

**MHAISMAL STANDALONE PUMPED STORAGE PROJECT
(800MW)**

PRE-FEASIBILITY REPORT



**GREENKO ENERGIES PRIVATE LIMITED
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CHAPTER – 1

EXECUTIVE SUMMARY

This Pre-Feasibility Report (PFR) is for the Standalone Pumped Storage project of 800 MW / 4800 MWH storage capacity, located at Aurangabad District, Maharashtra. The Mhaismal Standalone PSP Project will comprise of two reservoirs i.e. Mhaismal Upper reservoir (to be constructed newly) and Mhaismal Lower Reservoir (to be constructed newly). This scheme envisages non-consumptive re-utilization of 0.58 TMC of water from the nearby reservoir by recirculation. This Project is a standalone in nature and both the reservoirs are located away from all existing natural water systems and have no/negligible catchment area. Water will be lifted one time from existing nearby reservoir and will be stored in the reservoirs to be constructed and used cyclically for energy storage and discharge. Evaporation losses, if any will be recouped periodically from the nearby reservoir. This Project envisages non-consumptive re-utilization of 0.58 TMC of water for recirculation among two proposed reservoirs. The live storage capacity of Upper reservoir and Lower reservoir is 0.58 TMC. The gross storage capacity of upper reservoir is 0.61 TMC and that of Lower reservoir is 0.62 TMC. The geographical coordinates of the proposed upper reservoir are at longitude 75° 12' 26.34" East and latitude is 20° 04' 47.93" North and that of lower reservoir are at longitude 75° 12' 28.5" East and 20° 05' 22.80" North.

The cycle efficiency of the project is expected to be around 80%. It is proposed to use 400 KV Double Circuit Moose Conductor Transmission Lines of length 27 Km. The line will be connected to 400KV Substation at Waluj for evacuation of generated Power and for Supply of power during pumping mode. Other possibilities of connecting to CTU are also being explored and final connectivity will be decided accordingly.

Depending upon actual Peak demand capacity and peaking duration requirement of State Government / Central utility, Project configuration can be changed to 600MW for 8 hours by keeping overall daily storage capacity same. The peak demand capacity and peaking duration requirement will be studied prior to completion of DPR and accordingly final configuration either of two i.e. 600 MW for 8 hours or 800 MW for 6 hours will be adopted. However, the proposed upper reservoir and lower reservoir capacity and water utilization will remain same in both cases.

The total land required for the construction of various components including land required for infra item like road, job facilities, muck disposal area etc. are tentatively estimated to about 338 Ha. It is proposed to construct the project within a period of 3.5 years including infrastructure development which is proposed to be completed within 6 months. The total cost of the project is estimated to 3909.03 Crores.

CHAPTER – 2

INTRODUCTION OF THE PROJECT/BACKGROUND INFORMATION

2.1 Introduction

India is leading the world's renewable energy revolution and is on track to achieve 175 GW of RE capacity by 2022. Today, Wind & Solar, are the lowest cost source of new energy, however their inherent infirm nature & non-schedulability presents a huge challenge for integrating large RE capacities, while maintaining grid stability. Today, increasing RE capacities coupled with ever changing dynamic demand curves of the States/DISCOMs/STUs are leading to sub-optimal utilization of the existing base-load assets resulting in high fixed cost pass through per kWh and additional burden to the consumers.

In this scenario, standalone Pumped Storage Projects present a unique and viable solution to the needs of the National Grid by being able to provide lowest cost proven energy storage, grid management, frequency regulation and renewable energy integration solutions

Greenko Group is India's leading clean energy company, with **~4.8 GW** operational portfolio across 15 states in India. Greenko Group has an existing asset base of over **USD 5.5 Billion** with an equity investment of **USD 2.0 Billion**. Greenko enjoys strong shareholder support of the world's largest sovereign wealth funds of Singapore (GIC) and Abu Dhabi (ADIA). Greenko Group has an experienced & diverse management team to develop, execute and operate challenging projects with expertise across large-scale Wind, Solar PV and Hydro projects. The team has recently commissioned one of the **World's largest single 816 MW_{DC} Solar PV Plant in Kurnool**, Andhra Pradesh within a record time of **6 months**.

Greenko Group has over the past 10 years, developed capabilities not just in RE project execution, but also **state of the art digital capabilities** for **efficiently forecasting renewable generation trends** in Solar & Wind domains giving it a **unique capability to integrate diverse generation** streams of energy to lead the creation of a Decarbonized, Digitized future on the Energy sector in India.

Greenko has conceptualized two worlds first and largest GW scale Integrated Renewable Energy storage projects located in Andhra Pradesh and Karnataka. **IRESP Pinnapuram** is in Andhra Pradesh which configures **1000MW Solar, 550MW Wind and 1200MW PSP** with 7hrs of storage Similarly, other project is **IRESP Saundatti** which configures **1000MW Solar, 450MW Wind and 1260MW PSP** with 10.9hrs of storage. Both these projects are in advanced stage of obtaining statutory clearances and ground breaking as

site is expected shortly.

Greenko Group has been in the process of evaluating suitable locations for Grid scale energy management solutions for over 1 year and has identified Mhaismal, Aurangabad District, Maharashtra for the proposed Mhaismal Pumped Storage Project. Mhaismal Standalone Pumped storage will require 0.58 TMC of water for establishing 4800 MWh (800 MW x 6h or 600 MW x 8h) storage capacity.

The pumped storage solution will provide various benefits like:

1. Energy shifting, Load levelling and peak shaving
2. Frequency control and deviation management
3. Ancillary services like Black start, Voltage and reactive power support

This will enable greater Integration of Renewable Energy, Effective Peak demand management as well as better utilization of Transmission and Generation assets.

This PFR is prepared for Standalone Pumped Storage of 4800 MWH (800 MW X 6h or 600 MW X 8h) capacity, located at Aurangabad District, Maharashtra. Mhaismal Standalone PSP will comprise of two reservoirs to be constructed in existing natural depressions with low height embankments of average height 20m (with maximum height 27m) to create the desired storage capacity. This Project is standalone in nature and both the reservoirs are located away from all existing natural water systems and have no/negligible catchment area. Water will be lifted one time from existing nearby reservoir / irrigation system and will be stored in the reservoirs to be constructed and used cyclically for energy storage and discharge. Evaporation losses, if any will be recouped periodically. This Project envisages non-consumptive re-utilization of 0.58 TMC of water for recirculation among two proposed reservoirs. The geographical coordinates of the proposed upper reservoir are at longitude 75° 12' 26.34" East and latitude is 20° 04' 47.93" North and that of lower reservoir are at 75° 12' 28.15" East and 20° 05' 22.80" North.

Depending upon actual Peak demand capacity and peaking duration requirement of State Government / Central utility, Project configuration can be changed to 600MW for 8 hours by keeping overall daily storage capacity same. The peak demand capacity and peaking duration requirement will be studied prior to completion of DPR and accordingly final configuration either of two i.e. 600 MW for 8 hours or 800 MW for 6 hours will be adopted. However, the proposed upper reservoir capacity and water utilization will remain same in both cases.

2.2 Scope of Report

The proposed Mhaismal Standalone Pumped Storage Project is a self-identified project and this Pre-Feasibility Study Report has been prepared to study, evaluate and establish the technical feasibility and economic viability of the proposed Pumped Storage Project.

2.3 Scope of Works

The Standalone Pumped Storage Component of Mhaismal Standalone PSP envisages construction of upper and lower reservoir near Mhaismal village in Aurangabad District. The one-time filling of the proposed Mhaismal Standalone PSP upper reservoir will be taken up from nearby reservoir.

Two alternative layouts for this scheme were studied.

Alternative – 1: Layout with Surface Power House and other components of this scheme are Upper reservoir, Intake structure, Penstock / Pressure Shaft, Tail Race Outlet, Tail Race Tunnel/Channel and Lower reservoir.

Alternative -2: Layout with underground Power House and other components of this scheme are Upper reservoir, Intake structure, Pressure Shaft, Tail Race Tunnel, Tail Race Outlet, Tail Race Channel and Lower reservoir.

Alternative -1

The Alternative – 1 layout is proposed with surface power house. The surface power house involves little deeper excavation since the Standalone Pumped Storage project is placed much below the Minimum Draw Down Level of lower reservoir because of technical requirement during pumping operations. However, necessary slope protection measures are proposed to be provided for the cut slopes as it involves deeper excavation. Construction time for completion of this Alternative is estimated to 36 months excluding Pre-construction activities.

Alternative - 2

The Alternative – 2 layout is proposed with underground power house. The underground power house requires Adit tunnels viz., Main Access Tunnel to Power house Service bay and Transformer hall, Adit to Power house cavern top, Adit to Transformer cavern top, Bus duct tunnels etc. The total length of all adits are worked out to about more than 2000m. Though construction work can be carried out for underground structures all through the season, the time required to complete the activity is more and expensive also. Excavation of these tunnels will take longer duration to reach the power house and start works at power house.

The total construction time for the project is estimated to 54 months which is more compared to Alternative – 1 and total cost of the project is also more comparing to Alternative - 1. The construction duration of the scheme is very important which will impact the overall financial viability of the project adversely.

Due to the above reasons, Alternative -1 layout has been selected.

Proposed Scheme will involve construction of Rock fill embankments of average height of around 20m with maximum of 27m height in lower reservoir and upper reservoir of Mhaismal Standalone PSP reservoirs. Intake structure and trash rack for four number of independent pressure shafts will be taking off from Power block of Mhaismal Standalone PSP upper reservoir. A Surface Power House will be located on the downstream of the power block and shall be equipped with four vertical-axis reversible Francis type units composed each of a generator/motor and a turbine/pump having generating/pumping capacity of 200MW/224MW.

Indoor Gas insulated switchgear (GIS) will be provided in a separate building located nearby area of the Main Power House. Step up transformers will be placed adjacent to the GIS building, which will be connected by bus duct galleries to machine hall.

One no. of 400 KV Double Circuit Transmission Lines of length 27 Km shall connect the project to 400 kV Substation at Waluj for evacuation of Stored Power during Generating mode and for Supply of power during pumping mode. Alternate options to connect to CTU are also being examined and if found suitable evacuation proposal will be modified accordingly.

The Standalone Pumped Storage Project envisages construction of

- Rock fill embankments of average height of around 20m with maximum of 27m height in lower reservoir and average height of around 20 with maximum of 27m in upper reservoir for very short reach for creation of Mhaismal upper & lower reservoir with 0.58 TMC live storage capacity.
- 49.16m high RCC Intake structure.
- 4 nos. of 666m long and 7.0m dia. Surface circular steel lined Penstock / Pressure shaft to feed 4 units of 200 MW.
- A Surface Power house having an installation of four nos. reversible Francis turbine each of 200 MW capacity (2 units of fixed speed and 2 units of variable speed turbines) operating under a rated head of 125.00m in generating mode and 136.00m in pumping mode.

- 4 Nos. of 8.0m Ø tailrace tunnel 182m Long from power house to outlet structure.
- 45m wide concrete lined Tail race channel with FSD of 5.75m and 250m long connecting Tail race channel to the lower reservoir.

2.4 Hydrology

The Mhaismal Standalone PSP is proposed between two reservoirs i.e. Mhaismal Standalone PSP upper and lower reservoir (both are to be constructed newly) and one-time water will be pumped from existing nearby reservoir to fill up the proposed reservoir. Secondly since these two reservoirs are not located across any stream, no Specific hydrological studies are required to be carried out. The upper reservoir does not have any catchment area and the lower reservoir is having very negligible catchment area and hence the inflow from rainfall is negligible.

2.5 Installed Capacity

The Mhaismal Standalone Pumped Storage Project is proposed with rating of 800 MW and with a storage capacity of 4800 MWH (Combination 800 MW X 6h or 600 MW X 8h). This Project is comprising of 4 units of 200 MW each. The installed capacity of a pumped storage scheme is influenced by the requirements of daily peaking power requirements, flexibility in efficient operation of units, storage available in the reservoirs and the area capacity characteristics. The Project will generate 800 MW by utilizing a design discharge of 739.68 Cumec and rated head of 125m. The Mhaismal Standalone PSP will utilize 896 MW to pump 0.58 TMC of water to the upper reservoir in 7.54 hours.

The Key parameters of Mhaismal Standalone PSP are as follows:

SI. No.	Parameter	Unit	Value
1	Energy Storage Capacity	MWH	4800(800 MW x 6hr or 600MW x 8hr)
2	Rating	MW	800
3	No. of Units	Nos.	4
4	Rated Head in Turbine mode	M	125.00
5	Total Design Discharge	Cumec	739.68
6	Design Discharge per unit of 200 MW	Cumec	184.92
7	Water Requirement	TMC/Cumec	0.58 / 16.42
8	Generation Duration	Hrs	6.00
9	Turbine Capacity – 4 Units	MW	200
10	Annual Energy Generation	MU	1711
11	Pump Capacity – 4 Units	MW	224

Sl. No.	Parameter	Unit	Value
12	Rated Head in Pump mode	M	136.00
13	Pumping Duration	Hrs.	7.54
14	Expected Cycle Efficiency	%	80

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Mhaismal Standalone PSP in Turbine mode is 1711 MU, with 95% machine availability.

2.6 Power Evacuation

One no. of 400 KV Double Circuit Transmission Line of length 27 Km shall be used by the plant. The line will be connected to Maharashtra State 400 kV Substation at Waluj for evacuation of generated Power and for Supply of power during pumping mode. Other possibilities of connecting to CTU are also being explored and final connectivity will be decided accordingly.

2.7 Environmental Aspects

Upper and lower reservoir for Mhaismal Standalone PSP will be constructed newly and the onetime filling of the Mhaismal Standalone PSP upper reservoir will be taken up from nearby existing reservoir. There will be submergence of additional land required for the proposed Mhaismal Standalone PSP upper and lower reservoirs for the pumped storage project. Also, land will be required for the construction of power house complex and its appurtenant works Viz., Intake structure, Penstocks / Pressure Shafts, powerhouse, Tail Race Pool, Tail Race Channel etc. Total land required for the construction of various components are tentatively estimated to about 337.14 Ha including submergence by formation of Mhaismal Standalone PSP upper and lower reservoir including land required for other infra item like road, job facilities, muck disposal area etc. The same will be analysed once again after finalization of layout during DPR stage. Based on assessment of environmental impacts, management plans must be formulated for compensatory afforestation and other environmental issues. These issues would be addressed during the investigations for DPR.

2.8 Construction Planning & Schedule

It is proposed to construct the project within a period of 3.0 years excluding infrastructure development which is proposed to be completed within 6 months.

2.9 Employment generation due to the project

As project is planned to complete in 42 months, at the time of peak construction work in the project, around 2400 persons may be engaged. Out of 2400 nos. the majority of about 800 nos. will be from the local population/surrounding Villages and balance persons of about 1600 nos. will be skilled /semiskilled from other area. All the local persons will come from their homes only. Only the migrated manpower will stay at site camp.

Then after commissioning of the project, about 400 persons will be required for operations, which might be from local areas or migrated from another area.

2.10 Project Cost Estimate

The estimate of the project cost has been prepared as per the "Guidelines for formulation of Detailed Project Reports for Hydro- Electric Schemes" issued by Central Electricity Authority in January 2018 (Revision 5.0) to arrive at hard cost of the project at November 2018 price level. Quantities have been worked out on the basis of preliminary designs and drawings of different component works. Unit rate analysis was done as per the Guidelines for the preparation of Detailed Project Report of Irrigation and Multipurpose Projects and Guidelines for the preparation of Estimates for River valley projects. The quantities and ratings of various Hydro Mechanical and Electro-mechanical equipment's have been worked out on the basis of system design and equipment sizing calculations.

The total project cost works out as given below:

S.NO.	Description of Item	Cost in Crores
1	Cost of Civil Works	1595.80 Cr.
2	Cost of Power Plant Electro Mechanical Equipmen including Transmission line	1220.00 Cr.
3	Total Hard Cost	2815.80 Cr.
4	IDC & Others	1093.23 Cr.
5	Total cost of the Project	3909.03 Cr.

2.11 Economic Financial Analysis

The economical evaluation of Mhaismal Standalone PSP will be arrived at as per the prevailing guidelines of PSP.

2.12 Conclusions

The Mhaismal Standalone PSP is envisaged to be completed in a period of 3.5 years. The project would generate designed energy of 1711 MU at 95% plant availability. Other benefit of this storage project can be in the form of spinning reserve with almost instantaneous start-up from zero to full power supply, supply of reactive energy, primary frequency regulation, voltage regulation, etc.

CHAPTER – 3

3.1 SALIENT FEATURES OF THE PROJECT

1		NAME OF THE PROJECT	Mhaismal Standalone Pumped Storage Project
2		Location	
	a	Country	India
	b	State	Maharashtra
	c	District	Aurangabad
	d	Village near Power House	Mhaismal
3		Geographical Co-Ordinates	
	a	Mhaismal Standalone PSP Upper Reservoir - (Now Proposed)	
		Latitude	20° 04' 47.93" N
		Longitude	75° 12' 26.34" E
	b	Mhaismal Standalone PSP Lower Reservoir - (Now Proposed)	
		Latitude	20° 05' 22.80" N
		Longitude	75° 12' 28.15 E
4		Access To Project Site	
	a	Airport	Aurangabad Airport -36kms from project site
	b	Rail head	Aurangabad Railway Station, 37.3 kms via. NH52 from project site
	c	Road	NH 52
	d	Port	Jawaharlal Nehru Port- 367 kms via. NH160
5		Project	
	a	Type	Standalone Pumped Storage Project

	b	Storage Capacity	4800 MWH
	c	Rating	800 MW
	d	Peak Operation duration	6 Hours
6		Mhaismal Standalone PSP - Upper Reservoir	
	a	Live Storage	0.58 TMC
	b	Dead Storage	0.03 TMC
	c	Gross Storage	0.61 TMC
7		Upper Dam	
	a	Full Reservoir level (FRL)	EL +875.00 m
	b	Min. Draw Down Level (MDDL)	EL +855.00m
	c	Top Bund Level (TBL)	EL +878.00 m
	d	Type of Dam	Rock fill Embankment with central clay core
	e	Max. Height of Rockfill Embankment	27 m
	f	Length at the top of Rockfill Embankment	5253 m
	g	Top width of the Rockfill Embankment	10.0 m
	h	Type of Power Block	Concrete Gravity Structure
	i	Height of Power Block	49.16 m
	j	Length at the top of Power Block	124.0 m
	k	Top width of the Power Block	10.0 m
8		Mhaismal Standalone PSP – Lower Reservoir	
	a	Live Storage	0.58 TMC
	b	Dead Storage	0.04 TMC
	c	Gross Storage	0.62 TMC
9		Lower Dam	

	a	Full Reservoir level (FRL)	EL +745.00 m
	b	Min. Draw Down Level (MDDL)	EL +725.00m
	c	Top Bund Level (TBL)	EL +748.00 m
	d	Type of Dam	Rock fill Embankment with central clay core
	e	Max Height of Embankment	27
	f	Length of Embankment	706
10		Intake Structure	
	a	Type	Diffuser Type
	b	No. of Vents	4 nos.
	c	Size of Each Intake	26.40 m (W) x 9.00 m (H) including piers
	d	Length of each Intake	41.40 m (covered with RCC slab at top up to Intake Gate)
	e	Elevation of Intake centre line	EL +843.22 m
	f	Elevation of Intake bottom	EL +839.72 m
	g	Design Discharge of each Intake (Turbine mode)	184.92 Cumec
	h	Trash rack type	Vertical with inclination of 15°
	i	Size of Trash Rack	3 nos. of 7.80 m (W) x 9.32 m (H) for each unit
	j	Numbers & Size of Intake Service Gate	4 nos. of 5.50 m (W) x 7.00 m (H)
	k	Numbers & Size of Intake Emergency Gate	1 No. – 5.5 m (W) x 7.0 m (H) with Moving Gantry
11		Penstock /Pressure Shafts	
	A	Type	Finished steel lined - circular
	B	Number of Pressure Shaft	Total 4 Nos. of Independent Pressure Shafts
	C	Diameter of Pressure Shaft	7.0 m
	D	Length of Penstock / Pressure Shaft	666 m Length of surface penstock from Intake to

			Vertical Pressure Shaft – 488 m Length of Vertical Pressure Shaft – 89 m Length of Horizontal Pressure Shaft – 89 m
		Design Discharge of each Penstock	184.92 Cumec
		Velocity in the Penstock	4.81 m/sec
12		Powerhouse	
	A	Type	Surface Powerhouse
	B	Centre line of Unit	EL +695.00 m
	C	Dimensions (Excluding Service bay)	L 118.00m x B 24m x H 51.10 m
	D	Size of Service bay	40 m (L) x 24.0 m (W)
	E	Service bay level	EL +709.15 m
	F	Size of Unloading Bay	20 m (L) X 24.0 m (W)
	G	Unloading Bay Level	EL +732.70 m
13		Tail Race Tunnel	
	A	Type & Shape	Concrete Lined – Circular
	B	Number of Tunnels	4 Nos.
	C	Dia. of Tunnel	8 m
	D	Length of the Tunnel	182.00 m
	E	Design Discharge	184.92 Cumec
14		Tailrace Outlet	
	A	Type	Inclined
	B	No. of Outlet	4 Nos.
	C	Elevation of outlet centre line	EL +714.22 m
	D	Elevation of Outlet bottom	EL +710.22 m
	E	Trash rack Type	Vertical with inclination of 15°
	F	Size of Trash rack	3nos. of 5.75 m (W) x 19.78 m (H) for each unit
	G	Tailrace outlet Service Gate	4 nos. of 6.60 m (W) x 8.00 m (H)

	H	Tail Race outlet Emergency Gate	1 No. – 6.60 m (W) x 8.0 m (H) with Moving Gantry
15		Tail Race Channel	
	A	Type & Shape	Concrete lined & Trapezoidal
	B	Length of channel	250m
	C	Bed width	45m
	D	Full supply depth	5.75 m
	E	Bed slope	1 in 5300
16		Electro Mechanical Equipment	
		Pump Turbine	Francis type, vertical shaft reversible pump-turbine
		Total No of units	4 nos' (4 X 200MW)
		Total Design Discharge (Turbine Mode)	739.68 Cumec
		Rated Head in Turbine mode	125.00 m
	a	200MW Turbines	
		Total No.of units	4 Units (2Nos. with variable speed & 2 Nos. with Fixed Speed)
		Turbine Design Discharge	184.92 Cumec
		Pump Capacity	224 MW
		Rated Pumping Head	136.00m
		Rated Pump Discharge	151.19 Cumec
	i	Generator-Motor	
		Type	Three (3) phase, alternating current synchronous/asynchronous generator motor semi umbrella type with vertical shaft
		Number of units	4 Units (4 x 200MW)
		Rated Capacity	Generator – 200 MW;

			Pump Input – 224 MW
		Rated Voltage	18.0 KV
	ii	Main Power Transformer	
		Type	Outdoor Single-Phase Power transformers with Off-Circuit tap changer (OCTC)
		Number of units	12 Nos. ie. 3 nos. per unit
		Rated Capacity of each unit	Single Phase, 18 kV/400kV, 85 MVA
		Rated Voltage	Primary – 18.0 kV; Secondary - 400 kV adjustable range of the secondary voltage: -10% to +10%(3kV/tap)
17		400 KV Gas Insulated Switchgear	
	1	Type of GIS	Indoor Type
	2	No. of GIS units	One No. with one bus sectionaliser
	3	Location	Inside GIS building above ground
	4	Scheme	Double Busbar Arrangement with coupler
18		POWER EVACUATION	
	a	Voltage Level (KV)	400 KV
	b	No. of Transmission Lines	One Transmission line with double circuit
	e	Total Length	400 KV Double Circuit Transmission Lines of length 27 Kms from PSP will be connected to Maharashtra State 400 kV Substation at Waluj , Maharashtra State
19		Estimated Cost	
	a	Civil Works & Other works	1595.80 Cr.
	b	E & M Works incl. transmission	1220.00 Cr.
	c	I DC & Others	1093.23 Cr.

	Total Project Cost With IDC	3909.03 Cr.
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3.2 HYDROLOGY & POWER POTENTIAL STUDIES

Determination of Power Potential is the primary step in planning a Hydro Power Plant. The power potential of the project shall be dependent on the project layout, operating water levels, data on long term flow availability, selected turbo generating equipment type and its parameters etc.

The Standalone PSP is proposed between two reservoirs i.e. Mhaismal Standalone PSP upper and lower reservoir (both are to be constructed newly) and one-time water will be pumped from existing nearby reservoir to fill up the proposed reservoir. Secondly since these two reservoirs are not located across any stream, therefore, no Specific hydrological studies are required to be carried out and similarly power potential studies are also required to be carried out for the power potential possibility to be generated by recirculation of water in between these two reservoirs.

The Mhaismal Standalone PSP is proposed to utilize the water available in the existing nearby reservoir located in Aurangabad district. The two reservoirs are formed to have a live storage capacity of 0.58 TMC. The lower and upper reservoir comprises of max 27.0m high rockfill embankment with central clay core for short reach and the average height of embankment for both upper and lower reservoir are around 20m each. An RCC Concrete Structure is proposed in upper reservoir with power block of 124m long comprising of four power intake structure and four independent steel lined pressure shafts starts from the RCC intake structure for conveying water to powerhouse. The water from power house out fall is let back to the lower reservoir through Tail Race Tunnel and Tail Race Channel.

Since the proposed scheme is a pumped storage scheme and envisages to utilize 0.58 TMC of water, no modification in the operating levels are needed. Moreover, only recycling of water between these two reservoirs are proposed for Mhaismal Standalone PSP operation. As such hydrological study is required to the extent to see the required inflow into reservoir.

The Key parameters of proposed Mhaismal Standalone PSP Upper Reservoir are as follows:

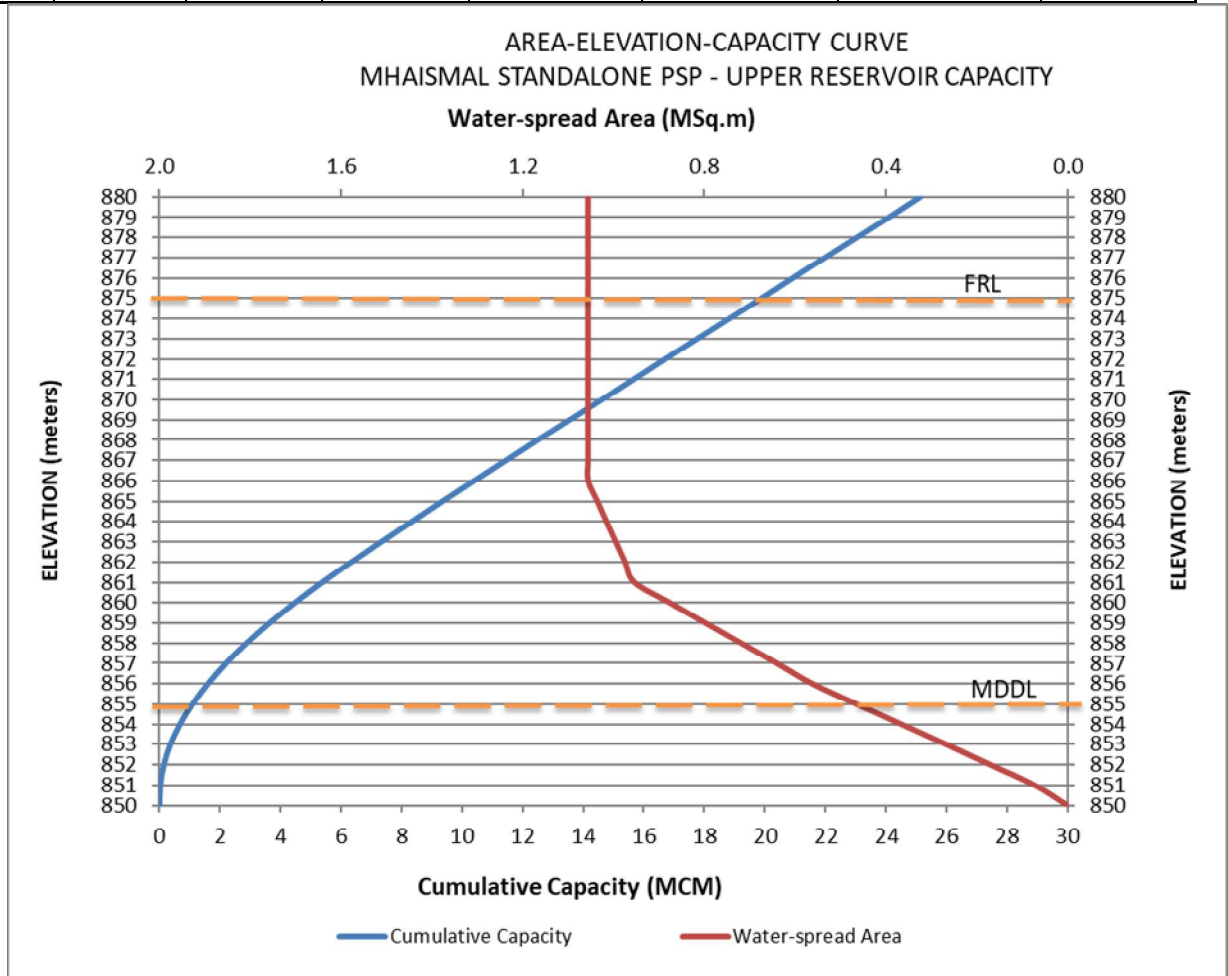
Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	M	EL 875.00
2	Minimum Draw Down Level (MDDL)	M	EL 855.00

3	Live Storage	TMC	0.58
4	Dead Storage	TMC	0.03
5	Gross Storage	TMC	0.61
6	Maximum Height of Rockfill	M	27.00
7	Average Height of Rock Fill	M	20.00

The area capacity table for the proposed upper reservoir is given in the table below

MHAISMAL STANDALONE PSP - UPPER RESERVOIR CAPACITY							
Sl.No	Elevation	Area in Sqm	Area in MSqm	Capacity in Cum	Capacity in MCum	Cumulative Capacity in Mcum	Cumulative Capacity in TMC
1	850	0	0	0	0	0.00	
2	851	71266	0.07	23755	0.02	0.02	0.00
3	852	169228	0.17	116771	0.12	0.14	0.00
4	853	267189	0.27	216352	0.22	0.36	0.01
5	854	365151	0.37	314898	0.31	0.67	0.02
6	855	463112	0.46	413163	0.41	1.08	0.03
7	856	561074	0.56	511311	0.51	1.60	0.05
8	857	639486	0.64	599853	0.60	2.20	0.07
9	858	717898	0.72	678314	0.68	2.87	0.09
10	859	796310	0.80	756765	0.76	3.63	0.11
11	860	874722	0.87	835209	0.84	4.47	0.14
12	861	953134	0.95	913648	0.91	5.38	0.17
13	862	973465	0.97	963282	0.96	6.34	0.19
14	863	993796	0.99	983613	0.98	7.33	0.23
15	864	1014127	1.01	1003944	1.00	8.33	0.26
16	865	1034458	1.03	1024276	1.02	9.36	0.29
17	866	1054789	1.05	1044607	1.04	10.40	0.32
18	867	1054789	1.05	1054789	1.05	11.45	0.35
19	868	1054789	1.05	1054789	1.05	12.51	0.38
20	869	1054789	1.05	1054789	1.05	13.56	0.42
21	870	1054789	1.05	1054789	1.05	14.62	0.45
22	871	1054789	1.05	1054789	1.05	15.67	0.48
23	872	1054789	1.05	1054789	1.05	16.73	0.51
24	873	1054789	1.05	1054789	1.05	17.78	0.55
25	874	1054789	1.05	1054789	1.05	18.84	0.58
26	875	1054789	1.05	1054789	1.05	19.89	0.61
27	876	1054789	1.05	1054789	1.05	20.95	0.64
28	877	1054789	1.05	1054789	1.05	22.00	0.68

29	878	1054789	1.05	1054789	1.05	23.06	0.71
30	879	1054789	1.05	1054789	1.05	24.11	0.74
31	880	1054789	1.05	1054789	1.05	25.17	0.77

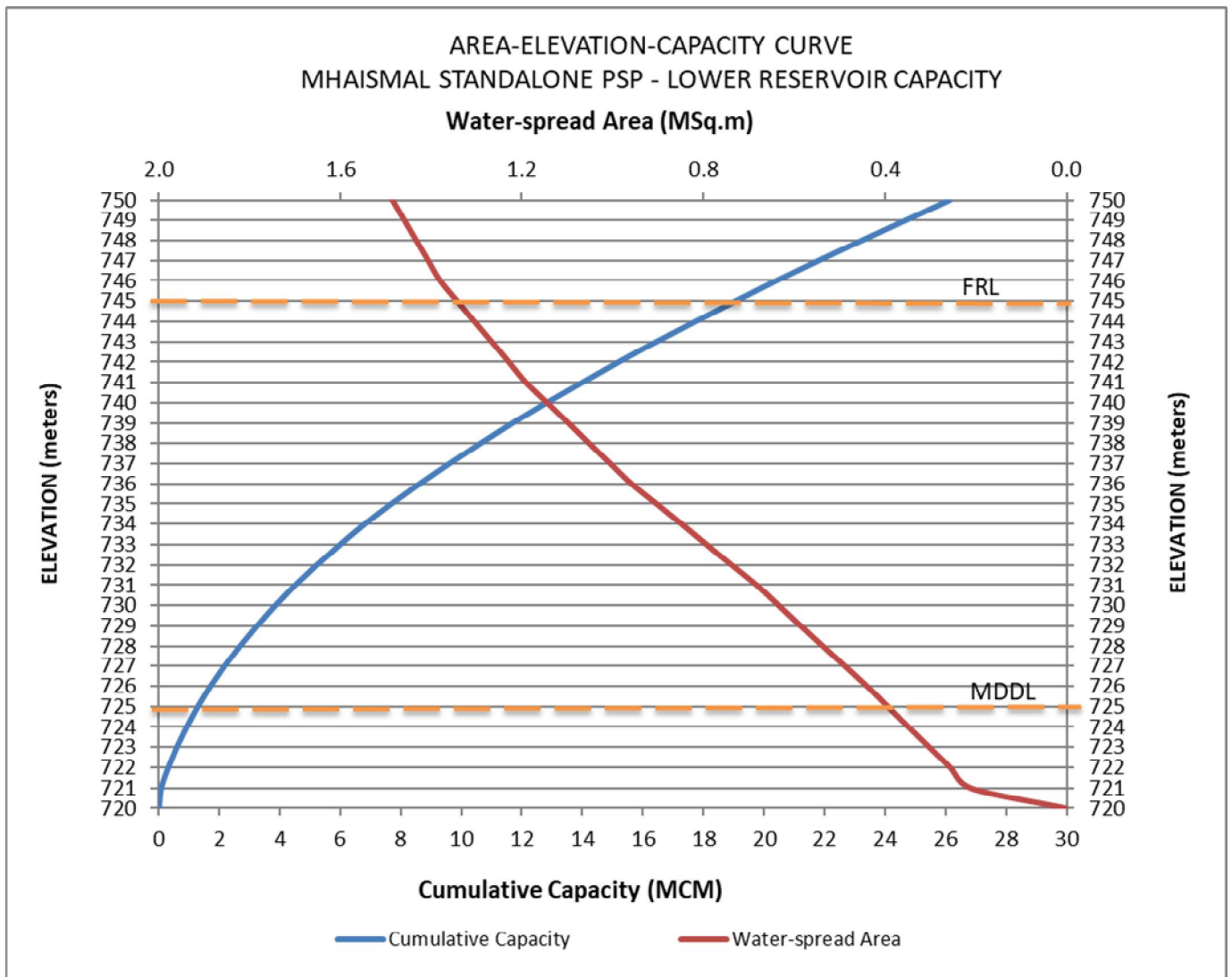


The Key parameters of proposed Mhaismal Standalone PSP Lower Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	M	EL 745.00
2	Minimum Draw Down Level (MDDL)	M	EL 725.00
3	Live Storage	TMC	0.58
4	Dead Storage	TMC	0.04
5	Gross Storage	TMC	0.62
6	Maximum Height of Rockfill	M	27.00
7	Average Height of Rock Fill	M	20.00

The area capacity table for the proposed Lower reservoir is given in the table below

MHAISMAL STANDALONE PSP - LOWER RESERVOIR CAPACITY							
Sl.No	Elevation	Area in Sqm	Area in MSqm	Capacity in Cum	Capacity in MCum	Cumulative Capacity in Mcum	Cumulative Capacity in TMC
1	720	0	0	0	0	0.00	
2	721	210385	0.21	70128	0.07	0.07	0.00
3	722	256183	0.26	232909	0.23	0.30	0.01
4	723	301981	0.30	278769	0.28	0.58	0.02
5	724	347780	0.35	324611	0.32	0.91	0.03
6	725	393578	0.39	370443	0.37	1.28	0.04
7	726	439376	0.44	416267	0.42	1.69	0.06
8	727	488056	0.49	463503	0.46	2.16	0.07
9	728	536736	0.54	512203	0.51	2.67	0.09
10	729	585417	0.59	560900	0.56	3.23	0.10
11	730	634097	0.63	609595	0.61	3.84	0.12
12	731	682777	0.68	658287	0.66	4.50	0.15
13	732	737870	0.74	710145	0.71	5.21	0.17
14	733	792963	0.79	765251	0.77	5.97	0.19
15	734	848056	0.85	820355	0.82	6.79	0.22
16	735	903149	0.90	875458	0.88	7.67	0.25
17	736	958242	0.96	930560	0.93	8.60	0.28
18	737	1004771	1.00	981415	0.98	9.58	0.31
19	738	1051300	1.05	1027948	1.03	10.61	0.34
20	739	1097830	1.10	1074481	1.07	11.68	0.38
21	740	1144359	1.14	1121014	1.12	12.80	0.42
22	741	1190888	1.19	1167546	1.17	13.97	0.45
23	742	1228784	1.23	1209787	1.21	15.18	0.49
24	743	1266680	1.27	1247684	1.25	16.43	0.53
25	744	1304577	1.30	1285582	1.29	17.71	0.58
26	745	1342473	1.34	1323479	1.32	19.04	0.62
27	746	1380369	1.38	1361377	1.36	20.40	0.66
28	747	1406565	1.41	1393447	1.39	21.79	0.71
29	748	1432761	1.43	1419643	1.42	23.21	0.75
30	749	1458958	1.46	1445840	1.45	24.66	0.80
31	750	1485154	1.49	1472036	1.47	26.13	0.85
32	751	1511350	1.51	1498233	1.50	27.63	0.90



3.2.1 Discharge Series

Based on the storage capacity of the proposed upper and lower reservoir, power potential study was carried out to assess the installed capacity. The Mhaismal Standalone PSP is envisaged to utilize 0.58 TMC of water to be pumped from the nearby existing reservoirs to the proposed upper Mhaismal Standalone PSP reservoir. The project is a pumped storage scheme and hence, no consumptive utilization of water is required for its operation.

3.2.2 Operation of Mhaismal Standalone Pumped Storage Project

The Mhaismal Standalone PSP is proposed with a Storage Capacity of 4800 MWH with Rating of 800 MW. This project is comprising of 4 units of 200 MW each. The Project will generate 800 MW by utilizing a design discharge of 739.68 Cumec and rated head of 125.00m. The Mhaismal Standalone PSP will utilize 896 MW to pump 0.58 TMC of water to the upper reservoir in 7.54 hours.

The Key parameters of Standalone Pumped Storage Project Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Energy Storage Capacity	MWH	4800(800 MW x 6h or 600 MW x 8h)
2	Rating	MW	800
3	No. of Units	Nos.	4
4	Rated Head in Turbine mode	M	125.00
5	Total Design Discharge	Cumec	739.68
6	Design Discharge per unit of 200 MW	Cumec	184.92
7	Water Requirement	TMC / MCum	0.58 / 16.42
8	Generation Duration	Hrs	6.00
9	Turbine Capacity – 4 Units	MW	200
10	Annual Energy Generation	MU	1711
11	Pump Capacity – 4 Units	MW	224
12	Rated Head in Pump mode	M	136.00
13	Pumping Duration	Hrs.	7.54
14	Expected Cycle Efficiency	%	80

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Mhaismal Standalone PSP in Turbine mode is 1711MU, at 95% machine availability.

3.2.3 Operating Head

The energy computations have been carried out based on headwater/full reservoir level (HWL/FRL), tail race water level conditions, efficiency of the turbo-generator and the minimum and maximum load. Full reservoir level at Mhaismal upper reservoir is at EL+875.00m and MDDL is at EL+855.00m. Full reservoir level Mhaismal lower reservoir is at EL +745.00m and MDDL is at EL+725.00m. The total head loss in the system is arrived as 5.0m. Thus, the rated head of 125.00m is considered for the proposed project. The normal tail water level is the level at the tail race outlet corresponds to design discharge flow of 739.68 Cumec passing through the turbine considering all machines running at full plant load. Normal tail water level corresponding to above design discharge is EL +725.00m. The bed level of the tail race channel is kept at EL +719.25m.

3.3 DESIGN FEATURES OF MAJOR COMPONENTS

3.3.1 Introduction

The Mhaismal Standalone Pumped Storage project envisages construction of upper and lower reservoir near village Mhaismal in Aurangabad District.

The scheme will involve construction of rock fill embankment of average height of around 20 m with the maximum height of 27m for short reach for creation of Mhaismal Standalone PSP upper reservoir of 0.61 TMC gross capacity. Similarly, this project envisages construction of rock fill embankment of average height of around 20m with the maximum height of 27m for short reach for creation of lower reservoir of 0.62 TMC gross capacity. The Mhaismal Standalone PSP is proposed in between two reservoirs i.e. Mhaismal Standalone PSP Upper (to be constructed newly) & Mhaismal Standalone PSP Lower (to be constructed newly) and one-time water will be pumped from the near by existing reservoir to fill up the proposed Upper reservoir.

Water will be let out from the Mhaismal Standalone PSP upper reservoir through Power Intake and Penstock/Pressure shaft of 666m long to feed the Mhaismal Standalone PSP, having a Storage Capacity of 4800 MWH with Rating of 800 MW. This project is comprising 4 units of 200 MW each. The water after power generation will be conveyed to proposed lower reservoir through Tail Race Tunnel / Channel. The total design discharge for the proposed scheme is 739.68 Cumec with the rated head of 125.00 m. General Layout of the proposed scheme is enclosed in the drawing no. MHL – PSP - 002.

3.3.2 Alternate Studies

Two alternative layouts for this scheme were studied.

Alternative – 1: Layout with Surface Power House and other components of this scheme are Upper reservoir, Intake structure, Penstock / Pressure Shaft, Tail Race Outlet, Tail Race Channel and Lower reservoir.

Alternative -2: Layout with underground Power House and other components of this scheme are Upper reservoir, Intake structure, Pressure Shaft, Tail Race Tunnel, Tail Race Outlet, Tail Race Channel and Lower reservoir.

Alternative -1

The Alternative – 1 layout is proposed with surface power house. The surface power house involves little deeper excavation since the pumped storage project is placed much below the Minimum Draw Down Level of lower reservoir because of technical requirement during pumping operations. However, necessary slope protection measures are proposed to be

provided for the cut slopes as it involves deeper excavation. Construction time for completion of this Alternative is estimated to 36 months excluding Pre-construction activities.

Alternative - 2

The Alternative – 2 layout is proposed with underground power house. The underground power house requires Adit tunnels viz., Main Access Tunnel to Power house Service bay and Transformer hall, Adit to Power house cavern top, Adit to Transformer cavern top, Bus duct tunnels etc. The total length of all adits are worked out to about more than 2000m. Though construction work can be carried out for underground structures all through the season, the time required to complete the activity is more and expensive also. Excavation of these tunnels will take longer duration to reach the power house and start works at power house.

The total construction time for the project is estimated to 54 months which is more compared to Alternative – 1 and total cost of the project is also more comparing to Alternative - 1. The construction duration of the scheme is very important which will impact the overall financial viability of the project adversely.

Due to the above reasons, Alternative -1 layout has been selected.

3.3.3 Key Parameters of Upper and Lower Reservoirs

The Key parameters of the proposed Upper Mhaismal Standalone PSP Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Top of Bund	M	EL +878.00
2	Full Reservoir Level (FRL)	M	EL +875.00
3	Minimum Draw Down Level (MDDL)	M	EL +855.00
4	Live Storage	TMC	0.58
5	Dead Storage	TMC	0.03
6	Gross Storage	TMC	0.61
7	Length of Embankment	M	5253m
8	Maximum Height of Rockfill Embankment	M	27
9	Avg. Height of Rockfill Embankment	M	20

The Key parameters of the Lower Reservoir are as follows:

SI. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	M	EL 745.00
2	Minimum Draw Down Level (MDDL)	M	EL 725.00
3	Live Storage	TMC	0.58
4	Dead Storage	TMC	0.04
5	Gross Storage	TMC	0.62
6	Length of Dam	M	706
7	Maximum Height of Rockfill Dam	M	27
8	Average Height of Rockfill Dam	M	20

3.3.4 RCC Intake Structure

The intake structure of Mhaismal Standalone PSP is proposed with Diffuser type and will be constructed in the Upper reservoir. Generally, for normal hydroelectric projects, the bell mouth entrance is ideal for generation (turbine) mode when water enters. In this case there is a minimal loss as water accelerates through the bell-mouth and in to the penstock. But in pumped storage project, this design may not be suitable for pumped storage operation as when in pumping mode water flows in the opposite direction through the bell-mouth transition. Water discharging from the penstock will not follow the bell-mouth and will continue as a column of water with minimum divergence.

Therefore, it is proposed to have long and gradual diffuser section at a shallow angle so that the discharging pump mode flow can be maintained with an even velocity distribution and decelerate with minimal losses prior to reaching the Intake tunnel.

Four separate intakes are provided to feed the steel lined Penstock/ pressure shaft independently. It is proposed to have independent trash rack in front of each intake structure which will be installed in slanting position with the slope of 15° with vertical. The hydraulic design of trash rack opening is done considering the velocity of flow through the trash rack which will be limited to 1.0 m/sec without clogging.

Submergence of Intake shall be checked for a discharge corresponding to design discharge to prevent vortex formation and entry of air in to the system as per IS: 9761 and accordingly the MDDL and center line of intake is kept at EL 855.00m and EL 843.22m respectively.

3.3.5 Penstock / Pressure Shaft

Four independent pressure shaft / penstock of 7.0 m diameter will feed 4 units of 200 MW each. The length of the pressure shaft up to powerhouse location shall be 666.00m. The

pressure shaft is designed to withstand the internal pressure from water and external pressure from rock. Rock participation factor is considered in the design of pressure shaft. The penstock/pressure shaft consists of Steel Lined-Circular 488.00m long surface type and 89.00m long Vertical Pressure Shaft followed by 89.00m long Horizontal Pressure shaft. The steel lined pressure shaft will be backfilled with concrete. Flow from each of these pressure shafts to turbines shall be controlled by a butterfly valve (MIV) in the power house. Economical dia. of the pressure shaft has been worked out by cost optimization studies for various diameters. Accordingly, a diameter of 7.0m has been adopted to carry the design discharge of 184.92 Cumec for each unit.

3.3.6 Power House

It has been proposed to have power house and all associated components on the surface. As the proposed power house involves little deeper excavation, intricate supporting arrangements for the cut slopes involving anchors etc., are provided. The control room is proposed on the downstream of machine hall above the Draft tubes.

The project envisages the utilization of the Rated head of 125.0m. The Pumped storage plant comprises of 4 units.

The Key parameters of Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Energy Storage Capacity	MWH	4800(800 MW x 6h or 600 MW x 8h)
2	Rating	MW	800
3	No. of Units	Nos.	4
4	Turbine Capacity – 4 Units	MW	200
5	Rated Head in Turbine mode	m	125.00
6	Design Discharge per unit of 200 MW	Cumec	184.92
7	Water Requirement	TMC / MCum	0.58 / 16.42
8	Total Design Discharge	Cumec	739.68
9	Generation Duration	Hrs.	6.00
10	Annual Energy Generation	Mu	1711
11	Pump Capacity – 4 Units	MW	224
12	Pumping Head	m	136.00
13	Pumping Duration	Hrs.	7.54
14	Expected Cycle Efficiency	%	80

Pumping operation is proposed at 7.54 hours/day. Each day turbine volume is equal to the Pumped volume. Turbine operation is proposed at 6.00 hours/day during morning peaking and evening peaking hours.

3.3.7 Machine Hall

The internal dimensions of power house have been proposed with length 118.00m and width 24m including control room. The units have been kept at about 26.00m spacing while the erection bay has been proposed as 40m long. For housing control room and various auxiliaries/offices, 4 nos. floor have been proposed on the D/s side of Power house over the draft tube. The main inlet valve is proposed to be housed in power house just u/s of turbine. 2 Nos. of EOT crane of suitable capacity shall be installed in erection bay and unit bay to facilitate erection and repair of heavy equipment including main inlet valves.

The machine floor is designed to carry load of machines, live load and thrust transferred through turbines, generators and other machinery. The machine floor is designed as a RCC raft with adequate openings as required for equipment foundations and cable trenches etc.

3.3.8 Tail Race Tunnel/Channel & Tail Pool

The tail water from the machines, is led back to the lower reservoir through a tailrace tunnel. Each turbine is provided with gated draft tube. Water from the draft tube of each of the machines will enter in to a tail pool constructed with RCC walls on three sides. The downstream wall of the powerhouse completes the tail pool structure. The tail pool is connected to a tail race channel that conveys the water into the Lower Reservoir.

3.4 ELECTRO - MECHANICAL EQUIPMENTS

3.4.1 ELECTRO-MECHANICAL EQUIPMENTS:

The Electro-Mechanical equipment required for the proposed **pumping scheme** comprises of the following:

- (1) Butterfly Valve for each Turbine.
- (2) Reversible Pump Turbine and it's auxiliaries like HP/LP air compressor system, water depression system, lubricating oil system, Governor and it's oil pressure unit and Cooling water system etc.
- (3) Generator/Motor (DFIM) and its auxiliaries like AC Excitation (VSI) for **variable speed** machines, DC excitation with SFC (Static Frequency Converter) for **fixed speed** machines & Automatic Voltage Regulation system, Cooling system, Brakes, PLC and Automation arrangement etc.,

- (4) Generator circuit breakers for variable speed machines with Phase reversal device and it's accessories.
- (5) Control, Protection, metering, measurement and annunciation panels for Turbine, synchronous generators, asynchronous generator-motor and 400KV feeders.
- (6) Bus duct (IPBD) shall be provided for connecting generator to the generating transformer, SAT, LAVT (for variable speed machines this is part of Generator circuit breaker), NGT etc., for trouble free reliable operation.
- (7) Single phase **18KV/400** KV Generator Transformers with OFF Load tap changer along with control and protective gear and breakers etc.
- (8) 400 KV Gas Insulated switch-gear (GIS) for secondary side of the transformers.
- (9) Auxiliary Power supply system consisting of unit auxiliary transformers, station auxiliary transformer, D.G Set for alternative emergency supply and station/ unit auxiliary boards for station auxiliaries, unit auxiliaries.
- (10) Control supply system consisting of station battery, charger and its distribution system.
- (11) The station auxiliaries like EOT crane, D.T crane, Air Compressor system, Dewatering and Drainage system, firefighting equipment, Air conditioning, Ventilation system and illumination system.
- (12) Power evacuation system consists of transmission line, protection/ metering equipment, CT's, PT's, LA's along with its supporting structures and Receiving end equipment including bay extension at the other end.
- (13) SCADA and Instrumentation system with necessary panels and workstations for GIS and for power plant operation from Local and Remote.

3.4.2 MECHANICAL EQUIPMENT:

The Mechanical equipment consists of Turbine, Main Inlet Valve, Governor, instrumentation & control system, HP/LP Air Compressor system, oil pumping system, cooling water system, Drainage, Dewatering system, crane etc.

3.4.2.1 BUTTER FLY VALVE:

Each Turbine is provided with a Butterfly valve to act as a main inlet valve to achieve quick closing to cut off the water supply for the Turbine in the event of any machine tripping on a lock out fault. The Butter fly valve shall be normally opened and closed by hydraulic system and also have backup closing system with counter weight for closing during emergency. Hydraulic operated Bypass valve is provided across the Butterfly valve for smooth operation

with pressure balance condition.

3.4.2.2 TURBINE/PUMP:

The type of turbine will be reversible vertical shaft Francis type directly coupled to the vertical synchronous generator/asynchronous generator-motor. The turbine will have adjustable guide vanes for control of the flow. In hours of low demand electricity gets consumed and water gets pumped into the higher reservoir. When the peak hours arrive, and the demand is high, water gets turbine and generates therefore Electricity. The final design of the Turbine components would be carried out by means of Model Test results of Turbine.

3.4.2.3 GOVERNING SYSTEM:

The turbine will be controlled by an electronic governor. The Governor in general shall be designed in accordance to IEC 61362. The guide vanes will be actuated by guide vane servomotor through the governor. The system will be so designed that the main functions of speed control, power control are handled as a separate program parts and shall be programmed to suit Francis turbine having adjustable guide vanes. Governor shall also support RGMO/FGMO mode of operation, Electrical Inertia as per the Indian Electricity Grid Code.

3.4.2.4 AUXILIARY SYSTEMS:

i) Air Conditioning System:

Chiller units of adequate capacity shall be provided for air-conditioning of the important areas of the plant. Chiller units are to be placed in transformer cavern. Detailed design of same shall be done at DPR stage.

ii) Ventilation System:

Adequate ventilation tunnels have been proposed in this project, consists of Transformer cavern, Power house and other areas. Air Handling units are to be placed in transformer cavern. Detailed design of same shall be done at DPR stage.

iii) Crane and Hoists:

Two nos. EOT cranes of suitable capacity each will be installed in the power house building for handling equipment during erection and maintenance. For handling of intake and draft tube gates suitable electrically operated hoisting mechanism will be provided individually. Tandem operation of two EOT cranes shall be provided.

iv) Dewatering and Drainage System:

For Dewatering of turbine casing water up to the Tail race gate, required number of submersible pumps with suitable capacity will be provided. The Dewatering sump will be located in the station floor and a pipe from the Tail race will be embedded and connected to the Dewatering sump. An isolation valve will be provided in this pipe which will be opened during Dewatering. The discharge from the pumps will be taken above the maximum flood level. The discharge line will be provided with necessary isolation valves and piping. Necessary level switches will be provided in the Dewatering sump to facilitate auto start / stop of the pumps. Sizing of pumps will be done during preparation of DPR.

To remove drain water collected in the drainage sump located in the BF valve pit / Station floor, required number of pumps of suitable capacity will be installed with necessary piping and valves. The discharge from the pumps will be taken above the maximum flood level. The discharge line will be provided with necessary isolation valves and piping. Necessary level switches will be provided in the drainage sump to facilitate auto start/stop of the pumps. Sizing of pumps will be done during preparation of DPR.

v) Fire Protection System:

The proposed fire protection system shall be designed to provide adequate safety measures in the area susceptible to fire in the power station. TAC classifies hydel power generating stations as "Light hazard Occupancy" and hence the system shall be designed accordingly. This system is designed as per applicable requirements of NFPA 70.

vi) Air Compressor System

Suitable Tank mounted HP and LP air compressor system to meet the station requirements such as for brakes, cleaning, Blowdown system etc. are considered.

3.4.3 ELECTRICAL EQUIPMENT:

The Electrical scheme showing the major system, such as the Generator and its connections to 400 KV Switch Yard for Power evacuation, 11KV Switchgear and 415V Auxiliary Power distribution.

3.4.3.1 SYNCHRONOUS/ASYNCHRONOUS MOTOR:

The Synchronous/Asynchronous generator/Motor will be 3 phase with 0.9 PF (lag), 50 Hz with Static type excitation system/AC Excitation (VSI) for variable speed machines, suitable for parallel operation with the grid. The generator neutral (star point) will be grounded through suitably rated grounding/ distribution Transformer with loading resistor connected

to secondary side to restrict earth fault current to a safe limit. Six terminals of the generator, 3 on the phase side and 3 on the neutral side will be brought out for external connection. The short circuit ratio of the generator shall be greater than 1 (for Fixed Speed machine) for better stability on faults.

3.4.3.2 STATIC EXCITATION SYSTEM:

For fixed speed machines the excitation system will be of static type system. The excitation voltage is controlled by (silicon Controlled Rectifier - SCR). The voltage is supplied by a pair of brushes and slip rings. The ceiling voltage of the excitation system will be at least 200% of the normal field voltage and response ratio will be about 2.0.

3.4.3.3 VOLTAGE SOURCE CONVERTER AND CONTROL SYSTEM:

The excitation system shall enable the operation of the generator motor units in frequency regulation, voltage regulation modes within the capability diagram of the units. The excitation system shall manage the DFIM operating point parameters such as active power, reactive power or stator voltage, shaft or runner speed according to desired P, Q set points (given by operator through SCADA system) and optimizing rules.

The excitation system shall include two types of controls:

- A guide vane regulation controlling the guide vane opening and thus the mechanical torque on shaft.
- A rotor current regulation controlling the electromagnetic torque in air gap and the magnetizing current of the DFIM.

The excitation system shall be designed to perform the following functions:

- Ensure the rotation of shaft line and voltage ramp up of DFIM stator.
- Bring the DFIM to synchronizing conditions
- Keep the unit at a desired set point within the capability curve of the primary mover and the DFIM.
- Contribute to grid support through primary and secondary frequency control and primary voltage control.
- Keep the unit within stability limits whether hydraulic, or electrical and within thermal limits
- Ensure safe state return in case of unit shut down whether normal shut down or trip whatever the cause.
- Ensure that all requirements arising from grid connection specification are met Perform the specific tasks required by generator/turbine mode, motor/pump mode, condenser mode (in

Motor rotation direction), STATCOM mode, electric braking, black start, line charging and islanded network operation.

The excitation system shall be connected to SCADA system.

The harmonic content injected into the neighboring power grids must comply with IEC 61000-2-4 class 3 and IEC 61000-3-6 standard.

The excitation system shall include two control strategies which can be switched from one to the other

(a) Active and reactive loads are controlled by the voltage source inverter (VSI) while the speed of shaft line is controlled by turbine governor.

(b) Speed and reactive load are controlled by the VSI while the active load is controlled by turbine governor.

3.4.3.4 STEP-UP TRANSFORMERS:

Power generated will be stepped up to 400 KV by means of Three Single Phase, 18KV/400KV, 85 MVA oil filled power transformers/Unit i.e. total 12 Numbers of Single Phase 18KV/400 KV Power transformers for 4 units.

3.4.3.5 400 KV GIS:

Indoor metal-enclosed phase segregated type SF₆ gas insulated switchgear system rated for 400 kV, 3 phases, 50 Hz SF₆ gas insulated metal enclosed bus bars complete with Generator transformer, Line, Bus coupler, SAT bays.

LOCAL CONTROL CUBICLE

The Local control cubicle shall contain all the equipment required for controlling and monitoring the bay.

400 KV POTHEAD YARD:

The 400 KV pothead yard will consist of two Outgoing line bays with isolator, CT, CVT, WT & LA and take off tower. The isolators will be of Horizontal double break type with motor operated mechanism.

3.4.4 CONTROL, INSTRUMENTATION & PROTECTION SYSTEMS:

There shall be one control panel each for the Turbine governing, unit & its auxiliaries, station and its auxiliaries, GIS & its auxiliaries. It should be able to synchronize the units either manually through these control boards or through SCADA system located in control room. Protection panel for turbine, units, generator transformer, GIS, auxiliary transformers, line protections etc. The protection system adopted should be state of art

type with latest practices in compliance with CEA requirements.

3.4.5 COMMUNICATION SYSTEM:

To communicate inside power house and pothead yard internally, to HO and LDC following communication systems are considered.

- a) Internal Telephone System
- b) External Communication.
- c) Power Line Carrier Communication/OPGW.

3.4.6 SALIENT FEATURES OF E & M EQUIPMENT

1		Electro Mechanical Equipment	
		Pump Turbine	Francis type, vertical shaft reversible pump-turbine
		Total No of units	4 no's (4 X 200 MW)
		Total Design Discharge (Turbine Mode)	739.68Cumec
		Rated Head in Turbine mode	125.00m.
	a	200MW Turbines	
		Total No of units	4 Units (2 Nos. with Fixed speed & 2 Nos with Variable Speed)
		Turbine Design Discharge	184.92 Cumecs
		Pump Capacity	224 MW
		Rated Pumping Head	136.00m
		Rated Pump Discharge	151.19 Cumec
	i	Generator-Motor	
		Type	Three (3) phase, alternating current synchronous/asynchronous generator motor semi umbrella type with vertical shaft
		Number of units	4 Units (2 Fixed + 2 Variable)
		Rated Capacity	Generator – 200 MW ; Pump Input – 224 MW
		Rated Voltage	18 KV
	ii	Main Power Transformer	
		Type	Three Single Phase Power transformers with Off-Circuit tap changer (OCTC)
		Number of units	12 Numbers (3 Numbers/Unit)

		Rated Capacity of each unit	Single Phase, 18KV/400 KV, 85 MVA
		Rated Voltage	Primary – 18 kV; Secondary - 400 kV adjustable range of the secondary voltage: - 10% to +10%(3kV/tap)
2		400 KV Gas Insulated Switchgear	
	1	Type of GIS	Indoor Type
	2	No. of GIS units	One No.
	3	Location	Inside GIS building above ground
	4	Scheme	Double Bus bar Arrangement with coupler
3		POWER EVACUATION	
	a	Voltage Level (KV)	400 KV
	b	No. of Transmission Lines	One 400 KV transmission line with double circuit.
	c	Total Length	400 KV Double Circuit Transmission Lines with Moose conductor of length 27kms from PSP will be connected to 400 KV substation at Waluj for evacuation of generated Power and for Supply of power during pumping mode. (Alternate options to connect to CTU are being explored).

CHAPTER – 4

SITE ANALYSIS

4.1 General

Mhaismal Standalone PSP is located in Aurangabad district of Maharashtra. It envisages creation of both upper and lower reservoir near Mhaismal village in Aurangabad district. The project is about 37.3 km from Aurangabad Railway station. Nearest airport is at Aurangabad. The nearest Village to project is Mhaismal. The Installed capacity of the Project is proposed as 800 MW.

Maharashtra is one of the 29 states of India, situated on the country's western peninsular region occupying a substantial portion of Deccan Plateau. The state is the 3rd largest and the 2nd most populated state in India with a geographical area of 3,07,713 km² and 112,372,972 residents as per 2011 census. Maharashtra is bordered by the states of Gujarat, Madhya Pradesh to the north, Chaattisgarh to the east, Goa, Karnataka and Telangana to the south and The Arabian sea to the west . The terrain of Maharashtra region consists mostly of hills, mountain ranges, and thick dense forests distribution of 27,292 sq. km. Forests comprise of 17% of the total area of the state.

The main rivers of the state are Krishna, Bhima, Godavari, Tapi-Purna and Wardha-Wainganga. Since the central parts of the state receives low rainfall, most of the rivers in the region have multiple dams. Maharashtra has around 1821 notable large dams.

4.2 General Features of the Project

Mhaismal Standalone PSP is located in Aurangabad district of Maharashtra and is proposed between two reservoirs i.e. Mhaismal Standalone PSP upper reservoir (to be constructed newly) Mhaismal Standalone PSP lower reservoir (to be constructed newly) and one-time water will be pumped from the existing reservoir to fill up the proposed upper reservoir. Installed capacity of the Project is proposed as 800 MW (4 x 200 MW). There are no monuments of archeological or national importance which would be affected by project activities directly or indirectly.

The project envisages construction of rock fill embankment of average height of around 20m with the maximum height of 27m for short reach for creation of Mhaismal Standalone PSP upper reservoir of 0.61 TMC gross capacity. Similarly, this project envisages construction of rock fill embankment of average height of around 20m with the maximum height of 27m for creation of lower reservoir of 0.62 TMC gross capacity. The Mhaismal Standalone PSP is proposed in between two reservoirs as mentioned above. The total

design discharge for the proposed scheme is 739.68 Cumec with the rated head of 125.00 m. Four intake structures are provided with trash rack and gated arrangements. Four independent pressure shafts of 7.0 m diameter will take off from intake structure to feed 4 units of 200 MW each. The length of the pressure shaft up to powerhouse location shall be 666.00m. Water from the draft tube of each of the machines after power generation will enter in to a tail pool. The tail pool is connected to a tail race Tunnel/Channel that conveys the water into the Lower Reservoir.

CHAPTER – 5**PLANNING BRIEF****5.1 General**

The Mhaismal Standalone Pumped Storage project envisages construction of upper and lower reservoir near village Mhaismal in Talmadugu Mandal of Aurangabad District.

The scheme will involve construction of rock fill embankment of average height of around 20 with the maximum height of 27m for short reach for creation of Mhaismal Standalone PSP upper reservoir of 0.61 TMC gross capacity. Similarly, this project envisages construction of rock fill embankment of average height of around 20m with the maximum height of 27m for short reach for creation of lower reservoir of 0.62 TMC gross capacity. The Mhaismal Standalone PSP is proposed in between two reservoirs i.e. Mhaismal Standalone PSP Upper (to be constructed newly) & Mhaismal Standalone PSP Lower (to be constructed newly) and one-time water will be pumped from the existing reservoir to fill up the proposed Upper reservoir. Water will be let out from the Mhaismal Standalone PSP upper reservoir through Power Intake and Penstock/Pressure shaft of 666m long to feed the Mhaismal Standalone PSP, having a Storage Capacity of 4800 MWH with Rating of 800 MW. This project is comprising 4 units of 200MW each. The water after power generation will be conveyed through a 182 m long Tail Race tunnel followed by 250m long tail race channel to discharge water in to Lower reservoir. The total design discharge for the proposed scheme is 739.68 Cumec with the rated head of 125.00m.

5.2 Planning Concept

The proper selection of construction methodology, projects scheduling followed by strict monitoring during construction are the major tools available in the hand of developers for ensuring completion of projects within scheduled time and cost. The project implementation schedule of the scheme is divided in to five stages as follows:

1. Preparation of DPR
2. Clearances & Permits
3. Pre-Construction Activities
4. Construction Activities
5. Testing & Commissioning

The preparation of Detailed Project Report including Topographic Survey & Geotechnical Investigation will be completed within 6-month time. The Clearances & Permits includes

Forest land clearance, Environmental clearances, DPR approval and other permits and licenses and all these activities will be completed within 1.5 to 2 years.

Pre-Construction activity involves construction infrastructure works like access road to project site and construction of building for accommodating men and materials, Award of tender for design works, Preparation of tender for Civil, H&M and E&M works, floating of tenders, Bid Evaluation, award of work and Mobilization to Site. This activity is proposed to be completed in 6 months.

The main Construction activities will be taken up once Pre-Construction activities are completed. The Construction work for Civil, H&M and E&M will be carried out either by EPC contract or based on item rate contract. Quality control of civil, H&M & E&M works will be taken care through internal / external agency. Based on the specific work of the project, equipment planning will be taken up and state of art equipment will be deployed at site during execution. It is proposed to get the Civil, Hydro-Mechanical and Electro-Mechanical works done through reputed contractors who have been doing similar kind of works.

The Testing & Commissioning including water filling in the system will be taken up once the construction works are completed. The total construction of the project including testing & commissioning are proposed to be completed within 3.0 years.

CHAPTER – 6

PROPOSED INFRASTRUCTURE

6.1 General

The Proposed Mhaismal Standalone PSP is located near Mhaismal is about 12 kilometres from Khuldabad and is about 40 Kilometres from Aurangabad City.

6.2 Access

6.2.1 Roads to Project

The project sites are accessible to motor vehicles from Mhaismal. All the project components are well connected with the district road up to the district headquarters.

6.2.2 Existing Road and Bridge Improvements

The conditions of Existing roads need to be improved and an Adit will be excavated for access to power house.

6.2.3 Roads in the Project Area

The access road to project site is planned to take off from Mhaismal road. The specification of access road has been kept equivalent to those pertaining to class-IX category of hill roads.

The permanent colony, office and other temporary facilities are planned along the access road discussed above.

6.3 Construction Power Requirement

The requirement of construction power will be met from the existing transmission network in the area. In addition to use of power from local grid, it is planned to install stand by Diesel Generating sets for ensuring un-interrupted power supply during project construction.

6.4 Telecommunication

Adequate provision required for telecommunications including:

- Development of the Existing telephone system to provide sufficient capacity for both voice and data transmission.
- Provision of radio and microwave facilities.
- Provision of VSAT connection at site for communication with head office

6.5 Project Colonies / Buildings

- The contractors for Civil, Electro-Mechanical and Hydro-Mechanical works are

planned to be hired for execution of this project. The skilled, semi-skilled and unskilled labor will be arranged by these contractors. Contractors shall themselves arrange for housing facilities for its work force in nearby villages.

- In addition, the developer will have his own staff or supervision of the works. Some of the existing houses in the nearby areas / villages will be hired on rent during construction period. It is proposed to construct residential as well as non-residential buildings for the project. Office buildings, guesthouse, security post, dispensary, etc. will also be constructed. These facilities shall be permanent in nature and shall also be used by O & M staff, once the construction is over.

6.6 Job facilities

Workshop is proposed near all the components to facilitate the various preparatory works batching plants, crushing plants, steel liner plates bending etc. The major fabrication and assembling of hydro- mechanical equipment can be done in this workshop and later can be transported to the desired sites. Labor colony, staff colonies will be provided nearer to the components.

6.7 Workshop

Workshop is proposed near diversion site to facilitate the various preparatory works like bending of reinforcements, steel liner plates bending etc. The major fabrication and assembling of hydro-mechanical equipment can be done in this workshop and later can be transported to the desired sites.

6.8 Water Supply

The provision of adequate water supplies for both the construction purposes and the use of personnel shall be done. In order to avoid any deterioration in water quality and subsequent changes in the aquatic biota, a proper sewage disposal system in and around various labour colonies shall be planned to check the discharge of waste.

6.9 Explosive Magazine

One explosive magazine store has been proposed in the project area Portable magazines shall be kept at the sites of work for day-to-day requirements.

6.10 Medical Facilities

Medical facilities are provided at Mhaisal by some private clinics. District Hospital is available at Aurangabad and is equipped with almost all medical facilities.

CHAPTER – 7

REHABILITATION AND RESETTLEMENT

7.1 Introduction

Resettlement and Rehabilitation Plan (R & R) is an important aspect to be considered for project implementation. As non-forest land is envisaged to be acquired for development of upper reservoir and ancillary infrastructure facilities, it's important to provide fair and just compensation to the affected families whose land has been acquired and to make adequate provisions for such affected persons for their rehabilitation and resettlement in accordance with the RFCTLARR policy of 2013 including its amendments.

The Land requirement for the Project may be categorized as Forest, Non-Forest (Govt) and Private Land.

7.2 Land Requirement

The total land requirement for proposed project is about 338 Ha; out of which about 70 Ha is forest land and remaining about 268 Ha is non-forest area.

The forest land involved in the project shall be applied for diversion as per the guidelines issued under the Forest (Conservation) Act, 1980, Non-Forest (Government) land shall be applied from competent authority of the State Govt as per the laid-out process, whereas the private land involved in the project will be purchased directly from respective land owners through private negotiations on land price and completed on a mutual agreement.

7.2.1 Purchase of Private Land

The private land required for the project, if any is proposed to be purchased through a voluntary sale with a willing buyer and seller process. The process is undertaken through direct negotiations between land owners and Project Proponent with no obligation on the seller. The land owners are informed in advance, and each land owner negotiated on the price of land as part of land take.

The some of the steps in the land procurement process shall include the following:

- Identification of land required for the project and due diligence of land through verification of Revenue Records.
- Undertake consultation and negotiations with the land owners about the project and private land requirement.
- After negotiations on all aspects of purchase the voluntary sale of land is completed through a registered sale agreement.

7.3 Rehabilitation And resettlement

During the EIA/EMP Studies, Socio-economic survey for the Project Affected Families (PAFs) shall be carried out. Based on the findings of the socio-economic studies and survey, an appropriate R&R compensation package as per the provisions of Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement, 2013 (RFCTLARR, 2013) and respective State R&R Policy in vogue would be required to be formulated. If the total private land purchased exceeds the specified limits notified by the relevant rules of concerned State Government policy, the provisions of under RFCTLARR, 2013 shall be applicable to the proposed Project.

CHAPTER – 8**PROJECT SCHEDULE AND COST ESTIMATES****8.1 General**

Construction of Mhaismal Standalone PSP including erection of 4 generating units are planned to be completed in a period of 42 months including Pre-constructions works, creation of infrastructure facilities viz. additional investigations, improvement of road network and colonies.

Two shift working is considered economical for surface works. Opting 25 working days in a month, shift wise scheduled working hours annually are proposed to be adopted.

8.2 Target Schedule

The Total Construction period is scheduled as follows.

Preconstruction Period incl. Statutory Clearances	: 6 months
Construction Period (Main Works)	: 3.0 Years
Total Construction Period	: 3.5 Years

Tentative Construction scheduled for this project is prepared and enclosed as Annexure - 8.1

8.3 Cost Estimates

The Civil Cost Estimates of the project has been prepared as per "Guidelines for preparation of estimates for the river valley projects" issued by CWC and Indian Standard IS: 4877 "Guide for Preparation of Estimate for River Valley Projects".

Rates of major items of works have been prepared based on SSR of Maharashtra & local prevailing rates are adopted for the items not covered by the SSR wherever quantification has not been possible at the present stage of design, lumpsum provisions have been made based on judgement / experience of other projects.

8.4 Preparation Of Estimates

The capital cost of the project includes all costs associated with investigations, design, construction and maintenance during construction period of the project.

For preparation of cost estimates of civil works, the unit costs of labor, materials and equipment necessary to perform the work designated in the various pay-items for the proposed construction are determined based on Schedule of Rates for the year 2018-19 of Maharashtra Irrigation and Water Resources Department and for items for which the rates are not available, the accepted schedule of rates of similar ongoing/recently executed

projects adopted. The rates of major items have been worked out by rate analysis.

The quantities of Civil Works are estimated based on designs and drawings prepared for various components of the project. The Daily wage rates have been taken as per Maharashtra I&CAD Schedule of Rates for the year 2018 - 19.

Provision for contingencies are considered at 3% of the works cost and are provided in the detailed works estimates prepared on the heads of item rates and quantities of works to be executed. These percentage provisions are not considered on lump-sum items.

Description of Item	Cost in Crores
Cost of Civil Works	1595.80 Cr.
Cost of Power Plant - Electro Mechanical Equipment including Transmission line	1220.00 Cr.
Total Hard Cost	2815.80 Cr.
IDC & Others	1093.23 Cr.
Total cost of the Project	3909.03 Cr.

CHAPTER – 9

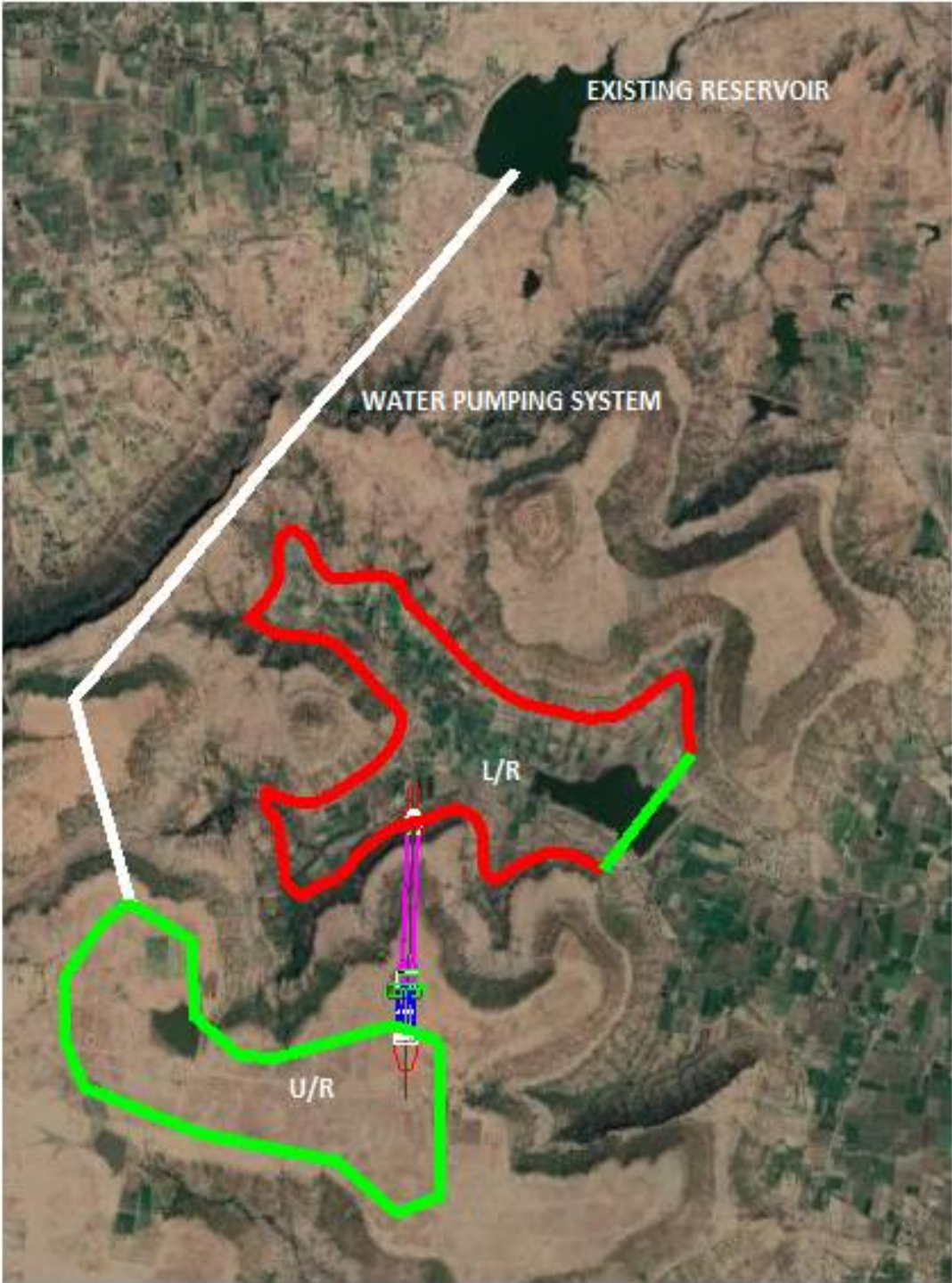
ANALYSIS OF PROPOSAL

This project is conceived as Integrated Renewable Energy Project along with solar and Wind. Therefore, financial analysis for the same will be carried out once Solar and Wind project proposals are finalized.

ANNEXURES

ANNEXURE 3.1

TENTATIVE PUMPING SCHEMATIC LAYOUT OF MHAHISMAL STANDALONE PSP

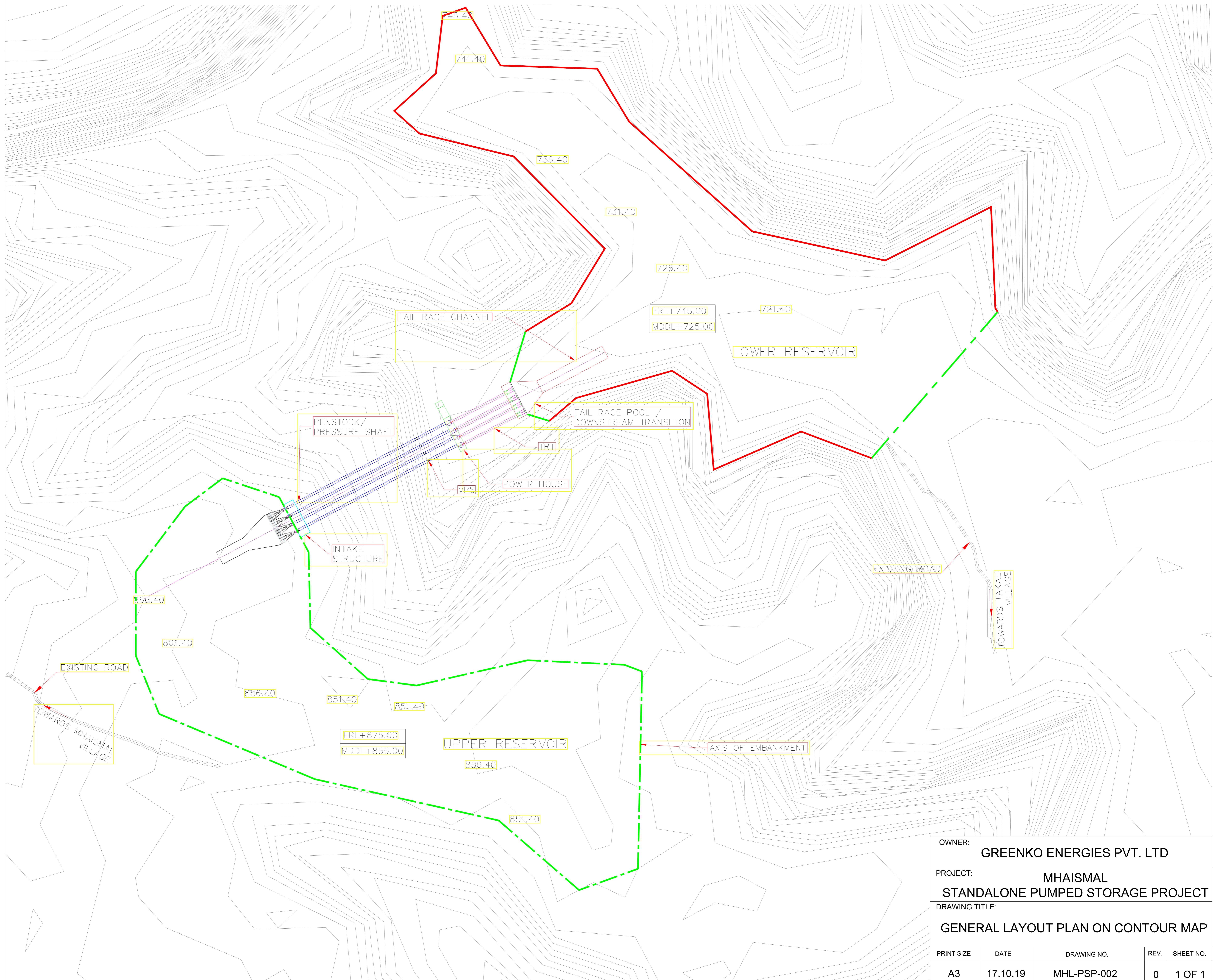


Mhaismal Standalone PSP (800 MW) - Tentative Construction Schedule														Annexure - 8.1	
Project Details	Year 1				Year 2				Year 3				Year 4		
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	
Project Timeline	[Yellow shaded cells]														
Pre-Construction Activities	[Blue shaded cells]				[White cells]										
Main Construction Activities	[White cells]														
Rockfill Dam	[White cells]		[Blue shaded cells]												
Intake Structure & Tunnel	[White cells]		[Blue shaded cells]										[White cells]		
Pressure Shaft	[White cells]		[Blue shaded cells]										[White cells]		
Power House	[White cells]		[Blue shaded cells]										[White cells]		
Tail Race Tunnel/ Tail Race Channel	[White cells]		[Blue shaded cells]										[White cells]		
Transmission Line	[White cells]		[Blue shaded cells]										[White cells]		
Filling of Upper Reservoir	[White cells]		[White cells]										[Blue shaded cells]		
Filling in Water Conductor System	[White cells]		[White cells]										[Blue shaded cells]		
Testing and Commissioning of Units	[White cells]		[White cells]										[Blue shaded cells]		

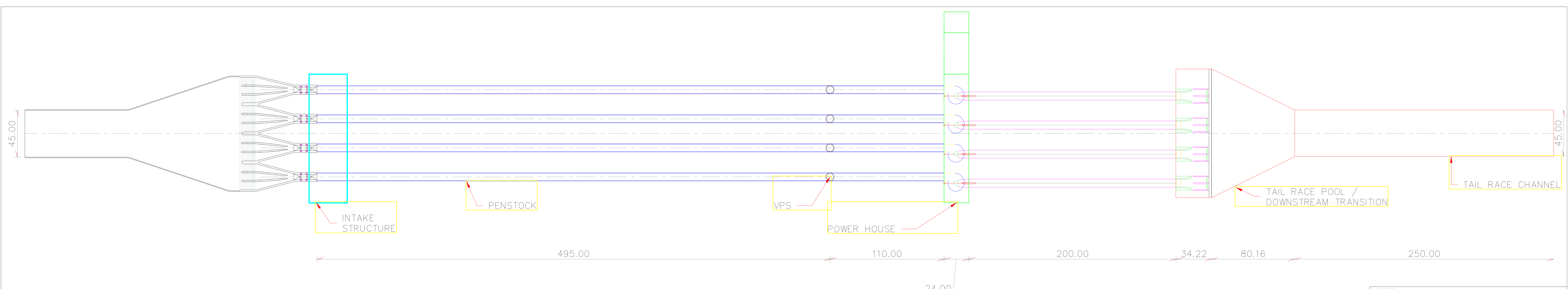
DRAWINGS



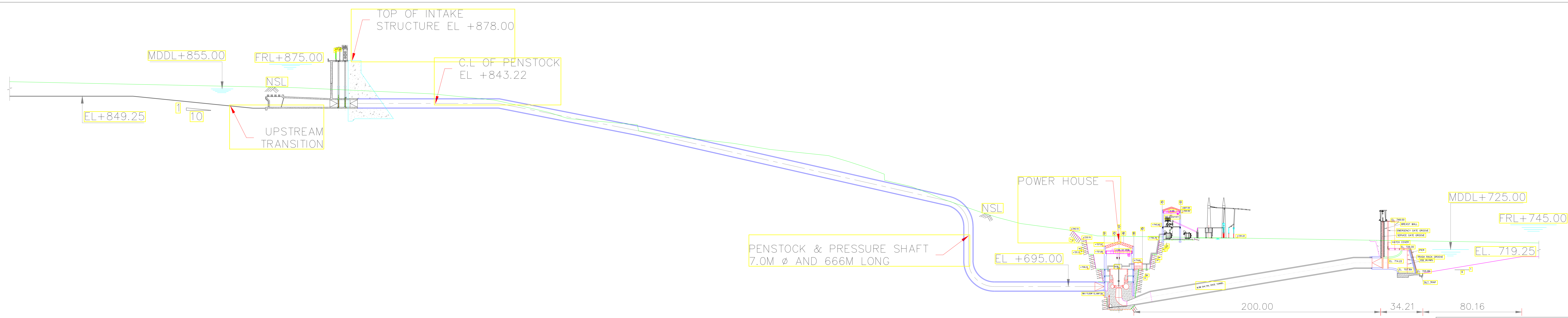
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DRAWING TITLE: PROJECT LOCATION MAP				
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PROJECT: MHAISMAL STANDALONE PUMPED STORAGE PROJECT				
DRAWING TITLE: GENERAL LAYOUT PLAN ON CONTOUR MAP				
PRINT SIZE	DATE	DRAWING NO.	REV.	SHEET NO.
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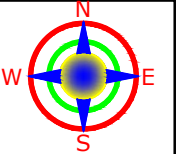
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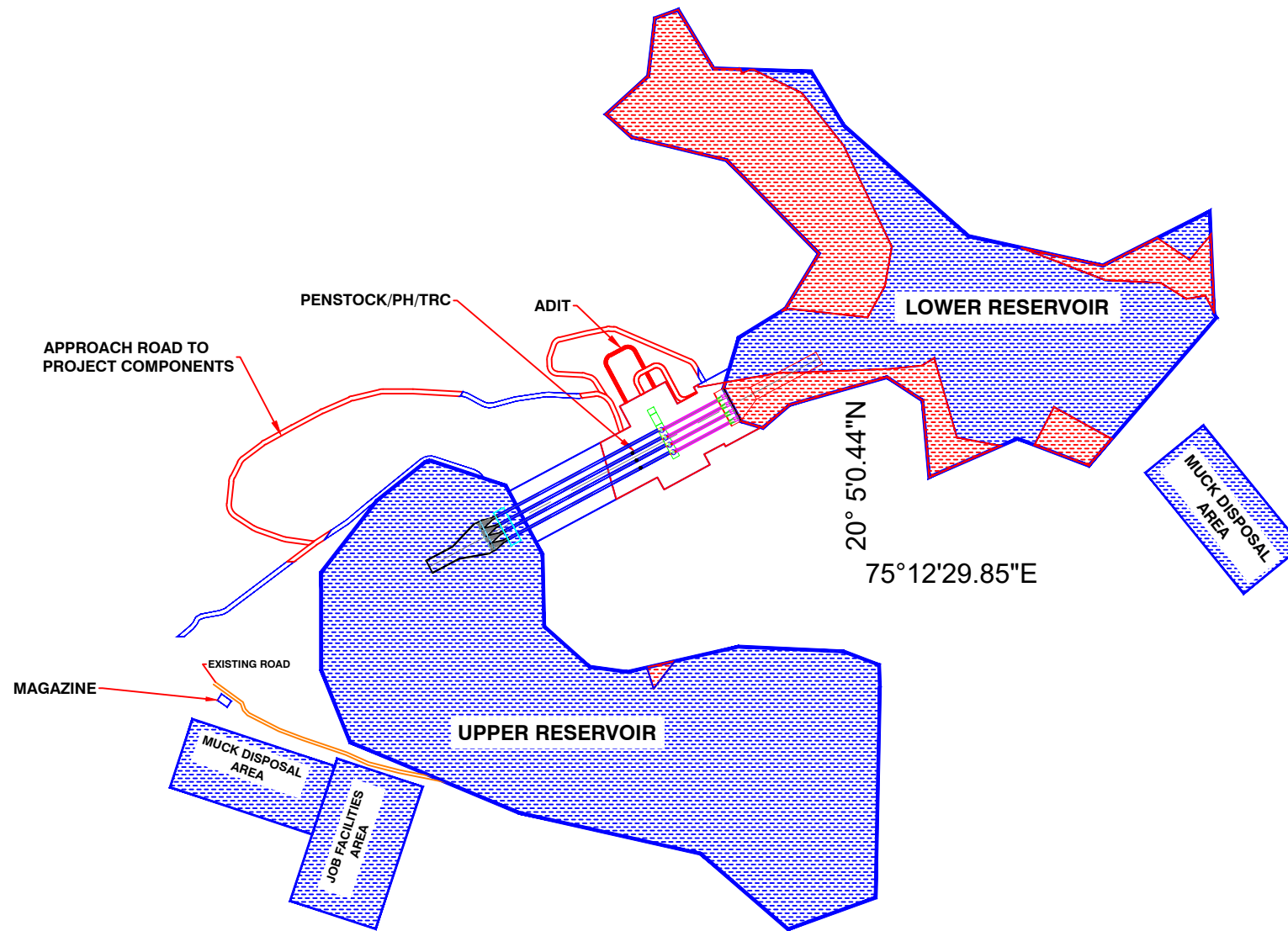
GENERAL ARRANGEMENT-LONGITUDINAL SECTION

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PROJECT: MHAISMAL STANDALONE PUMPED STORAGE PROJECT				
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PRINT SIZE	DATE	DRAWING NO.	REV.	SHEET NO.
A3	17.10.19	MHL-PSP-004	0	1 OF 1

MHAISMAL STANDALONE PUMPED STORAGE PROJECT (800MW/4800 MWh)



SCALE: 1:50000
TOPO SHEET NO: 46P/4



LAND REQUIREMENT (Ha)			
S/N	Project Components	Forest	Non-Forest
1	Upper Reservoir	0.36	147.74
2	Lower Reservoir	53.81	70.49
3	Approach Road to Upper Reservoir	0.23	1.60
	Approach Road to VPS	2.22	0.62
	Approach Road to Power house	1.71	0.05
4	Adit	0.36	0.00
5	WCS, PH, TRC	11.39	6.48
6	Job Facilities Area	0.00	15.00
7	Muck Disposal area	0.00	25.00
8	Magazine	0.00	0.10
	TOTAL	70.07	267.07
	Total	337.14	

LEGENDS	
■	Forest Components
■	Non-Forest Components

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PROJECT:	MHAISMAL STANDALONE PUMPED STORAGE PROJECT			
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PRINT SIZE	DATE	DRAWING NO.	REV.	SHEET NO.
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