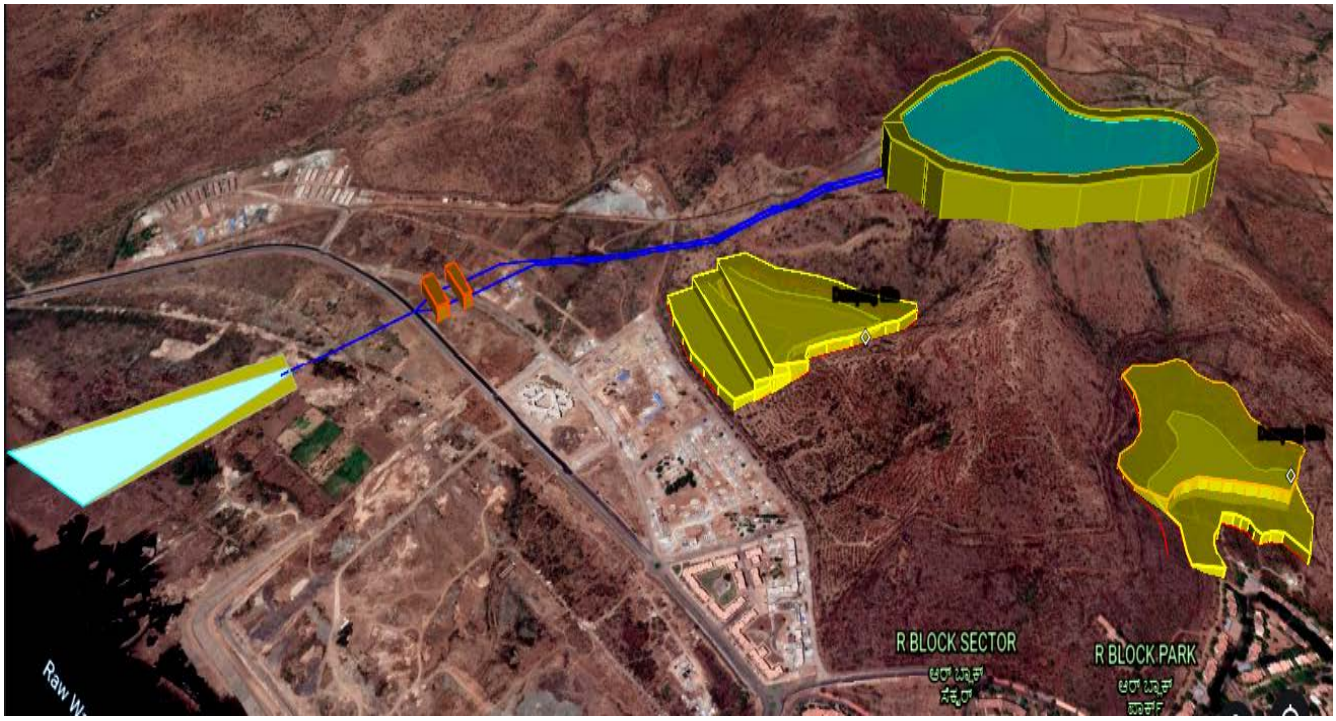
JSW RENEWABLE ENERGY (VIJAYANAGAR) LIMITED

VIJAYANAGAR PUMPED STORAGE PROJECT (2 x 65 MW)



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EXECUTIVE SUMMARY

Executive Summary

Vijayanagar Pumped Storage Project is located in Vidya Nagar area of JSW Steel Plant in Vijayanagar district of Karnataka. The project is a closed loop pumped storage project. The project is planned to generate 130 MW hydro power during peak hours and shall act as a green battery. The scheme envisages construction of an upper reservoir, steel lined penstock, a surface power house and Tailrace channel. In this case, the existing Raw Water Reservoir 1 in Vidya Nagar shall be used as Lower Reservoir. The upper reservoir is located on the hillock adjacent to the existing Reservoir 1 of JSW Steel Plant.

Based on the desk studies and site visit, the planning for the project has been carried out with required inputs from JSW Energy Ltd at Vijayanagar. The installed capacity has been planned to be 130 MW with available water.

The one-time requirement of water for the closed loop Vijayanagar PSP shall be 2.42 mcm. Considering evaporation loss of 10%, 0. 242 mcm of water would be required every year to replenish the storage lost due to evaporation. Actual loss of storage due to evaporation shall be studied in detail during DPR stage.

At present, the raw water allotted for JSW Steel by Government of Karnataka is 3,30, 948 cum per day, out of which approximately 1,49,108 cum per day is from Tungabhadra dam located 40 km away from the site and 1,81,840 cum per day is from Almaty dam located 170 km away from the site. The water is pumped to Raw water pond or Raw Water Reservoir 1 of capacity 5.50 mcm which is situated in Vidyanagar, JSW Steel. The surplus water from present allocation or one time allotment from these reservoirs shall be required to start operations of the PSP.

The Upper Reservoir is constructed on a relatively flat surface of a hillock close to Raw water Reservoir 1 at RL 640m with construction of concrete gravity dam of 25m high all along the reservoir. The top level of the dam shall be at RL 665m.

The existing Raw Water Reservoir 1 in JSW area shall be used as Lower reservoir with water level fluctuations from RL 518m to RL 520m. An intake with bell mouth shape and required submergence shall be constructed to divert water through two independent penstocks, each of 5m dia to carry total discharge of 112 m3/s to a surface power house. The power house accommodates two reversible Francis Pump turbines, each of 65 MW capacity at a rated head of 132.33m. The water is then diverted to Lower reservoir through a RCC box type channel.

The project is planned to be used as a captive power plant at JSW Steel as JSW has set a target of zero emission of green house gases by 2030. The existing substation and transmission line in JSW plant area would be utilized for evacuation of power from the PSP.

The total estimated cost of the project including IDC and Front-end fee with Escalation is Rs. 679.51 Crores. The cost of civil works and electro-mechanical works are estimated as Rs. 444.48 Crores and Rs. 196.39 Crores respectively. The break up of cost is follows.

Sl. No.	Works	Cost (in Rs. Lakhs)
1	Civil and Hydro Mechanical Works	44448.48
2	Electrical and Electro-Mechanical Works	19639.62
Total Hard Cost		**64088.10**

The project will produce annual energy of 270.465 GWh with 6 hours peaking generation and the energy requirement for pumping will be 348.839 GWh considering 95% plant availability. The cycle efficiency of the project shall be 77.53%. The levellised tariff for various pumping costs is given below.

Sl. No.	Pumping Cost (Rs per Unit)	Levellised tariff (Rs per unit)
1	Nil	4.67
2	1.00	5.99
3	2.00	7.31
4	3.00	8.63

It is recommended to take up preparation of DPR for finalization of layout, cost and tariff to be based on detailed survey and investigations.

SALIENT FEATURES

Salient Features

		NAME OF THE PROJECT	VIJAYANAGAR PUMPED STORAGE PROJECT
1		**Location**	
	a	Country	India
	b	State	Karnataka
	c	District	Vijayanagar
	d	Taluk	Sandur
	d	Village near Upper Reservoir	Bannihatti
2		**Geographical Co-Ordinates**	
	a	**Upper Reservoir (Proposed)**	
		Latitude	15°09'32.4"N
		Longitude	76°38'0.83"E
	b	**Lower Reservoir (Proposed)**	
		Latitude	15°09'51.54"N
		Longitude	76°39'3.78"E
3		**Access To Project Site**	
	a	Rail head	Torangallu
	b	Port	Goa
	c	Airport	Vijayanagar
4		**Type of Project**	
	a	Type	Pumped Storage Project with Upper & Lower Reservoirs
	b	Storage Capacity	780 MWH
	c	Rating	130 MW

	d	Peak operation duration	6.00 Hours daily
5		**Upper Reservoir (Proposed)**	
	a	Live Storage	2.42 MCM
	b	Dead Storage	0.05MCM
	c	Gross Storage	2.47 MCM
6		**Upper Dam**	
	a	Type of Dam	Concrete Gravity Dam
	b	Top of Dam	EL +665.00 m
	c	Full Reservoir level (FRL)	EL +662.00 m
	d	Minimum Draw Down Level (MDDL)	EL +630.00m
	e	Length of Dam	1500 m
	f	Max Height of Dam	25.0 m (above Lowest NSL)
7		**Lower Reservoir (Proposed)**	
	a	Live Storage	4.50 MCM
	b	Dead Storage	1.03 MCM
	c	Gross Storage	5.53 MCM
8		**Lower Dam (Existing)**	
	a	Type of Dam	Earthen Bunds
	b	Full Reservoir level (FRL)	EL +520.00 m
	c	Minimum Draw Down Level (MDDL)	EL +518.0m
9		**Penstock**	
	a	Type	Circular Steel Lined
	b	Number of Penstocks	2 Nos
	c	Dia of each Penstock	5m

	d	Length of each Penstock	718m
	e	Velocity of tunnel	2.85 m/s
10		**Powerhouse**	
	a	Type	Surface Powerhouse
	b	Size of power house	45m X 18m X48m
	c	Center line of Power house	498m
11		**Tail Race Channel**	
	a	Type Channel	RCC Box type
	b	Number of Channels	1
	c	Width of the Channel	8m
	d	Depth of Channel	4m
	e	Length of Channel	800m
12		**Electro Mechanical Equipment**	
	a	Pump Turbine	Francis type, vertical shaft reversible pump-turbine
	b	Total No of units	2
	c	Each Turbine Capacity	65 MW
	d	Turbine Design Discharge	56 m^3/s for each Unit
	e	Rated Head in Turbine Mode	132.33 m
	f	Pump Capacity	78.06 MW
	g	Pump Design Discharge	52.14 m^3/s for each Unit
	e	Rated Head in Pump Mode	137.33 m
13		**Project Cost**	
	a	Cost of civil Works	444.48 Crore
	b	Cost of EM Works	196.39 crore

	c	Total Hard Cost	640.88 Crore
	d	IDC & FC	38.63 Crore
	e	Total Project Cost	679.51 Crore
14		**Levellised Tariff**	
		Levellised Tariff at no Pumping cost	Rs 4.67
		Levellised Tariff (Pumping cost Rs 1/ unit)	Rs 5.99
		Levellised Tariff (Pumping cost Rs 2/ unit)	Rs 7.31
		Levellised Tariff (Pumping cost Rs 3/ unit)	Rs 8.63

CHAPTER 1
INTRODUCTION

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CHAPTER 1 INTRODUCTION

1.1 *General*

JSW Energy Limited is one of the leading Independent Power Producers in India and part of the USD 12 billion JSW Group which has significant presence in sectors such as steel, energy, infrastructure, cement, sports among others. JSW Energy Limited has established its presence across the value chains of power sector with an installed power generation capacity of 4.6 GW across Thermal (3.2 GW), Hydro (1.4 GW) & Solar (10 MW) portfolios, ensuring diversity in geographic presence, fuel sources and power off-take arrangements.

JSW Hydro Energy Limited (JSWHEL) became a 100% subsidiary of JSW Energy Limited pursuant to acquisition of Karcham and Baspa hydro-electric power plants from Jaiprakash Power Ventures Limited in September, 2015. The Karcham plant is a 1,000 MW (4X250 MW) run of the river hydro-electric power plant located on river Sutlej in District Kinnaur of Himachal Pradesh. It has an in-built capacity of 1,091 MW with 10% overload and design energy of 4,131 million units for 1,000 MW capacity. The project commenced operations in September 2011. JSWHEL has a Power Purchase Agreement (PPA) through PTC India Limited for the entire 880 MW saleable capacity of the Karcham plant, net of current 12% free power to Government of Himachal Pradesh (GoHP), with various distribution utilities like Haryana, Uttar Pradesh, Punjab and Rajasthan on long term basis valid till September, 2046. The Baspa plant is a 300 MW (3X100 MW) run of the river hydro-electric power plant located on the river Baspa, a tributary of river Sutlej in District Kinnaur, Himachal Pradesh with a design energy of 1,213 million units. The project commenced operations in June 2003. JSWHEL has a Power Purchase Agreement for the entire 264 MW saleable capacity of the Baspa plant, net of 12% free power to GoHP with Himachal Pradesh State Electricity Board Limited valid till June, 2043. JSW Energy (Kutehr) Limited, is a 100% owned subsidiary of JSWHEL, set up for the purpose of implementing the 240 MW Kutehr Hydroelectric Project (3x80 MW Kutehr HEP) located in the upper reaches of Ravi Basin in district Chamba of Himachal Pradesh. Kutehr HEP is currently under construction.

JSWHEL now plans to add pumped storage projects to its renewable portfolio with the objective of zero emission of Green House Gas by the company. The company has selected a site close to its Vijayanagar plant.

Vijayanagar PSP is situated in Vijayanagar district of Karnataka and is accessible by air with nearest airport in Vijayanagar itself. The place is also connected to Toranagalu railway station. The co-ordinates of the project location are 15°09'32.4"N to 15°09'51.54"N and 76°38'0.83"E to 76°39'3.78"E.

1.2 *Justification for the Project*

JSW Energy has set a vision of becoming a 10 GW company by 2025 and 20 GW company by 2030, with all the incremental capacity additions coming predominantly from the Renewable Energy sources. The bold and ambitious plan of the company further reinforces its position as a leader in the energy transition, with its renewables portfolio, currently at 30%, growing to 68% of total total energy portfolio by 2025, and to about 84% by 2030. With renewable capacity additions already on blueprint, JSW Energy would become carbon neutral well before 2030. By contributing towards a more balanced and sustainable world, JSW Energy aims to play a meaningful role in meeting the country's growing future demand for energy; in meeting the Government's target for adding 450GW of renewable generation by 2030; and in enabling India to outperform its Paris pledges.

The pumped Storage Project at Vijayanagar shall be one of the targeted renewables to be used as a captive power plant to meet the load requirement of the company partly. The construction of the project has a merit because of existing infrastructure is in place.

The advantages of the Pumped Storage Project are mentioned below.

- Spinning Reserves – Online reserve capacity that is synchronized to the grid and ready to meet electricity demand within minutes of request.
- Non-Spinning Reserves – This is needed to maintain system frequency stability during emergency conditions
- Frequency Regulation -

1.3 *Type of Project*

Vijayanagar Pumped Storage Project is located in Vidya Nagar area of JSW Steel Plant in Vijayanagar district of Karnataka with an installed capacity of 130 MW. The project is a closed loop pumped storage project where the reservoirs are not connected to any natural river sources. The upper reservoir is located close to JSW boundary near existing Raw Water Reservoir 1, constructed to meet the water demand of JSW steel and power plant. But due to construction of Raw water Reservoir 3 with a capacity of 35 mcm, the dependance of Raw water Reservoir 1 is very low. As a result, it is decided to use the existing Raw water Reservoir 1 as the lower reservoir. The upper reservoir shall be constructed about 130m above lower reservoir on the hillock.

1.4 *Project Features*

The project is envisaged to have installed capacity of 130 MW, with two reversible pump turbines each of 65 MW capacity. The design discharge is 112 m3/s and the rated net head is 132.33m. The project consists of the following components.

- an upper reservoir to be constructed on the adjacent hillock
- existing Raw Water Reservoir 1 as lower reservoir
- 25m high gravity dam of 1500m long all around upper reservoir
- Two steel lined penstocks each of 5m dia and 718m long
- Surface Power House (45m L x 18m B x 48m H)
- Tail race Channel of rectangular concrete conduit of 800m long

<u>Upper Reservoir</u>

The area of the upper reservoir is about 1,10,000 sq. m. The water depth in the reservoir is 22m, which gives a live storage of 2.42 mcm. The dam will be founded on surface at RL 640m. The earth above RL 640m shall be excavated to provide the required live storage. The volume of excavation will be around 12. 11 lakh m3. The earth will be dumped on the designated dumping yard. The photographs of upper reservoir site are given below.

Photograph 1-1 View of NSL of Upper Reservoir

Lower Reservoir

The lower reservoir is the existing Raw Water Reservoir 1, at present which is being rarely used for the JSW steel and Power project in Vijayanagar following commissioning of Raw Water Reservoir 3. The pond level here is RL 520m and fluctuates to RL 518m. The pond has present capacity of 5.5 mcm after reduction of some volume due to Airport expansion. As the water requirement for the PSP is 2.42 mcm, it would not be problem to accommodate this volume for operation of the PSP. The photographs below show location of lower reservoir.

Photograph 1-5 Closer view of Lower reservoir

1.5 *Organization of the Report*

The prefeasibility report consists of nine chapters. The chapter 1 discusses about the project and justification for the project. Chapter 2 deals with survey and investigations, and Chapter 3 deals with Hydrology and Potential Studies. Chapter 4 mentions about conceptual planning of civil and hydro-mechanical works. Chapter 5 deals with Electro-mechanical works. Chapter 6 discusses about cost estimates. Chapter 7 mentions about Environmental aspects and Chapter 8 is devoted to cost estimates. Chapter 9 gives the economic analysis of the project. The conclusion of the study along with recommendations is drawn in Chapter 10.

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CHAPTER 2
SURVEY & INVESTIGATIONS

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CHAPTER 2 SURVEY & INVESTIGATIONS

2.1 *General*

The PFR report, being the preliminary report does not require extensive survey & investigations. The study is carried out based on topographical maps prepared by the Survey of India, Google maps and other satellite imageries, followed by a reconnaissance survey.

2.2 *Topographical Survey*

The detailed topographical survey is not available for the project area and the same has not been undertaken. The planning is based on Topo sheet of the area and the Google map.

A reconnaissance site visit was made to assess the suitability of the site for the proposed Pumped Storage Project. On the basis of PFR studies, it will be recommended to carry out detailed survey and investigations to finalize the layout and project features.

2.3 *Geology of the Area*

The geological formations of the Bellary, Hospet & Sandur region are known by the name Sandur Schist Belt, belongs to Dharwar Super Group.

2.3.1 *Regional Geology*

The following formations in Dharwar Super Group is encountered.

Older gneisses and granites: These are the oldest rocks of the area and occur mainly along the Western and South western boundaries of the schist belt.

Basic igneous rocks: This group comprises mainly of meta basalt and epidiorites and overlies the gneisses and granites with an unconformity.

Sedimentaries: The sedimentary formations consist largely arenaceous sediment (sandstones & quartzites) successively followed by argillaceous (shales, phyllites & slates) and ferruginous sediments (ferruginous shales, quartzites, manganese and iron ores).

Intrusive rocks: These include both acid and basic intrusives. The acid intrusives are in the form of granites while the basic ones are in the form of dioritic or doleritic sills

The two most significant economic mineral deposits of the area are manganese and Iron ores. The manganese ore is confined mainly to the southern portion of Kumaraswamy range and the western flanks of the Ramandurg range. Iron ore occurrences are spread over almost all the major hill ranges viz., Ramandurg, Kumaraswamy, Donimalai, Devadarigudda, Thimmappanagudi, NEB range and Copper Mountain (Belagal) range.

2.3.2 *Seismicity*

As per latest seismic zoning map of India, this region falls in Zone II seismic zone which is referred to as low damage risk zone.

2.3.3 *Hydrological & Meteorological Investigations*

Climate of the region is characterized by dry weather in major parts of the year and is noted for very hot summer especially during the periods of June to September. It experiences south west monsoon during the periods of June to September and post monsoon season during months of October and November.

The place is very hot during summer and the temperature reaches up to 40^0C. The lowest temperature is during the months of December and is about 17^0C.

CHAPTER 3
HYDROLOGY & POWER POTENTIAL STUDIES

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CHAPTER 3 HYDROLOGY & POWER POTENTIAL STUDIES

3.1 *General*

The hydrological analysis is crucial for any hydropower projects. The profitability of the project would depend upon the reliability of available water through the year. In the present case, the project is a closed loop pumped storage project. In this case, the reservoirs are not connected to any natural water sources. The project would require one time filling and later on would require replenishing the water, lost due to evaporation in order to generate the stipulated energy from the project

3.2 *Objectives of Study*

The objectives of the study shall be as follows:

- To assess the water availability for operation of the project throughout the year
- To assess the water requirement to replenish the storage lost due to evaporation
- To assess the sediment deposition in the reservoirs
- To determine the installed capacity of the plant based on available head and discharge and unit sizing
- To estimate the annual energy generation

3.3 *Hydro-meteorological Data*

The climate of Vijayanagar is generally dry and hot. The summer season is from March to June. Monsoon brings some wet weather that typically lasts from late June to early August. The colder period of the year is from November to February. The day temperature in summer reaches close to 40^0C.

3.4 *Water Availability Study*

At present, the raw water allotted for JSW Steel by Government of Karnataka is 3,30, 948 cum per day, out of which approximately 1,49,108 cum per day is from Tungabhadra dam located 40 km away from the site and 1,81,840 cum per day is from Almaty dam located 170 km away from the site. The water is pumped to Raw water

pond or Raw Water Reservoir 1 of capacity 5.50 mcm which is situated in Vidyanagar, JSW Steel.

Recently Raw Water Reservoir 3 has been constructed with a capacity of 35 mcm to cater to needs of the plant. The Raw Water Reservoir No. 1 has capacity of 5.5 mcm. It is planned to utilize the water from Raw Water Reservoir 1 for the Pumped Storage Project.

The project is planned to use 2.42 mcm of water annually, with an annual top up requirement of 0.242 mcm. The surplus water from present allocation or one time allotment from these reservoirs shall be required to start operations of the PSP.

3.5 *Evaporation*

The evaporation from the Upper and Lower Reservoirs would depend upon the water spread area and the temperature of the region. The evaporation is assumed to be 10% of total planned storage i.e. 0.242 mcm, which will be recouped with water brought from Raw Water Reservoir 3.

3.6 *Sedimentation*

The sedimentation is not a problem here as the reservoir is not connected to any natural water source. The water in the reservoirs is stagnant for a substantial period of the day. This will help settle the suspended particles, if any. Once suspended particles get settled, there would not be any sedimentation as the recirculation of the same sediment free water shall be carried out for operation of the plant.

3.7 *Power Potential Studies*

Based on the available water and the head, the power potential studies has been carried out and described below.

3.7.1 *Installed Capacity*

The water storage volume in the Upper Reservoir is planned to be 2.42 mcm. The objective of the power plant is to generate power during peak hours by diverting the flow from Upper Reservoir to Lower Reservoir through turbines. Then, it is to pump water from Lower Reservoir to Upper Reservoir with pumps during off peak hours. The turbine and pumps are part of reversible pump turbine machine.

It is planned to generate by considering peak hours of 6 hours duration. Hence the design discharge shall be 2.42 x 10^6 / (6 x 60 x 60) = 112 m3/s.

The characteristics of both reservoirs are mentioned in Table 3.1.

Reservoir	FRL	MDDL
Upper Reservoir	662	640
Lower Reservoir	520	518

Table 3.1 Reservoir Characteristics

The installed capacity of the plant is determined as below.

FRL of Upper Reservoir	662	m
MDDL of Upper reservoir	640	m
FRL of Lower Reservoir	520	m
MDDL of Lower reservoir	518	m
Normal Water Level	654.67	m
Tail Water Level	519.33	m
Maximum Head	144	m
Gross Head	135.33	m
Head Loss	3.000	m
Net Head	132.33	m
Design Discharge	112	m3/s
Installed Capacity of Turbine	130.86	MW
Adopt Installed Capacity	130	MW

3.7.2 *Unit Sizing*

The plant shall have two units from the economy consideration. Each unit shall be of 65 MW capacity.

3.7.3 *Energy Generation*

The turbine shall operate for 6 hours during peak hours daily. The energy to be generated daily shall be 130000 x 6 = 7,80,000 kWh. Considering 95% plant availability, the annual generation shall be 270.465 GWh (MU).

Each pump shall have capacity of 78.06 MW and pumping discharge is 52.15 m3/s.

The required hours of pumping of 2.42 mcm of water shall be 2.42×10^6 / (2 x 52.15 x3600) = 6.444 hours.

The pumping energy required for a year shall be 2 x 78.06 x 1000 x 6.44 x 365 x 95% = 348,839,880 kWh i.e. 348.839 GWh (MU).

CHAPTER 4
CONCEPTUAL DESIGN OF CIVIL & HM WORKS

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CHAPTER 4 CONCEPTUAL PLANNING OF CIVIL AND HM WORKS

4.1 *General*

The Pumped Storage Project at Vijayanagar is a closed loop system. There is no continuous inflow to reservoirs through any water source. The water stored once in the reservoir shall be recirculated for generation during peak hours and pumping during off peak hours.

The topographical advantage of locating an upper reservoir close to JSW boundary is taken. The lower reservoir is existing Raw Water Reservoir 1 in the JSW area. The planning is done to minimize the cost of construction.

4.2 *Alternative Studies*

Various alternatives have been considered to get an optimum capacity of plant. The main consideration is the cost of the plant as technical aspects do not pose any problem here.

At first, the deep valleys are thought of providing storage as upper reservoir. But it is found that the head will be reduced if the valleys are chosen as upper reservoir. Hence the relatively flat surface at around RL 640 is chosen as site for upper reservoir. This will require excavation of 12.11 lakh m^3 of earthwork as calculated below.

Table 4.1 Excavated Volume of earthwork

Elevation (m)	Area (m^2)	Mean Area (m^2)	Vertical Interval (m)	Interval Volume (m^3)	Accumulated Volume (m^3)
659	349				0
658	1129	739	1	739	739
657	2365.1	1747.05	1	1747.05	2486.05
656	4795	3580.05	1	3580.05	6066.1
655	8816	6805.5	1	6805.5	12871.6
654	14449	11632.5	1	11632.5	24504.1
653	21391	17920	1	17920	42424.1
652	30614	26002.5	1	26002.5	68426.6
651	43464	37039	1	37039	105465.6
650	54633	49048.5	1	49048.5	154514.1
649	64744	59688.5	1	59688.5	214202.6
648	74796	69770	1	69770	283972.6
647	84562	79679	1	79679	363651.6
646	95668	90115	1	90115	453766.6
645	105638	100653	1	100653	554419.6

644	115233	110435.5	1	110435.5	664855.1
643	128162	121697.5	1	121697.5	786552.6
642	137430	132796	1	132796	919348.6
641	146266	141848	1	141848	1061196.6
640	154500	150383	1	150383	1211579.6

After deciding upon the location of upper reservoir, various alternatives with dams all around the upper reservoir are studied. The possibility of providing embankment and gravity dams is studied in detail.

Four alternatives narrowed down from a number of possible alternatives. They are:

1) **Alternative 1** - This alternative consists of Upper Reservoir (Concrete Dyke System), Intake/ Outlet (Upper Reservoir), Water Conductor System, Powerhouse (Surface), Tail Race Channel, Outlet/ Inlet (Lower Reservoir).

2) **Alternative 2 –** This alternative is same as Alternative 1 except that the powerhouse location has been shifted near to hill toe.

3) **Alternative 3** - This alternative consists of Upper Reservoir (Concrete Faced Rockfill Dyke), Intake/ Outlet (Upper Reservoir), Water Conductor System, Powerhouse (Surface), Tail Race Channel, Outlet/ Inlet (Lower Reservoir).

4) **Alternative 4** – This alternative is same as the Alternative 2 but the penstocks have been aligned straight without any bends.

The technical study of all the alternatives have been done and the summary of the same has been given in the following sections.

Alternative 1

In this alternative, the project comprises of Upper Reservoir with a concrete dyke of 25.0 m maximum height with its FRL at 662.0 m and top at EL. 665.0 m would be constructed to hold 2.47 MCM of gross storage and 2.42 MCM of live storage. The total dam length is about 1522 m.

The intake/ outlet structure would be accommodated within this dam section from where the water conductor system is proposed.

The WCS consists of 2 nos. of 5.0 m diameter steel penstocks of approx. 969.87 m length aligned along the slope of the hill. The total net head available for the project is about 132 m and considering l/h ratio, surge management would be required in the system.

A surface powerhouse is located at the end of the WCS which houses 2 pump turbines of 65 MW each. The tail race tunnel conveys the water to the intake/outlet structure which is located within the lower reservoir.

The lower reservoir is the existing raw water pond no. 1 located within the JSW plant. The total capacity of the reservoir is estimated to be about 5.53 MCM which is available completely for the project.

The layout map of this alternative has been given in **Drg. No. 1**.

Alternative 2

This alternative is same as Alternative 1, but the power house location has been shifted nearer to hillock. This arrangement will result in the following.

- Reduction of penstock length
- Naturally available back slope
- Small Tailrace Tunnel
- Powerhouse located near the foothill
- Longer Tailrace channel

The water conductor system proposed to take off from intake/outlet structure at the upper reservoir and aligned along the hill slope up to the surface powerhouse. The total length of the WCS will be about 619.53 m consisting of 2 nos. of 5.0 m diameter steel penstocks. The shorter length of the WCS will also give the additional advantage of eliminating surge management in the system.

The powerhouse is proposed to house 2 units of pump turbines of 65 MW each with the draft tube of the units is connected to the tail race tunnels which in turn is connected to the lower reservoir vide the intake/ outlet structure.

The lower reservoir is the existing raw water pond no. 1 located within the JSW plant which is the same as proposed in Alternative 1. The general layout of this alternative has been shown in **Drg. No. 2** of this report.

Alternative 3

This alternative is completely resembling alternative 2 with the change in dam type of the upper reservoir. A concrete faced rockfill dyke (CFRD) has been proposed in place of a concrete gravity dyke with its side slope of 1:1.5 on both upstream and downstream side. The proposal of the CFRD has been done with keeping the volume available in the upper reservoir same as in other alternatives.

The advantages of adopting a CFRD are as below:

- Increased overall stability of the dyke as the water pressure acts on the u/s concrete face
- No development of pore water pressure in pervious/free draining compacted rock-fill zone
- A well-compacted CFRD has a high resistance to earthquake loading.
- The sliding factor of safety often exceeds 7 & the dam supports the abutments.
- Plinth with appropriate foundation treatment below, U/s and/or D/s, connects the water barrier (concrete face slab) to the foundation.
- Uplift is not an issue. The pressure on the foundation exceeds reservoir pressure over three quarters of the base width.
- Water load is transmitted into the foundation upstream from the dyke axis, an inherently safe feature.
- All the rockfill is dry, earthquake shaking cannot cause internal pore water pressure.
- The conditions of high shear strength, no pore pressure, and small settlement under seismic loading makes the zoned rockfill inherently resistant to seismic loading

Taking benefits of the above stated advantages, a CFRD with the following salient features is proposed for forming the Upper Reservoir:

a. Type of dyke - CFRD
b. Dyke height - average height is 25 m
c. Dyke length - 1757.5 m
d. U/s Slope - 1 (V):1.5 (H)
e. D/s Slope - 1 (V):1.5 (H)

To accommodate 2.42 MCM of storage required to generate 130 MW over a peaking time of 6 hours, the dam length must be increased to account for the loss of volume due to the placing of the CFRD at a slope of 1:1.5. In the case of both earlier alternatives, the concrete gravity dam has a vertical face which resulted in smaller upper reservoir area.

The water conductor system proposed to take off from intake/outlet structure at the upper reservoir and aligned along the hill slope up the surface powerhouse. The total length of the WCS will be about 634.79 m consisting of 2 nos. of 5.0 m diameter steel penstocks.

The powerhouse is proposed to house 2 units of pump turbines of 65 MW each with the draft tube of the units is connected to the tail race tunnels which in turn is connected to the lower reservoir vide

the intake/ outlet structure. The lower reservoir is the existing raw water pond no. 1 located within the JSW plant which is the same has proposed in Alternative 1. The general layout of this alternative has been shown in **Drg. No. 3** of this report.

Alternative 4

This alternative is the same as Alternative 2 except the change in layout of the penstock. The penstocks are aligned straight avoiding the bends as in the case of other alternatives which would result in reduced head loss.

The length of penstock is 718 m. The general layout of this alternative has been shown in **Drg. No. 4** of this report.

Comparison of Alternatives

In case of **Alternative 1**, the concrete gravity dams all around the upper reservoir would lead to high cost. The length of penstock is more which may require to introduce a u/s surge shaft. This would result in higher cost of the project.

In case of **Alternative 2**, the concrete gravity dam around the upper reservoir is planned similar to Alternative 1. The length of the penstock in this alternative is less, which will eliminate the requirement of surge shaft. This alternative is better than **Alternative 1**.

In case of **Alternative 3**, a CFRD as proposed for the upper reservoir will be highly advantageous for any project due to the ease of the construction, cost of the dyke and performance of the dyke itself. Yet, it carries a significant disadvantage in this instant case. The CFRD is known to allow permissible leakages downstream which in this case is not favourable as this reservoir is located over a hill and constant seepages which even under permissible limits may adversely affect the downhill located township of plant. The seepage from the dyke will form a perineal water flow in the valley which may need further training works to divert safely downstream. As seen from the studies the downstream face of the CFRD will require substantial construction material to suit the prevalent topography.

In case of **Alternative 4**, all the project components are similar to **Alternative 2**. But the bends in the penstock alignment is avoided by laying the penstock straight. The upper reservoir site is well suited for constructing a concrete gravity dyke of required height in building up the upper reservoir with corresponding storage in requirement of power generation. The upstream face being vertical will aide in increasing storage when compared against the CFRD option.

In conclusion, the **Alternative 4** will be adopted for Vijayanagar PSP based on the various considerations as given above.

4.3 *Selection of Best Alternative*

The Alternative 4 is selected as the best one. The final details of the selected alternative are given in following sections.

4.3.1 *Upper Reservoir*

The upper reservoir will have a gravity dam with its top at RL 665 and FRL at 662m. The downstream batter of 0.8 (H) to 1 (V) is provided from FRL. The upstream batter of 0.1 (H) to 1 (V) is provided. This typical section gives an idea of the tentative cost per meter run of the dam. A freeboard of 3m is provided. However, all these parameters of the dam shall be designed at DPR stage. The MDDL shall be at RL 640. The live storage is calculated to be 2.42 mcm.

4.3.2 *Lower Reservoir*

The existing Raw Water Reservoir 1 within JSW area shall be used as lower reservoir. The normal level in the reservoir is at RL 520m. However, the fluctuation of level in the reservoir is assumed to be up to RL 518m. The reservoir volume has been reduced due to expansion of a runway for the airport, but the reduced volume of the reservoir is 5.5 mcm. As this pond is rarely used for existing JSW operations after construction of Raw Water Reservoir 3 with a capacity of 35 mcm. One time filling of the reservoirs shall be done from this reservoir.

4.3.3 *Water Conductor System*

The water conductor system comprises of the following structures:

- Bell mouthed Intake
- Two steel lined penstocks each 5m dia and 718m long
- Tailrace Channel of 8m wide and 4m deep RCC box type of 800m long

The bell mouthed intake is provided to reduce the head loss at the entry. A minimum submergence of 2.5m is provided above the top of Intake. The invert of the Penstock shall be at RL 632.5m. The bottom surface of the reservoir is lowered locally at the intake to RL 632.5m in order to get the required submergence.

The Penstocks is taken as 5m dia with a velocity of 2.58 m/s. The diameters of the penstock are comparatively large so that there will be no requirement of surge shaft in between from turbine governing point of view. Due the increased area of penstock, the penstock acceleration time is just about 2 seconds. However, during DPR stage, a detailed transient analysis shall be carried out to study if surge tank is required.

4.3.4 *Power House*

The power is planned to be surface type. The tentative dimension of the power house shall be 45m (L) x 18m (W) x 48m (H). However, the power house type and size shall be optimized at DPR stage.

4.3.5 *Tailrace Channel*

The Tailrace channel shall be RCC box type with width as 8m and depth of 4m and longitudinal slope of 1 in 850 to meet the lower reservoir. The Tailrace channel shall be finalized at DPR stage on availability of topographical and geological data.

4.3.6 *HM Works*

The HM works shall comprise the following structures:

- Trash rack structure in upper reservoir
- Stoplog gate at intake of upper reservoir
- Service gate at Intake of upper reservoir
- Steel pipes in HR and penstock
- Main Inlet Valve
- Stoplog Service gate and stoplog gates
- Stoplog and service gate at intake of lower reservoir
- Trash rack at intake of lower reservoir

4.4 *Land Requirement*

The land requirement for various components of the project shall be as follows.

Sl. No.	Component	Unit	Area
1	Upper Reservoir	Ha	19.5314
2	Penstock and power house area	Ha	7.2212
3	Tail Race Canal	Ha	12.38
4	Dumping Site-1	Ha	7.1632
5	Dumping Site-2	Ha	7.8646
6	Dumping Site-3	Ha	7.0135
7	Dumping Site-4	Ha	18.4077
8	Approach Road	Ha	1.4851
9	Facilitation Area	Ha	2.9944
Total			**84.0611**

Sl. No.	Ownership of Land	Unit	Area
1	Forest Land	Ha	20.4501
2	Govt. Land	Ha	25.7605
3	JSW Steel	Ha	37.8505
Total			**84.0611**

CHAPTER 5
ELECTRO-MECHANICAL WORKS

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CHAPTER 5 ELECTRO-MECHANICAL WORKS

5.1 *General*

The Vijayanagar Pumped Storage Project is planned to install reversible pump turbines and generator-motors along with auxiliaries having capacity matching with the outcome of power potential studies It is proposed to provide a surface power house comprising of service bay, machine hall, control room etc. The plant is proposed to have 2 units of reversible pump turbines accommodated in a surface power house.

5.2 *Sizing and Technical Specification of Main Plant Equipment*

5.2.1 *Pump Turbine Operating Levels*

The operating Levels of Pump Turbine are as follows:

FRL of Upper Reservoir	662	m
MDDL of Upper reservoir	640	m
FRL of Lower Reservoir	520	m
MDDL of Lower reservoir	518	m
NWL	654.67	m
TWL	519.33	m
Maximum Head	144	m
Gross Head	135.33	m
Head Loss	3.000	m
Net Head	132.33	m
Design Discharge	112	m3/s
Installed Capacity of Turbine	130.86	MW

Adopt Installed Capacity	130	MW
Maximum Pumping Head	146.5	m
Rated Head for Pumping	137.33	m

5.3 *Pump and Turbine Capacity*

No. of Turbines	2	
Unit Capacity	65	MW
Specific Speed of Pump Turbine	165	
Specific Speed of Pump	45	
Rated Speed of Turbine	249.2665	rpm
Select speed of turbine	250	rpm
Rated Pump Discharge	52.14455	m3/s
Pump Output	78.05692	MW
Capacity of Motor Generator	80.24517	MW
5% margin over Pmax	84.25742	MW
Capacity of Motor Generator	84.25742	MW

5.4 *Turbine Setting*

Barometric Pressure Hb	10	m
Vapour Pressure at PH level	0.4	m
Sigma from Graph	0.22	

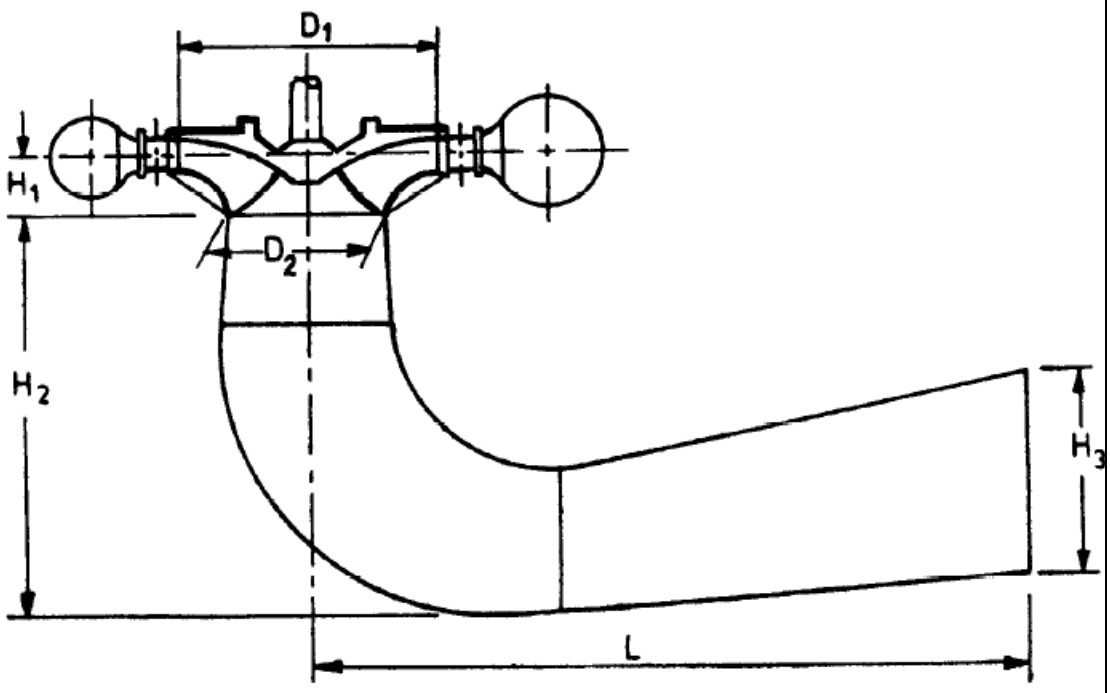
Suction Height below Min TWL Hs	-20.61333	m
Margin above the value	3	m
Turbine Centre below Min TWL	-23.61333	m
Provide turbine centreline below TWL	23	m

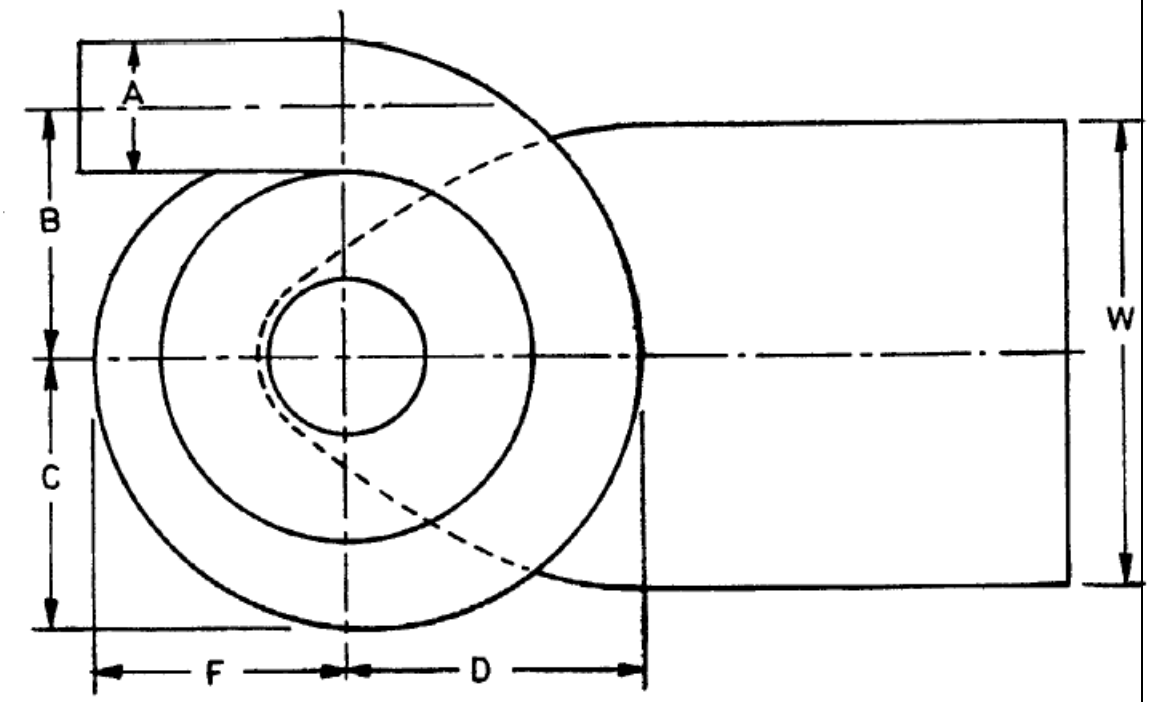
5.5 *Sizing of the Turbine*

Ku from Graph	1.03	
D1	3.96752	m
Provide D1	4.00	m
Dimension of spiral case		
Recommended velocity at 137m	11	m/s
Inlet Diameter D	2.456763	m
Assume	2.5	m
A	2.5	m
B	4.12	m
C	4.6	m
D	5	m
E	4.04	m

5.6 *Sizing of Draft Tube*

H1	1.04	m
H3	3.8	m
H1+H2	8.4	m
L	13.2	m
W	7.4	m
Weight of runner	25	Tonnes
Axial Hydraulic Thrust	238.1867	Tonnes





5.7 *Generator Parameters*

Generator Capacity	72222.22	kVA
Pair of Poles	12	
Maxm Peripheral Velocity Vr from Graph	75	m/s
Air Gap Diameter	5.729578	m
say	5.75	m
Outer Core Diameter D0	6.502673	m
say	6.6	m
Stator Frame Diameter	7.8	m
Inner Diameter of barrel	10	m
Core Length of Stator		
K0 from Graph	6.4	

Core Length of Stator Lc	1.365259	
say	1.4	m
Length of Stator Frame L	2.9	m
Height of Load bearing Bracket	1.558645	m
say	1.6	m
Weight of generator rotor/m length Graph	170	T/m
Weight of Rotor	238	Tonnes
Axial Load	501.1867	Tonnes

5.8 *Power Evacuation*

The power generated from the project shall be used for JSW Steel at Vijayanagar. So the power from the project shall be evacuated from the switchyard to JSW Steel through the existing substation and transmission line.

CHAPTER 6
CONSTRUCTION PLANNING

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CHAPTER 6 CONSTRUCTION PLANNING

6.1 General

Vijayanagar PSP is located in JSW plant area except the upper reservoir and part of penstock. The project has been contemplated comprising following main civil structures:

- Upper Reservoir and Concrete Gravity Dam
- Intake structure
- Steel Penstocks
- Surface Power House complex and switchyard
- Tailrace Channel

6.2 Construction Time and Working Season

Construction programme, selection of methodology and equipment has been planned with the aim of commissioning the project in two years. Available working season in a year in the project area shall be carried out throughout the year except a few rainy days in monsoon.

6.3 Construction Power

All the major equipment is proposed with diesel engines. The demand for construction power for colony, workshop can be met from the existing transmission line existing in the area.

6.4 Dumping Area

The excavated materials from upper reservoir area, penstock area, power house and tailrace shall be dumped in designated dumping sites, which are close to construction site.

6.5 Preconstruction Facilities

Pre-construction facilities such as obtaining various permits and licences, land acquisition for project shall be made to facilitate construction of the project. Most of these activities shall be completed prior to commencement of works by the contractor.

6.6 Sequence of Works

The project is planned to be completed in two years. The execution of works shall be carried out as follows.

6.6.1 First Year

i) Excavation of hillock up to RL 640m in the upper reservoir area

ii) Preparation of Dam base and curtain and consolidation grouting of dam base

iii) Construction of part of the dam up to RL 655m

iv) Construction of Intake complete

v) Excavation for Penstock

vi) Excavation and construction of Power House foundation

vii) Excavation and construction of Tailrace Channel complete.

6.6.2 Second Year

i) Completion of construction of Dam

ii) Fabrication, erection of steel liner for penstock

iii) Completion of Civil works for Power House

iv) Completion of EM works in Power House and Switchyard

v) Completion of all gates

vi) Commissioning of project.

6.7 Material Planning

The important and major construction materials will be reinforcing steel, cement, aggregates and steel liner. These materials except steel liner are easily available in the area. Only the steel liner shall be procured from outside.

6.8 Manpower Planning

As the work is proposed to be executed through contractors, the manpower planning for execution shall be carried out by the contractor. Whereas the owner will have some supervisory staff to monitor the progress and coordinate with various agencies for interfacing and completion of project within the scheduled date of completion.

6.9 Mode of Execution

The works are proposed to be executed through contractors: Civil & HM works, and E & M works.

CHAPTER 7
ENVIRONMENTAL ASPECTS

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CHAPTER 7 ENVIRONMENTAL ASPECTS

7.1 General

Most of the components of Vijayanagar PSP shall be constructed in JSW plant area except the upper reservoir. The upper reservoir shall be constructed on adjacent hillock. The Raw Water Reservoir 1 of JSW plant shall be used as Lower Reservoir. The penstocks, surface power house complex and tailrace form part of the project components.

7.2 Description of the Environment

7.2.1 Climate

Climate of the region is characterized by dry weather in major parts of the year and is noted for very hot summer especially during the periods of June to September. It experiences south west monsoon during the periods of June to September and post monsoon season during months of October and November.

The place is very hot during summer and the temperature reaches up to 40^0C. The lowest temperature is during the months of December and is about 17^0C.

7.2.2 Regional Geology

The geological formations of the Bellary, Hospet & Sandur region are known by the name Sandur Schist Belt, belongs to Dharwar Super Group.

7.2.3 Seismicity

As per latest seismic zoning map of India, this region falls in Zone II seismic zone which is referred to as low damage risk zone.

7.2.4 Flora & Fauna

The detailed study of flora & fauna shall be made during DPR stage and application for Environmental Clearance.

7.3 Prediction of Impacts

The environmental impacts of the proposed PSP have been predicted and are being forecast in light of the activities that would be undertaken during the construction of various project appurtenances. The likely impacts have been considered for various

aspects of environment, including physico-chemical, ecological and socio-economic aspects are briefly detailed as below.

7.4 Impacts on Land Environment

Very few impacts of construction phase are permanent. Majority of the environmental impacts attributed to construction works are temporary in nature, lasting mainly during the construction phase and often little beyond the construction period. The following impacts may be experienced.

i) Environmental Degradation due to immigration of labour Population

ii) Operation of Construction Equipment

iii) Soil erosion

iv) Muck Disposal

But these impacts shall be well taken care of during construction phase.

7.5 Impacts on Air Environment

No major impact is foreseen on this account on ambient air quality

7.6 Impacts on Noise Environment

There may be some noise due to operation of construction machineries. But these impacts are localised

7.7 Impacts on Water Quality

There will be no impact on water quality as the project is not connected to any natural source

7.8 Impact on Flora & Fauna

As the construction is limited to few hectors and the land is not covered with dense plantation, there will be little or no impact on flora & fauna

7.9 R&R Issues

There will be no R&R issues.

7.10 Environmental Management Plans

Environmental Management Plan (EMP) aims at the preservation of ecological system by considering certain mitigating measures at the proposed site. The mitigation

measures are used to minimize or prevent adverse impacts on environment due to the proposed development activity.

It is expected that the project area shall not be affected much with the proposed activity. The majority of the environmental impact pertains to the construction phase. It is planned to take corrective measures to ensure that these effects are kept to bare minimum. The EMP will therefore, be initiated during planning stage itself.

7.10.1 Air Environment

The construction activities will generate large quantities of dust during drilling, blasting, loading and transportation operations. The following measures are required be taken to mitigate the dust from different operations.

To avoid the dust generation from the drilling operations, wet-drilling methods will be adopted.

Ceasing dust -generating activities during high winds Covering of vehicles carrying solid waste (muck).

Watering of haul roads and other roads at regular intervals Plantation near muck disposal places and dumping yards.

7.10.2 Noise Environments

The major noise generating sources from the proposed activity are working machinery and movement of vehicles. The following control measures are to be undertaken to bring down the noise levels.

Traffic (vehicular movement) to be managed to produce a smooth flow instead of a noisier stop -and start flow.

Ensuring timely preventive maintenance of the equipment involved. Since a well maintained equipment is generally quieter than poorly maintained equipment.

Ensuring usage of personal protective devices i.e., earmuffs and earplugs by workers, working in high noise activity canters.

Plantation in the vicinity of the construction area will further reduce the noise levels.

7.10.3 Water environment

During construction phase the wastewater (sewage) coming from temporary Arrangements like offices, labour camp sheds, canteens etc., and impact due to soil erosion during monsoon period may cause surface water pollution. Some of the control measures adopted for controlling water pollution are as follows:

Establishing septic tanks followed by soak pits to treat the domestic waste water generated from the offices, canteens, labour camp sheds.

7.10.4 Compensatory Afforestation

The loss of vegetal cover shall be compensated by compensatory afforestation. The Indian Forest Conservation Act (1980) stipulates:

if non-forest land is not available, compensatory forest plantations are to be established on degraded forest lands, which must be twice the forest area affected or lost, and if non-forest land is available, compensatory forest are to be raised over an area equivalent to the forest area affected or lost.

As per the applicable forest laws in vogue, the cost of compensatory afforestation, the NPV for environment loss as well as cost of trees are also payable as per the applicable norms.

7.10.5 Greenbelt Development

The forest loss due to various project appurtenances has been compensated as a part of compensatory afforestation. However, in addition to compensatory afforestation, it is proposed to develop greenbelt around the perimeter of various project appurtenances, selected stretches along the periphery of water spread area, roads, etc.

CHAPTER 8
COST ESTIMATES

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CHAPTER 8 COST ESTIMATES

8.1 General

The cost estimate of Vijayanagar PSP has been worked out by calculating the quantities of major items for works involved in the execution of project components. The applicable unit rates are based upon the rates from various projects, which are under execution now.

8.2 Major Heads and Sub-heads

The cost estimate has been worked out under two sub-headings viz. Direct Charges and Indirect charges as per CWC guidelines.

8.3 Direct Charges

Direct charges are the expenses incurred on various civil/electro-mechanical works, establishment, tool and plants, suspense account and receipts and recoveries. Direct Charges have been further classified into five categories:

I I - Works

II Establishment

III Tools and Plants

IV Suspense

V Receipt and Recoveries.

The details of above sub-heads under Direct Charges are given in the following paragraphs.

8.4 I - Works

Under this heading, provision has been made for Civil, Electrical and Mechanical works of various components of the project as detailed hereunder:

A - Preliminary

Provision under this heading has been made for surveys and investigations to be conducted to arrive at the optimum designs of project components. A provision of Rs. 500 Lacs has been made under this head.

B - Land

This covers the provision for acquisition of land for project components and dumping area. A total provision of Rs 300 Lacs has been made under this head.

C - Civil Works

These cover the cost of civil engineering structures comprising gravity dam of 25m high and excavation of hillock above RL 640m in the Upper Reservoir. A provision of Rs. 22850 Lacs has been made for Civil Works.

J - Power Plant Civil Works

This head consists of cost of Power Plant Civil Works like Intake Structure, Penstock, Power House Complex, Tail Race Channel and switchyard. A provision of Rs. 8500 Lacs has been considered for J-Power Plant civil Works.

K - Buildings

Buildings are available within JSW plant area. A provision of Rs. 100 Lacs has been made under this head.

M - Plantation

A provision of Rs. 200 Lacs has been kept for plantations along project road and around reservoir structures.

O – Miscellaneous

A provision for Rs. 699.86 Lacs has been made for meeting cost of various items under this head. These include the provisions for construction power, drinking water and sanitation arrangement etc. Provision has been made for maintenance of these facilities during the Construction Period of Project.

P – Maintenance

A total provision of Rs. 314.50 Lacs has been kept under this heading. As per the applicable norms, this has been worked out as 1% of I-works less A-Preliminary, B-Land and Q-Special T&P.

Q - Special T&P

The purpose under this head covers the residual value of the general-purpose equipment for infrastructure. It is assumed that 75% of machinery life shall be spent on construction of project. Further provision for inspection vehicle has also been made. The total provision under this head is Rs. 200 Lacs.

R - Communication

Provision under this head covers the cost of roads and bridges. The road widths have been planned to cater to the anticipated traffic including movement of heavy trucks. The total provision under this head is Rs. 150 Lacs.

S - Power Plants

The provision made under this head includes the cost of procurement and installation of turbines, generators, transformers, HOT Cranes, auxiliary equipment for power house, cables, switchyard equipment etc. A total provision of Rs. 16250 Lacs has been made under this head.

X - Environment, Ecology & Afforestation

A provision of Rs. 1000 Lacs has been made under this head for maintaining & improving the environment status of the project area and the afforestation of affected area.

Y - Losses on Stock

A provision of Rs. 78.63 Lacs has been made under this sub-heading. As per applicable norms; this has been worked out as 0.25% of C-Civil works, J- Power Plant works, K-buildings and R-communication.

8.5 II - Establishment

Establishment Charges has been considered @ 8% of cost of I-works less B-Land under this heading amounting to a total of Rs. 2516 Lacs.

8.6 III – T&P

Tools & Plants has been considered @ 1% of cost of I-works under this heading amounting to a total of Rs. 200 Lacs.

8.7 IV - Suspense

No provision has been made under this head.

8.8 V – receipts & Recoveries

No provision has been made under this head.

8.9 Indirect Charges

These charges cover the cost towards fees for audit and accounts which has been taken as 1% of cost of I-works. No provision has been made for capitalization of land abatement revenue. A provision of Rs. 50 Lacs has been kept for the indirect charges.

8.10 Total Cost of the Project

The cost estimate of Vijayanagar PSP has been worked out by calculating the quantities of major items for works involved in the execution of project components. The applicable unit rates are based upon the rates from various projects, which are under execution now.

Sl. No.	Works	Cost (in Rs. Lakhs)
1	Civil and Hydro Mechanical Works	44448.48
2	Electrical and Electro-Mechanical Works	19639.62
Total Hard Cost		**64088.10**

The abstract of Cost estimate is given in Annexure 8.1.

CHAPTER 9
ECONOMIC ANALYSIS

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CHAPTER 9 ECONOMIC EVALUATION

9.1 General

The Government of India has made a number of policy changes in the power sector for providing an enabling framework for increased participation of various sectors in the electricity generation, transmission and distribution. Restructuring and regulation of the procedure for fixation of power tariff is part of this initiative.

The energy cost for hydro power generating stations shall comprise the recovery for annual capacity charges and energy charges. Annual capacity charges will consist of interest on loan capital and depreciation. Energy charges will consist of operation and maintenance expenses, return on equity, tax on return on equity and interest on working capital

9.2 Project Cost

The Project cost is as below.

Sl. No.	Works	Cost (in Rs. Lakhs)
1	Civil and Hydro Mechanical Works	44448.48
2	Electrical and Electro-Mechanical Works	19639.62
Total Hard Cost		**64088.10**
IDC & FC		3863.00
Total Project Cost		**67951.10**

9.3 Phasing of Expenditure

The project is planned to be completed in two years. The expenditure is phased as below.

Sl. No.	Works	Period				Total
		1st Half Year	2nd Half Year	3rd Half Year	4th Half Year	
1	Civil & HM Works	20%	30%	35%	15%	100%
2	EM Works	15%	20%	30%	35%	100%

9.4 Generation Benefits

The annual energy generation shall be 270.465 GWh. Auxiliary consumption shall be 1.2%

9.5 Pumping Energy

The annual pumping energy shall be 348.43 GWh.

9.6 Inputs for Financial Analysis

The following are the inputs for financial model.

Debt	70% of Project Cost
Equity	30% of Project Cost
Auxiliary Consumption	1.2%
Rate of Interest on Term Loans	8%
Repayment Period	12 years
Interest on Working Capital	8%
Base Rate of ROE	16.5%
O& M expenses	3.5% of Capital Cost escalated @4.77% every year
Depreciation	For initial period of 14 years @5.28% and the

	remaining depreciation shall be spread over balance useful life of 40 years

9.7 Levellised Tariff

The levellised tariff for various scenarios is given in the following table.

Sl. No.	Pumping Cost (Rs per Unit)	Levellised tariff (Rs per unit)
1	Nil	4.67
2	1.00	5.99
3	2.00	7.31
4	3.00	8,63

CHAPTER 10
CONCLUSION & RECOMMENDATIONS

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CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

The planning for the PSP has been done based on the available topo sheet, Google maps and site visits. The conceptual planning and design has been made accordingly. The optimum installed capacity is found to be 130 MW based on the available water and the net head of 132.33m. The Upper Reservoir, water conductor system, surface power house complex and the Tailrace shall be constructed. The Raw Water Reservoir 1 which is existing shall be used as Lower Reservoir.

The cost estimates of PFR level has been made and the project cost is given below.

Sl. No.	Works	Cost (in Rs. Lakhs)
1	Civil and Hydro Mechanical Works	44448.48
2	Electrical and Electro-Mechanical Works	19639.62
Total Hard Cost		**64088.10**

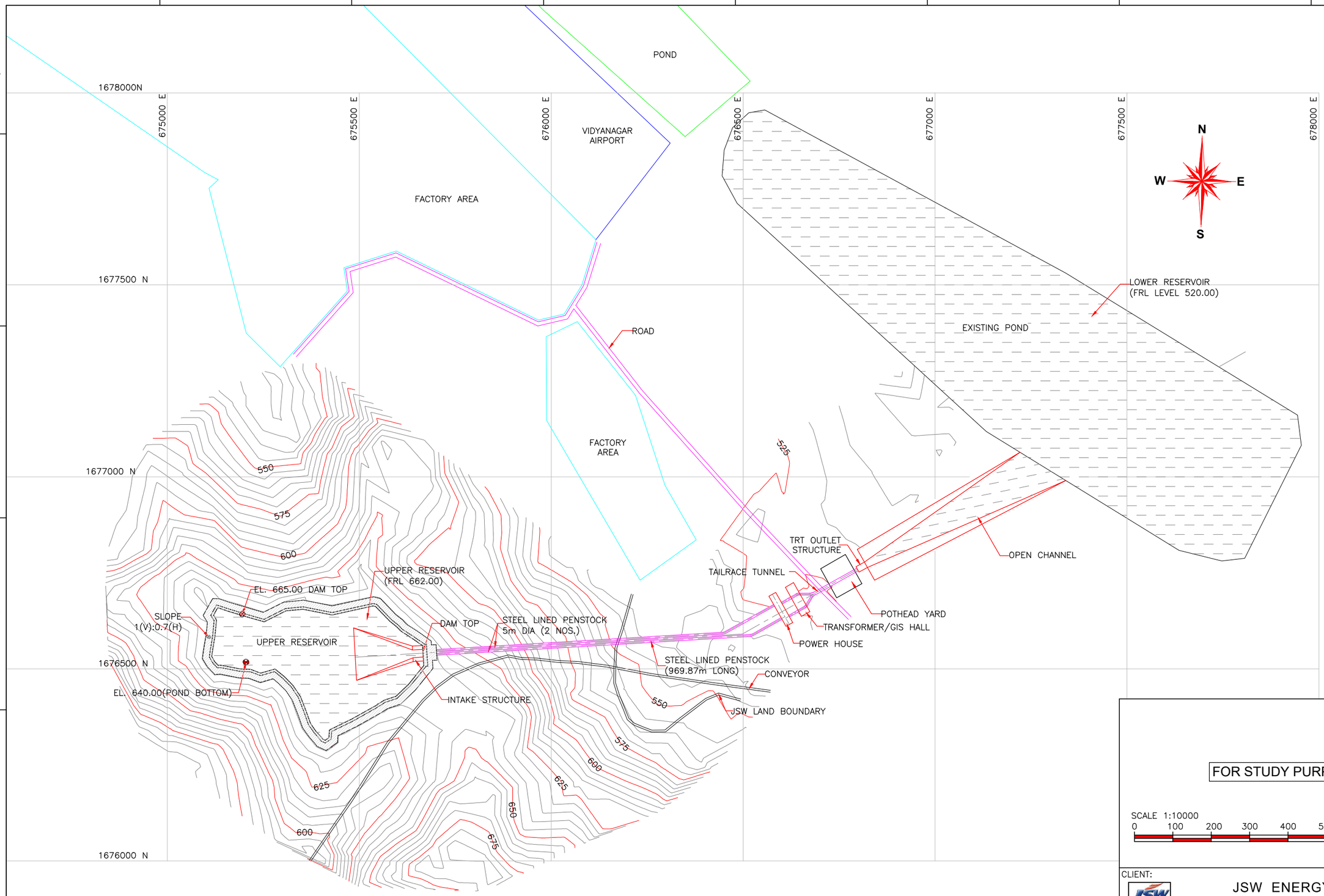
The project will produce annual energy of 270.465 GWh with 6 hours peaking generation and the energy requirement for pumping will be 348.839 GWh considering 95% plant availability. The cycle efficiency of the project shall be 77.53%. The levellised tariff for various pumping costs is given below.

Sl. No.	Pumping Cost (Rs per Unit)	Levellised tariff (Rs per unit)
1	Nil	4.67
2	1.00	5.99
3	2.00	7.31
4	3.00	8.63

10.2 Recommendations

It is recommended to take up preparation of DPR for finalization of layout, cost and tariff to be based on detailed survey and investigations.

DRAWINGS



NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETER AND ELEVATIONS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE SCALED FROM THE DRAWING,ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED. THE DESIGNER SHALL BE CONSULTED IN CASE OF ANY MISSING DETAILS IN THE DRAWING.

FOR STUDY PURPOSE

SCALE 1:10000

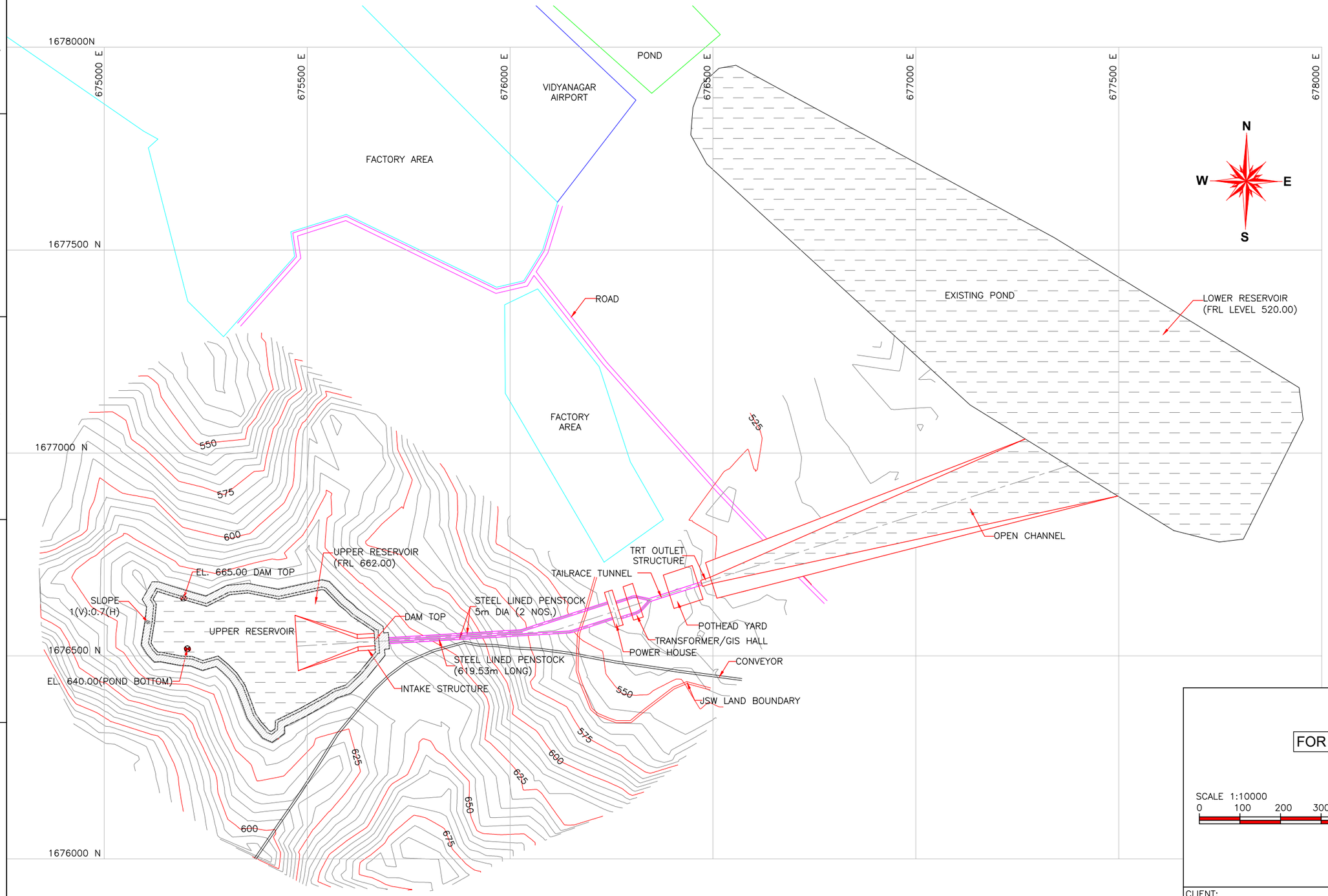
0 100 200 300 400 500 600m

CLIENT: JSW ENERGY LIMITED

PROJECT: VIJAYNAGAR PUMPED STORAGE PROJECT (130 MW)

DRAWING TITLE: LAYOUT PLAN ALTERNATIVE -1

DATE:	ORIGINAL PRINT SIZE	DRAWING NO	REV.	SHEET NO
JAN.2022	A3	DRAWING NO.1	0	1 OF 1



NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETER AND ELEVATIONS ARE IN METER UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE SCALED FROM THE DRAWING,ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED. THE DESIGNER SHALL BE CONSULTED IN CASE OF ANY MISSING DETAILS IN THE DRAWING.

FOR STUDY PURPOSE

SCALE 1:10000

0 100 200 300 400 500 600m

CLIENT: JSW ENERGY LIMITED

PROJECT: VIJAYNAGAR PUMPED STORAGE PROJECT (130 MW)

DRAWING TITLE: LAYOUT PLAN ALTERNATIVE-2

DATE:	ORIGINAL PRINT SIZE	DRAWING NO	REV.	SHEET NO
JAN.2022	A3	DRAWING NO.2	0	1 OF 1

1678000N

675000 E | 675500 E | 676000 E | 676500 E | 677000 E | 677500 E | 678000 E

1677500 N

1677000 N

1676500 N

1676000 N

POND

VIDYANAGAR AIRPORT

FACTORY AREA

FACTORY AREA

ROAD

EXISTING POND

LOWER RESERVOIR (FRL LEVEL 520.00)

N

W E

S

525

550

575

600

625

650

675

UPPER RESERVOIR (FRL 662.00)

SLOPE 1:1.5

DAM TOP

UPPER RESERVOIR

SLOPE 1:1.5

EL. 640.00(POND BOTTOM)

INTAKE STRUCTURE

EL. 665.00 DAM TOP

TRT OUTLET STRUCTURE

TAILRACE TUNNEL

STEEL LINED PENSTOCK 5m DIA (2 NOS.)

STEEL LINED PENSTOCK (634.79m LONG)

POTHEAD YARD

TRANSFORMER/GIS HALL

POWER HOUSE

CONVEYOR

JSW LAND BOUNDARY

OPEN CHANNEL

NOTES:-

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FOR STUDY PURPOSE

SCALE 1:10000

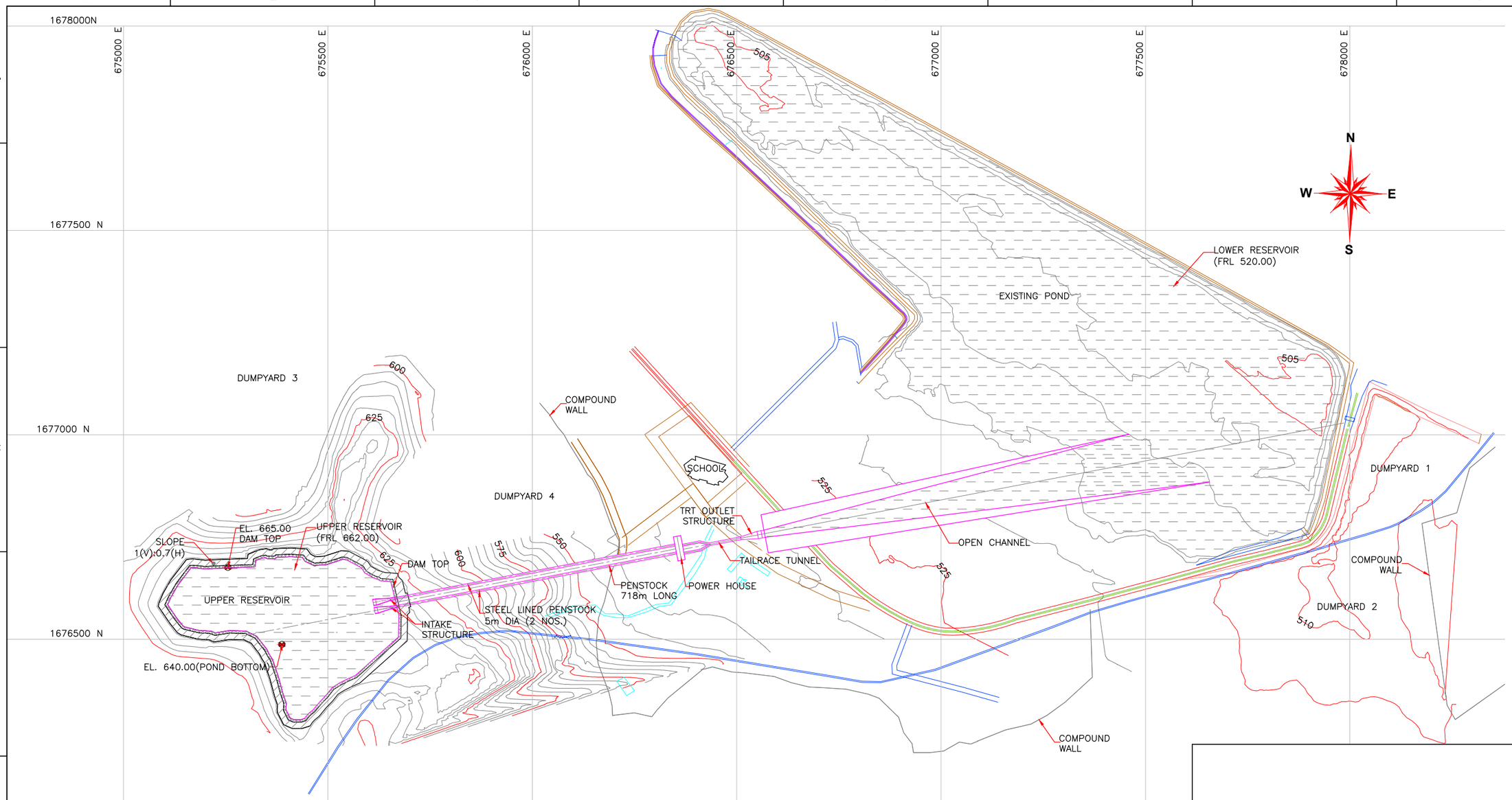
0 100 200 300 400 500 600m

CLIENT: JSW ENERGY LIMITED

PROJECT: VIJAYNAGAR PUMPED STORAGE PROJECT (130 MW)

DRAWING TITLE: LAYOUT PLAN ALTERNATIVE-3

DATE:	ORIGINAL PRINT SIZE	DRAWING NO	REV.	SHEET NO
JAN.2022	A3	DRAWING NO.3	0	1 OF 1



NOTES:-

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FOR STUDY PURPOSE

SCALE 1:10000

0 100 200 300 400 500 600m

CLIENT: JSW ENERGY LIMITED

PROJECT: VIJAYNAGAR PUMPED STORAGE PROJECT (130 MW)

DRAWING TITLE: LAYOUT PLAN ALTERNATIVE-4

DATE:	ORIGINAL PRINT SIZE	DRAWING NO	REV.	SHEET NO
JAN.2022	A3	DRAWING NO.4	0	1 OF 1