2

Description of the Project

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2. Description of the Project

2.1 Location of Project and Integrated Development

2.1.1 General

The Madian Hydropower Project (HPP) is located in the north of Northwest Frontier Province (NWFP) of Pakistan. The Province NWFP is surrounded by the Northern Areas of Pakistan in the North, Kashmir in the East, Punjab Province of Pakistan in the Southeast, Balochistan Province in the Southwest and Afghanistan in the West, see Figure 3.1 and Plate 2.

The project area is located in the Swat District, north of Madian Town. Madian Town is located at a distance of approximately 200 km from Peshawar, the capital of NWFP and 60 km from Mingora, the district headquarter of Swat Valley.

2.1.2 Administrative Organization

Swat is one of the twelve districts constituting the NWFP of Pakistan. The highest administrative authority is the Deputy Commissioner / District Coordination Officer, who is assisted by three Assistant Commissioners for Alpuri, Daggar and Swat Sub-Divisions.

The Swat Sub-Division is divided into 8 tehsils. Saidu Sharif is the main city of the district and also the seat of the Malakand Commissioner. These institutions in Saidu Sharif and Mingora have the technical support of various departments of the Federal Government and the Government of NWFP. Departments for Communications, Roads, Agriculture, Irrigation, Fishing, Education, Health, Revenue, Food, Social Welfare Office, Forest Division, Offices of WAPDA and SHYDO are established in the project area among others.

2.1.3 Project Area and Integrated Development

The proposed weir site of the Madian HPP is located on the Swat River some 14 km north of Madian town and the powerhouse just 1.2 km upstream where the approximately 35 km long V-shaped gorge section of the Swat River ends and continues further as a river with wide flood plains.

Comprehensive studies for the assessment of the hydropower potential of the Swat valley were carried out between 1990 and 1995 under a Program of Pakistan-German Cooperation as outlined in Section 1.

In June 2006 Mirza Associates Engineering Services (PVT) Ltd. submitted a study on the development of the hydropower potential in the Swat River and proposed among others the development of the following run-off river hydropower plants:

- Gabral – Kalam, 101 MW
- Kalam-Asrit, 197 MW
- Asrit-Kedam, 209 MW
- Madian, 148 MW (subject of this feasibility study)

At present the projects Kalam – Asrit, Asrit – Kedam and Madian are under development whereas work on the Gabral – Kalam HPP was suspended in the year 2007.

The Private Power & Infrastructure Board (PPIB) issued licenses to private investors and supervises the coordinated development of the potential hydropower projects on Swat River. On 12th September the PPIB clarified the boundary conditions for the development of the Madian Hydropower Project (HPP) in the Swat River reach between Kedam and Madian and the upstream located project between Asrit and Kedam. The following decisions were made as regards the development of the Madian HPP:

1. *"…the sponsors should use Common Reference for the topographic survey for all future studies related to their respective projects based on Survey of Pakistan Bench Mark at Kedam Town"*
   (actually SoP BM Madian was meant)

2. *"Weir/dam height and location of Madian HPP will be selected such that the reservoir reach under normal operating conditions will not extend beyond 2.3 km along the river upstream of Bridge on Swat River at Kedam"*

The corresponding normal reservoir operation level at a location 2300 m upstream of Kedam bridge is 1494.4 m asl (SoP). With the normal reservoir operation level of 1494 m asl (riverbed at weir site at elevation 1477 m asl) and the minimum water level at the selected power outlet some 1.2 km north of Madian town of 1339.6 m asl, the maximum gross head of 154.4 m was obtained.

2.2 General Description of the Project Layout

The project concept is based on diversion of part of flow from Swat River by means of a diversion weir and further through a system of power tunnels to the powerhouse where the water is returned to the Swat River.

Based on the design studies the project concept consists of the following major components:

a) Gated weir structure at Kedam village
b) Power intake on left bank adjacent to the weir
c) Desander basins
d) Headrace tunnel, 11.8 km long
e) Surge tank
f) Vertical pressure shaft
g) Horizontal pressure tunnel
h) Manifold
i) Powerhouse
j) Tailrace and Power outlet

The average river slope is approximately 11 m per km between weir and powerhouse site. By means of an approximately 11.8 km long headrace tunnel, a maximum total gross head of 154.4 m can be made available for power generation. At times of high river flow the gross head may reduce to 148 m as the result of the higher water level at the power outlet.

Maximum Operation Level	1494.0	m asl
Minimum Operation Level	1492.0	m asl
Minimum Tailwater Level	1339.6	m asl
Maximum Tailwater Level	1346.0	m asl

The mean annual river flow of Swat River is 118.5 m^3/s at the selected weir site. River flow varies considerable around the year with a high flow (May to September) and low flow period (December to March). In an average hydrological year such as the year 1995, daily river flow varies between 18.5 and 447.6 m^3/s.

During the high flow season the sediment concentration in the river flow increases and may reach up to 4000 g/m^3. The suspended sediments consist largely of clay and silt fractions, however, they consist in addition of some 25 % of fine sand.

As mentioned above, at present three hydropower projects are in parallel under development, and Madian HPP is the most downstream located project which might benefit from a certain removal of sediments from river flow at the upstream located reservoirs. However, at the moment it cannot be assumed with sufficient reliability that the upstream located hydropower projects are operational when Madian HPP is commissioned. Therefore, the Project Sponsor in co-ordination with PPIB decided to develop the Madian HPP (as the other hydropower projects on Swat River) as stand-alone run-of river project with its own independent desanding facilities.

As communicated by PPIB in May 2008, the hydropower projects along Swat River shall feed into a common high voltage transmission line. The corresponding load flow studies are in progress and the Consultant was informed that the voltage level for interconnection shall be 220 kV at the project's switchyard.

2.2.1 Project Concept

For diversion of part of the river flow for power generation a concrete weir of 19 m height (above riverbed) is arranged at Kedam village. In the central part of the weir structure a spillway with 3 tainter gates is arranged discharging into a stilling basin where the excess hydraulic energy is dissipated. At the weir structure two flushing outlets are provided to evacuate sediments that may deposit in front of the power intake arranged on the left side of the weir. The weir structure is designed to withstand safely floods up to a return period of 10,000 years and the design earthquake without major damages.

For diversion of the Swat River during construction of the weir, stilling basin and power intake, conventional diversion works are designed. The diversion works consist of a conventional upstream rock fill cofferdam sealed by jet grouting, a downstream cofferdam and a diversion tunnel. The existing Madian-Kalam road needs to be relocated over a length of approximately 250 m at the weir site.

The headrace tunnel starts at the power intake and has a length of 11.8 km. Its alignment was selected for conventional drill and blast excavation method nearly parallel to the Swat River. Three adits are planned to ensure tunnel construction within a reasonable period. The desanding facilities are arranged 2.1 km downstream of the weir and consist of three desanding caverns with the corresponding ducts and gates for evacuation of sediments.

At the downstream end of the low pressure headrace tunnel a surge tank is arranged to limit pressure rise in the headrace tunnel and ensure the required flexibility of the hydropower plant in operation. A vertical pressure shaft leads the flow to the elevation of the three Francis turbine units arranged in an underground powerhouse. The steel lined pressure tunnel and manifolds are kept short to achieve an economic design. Transformer and Switchyard are arranged underground as well in a cavern parallel and at 30 m distance from the powerhouse cavern. From the powerhouse cavern a short tailrace tunnel releases the flow back to Swat River.

For further design details reference is given to the design drawings presented in Volume VII of the Feasibility Study Report and the description of the civil design presented in Section 4 of this Feasibility Report.

Since the major works of the Madian Hydropower Project are underground, the environmental and socio-economic impact (including the required resettlement) of the Project is minor and is largely related to dumping of excavation material at sites which are presently cultivated.

2.3 Salient Features of the Madian Hydropower Project

The following Table 2.1 presents the salient features of the Madian HPP.

Hydrological Features at Weir Site:		
Catchment Area	2,403	km²
Mean Annual Flow	118.5	m³/s
Diversion Flood	656	m³/s
$HQ_{1,000}$	1,450	m³/s
$HQ_{10,000}$	2,002	m³/s
Reservoir:		
Total Volume	480,000	m³
Normal Reservoir Operation Level	1494.0	m SoP
Max. Operation Level	1994.5	m SoP
Weir Structure:		
Crest Level of Weir	1496.0	m SoP
Max. Weir Height	18.0	m above river bed
Length of Weir Crest	77.0	m
Invert of Flushing Outlet	1477.0	m SoP
Spillway:		
Level of Spillway Crest	1482.5	m SoP
Number of Tainter Gates	3	
Width of Gate	7.6	m
Height of Gate	12	m
Desander:		
Design Discharge	129.0	m³/s
Design Particle Diameter	0.20	mm
Number of settling chambers	3	
Effective length of chamber	206.0	m w/o transition
Width of chamber	13.7	m
Average depth of chamber	16.8	m
Low-pressure Headrace Tunnel:		
Length	11.80	km
Net Diameter	7.00	m
Max. Flow velocity	3.35	m/s
Surge Tank:		
Diameter:	21.00	m
Height:	69.0	m
Pressure Shaft and High-Pressure Tunnel:		
Total length (shaft & tunnel)	180.3	m
Length of vertical shaft	120.8	m
Diameter	5.80	concrete lined
Flow velocity	4.88	m/s
Diameter	5.40	steel lined
Flow velocity	5.63	m/s
Steel lining	20 – 28	mm

Powerhouse:		
No. of units	3	Vertical Francis
Installed Capacity	3 x 60.8	MW
Available Capacity (ex transformer 3 units in operation)	3 x 52.43	MW
Max. Turbine Design Discharge	43.0	m³/s
Cavern Width	20.0	m
Cavern Length	70.0	m
Turbine Setting	1336.0	m asl (SoP)
Electomechanical Equipment:		
No of Transformers	9	
Type of GIS Switchyard	SF6	
Voltage	220	KV
Tailrace Tunnel:		
Total length (w/ manifold)	93.6	m
Diameter	7.30	m
Diameter of manifold	4.20	concrete lined
Flow velocity	3.08	m/s
Additional Project Parameters:		
Mean Annual Energy	767.5	GWh
Plant Factor	0.56	
Estimated Construction Costs	366,163	1000 US $

Table 2.1 Salient Features of Main Civil Work Components