



# Dam Break Analysis for Aparan Reservoir, Armenia

*Per Ludvig Bjerke*

1  
2011



O P P D R A G S R A P P O R T A

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Norwegian Water Resources and Energy Directorate  
2011

# **Oppdragsrapport A nr 1 – 2011**

## **Dam Break Analysis for Aparan Reservoir, Armenia**

**Published by:** Norwegian Water Resources and Energy Directorate

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**Print:** Norwegian Water Resources and Energy Directorate

**Number of  
copies:** 20

**Cover photo:** Aparan dam (Photo: Svein Taksdal, NVE)

**ISSN:** 1503-0318

**Abstract:** This report is a part of the ongoing cooperation between Armstatehydromet (ASH) and Norwegian Water Resources and Energy Directorate (NVE). A numerical simulation with Hec-Ras on the failure of Aparan Dam was carried out for two scenarios. The simulated results showed a peak discharge of respectively 625 m<sup>3</sup>/s and 4350 m<sup>3</sup>/s. The travel time of the flood wave from the Aparan dam to Ashtarak was 1 hour.

**Key words:** Dambreak, Simulation, Hec-Ras, Armenia

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Januar 2011

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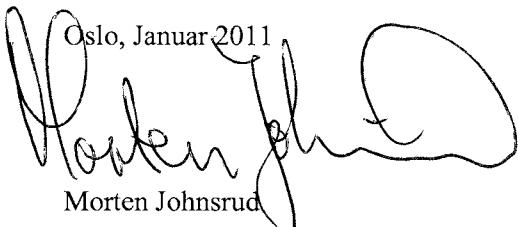
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# Preface

This report is part of the ongoing cooperation between Armstatehydromet (ASH) in Armenia and Norwegian Water Resources and Energy Directorate (NVE). It is a presentation of the work carried out in 2010 on dambreak simulation of Aparan Dam in the Kasach River.

The project is financed by the Department for Foreign affairs in Norway.

Lars-Evan Pettersson is project leader for this part of the cooperation. Per Ludvig Bjerke has been responsible for the report and Grethe Holm Midttømme has contributed technical expertise and made valuable improvement and corrections to the text.



Oslo, Januar 2011  
Morten Johnsrud

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# Summary

Dams are built for water supply, hydro-power, flood control, etc. However, dams may cause catastrophic damage to human life and property if they collapse. In order to be able to assess the consequences of a dam failure, simulation of the flood caused by a dam break is required. In the present investigation, the unsteady flow caused by a dam break on Aparan dam in Armenia is approximated as one-dimensional flow and simulated with the flood routing model Hec-Ras.

A numerical simulation of the dam failure using Hec-Ras was carried out for two scenarios. The purpose was to determine the extent of flooding downstream, flood wave travel time and flood discharges due to failure of the dam structure.

The dambreak has been simulated with two different breach openings, width 5m and 50m, both with a breach time of 10 hours. The simulated results reached peak discharges of  $625 \text{ m}^3/\text{s}$  and  $4350 \text{ m}^3/\text{s}$ , respectively. The maximum discharge at the lower end, 28 km below the dam, was reduced to 614 and  $4280 \text{ m}^3/\text{s}$ . The water velocities for scenario 2 are approximately 10 m/s in the upper 10 km with mild slope, 16-18 m/s for the steep part between 10 and 20 km below the dam and 4-5 m/s for the mild lower part below Ashtarak. The phase speed of the flood wave have an average value of 8 m/s. The travel time of the flood peak from the dam to Ashtarak for both scenarios is 1 hour.

# 1 Introduction

One of the tasks in the cooperation project between ASH and NVE has been to conduct dambreak analysis on the dam in the Aparan reservoir on the upper Kasach River, see figure 1. This has been done based on available data and maps from ASH.

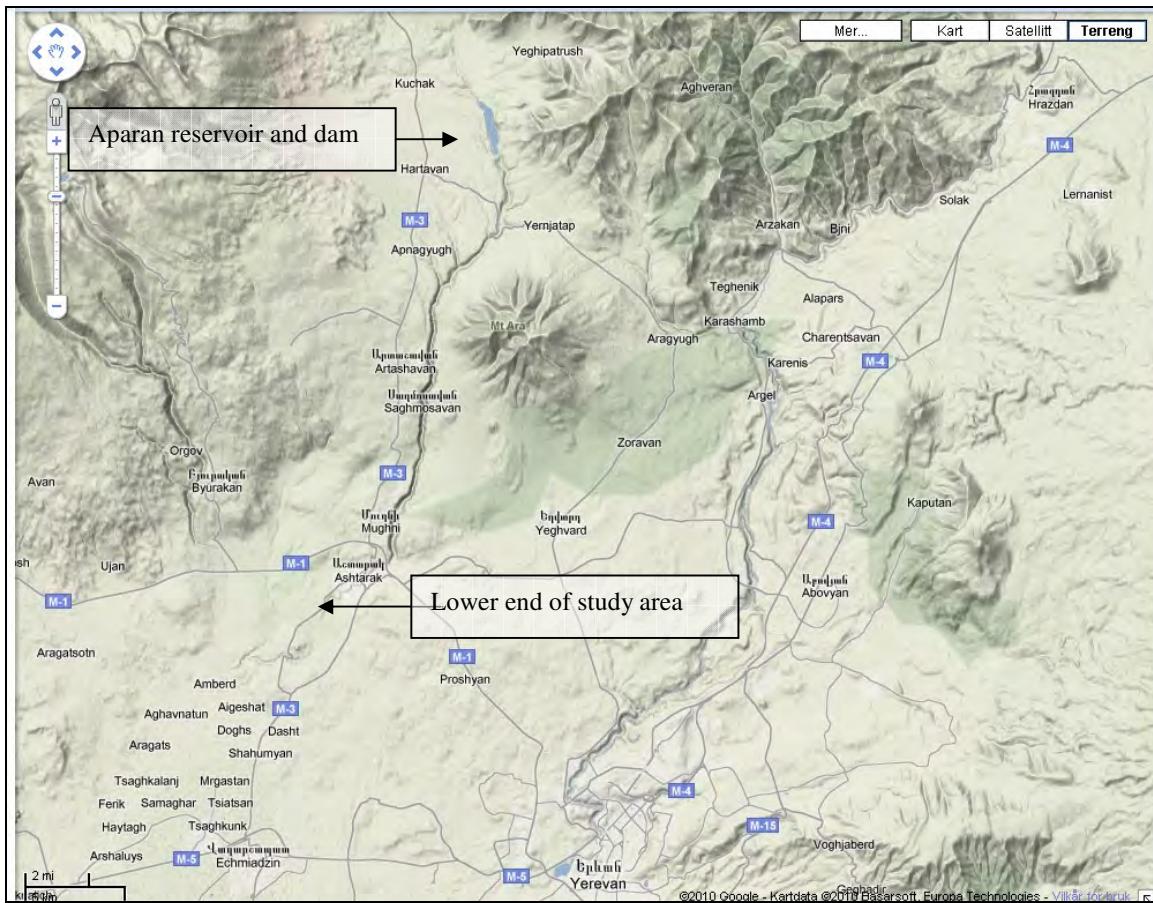
The purpose of the dam break analyses has been to illustrate how the flood wave propagates and attenuates along the river valley from Aparan dam to Ashtarak. In the present analyses the Hec-Ras model is used for simulation of the flood wave caused by dam failure. This model is one of the most widely accepted model of its kind.

A main goal has been to work out inundation maps. These will assist dam owners, regulators and emergency agencies in the preparation of evacuation plans, planning of warning systems for dam failure and flood and for hazard classification of affected areas.

The extent of the study area covered the entire watershed from Aparan reservoir to 5 km below Ashtarak, see figure 2.



**Figure 1 Picture showing the area downstream the Aparan dam.**

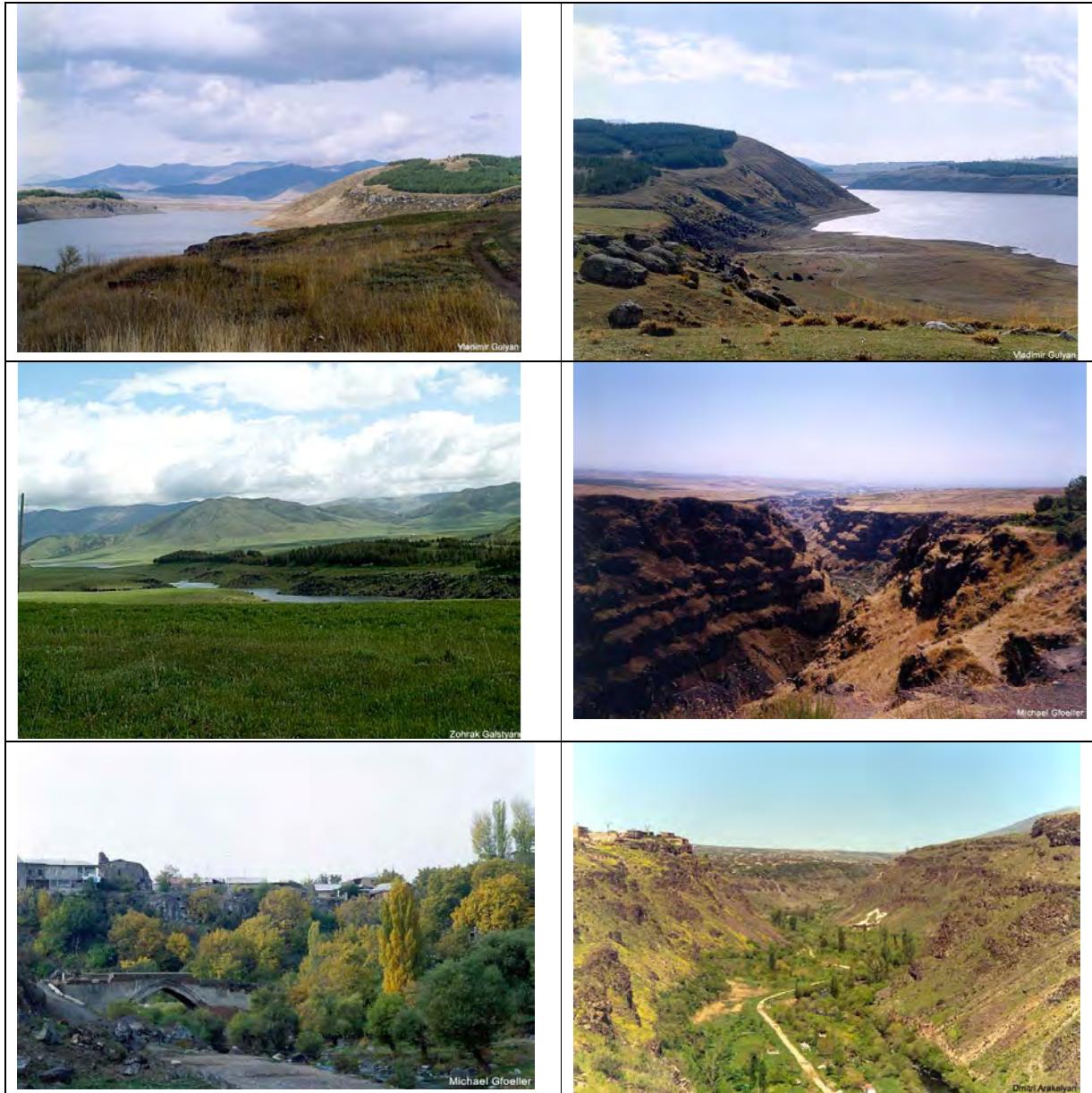


**Figure 2 Map showing the Kasach river with the Aparan dam.**

## 2 Data collection

Information and data about the reservoir and the river have been collected from several sources.

NVE performed a site visit in September 2007. During this visit technical information on the dam construction, the reservoir volume, capacity of flood gates and spillways were collected. Maps in scale 1:25 000 for the area were supplied from ASH. Hydrological data from the gauging stations downstream the dam have also been obtained from Armstathydromet. The information from this site visit are summarised in an internal memo [2].



**Figure 3** The two pictures in row 1 are showing the Aparan dam, the pictures in row 2 are from Jarabbar and the pictures in row 3 are from Ashtarak.

The cross section profiles and bottom elevation were derived from 1:25 000 maps with a equidistance of 5 m which is pretty rough. Availability of more detailed maps or a dedicated survey along the river would have given more detailed information and improved the accuracy of simulations. There are also some missing data/uncertainties about the reservoir, the design of the dam and the elevation of the dam and the spillways.

For these reasons we have not carried out detailed simulations and only minimal effort has been spent on improving the stability of the model. Some numerical instabilities do occur in the simulations and these can be seen as irregularities in the hydrographs.

## 3 Dam and River Characteristics

The Aparan reservoir is located in the upper part of Kasach valley and collects water from the Upper Kasach River Basin which is a generally mountainous area. The topography of the surrounding area can be characterized as steep terrain. The basin ranges in elevation from 2300 masl at the northern boundary to about 1820 masl at the reservoir.

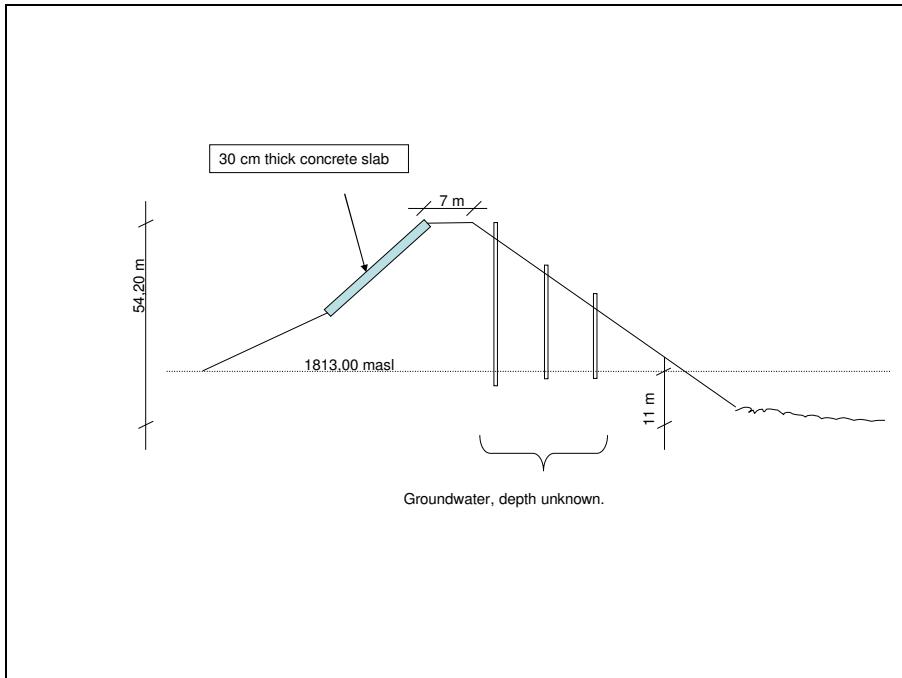
The reservoir is 8.5 km long and up to 2.5 km wide. It has a volume of 90 mill m<sup>3</sup> between 1813 masl and 1835 masl, from [3]. The Aparan reservoir supplies drinking water to Yerevan. It was built in the period 1962-68 and is also used for irrigation purposes. The Aparan dam is an embankment dam, but the design is not known in detail.

The dam has a gate in normal operation with bottom sill on 1813 masl and a capacity of 22 m<sup>3</sup>/sec. There are two flood spillways which are both shown in figure 4. One has a length of 22 m, with an overflow crest at 1835 masl and a capacity of 40 m<sup>3</sup>/s. The other has a length of 35 m, with an overflow crest at 1836 masl and a capacity of 22 m<sup>3</sup>/s.

A 30 cm thickness concrete slab has been built on the upstream side of the dam to prevent erosion. A schematic drawing of the dam is shown in figure 5.



Figure 4 The figure shows the two spillways. The capacities are 40 and 22 m<sup>3</sup>/sec.

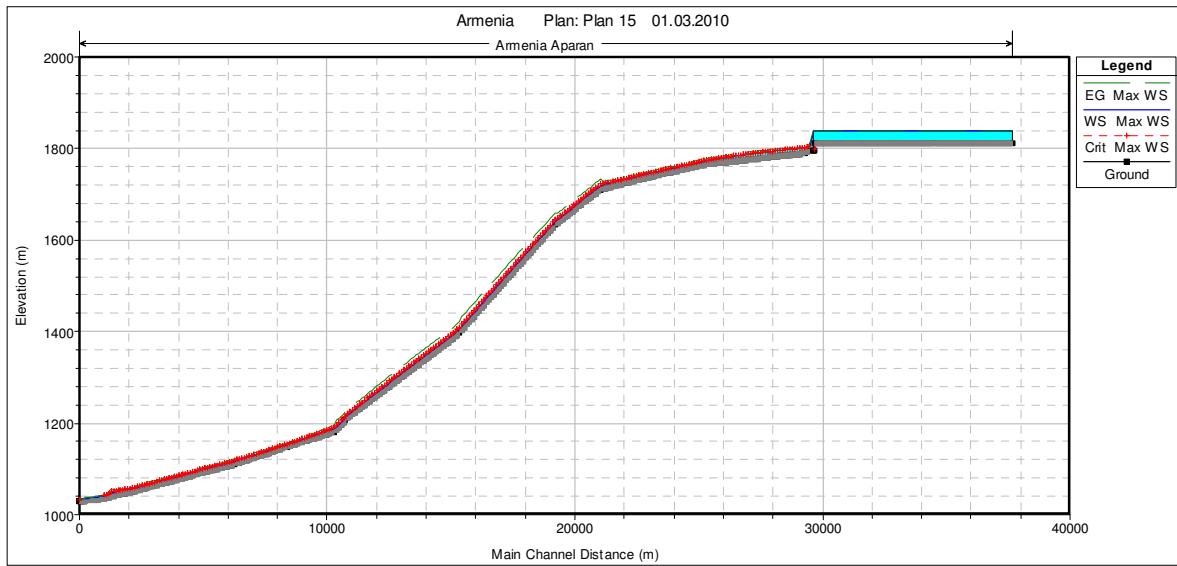


**Figur 5 Schematic drawing of Aparan dam (From NVE 2008).**

The river flows from the Aparan dam to Ashtarak in a canyon type valley and pictures from different parts of the valley are given in figure 3. The river drops from a height at the reservoir of 1813 masl to 1110 masl 5 km below Ashtarak town. The mean slope of the river is 2.8 %. However there are strong variations in the river slope. For the first 10 km river stretch downstream the dam the slope is 1 %, while the 10 km stretch passing by the towns of Artashavan and Saghmosavan has a slope of 5 %. In the lower part of the river around Ashtarak the slope is 2 %.

The simulated stretch is 29 km in length and the canyon sides are up to 100 m above the river bed. The top width of the river valley varies from 300 to 500 m. The vegetation in the reaches is thick and the area is generally overgrown. The parameters used to define the river channels were determined from topographic maps and observations made during the site visit.

There are several bridges in the valley, but since we do not have any information about them they are not included in the simulations.



**Figur 6 The longitudinal profile of the simulated stretch of the Kasach river.**

## 4 Dam failure scenarios

Embankment dams is often a preferred dam type in areas with surplus of suitable loose material due to the low cost of construction and because they preserves the natural appearance of the site. There are two categories of embankment dam: Earth fill and rock fill. A main cause for failure of embankment dams are overtopping due a extreme discharge/runoff combined with clogging of the spillway or insufficient spillway capacity caused by a flood larger than the design flood or malfunction of spillway gates. Table 1 shows the likely failure modes for the different types of dams (x means that this type of dam can fail under this mode).

Table 1 Modes of failure that can hit different types of dams (From 5)

|                         | Embankment | Gravity | Buttress | Arch | Multiple Arch |
|-------------------------|------------|---------|----------|------|---------------|
| <b>Sliding</b>          | X          | X       | X        |      |               |
| <b>Piping</b>           | X          | X       | X        | X    |               |
| <b>Overturning</b>      |            | X       |          | X    |               |
| <b>Overtopping</b>      | X          | X       | X        | X    | X             |
| <b>Poor maintenance</b> | X          | X       | X        | X    | X             |
| <b>Cracking</b>         | X          | X       | X        | X    | X             |
| <b>Rapid drawdown</b>   | X          |         |          |      |               |
| <b>Internal erosion</b> | X          | X       | X        | X    | X             |

In the simulations of the failure for Aparan dam the two selected scenarios of dam failure were both caused by overtopping of the dam.

## 5 The Hydraulic Model (Hec-Ras)

HEC-RAS is a computer program for modeling water flowing through systems of open channels and water surface profiles. The basic computational procedure of HEC-RAS is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction and contraction / expansion. The momentum equation may be used in situations where the water surface profile is rapidly varied. These situations include hydraulic jumps, hydraulics of bridges, and evaluating profiles at river confluences.

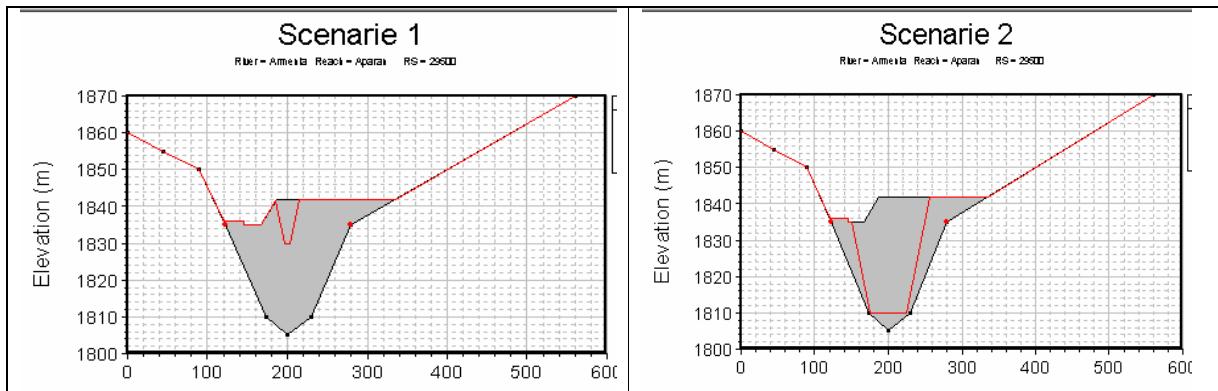
## 6 Input model parameter data

The Aparan Reservoir watershed and downstream reach was constructed as a single reach in the model. The reservoir was modelled with cross sections to capture the full dynamic routing effects of both the flood inflows and dam breach outflows. No on-site surveys have been conducted and the cross sections describing the topography have been taken from maps. The cross section locations are shown in figure 8.

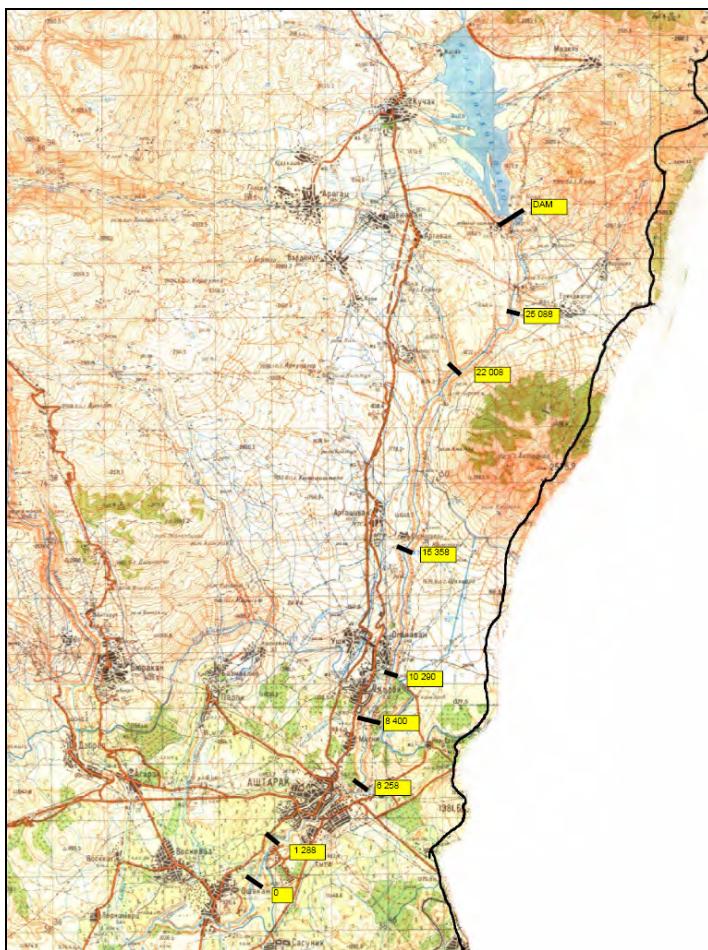
Channel roughness coefficients were estimated using standard references and engineering judgment based on field conditions. Mannings ‘n’=0.033 were used in the simulations. The “normal current” definition was used as the known water discharge for the downstream boundary condition.

The breach shape was assumed to be trapezoidal, growing with time. The breach formation time was set to 10 hrs in both scenarios. The end openings of the breaches in the two scenarios were 50 m wide and 30 m deep and 5 m wide and 10 m deep, respectively, as shown in figure 7.

The volume of the reservoir is 91 mill m<sup>3</sup> and the height of the dam is 34 m. The flow into the reservoir was set to 300 m<sup>3</sup>/s and used as input to the HEC-RAS dam breach model.



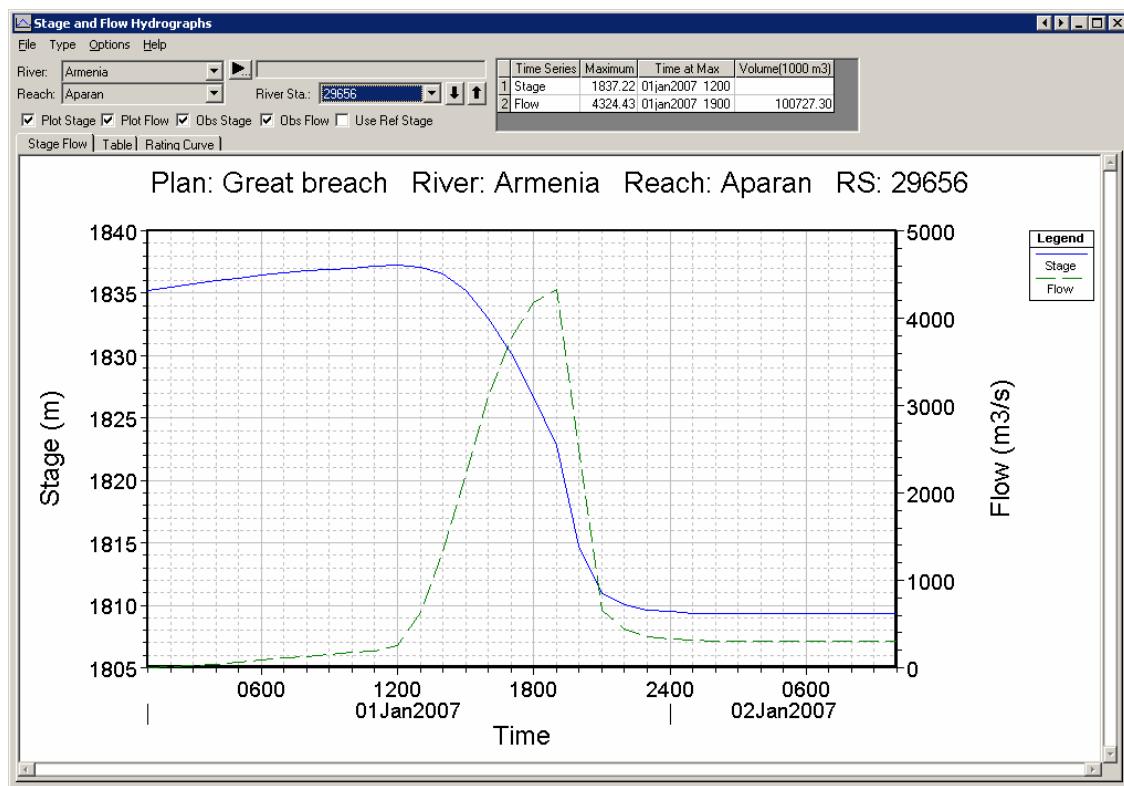
**Figur 7** The figure shows the final opening used in the scenarios.



**Figure 8** map showing the cross sections used in the simulations.

## 7 Results

The results from the two scenarios are presented as figures and tables. Figure 9 shows the water level in the dam opening as a blue solid line and the discharge as green dotted line for scenario 2, figure 10 shows the same for the cross section downstream of the dam and figure 11 for the cross section in the downstream end of the simulation stretch. Key results such as arrival time, maximum discharge and maximum water depth for both scenarios are given in table 2. The results are given for 4 selected locations. The maximum discharge decrease from 4400 m<sup>3</sup>/s at the outlet of Aparan dam to 4300 m<sup>3</sup>/s downstream from Ashtarak for scenario 2. The maximum increase in water surface elevation is on average 2-3 m in scenario 1 (not shown) and up to 8-10 m in scenario 2.



**Figure 9** The figure shows the water level in the reservoir (blue line) and the discharge flowing out of the dam during the dambreak for scenario 2 (breach width = 50 m).

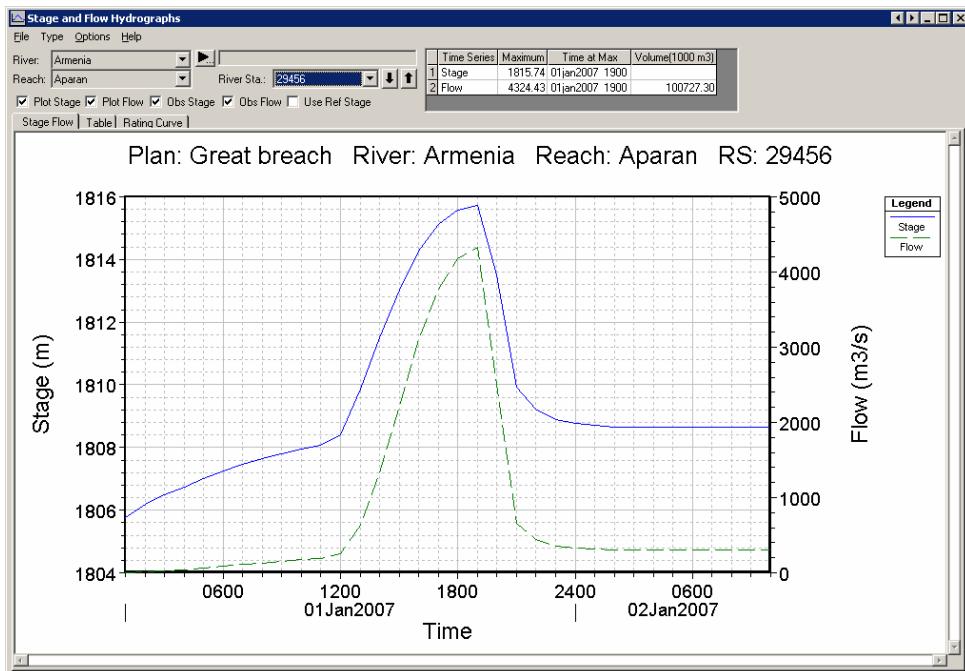


Figure 10 The figure shows the water level (blue line) and the discharge (green dotted line) at the cross section just below the dam for scenario 2.

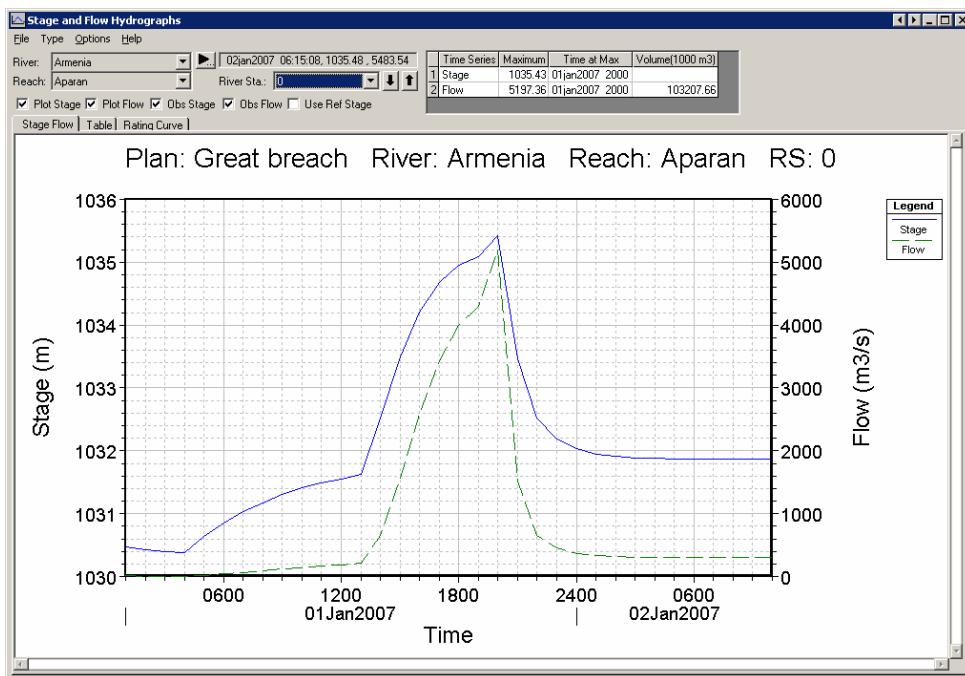


Figure 11 The figure shows the water level (blue line) and the discharge (green dotted line) at the boundary of the river stretch being modelled for scenario 2.

Table 2 Results from the simulation for both scenarios are given as arrival time of the maximum level height, maximum discharge and maximum water depth.

| Location             | Dist. from dam (km) | Arrival time (min) | Max discharge Sc2/Sc1 (m <sup>3</sup> /s) | Water depth Sc2/Sc1 (m) |
|----------------------|---------------------|--------------------|---|-------------------------|
| <b>Dam Aparan</b>    | 0                   | 0                  | 4404/625                                  | 11/4.8                  |
| <b>Profile 21028</b> | 8                   | 20                 | 4350/618                                  | 8.5/3.5                 |
| <b>Profile 10290</b> | 18                  | 40                 | 4325/616                                  | 8/3.3                   |
| <b>Profile 0</b>     | 29                  | 60                 | 4300/614                                  | 5.5/2.5                 |

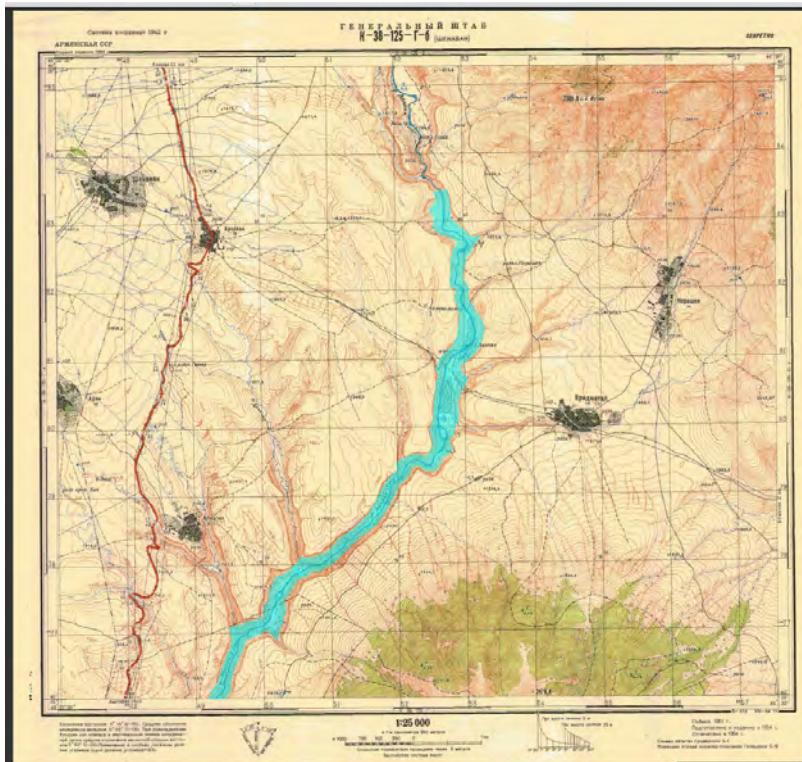
The dam breaks were simulated with two different breach openings, 5 m and 50 m, both with a breach time of 10 hours. The simulated results reached a peak discharge over the dam of 625 m<sup>3</sup>/s and 4350 m<sup>3</sup>/s, respectively. The maximum discharges at the lower end, 28 km below the dam, was reduced to 614 and 4280 m<sup>3</sup>/s.

This is a small reduction of the discharge and is caused by the steep river slope and the narrow cross sections. A milder slope, a increased roughness or a widening of the cross sections would have increased the flood wave attenuation.

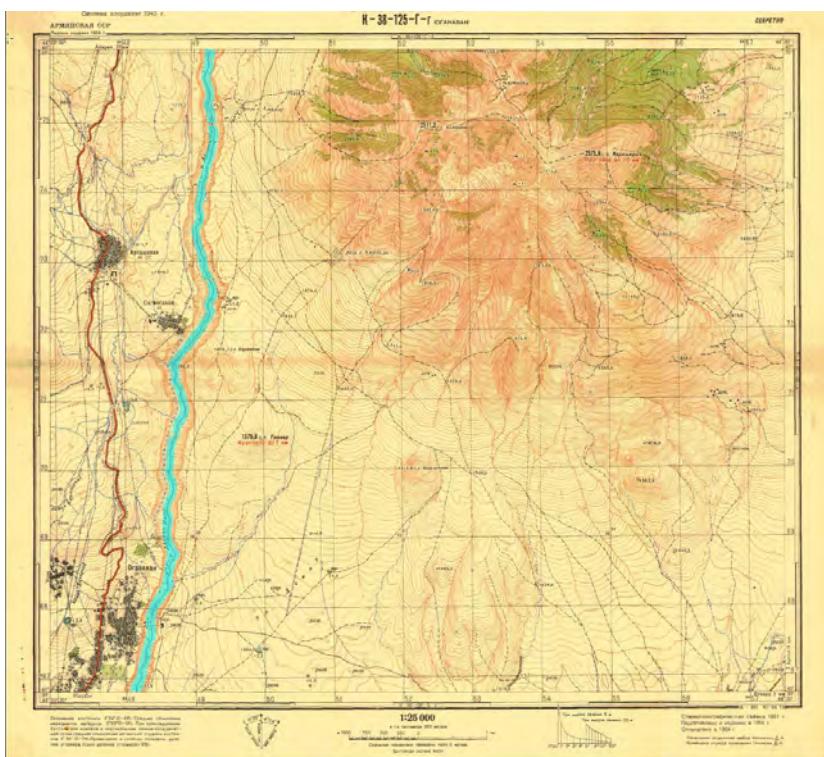
The water velocities were approximately 10 m/s in the upper 10 km with mild slope, 16-18 m/s for the steep part between 10 and 20 km below the dam and 4-5 m/s for the mild steep lower part below Ashtarak. The phase speed of the flood wave is faster than the speed of the water and was in middle 8 m/s. The travel time of the flood peak from the dam to Ashtarak was 1 hour.

The inundated areas are drawn on maps and shown in figures 12 to 15. The maps are not detailed and are meant for illustrations purposes only. Mapping of floodplains were carried out by drawing the water levels on scanned maps received from ASH.

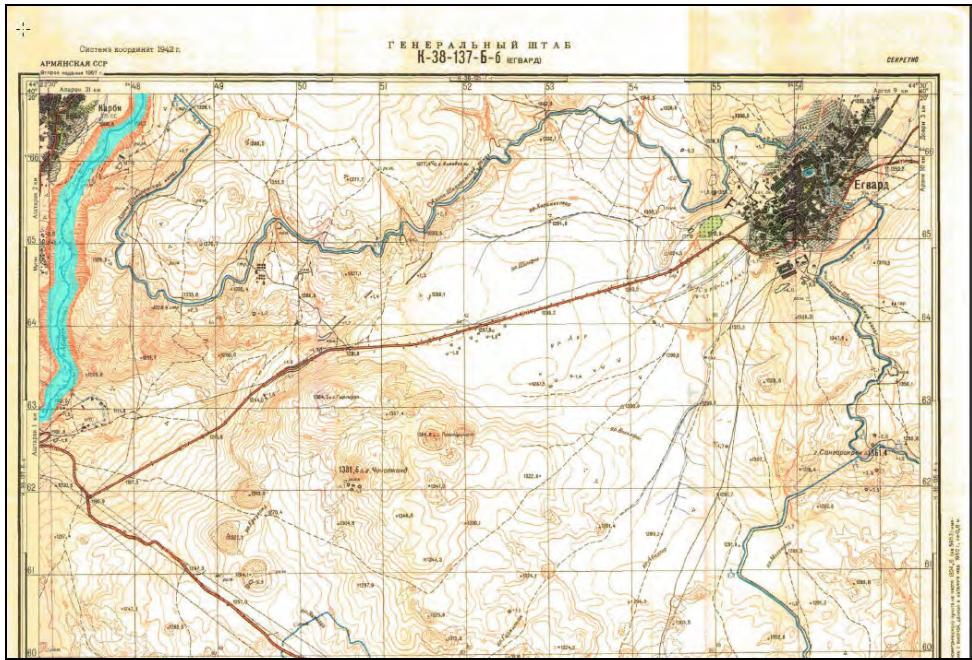
Figure 12 shows the flooded area from the dam and 10 km downstream of the dam. Figure 13 shows the river passing the towns Artashavan and Saghmosavan. This part of the river has a steep slope of 5 %. The figures 14 and 15 show the flooded area by the towns Mughin and Ashtarak. The river is here changing to a mild slope of 1 %.



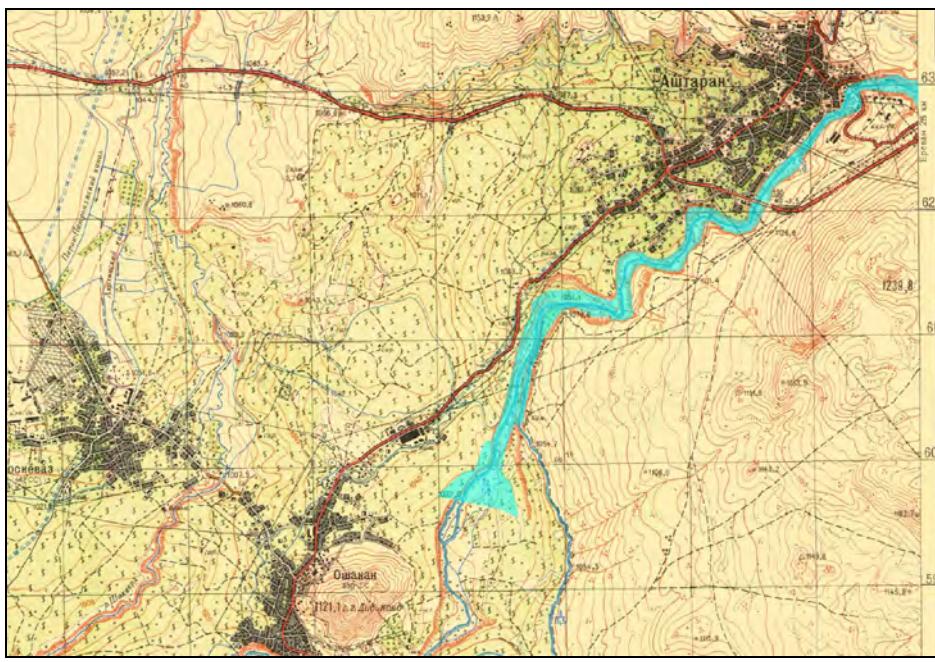
**Figure 12** The figure shows the river from the dam and 10 km downstream.



**Figure 13** The figure shows the river passing the town Artashavan and Saghmosavan.



**Figure 14** The figure shows the flooded area by Mughin.



**Figure 15** The figure shows the flooded area in the river by the town Ashtarak.

## 8 Example from Norway

An illustration on a inundation map based on detailed data is shown in figure 16. Red is flooded by a dambreak, light blue is flooded by 1000 yr flood an dark blue is flood by middle flow. The river is flowing from right to left into the sea which also is dark blue.

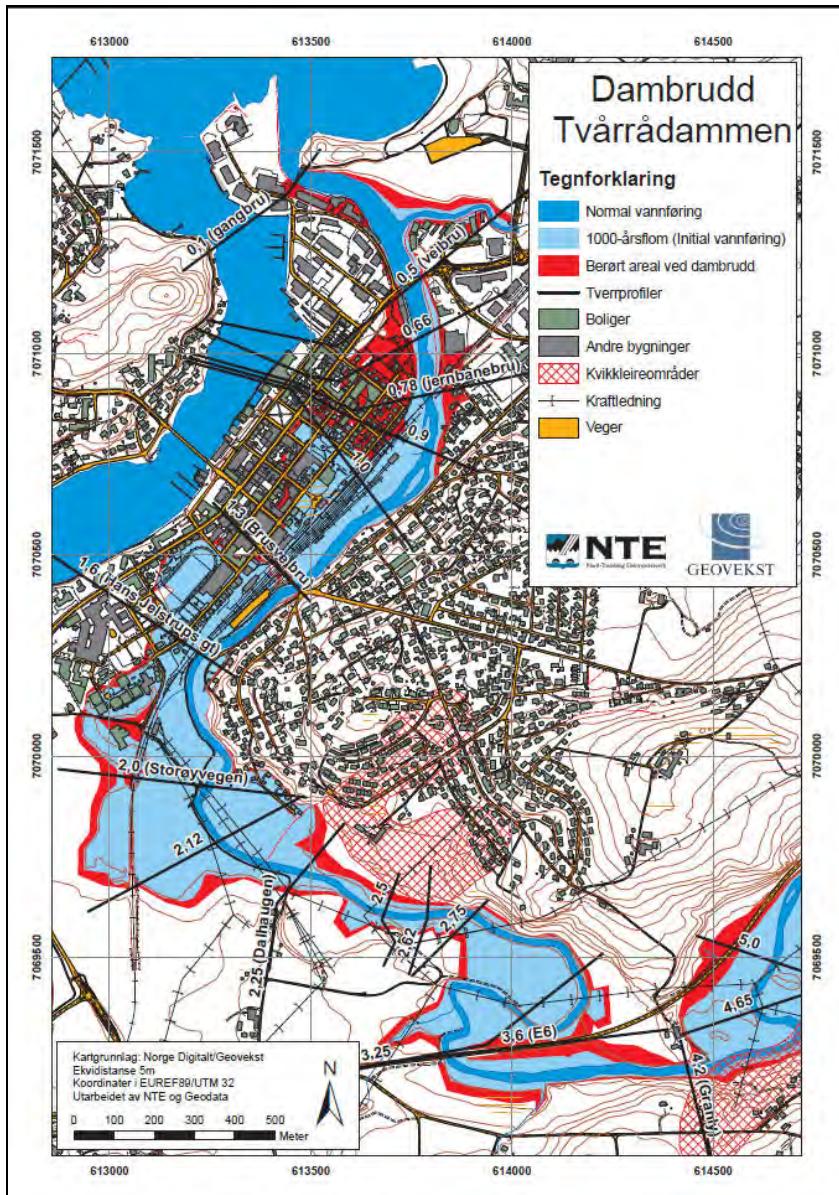


Figure 16 An inundation map from Norway generated in Arc Gis and based on a digital terrain model.

## **9 Recommendation for further study**

This dambreak simulation study is based on limited information about the dam and the river topography. The inundation maps in this report are for illustration purposes only. The map used for defining the cross sections and the heights have a scale of 1:25 000 and a equidistance of 5 m. We recommend using a more detailed map. The cross sections used in these simulations are therefore very coarse and simplified. In addition to using a more detailed map a detailed survey mapping of the river to make the data more complete shoul be carried out., Another solution is to generate a digital map based for example on laser scanning. Both these methods will improve the accuracy by giving more exact input to the model. When any of these methods is made available, new simulations should be carried out.

More information about the dam should be obtained. The development and progression of a dam break depend greatly on the size and on the design of the dam. A failure of an rock fill dam will develop in another way than a earth fill dam. More detailed information of the dam could give more realistic and accurate modelling of the breach time and breach opening.

## **10 References**

1) NVE(2009): Guidelines for Dam break analysis.

2) NVE (2008): Internal memo: Aparan Dam. Svein Taksdal.

Links:

3)<http://www.mde.state.md.us/assets/document/damsafety/workshop/Dam%20Failure%20Analysis%20by%20Bruce%20Harrington.pdf>

4)[http://www.mde.state.md.us/Programs/WaterPrograms/Dam\\_Safety/techref/dambreakguidelines.asp](http://www.mde.state.md.us/Programs/WaterPrograms/Dam_Safety/techref/dambreakguidelines.asp)

5)<http://scholar.lib.vt.edu/theses/available/etd-05232002-234249/unrestricted/finalone.pdf>

6) <http://140.194.76.129/publications/eng-manuals/em1110-2-1420/c-16.pdf>

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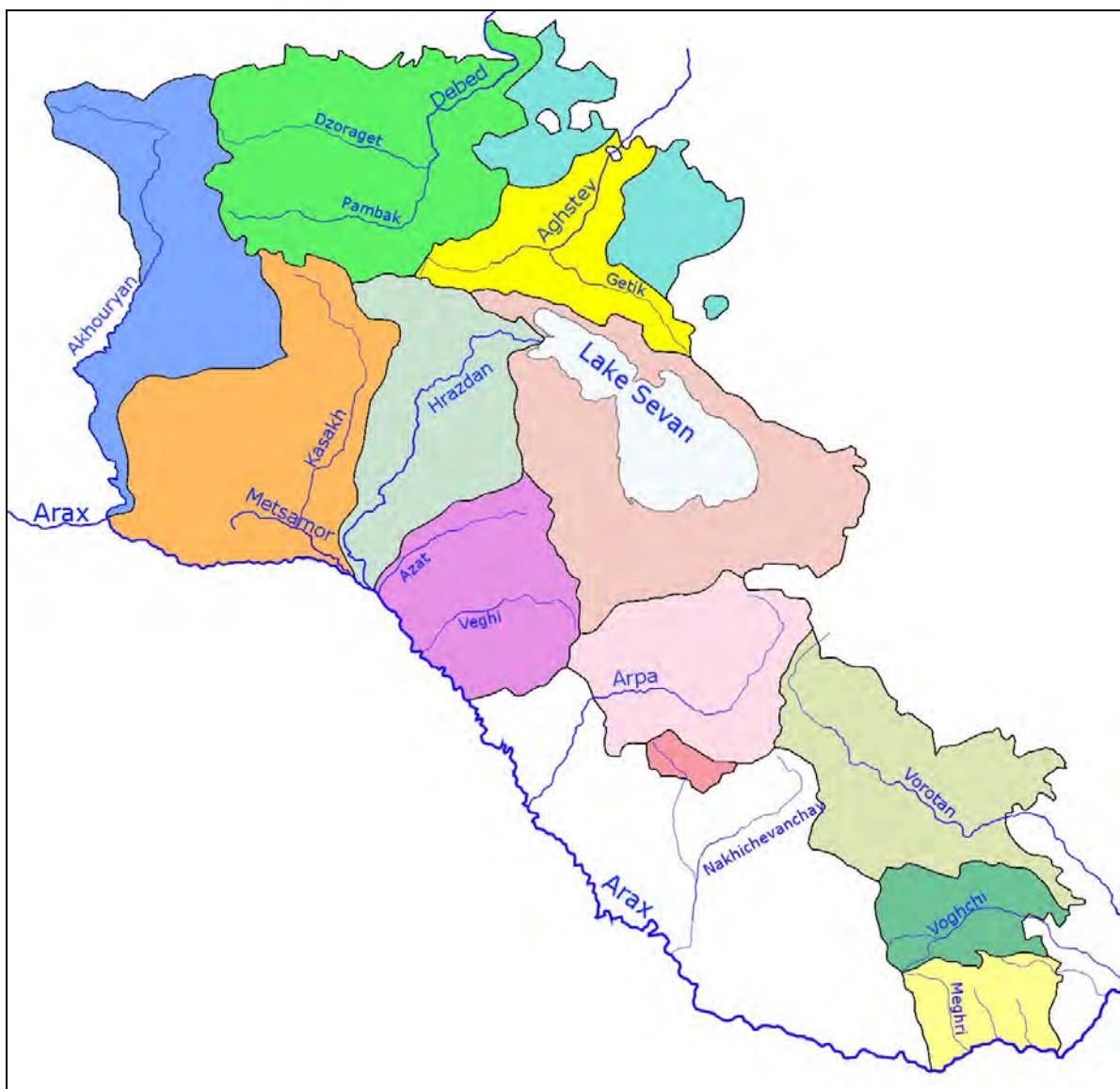
8) <http://www.hrwallingford.co.uk/projects/CADAM/CADAM/Zaragoza/Z20.pdf>

9) [http://furat.eng.uci.edu/wsmodeling/Software/USACE\\_HEC/HEC-RAS/V4Beta/docs/HEC-RAS Reference Manual.pdf](http://furat.eng.uci.edu/wsmodeling/Software/USACE_HEC/HEC-RAS/V4Beta/docs/HEC-RAS Reference Manual.pdf)

10) <http://www.iwaponline.com/nh/020/0249/0200249.pdf>

## Appendix

Map showing the rivers of Armenia



## Table with results from the simulations in Scenario 1 and 2

| Profile Output Table - Standard Table 1 |           |         |            |           |           |           |           |            |          |           |           |              |
|---|-----------|---------|------------|-----------|-----------|-----------|-----------|------------|----------|-----------|-----------|--------------|
| Reach                                   | River Sta | Profile | Q Total    | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|   |           |         | (m³/s)     | (m)       | (m)       | (m)       | (m)       | (m/m)      | (m/s)    | (m²)      | (m)       |              |
| Aparan                                  | 37460     | Max WS  | 300.00     | 1817.50   | 1837.44   |           | 1837.44   | 0.000000   | 0.03     | 9524.32   | 517.88    | 0.00         |
| Aparan                                  | 32000     | Max WS  | 301.78     | 1817.50   | 1837.44   |           | 1837.44   | 0.000000   | 0.03     | 9524.16   | 517.88    | 0.00         |
| Aparan                                  | 29666     | Max WS  | 298.07     | 1805.00   | 1837.44   |           | 1837.44   | 0.000000   | 0.02     | 14019.34  | 524.86    | 0.00         |
| Aparan                                  | 29656     | Max WS  | 302.40     | 1805.00   | 1837.44   | 1808.59   | 1837.44   | 0.000000   | 0.09     | 3215.70   | 181.87    | 0.01         |
| Aparan                                  | 29500     |         | Inl Struct |           |           |           |           |            |          |           |           |              |
| Aparan                                  | 29456     | Max WS  | 625.23     | 1805.00   | 1809.82   | 1810.79   | 1812.83   | 0.020906   | 7.68     | 81.45     | 33.77     | 1.58         |
| Aparan                                  | 29288     | Max WS  | 624.72     | 1803.00   | 1807.17   | 1807.32   | 1808.83   | 0.008999   | 5.71     | 109.32    | 37.49     | 1.07         |
| Aparan                                  | 25088     | Max WS  | 619.77     | 1764.20   | 1766.53   | 1766.74   | 1767.79   | 0.012322   | 4.98     | 124.43    | 68.31     | 1.18         |
| Aparan                                  | 22008     | Max WS  | 618.75     | 1725.00   | 1728.59   | 1728.91   | 1729.98   | 0.013684   | 5.22     | 118.62    | 66.07     | 1.24         |
| Aparan                                  | 21028     | Max WS  | 618.09     | 1710.80   | 1714.34   | 1715.56   | 1718.49   | 0.042483   | 9.02     | 68.49     | 38.73     | 2.17         |
| Aparan                                  | 19208     | Max WS  | 618.23     | 1634.00   | 1636.22   | 1637.66   | 1641.45   | 0.057529   | 10.14    | 60.97     | 36.13     | 2.49         |
| Aparan                                  | 15358     | Max WS  | 617.76     | 1398.50   | 1401.29   | 1402.62   | 1405.80   | 0.042563   | 9.41     | 65.66     | 33.71     | 2.15         |
| Aparan                                  | 10738     | Max WS  | 617.09     | 1202.80   | 1205.07   | 1205.86   | 1207.89   | 0.049283   | 7.44     | 82.95     | 71.14     | 2.20         |
| Aparan                                  | 10290     | Max WS  | 616.95     | 1181.20   | 1184.61   | 1185.08   | 1186.30   | 0.017814   | 5.75     | 107.26    | 62.86     | 1.41         |
| Aparan                                  | 8400      | Max WS  | 616.55     | 1149.80   | 1150.95   | 1151.15   | 1151.83   | 0.017833   | 4.15     | 148.73    | 142.83    | 1.30         |
| Aparan                                  | 6258      | Max WS  | 615.99     | 1110.50   | 1113.67   | 1113.96   | 1114.91   | 0.014485   | 4.94     | 124.65    | 78.77     | 1.25         |
| Aparan                                  | 2128      | Max WS  | 614.92     | 1051.10   | 1054.22   | 1054.35   | 1055.17   | 0.011331   | 4.33     | 142.08    | 91.14     | 1.11         |
| Aparan                                  | 1288      | Max WS  | 615.02     | 1040.00   | 1043.84   | 1044.63   | 1046.30   | 0.022331   | 6.94     | 88.66     | 46.13     | 1.60         |
| Aparan                                  | 910       | Max WS  | 614.92     | 1035.00   | 1037.42   |           | 1037.79   | 0.006065   | 2.68     | 229.53    | 189.71    | 0.78         |
| Aparan                                  | 0         | Max WS  | 614.34     | 1030.00   | 1032.45   | 1031.55   | 1032.51   | 0.001017   | 1.11     | 555.18    | 452.99    | 0.32         |

| Profile Output Table - Standard Table 1 |           |                |            |           |           |           |           |            |          |           |           |              |
|---|-----------|----------------|------------|-----------|-----------|-----------|-----------|------------|----------|-----------|-----------|--------------|
| Reach                                   | River Sta | Profile        | Q Total    | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|   |           |                | (m³/s)     | (m)       | (m)       | (m)       | (m)       | (m/m)      | (m/s)    | (m²)      | (m)       |              |
| Aparan                                  | 37460     | 01JAN2007 1900 | 300.00     | 1817.50   | 1823.71   |           | 1823.71   | 0.000002   | 0.12     | 2435.07   | 514.82    | 0.02         |
| Aparan                                  | 32000     | 01JAN2007 1900 | 2878.75    | 1817.50   | 1823.14   |           | 1823.23   | 0.000297   | 1.35     | 2139.81   | 514.70    | 0.21         |
| Aparan                                  | 29666     | 01JAN2007 1900 | 4320.63    | 1805.00   | 1823.00   |           | 1823.03   | 0.000017   | 0.67     | 6488.19   | 518.45    | 0.06         |
| Aparan                                  | 29656     | 01JAN2007 1900 | 4324.43    | 1805.00   | 1822.78   | 1815.76   | 1823.46   | 0.000642   | 3.65     | 1185.27   | 107.62    | 0.35         |
| Aparan                                  | 29500     |                | Inl Struct |           |           |           |           |            |          |           |           |              |
| Aparan                                  | 29456     | 01JAN2007 1900 | 4324.43    | 1805.00   | 1815.74   | 1817.54   | 1821.91   | 0.013422   | 11.01    | 392.84    | 67.23     | 1.45         |
| Aparan                                  | 29288     | 01JAN2007 1900 | 4324.84    | 1803.00   | 1813.68   | 1814.67   | 1818.82   | 0.008919   | 10.05    | 430.34    | 59.41     | 1.19         |
| Aparan                                  | 25088     | 01JAN2007 1900 | 4331.63    | 1764.20   | 1770.63   | 1771.97   | 1775.58   | 0.012391   | 9.86     | 439.44    | 85.22     | 1.39         |
| Aparan                                  | 22008     | 01JAN2007 1900 | 4333.08    | 1725.00   | 1732.61   | 1733.59   | 1736.74   | 0.011264   | 9.01     | 480.90    | 100.51    | 1.31         |
| Aparan                                  | 21028     | 01JAN2007 1900 | 4333.04    | 1710.80   | 1718.18   | 1722.20   | 1732.60   | 0.042381   | 16.83    | 257.52    | 55.33     | 2.49         |
| Aparan                                  | 19208     | 01JAN2007 1900 | 4332.63    | 1634.00   | 1640.05   | 1644.75   | 1658.56   | 0.057666   | 19.06    | 227.28    | 50.69     | 2.87         |
| Aparan                                  | 15358     | 01JAN2007 1900 | 4331.31    | 1398.50   | 1405.86   | 1410.65   | 1422.71   | 0.042375   | 18.19    | 238.13    | 41.91     | 2.44         |
| Aparan                                  | 10738     | 01JAN2007 1900 | 4328.11    | 1202.80   | 1207.79   | 1211.01   | 1219.61   | 0.045834   | 15.23    | 284.22    | 76.57     | 2.52         |
| Aparan                                  | 10290     | 01JAN2007 1900 | 4327.68    | 1181.20   | 1188.27   | 1190.14   | 1194.27   | 0.018841   | 10.85    | 398.74    | 92.37     | 1.67         |
| Aparan                                  | 8400      | 01JAN2007 1900 | 4324.78    | 1149.80   | 1153.32   | 1154.41   | 1157.21   | 0.017224   | 8.74     | 495.03    | 149.84    | 1.53         |
| Aparan                                  | 6258      | 01JAN2007 1900 | 4320.55    | 1110.50   | 1116.92   | 1118.08   | 1121.20   | 0.014471   | 9.16     | 471.69    | 116.62    | 1.45         |
| Aparan                                  | 2128      | 01JAN2007 1900 | 4310.04    | 1051.10   | 1057.74   | 1058.30   | 1060.65   | 0.009691   | 7.55     | 570.93    | 140.32    | 1.19         |
| Aparan                                  | 1288      | 01JAN2007 1900 | 4307.08    | 1040.00   | 1047.55   | 1050.10   | 1055.69   | 0.029964   | 12.65    | 340.58    | 89.70     | 2.07         |
| Aparan                                  | 910       | 01JAN2007 1900 | 4305.66    | 1035.00   | 1039.94   |           | 1040.97   | 0.006624   | 4.50     | 955.90    | 387.15    | 0.92         |
| Aparan                                  | 0         | 01JAN2007 1900 | 4296.97    | 1030.00   | 1035.09   | 1033.36   | 1035.25   | 0.001002   | 1.80     | 2389.12   | 930.53    | 0.36         |



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