Detailed note on
Site selection for Shahpur Pumped Storage Project proposed to be developed by Greenko Energies Private Limited.

Site-Specific requirements:

Pumped Storage Projects (PSP) have very stringent site-specific requirements and thus can only be developed at very few suitable locations. PSPs are site specific projects and have quite stringent requirements from Topographical, Geological, Availability of Water Source and Techno Commercial Viability points of view. Detailed justification and reasons for selecting the present site for the proposed Shahpur PSP are given below:

Topographical:

PSPs require suitable topography where substantial elevation difference is available at close distance i.e., two level areas connected by steep sloping hills.

These locations with elevation difference have to be suitable to create reservoirs of required capacity.

Geological:

Geology of the area of both lower and upper reservoirs must have acceptable geology to be capable of storing water for long duration.

Availability of water Source:

The project requires water to store energy, a water source with sufficient capacity/flow to fill up the reservoir and to supply for losses during operation shall also be available in close proximity.

Techno Commercial viability:

Since these projects operate at around 80% cycle efficiency (i.e., they consume 100 units for 80 units produced) thus techno commercial viability is also one of most important aspects of selection of these sites.

Alternatives Examined:

- Possibility was explored to locate the project near existing big reservoirs so that only one reservoir for the project needs to be constructed for the project. Wherever, other conditions were found to be suitable for setting up of the project, it was observed that areas around all such big reservoirs have been declared as Protected Areas (e.g. Rana Pratap Sagar, Jaismand lake, Bislapur Reservoir & Mahi Reservoir, etc.) and therefore such locations were not considered.
- Possibility was explored near major rivers Mahi & Chambal (and its tributaries) and it was observed that most of the area along Chambal river is forest / protected area and some possibilities existed only around some tributaries subject to other requirements being met, while no suitable locations are available in Mahi River area.

- Most of the hilly areas in Rajasthan have been declared as Protected Areas whereas some other locations are identified as Mining Areas, further restricting the selection of suitable sites for Pumped Storage Project.

1. Sukhpura location

A site was identified near Sukhpura Village in Chittorgarh Distt. Application was submitted for permission for the project at this location to MoEF&CC. But after detailed investigation, the geology of lower reservoir was found to be vulnerable wherein the strata was not found suitable.

2. Teekhi Khera location

Second Site was identified near Teekhi Khera Village in Chittorgarh Distt., but was given up during Pre-Feasibility Report (PFR) stage because water source was not sufficient to meet the project requirement.

3. Shahpur location

The third site identified was near Shahpur Village in Baran district. The Site was found suitable from site-specific requirements for implementation of the project.

Out of the three locations, Shahpur location was found most suitable and has been selected for implementation of the project.

Justification for the selection of Shahpur location:

1) The Site is close to Kuno River, which is one of the most important criteria for selection of PSP location. Kuno river has enough water flow to cater the needs of the project.

2) Area is having elevation difference of about 150m which is ideal for setting up of Pumped Storage Project.

3) No National Park, Wildlife Sanctuary or Tiger Reserve is located near the Proposed Project Site. Also, there is no migratory route of wildlife identified near the proposed site.

4) Forest land proposed for diversion is located at edge of the forest blocks, therefore forest diversion would not lead to fragmentation of forest land.

5) Proposed Site is approachable and can be connected through approach road from National Highway-76, which is located at approx. 3 km. distance from the proposed site.

6) At this location, the requirement of forest land is minimum for the construction of the project.

7) There is no public scheme is existing nor is proposed in the area proposed for the project or which is going to be affected due to the diversion of this forest land.

Other Reasons:

1. There is no alternate (and cost-effective) technology available in the world today that could be employed for the construction of man-made reservoirs at a typical head of 100 meters or more. Even if such technologies were to exist, it is understood that it may result in a significant impact on project cost (2 to 3 times the estimated cost of the project with proposed approach), rendering sale of power generated from the project to be financially unviable, which would defeat the whole purpose of setting up of the project.
2. All existing Pumped Storage projects operational in the country and most of such projects around the world have been built on vast areas of forest land with some of them having large Forest Land - Non-Forest Land ratio with forest land requirement estimated to be 80% ~ 90% of the total land required.

Thus, the proposed location (Shahpur) is the most suitable site due to the available elevation difference (head) of about 150m and the areas required for the construction of the upper and lower reservoirs are in close vicinity of natural water source (River Kuno). Considering all aspects, the project has been proposed at the present location with minimum forest land requirement by carefully planning the layout of the project.

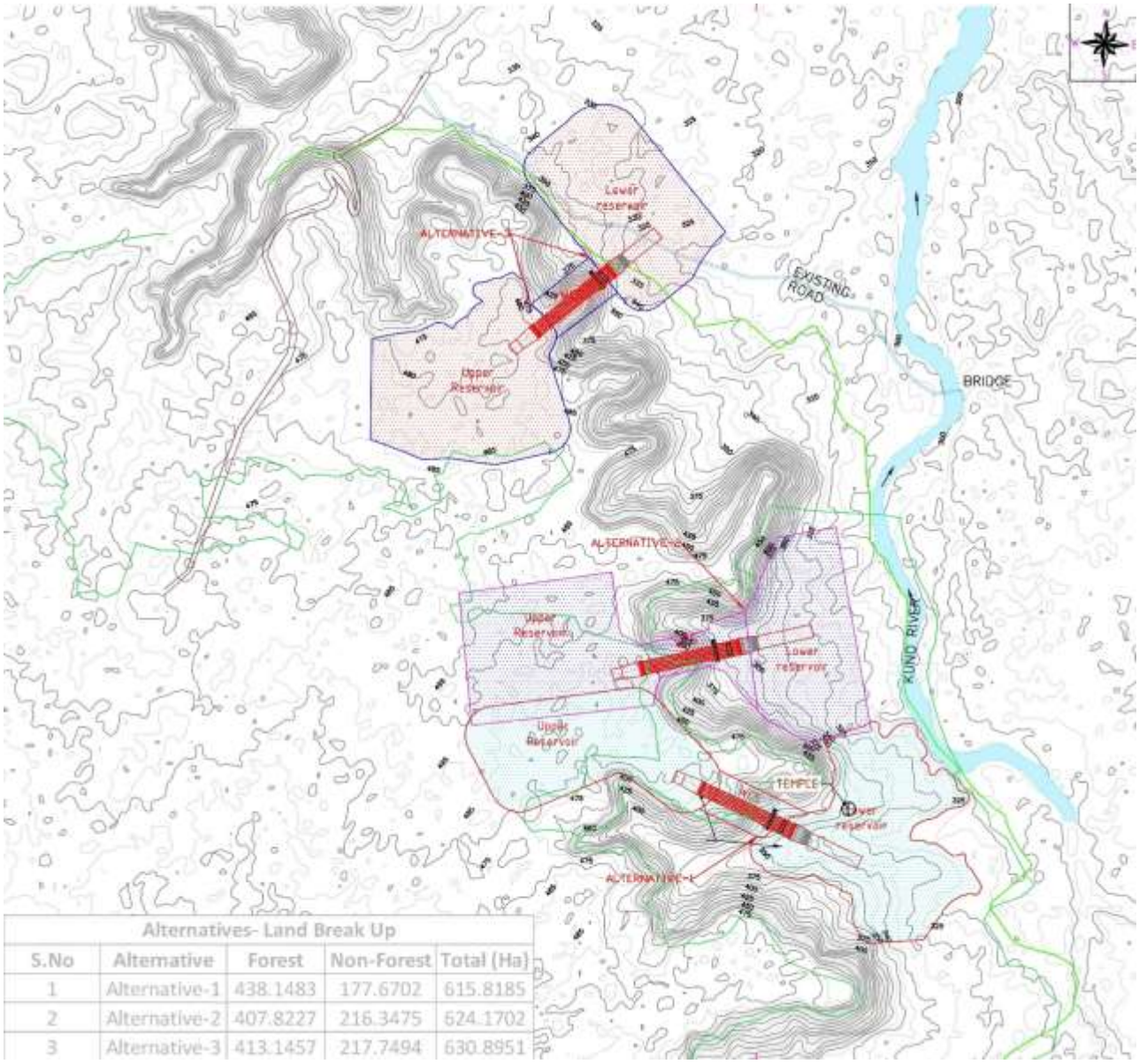
Effort was made to keep the forest area required for the project minimum. Different sites were examined near Shahpur. Three sites have been shortlisted. Detailed examination was done to minimise the forest area requirement and other issues. Details are given below.

Alternative Reservoir Studies:

The following parameters were kept in mind during the optimization study.

- Topography & Geology
- Accessibility
- Availability of water & its distance for initial filling of lower reservoir
- To meet the minimum storage requirement for 6.0 hours of generation.
- Installed Capacity
- Length & Height of Upper and Lower Reservoir Embankment
- Length of Water Conductor System
- Natural Head between two reservoirs
- L/H Ratio for Water Conductor system
- Type of Powerhouse (surface/ Underground)
- Type of Land (Forest/Non- Forest)

Considering the above points, desk study/reconnaissance survey is carried out based on the SOI toposheets and contours generated from SRTM data. Total three project layout alternatives have been studied and their details are given in the subsequent sections. All the three project layouts are marked on contours generated from SRTM data and toposheets (54G/3 & 54G/4) and are shown in Figure 1 & Figure 2 respectively.



Alternatives- Land Break Up				
S.No	Alternative	Forest	Non-Forest	Total (Ha)
1	Alternative-1	438.1483	177.6702	615.8185
2	Alternative-2	407.8227	216.3475	624.1702
3	Alternative-3	413.1457	217.7494	630.8951

Figure 1: Project Layout Alternatives on the contour plan generated from SRTM data.

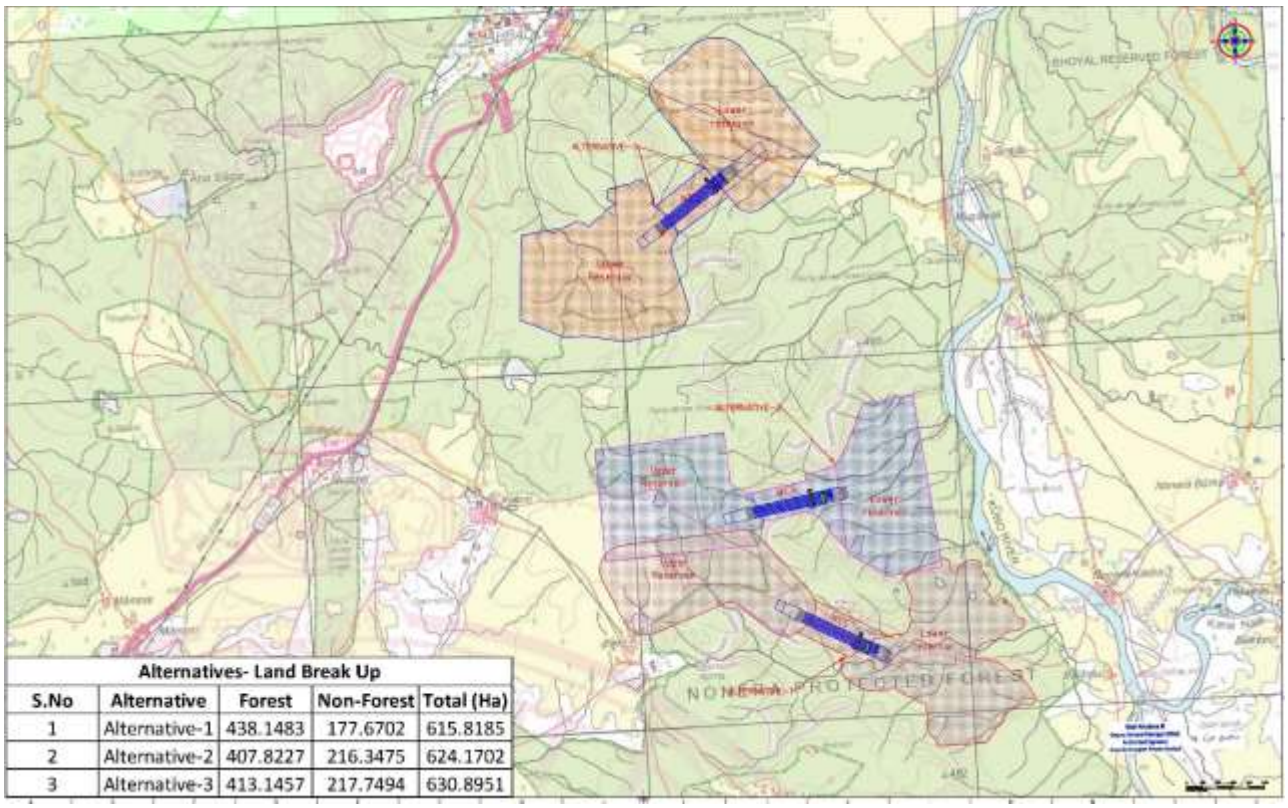


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Figure 2: Project Layout Alternatives on Toposheets (54G/3 & 54G/4).

Geology of Alternative Reservoir Locations

All the Alternate reservoir layouts have similar geological setup. The geology is represented by >40m thick bed of sandstone underlain by shale with intermediate thin beds of sandstone/ siltstone. The Upper Reservoirs rests over the sandstone and the Lower Reservoirs over the shale.

Topographically, the area in general, from Upper Reservoir to Lower Reservoir represents the vertical cut face of sandstone for about 20-25m height followed by slumped rock blocks dominating slopes having dislodged rock blocks of mostly sandstone having slope angles of >45°. Immediately after the moderate to steep slopes of the slumped rock blocks, moderate overburden slopes consisting of rock blocks of sandstone and shale in sandy and silty matrix having slope angle of about 30° is evident which finally merges to the flat horizontal slopes comprising rounded to sub-rounded boulders mixed with angular rock blocks. The slopes towards the Kuno River represent vertical cut sections of thick shale with thin intermediate sandstone/ siltstone bands. The plateau area where the Upper Reservoir is proposed is having an elevation of about El >480m and that of the Lower Reservoir the general elevations are about El >320m in most of the reaches.

Alternative 1

The reservoirs of Alternative-1 are in the southernmost part of the explored region at around 5 kms from NH 76. The upper reservoir is envisaged on top of the plateau and the lower reservoir is identified in the bottom within the alluvial plains.

The average elevation of the plateau where the Upper reservoir is proposed is about 485.0m and gradually declines towards the SE boundaries and reaches to elevation El 480.0m. Thus, the average

embankment height in the southern part becomes relatively higher and reaches to about 31m. The length of the Upper reservoir embankment in this alternative is 6384m. The proposed area occupies partially forest and mainly private lands.

The proposed Lower reservoir for this alternative in the alluvial plains having elevation variance from El 350.0m to El 325.0m. With the catchment area of 1.53 Km^2 the maximum height of the embankment reaches upto 26.5m. The proposed reservoir is completely located in forest area. A major Nallah flows in this alignment which will require diversion. Also, a local temple will be submerged if the lower reservoir is constructed at this location and will invite local issues.

The structures envisaged according to these proposed reservoirs are Upper embankment and upper intake, surface steel head race pipe, vertical pressure shaft, horizontal pressure tunnel, surface pit type powerhouse, tail race tunnel and lower embankment and lower intake (Figure 3).

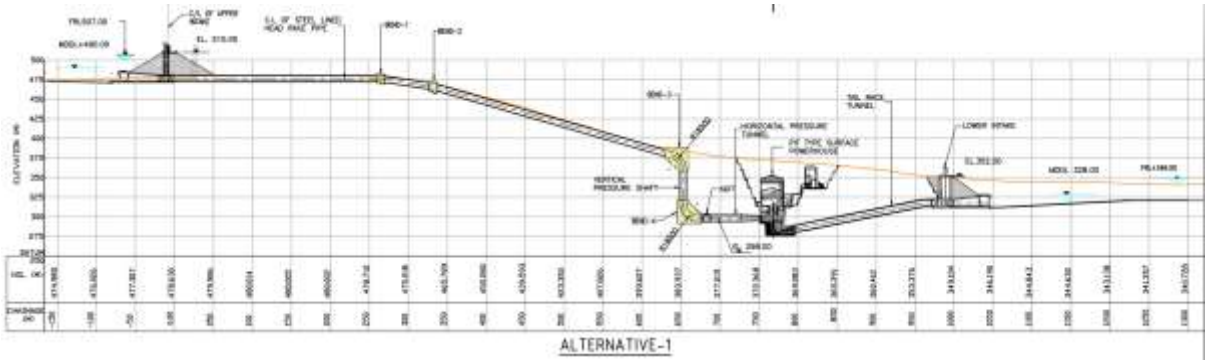

Figure 3: L-section along water conductor system for proposed Alternative-1.

Alternative 2

This alternative is envisaged just north of Alternative-1 with Upper reservoir located at around 3.5 kms from NH 76. The Upper reservoir of this proposal shares the southern boundary with the Upper reservoir of Alternative- 1. The upper reservoir is envisaged on top of the plateau and the lower reservoir is identified in the bottom within the alluvial plains.

The elevation of the plateau where the Upper reservoir is proposed varies from El 485.0m to El 495.0m with the higher elevations on the northern and western parts of the embankment. However, the change in elevations is very gradual and uniform all along the proposed reservoir boundary. Thus, the average embankment height reaches upto 24.5m. The length of the Upper reservoir embankment in this alternative is 5450m. The proposed area occupies partially forest and mainly private lands.

The proposed Lower reservoir for this alternative in the alluvial plains having elevation variance from El 350.0m to El 320.0m. With the catchment area of 1.27 km^2 the maximum height of the embankment reaches upto 26.5m. No major perennial drainage exists in the proposed reservoir area. The proposed reservoir is completely located in forest area.

The structures envisaged according to these proposed reservoirs are Upper embankment and upper intake, surface steel head race pipe, vertical pressure shaft, horizontal pressure tunnel, surface pit type powerhouse, tail race tunnel and lower embankment and lower intake (Figure 4).

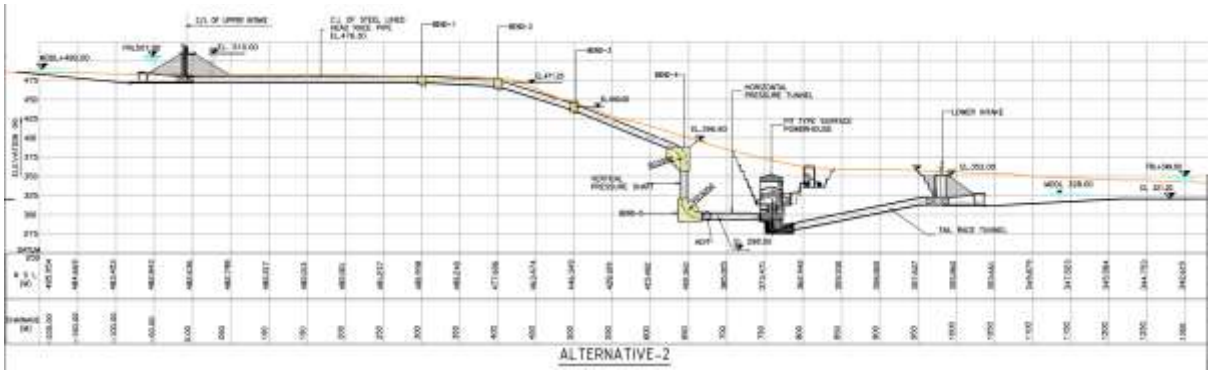

Figure 4: L-section along water conductor system for proposed Alternative-2.

Alternative 3

This alternative is envisaged about 1.7 km north of Alternative-2 near to the NH76 which is about 700m to 900m from Upper reservoir and Lower reservoir, respectively. Similar to the other alternatives, the upper reservoir is envisaged on top of the plateau and the lower reservoir is identified in the bottom within the alluvial plains.

The elevation of the plateau where the Upper reservoir is proposed varies from elevation El 480m to El 485m in most of its area. The average embankment height reaches to about 30m. The length of the Upper reservoir embankment in this alternative is 5453m. The proposed area is mostly in the forest land and very few in private lands.

The envisaged Lower reservoir for this alternative in the alluvial plains having elevation variance from El 350.0m to El 325.0m. With the catchment area of 1.27 Km^2 the maximum height of the embankment reaches upto 28m. The area for lower reservoir is mostly in the private land. The State Road of about 2km connecting the NH76 comes under submergence alongwith few village habitations along the roads. The rehabilitation of the nearby villages and the realignment of the State Road are mandatory to construct this reservoir.

The structures envisaged according to these proposed reservoirs are Upper embankment and upper intake, surface steel head race pipe, vertical pressure shaft, horizontal pressure tunnel, surface pit type powerhouse, tail race tunnel and lower embankment and lower intake (Figure 5).

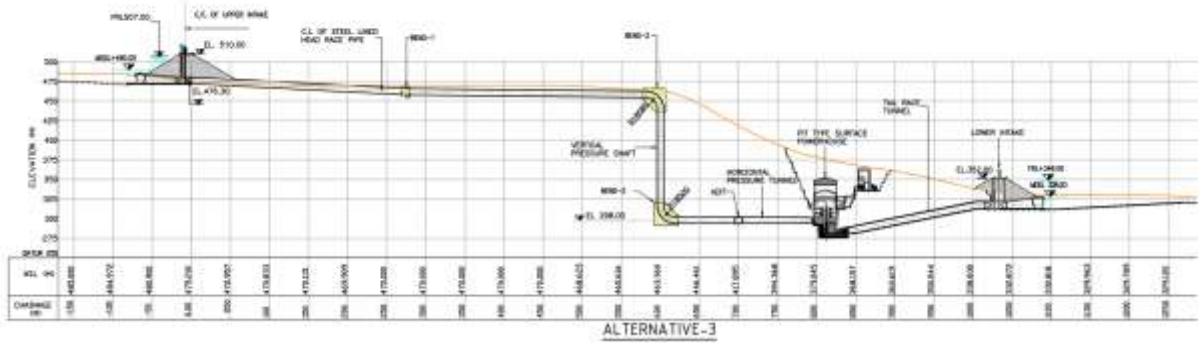

Figure 5: L-section along water conductor system for proposed Alternative-3.

The comparison of parameters for all the three alternative reservoir locations are given below in Table 1.

Table 1: Comparison of parameters of Reservoir Alternatives

#	Parameter	Unit	Alternative 1	Alternative 2	Alternative 3
1	Storage Capacity	MWh	10,800	10,800	10,800
2	Installed Capacity	MW	1800	1800	1800
3	FRL of Upper Reservoir	m	507	507	507
4	MDDL of Upper Reservoir	m	490	490	490
5	FRL of Lower Reservoir	m	349	349	349
6	MDDL of Lower Reservoir	m	328	328	328
7	Plan Area of Upper Reservoir at FRL	Sq km	1.762	1.762	1.762
8	Plan Area of Upper Reservoir at MDDL	Sq km	1.602	1.602	1.602
9	Plan Area of Lower Reservoir at FRL	Sq km	1.519	1.519	1.519
10	Plan Area of Lower Reservoir at MDDL	Sq km	1.269	1.269	1.269
11	Available Live Storage in Upper Reservoir	TMC	1.01	1.01	1.01
12	Available Live Storage in Upper Reservoir	TMC	1.00	1.00	1.00
13	Length of Upper Reservoir Embankment	m	6384	5450	5453
14	Length of Lower Reservoir Embankment	m	2901	2937	5177
15	Average Height of Upper Reservoir Embankment	m	31.0	24.5	30.0
16	Maximum Height of Lower Reservoir Embankment	m	26.5	26.5	28.0
17	Length of Water Conductor System	m	1083.4	1083.4	1194.3
18	L/H Ratio of Water Conductor System	m	7.0	7.0	7.7
19	Type of Land in Upper Reservoir		Partially Forest	Partially Forest	Mostly Forest
20	Natural Head between Reservoirs	m	154.73	154.73	154.73
21	Type of powerhouse (Surface/ Underground)		Surface	Surface	Surface
22	Type of Land in Lower Reservoir		Entirely Forest Land	Entirely Forest Land	Mostly Private Land

23	Land requirement				
i	Forest		438.1483	407.8227	413.1457
ii	Non forest		177.6702	216.3475	217.7494
24	Social Issues		Requires Relocation of Hindu Temple	-	Requires diversion of the State road and rehabilitation of village.
25	Diversion of Nallah		Requires Diversion of Nallah	Presence of minor Nallah. Diversion not required.	No Nalla along the Alignment
26	Length of Water Conductor for Initial Filling	m	450	500	2382

Conclusions

Based on the above studies carried out for various locations of reservoirs, the following has been concluded.

- The approach for all the studied reservoirs would be through the available road network (National Highway & State Road) with additional construction road to the reservoir locations for reasonable lengths.
- Topographically, the availability of the desired elevation with desired lengths are also not constraints for the selected reservoir locations. The Kuno river is also available for the initial filling at an reasonable distance, except that for the Alternative-3 with a required water conductor length of about 2.3km.
- Geological conditions will remain same for all the three alternatives with Upper reservoir resting on Sandstone and the Lower reservoir on Shale with intermittent bands of siltstone/ sandstone.
- For the development of Lower reservoirs complete forest land is available for Alternative-1 and Alternative-2, whereas, for Alternative-3, private land with village habitation and state road are coming in submergence which would lead to diversion of state road and village rehabilitation. Similarly, for the Upper reservoir, partial forest land is involved in Alternative-1 and Alternative-2, whereas mostly forest land is involved in Alternative-3. Social issue of relocation of existing Temple is involved in Lower reservoir of Alternative-2.
- Regarding the length of embankments, the Upper Reservoir embankment of all the 3 alternatives is reasonably same, whereas, for the Lower Reservoirs, the length of the embankment for Alternative-3 is almost double than the other alternatives.

- The envisaged civil components are mostly same consisting of Upper embankment and upper intake, surface steel head race pipe, vertical pressure shaft, horizontal pressure tunnel, surface pit type powerhouse, tail race tunnel and lower embankment and lower intake. The lengths of water conductor are varied with pit type surface powerhouse.

Based on above, the **Alternative-2** has been selected.

M/s Greenko Energies Private Limited

Authorization Signatory