CONTENTS

1 *RECOMMENDATION OF MINIMUM WATER FLOW REQUIRED DOWNSTREAM DIVERSION STRUCTURES ON ALLAIN& DUHANGAN STREAMS: ALLAIN DUHANGAN HYDROELECTRIC PROJECT, MANALI, DISTRICT KULLU, HIMACHAL PRADESH*

1.1 *INTRODUCTION*

In continuation to the disclosure of Draft Environmental and Social Impact Assessment (ESIA) documents in December 2003 and Addendum to ESIA in September 2004 and public consultations held from time to time for the proposed *Allain Duhangan* Hydroelectric Project, *Manali*, District *Kullu*, *Himachal Pradesh*, a meeting of Compliance Advisor Ombudsman (CAO), International Finance Corporation (IFC)/ Multilateral Investment Guarantee Agency was held at village *Jagatsukh* on 3 April 2005. During the meeting, a clarification note has been sought on the assumptions and methods used to calculate minimum flows required at *Duhangan* weir for the proposed project. This note is released to fulfil the requirement.

1.2 *PROJECT BACKGROUND*

The proposed project is a run-of-the streams project involving diversion of water from *Allain* and *Duhangan* streams through underground tunnels leading to surge shaft via headrace tunnel, which in turn will feed powerhouse. The combined flow from the powerhouse i.e. tailrace discharge will be released back into the *Allain* stream near *Aleo* village before it confluences into the *Beas* River.

The diversion of water for the project may have adverse impacts on downstream users of the streams, thereby requiring adequate management and mitigation measures among others to be put in place well in advance. A detailed explanation of the rationale used to derive minimum water flow required for *Allain* and *Duhangan* streams to mitigate the adverse impacts is being discussed in the following sections.

1.3 *AVAILABLE WATER FLOWS*

The *Himachal Pradesh* State Electricity Board (HPSEB) had been measuring water flows of both *Allain* and *Duhangan* streams from January 1971 to May 1995. The month-wise water flows for the two streams is presented in the following sub sections.

1.3.1 *Water Flows Observed on Duhangan stream*

The month-wise water flows based on data measured by HPSEB for the *Duhangan* stream near the proposed diversion structure and downstream are given in ***Table 1.1***.

Table 1.1 ***Duhangan Water Flows (in litres per second) based on data measured by HPSEB from 1971 to 1995 near proposed Diversion Site and Jagatsukh – showing Additional Flows from Other Channels Downstream the Diversion Structure***

Month	**Water Flow Observed on *Duhangan* stream**								
	Average Flow Downstream at *Jagatsukh* (1)	Average Flow at proposed Diversion structure (2)	Average Additional Flow from other channels (3=1 – 2)	Min. Flow Downstream at *Jagatsukh* (4)	Min. Flow at proposed Diversion weir (5)	Min. Additional Flow from other channels (6=4 – 5)	Max Flow Downstream at *Jagatsukh* (7)	Max Flow at proposed Diversion structure (8)	Max Additional Flow from other channels (9=8 – 7)
January	1,955	1,453	502	1,340	968	372	3,840	2,775	1,065
February	1,829	1,355	474	1,270	918	352	3,986	2,881	1,105
March	2,064	1,526	538	1,420	1,026	394	3,350	2,421	929
April	3,490	2,565	925	1,770	1,279	491	9,836	7,109	2,727
May	7,094	5,227	1,867	2760	1,995	765	15,140	10,942	4,198
June	11,764	8,471	3,293	3983	2,879	1,104	23,464	16,958	6,506
July	15,919	11,597	4,367	7,069	5,109	1,960	45,100	32,594	12,506
August	15,101	10,899	4,202	6,355	4,593	1,762	35,890	25,938	9,952
September	9,354	6,599	2,755	3,240	2,342	898	21,075	15,231	5,844
October	5,095	3,572	1,523	2,700	1,951	749	12,344	8,921	3,423
November	3,252	2,261	991	1,640	1,093	547	7,806	5,641	2,165
December	2,364	1,696	668	1,440	1,041	399	4,510	3,259	1,251

1.3.2 Water Flows Observed on Allain stream

The month-wise water flows based on data measured by HPSEB for the *Allain* stream near the proposed diversion structure and downstream are given in ***Table 1.2***.

Table 1.2 ***Allain Water Flows (in litres per second) based on data measured by HPSEB from 1973 to 1995 near proposed Diversion Site and Aleo village– showing Additional Flows from other channels downstream the Diversion Structure***

Month	**Water Flow Observed on *Allain* stream**								
	Average Flow Downstream at *Aleo* (1)	Average Flow at proposed Diversion structure (2)	Average Additional Flow from other streams (3=1 – 2)	Min. Flow Downstream at *Aleo* (4)	Min. Flow at proposed Diversion structure (5)	Min. Additional Flow from other channels (6=4 – 5)	Max Flow Downstream at *Aleo* (7)	Max Flow at proposed Diversion structure (8)	Max Additional Flow from other streams (9=7 – 8)
January	3,899	3,470	429	1,920	1,714	206	6,070	5,418	652
February	3,664	3,262	402	1,740	1,553	187	4,930	4,401	529
March	4,018	3,582	436	2,010	1,794	216	5,690	5,079	611
April	6,047	5,504	543	2,930	2,615	315	12,850	11,730	1,120
May	11,689	10,406	1,283	4,440	3,963	477	22,700	20,263	2,437
June	17,133	15,451	1,682	6,131	5,473	658	31,350	27,985	3,365
July	23,286	20,588	2,698	7,950	7,097	853	105,770	94,417	11,353
August	21,275	19,071	2,204	6,820	6,088	732	48,410	43,214	5,196
September	13,401	12,191	1,210	4,720	4,213	507	26,990	24,093	2,897
October	7,762	7,111	651	3,050	2,723	327	17,410	15,541	1,869
November	5,571	4,977	594	2,880	2,571	309	9,970	8,900	1,070
December	4,308	3,851	457	2,280	2,035	245	7,910	7,061	849

The above tables show higher water flows available downstream the two streams (than at the respective diversion structures) indicating contribution of additional water from perennial sources downstream the proposed diversion structures.

1.4 *CURRENT AND PROJECTED WATER REQUIREMENT FROM THE PROJECT STREAMS*

The current and projected water requirements by the local people from the two streams are presented in the following subsections.

1.4.1 *From Duhangan stream*

Currently, *Jagatsukh* village is dependent on *Duhangan* stream for its irrigation needs as drinking and other water requirements are met through spring waters. However, with the growth of its population, the village *Jagatsukh* would require water for the following purposes:

a) Drinking and domestic water needs of village people;
b) Water required for cattle;
c) Tourists and floating population; and
d) Irrigation water needs.

a) Drinking and Domestic Water Needs

Currently, drinking and domestic water requirement for the village *Jagatsukh* is met through local springs called *Chor Pani* and *Riyaan* located about 1.4 km upstream the bridge on *Duhangan* stream. These springs are independent of water flow in *Duhangan* stream.

Current population of village *Jagatsukh* (including of village *Chhannala* falling within the *Jagatsukh* Panchayat) is 2,900[1]. It is expected that there will be increase in water demand of the village due to increase of population during the project life of 40 years. The expected population would be 11,140 assuming 40% decadal growth as against 25% decadal growth for the *Kullu* district[2]. An estimate of current and projected water requirements for the drinking and domestic water needs is given in ***Table 1.3***.

b) Water Required for Cattle

The total number of households in *Jagatsukh* village is estimated to be 580, of which about 70% own two cattle, which makes approximately 812 [3] cattle heads in the village (although number is not verified through actual count).

It is projected that there will be 1,684 cattle heads 40 years from now (project life) by assuming 20% decadal growth for the cattle. An estimate of current and projected water requirements for the water required for cattle is given in ***Table 1.3***.

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(1) [1] The population is based on a 40% decadal growth extrapolated over Census 2001 for the *Jagatsukh* village.

(2) [2] A higher percentage growth is essential as sub district *Manali* is expected to grow faster.

(3) [3] Considering household size of 5, total number of households = 2900 ÷ 5 = 580. Total number of cattle heads = 580 x 0.70 x 2 = 812

c) Tourists and Floating Population

Based on discussions with the community of village *Jagatsukh*, it was reported that tourists and floating population for the village is about 100 people per day. The water requirement has been estimated @ 135 litres per capita per day. The expected floating population would be 385 assuming 40% decadal growth 40 years from now. An estimate of current and projected water requirements for the floating population is given in ***Table 1.3***.

Table 1.3 ***Estimated Current and Projected Water Demand (in litres per second) for Jagatsukh Village (Other than for Irrigation)***

S.N.	Water Usage	Present Population (Year 2005)	Estimated Current Water Demand [1] (litres per second)	Projected Population (for the year 2045: 40 years from now)	Estimated Projected Water Demand (litres per second)
1	Drinking and Domestic	2,900	4.53 [2]	11,140 [3]	17.4
2	Cattle Heads	812 [4]	0.37 [5]	1,684 [6]	0.779
3	Tourists and Floating Population	100 [7]	0.16 (2)	385 (3)	0.6
Total Water Demand (other than for Irrigation) Litres per second			5.06	-	18.8 Say 20.0

d) Irrigation Water Requirement

Irrigation water needs for *Jagatsukh* Panchayat is dependent upon two channels (locally called *Kuhls*) running along right and left banks of *Duhangan* stream. These two channels source water from *Duhangan* approximately 1.0 km upstream from the *Jagatsukh* Bridge.

Flow measurements of these two channels were undertaken in April 2003 and 2005 using Area – Velocity method. The methodology for the flow measurements included selection of well-constructed fairly rectangular locations. For each of the selected locations, cross sectional areas were calculated by multiplying observed

(1) [1] Currently, the water demand is met through local springs.

(2) [2] This is based on urban water norms of 135 litres per person per day.

(3) [3] The projected population is based on assumption of 40% of decadal growth as against 25% of decadal growth for the *Kullu* district.

(4) [4] It is assumed that about 70% of households in *Jagatsukh* own two cattle.

(5) [5] This is based on water requirement of 40 litres per day per cattle

(6) [6] The projected population for cattle is based on assumption of 20% of decadal growth.

(7) [7] Current floating population assumed to be 100 people per day.

width and observed average depth of the channel. Average velocity[1] of water was measured using Pigmy Water Current Meter (Watt Type)[2].

Flow rate (Q in cubic meter per second) is calculated by multiplying observed *average velocity* (V in meters per second) and *area* (A in square meter). This is represented by the equation: Q = A. x V.

Table 1.4 ***Maximum Water Flow Observed in the Irrigation Channels (Kuhls)***

S.N.	**Channel Width (m) (1)**	**Average Depth (m) (2)**	**Average Velocity (m/sec) (3)**	**Discharge (Litres per sec) (1*2*3*1,000)**
A) Right Bank of the Channel (Towards *Jagatsukh* village)				
1.	0.62	0.1166	0.871	63.0
B) Left Bank of Channel (Away from *Jagatsukh* village)				
2	1.0	0.094	0.679	63.8
Total of Maximum Water Flow Observed in the two Channels (*Kuhls*)				126.8 (Say 130)

Note: During the observed maximum flows, the two channels were running to almost full capacity and any further increase would have resulted in overflow of the channels from some of the locations.

The estimated combined water flow of the two channels was thus considered to be 130 litres per second.

The total projected water requirement from *Duhangan* stream during the project life is estimated to be 130 + 20 = 150 liters per second, as indicated in the ***Tables 1.3 and 1.4****.*

1.4.2 From Allain stream

There is no village located downstream on the right bank of *Allain* stream (between the proposed diversion structure and *Aleo* village), while away along left bank lie *Prini* and *Shuru* villages. The domestic and irrigation needs of *Prini* and *Shuru* villages are mainly dependent on *Pahali* stream, which is an independent stream that drains into the *Beas* river (located approximately 0.5km as the crow flies from *Allain* stream when measured from the state highway), and is not likely to be affected by the project.

No likely users are dependent on downstream *Allain* between the stretch from the proposed diversion structure and tailrace discharge from the powerhouse. After tailrace discharge, water will be available downstream the *Allain* stream till it confluences with the *Beas* River.

There would be insignificant impacts of diversion of *Allain* stream for the project so far as domestic and irrigation needs of locals is concerned.

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(8) [1] Average velocity of the water for the shallow depths (less than 0.75 m) can be determined by measuring velocities at 0.6 times the total depth from the water surface or 0.4 times the total depth from the bottom of the channel across the cross section under flow measurement.

(9) [2] The instrument measures time to the accuracy of 0.01 second. The completion of velocity measurement is indicated with beep sound and display of number of revolutions. For the observed number of revolutions and pre-set time, corresponding velocity is determined using calibration chart.

1.5 *WATER REQUIREMENT FOR ECOLOGICAL SUSTENANCE IN THE TWO STREAMS*

The water required for ecological sustenance depends upon habitats or spawning grounds of the aquatic species. The baseline on fish catch attempted twice in the months of January and April 2003 showed presence of no fish in the *Allain* and *Duhangan* streams except near their confluence with the *Beas* River. The *Allain* and *Duhangan* streams flow with many abrupt falls leaving lesser chances of migrating fish to traverse upstream from the *Beas* River. Both of the streams sustain low to medium diversity of benthic population.

As downstream of both of the streams do not support fish but support benthic population, the change in water levels, currents and water quality may impact benthic population - aquatic ecology, therefore, some water flows must be maintained on both *Allain* and *Duhangan* streams downstream the diversion structures.

Additional water flows are available from other channels downstream the proposed diversion structures. No human population is dependent on water of *Allain* stream between the stretch starting from diversion structure and *Aleo* village. Similarly, on *Duhangan* stream no human population is dependent between the stretches starting from diversion structure and the location where two irrigation channels divert for *Jagatsukh* village. Thus between these stretches water will be available all the time for ecological sustenance.

Downstream of the diversion structures on *Allain* and *Duhangan* streams, other additional channels contribute to the streams. As per ***Tables 1.1*** and ***1.2***, water flows likely to be available from other channels post diversion structure (without addition of any project water release):

- In *Duhangan*, discharge will vary from a minimum of 352 to a maximum of 12,506 liters per second while the average variation will likely be in the range of 502 to 4,367 liters per second; and
- In *Allain*, discharge will vary from a minimum of 187 to a maximum of 11,353 liters per second while average variation will likely be in the range of 402 to 2,698 liters per second.

These flows together with minimum recommended release of water from project diversion structures would be available for ecological sustenance on both of the streams. Baseline information for the two streams is ongoing and requirement of water for ecological sustenance will be further strengthened with the completion of the study.

1.6 *RECOMMENDED MINIMUM FLOW TO BE DISCHARGED BY RSWML FROM THE DIVERSION STRUCTURES DURING OPERATION PHASE OF THE PROJECT*

The minimum recommended discharges downstream the *Allain* and *Duhangan* streams are maintained so as to meet the projected water demand for the dependent population and ecological sustenance.

1.6.1 From Duhangan Stream

Based on the foregoing discussions, projected water requirement of 150 liters per second has been worked out for the *Jagatsukh* village for the project life of 40 years. Therefore, the project during its operation phase will have to make a minimum recommended discharge of 150 liters per second, which together with water from other streams, would make an average water availability in the range of 624 to 4,517 liters per second (refer to ***Table 1.5*** given below) and minimum water availability in the range of 502 to 2,110 liters per second.

Table 1.5 ***Operation Phase Water Flows* downstream at Duhangan stream after addition of minimum flow of 150 litres per second from the project and additional flows from other perennial channels contributing to Duhangan Stream (litres per sec)***

Month	Likely Average Flow	Likely Minimum Flow	Likely Maximum Flow
January	652	522	1,215
February	624	502	1,255
March	688	544	1,079
April	1,075	641	2,877
May	2,017	915	4,348
June	3,443	1,254	6,656
July	4,517	2,110	12,656
August	4,352	1,912	10,102
September	2,905	1,048	5,994
October	1,673	899	3,573
November	1,141	697	2,315
December	818	549	1,401

* Based on 24 years flows observed by HP Electricity Board during1971-72 to '94-'95.

1.6.2 From Allain Stream

Although no likely users are available downstream the proposed diversion structure and tail race discharge, but the flows available from other channels are less than when compared with the *Duhangan* stream, hence a minimum discharge of 150 liters per second has also been recommended for *Allain* to be maintained for ecological sustenance of the *Allain* stream.

The water flows likely to be available from the *Allain* stream are described in ***Table 1.6***. The project during its operation phase will have to make a minimum recommended discharge of 150 liters per second from proposed diversion structure on Allain, which together with water from other streams, would make an average water availability in the range of 552 to 2,848 liters per second (refer to ***Table 1.6***) and minimum water availability in the range of 337 to 1,003 liters per second.

Table 1.6 ***Operation Phase Water Flows* downstream at Allain stream after addition of minimum flow of 150 litres per second from the project and additional flows from other channels contributing to Allain stream (litres per sec)***

Month	Likely Average Flow	Likely Minimum Flow	Likely Maximum Flow
January	579	356	802
February	552	337	679
March	586	366	761
April	693	465	1,270
May	1,433	627	2,587
June	1,832	808	3,515
July	2,848	1,003	11,503
August	2,354	882	5,346
September	1,360	657	3,047
October	801	477	2,019
November	744	459	1,220
December	607	395	999

* Based on 22 years flows observed by HP Electricity Board during 1973-'74 to '94-'95.

1.6.3 Recommendations

RSWML is to maintain a minimum of 150 litres per second as the discharge from diversion structures on both *Allain* and *Duhangan* streams.

RSWML is to install both electronic and manual flow measuring devices downstream of both *Allain* and *Duhangan* streams (across the diversion structures) so as to assure that a minimum flow of 150 litres per second is maintained on both of the streams at all the time. The riparian rights i.e. rights of access to drinking and irrigation water of the project-affected villages will be respected as per project's commitment to the State Government. The project will assure that a combined water flow of 130 liters per second be made available all the time in the two irrigation channels (*kuhls)* downstream the *Duhangan* stream.

The minimum water discharge together with available flow from additional channels downstream the two streams will be available for ecological sustenance, which will be further confirmed following completion of detailed ecological assessment.