SWECO

REPORT

Dambreak Analysis Allain river

Report no.: 170160-1	Project no.: 170160	Date: 5 Mars 2012
Client: SN Power AS		

Dam Break Analysis for the intake basin of the river of Allain

Summary:

It was performed a dam break analysis for the river of Allain with outflow in the river of Beas to investigate the consequences for infrastructure along Allain and Beas.

The model is based on two different friction values expressed by the Manning's factor. There will be presented an overview of the results for a Manning's factor M = 25 $m^{1/3}$/s (n = 0.04) and M = 15 $m^{1/3}$/s (n = 0.067).
Comparing the results it is observed that a lower Manning's factor dampens the dam break wave significantly. It can be assumed that no infrastructure will be hit by the dam break wave with a roughness expressed by Manning's factor 15 $m^{1/3}$/s.

This report is describing the methodology and the results of the dam break analysis for the river of Allain. For finding out about consequences on the infrastructure are further investigations of the roughness of the river of Allain necessary.

Rev.	Date	Revision applies to	Sign.

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1 Introduction

The main purpose of a dam break analysis is to find out the consequences of a potential dam break for the nature and infrastructure.

It is accomplished a dam break analysis for the intake basin of the river of Allain. The river of Allain is located in the north of India in the region Himachal Pradesh (Fig.1.1).

Fig.1.1 Location of the intake basin in India

The intake basin for the Allain - Duhangan Hydroelectric plant is located in an area with high avalanche risk. For the dam break analysis it will be investigated how a break of the intake basin caused by an avalanche will damage the infrastructure (especially 2 hotels in the lower part of the river Allain). The model starts ca. 2.5 km upstream of the intake basin and ends after approximately 8.5 km in the junction Beas and Allain River close to the town Manali.

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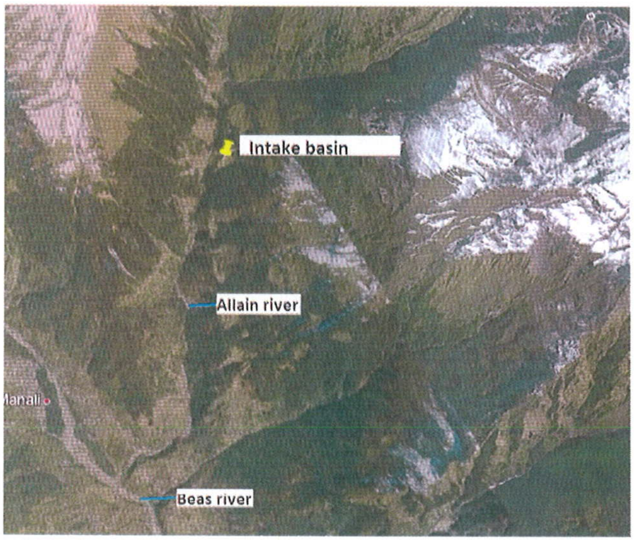

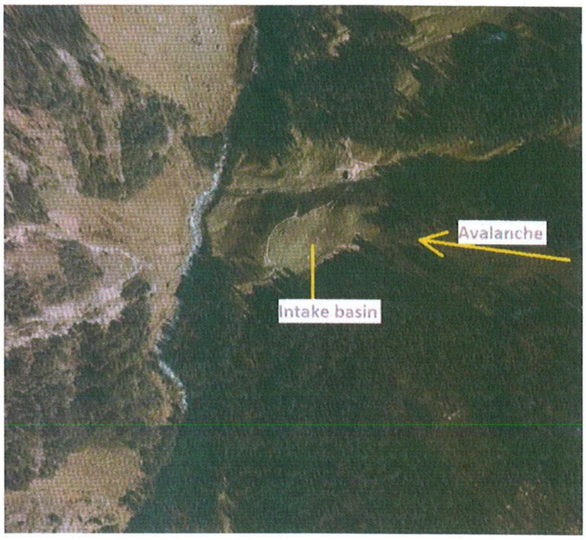

Fig.1.2 Location of the intake basin and course of avalanche

2 Description

The river of Allain is characterized with small bends and a very steep slope. Moreover the river bed is lying deep in the terrain. The investigated part of the river Allain is around 6.7 km long. The altitude difference of the river bed extends from 2735 masl (upstream cross section) to 1791 masl (Beas River) which gives a slope of the river bed of around 15 %. The river is characterized with many constrictions and expansions. A constriction leads to an acceleration of the water velocity, whereas an expansion reduces the water velocity and the water depth increases.

There is a high possibility that an avalanche from the Manali Mountain (4000 masl) reaches the intake basin. For more information about the intake basin see Table 2.1.

There are few houses and cabins along the river of Allain. At the downstream part of the river, between cross section 6162 and 6293, are two hotels lying close to the river. Additionally is the road to Manali/Chandigarh located parallel to the river of Beas and is in danger to get hit by the dam break wave if the wave is not dampened in the river of Beas. The hotels and the road to Manali/Chandigarh will be crucial for the calculations.

2.1 Intake Basin

Intake Basin	
Crest Level [masl]	2670
Foundation level [masl]	2658
Dam height [m]	12
Failure water level [masl]	2670
Area of intake [m^2]	16882
Volume of intake [m^3]	225 000
Crest Length [m]	88
Break	Instantaneous break

Tab. 2.1: Data of the intake basin/dam structure

3 Methodology of Dam Break Analysis

The dam break analysis is performed with the software Mike 11 (Release 2009, Service Pack 5). Mike 11 is a commercial software produced by the Danish Hydraulic Institute. It is a one-dimensional program which is solving the Saint-Venant equations.

For the calculations a conservative method is used. The intake basin is moved into the river of Allain. This intervention influences the natural flow spreading when an avalanche hits the intake basin. Furthermore, it is defined a dam structure (at cross section 674) instead of the intake basin. For defining the dam structure a representative cross section was assumed which is lying in a distance of 2 x diameter of the intake basin (length of water spreading). The dam height was calculated to 12 m and the crest length to 88 m. The dam failure occurs instantaneously.

The water volume of the intake basin (225 000 m^3) is included in the cross section upstream of the dam structure. For the upstream boundary condition a constant inflow of 10 m^3/s was defined.

There were to different calculations performed each with another roughness. The two different Manning's factors which were chosen for the model are: M = 25 m$^{1/3}$/s (n = 0.04) and M = 15 m$^{1/3}$/s (n = 0.067). The assumed factors are corresponding to a mountain stream with no vegetation in the channel and with steep banks. The bottom of the river with the roughness expressed by M = 25 m$^{1/3}$/s is covered with gravels, cobbles and few boulders. Whereas M = 15 m$^{1/3}$/s has cobbles with large boulders [1].

The evaluation of the calculation is presented in subchapter 3.1.1 and 3.1.2 in form of spreadsheets. The spreadsheets include the following results:

- Arrival time of the wave peak (hour, minutes)
- Maximum water level rising over initial water level (m)
- Maximal water level (masl)
- Initial water level (masl)
- Maximum discharge (m^3/s)
- Maximum water velocity (m/s)
- Numbering cross section in Mike 11
- Numbering cross section in AutoCAD

The model is based on a time step of 0.05 sec. A low time step leads to a better stability and increases the accuracy of the calculation.

3.1 Presentation of results

An overview of the cross sections used for the model is given in Fig. 3.1.

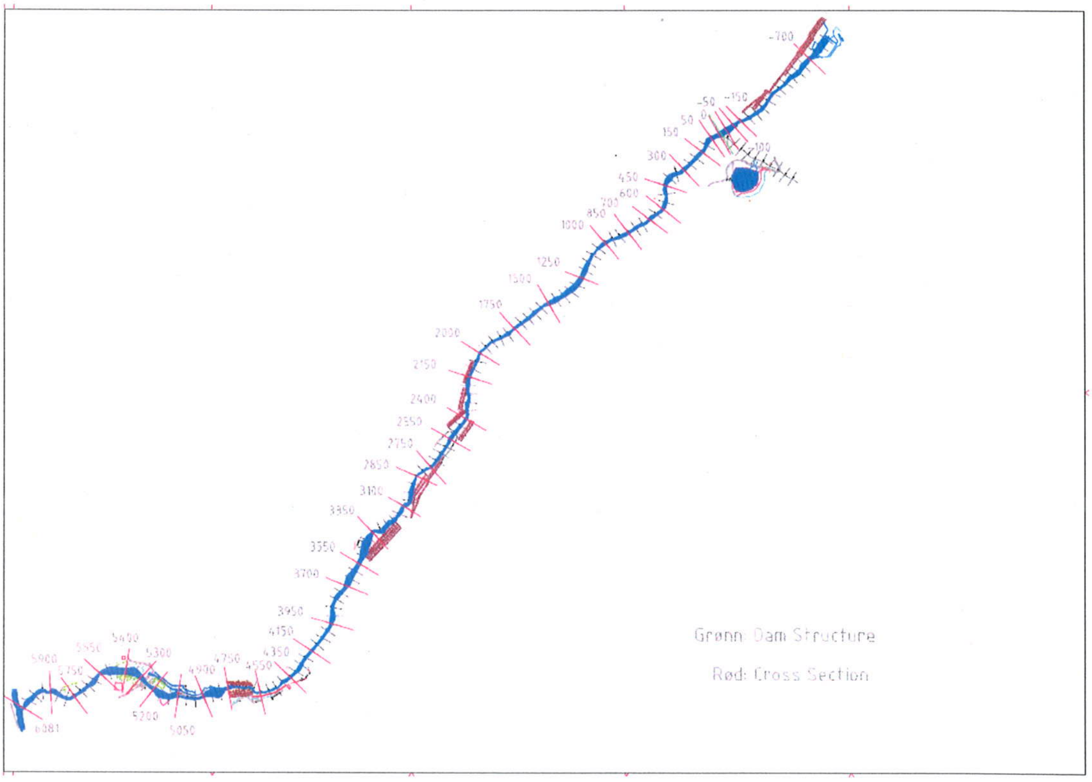

Fig. 3.1 Overview of cross sections used in Mike 11 (numbering equal to AutoCAD description)

A longitudinal profile of Allain at the time of the dam break is shown in figure 3.2.

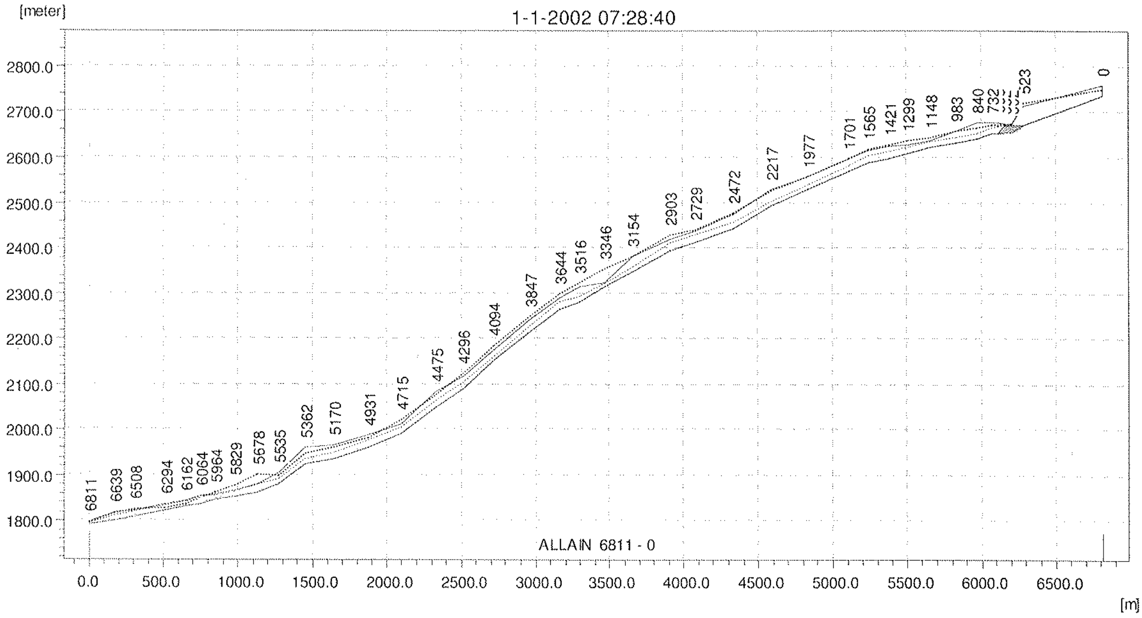

Fig. 3.2 Longitudinal profile of Allain with cross section

The following diagrams show the water level rising at 3 different cross sections of the model with the roughness M = 25.

Figure 3.3 shows the water level rising at cross section 732 (equal 50 to AutoCAD numbering). This cross section lays ca. 58 m downstream the dam structure.

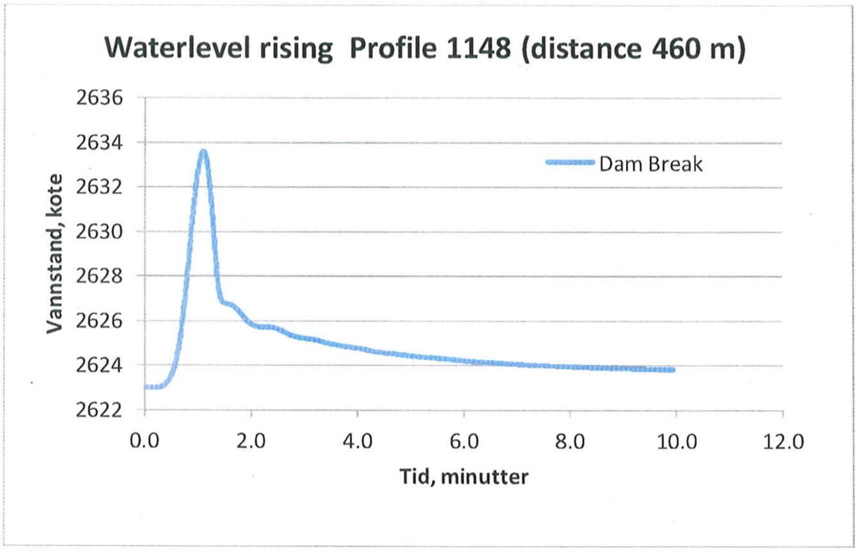

Fig. 3.3 Water level rising at cross section 1148 (model) or 450 (AutoCAD)

Fig. 3.4 shows the water level rising at cross section 3516 (AutoCAD numbering 2750).

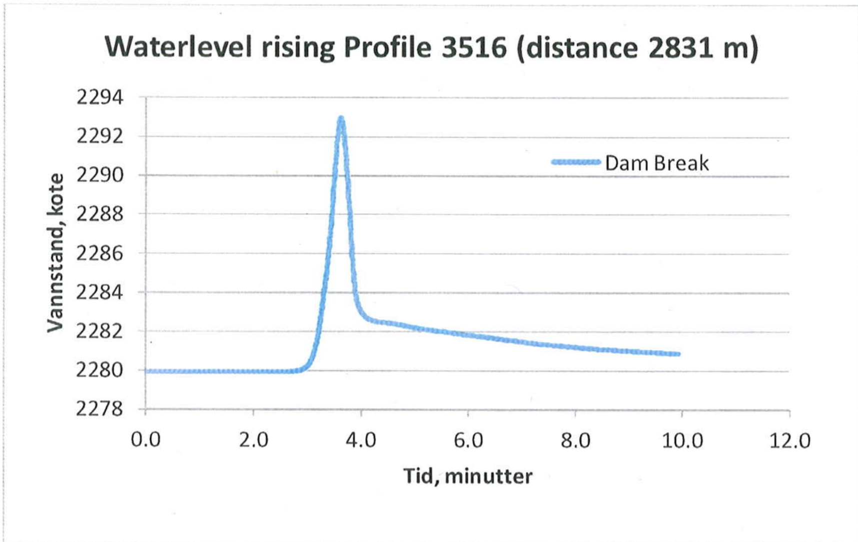

Fig. 3.4 Water level rising at cross section 3516 (model) or 2750 (AutoCAD)

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Fig. 3.5 shows the water level rising at cross section 6162 which is laying 5477 m downstream the dam structure.

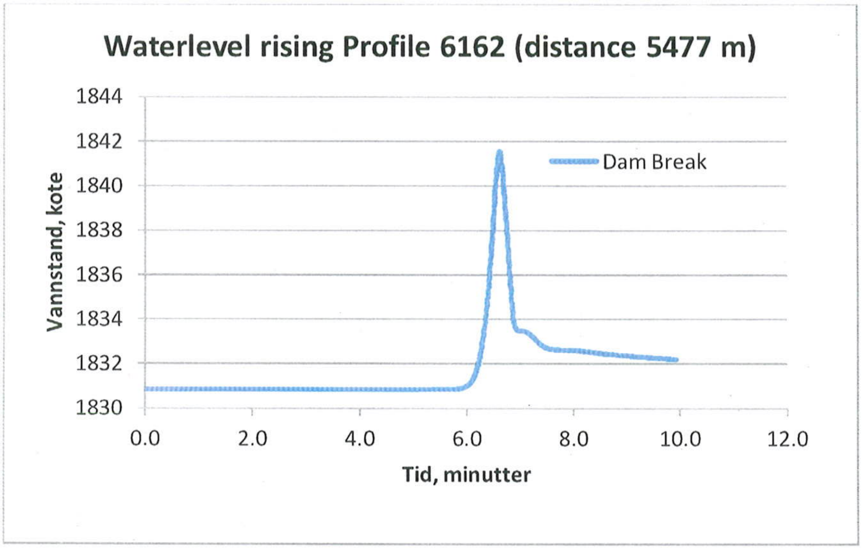

Fig. 3.5 Water level rising at cross section 6162 (model) or 5400 (AutoCAD)

3.1.1 Results for Manning's factor M = 25 $m^{1/3}/s$

The results for the dam break analysis with a roughness corresponding to the Manning's factor M = 25 $m^{1/3}/s$ is shown in the following spreadsheet.

Dam Break of intake basin of the river Allain for Manning's factor M = 25 m$^{1/3}$/s									
Location	Cross Section Number in AutoCAD	Cross Section Number in Modell	Distance From Intake (meter)	Water Level Rising (meter)	Maximum Water Level (masl)	Maximum discharge (m^3/s)	Arrival Time Wave Peak (hour,min)	Maximum Velocity (m/s)	Initial Water Level (m.o.h.)
Intake	Dam profile	674	0	0.0	2670	2423	0,00	8.3	2670.0
	0	696	22	12.1	2666.3	4585	0,00	106.2	2654
	50	732	58	11.8	2665.3	4570	0,00	80.2	2653
	150	841	167	11.2	2653.2	4076	0,00	51.8	2642
	300	983	309	11.2	2643.2	3852	0,00	41.1	2632
	450	1148	464	10.0	2633.6	4143	0,01	26.6	2624
	600	1299	615	11.8	2622.1	5300	0,01	33.8	2610
	700	1421	737	15.9	2613.5	5305	0,01	36.2	2598
	850	1565	881	13.8	2603.5	6693	0,01	40.5	2590
	1000	1701	1017	12.4	2580.9	7419	0,01	37.3	2569
	1250	1977	1291	10.5	2539.7	5063	0,02	31.2	2529
	1500	2217	1532	8.2	2500.7	5219	0,02	32.2	2493
	1750	2472	1787	11.8	2456.6	4522	0,02	31.5	2445
	2000	2728	2043	12.6	2427.2	4432	0,02	29.3	2415
	2150	2903	2218	13.2	2409.2	5820	0,03	32.2	2396
	2400	3154	2469	10.2	2357.8	5924	0,03	27.2	2348
Allain	2550	3346	2661	8.0	2321.5	5964	0,03	24.4	2313
	2750	3516	2831	12.7	2293.0	5408	0,03	28.9	2280
	2850	3644	2959	11.9	2279.0	6903	0,03	34.8	2267
	3100	3847	3162	11.9	2229.8	7287	0,03	33.3	2218
	3350	4094	3409	6.5	2161.4	6827	0,04	27.4	2155
	3550	4296	3611	11.7	2102.4	6116	0,04	36.6	2091
	3700	4475	3789	12.3	2061.9	6764	0,04	32.9	2050
	3950	4715	4030	12.1	2004.3	5424	0,04	27.8	1992
	4150	4931	4246	13.6	1975.7	4800	0,04	31.0	1962
	4350	5170	4485	11.9	1947.4	3923	0,05	23.8	1936
	4550	5362	4677	8.4	1933.4	6047	0,05	40.3	1925
	4750	5535	4850	8.4	1890.2	4813	0,05	29.4	1882
	4900	5678	4993	13.0	1877.6	4976	0,05	22.6	1865
	5050	5829	5144	11.1	1866.1	4788	0,06	18.2	1855
	5200	5963	5278	9.6	1856.9	5739	0,06	19.3	1847
	5300	6063	5378	10.9	1849.6	6113	0,06	20.6	1839
Hotels	5400	6162	5477	10.4	1841.5	6205	0,06	18.9	1831
	5550	6293	5608	8.5	1831.7	5125	0,06	30.5	1823
Allain	5750	6508	5822	8.4	1819.2	3841	0,07	19.8	1811
	5900	6639	5954	7.9	1810.3	3957	0,07	25.2	1802
Beas	6081	6811	6126	0.0	1792.0	5310	...	...	1792

The highest water level rising is around 15.7 m and occur ca. 740 m downstream of the intake basin. The maximum discharge is 7419 m^3/s and occurs ca. 1020 m downstream the intake basin. The peak of the dam break wave reaches the river of Beas after 7 minutes. The water level rising upstream the tributary Beas/Allain will be around 7.9 m. It needs further investigation if the river of Beas has enough capacity to dampen the dam break wave. The road to Manali along the river of Beas could be affected by the dam break water.

3.1.2 Results for Manning's factor M = 15 $m^{1/3}/s$

The results for the dam break analysis with a roughness corresponding to the Manning's factor M = 15 $m^{1/3}/s$ is shown in the following spreadsheet.

Dam Break of intake basin of the river Allain for Manning's factor M = 15 $m^{1/3}/s$									
Location	Cross Section Number in AutoCAD	Cross Section Number in Modell	Distance From Intake (meter)	Water Level Rising (meter)	Maximum Water Level (masl)	Maximum discharge (m^3/s)	Arrival Time Wave Peak (hour,min)	Maximum Velocity (m/s)	Initial Water Level (m.o.h.)
Intake	Dam profile	674	0	0.0	2670	2401	0,00	8.3	2670
Allain	0	696	22	12.0	2666.3	4463	0,00	96.9	2654
	50	732	58	11.4	2664.9	4350	0,00	79.2	2653
	150	841	167	10.7	2652.8	3554	0,00	50.7	2642
	300	983	309	10.2	2642.3	3206	0,00	39.9	2632
	450	1148	464	8.9	2632.6	3297	0,01	26.3	2624
	600	1299	615	9.7	2620.1	3834	0,01	34.3	2610
	700	1421	737	12.7	2610.3	3489	0,01	36.1	2598
	850	1565	881	11.0	2600.8	4548	0,01	22.2	2590
	1000	1701	1017	9.3	2577.9	4545	0,01	37.3	2569
	1250	1977	1291	8.0	2537.3	3183	0,02	30.6	2529
	1500	2217	1532	6.0	2498.7	3003	0,02	31.0	2493
	1750	2472	1787	8.3	2453.2	2397	0,02	30.2	2445
	2000	2728	2043	8.5	2423.2	2560	0,03	19.1	2415
	2150	2903	2218	8.6	2404.7	2863	0,03	28.3	2396
	2400	3154	2469	6.4	2354.2	2656	0,03	20.3	2348
	2550	3346	2661	4.5	2318.1	2563	0,03	17.4	2314
	2750	3516	2831	7.6	2287.9	2373	0,03	22.6	2280
	2850	3644	2959	7.3	2274.5	2732	0,04	25.4	2267
	3100	3847	3162	6.6	2224.6	2607	0,04	29.3	2218
	3350	4094	3409	3.3	2158.4	2343	0,04	23.6	2155
	3550	4296	3611	5.8	2096.6	2183	0,04	23.0	2091
	3700	4475	3789	5.9	2055.7	2088	0,04	29.9	2050
	3950	4715	4030	6.2	1998.5	1742	0,05	27.2	1992
	4150	4931	4246	7.8	1970.1	1666	0,05	28.2	1962
	4350	5170	4485	6.0	1941.6	1412	0,05	19.5	1936
	4550	5362	4677	4.3	1929.3	1746	0,05	18.5	1925
	4750	5535	4850	3.4	1885.1	1528	0,06	25.8	1882
	4900	5678	4993	7.0	1871.7	1532	0,06	18.1	1865
	5050	5829	5144	5.2	1860.3	1429	0,06	13.8	1855
	5200	5963	5278	4.9	1852.3	1637	0,06	11.9	1847
	5300	6063	5378	4.2	1843.0	1623	0,07	11.2	1839
Hotels	5400	6162	5477	4.3	1835.5	1441	0,07	16.1	1831
Allain	5550	6293	5608	3.7	1827.1	1248	0,07	25.5	1823
	5750	6508	5822	3.5	1814.5	1049	0,08	16.5	1811
	5900	6639	5954	3.2	1805.7	925	0,08	17.1	1803
Beas	6081	6811	6126	0.0	1792.0	1049	...	...	1792

For M = 15 occurs the highest water level rising of 12.7 m ca. 740 m downstream of the intake basin. The maximum discharge is observed 880 m downstream the intake basin and is around 4548 m3/s. The water level rising close to the tributary Beas/Allain will be very low.

4 Summary

Comparing the results for the different Manning's factors (M = 25 and M = 15) show that a higher roughness (lower Manning's factor) will dampen the dam break considerable. The water level rising at the outflow into the river of Beas decreases from 7.9 m (M = 25) to 3.2 m (M = 15).

The roughness of the river of Allain is represented by two different Manning's factor. It is adverted that further investigations are necessary to find the representative roughness of the river bed. Moreover there are more investigations necessary for finding out if infrastructure gets hit by the dam break wave (referred to the results of the dam break analysis).

5 References

[1] French, R. H., Open-Channel Hydraulics, 1985