDING WHICH CORRESPONDS TO RL (+) 478.30M

No.	EQUIPMENT NAME
101A	HP CONDENSER
101B	LP CONDENSER
102A	CONDENSATE EXTRACTION PUMP(A)
102B	CONDENSATE EXTRACTION PUMP(B)
102C	CONDENSATE EXTRACTION PUMP(C)
103	CONDENSATE POLISHING UNIT
104	MDBFP BOOSTER PUMP
105	MOTOR DRIVEN BOILER FEED WATER PUMP
106	MDBFP FLUID COUPLING
107	MDBFP MOTOR
108A	TDBFP (A) BOOSTER PUMP
108B	TDBFP (B) BOOSTER PUMP
109A	TURBINE BOILER FEED WATER PUMP (A)
109B	TURBINE BOILER FEED WATER PUMP (B)
110A	TURBINE DRIVEN BOILER FEED WATER PUMP (A)
110B	TURBINE DRIVEN BOILER FEED WATER PUMP (B)
111A	BFPT MAIN OIL TANK (A)
111B	BFPT MAIN OIL TANK (B)
112A	BFPT (A) MAIN OIL COOLER
112B	BFPT (B) MAIN OIL COOLER
112C	BFPT (C) MAIN OIL COOLER
112D	BFPT (D) MAIN OIL COOLER
113A	BFPT (A) LUBE OIL CONDITIONER
113B	BFPT (B) LUBE OIL CONDITIONER
114A	MBFP (A) WORKING OIL COOLER
114B	MBFP (B) LUBE OIL COOLER
122A	CONDENSER VACUUM PUMP UNIT(A)
122B	CONDENSER VACUUM PUMP UNIT(B)
122C	CONDENSER VACUUM PUMP UNIT(C)
122D	CONDENSER VACUUM PUMP UNIT(D)
123A	AUXILIARY COOLING WATER PUMP (A)
123B	AUXILIARY COOLING WATER PUMP (B)
124A	DM CLOSE COOLING WATER PUMP(A)
124B	DM CLOSE COOLING WATER PUMP(B)
124C	DM CLOSE COOLING WATER PUMP(C)
125	SWAS ROOM
126	COMMON DOSING SKID AREA
128A	DM COOLING WATER HEAT EXCHANGER (A)
128B	DM COOLING WATER HEAT EXCHANGER (B)
128C	DM COOLING WATER HEAT EXCHANGER (C)
131	EHC OIL UNIT
132A	GENERATOR SEAL OIL PUMP(A)
132B	GENERATOR SEAL OIL PUMP(B)
133A	H2 GAS MEASURING RACK
133B	H2 GAS PURITY METER
134	H2/SEAL OIL VALVE STATION
140	MV SWITCH GEAR ROOM
141	–
142A	COT/DOT TANKS
142B	COT/DOT TANK CENTRIFUGE
142C	COT/DOT FORWARDING PUMPS (A)
142D	COT/DOT FORWARDING PUMPS (B)
143	BOILER FEED PUMP EOT
144	ATMOSPHERIC FLASH TANK (5m3)
147	SEAL OIL COOLERS
148	STATOR COOLING WATER SKID
149A	CONDENSER TUBE CLEANING SYSTEM
149B	CONDENSER TUBE CLEANING SYSTEM
150A	BALL STRAINER
150B	BALL STRAINER
151	LP HEATER DRAIN TANK
152A	LP HEATER DRAIN PUMP (A)
152B	LP HEATER DRAIN PUMP (B)
153	H2 CYLINDER ROOM
160	STATION BATTERY
167A	UNIT 1 BATTERY
167B	UNIT 1 BATTERY

LEGEND

VB	VERTICAL BRACING
	GRATING
	REMOVABLE GRATING
	CHEQUERED PLATE
UP	UPWARD DIRECTION
DN	DOWNWARD DIRECTION
	CONCRETE
	HAND RAILING
C	CUSTOMER SCOPE
T	TOSHIBA SCOPE
B	BOILER SCOPE
	RAIL TRACK
	FLOOR DRAIN SLOPE
BOS	BOTTOM OF STEEL
	BRICK WALL
Ⓡ	REMOVABLE

FOR DETAILED PROJECT REPORT

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: GENERAL EQUIPMENT ARRANGEMENT OF STEAM TURBINE GENERATOR & AUXILIARIES GROUND FLOOR PLAN (FL.(±)0.00M)

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

REV. NO.	
DATE	
APPROVED BY	
CHECKED BY	
REVISED BY	
CONTENTS	

REVISIONS

DRAWING SCALE	1:200
UNITS	MM
APPROVED BY	--- 18/08/2015
CHECKED BY	--- 18/08/2015
DESIGNED BY	--- 18/08/2015
DRAWN BY	--- 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

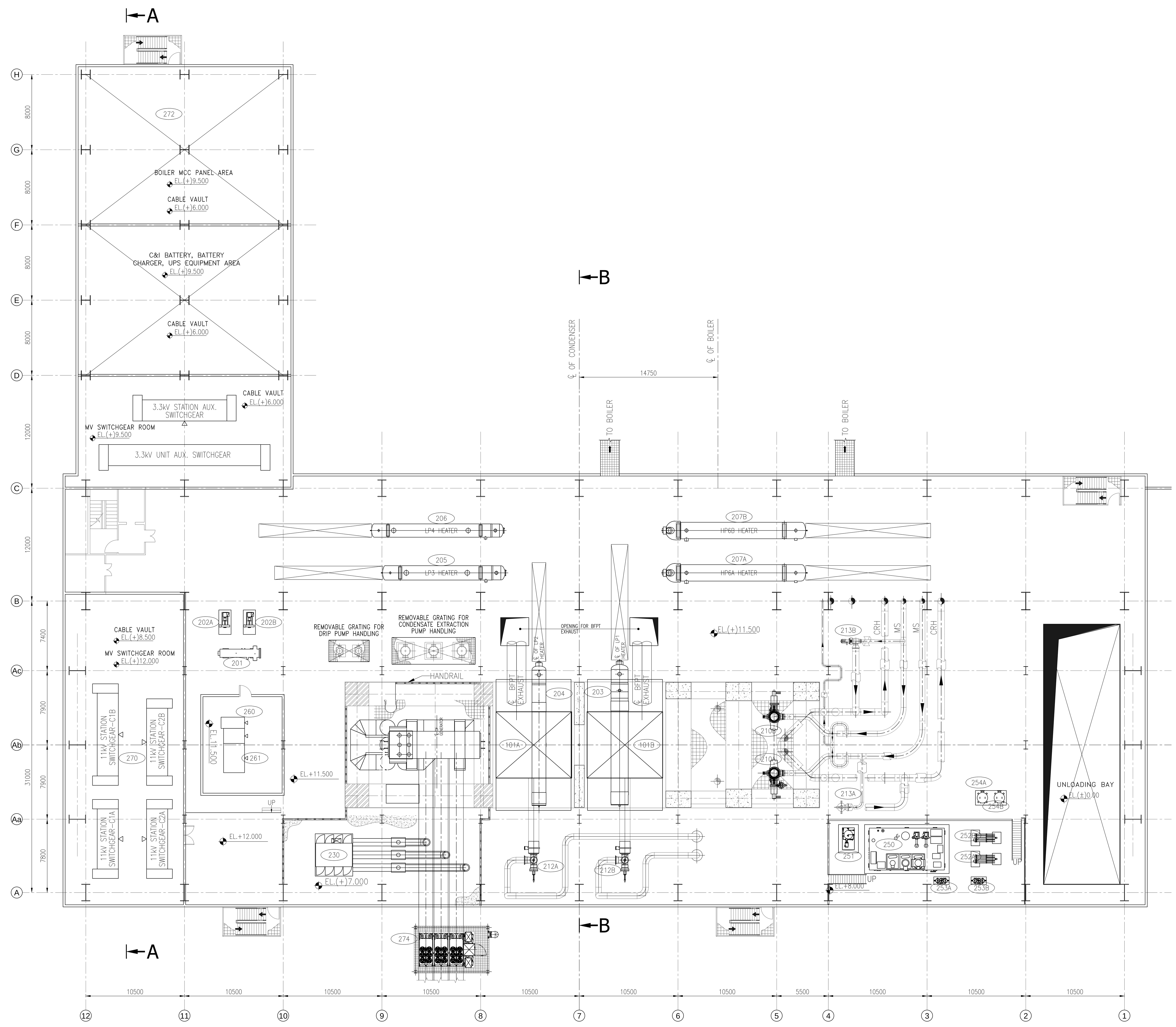
DWG. NO. 1/5

REV.NO. 0

A0 (841mm x 1189mm)

NORTH

TRUE NORTH



UNIT#10

MEZZANINE FLOOR PLAN AT (FL+11.500M)

KEY PLAN

NOTES ;-

1. ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE INDICATED
2. ALL EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.
3. FACING CHIMNEY FROM LEFT TO RIGHT AND FROM ROW A TO C EQUIPMENT MARKING IS IN ORDER OF A, B, C
4. EL (±)0.000M CORRESPONDS TO FINISHED FLOOR LEVEL OF ST BUILDING WHICH CORRESPONDS TO RL (+) 478.30M

No.	EQUIPMENT NAME
101A	HP CONDENSER
101B	LP CONDENSER
201	GLAND STEAM CONDENSER
202A	GLAND STEAM EXHAUSTER(A)
202B	GLAND STEAM EXHAUSTER(B)
203	LP HEATER 1
204	LP HEATER 2
205	LP HEATER 3
206	LP HEATER 4
207A	HP HEATER 6A
207B	HP HEATER 6B
210A	MSV/CV(A)
210B	MSV/CV(B)
212A	LP TURBINE BYPASS VALVE(A)
212B	LP TURBINE BYPASS VALVE(B)
213A	HP TURBINE BYPASS VALVE (A)
213B	HP TURBINE BYPASS VALVE (B)
230	EXCITATION TRANSFORMER
250	MAIN OIL TANK
251	OIL CONDITONER
252A	MAIN OIL COOLER(A)
252B	MAIN OIL COOLER(B)
253A	DUPLEX OIL FILTER(A)
253B	DUPLEX OIL FILTER(B)
254A	OIL MIST SEPARATOR(A)
254B	OIL MIST SEPARATOR(B)
260	FCB CUBICLE
261	THYRISTER CUBICLE
270	MV SWITCH GEAR ROOM
272	UPS ROOM
273	STATION BATTERY
274	GENERATOR CIRCUIT BREAKER

LEGEND

VB	VERTICAL BRACING
	GRATING
	REMOVABLE GRATING
	CHEQUERED PLATE
UP	UPWARD DIRECTION
DN	DOWNWARD DIRECTION
	CONCRETE
	HAND RAILING
C	CUSTOMER SCOPE
T	TOSHIBA SCOPE
B	BOILER SCOPE
	RAIL TRACK
	FLOOR DRAIN SLOPE
BOS	BOTTOM OF STEEL
	BRICK WALL
	REMOVABLE

FOR DETAILED PROJECT REPORT

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UNITS MM	DESIGNED BY --- 18/08/2015	DRAWN BY --- 18/08/2015	

OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: GENERAL EQUIPMENT ARRANGEMENT OF STEAM TURBINE GENERATOR & AUXILIARIES MEZZANINE FLOOR PLAN (FL.(+)11.500M)

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

KYUSHU ELECTRIC POWER CO., INC.

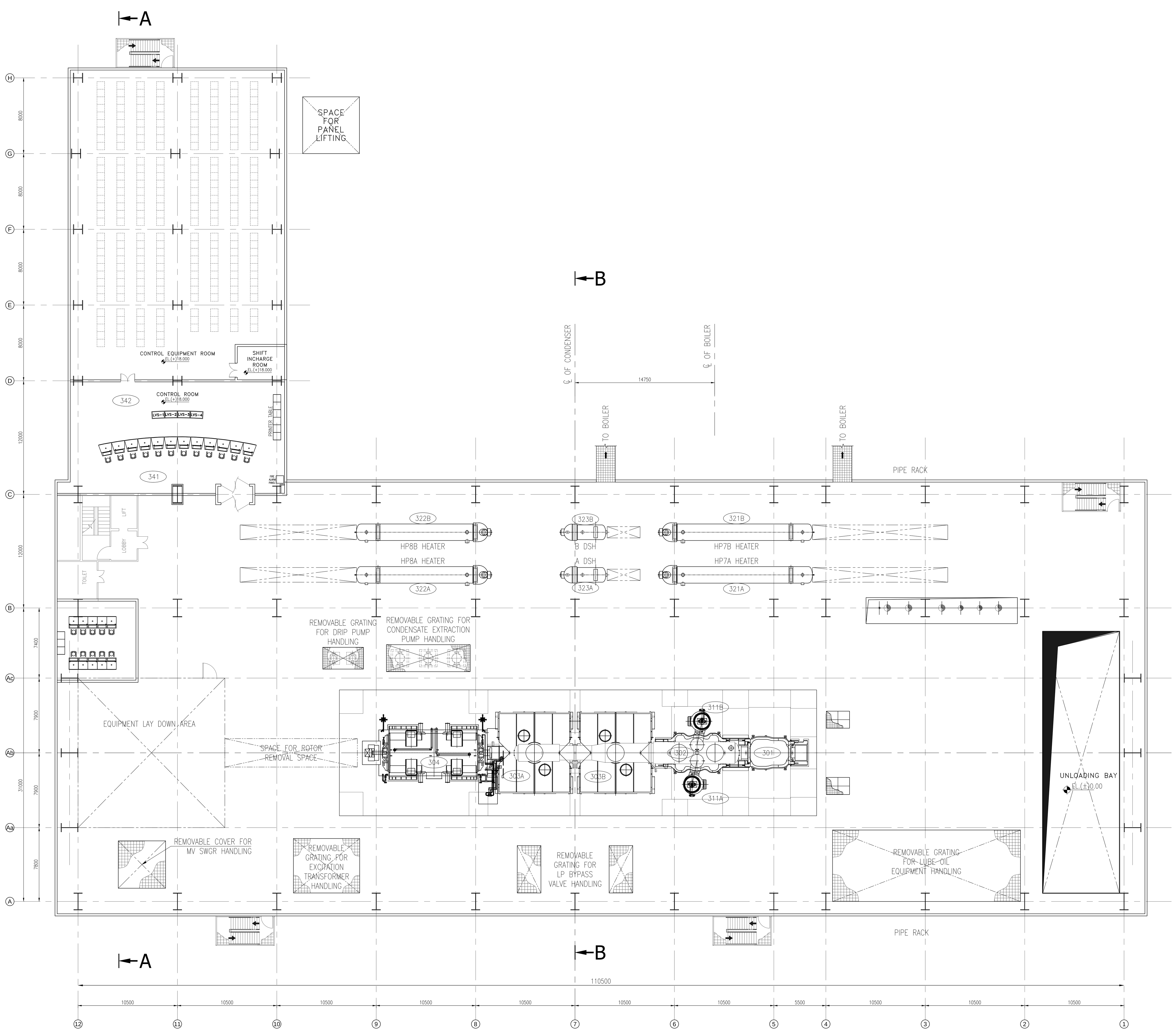
DWG. NO. 2/5

REV.NO. 0

A0 (841mm x 1189mm)

NORTH

TRUE NORTH



UNIT#10

OPERATING FLOOR PLAN AT (FL+18.000M)

KEY PLAN

NOTES ;-
1. ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE INDICATED
2. ALL EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.
3. FACING CHIMNEY FROM LEFT TO RIGHT AND FROM ROW A TO C EQUIPMENT MARKING IS IN ORDER OF A, B, C
4. EL (±)0.000M CORRESPONDS TO FINISHED FLOOR LEVEL OF ST BUILDING WHICH CORRESPONDS TO RL (+) 478.30M

No.	EQUIPMENT NAME
301	HP TURBINE
302	IP TURBINE
303A	LP TURBINE (A)
303B	LP TURBINE (B)
304	GENERATOR
311A	CONBINED REHEAT VALVE(A)
311B	CONBINED REHEAT VALVE(B)
321A	HP HEATER 7A
321B	HP HEATER 7B
322A	HP HEATER 8A
322B	HP HEATER 8B
323A	DSUPER HEATER (A)
323B	DSUPER HEATER (B)
341	CENTRAL CONTROL ROOM
342	CENTRAL EQUIPMENT ROOM

LEGEND

VB	VERTICAL BRACING
	GRATING
	REMOVABLE GRATING
	CHEQUERED PLATE
UP	UPWARD DIRECTION
DN	DOWNWARD DIRECTION
	CONCRETE
	HAND RAILING
C	CUSTOMER SCOPE
T	TOSHIBA SCOPE
B	BOILER SCOPE
	RAIL TRACK
	FLOOR DRAIN SLOPE
BOS	BOTTOM OF STEEL
	BRICK WALL
Ⓡ	REMOVABLE

FOR DETAILED PROJECT REPORT

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

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UNITS MM

APPROVED BY	CHECKED BY
--- 18/08/2015	--- 18/08/2015
DESIGNED BY	DRAWN BY
--- 18/08/2015	--- 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

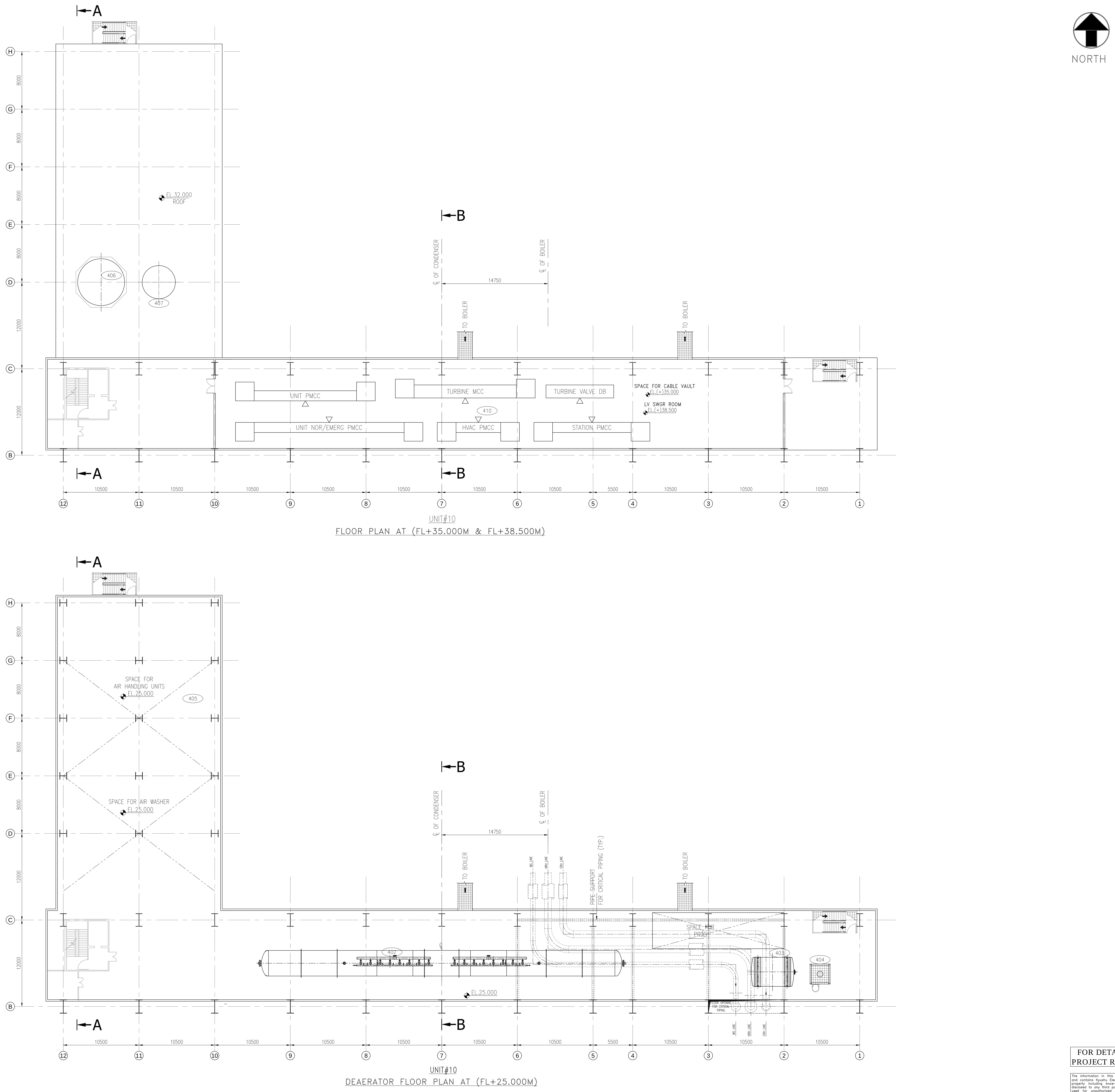
TITLE: GENERAL EQUIPMENT ARRANGEMENT OF STEAM TURBINE GENERATOR & AUXILIARIES OPERATING FLOOR PLAN (FL.(+)18.000M)

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO. 3/5

REV.NO. 0

A0 (841mm x 1189mm)



TRUE NORTH

KEY PLAN

NOTES ;-

1. ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE INDICATED
2. ALL EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.
3. FACING CHIMNEY FROM LEFT TO RIGHT AND FROM ROW A TO C EQUIPMENT MARKING IS IN ORDER OF A, B, C
4. EL (±)0.000M CORRESPONDS TO FINISHED FLOOR LEVEL OF ST BUILDING WHICH CORRESPONDS TO RL (+) 478.30M

No.	EQUIPMENT NAME
402	DEAERATOR
403	DM CCW HEAD TANK(10m3)
404	NAOH DOSING TANK
405	AIR HANDLING UNIT
406	OVERHEAD SERVICE WATER TANK
407	OVERHEAD POTABLE WATER TANK
410	LV SWITCH GEAR ROOM

LEGEND

VB	VERTICAL BRACING
	GRATING
	REMOVABLE GRATING
	CHEQUERED PLATE
UP	UPWARD DIRECTION
DN	DOWNWARD DIRECTION
	CONCRETE
	HAND RAILING
C	CUSTOMER SCOPE
T	TOSHIBA SCOPE
B	BOILER SCOPE
	RAIL TRACK
	FLOOR DRAIN SLOPE
BOS	BOTTOM OF STEEL
	BRICK WALL
	REMOVABLE

FOR DETAILED PROJECT REPORT

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

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1:200	--- 18/08/2015	--- 18/08/2015
UNITS	DESIGNED BY	DRAWN BY
MM	--- 18/08/2015	--- 18/08/2015

KYUSHU ELECTRIC POWER CO.,INC.

KYUSHU ELECTRIC POWER CO., INC.

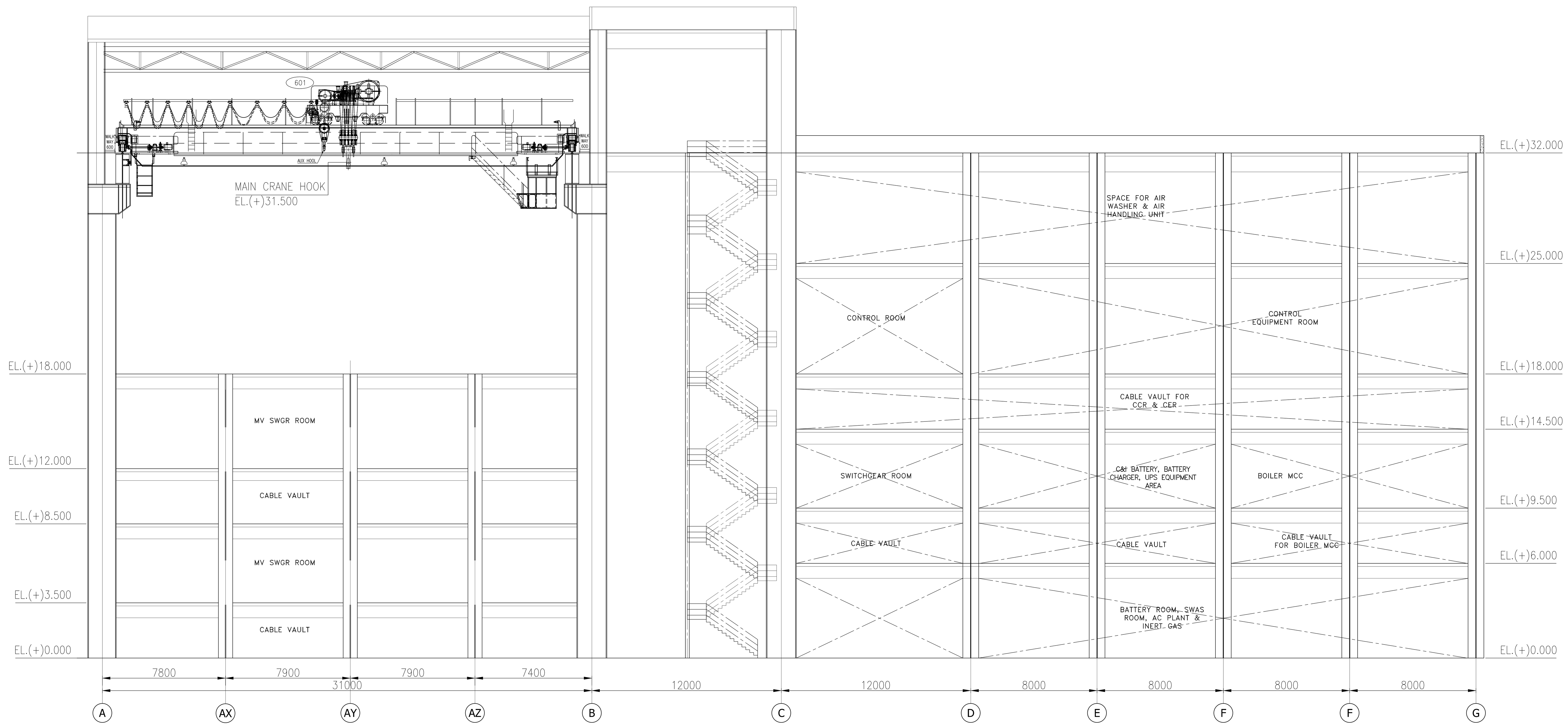
TITLE: GENERAL EQUIPMENT ARRANGEMENT OF STEAM TURBINE GENERATOR & AUXILIARIES DEAERATOR FLOOR PLAN (FL.(+)25.000M) & ABOVE

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

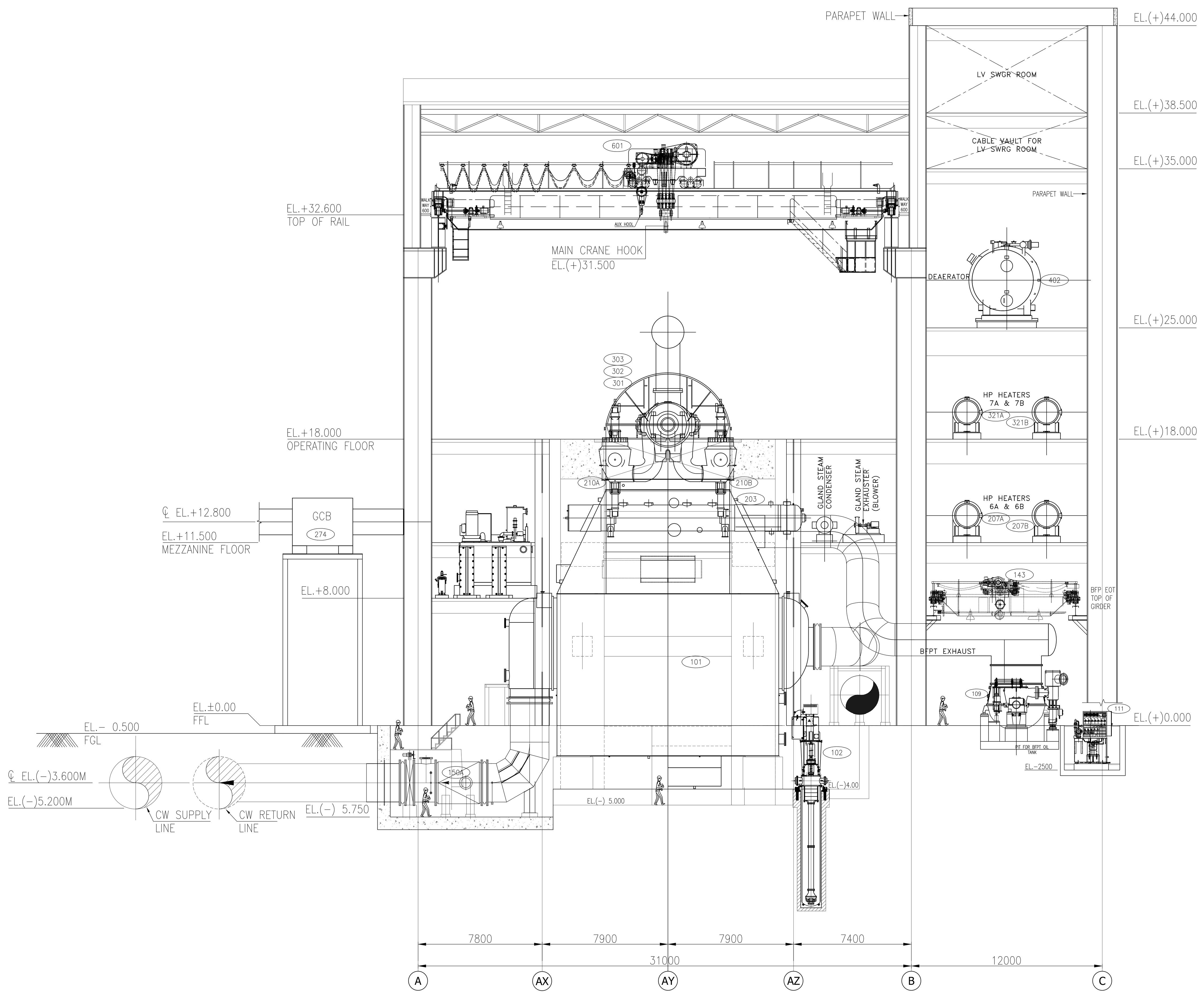
DWG. NO. 4/5

REV.NO. 0

A0 (841mm x 1189mm)



SECTION – 'A-A'



SECTION – 'B-B'

NOTES ;–

1. ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE INDICATED
2. ALL EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.
3. FACING CHIMNEY FROM LEFT TO RIGHT AND FROM ROW A TO C EQUIPMENT MARKING IS IN ORDER OF A, B, C
4. EL (±)0.000M CORRESPONDS TO FINISHED FLOOR LEVEL OF ST BUILDING WHICH CORRESPONDS TO RL (+) 478.30M

No.	EQUIPMENT NAME
101	CONDENSER
102	CONDENSATE EXTRACTION PUMP
109	TDBFP TURBINE
111	BFPTMAIN OIL TANK
143	BFP OVERHEAD CRANE
150	CONDENSER TUBE BALL COLLECTING STRAINERS
203	LP HEATER 1 & 2
205	LP HEATER 3
210A	MSV/CV (A)
210B	MSV/CV (B)
274	GENERATOR CIRCUIT BREAKER
301	HP TURBINE
302	IP TURBINE
303	LP TURBINE
322A	HP HEATER 8A
322B	HP HEATER 8B
402	DEAERATOR
601	STEAM TURBINE OVERHEAD CRANE

LEGEND

VB	VERTICAL BRACING
	GRATING
	REMOVABLE GRATING
	CHEQUERED PLATE
UP	UPWARD DIRECTION
DN	DOWNWARD DIRECTION
	CONCRETE
	HAND RAILING
C	CUSTOMER SCOPE
T	TOSHIBA SCOPE
B	BOILER SCOPE
	RAIL TRACK
	FLOOR DRAIN SLOPE
BOS	BOTTOM OF STEEL
	BRICK WALL
Ⓡ	REMOVABLE

FOR DETAILED PROJECT REPORT

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

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UNITS	MM
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CHECKED BY	--- 18/08/2015
DESIGNED BY	--- 18/08/2015
DRAWN BY	--- 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

TITLE: GENERAL EQUIPMENT ARRANGEMENT OF STEAM TURBINE GENERATOR & AUXILIARIES SECTION 'A-A' & SECTION 'B-B'

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO.

5/5

REV.NO. 0

A0 (841mm x 1189mm)

13. BTG CROSS SECTION DRAWING

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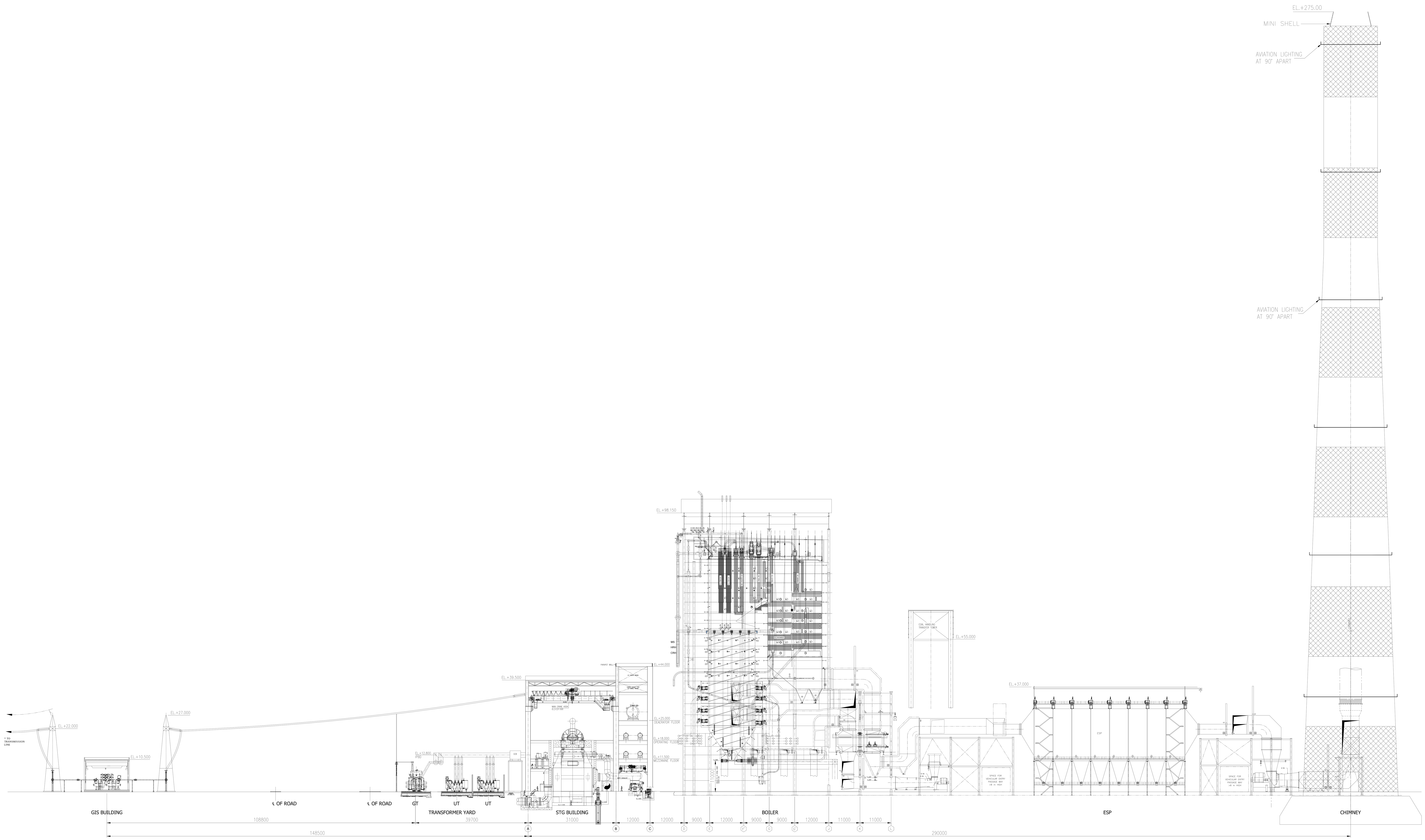
NOTES ;-

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE INDICATED
2. ALL BUILDING & STRUCTURE SIZES AND LOCATION ARE TENTATIVE SHALL BE CONFIRMED DURING DETAIL ENGINEERING.



ELEVATION

FOR DETAILED PROJECT REPORT

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DRAWING SCALE 1:500

UNITS MM

APPROVED BY	CHECKED BY
– 18/08/2015	– 18/08/2015
DESIGNED BY	DRAWN BY
– 18/08/2015	– 18/08/2015

KYUSHU ELECTRIC POWER CO., INC.

TITLE: CROSS-SECTIONAL DRAWING FROM TURBINE BUILDING TO CHIMNEY

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DWG. NO.

1/1

REV.NO. 0

A0 (841mm x 1189mm)

14. GA OF RIVER WATER INTAKE SYSTEM

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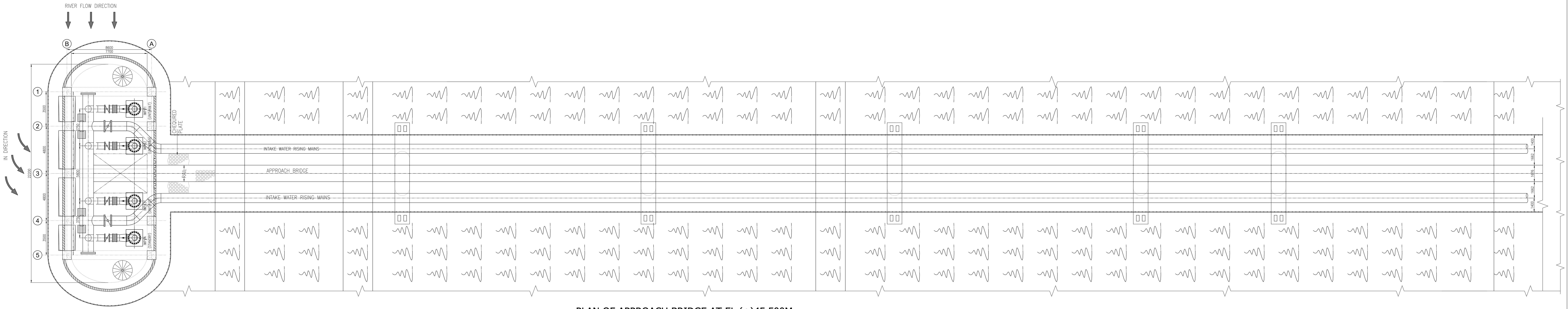
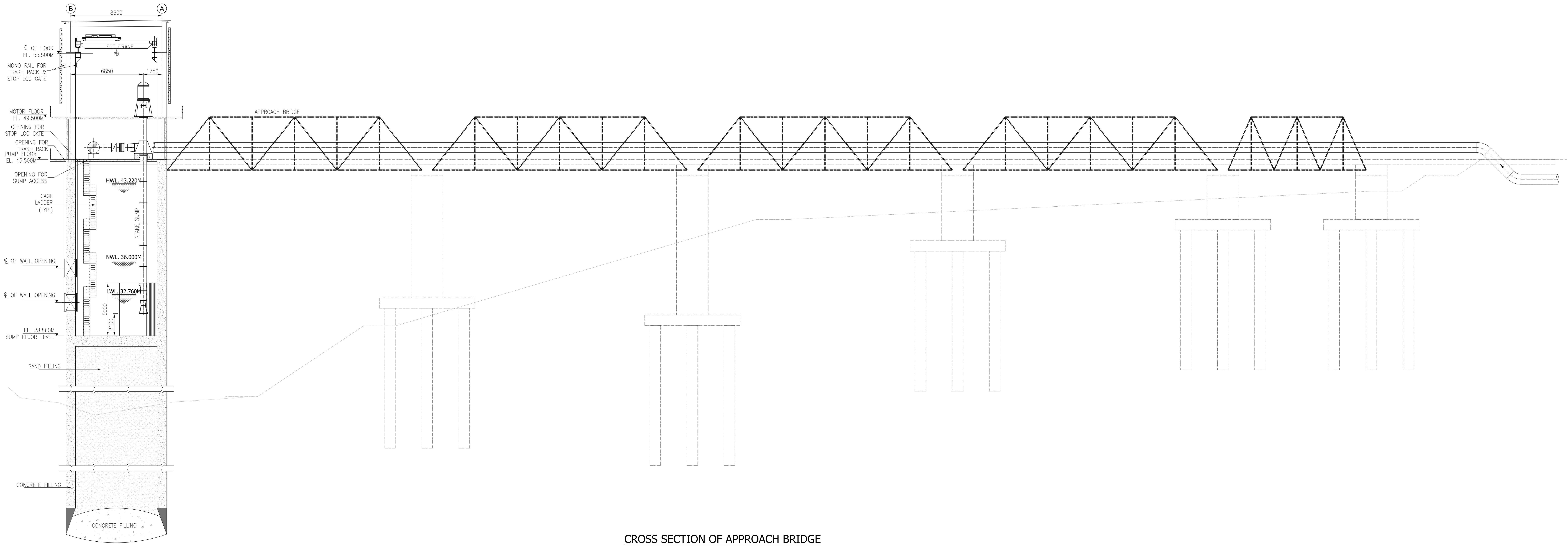
NOTES :

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.
2. EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.



PLAN OF APPROACH BRIDGE AT EL.(+)45.500M



SECTION - 'X-X'

CROSS SECTION OF APPROACH BRIDGE

LEGEND

VB	VERTICAL BRACING
	GRATING
	REMOVABLE GRATING
	CHEQUERED PLATE
UP	UPWARD DIRECTION
DN	DOWNWARD DIRECTION
	CONCRETE
	HAND RAILING
	RAIL TRACK
	FLOOR DRAIN SLOPE
BOS	BOTTOM OF STEEL
	BRICK WALL
®	REMOVABLE
	EMBANKMENT
LWL	LOW WATER LEVEL
NWL	NORMAL WATER LEVEL
HWL	HIGH WATER LEVEL
IWP	INTAKE WATER PUMP
IWRM	INTAKE WATER RISING MAINS

FOR FEASIBILITY STUDY REPORT

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UNITS	MM
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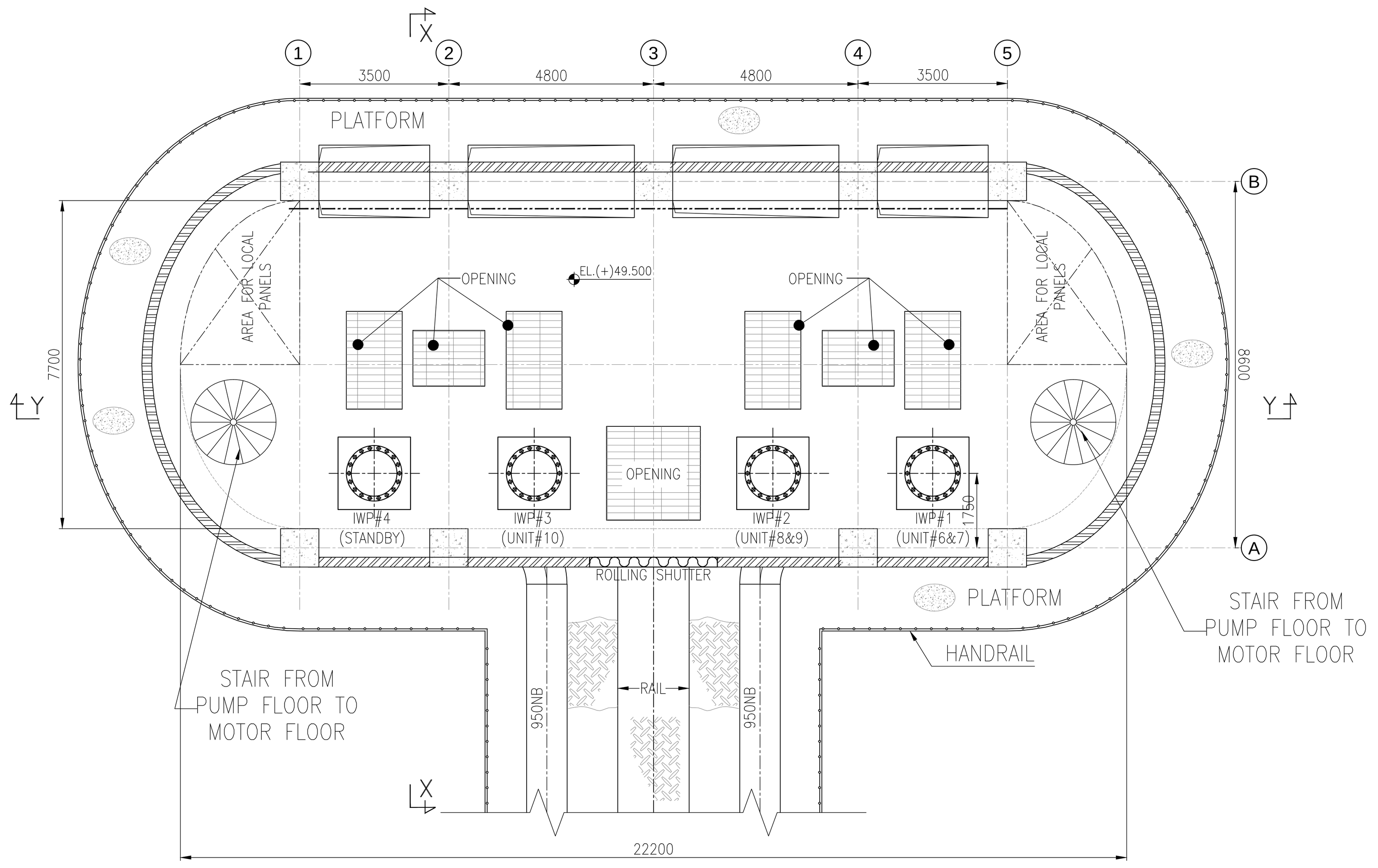
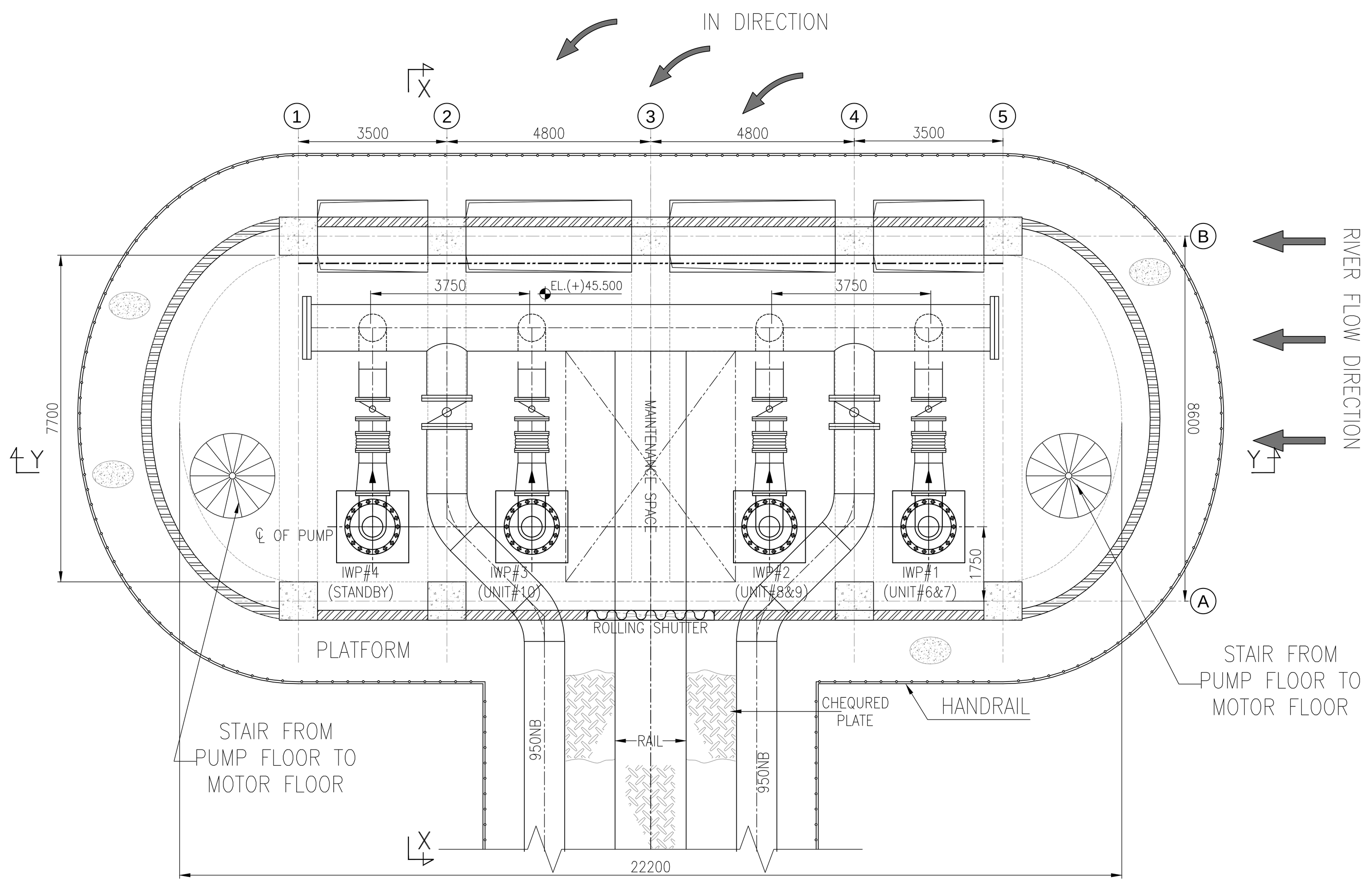
DRAWN BY	-- DD/MM/YYYY
OWNER	BIHAR STATE ELECTRICITY BOARD
TITLE	GENERAL ARRANGEMENT OF RIVER WATER INTAKE SYSTEM
PROJECT	1x660 MW BARAUNI TPS, UNIT#10 EXTENSION PROJECT, BIHAR
CONTRACTOR'S DWG. NO.	1/2
REV.NO.	-

KYUSHU ELECTRIC POWER CO.,INC. KYUSHU ELECTRIC POWER CO., INC.

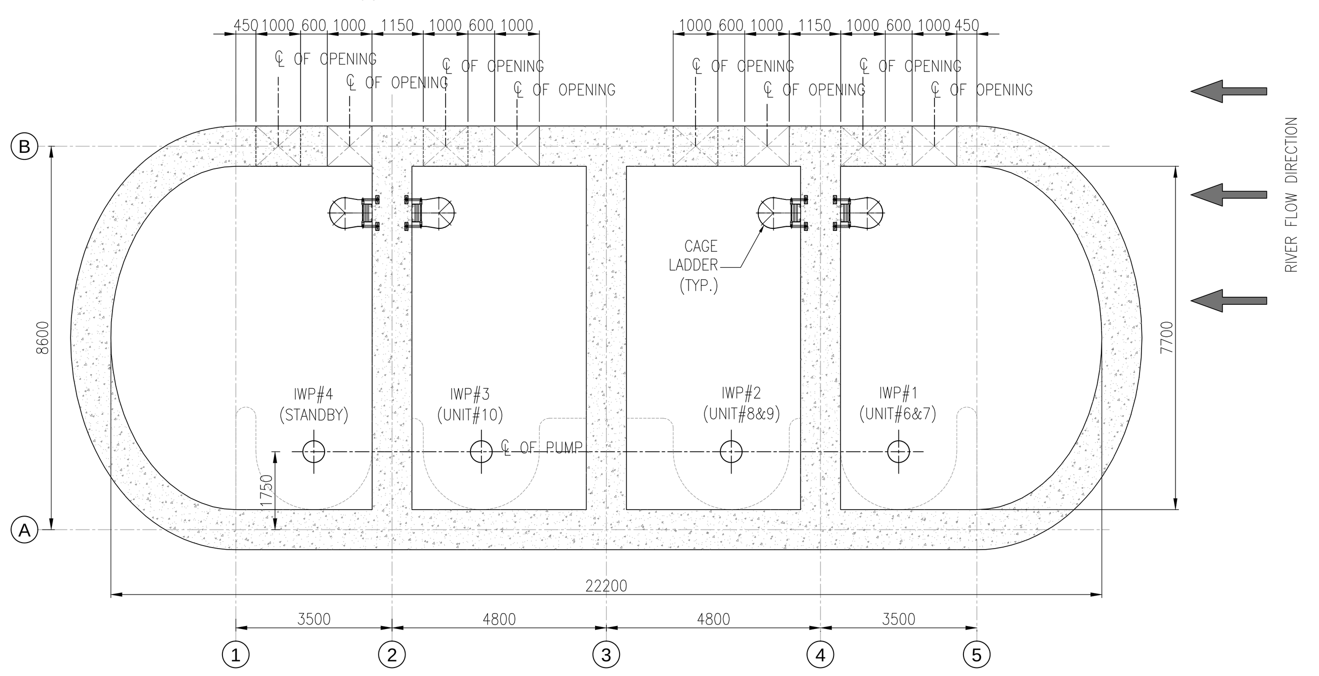
A0 (841mm x 1189mm)



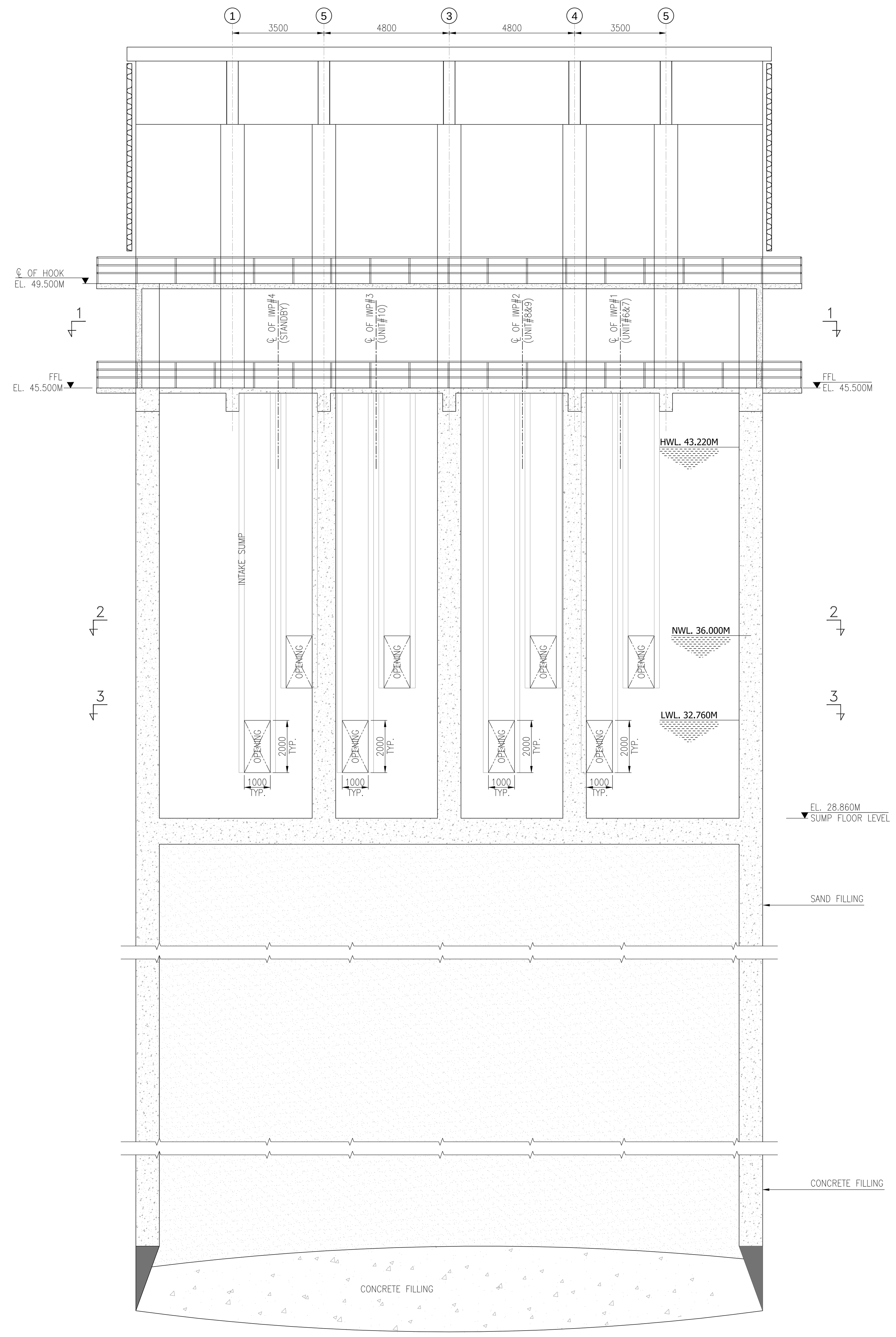
PLAN OF MOTOR FLOOR AT EL.(+)49.500M



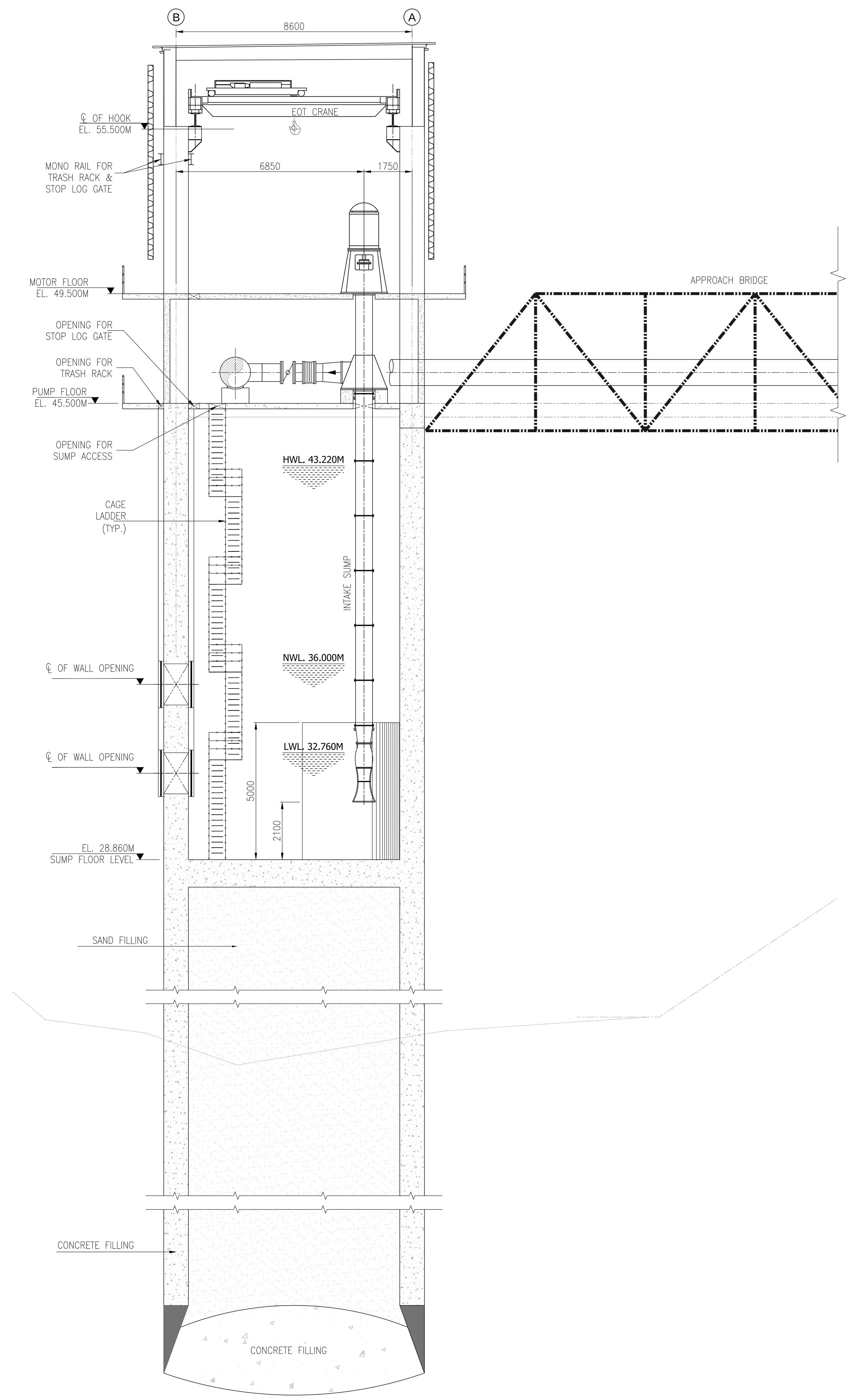
SECTION : 1-1 @ EL.(+)45.500M
PUMP FLOOR PLAN



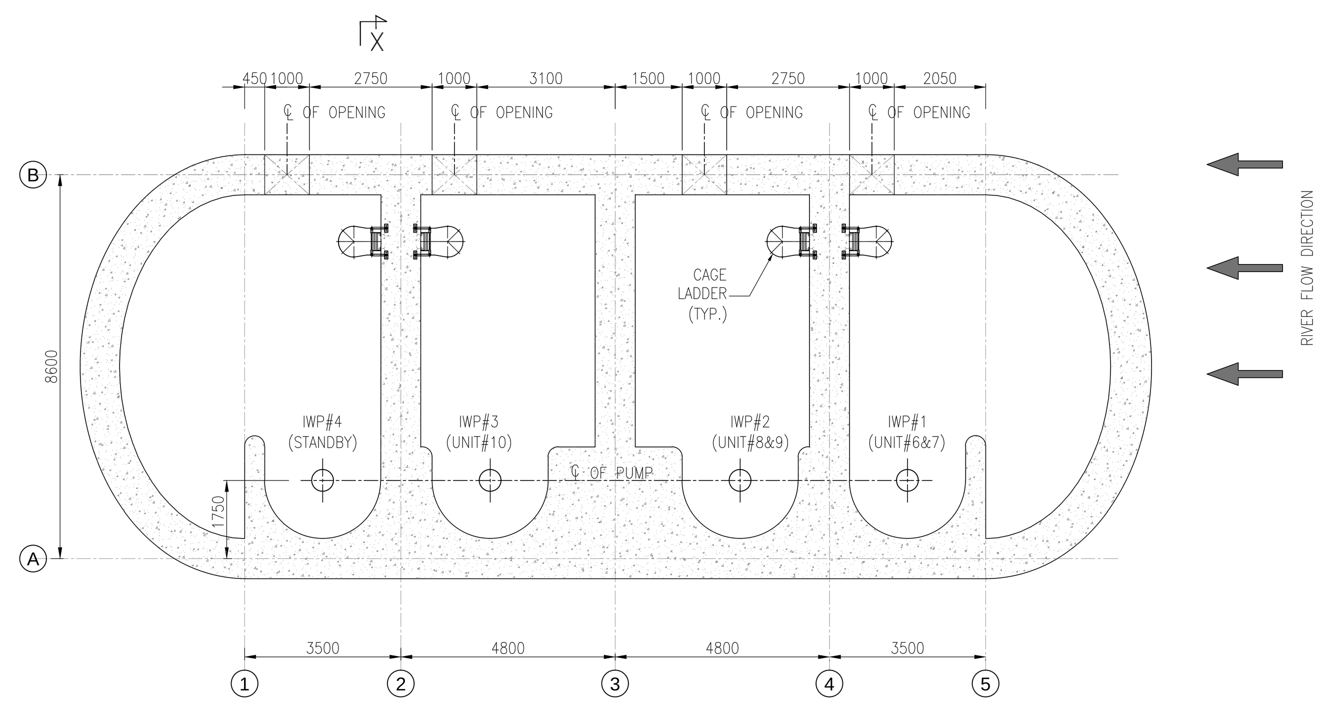
SECTION : 2-2 @ EL.(+) 36.000M



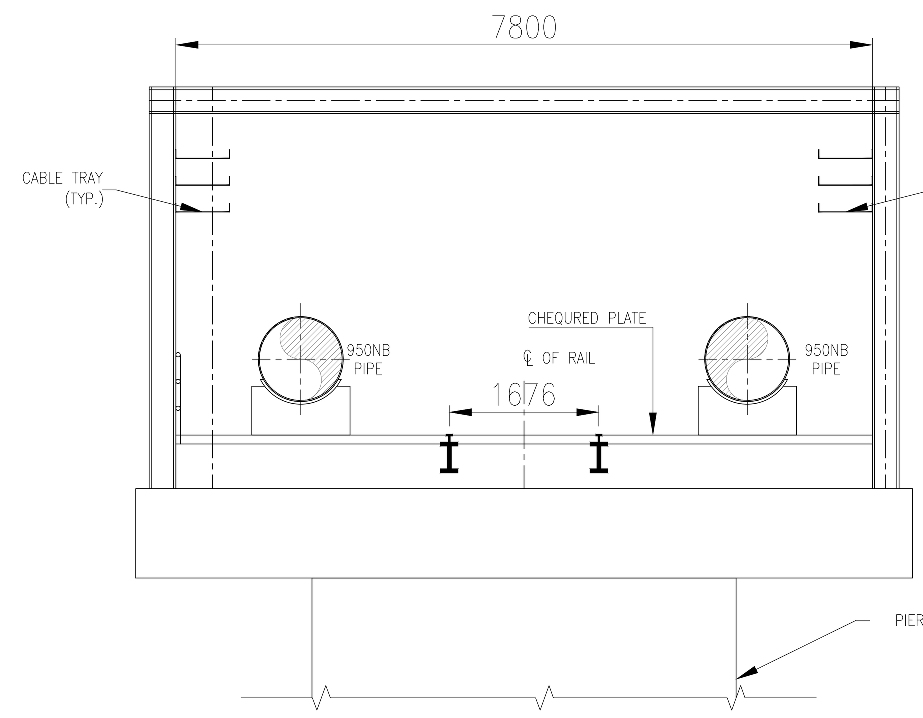
SECTION - 'Y-Y'



SECTION - 'X-X'



SECTION : 3-3 @ EL.(+) 32.760M



APPROCH BRIDGE CROSS SECTION
SCALE 1:50

NOTES :

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.
2. EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.

LEGEND

VB	VERTICAL BRACING
	GRATING
Ⓡ	REMOVABLE GRATING
	CHEQUERED PLATE
UP	UPWARD DIRECTION
DN	DOWNWARD DIRECTION
	CONCRETE
	HAND RAILING
	RAIL TRACK
	FLOOR DRAIN SLOPE
BOS	BOTTOM OF STEEL
	BRICK WALL
Ⓡ	REMOVABLE
	EMBANKMENT
LWL	LOW WATER LEVEL
NWL	NORMAL WATER LEVEL
HWL	HIGH WATER LEVEL
IWP	INTAKE WATER PUMP
IWRM	INTAKE WATER RISING MAINS

FOR FEASIBILITY STUDY REPORT

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OWNER: BIHAR STATE ELECTRICITY BOARD

TITLE: GENERAL ARRANGEMENT OF RIVER WATER INTAKE SYSTEM

PROJECT: 1x660 MW BARAUNI TPS, UNIT#10 EXTENSION PROJECT, BIHAR

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KYUSHU ELECTRIC POWER CO.,INC. KYUSHU ELECTRIC POWER CO., INC.

CONTRACTOR'S DWG. NO. 2/2
REV.NO.

A0 (841mm x 1189mm)

15. GA OF CLEAR WATER MAKE-UP PUMP HOUSE

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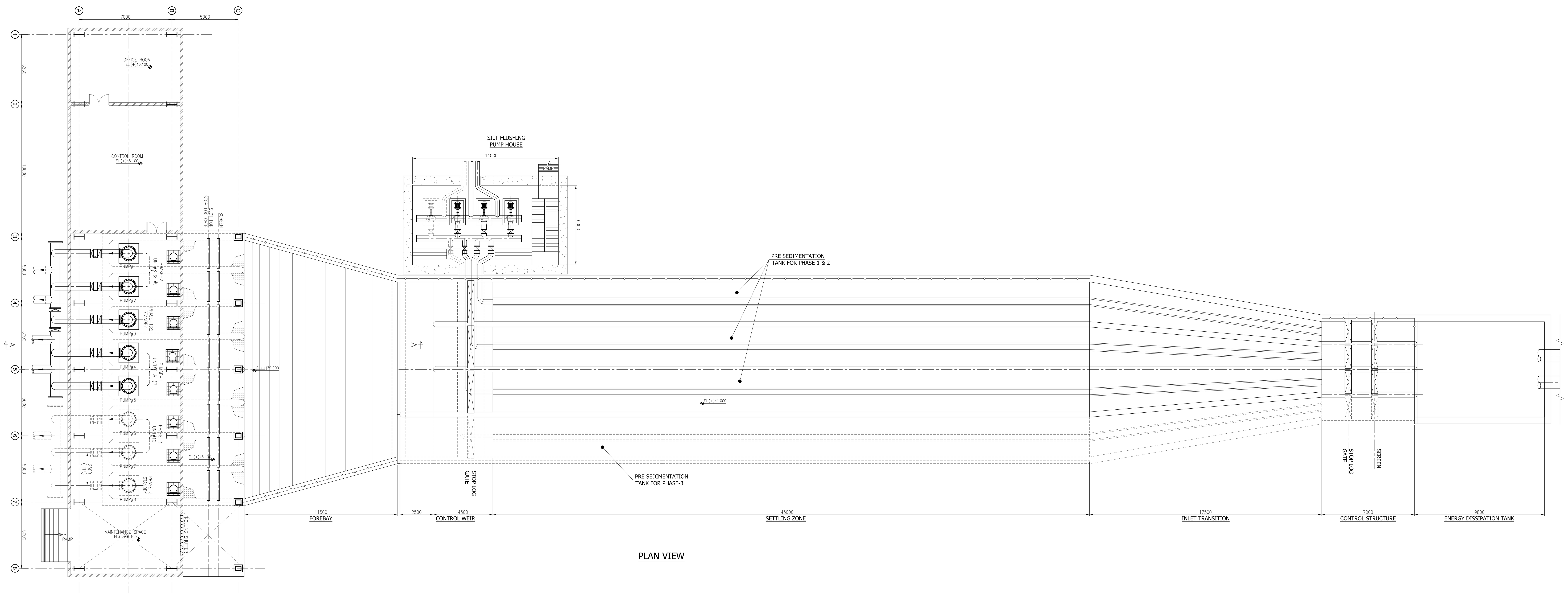
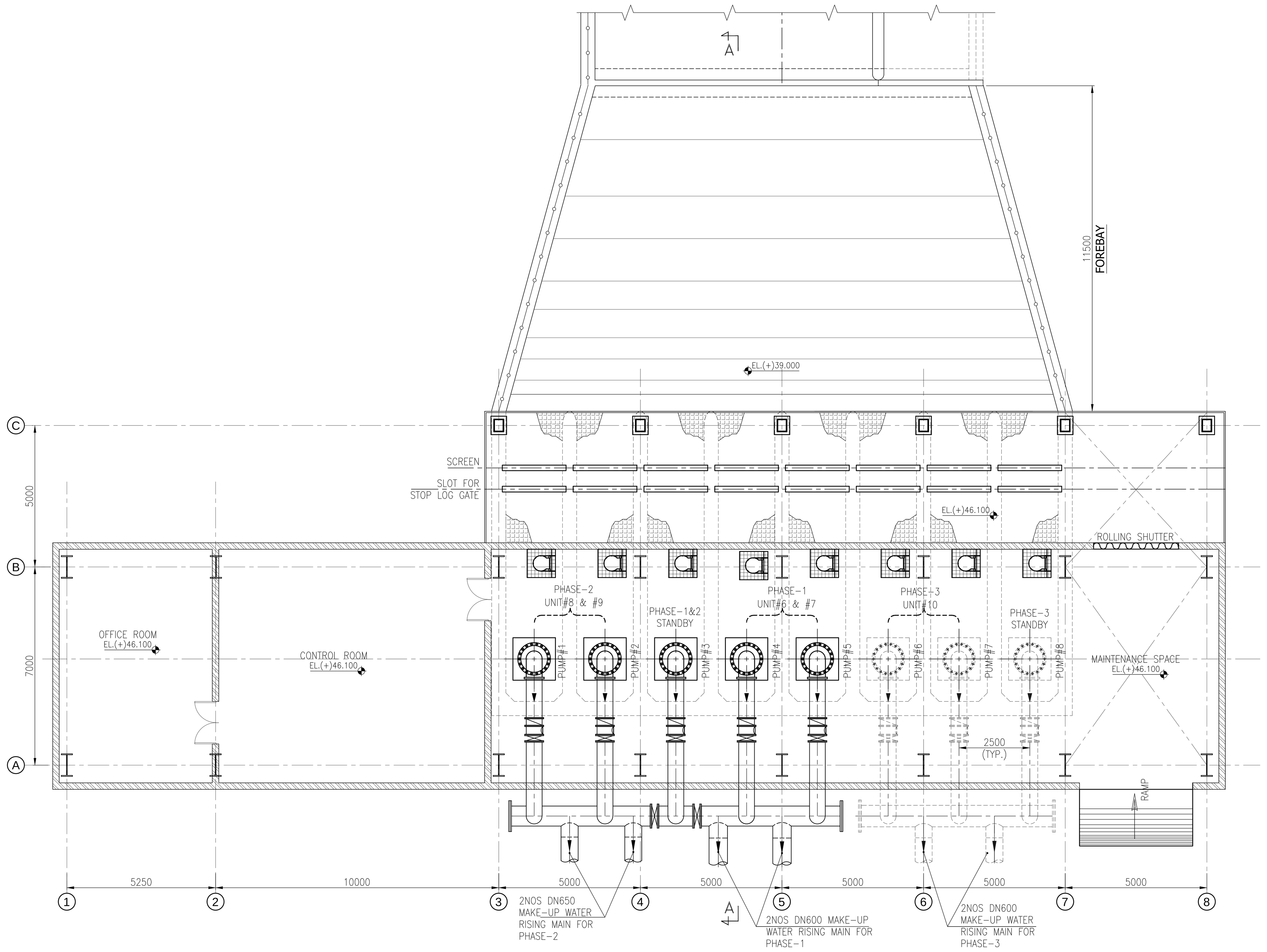
NOTES :

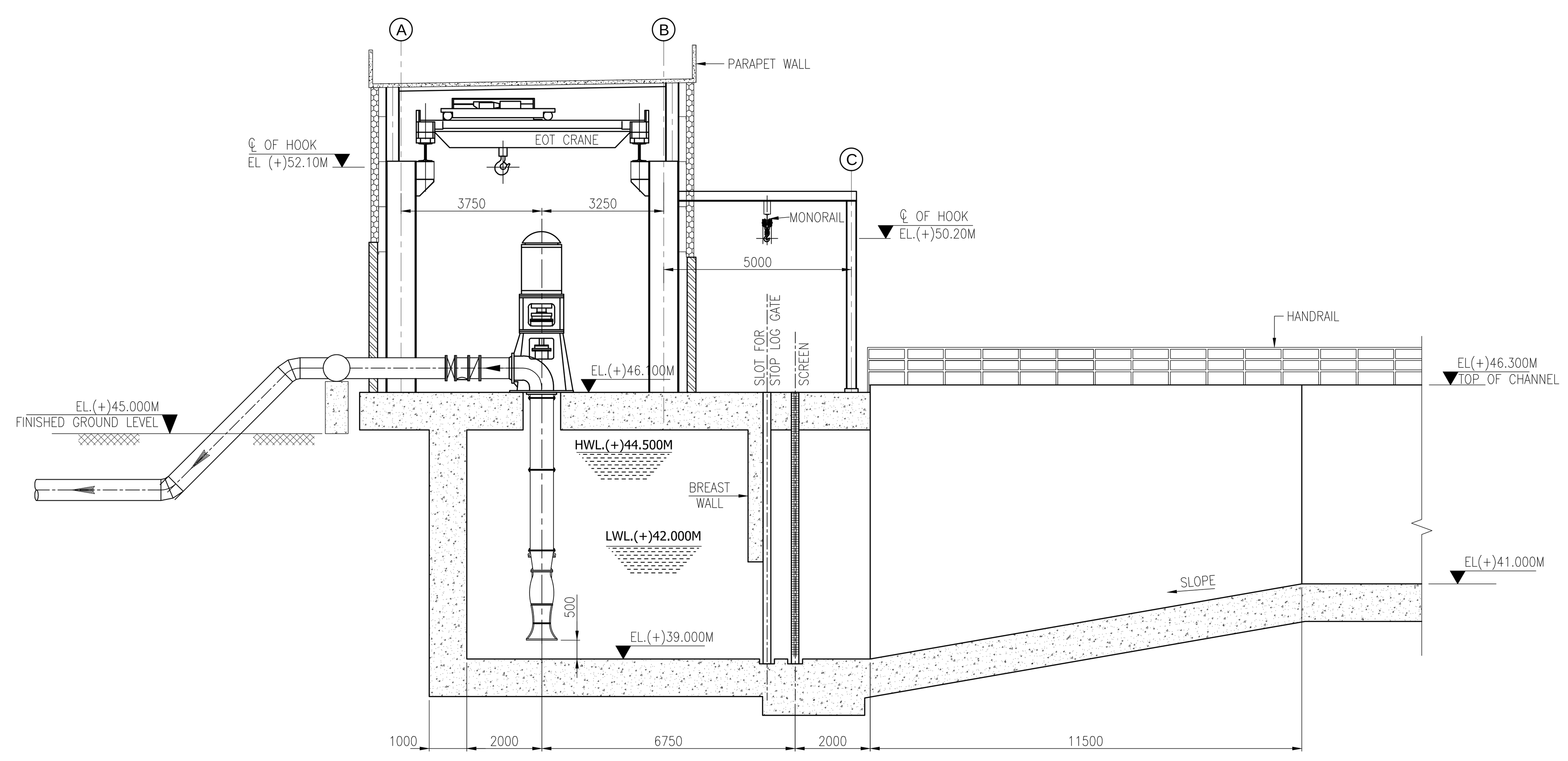
1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.
2. EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.



PLAN VIEW



PLAN VIEW



SECTION - 'A-A'

LEGEND

	GRATING
	CHEQUERED PLATE
UP	UPWARD DIRECTION
DN	DOWNWARD DIRECTION
	CONCRETE
	HAND RAILING
	RAIL TRACK
	FLOOR DRAIN SLOPE
BOS	BOTTOM OF STEEL
	BRICK WALL
	REMOVABLE
LWL	LOW WATER LEVEL
NWL	NORMAL WATER LEVEL
HWL	HIGH WATER LEVEL

FOR DETAILED PROJECT REPORT

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OWNER: BIHAR STATE POWER GENERATION COMPANY LIMITED

TITLE: GENERAL ARRANGEMENT OF CLEAR WATER MAKE-UP PUMP HOUSE

PROJECT: 1 x 660 MW BARAUNI TPS, UNIT # 10 EXTENSION PROJECT, BIHAR

DRAWING SCALE	1:100
UNITS	MM
APPROVED BY	–
CHECKED BY	–
DESIGNED BY	–
DRAWN BY	–
DWG. NO.	1/1
REV.NO.	0

KYUSHU ELECTRIC POWER CO., INC.

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DATE	–
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CONTENTS	–

A0 (841mm x 1189mm)

16. PLOT PLAN OF RIVER WATER INTAKE SYSTEM

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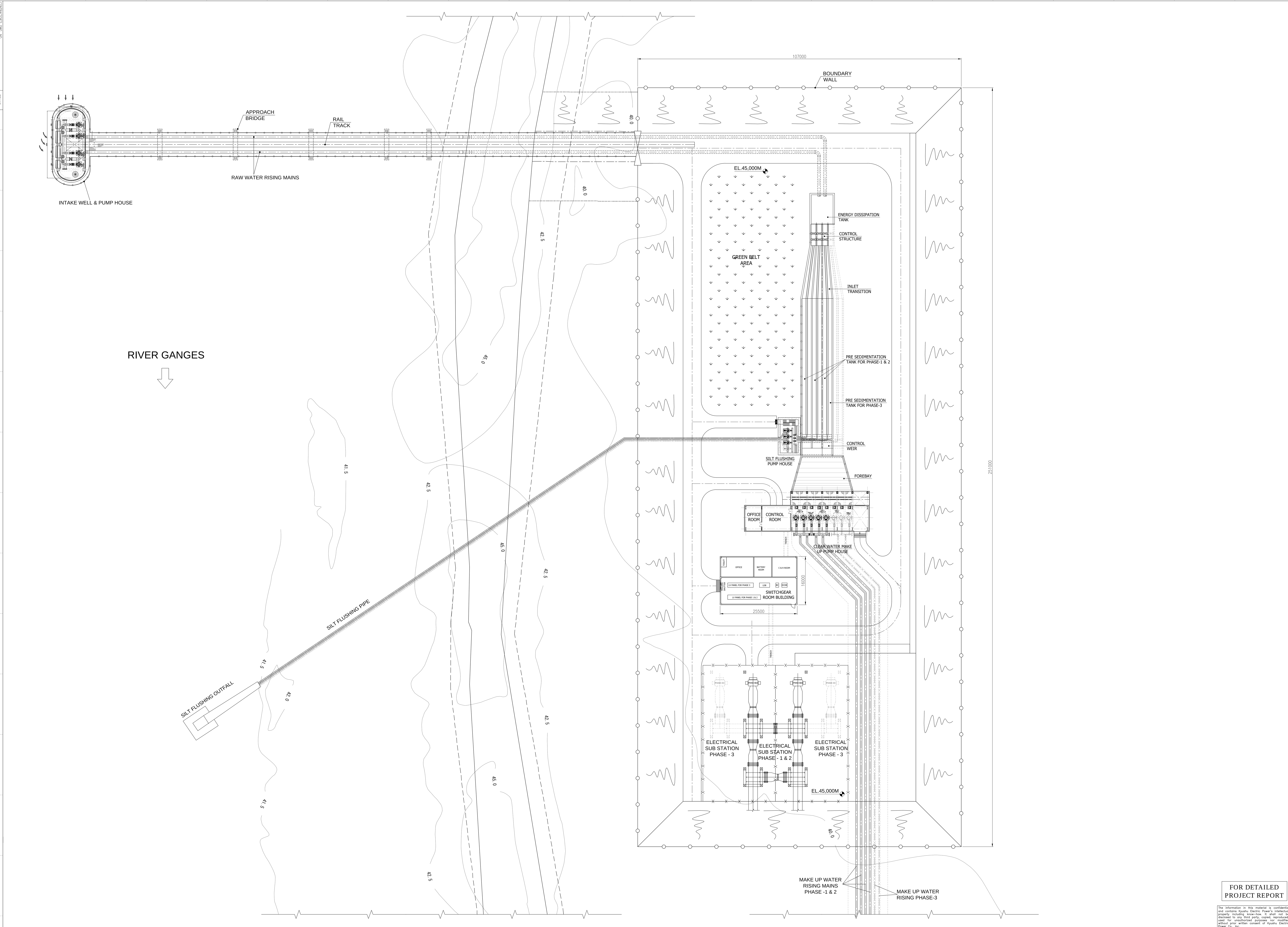

NOTES :

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.
2. EQUIPMENTS LOCATIONS & DIMENSIONS ARE INDICATIVE & WILL BE FINALIZED IN DETAIL ENGINEERING.

LEGEND

- GRATING
- REMOVABLE GRATING
- CHEQUERED PLATE
- CONCRETE
- BOUNDARY LINE
- FENCE LINE
- RAIL TRACK
- GREEN BELT
- BRICK WALL
- EMBANKMENT

FOR DETAILED PROJECT REPORT

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OWNER: BIHAR STATE ELECTRICITY BOARD

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DD/MM/YYYY	DATE	DESIGNED BY --	DRAWN BY -- DD/MM/YYYY
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–	CHECKED BY		
–	REVISED BY		
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TITLE: PLOT PLAN OF RIVER WATER INTAKE SYSTEM

PROJECT: 1x660 MW BARAUNI TPS, UNIT#10 EXTENSION PROJECT, BIHAR

KYUSHU ELECTRIC POWER CO., INC.

CONTRACTOR'S DWG. NO. 1/1

REV.NO.

A0 (841mm x 1189mm)

17. TYPICAL KEY SINGLE LINE DIAGRAM

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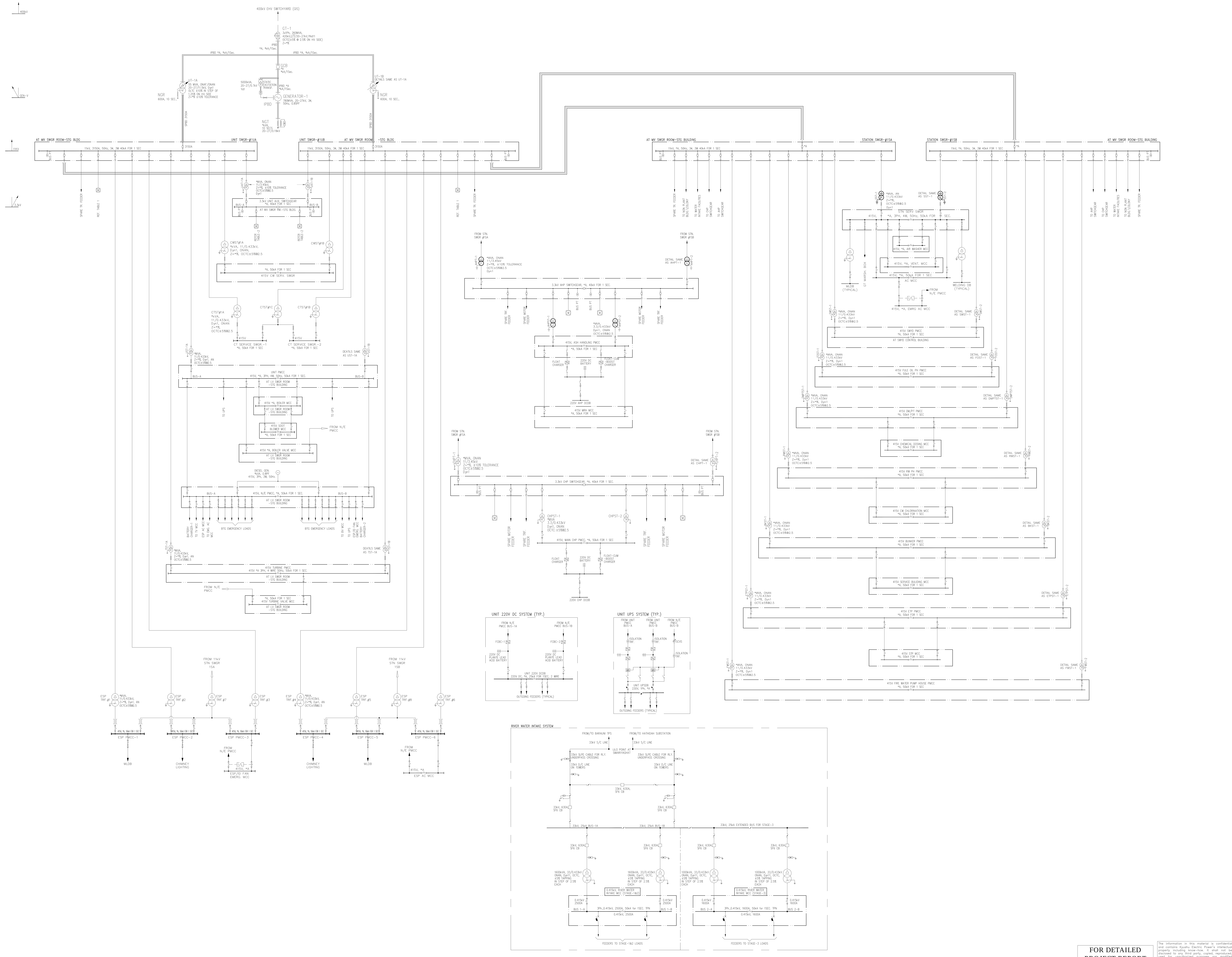

LEGEND

- THREE WINDING TRANSFORMER WITH OLTC
- TWO WINDING TRANSFORMER WITH OLTC
- TWO WINDING TRANSFORMER WITH OCTC
- VCB (DRAWOUT)
- ACB (DRAWOUT)
- MCCB
- MCB
- SWITCH-FUSE UNIT (DRAWOUT)
- IPBD
- SPBD
- NSPBD
- MOTOR
- GROUP OF MOTORS
- NEUTRAL GROUNDING RESISTOR
- NEUTRAL GROUNDING TRANSFORMER
- BATTERY
- RECTIFIER CHARGER
- INVERTOR
- SERVO CONTROLLED VOLTAGE STABILIZER
- LIGHTNING ARRESTOR
- GENERATOR STATIC EXCITATION CUBICLE
- CABLE CONNECTION

ABBREVIATION

GT	GENERATOR TRANSFORMER
UT	UNIT TRANSFORMER
ST	STATION TRANSFORMER
UAT	UNIT AUXILIARY TRANSFORMER
UST	UNIT SERVICE TRANSFORMER
ESPST	ELECTROSTATIC PRECIPITATOR SER. TRF.
EST	EMERGENCY SERVICE TRF.
SST	STATION SERVICE TRF.
TST	TURBINE SERVICE TRF.
IPBD	ISOLATED PHASE BUSDUCT
SPBD	SEGREGATED PHASE BUSDUCT
DG	DIESEL GENERATOR
OLTC	ON LOAD TAP CHANGER
OCTC	OFF CKT. TAP CHANGER
CHP	COAL HANDLING PLANT
AHP	ASH HANDLING PLANT
MDBFP	MOTOR DRIVEN BOILER FEED PUMP
ID FAN	INDUCED DRAFT FAN
FD FAN	FORCED DRAFT FAN
PA FAN	PRIMARY AIR FAN
CWP	CIRCULATING WATER PUMP
CEP	CONDENSATE EXTRACTION PUMP
ACWP	AUX. COOLING WATER PUMP
CCWP	CLOSED COOLING WATER PUMP
BRP	BOILER RECIRCULATION PUMP
BV	BOILER VALVE
TV	TURBINE VALVE

NOTES :-

1. RATING OF DIFFERENT EQUIPMENTS SHOWN IN THE DRG. IS TENTATIVE AND SHALL BE UPDATED, WHEREVER IF REQUIRED, DURING DETAIL ENGINEERING.
2. THE VOLTAGE LEVEL FOR MOTORS SHALL BE AS FOLLOWS:
   A) ABOVE 1500kW :- 11kV
   C) ABOVE 200kW UPTO 1500kW :- 3.3kV
   B) UPTO 200kW :- 415V
3. ALL LV SERVICE TRANSFORMERS SHALL BE WITH OCTC WITH ±5% TAP IN STEPS OF 2.5% ON HV SIDE.
4. 11kV AND 3.3kV SYSTEMS ARE 3Ph, 3W, 50Hz; 415V SYSTEM IS 3PH, 4 WIRE 50Hz EXCEPT EMERGENCY BOARD. WHICH IS 3PH, 3 WIRE 50Hz.
5. UNIT SHALL BE PROVIDED WITH ONE EMERGENCY DIESEL GENERATOR WHICH SHALL BE CONNECTED TO THE UNIT NORMAL EMERGENCY SWITCHGEAR.
6. SYMMETRICAL FAULT LEVEL:
   A) 11kV SYSTEM: 40kA FOR 1 SEC.
   B) 3.3kV SYSTEM: 40kA FOR 1 SEC.
   C) 415V SYSTEM: 50kA FOR 1 SEC.
   TO BE UPDATED AFTER SYSTEM STUDY.
7. NO. OF 415V MCC/PMCC/ACDB/DCDB/LV TRANSFORMER ETC. SHOWN ARE INDICATIVE. EXACT REQUIREMENT OF THE SAME SHALL BE DECIDED DURING DETAIL ENGINEERING STAGE.
8. SWITCHGEARS SHALL BE PROVIDED WITH MECHANICAL AND ELECTRICAL INTERLOCKS SO THAT ONLY TWO BREAKERS OUT OF THREE ARE CLOSED AT A TIME.
9. FEEDER DETAILS SHOWN IN THIS DWG. ARE TYPICAL ONLY. DETAILED DESIGN SHALL BE SHOWN AND INCLUDED IN THE RESPECTIVE SWITCHBOARD SLDS.
10. '*' MEANS SHALL BE FURNISHED DURING DETAIL ENGINEERING.

TABLE-1: UNIT SWITCHGEARS – 11kV MOTORS

S.NO.	MOTOR ID	RATING (kW)	NO. OF DRIVES CONNECTED TO SWGR.	
			UNIT SWGR-#1UA	UNIT SWGR-#1UB
1	ID FAN	*	1	1
2	FD FAN	*	1	1
3	PA FAN	*	1	1
4	CWP	*	2	1
5	MDBFP	*	1	0
6	SPARE	*	1	1

TABLE-2: UNIT AUXILIARY SWITCHGEAR – 3.3kV MOTORS

S.NO.	MOTOR ID	RATING (kW)	NO. OF DRIVES CONNECTED TO SWGR	
			BUS-A	BUS-B
1	ACW PUMP	*	1	1
2	DMCW PUMP	*	1	2
3	BRP	*	1	0
4	PULVERIZERS	*	4	4
5	SERVICE AIR COMP.	*	1	1
6	CEP	*	2	1
7	IAC	*	1	1
8	SPARE	*	1	1

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2	1	0	REV. NO.
01/10/2015	24/04/2015	16/04/2015	DATE
MP	MP	MP	APPROVED BY
MS	MS	MS	CHECKED BY
VB	MMD	MMD	REVISED BY
THIRD ISSUE	SECOND ISSUE	FIRST ISSUE	CONTENTS

REVISIONS

DRAWING SCALE: -/-
UNITS: MM

APPROVED BY: MP 16/04/2015
CHECKED BY: MS 16/04/2015
DESIGNED BY: MMD 16/04/2015
DRAWN BY: PJ 16/04/2015

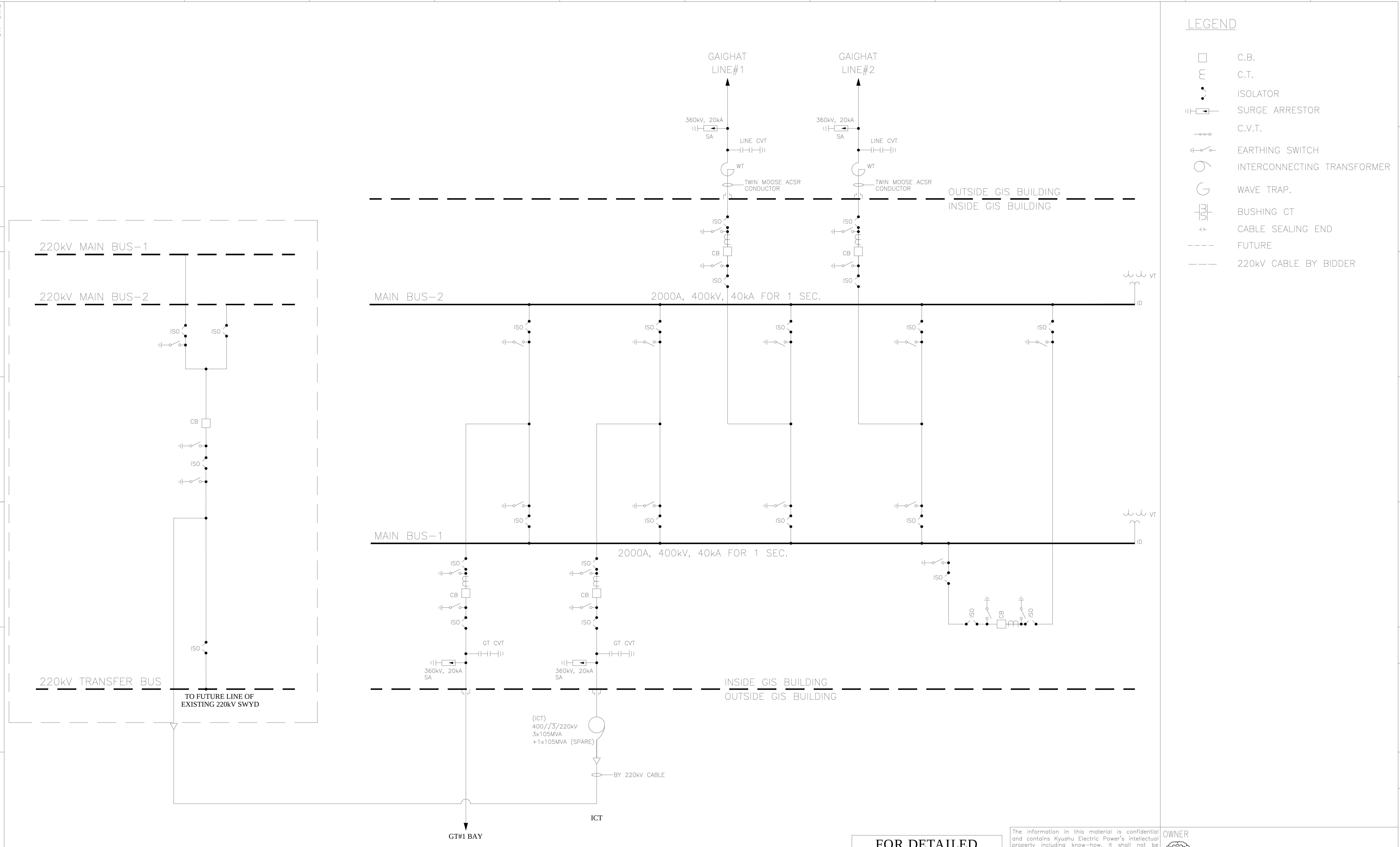
KYUSHU ELECTRIC POWER CO., INC.

TITLE: KEY SINGLE LINE DIAGRAM

PROJECT: 1x660MW BARAUNI TPS, UNIT#10 EXTENSION PROJECT, BIHAR

DWG. NO. —
1/1
REV.NO. 2

A0 (841mm x 1189mm)



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REV. NO.	–	DRAWING SCALE	APPROVED BY – 31/08/2015	CHECKED BY – 31/08/2015
DATE	–	–		
APPROVED BY	–	UNITS N/A	DESIGNED BY – 31/08/2015	DRAWN BY – 31/08/2015
CHECKED BY	–			
REVISED BY	–			
CONTENTS	–	KYUSHU ELECTRIC POWER CO., INC.		

TITLE: 400kV SWITCHYARD SINGLE LINE DIAGRAM (GIS)

PROJECT: 1x660 MW BARAUNI TPS, UNIT#10 EXTENSION PROJECT, BIHAR

DWG. NO. 1/1 REV.NO. 0

18. PLOT PLAN OF SWITCHYARD (GIS)

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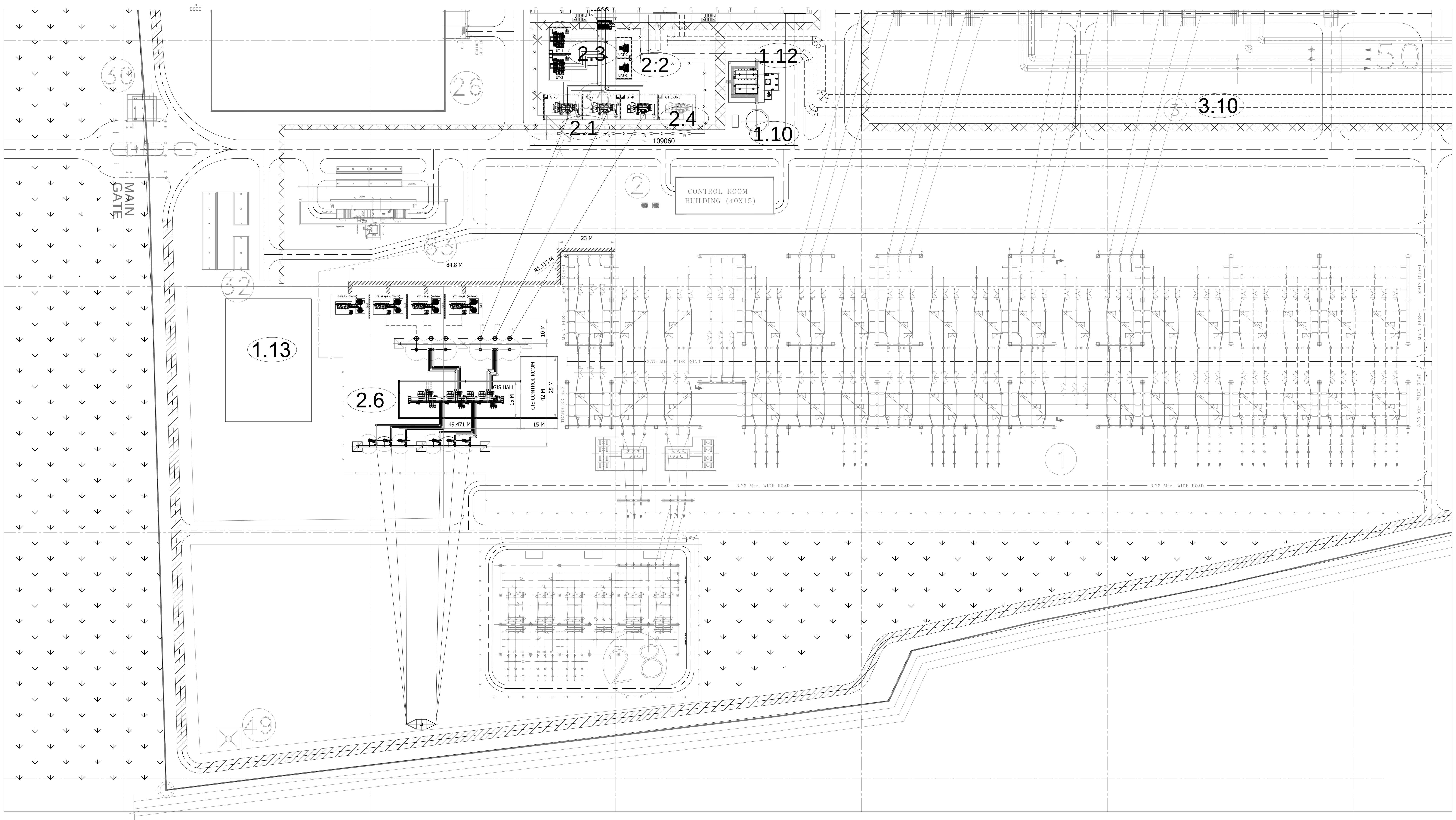

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REV. NO.	0
DATE	21/10/2015
APPROVED BY	MP
CHECKED BY	MS
REVISED BY	AG
CONTENTS	FIRST ISSUE

REVISIONS

DRAWING SCALE –

UNITS MM

APPROVED BY MP 21/10/2015	CHECKED BY MS 21/10/2015
DESIGNED BY AG 21/10/2015	DRAWN BY PJ 21/10/2015

TITLE
SWITCHYARD LAYOUT
400kV GIS
(OPTION - 315 (105x3+1SP) MVA)

PROJECT
1x660 MW BARAUNI TPS, UNIT#10 EXTENSION
PROJECT, BIHAR

KYUSHU ELECTRIC POWER CO., INC.

DWG. NO.
BAB3-TEA-0XX-XX0-XXXX 1/1

REV.NO. 0

19. DCS SYSTEM CONFIGURATION BLOCK DIAGRAM

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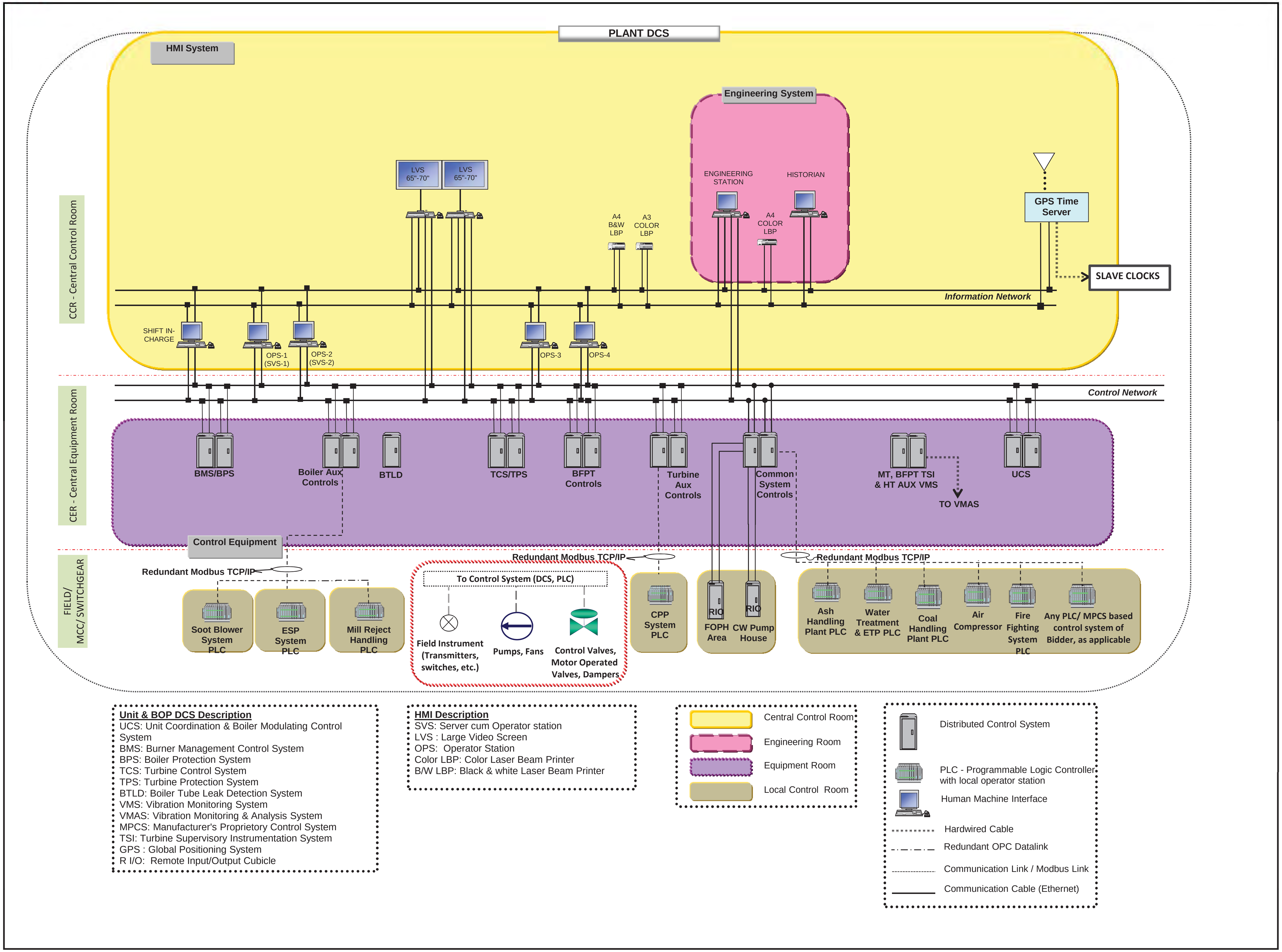

1X 660MW BARAUNI THERMAL POWER STATION
DCS System Configuration Diagram

20. PROJECT MILESTONE SCHEDULE

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1x660 MW Barauni Thermal Power Project

L-1 Schedule

Activity ID	Activity Name	Original Duration	Start Month from NTP	Finish (Months from NTP)
1X660 MW Barauni Thermal Power Project (52 Months)		1582		
MAJOR MILESTONES/ACTIVITIES		1582		
M1300	BTG Input for Civil Engineering (Data Exchange)	122	00 M	04 M
M1340	TG Building Foundation Construction	244	08 M	15 M
M1345	Boiler Foundation Construction	305	07 M	16 M
M1390	TG Foundation Construction	580	08 M	27 M
M1310	Detail Engineering	761	04 M	28 M
M1320	Completion of Major Ordering	0		30 M
M1360	Boiler Structure Erection	395	18 M	30 M
M1580	Pressure Parts erection	365	25 M	36 M
M1630	Boiler Hydro Test	0		37 M
M1590	Start of Condenser	395	27 M	39 M
M1600	TG Erection	365	29 M	40 M
M1610	Power Cycle Piping Erection	274	32 M	40 M
M1640	TG Box Up	0		40 M
M1620	LP Piping Erection Start	305	34 M	43 M
M1650	TG Oil Flushing	90	41 M	43 M
M1660	Erection of TG Auxiliaries-Finish	0		43 M
M1670	ESP Readiness	0		43 M
M1680	Boiler Light Up	0		44 M
M1690	TG on Barring Gear	0		44 M
M1070	Switchyard Readiness for Synchronization	0		46 M
M1700	Steam Blowing	90	45 M	46 M
M1720	Vacuum up test	0		47 M
M1730	Steam Admission	0		47.5 M
M1740	First Coal Firing	0		47.5 M
M1735	Synchonization	0		48 M
M1750	Readiness for Full Load Operation	0		50 M
M1760	Trial Operation Finish	0		51 M
M1770	Performance Guarantee Test & Handing Over	0		52 M
M1000	Notice To Proceed	0	00 M	
OWNER INPUT MILESTONES		1339		
M1010	All Statuary Clearances	0		00 M
M1020	Availability of Study Reports	0		00 M
M1030	Handing over of Complete site	0		00 M
M1040	Availability of Start up power	0		34 M
M1045	Availability of Auxillary Steam	0		40 M
M1050	Availability of Fuel Oil	0		41 M
M1080	Availabiltiy of Coal	0		44 M
SITE ENABLING WORKS		180		
M1260	Construction Water Availability	60	00 M	02 M
M1270	Construction Power Availability	60	00 M	02 M
M1255	Mobilization Start of Civil Contractor at Site	90	03 M	05 M
M1280	Compl. Geotech study, site survey, & site Cleaning/Leveling	120	03 M	06 M
M1290	Establishment of Site Office	150	02 M	06 M
BTG ACTIVITIES		854		
BTG MATERIAL SUPPLY AT SITE		547		
M1400	Embedded plates for Turbine and Generator Items-Finish	0		22 M
M1410	Boiler Steel Structure Supply - Sequentially	150	19 M	24 M
M1420	Condenser Material Supply - Sequentially	152	24 M	28 M
M1480	MIlls and feeder items Supply - Sequentially	183	23 M	28 M
M1430	Air Heater Items Supply - Sequentially	153	26 M	30 M
M1460	Finish of Generator material supply - Squentially	183	25 M	30 M
M1440	Pressure Parts Material Supply - Sequentially	244	24 M	31 M
M1500	Deaerator/ HP/LP Heaters Supply - Sequentially	91	29 M	31 M
M1520	Turbine Oil Purification System	0		31 M

Actual Work — Critical Remaining Work — Remaining Work — Milestone

KYUSHU ELECTRIC POWER CO.,INC.

1x660 MW Barauni Thermal Power Project

L-1 Schedule

Activity ID	Activity Name	Original Duration	Start Month from NTP	Finish (Months from NTP)
M1550	DCS, C&I Supply - Sequentially	183	26 M	31 M
M1470	Boiler Feed Water Pumps with Motor Supply - Sequentially	181	27 M	32 M
M1490	Air & Gas Ducts Supply Finish	243	26 M	33 M
M1540	Steam Turbine Material Supply - Sequentially	274	26 M	34 M
M1450	ESP Material Supply - Sequentially	425	22 M	35 M
M1510	FD/ID/PA fans with Motor Supply - Sequentially	183	30 M	35 M
M1530	Supply of Power Cycle Piping - Sequentially	244	28 M	35 M
M1570	Completion of All Major Supplies	0		36 M
BTG MAJOR ERECTION ACTIVITIES		854		
M1380	EOT Crane Erection	122	22 M	25 M
M1350	TG Building Structure Erection	427	15 M	28 M
M1231	Mills and Coal Bunker along with Steel Structure Erection	732	18 M	42 M
M1370	ESP Structure and Mechanical Erection	518	26 M	42 M
BOP PACKAGES(CIVIL WORKS TO COMMISSIONING)		1218		
M1090	Fire protection system for Start up power	485	19 M	34 M
M1100	Switchyard for back charging (Start up Power)	701	12 M	34 M
M1710	Intake Water System	640	14 M	34 M
M1110	Raw Water System	670	14 M	35 M
M1210	Compressed Air System	457	21 M	35 M
M1120	Pre - Treatment Plant	854	09 M	36 M
M1130	DM Plant	792	11 M	36 M
M1780	Waste Water Effluent treatment Plant	671	15 M	36 M
M1150	Cooling Tower	1067	06 M	40 M
M1180	CW System	854	13 M	40 M
M1160	CCW System	640	21 M	41 M
M1170	ACW System	640	21 M	41 M
M1190	Emergency DG	823	15 M	41 M
M1200	Chimney	1001	10 M	42 M
M1790	Potable & Service Water	670	21 M	42 M
M1140	HVAC System	549	26 M	43 M
M1220	Fuel Oil Handling System	850	16 M	43 M
M1155	Fire Protection System - Balance	610	25 M	44 M
M1240	Coal Handling Plant	946	14 M	44 M
M1250	Ash Handling Plant	883	16 M	44 M
M1230	Generator Transformer	1005	13 M	45 M

Actual Work Critical Remaining Work
Remaining Work Milestone

KYUSHU ELECTRIC POWER CO.,INC.