Full title of the Project: Diversion of Forest Land for construction of Bhavali Pumped Storage Project (1500 MW) in Thane & Nasik Districts of Maharashtra State
File No.: FP/ MH/HYD/153240/2022
Date of Proposal: 06/03/2022

(Sr. No. 2 of Checklist)

JUSTIFICATION

Of Site Specificity

The Pumped Storage Project is essentially a "site-specific" project as it requires a particular type of topographical and geo- technical conditions with availability of water source at a close proximity to the identified project site. The sites of elevation variance are required to create upper & lower reservoirs of desired capacity. The reservoirs are critical for storing water for long duration. Their location should compulsorily be fulfilling the geo-technical criteria needed for establishing the Pumped Storage Project. Since this project requires water as a means to store energy, a techno-commercially viable water source, with sufficient capacity, to fill up the reservoir one time at the beginning of its operation and to supply for losses during its operation (mainly evaporation loss, quarterly or semi-annually or annually) has to be available in close proximity of project.

The proposed site has initially been identified by the Government of Maharashtra. Attempts were also made to explore the possibilities for alternate sites based on topographical, geological, geo-technical and techno-economic feasibility parameters. However, the JSW Energy PSP Two Limited has found proposed 275.00 Ha. of land, including Forest & Non-Forest, in Jamunde village of Igatpuri Tehsil of Nasik District and Kalbhonde, Kothale villages in Shahapur Tehsil of Thane District as most suitable site for the proposed project. The Government of Maharashtra has entered into an agreement by signing the Memorandum of Understanding for setting up of the extant project in Jamunde village of Igatpuri Tehsil of Nasik District and Kalbhonde, Kothale villages in Shahapur Tehsil of Thane District.

A detailed alternative study to find out the best optimized alignment of water conductor system on left bank of the upper reservoir along with other appurtenant structures was carried out. The location of powerhouse has also been selected based on the due consideration being given to topographical and Geological features. An attempt to optimize the orientation of PH on account of Geo- logical requirements viz-a-viz angle of deviation w.r.t. to the flow direction along the WCS has been done. The location of powerhouse is positioned in such way as to avoid the requirement of upstream surge shaft on the Headrace tunnel.

Underground power house is more suitable as compare to surface powerhouse. Therefore, the **following three "alternative layouts" of the project have been developed for techno economic comparison** and the pros and cons of all the alternatives are discussed below: -

Alternative I:

This alternative envisages the construction of following Major Components:

- Construction of Upper and lower dam of Height 47.0 m and 70.0 m respectively from the lowest natural surface level.
- Construction of Upper and Lower intake.
- one number of 11m dia water conductor system comprising of about 475.0 m long Head Race Tunnel (HRT) bifurcated into two penstocks of 7.7m dia of 647.107m length and each penstock is trifurcated into 3 branch penstocks of 4.0m dia and 135.32m long, 6 No's of each 5.0m TRT of length 90m is connected to the surge chamber in the downstream end in-turn connected to one number of tail race tunnel (TRT) of 11m dia and 808.75 m long.
- Downstream underground surge chamber on Tail Race Tunnel

- An underground power house and Transformer cavern, the arrangement of powerhouse is positioned under high cover zone of about 365m or more.

Alternative II:

This alternative envisages the construction of following Major Components:
Upper and Lower dam is similar to Alternative-1.
Construction of Upper intake, the location of lower intake is same as Alternative-1.
one number of 11m dia water conductor system would comprise of about 1605.302 m long Head race tunnel bifurcated into two numbers of 7.7m dia penstocks of length 169.90m in which each penstock intern trifurcated into small branch penstock of 4.0m dia and tail race tunnel (TRT) 358.52m long
Underground Powerhouse location is similar to Alternative-1 but positioned under optimized top cover to avoid problems related to high cover zone on the underground caverns.

Alternative III:

This alternative envisages the construction of following Major Components:

- Upper and Lower dam is similar to Alternative-1.
- Construction of Upper intake, the location of lower intake is same as Alternative-1.
- One number of HRT of 11m dia 653m long bifurcated into two numbers of 7.7m dia with a length of 1704.11m at the upstream surge chamber of 25m dia and each penstock is divided into branch penstock of 4.0 m dia and 76m long and tail race tunnel (TRT) 213.5m long.
- Surface Powerhouse location shifted downstream towards lower reservoir but involves deep surface cut

Conclusion

- Both the alternative for underground scheme has similar arrangement except minor changes in the length of various tunnels. In Alternative 2 the Power House location is located such that D/S Surge Chamber get eliminated. The overall impact is reduction in the overall cost. Hence Alternative-2 has been selected for the further studies as compare to Alternative-1.
- Also, based on Techno-Economic comparison of all the alternatives, Alternative-2 has less Levellised Tariff as compared to Alternative-1 & 3.

Hence, considering Techno-Economic Parameter underground power house with Alternative-2 is chosen for the development of the proposed PSP.

The above layout was received by the CEA/ CWC and further modification in Water Conductor System was suggested; like, instead as one HRT and Pressure Shaft, three HRT(s) & PS(s) were suggested. Accordingly, further layout was optimized and details of the same are given in the Salient Features mentioned in this note.

The proposed site involves 243.74 Ha. of Forest Land and 31.08 Ha. of Non- Forest Land. Attempts have been made to minimize the use of Forest Land for the project. However, the Forest Land cannot be avoided or no alternative can be substituted. The Forest Land proposed for diversion is, thus, unavoidable. The barest minimum Forest Land, to the extent of 243.74 Ha., is proposed to be diverted in the extant proposal.

JSW Energy PSP Two Limited

Date: / /2025
Place: Mumbai
Office Seal:

(Lalit Parab)
Authorized Signatory
JSW Energy PSP Two Limited, Mumbai

Summary Note on Alternative Analysis for Bhavali Pumped Storage Project

Conceptualization of Bhavali Pumped Storage Project was done through adopting careful evaluation criteria to ensure technical feasibility, economic viability and environmental sustainability. The foremost considerations involve identifying suitable locations for both the upper and lower reservoirs, ensuring the availability of reliable water sources, determining the most techno-economically viable alignment for the Water Conductor System (WCS) and finalizing the most optimal powerhouse location.

In addition to these technical aspects, the process of alternative site analysis was done following a holistic approach that incorporates the following criteria:

- **Minimization of ecological and social impacts:** ensure minimum disruption to local ecosystems, wildlife habitats, and communities.
- **Optimal utilization of available head:** The natural elevation difference at the project site should be maximized to achieve higher efficiency and energy output.
- **Minimum land acquisition:** Reducing the extent of land required for reservoirs, access roads, and associated facilities helps lower costs and mitigate displacement.
- **Ease and feasibility of construction:** Select site with most suitable Geological conditions & terrain, safety of construction activities and accessibility to all major components with minimum conflict and disruption adjoining areas.
- **Minimal interference with existing infrastructure:** Project layout was finalized keeping in minimum conflict with other infrastructures like nearby roads, settlements, transmission lines, and other facilities to avoid conflicts and additional costs.
- **Geological suitability and stability of reservoir banks:** Site configuration was firmed up while ensuring long-term structural stability, minimizing risks of seepage, slope failure, or reservoir-induced hazards.

Based on these considerations, a detailed analysis of potential alternatives was undertaken for the upper reservoir, lower reservoir, WCS alignment, powerhouse location, and transmission line corridor. This comparative study was carried out as part of investigation and Detailed Project Report (DPR) preparation stage. These alternatives were discussed in detail with concerned departments in Central Electricity Authority (CEA) before awarding Technical concurrence to this project.

The layout alternatives were discussed in detail during the Expert Appraisal Committee (EAC), MoEF&CC meeting. Furthermore, the proposal was appraised for Grant of Environmental Clearance before the Expert Appraisal Committee (River Valley and Hydroelectric Projects), MoEF&CC, in its 14th meeting held on 31st August 2024.. In the meeting, it was recommended that *"As the project cover area is located in Western Ghats, the EAC sub-committee shall conduct site visit for assessing the ground conditions and possible environmental impacts due to project comprehensively before further consideration of the proposal".*

In compliance of the above, Dr. Ajay Kumar Lal, Member EAC (Hydro & River Valley project) and Dr. P. R. Sakhare Members & Representative from MoEF&CC visited the Proposed Bhavali Pumped Storage Project" site on 2nd & 3rd Jan., 2025 and the findings of the site visit were discussed amongst the Hon'ble EAC members at Additional Agenda Item 22.4 in the 22nd EAC Meeting held on 10th Jan., 2025. In the site visit report, it has been recommended

that," The proposed project site is topographically stable and not prone to landslides, with minimal risk of adverse geological impacts, provided safeguards and TOR conditions are followed.

Considering the above, the Hon'ble Expert Appraisal Committee (River Valley and Hydroelectric Projects) recommended the proposal for grant of prior Environmental Clearance in its 32nd meeting held on 29th May, 2025.

Alternatives Examined

During the planning phase, three alternative project layouts were identified and investigated thoroughly. Extensive surface and sub-surface investigations were conducted at multiple potential sites to assess technical, environmental, and social implications. The selection process aimed to achieve an optimal balance between techno-economic viability, environmental conservation, and social acceptability. Ultimately, the most suitable alternative was chosen as the basis for further project development. These detailed analyses for these three alternatives is already submitted as part of the Forest Diversion Proposal (Proposal no: FP/MH/HYD/153240/2022 for ready reference summary of these three options is placed below;

A detailed alternative study has been carried out to find out the best optimized location for upper and lower dam, powerhouse location and water conductor system based on topographical survey and geological traverse. The main parameters considered during identification & finalization of the reservoirs were: proximity between the two reservoirs; capacity; topography & geological setup; reservoir water tightness & head. Typically, in a Pumped storage hydropower project, the lower and upper reservoir locations are selected in local depressions at close vicinity which can be connected by a short water conductor system

Selection of Upper Reservoir

The Topography of the proposed area of upper reservoir depicts small depression around the top of hill area showing possibility of creation of reservoir. The capacity of the upper reservoir is proposed with a target live storage of 0.40 TMC), so as the scheme can be operated for a peaking power generation of about 8 hours. The vegetation density in most of the reservoir is very low. The boundary of the project has been fixed keeping in view the safe distance from the nearby Villages, Wildlife and ESZ. During detailed geological assessment, no adverse geological features were observed in this area and this location appears to be geologically suitable for water retention in the reservoir. No major social environmental issues are expected to be involved in this particular location.

Selection of Lower Reservoir

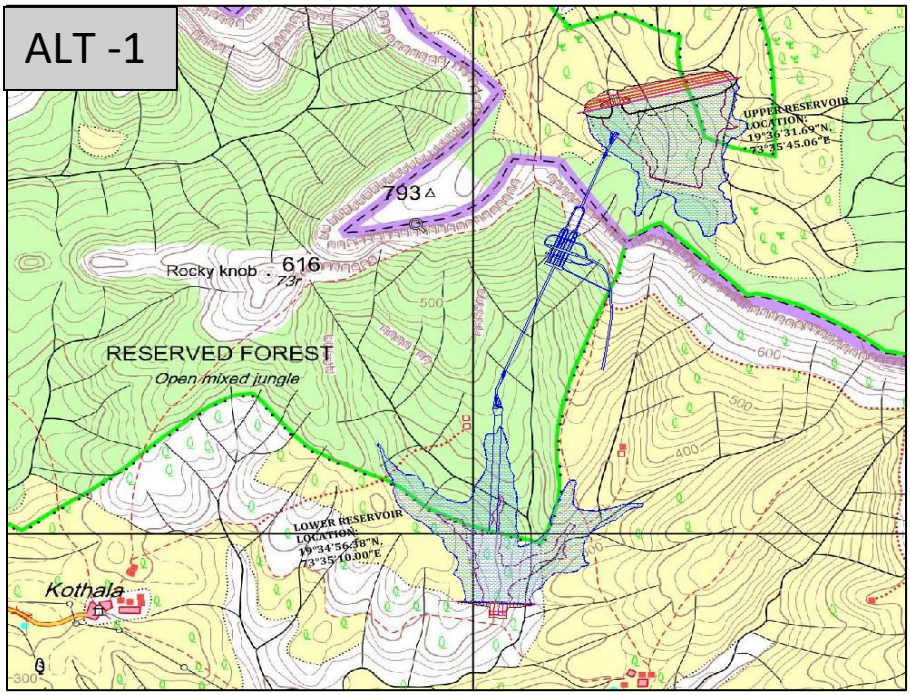
Having Finalized the location of upper reservoir and based on the basic technical parameters required for the pumped storage project only one location was found suitable for lower reservoir which is located in natural depression and allowing to create the desired live storage capacity of 0.40 TMC. This location is within the technical suitability requirements and no major Social and environmental issues were noticed for this particular area.

Selection of Water Conductor System & Power house

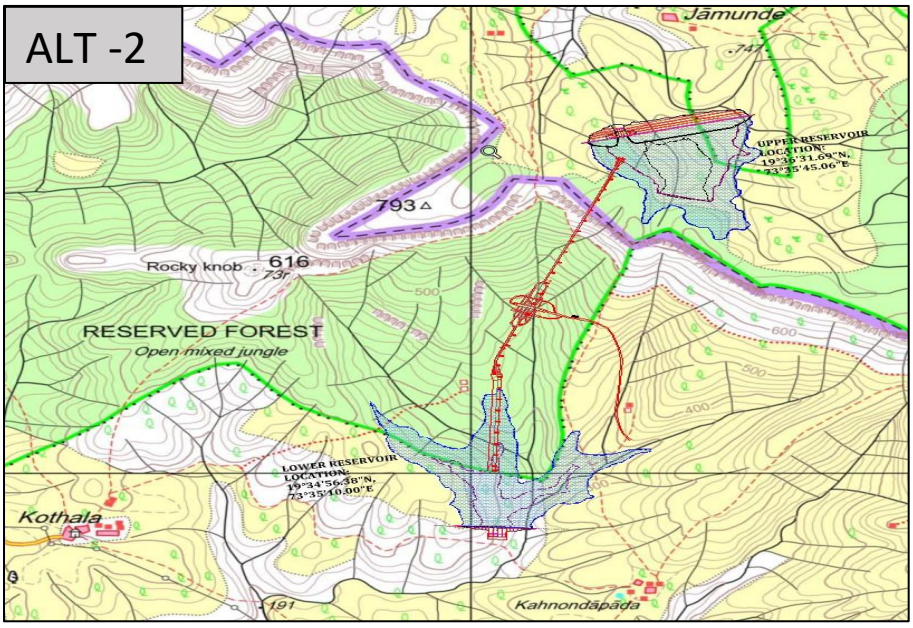
The alignment of water conductor system along the left bank of the upper reservoir has been selected based on the study of various alternate arrangements to arrive at the most optimized alignment of WCS based on the present level of Geological features, Topographical features and availability of sufficient rockmass cover. Further, detailed

alternative study has been carried to find out the best optimized sizing/configuration of water conductor system along with other appurtenant structures having minimum length to avoid energy losses with due considerations on the requirement of surge arrestors for both upstream and downstream. Three alternatives of Powerhouse were studied (1) near upper reservoir with underground power house (2) near lower reservoir with underground power house (3) near lower reservoir with surface power house option. The arrangement of powerhouse is positioned in such way to avoid/minimize the requirements of additional large underground surge chambers at u/s and d/s of the water conductor system.

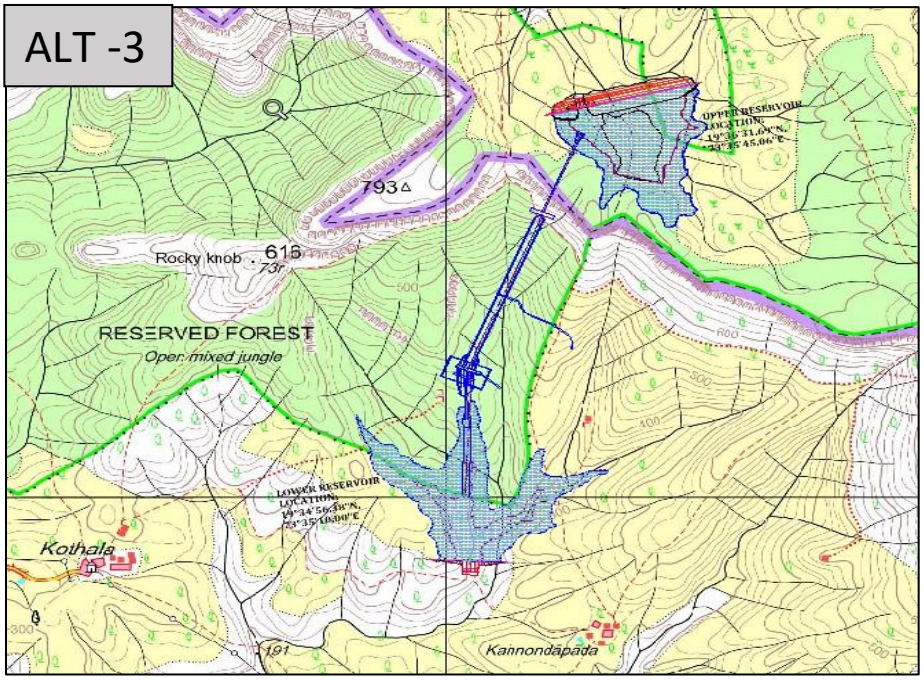
Topomap of Alternative-1



Topomap of Alternative-2



Topomap of Alternative-3



Comparative Assessment of Alternatives

Sl. No.	Parameter	Alternative – 1	Alternative – 2	Alternative – 3
1	Storage Capacity	12000 MWh	12000 MWh	12000 MWh
2	Installed Capacity	1500 MW	1500 MW	1500 MW

Sl. No.	Parameter	Alternative – 1	Alternative – 2	Alternative – 3
3	Upper Reservoir FRL/MDDL	EL. 737m / EL. 711m	EL. 737m / EL. 711m	EL. 737m / EL. 711m
4	Upper Reservoir Available Live Storage	0.40 TMC	0.40 TMC	0.40 TMC
5	Type of powerhouse	Underground	Underground	Surface
6	Upper Dam Type / Length	Rockfill dam, 956 m	Rockfill dam, 956 m	Rockfill dam, 956 m
7	Lower Reservoir FRL/MDDL	EL. 300m / EL. 270m	EL. 300m / EL. 270m	EL. 300m / EL. 270m
8	Lower Reservoir Live Storage	0.40 TMC	0.40 TMC	0.40 TMC
9	Lower Dam Type / Length	Rockfill Dam, 470 m	Rockfill Dam, 470 m	Rockfill Dam, 470 m
10	Maximum Gross Head	467m	467m	467m
11	L/H Ratio of Water Conductor System	4.4m	4.4m	5.0m
12	Water Availability (Initial Filling & Replenishment)	Self- yield from the catchment	Self- yield from the catchment	Self- yield from the catchment
13	Type of Land for Project	Mostly Forest	Mostly Forest	Mostly Forest
14	Environmental Impacts	Moderate, manageable with mitigation plans (CAT, Comp. Afforestation, Wildlife Plan)	Moderate, manageable with mitigation plans (CAT, Comp. Afforestation, Wildlife Plan)	Comparably High – larger forest diversion, greater disturbance
15	Social impact	Limited R&R	Limited R&R	Limited R&R
16	Social Issues	None	None	None
17	Technical Viability	Technically feasible, but higher project & forest cost	Fully feasible, stable, and optimized layout with minimum project & forest cost	Technically feasible, but higher project & forest cost
18	Land Requirement			

Sl. No.	Parameter	Alternative – 1	Alternative – 2	Alternative – 3
i	Total Area (Ha.)	301.64	291.51	314.13
ii.	Forest Area (ha.)	272.64	261.51	283.13

Conclusion

- ✓ Both the **Alternative-1** and **Alternative-2** for underground scheme has similar arrangement except changes in the length of various tunnels and location of Powerhouse. In Alternative-1 the underground power house is seated in high rockmass cover of about 400 m near upper reservoir which leads to longer lengths of Access tunnels and large surge chamber in the tail race tunnel. In **Alternative -2** the Power House location is located such that D/S Surge Chamber get eliminated and tunnel lengths are small. The overall impact is reduction in the **land requirement, construction period and the project cost for Alternative-2**.
- ✓ **Alternative-3** which envisages a surface powerhouse scheme, entails very deep cutting of more than 130 m near the lower reservoir. This raises concerns regarding long-term operational issues such as flooding, continuous dewatering and slope stability. Moreover, the scheme would require massive excavation works, leading to an increased land requirement for project components and disposal of excavated material as well as extended timelines for execution. The overall impact of additional mitigations for dewatering arrangements, increased land requirements and slope stabilization measures for deep pit shall increase the project cost.

Considering above aspects, **Alternative-2** (Underground Power house Scheme) is more feasible than any other alternative in terms of techno-economic parameters and environmental impact.

During the review process by **CEA/CWC**, it was recommended that the Water Conductor System be optimized for operational flexibility. Instead of a single Head Race Tunnel (HRT) and pressure shaft, the design was revised to include **three HRTs and pressure shafts**. These modifications has optimized the project layout for constructability, operational flexibility and successfully reduced the overall land requirement to **275.00 ha**.

It is respectfully submitted that the selected project site involves **243.74 ha of Forest land** and **31.05 ha of** non-forest land. Every effort has been made to minimize forest land use; however, due to the specific topographical configuration of the reservoirs and the essential nature of the project components, diversion of forest land is unavoidable. Accordingly, only the barest minimum extent—**243.74 ha of Forest land** is proposed for diversion under the present proposal.

*****