# Case Studies of Recent Flood Events

by

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# Sunkosi land slide dam, Nepal

- On the 02.08.2014 at 2:35 AM a major landslide took place in the upper reaches of Sun Kosi river in Sindhupalchowk district in Nepal at a location having latitude: 27°45′40″ N, longitude: 85°52′08″ E

- The landslide location is around 1.2 km u/s of existing Sun Kosi Hydro Power Dam and around 11.3 km u/s of confluence of Sun Kosi and Bhute Kosi

- As per the initial information the depth of water column was approximately 50 m to 60 m. The reservoir thus formed submerged the area upto around 4 to 5 km u/s of the landslide location. The volume of the lake was about 2.2 MCM.

# Photograph of Land Slide Dam

# Data constraints

**Data available**

- Latitude and Longitude of land slide dam (LSD)location and photograph of LSD
- Approximate height of LSD and very rough estimate of reservoir volume
- Prevailing discharge at Kosi barrage located about 280 km downstream of land slide dam location, which was about 3540 cumec

**Data required**

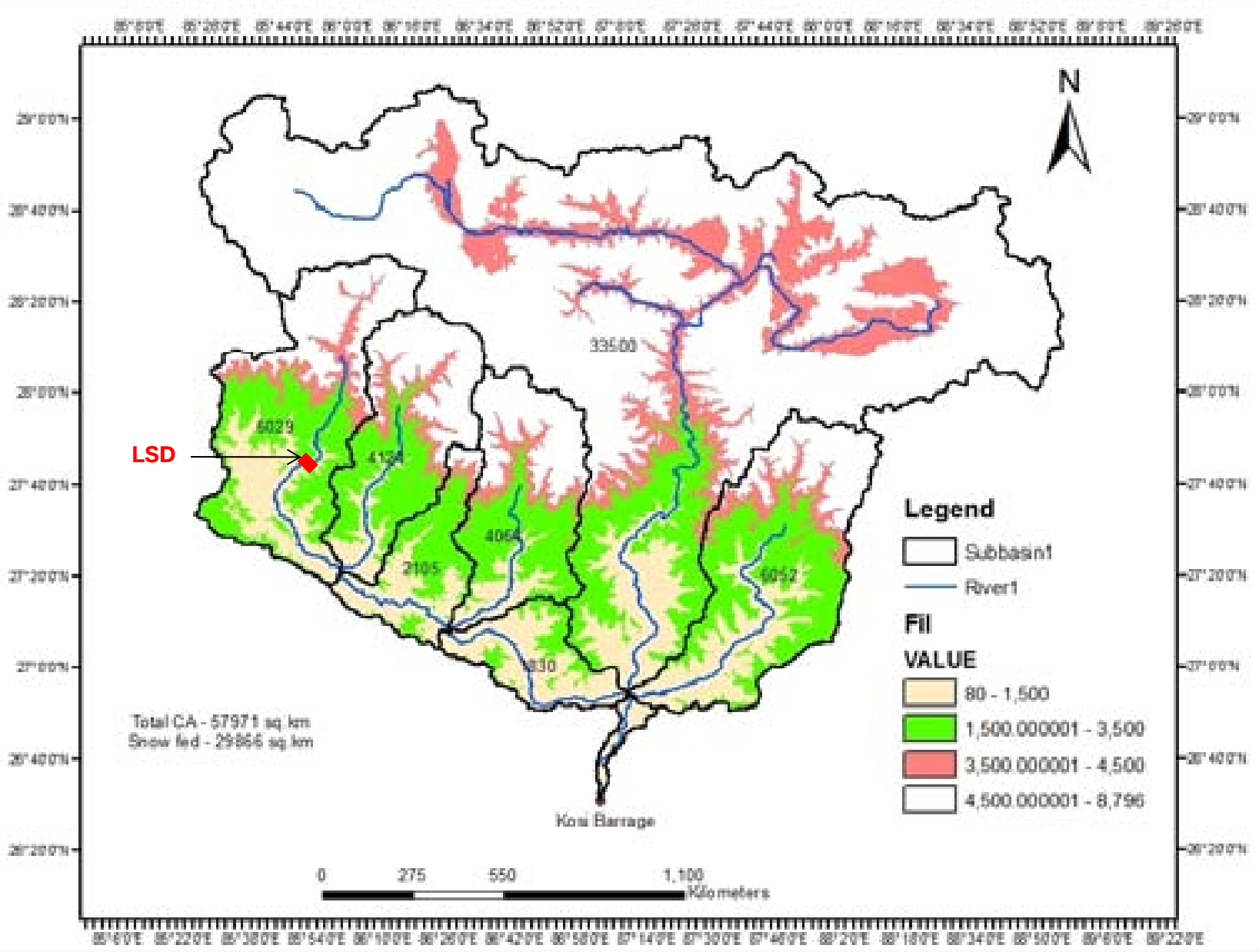
- Proper estimate of storage volume behind LSD
- Cross section of river from LSD location up to Kosi barrage
- Catchment area of the river at LSD and Kosi barrage

# Major Challenge

- To estimate the possible rise in Kosi water level in the event of LSD breach

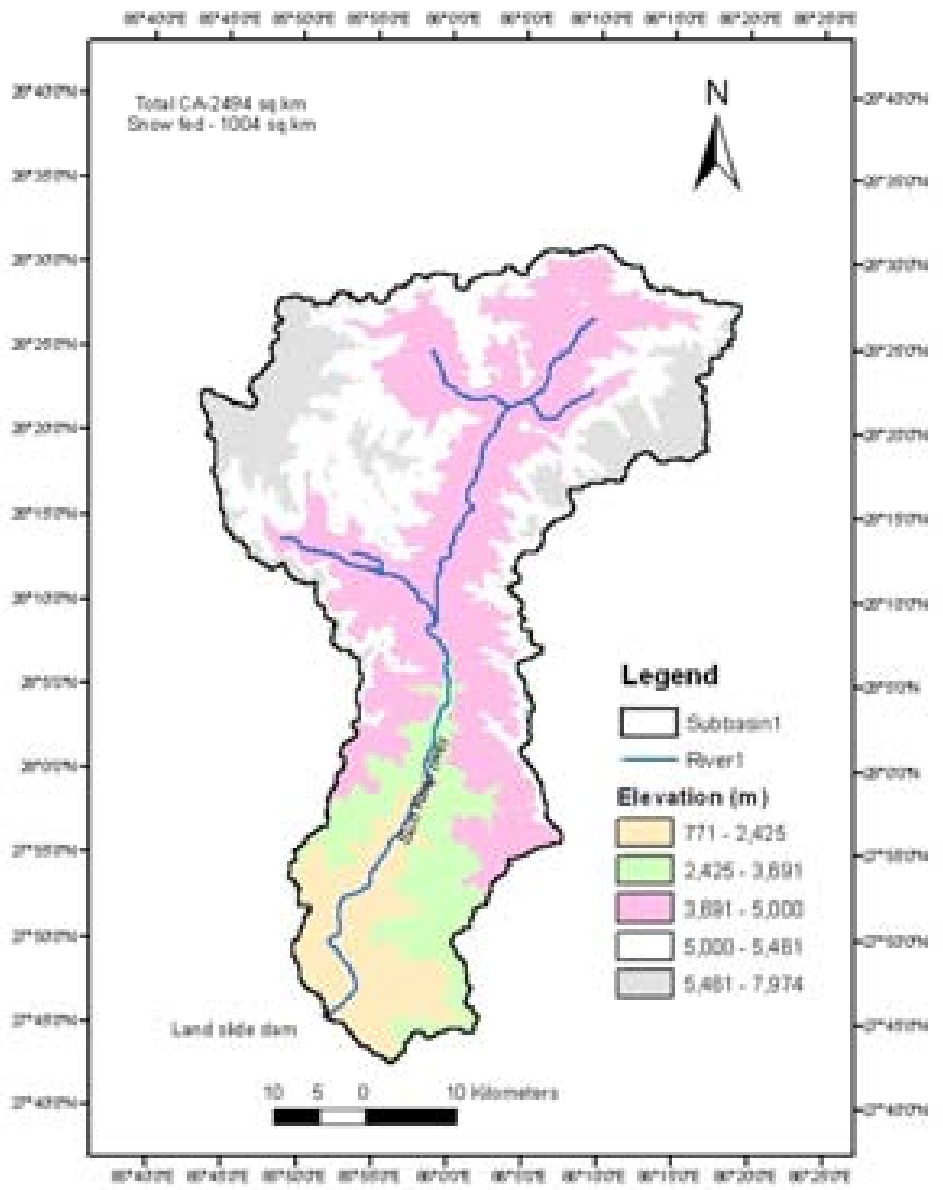
- To achieve the target, better estimate of storage volume behind LSD, catchment details and river cross sections from LSD upto Kosi barrage were essential

# Drainage area of Kosi river at Kosi barrage

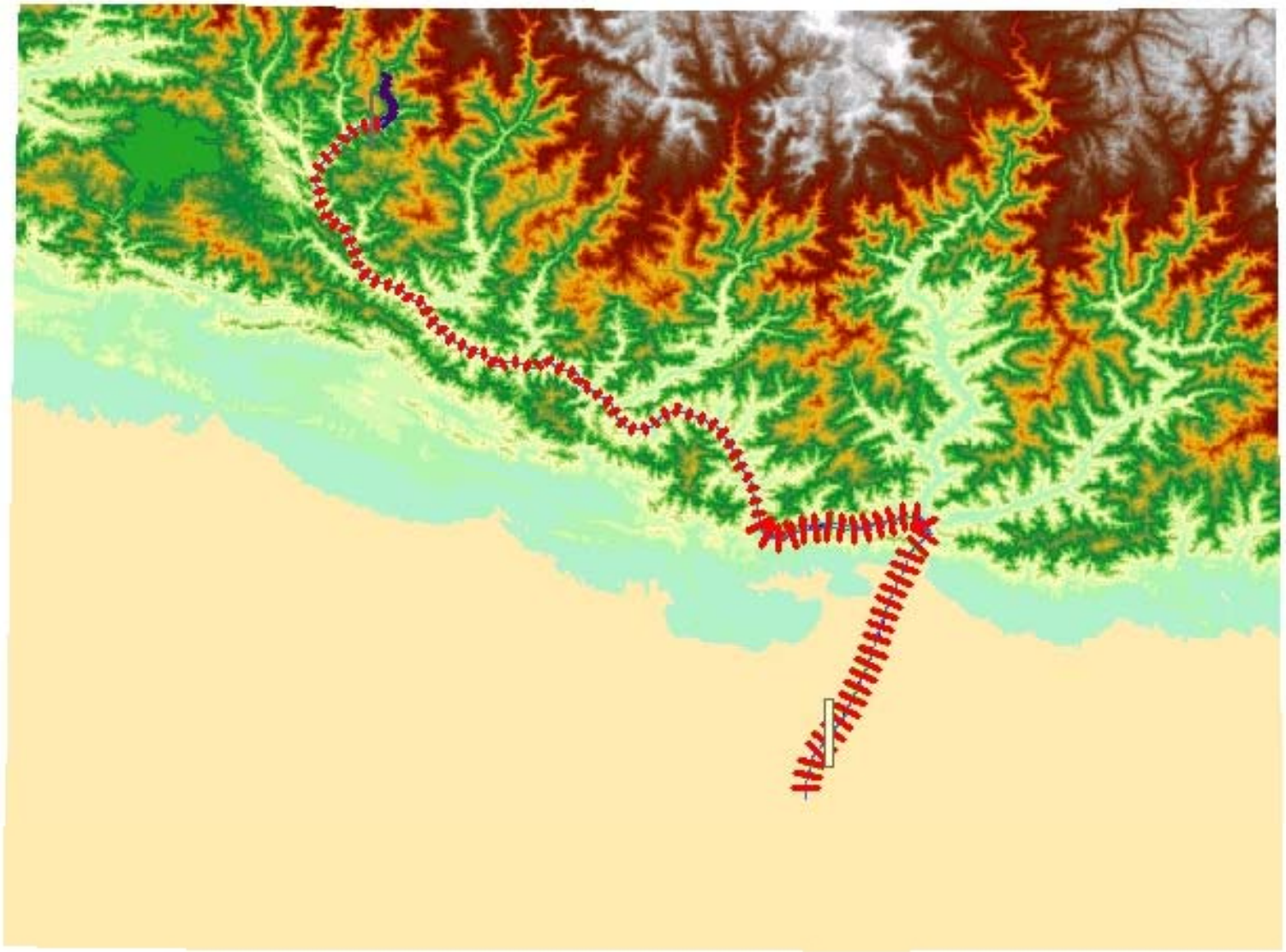


# Drainage area of Sun Kosi river at LSD

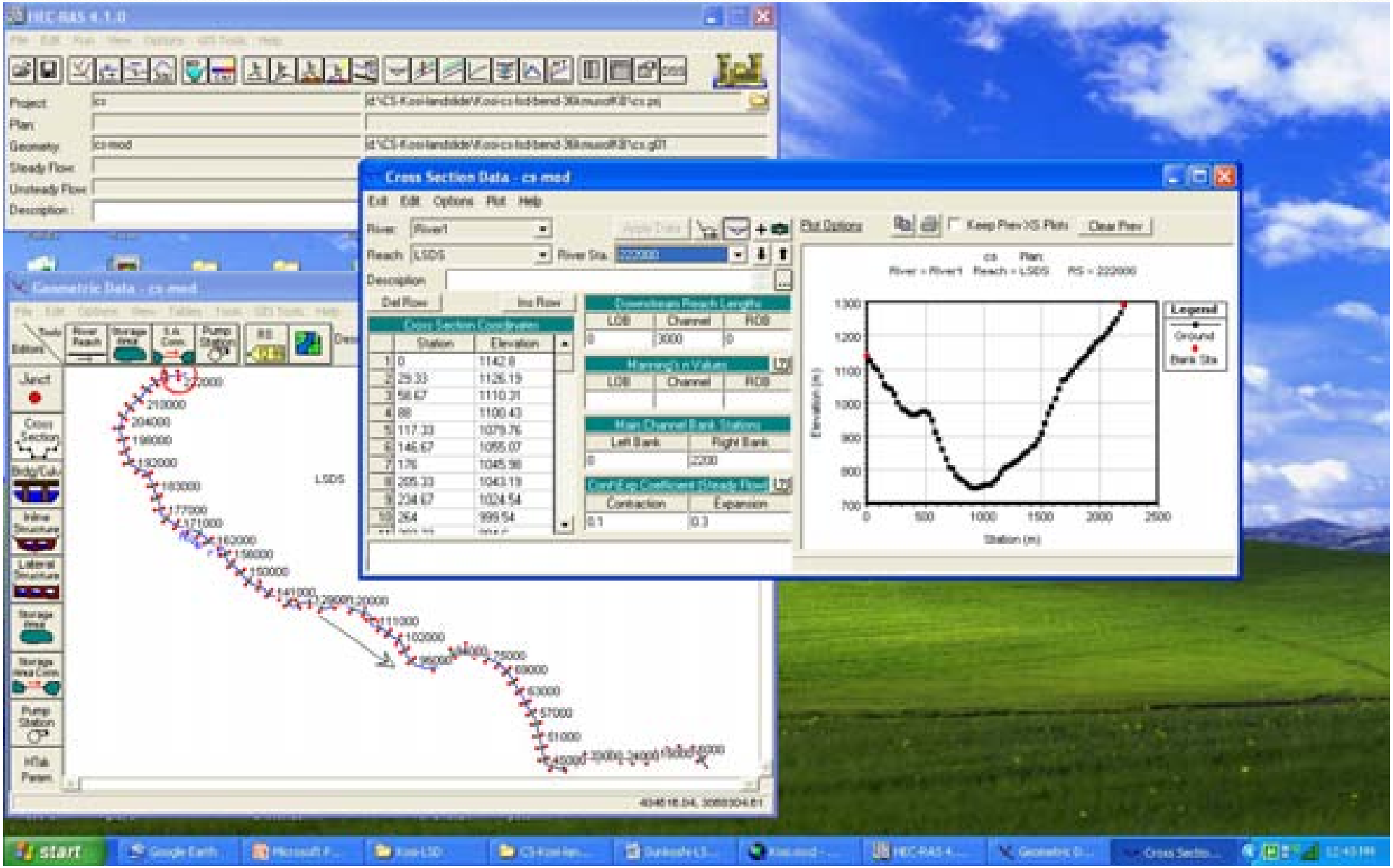
- Possible peak discharge for 60 mm rainfall in 24 hrs- 620 cumec
- Possible peak discharge for 80 mm rainfall in 24 hrs – 925 cumec



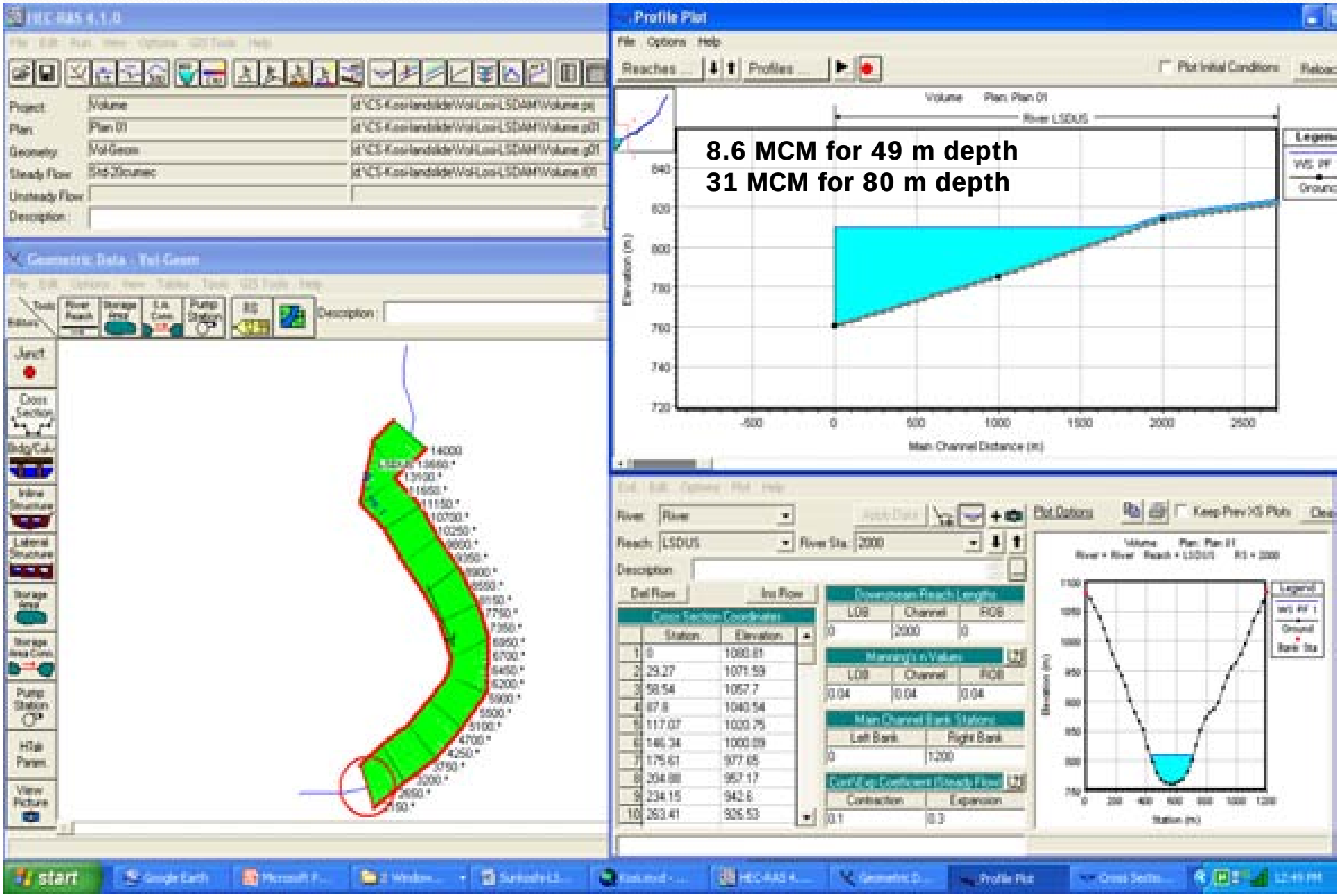
# ASTER DEM of Kosi Drainage area



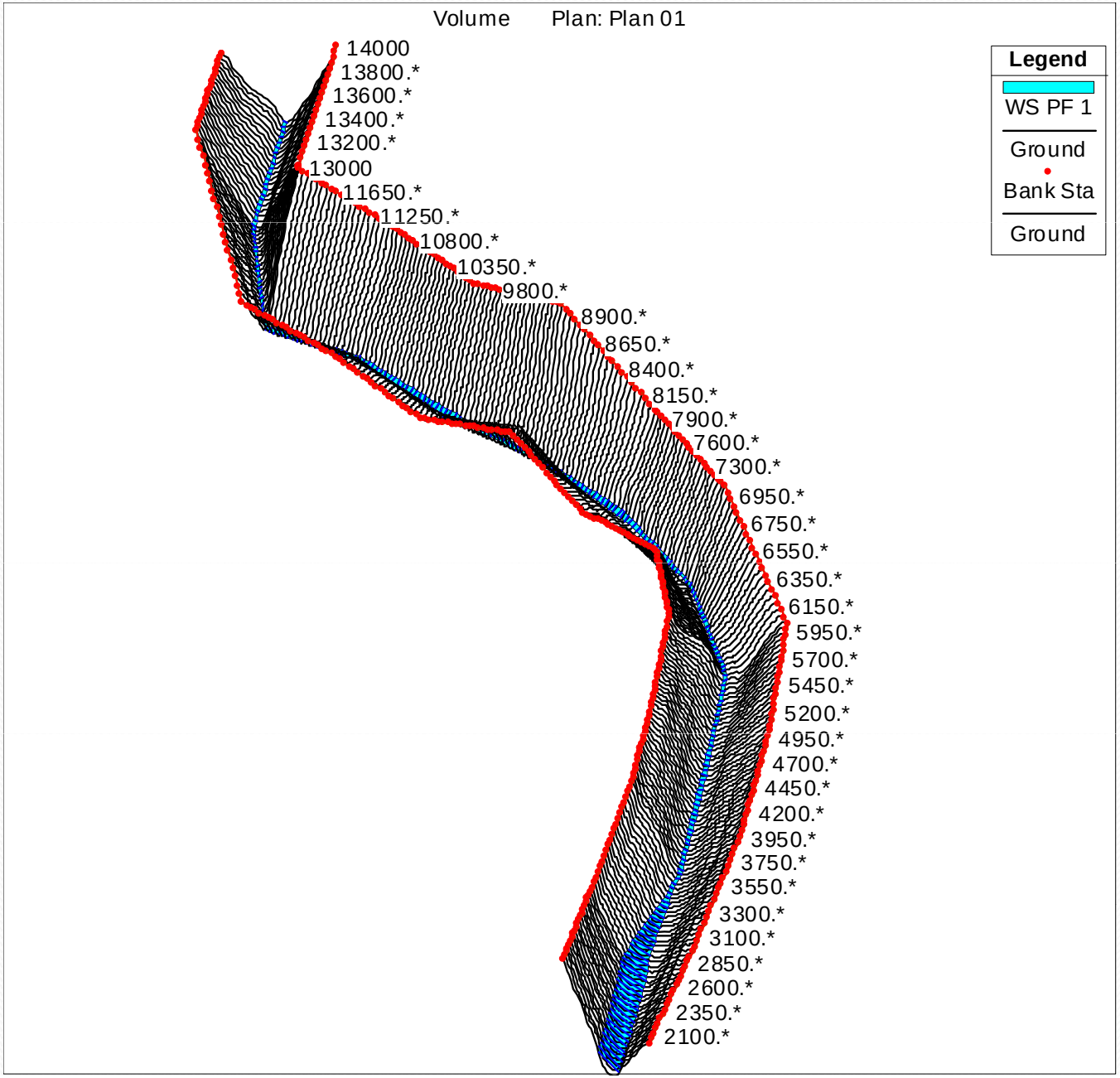
# Cross sections of Sun Kosi and Kosi rivers



# Estimate of storage volume behind LSD

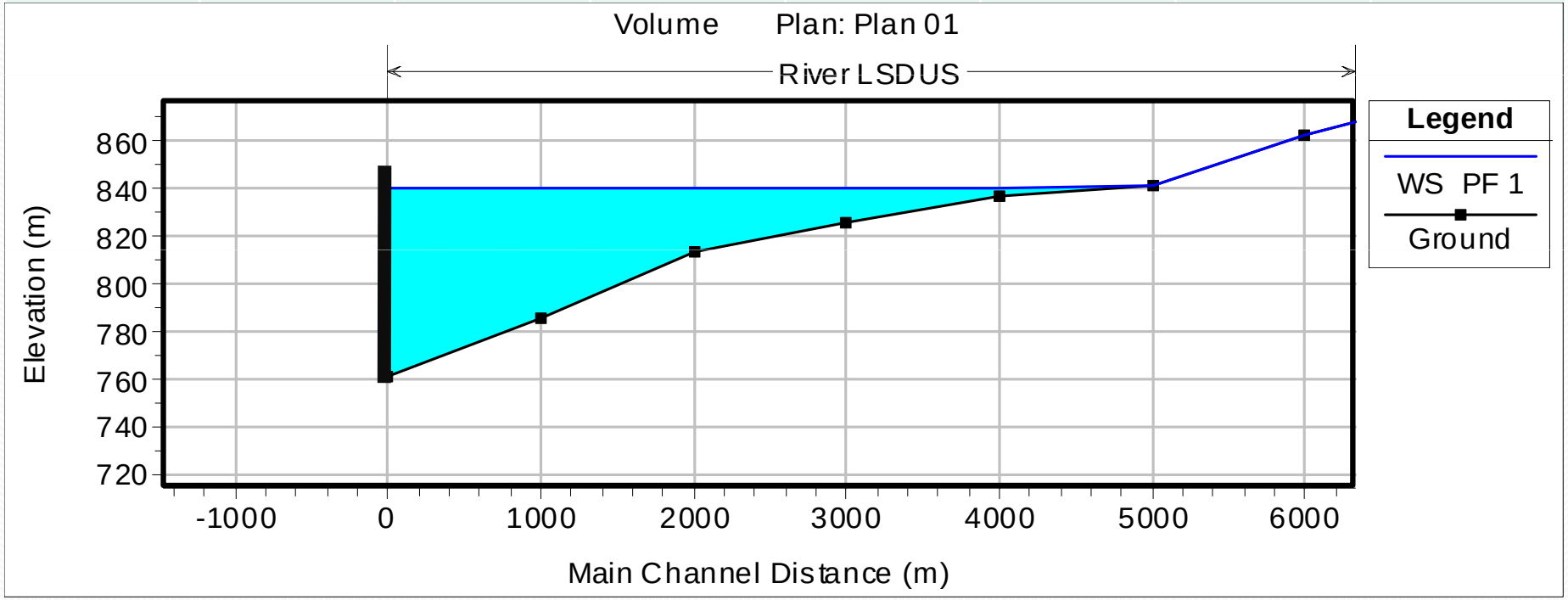


# 3D View of valley upstream of landslide dam on Sun Kosi

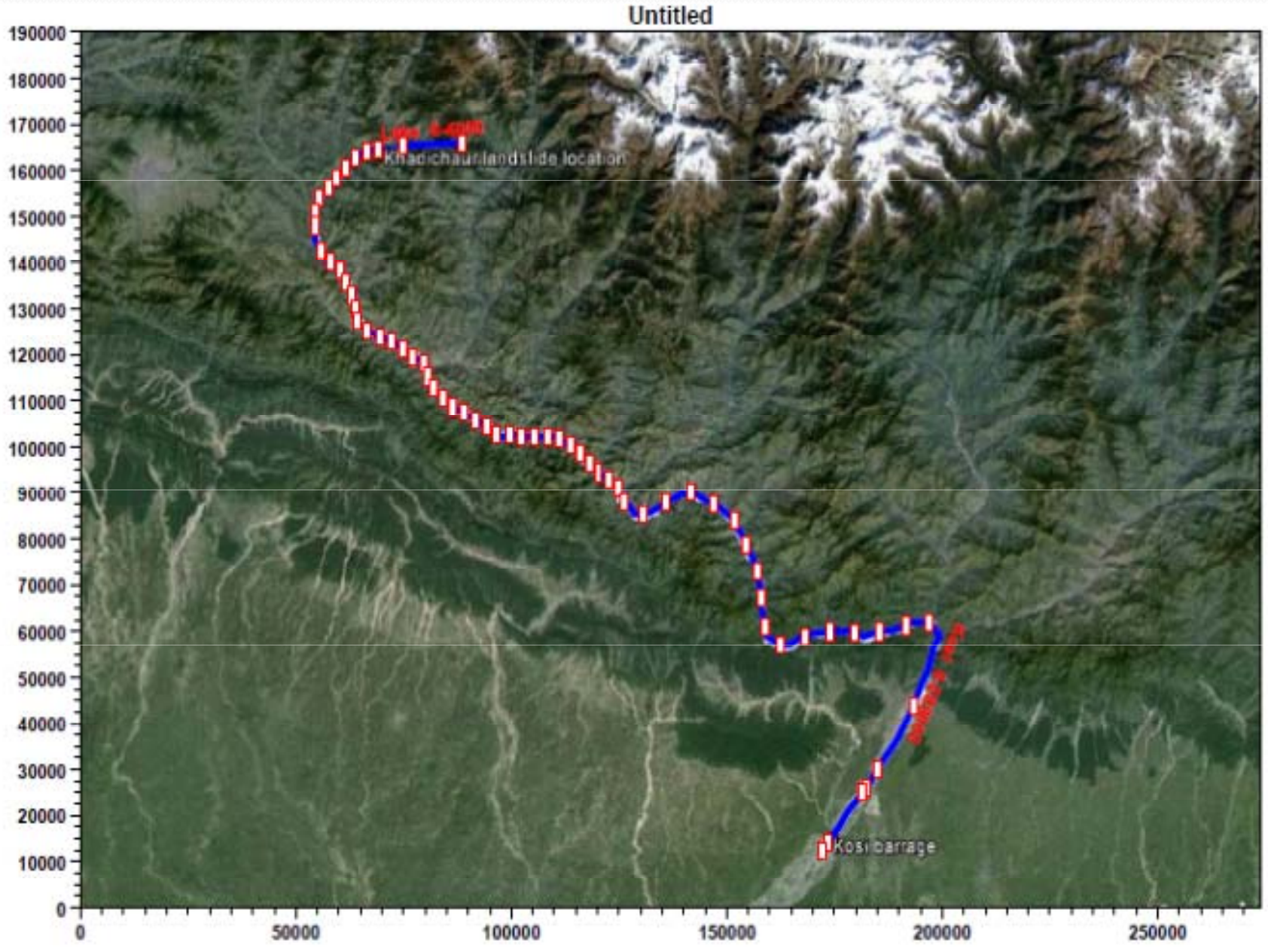


# Estimated volume for 80 m depth of water

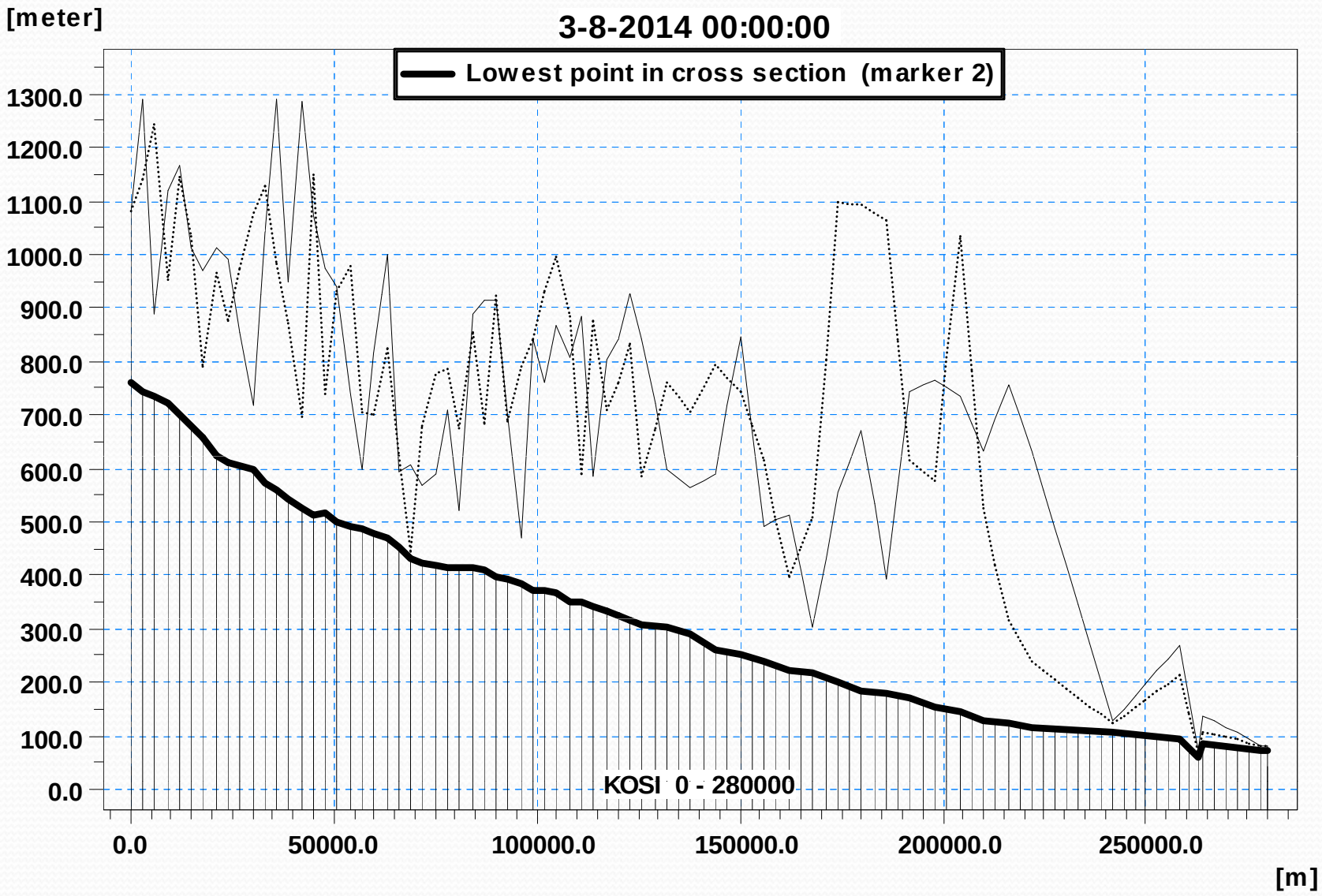
| Reach | River Sta | Profile | Min Ch El | W.S. Elev | Flow Area | Top Width | Volume |
|---|---|---|---|---|---|---|---|
| | | | (m) | (m) | (m2) | (m) | (1000 m3) |
| LSDUS | 8000 | PF 1 | 862.11 | 862.74 | 11.83 | 37.6 | 31248.43 |
| LSDUS | 7000 | PF 1 | 840.59 | 841.52 | 9.25 | 19.79 | 31237.89 |
| LSDUS | 6000 | PF 1 | 836.36 | 840 | 75.49 | 43.27 | 31195.52 |
| LSDUS | 5000 | PF 1 | 825.37 | 840 | 1600.46 | 157.22 | 30357.55 |
| LSDUS | 4000 | PF 1 | 813.73 | 840 | 3294.37 | 195.52 | 27910.13 |
| LSDUS | 3000 | PF 1 | 785.49 | 840 | 16380.13 | 474.23 | 18072.88 |



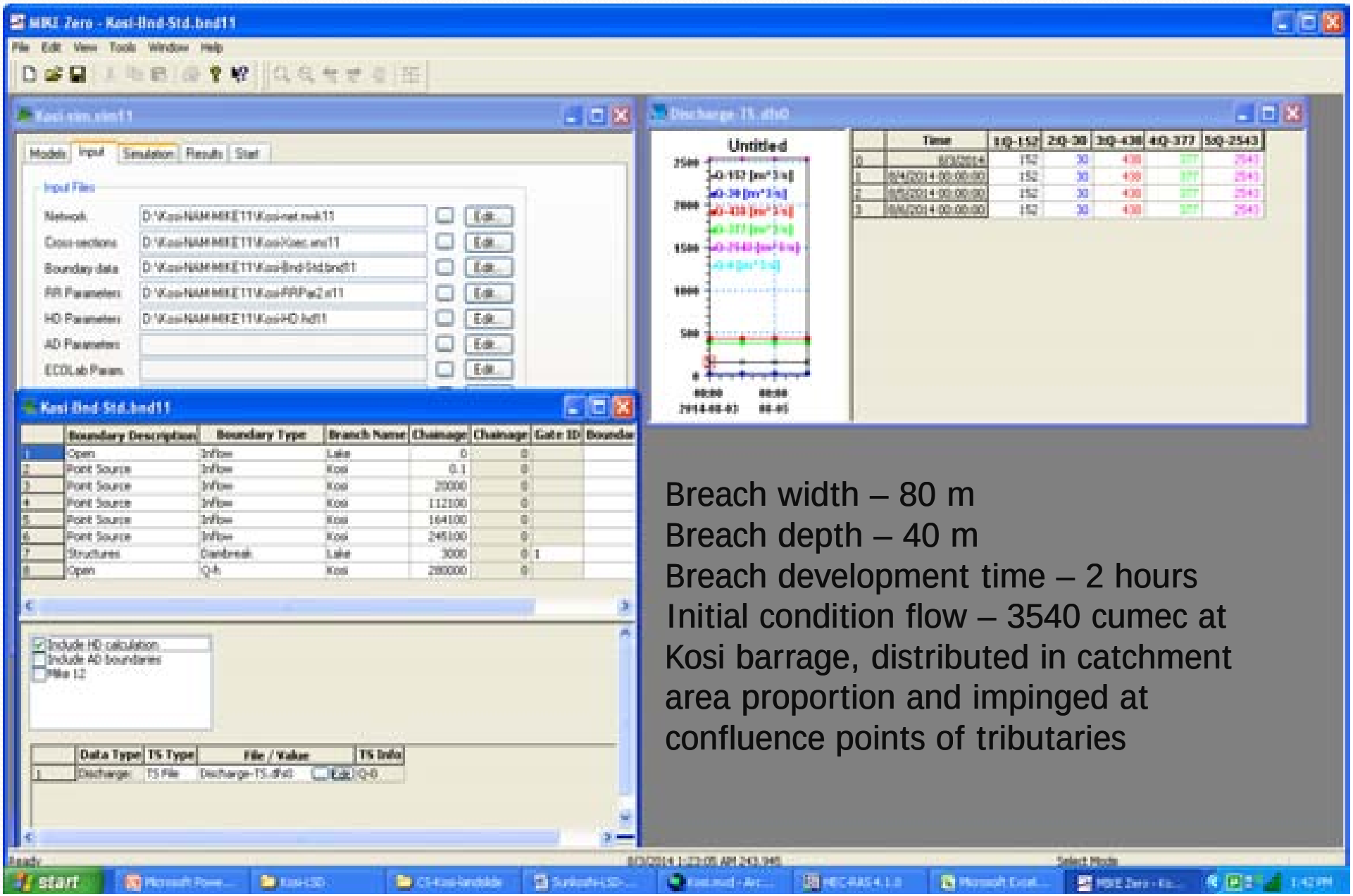
# MIKE11 model set up for dam break simulation



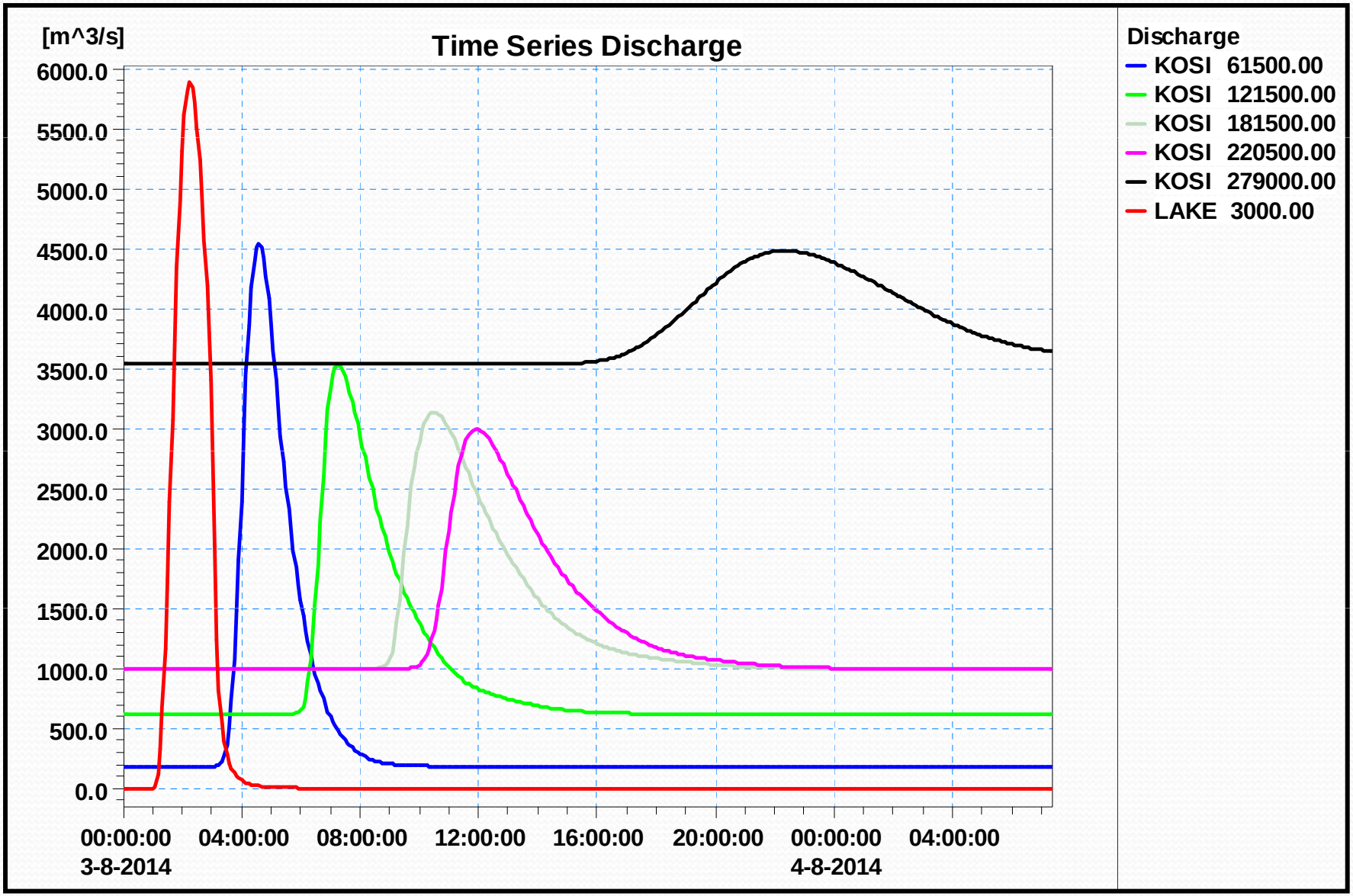
# Bed profile of river from land slide dam up to kosi barrage



# Distribution of Initial condition flow



# Flood peak and its travel time



# Flood peak and additional rise in water level

| Locatiom (m) downstream of land slide dam | Initial flood in river (cumec) | Initial flood + land slide dam breach flood (cumec) | Flood peak due to land slide dam (cumec) | Possible additional rise in water level due to land slide dam breach (m) | Flood peak occurrence time (date- hr:min |
|---|---|---|---|---|---|
| Land slide dam | 0 | 5885 | 5885 | 8.50 | 3/8/2014 2:15 |
| KOSI 1500.00 | 152 | 5977 | 5825 | 8.89 | 3/8/2014 2:19 |
| KOSI 4500.00 | 152 | 5895 | 5743 | 6.72 | 3/8/2014 2:30 |
| KOSI 7500.00 | 152 | 5858 | 5706 | 7.36 | 3/8/2014 2:34 |
| KOSI 22500.00 | 182 | 5764 | 5582 | 9.96 | 3/8/2014 2:55 |
| KOSI 31500.00 | 182 | 5413 | 5231 | 10.03 | 3/8/2014 3:19 |
| KOSI 124500.00 | 620 | 3470 | 2850 | 4.31 | 3/8/2014 7:24 |
| KOSI 175500.00 | 997 | 3197 | 2200 | 2.89 | 3/8/2014 10:04 |
| KOSI 237714.28 | 997 | 2618 | 1621 | 1.88 | 3/8/2014 13:34 |
| KOSI 279000.00 (Near Kosi barrage) | 3540 | 4482 | 942 | 0.44 | 3/8/2014 22:20 |

# Findings

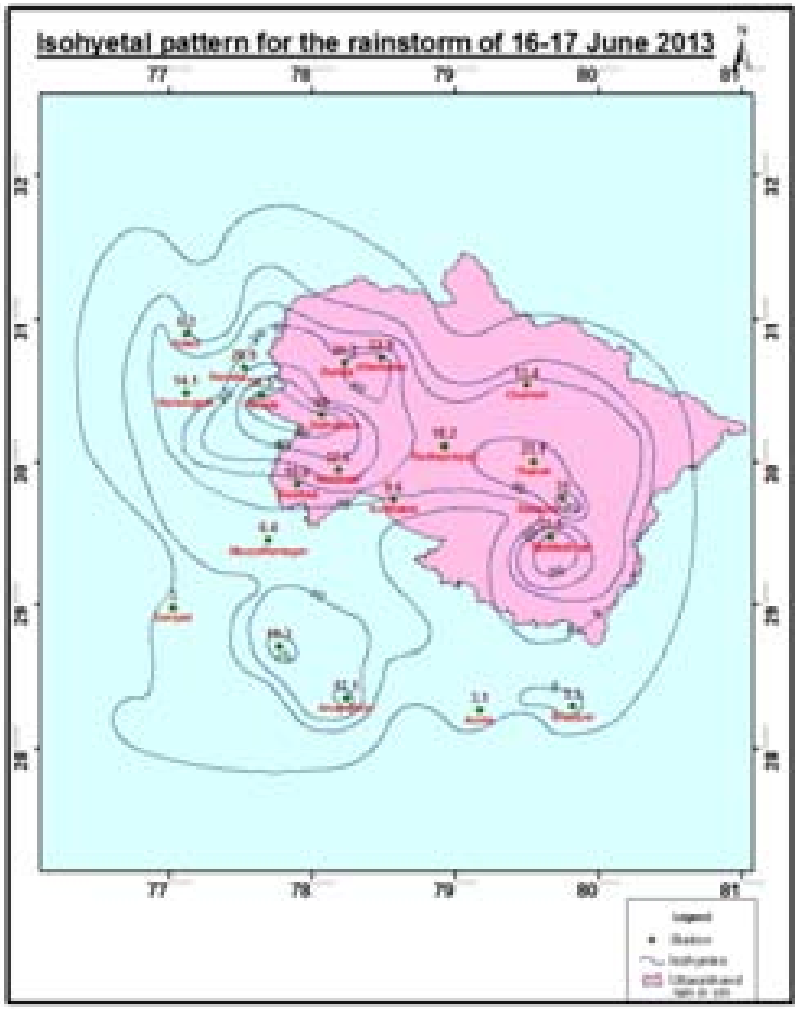
Due to breaching of landslide dam expected rise in water level :

- 8-10 m up to first 40 km in Nepal
- About 0.5 m in Indian Territory

# Uttarakhand Flood of June 2013

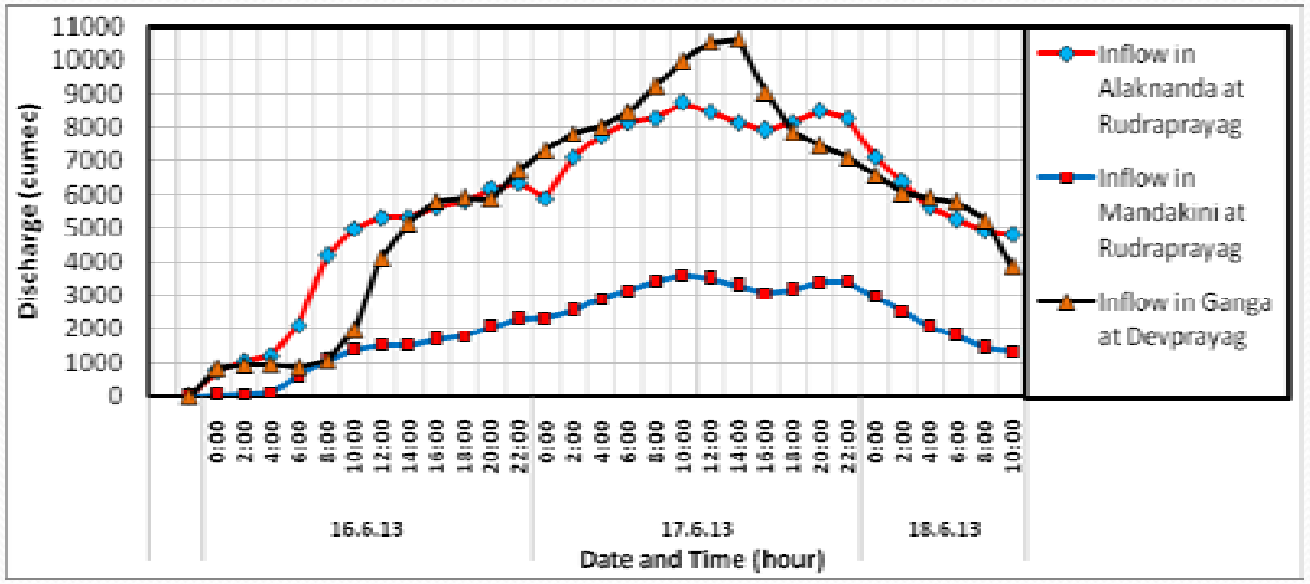
| Area (sq.km) | 1-day (17th June 2013) | 2-day (16-17th June 2013) |
|---|---|---|
| | Depth (cm) | Depth (cm) |
| Point (25 sq km) | 40.5 | 59.0 |
| 500 | 39.5 | 57.3 |
| 1000 | 38.5 | 55.5 |
| 2000 | 36.7 | 52.4 |
| 5000 | 32.4 | 45.2 |
| 10000 | 26.9 | 38.3 |
| 20000 | 21.4 | 31.0 |

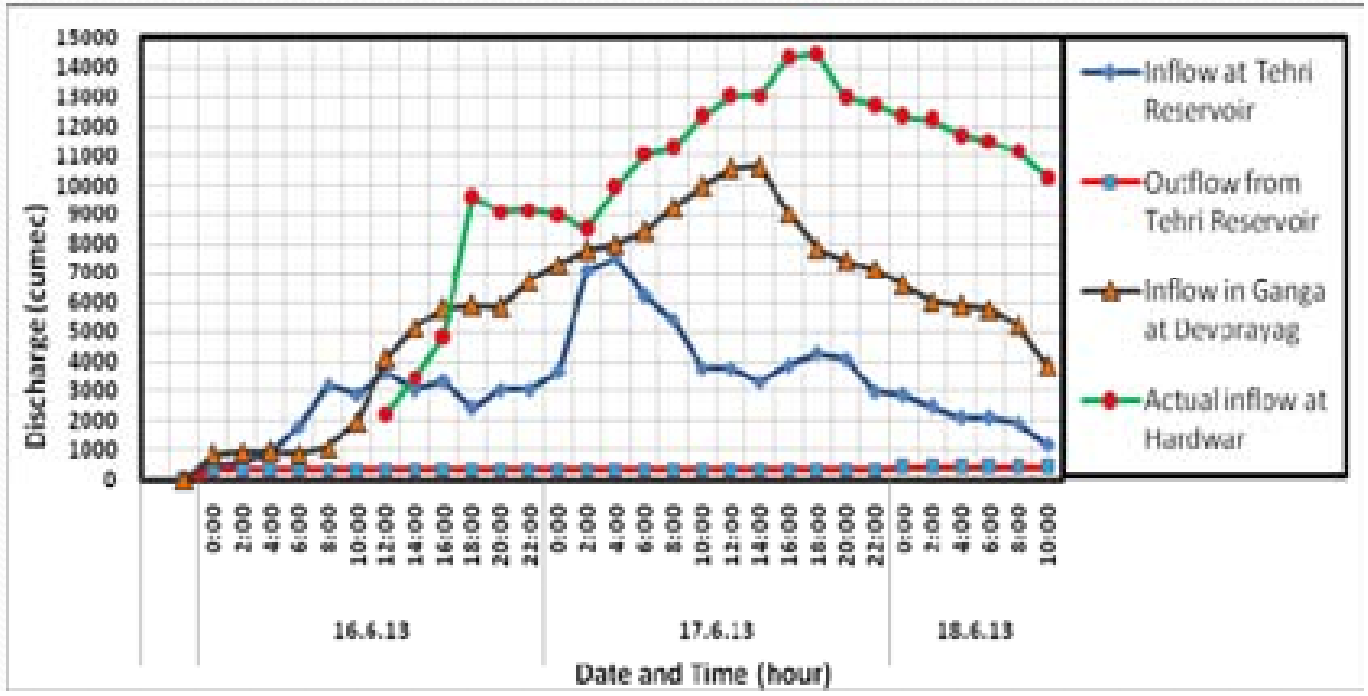
**WIHG Observatory at Chorabari Camp (EL 3820m) – 210 mm from 15th June 5PM 16th June 5AM, 115 mm in next 12 hours. 325 mm in 24 hr at EL 3820 m very rare event**



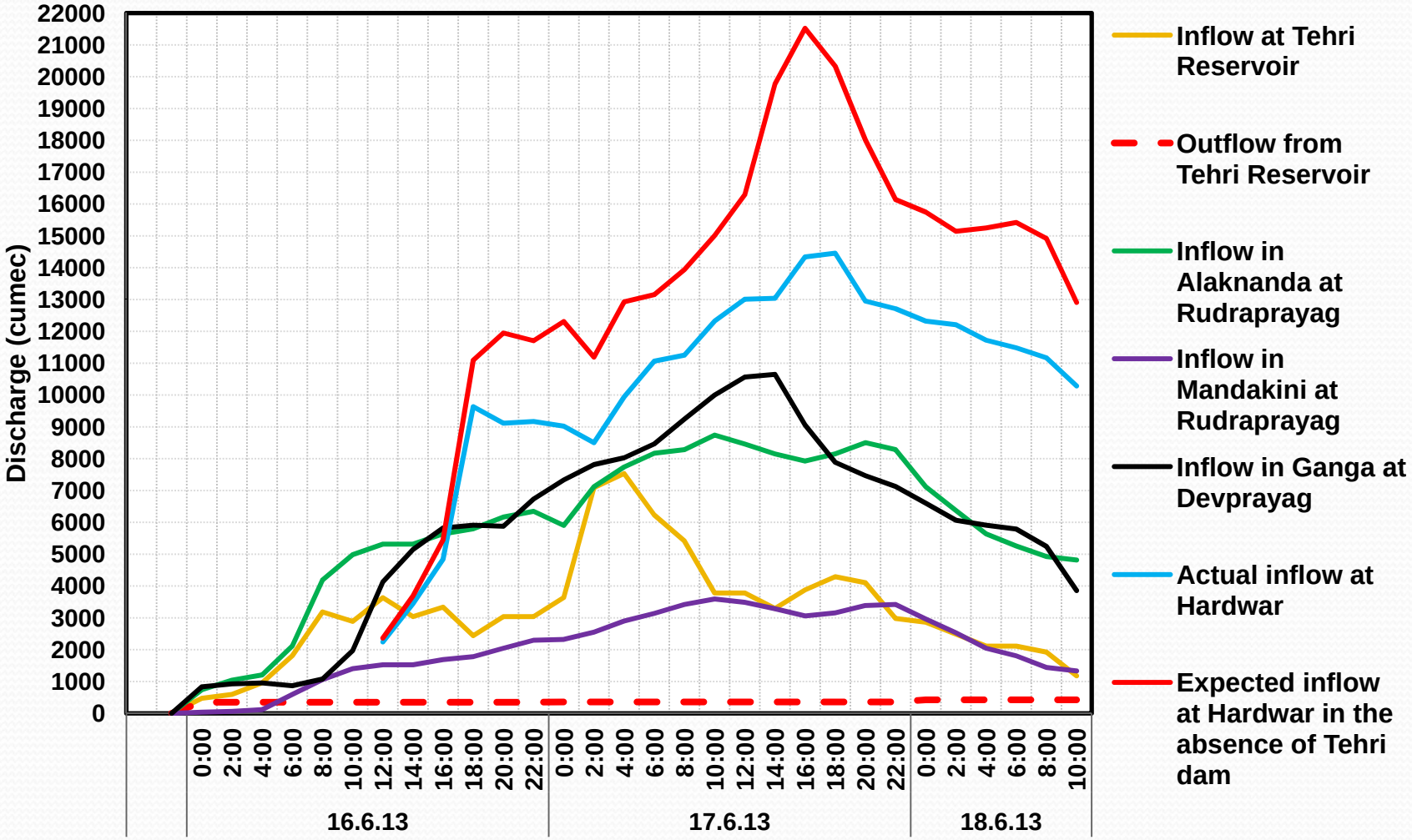
# FLOOD hydrograph of June-2013 Flood

| Location | Flood Peak (cumec) |
|---|---|
| Mandakini *Rudraprayag* | 3590 |
| Alaknanda *Rudraprayag* | 8740 |
| Bhagirathi *Tehri* | 7535 |
| Ganga *Devprayag* | 10647 |
| Ganga *Hardwar* | 14457 |



# Effect of Tehri Reservoir on Flood



# Flooding at Kedarnath

- On 16 June 2013 at 5:15PM, the torrential rains flooded the Saraswati River and Dudh Ganga catchment area, resulting in excessive flow across all the channels.

- The second event occurred on 17 June2013 at 6:45a.m., after overflow and collapse of the moraine dammed Chorabari Lake which released large volume of water that caused another flash flood in the Kedarnath town leading to heavy devastation downstream viz Gaurikund, Sonprayag, Phata, etc.

# Comparison of June-2013 flood with Historical Flood

| Name of site | River | Historical Flood Peak | | Date of establish-ment of Site / starting of observation | Flood Peak during June-2013 | |
|---|---|---|---|---|---|---|
| | | Discharge (cumec) | Date of occurrence | | Discharge (cumec) | Date of occurrence |
| Rudraprayag | Mandakani | 2500 | 05.09.1995 | 09.02.1971 | 3590 | 17.06.2013 |
| Rudraprayag | Alaknanda | 6500 | 05.09.1995 | 09.02.1971 | 8740 | 17.06.2013 |
| Devprayag | Ganga | 8900 | 05.09.1995 | 06.03.1972 | 10647 | 17.06.2013 |
| Rishikesh | Ganga | 10600 | 05.09.1995 | 01.12.1970 | 14457 (Hardwar) | 17.06.2013 |

**The September 1995 flood peak was due to storm of 05.09.1995 ocurred in the district Tehri-Garhwal in which 1 day recorded point rainfall was about 450 mm at Mukhim.**

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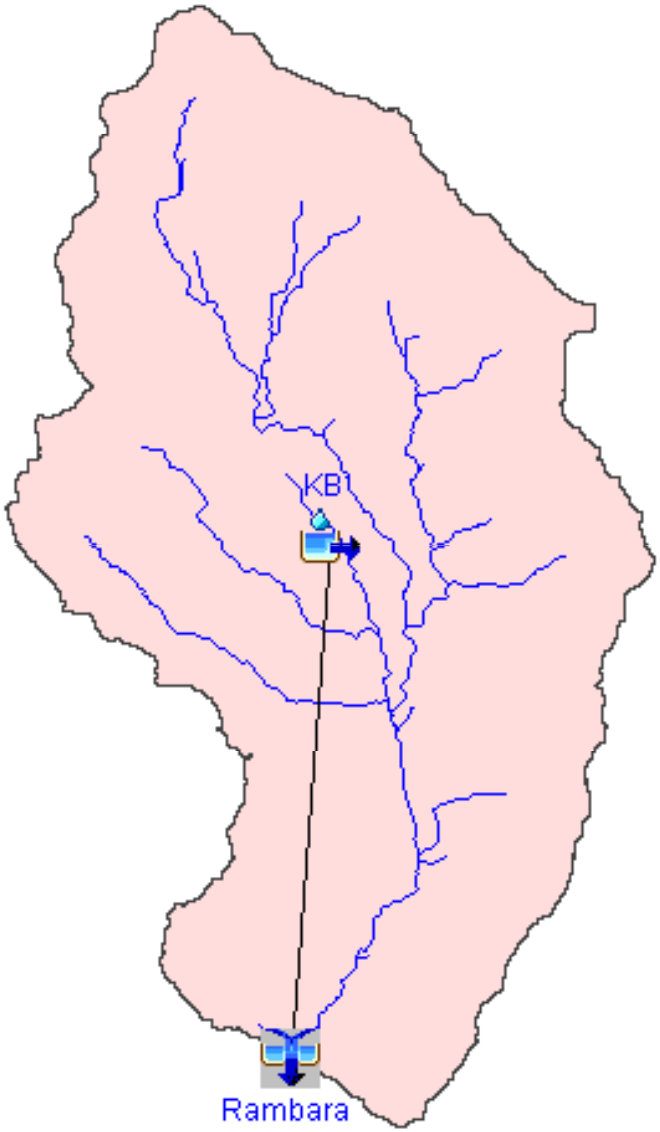
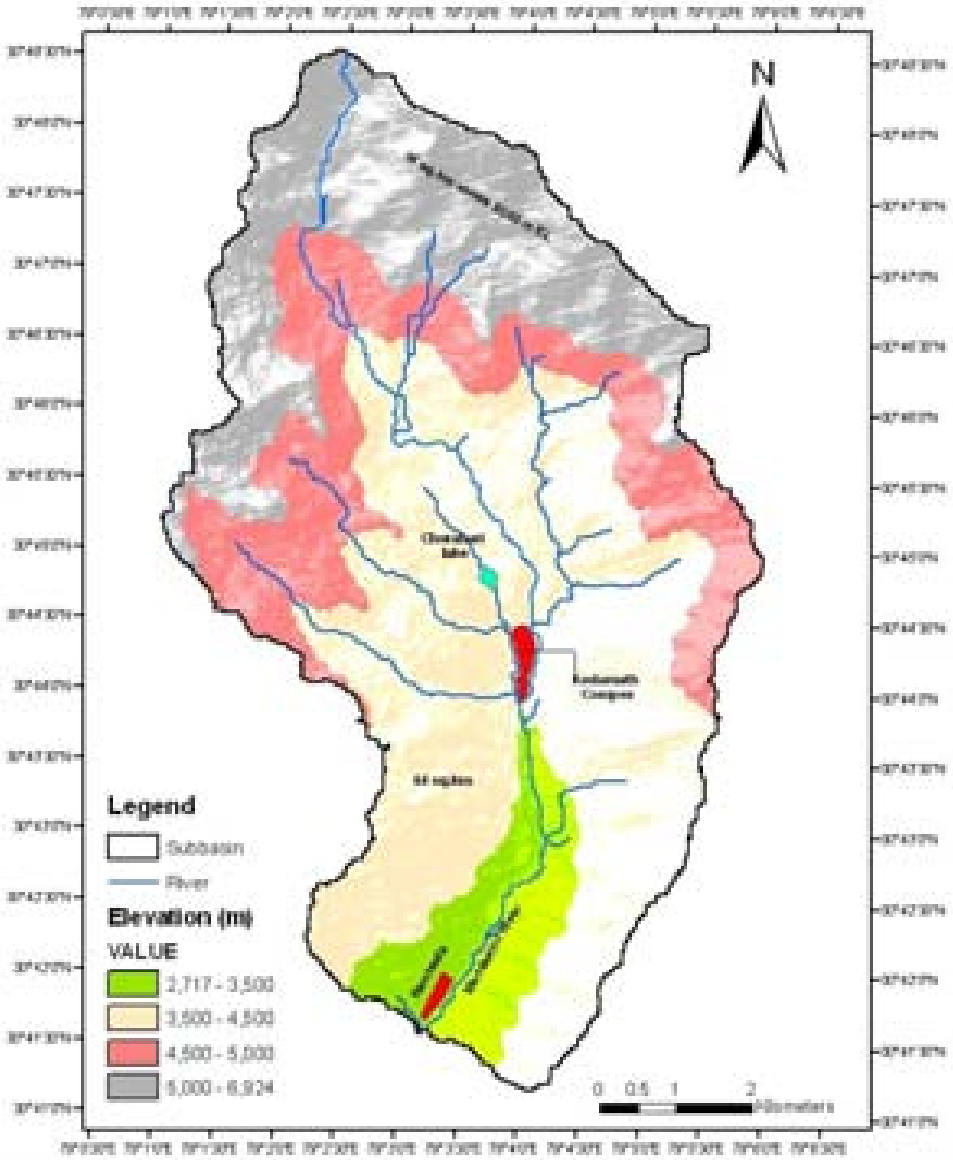
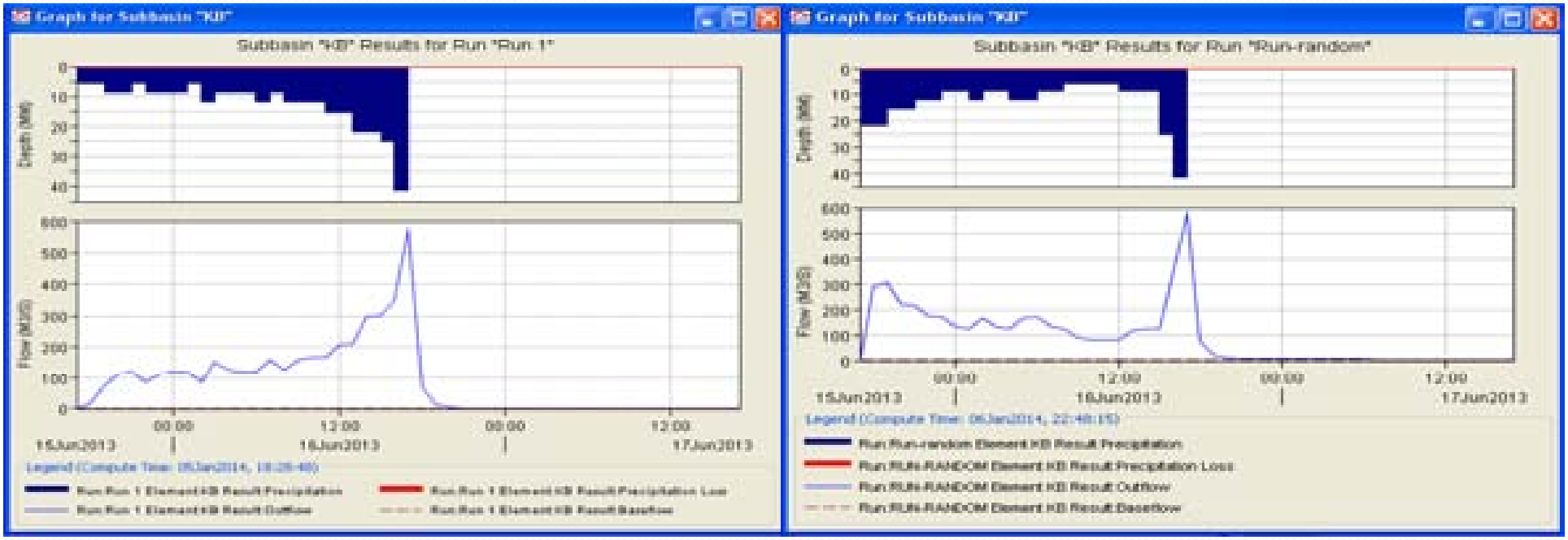
# Flood computations

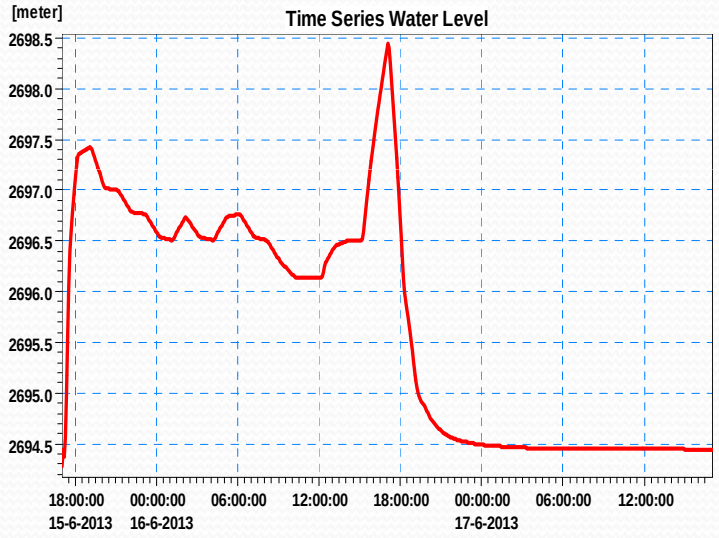
**Rainfed CA at Rambara-50 sq.km, SF-14 sq.km**

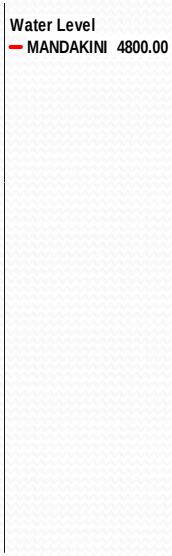


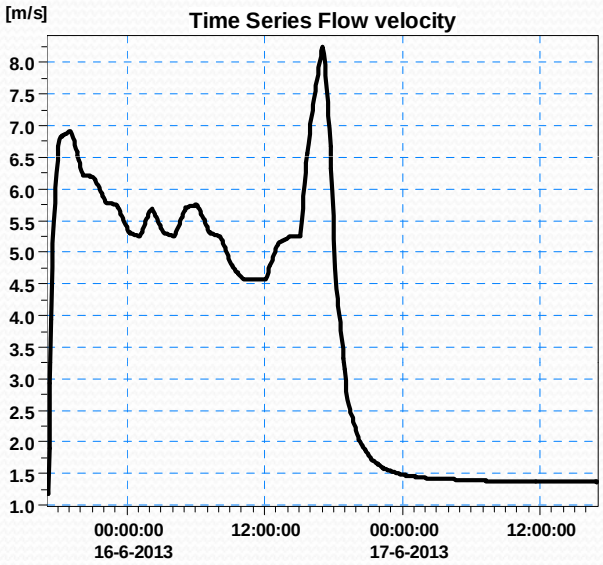



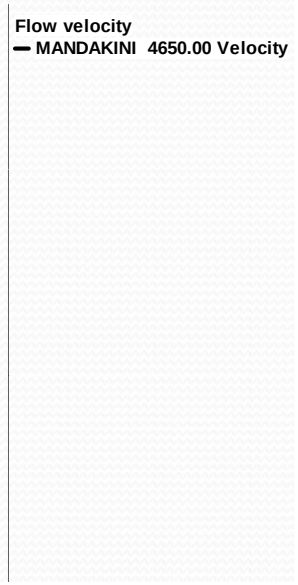
# Flood hydrograph, water depth and velocity



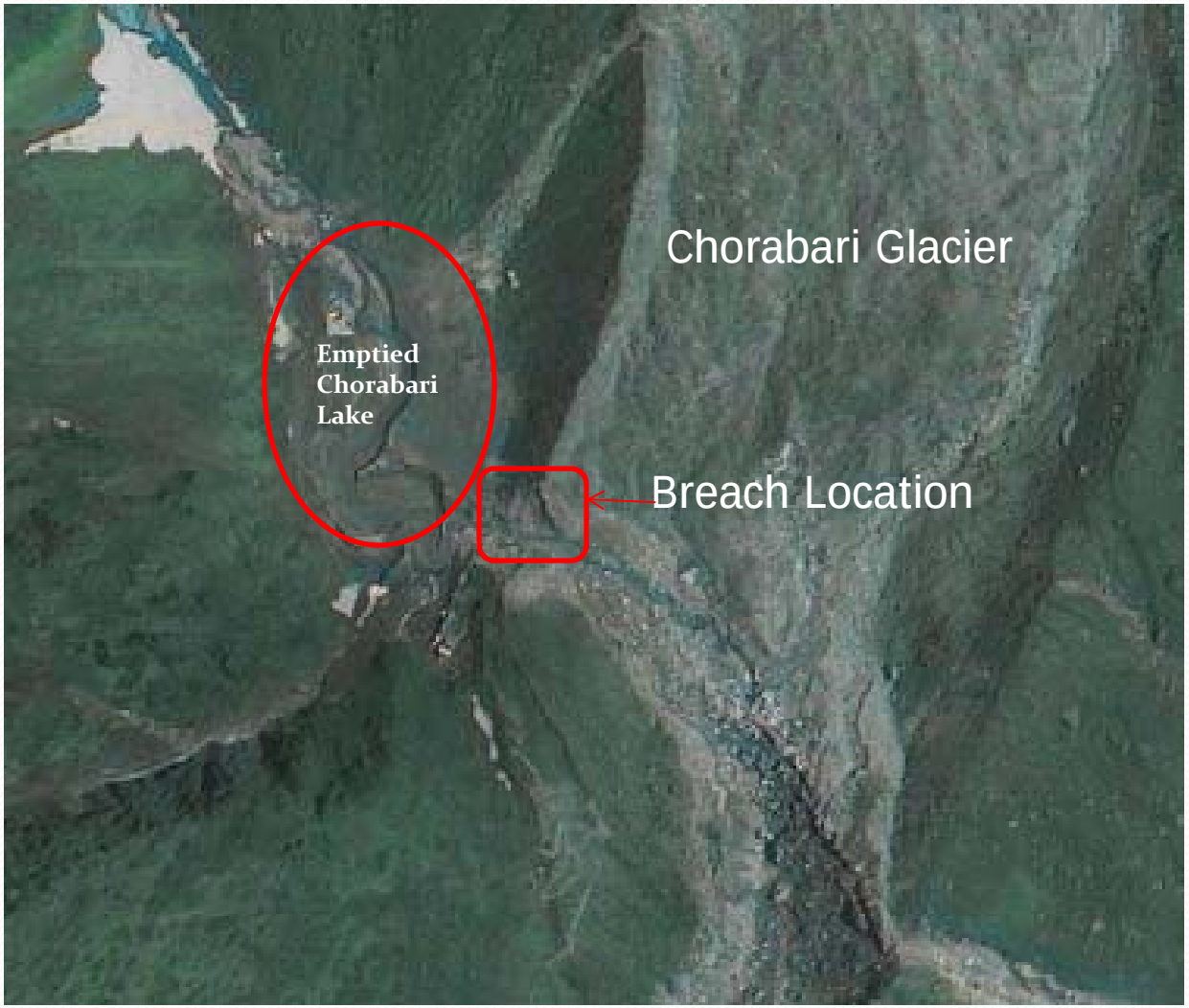



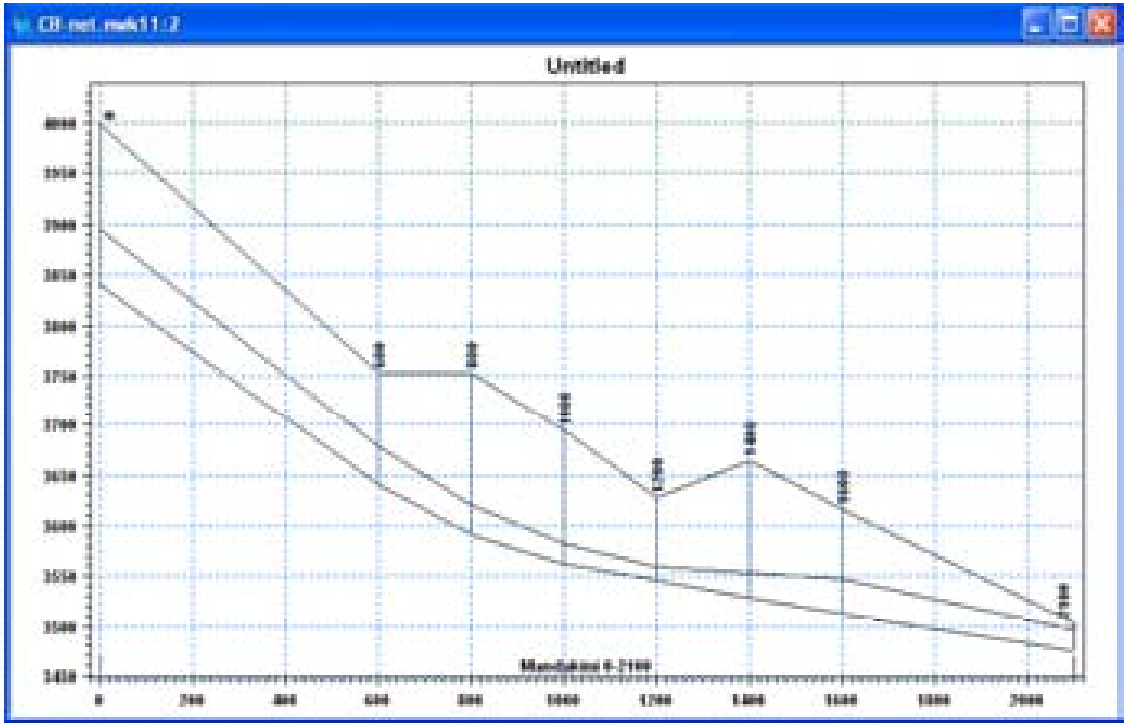



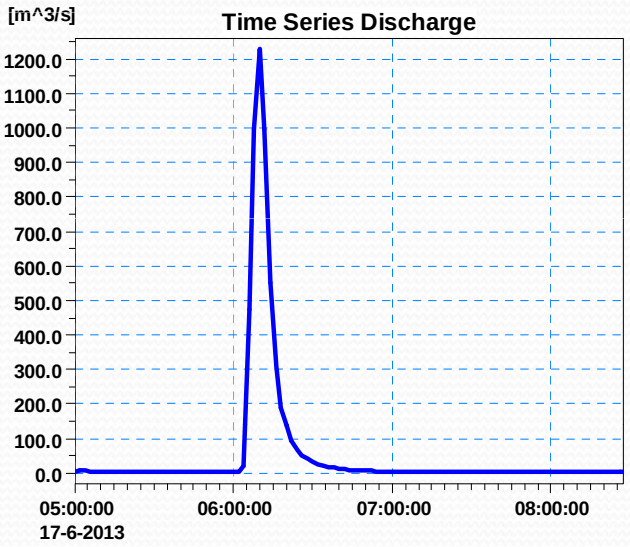



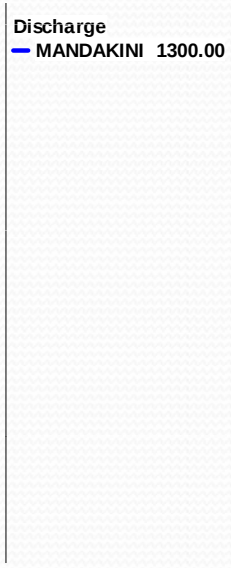
# Chorabari glacial lake burst

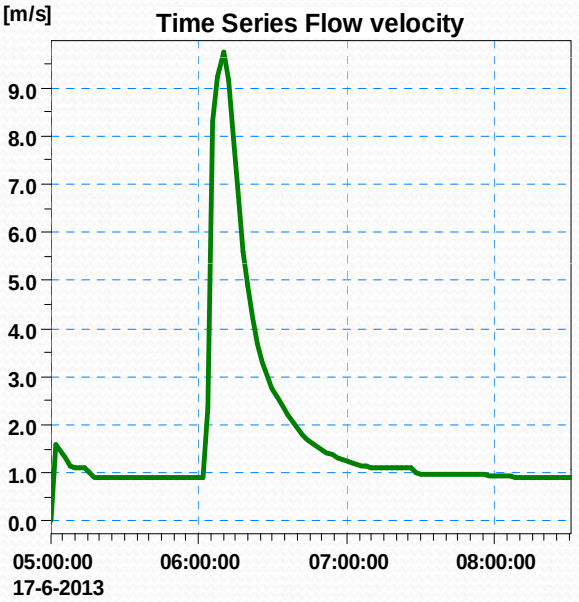


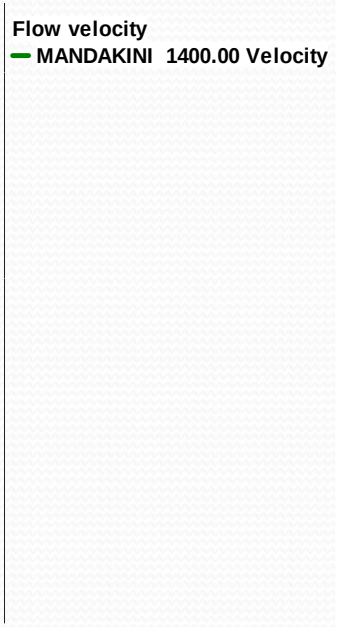
# Lake outburst flood



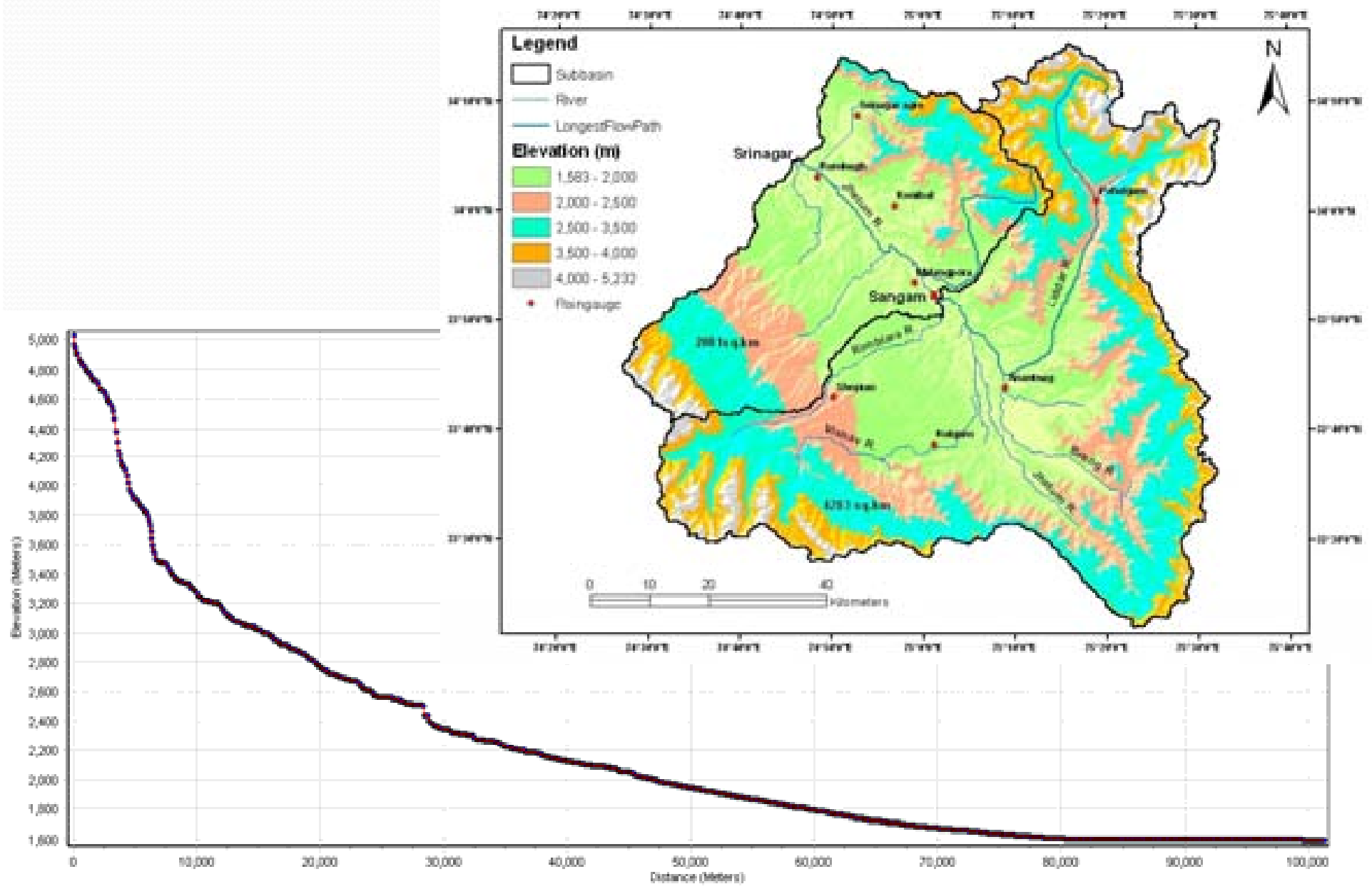
# Findings

- The continuous heavy rainfall coupled with the Chorabari lake outburst generated the flood wave with very high magnitude and velocity, causing heavy devastation in Himalayan Ganga.

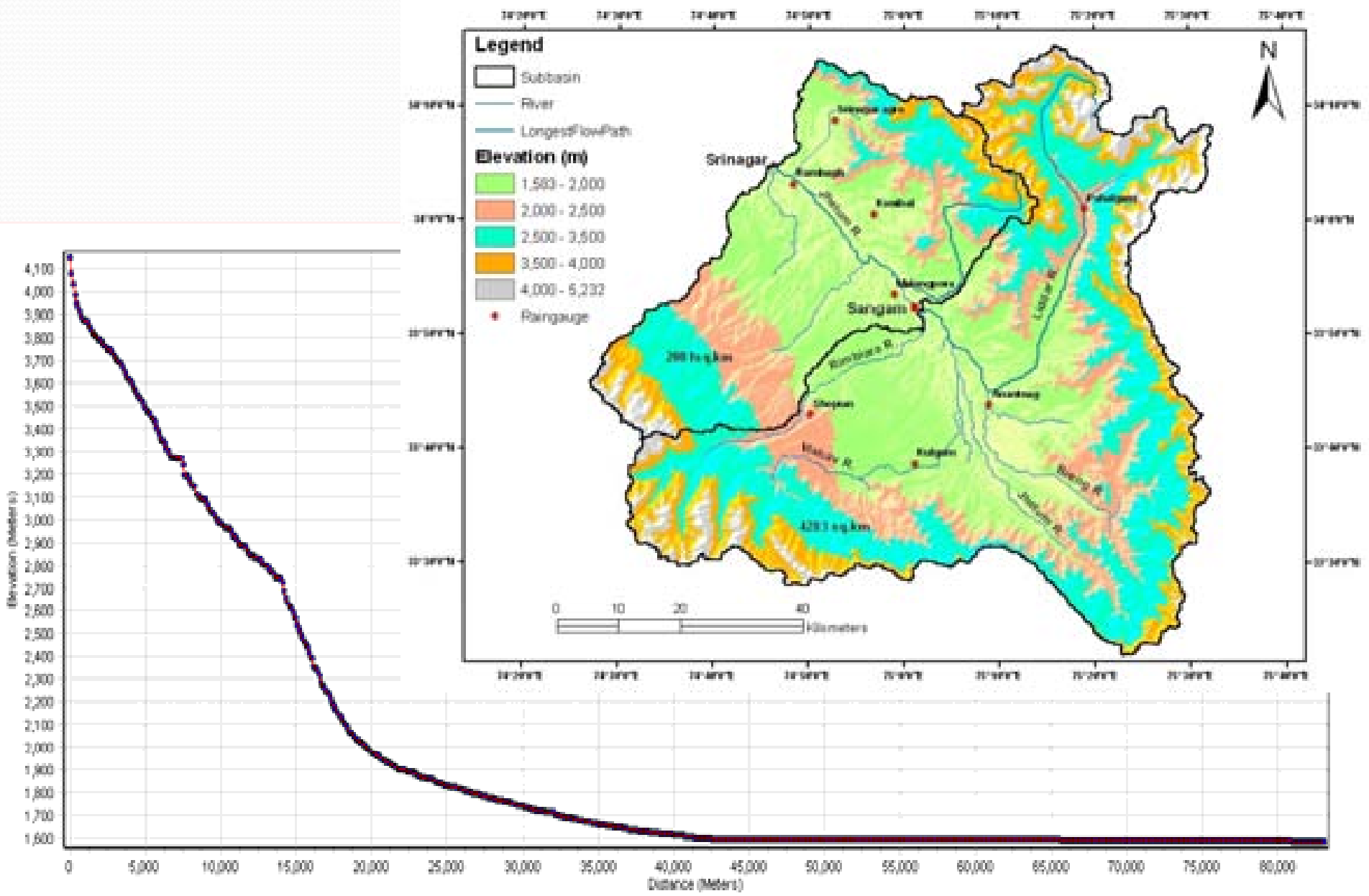
- There are a number of such flood occurrences in the past also but the magnitude of flood in river Ganga during 16-18$^{th}$ June 2013 was unprecedented. This is because the prolonged heavy rain in the entire drainage area of Ganga river in Uttarakhand, resulting simultaneous very high discharge in Alaknanda, Mandakini, Bhagirathi and other important tributaries of the river.

- The Tehri dam played a very important role in flood mitigation in the downstream area. It attenuated the flood peak at Hardwar by about 7000 cumec, resulting a flood peak of about 14500 cumec, which would otherwise had been about 21500 cumec

# J&K Flood of September-2014

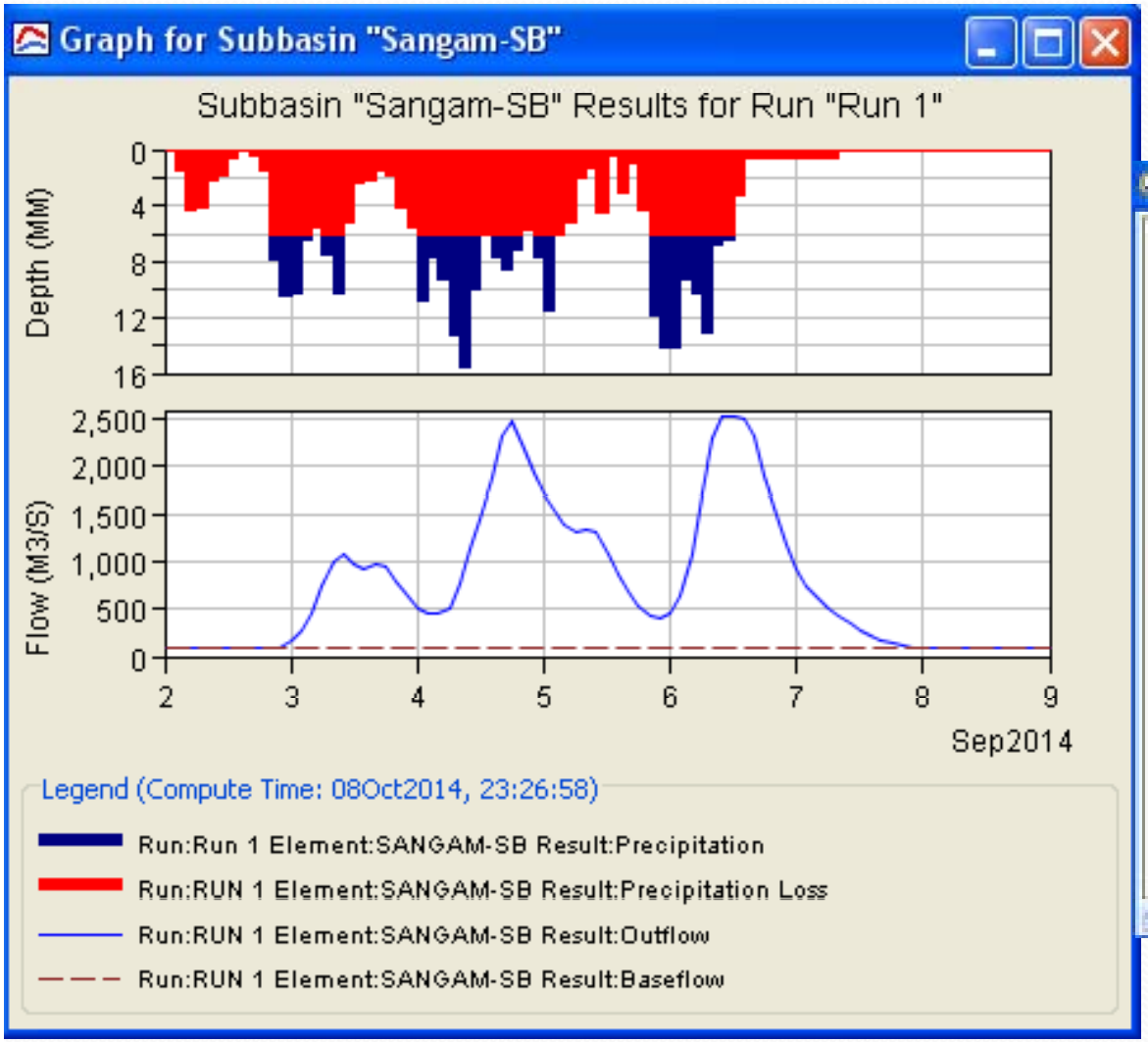


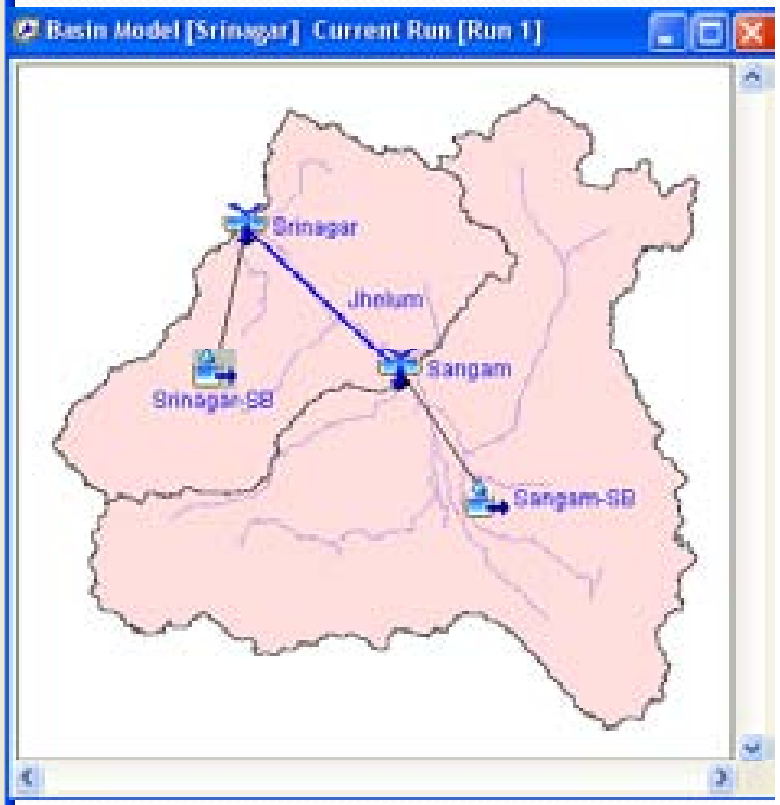
# Bed profile of river



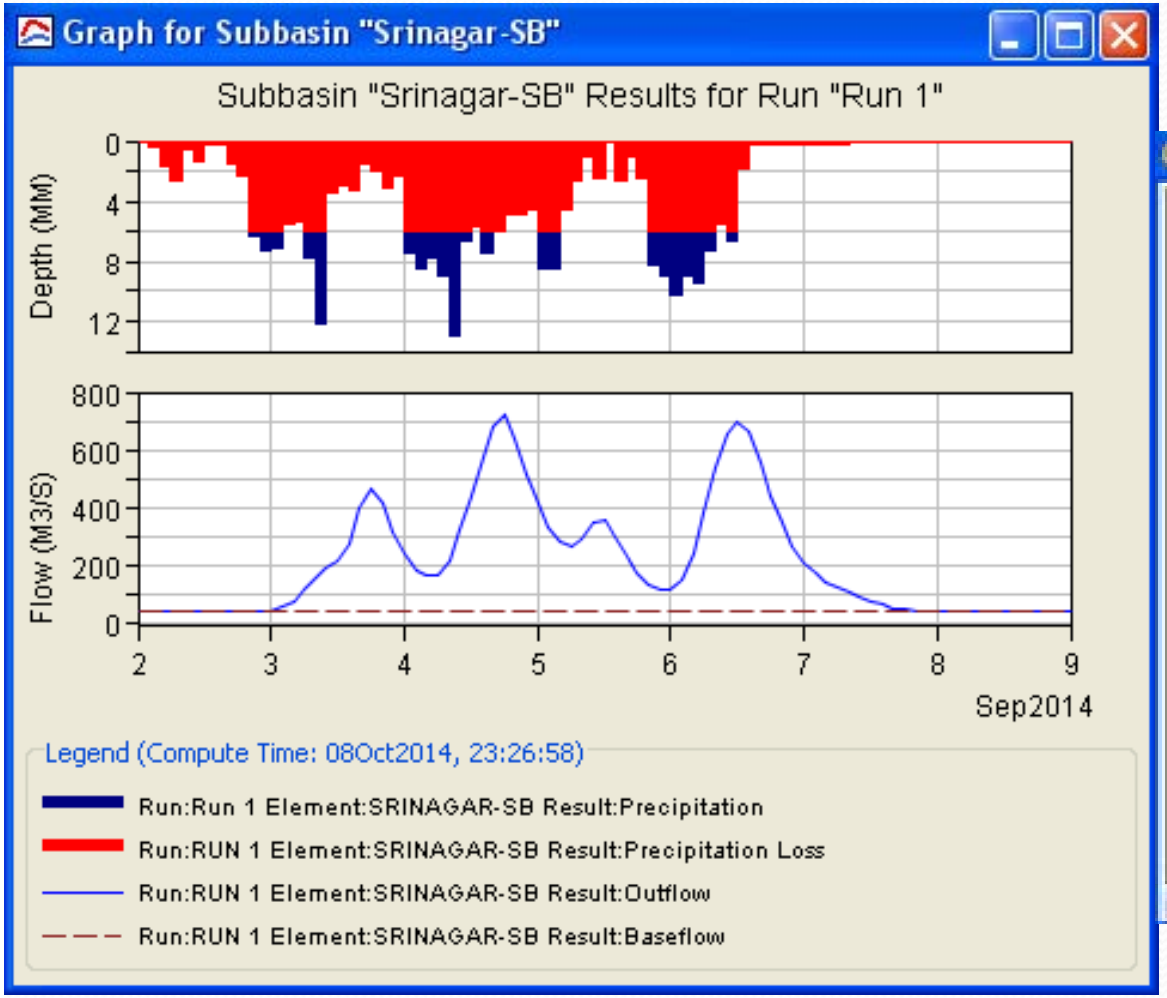
| Rainfall Departure from Normal during the J&K Floods in Jhelum Basin 3-7 September 2014 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| District | Actual rainfall (mm) from 3-7 September | District Level Monthly Normal Rainfall (mm) | | | | | | District Level daily normal rainfall (mm) between 3-7 Sept | % Dep |
| | | Jul | % Dep | Aug | % Dep | Sep | % Dep | | |
| Phulwama | 311 | 42 | 640 | 47 | 562 | 36 | 764 | 4.9 | 6247 |
| Pahalgam | 248 | 88 | 182 | 82 | 202 | 50 | 396 | 8 | 3000 |
| Kulgam | 394 | 80 | 393 | 79 | 399 | 67 | 488 | 14.2 | 2675 |
| Shopian | 389 | 85 | 358 | 92 | 323 | 46 | 746 | 6.5 | 5885 |
| Srinagar | 175 | 56 | 213 | 61 | 187 | 30 | 483 | 4.9 | 3471 |
| Av | 303.4 | 70.2 | 332 | 72.2 | 320 | 45.8 | 562 | 7.7 | 3840 |

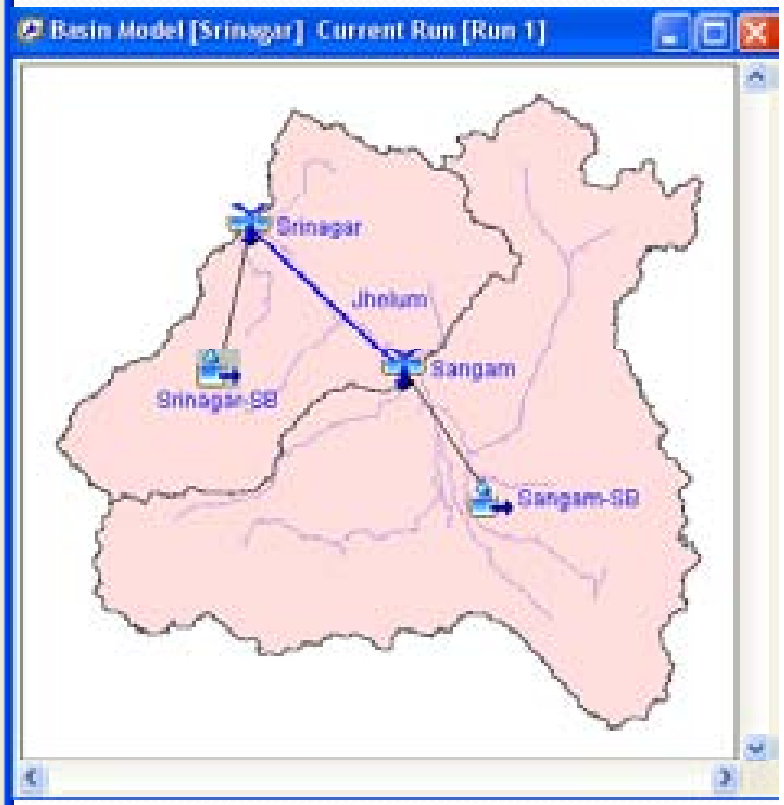
# Flood contribution of Sangam Sub basin



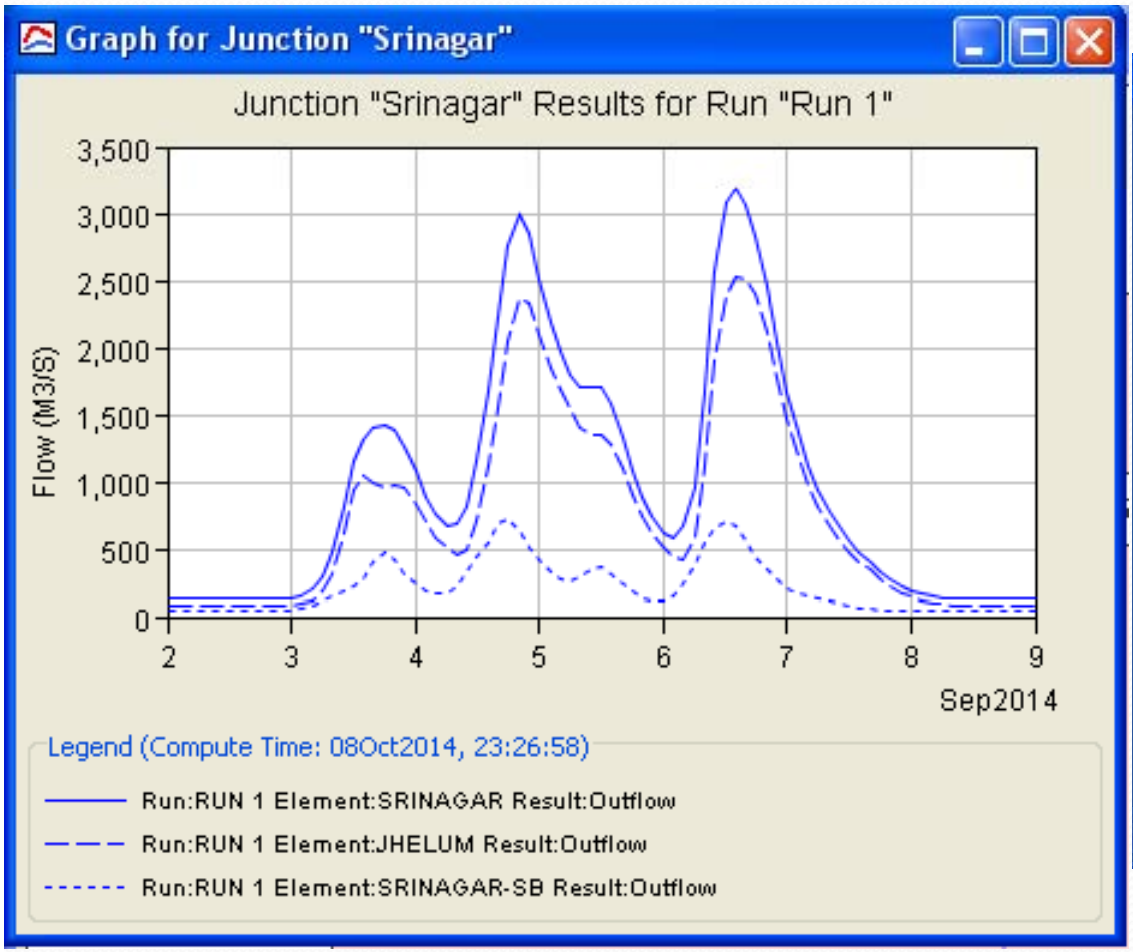



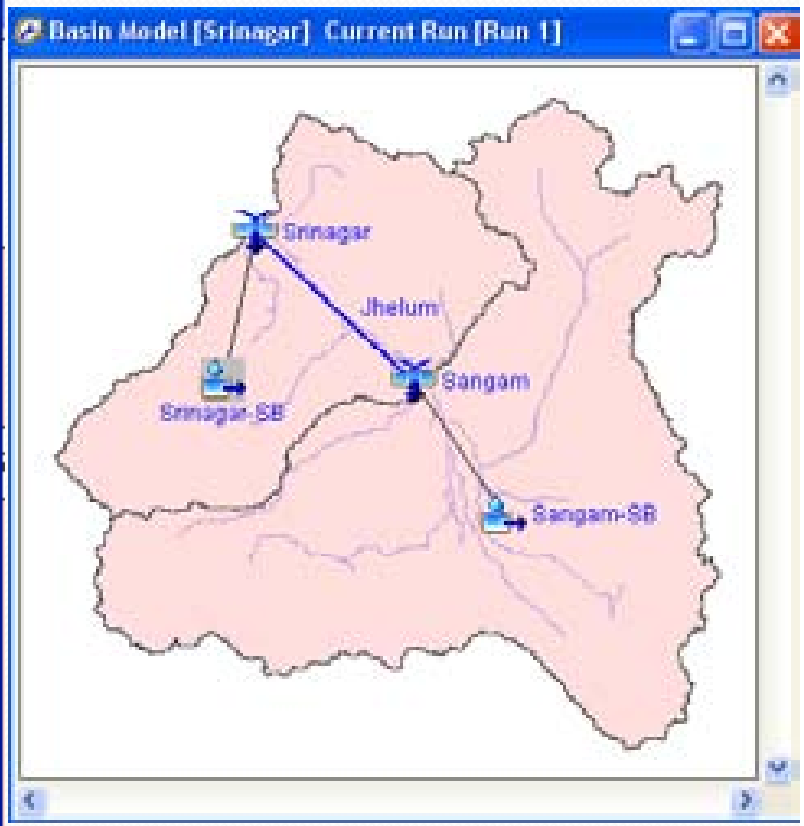
# Flood contributiion of Srinagar-SB



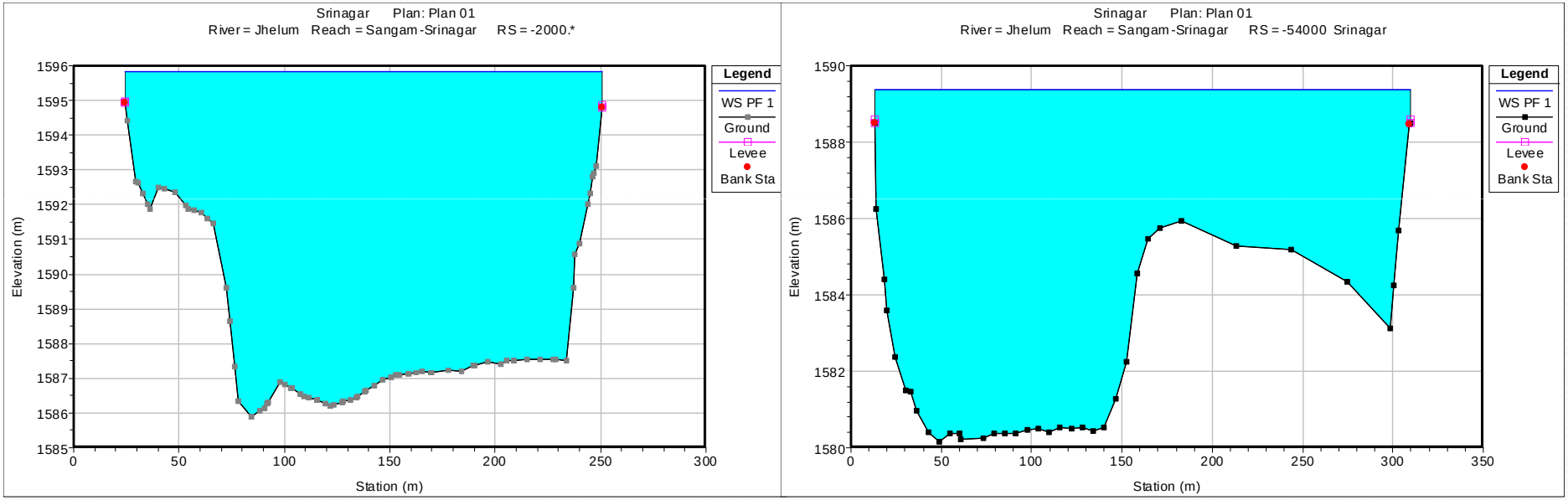



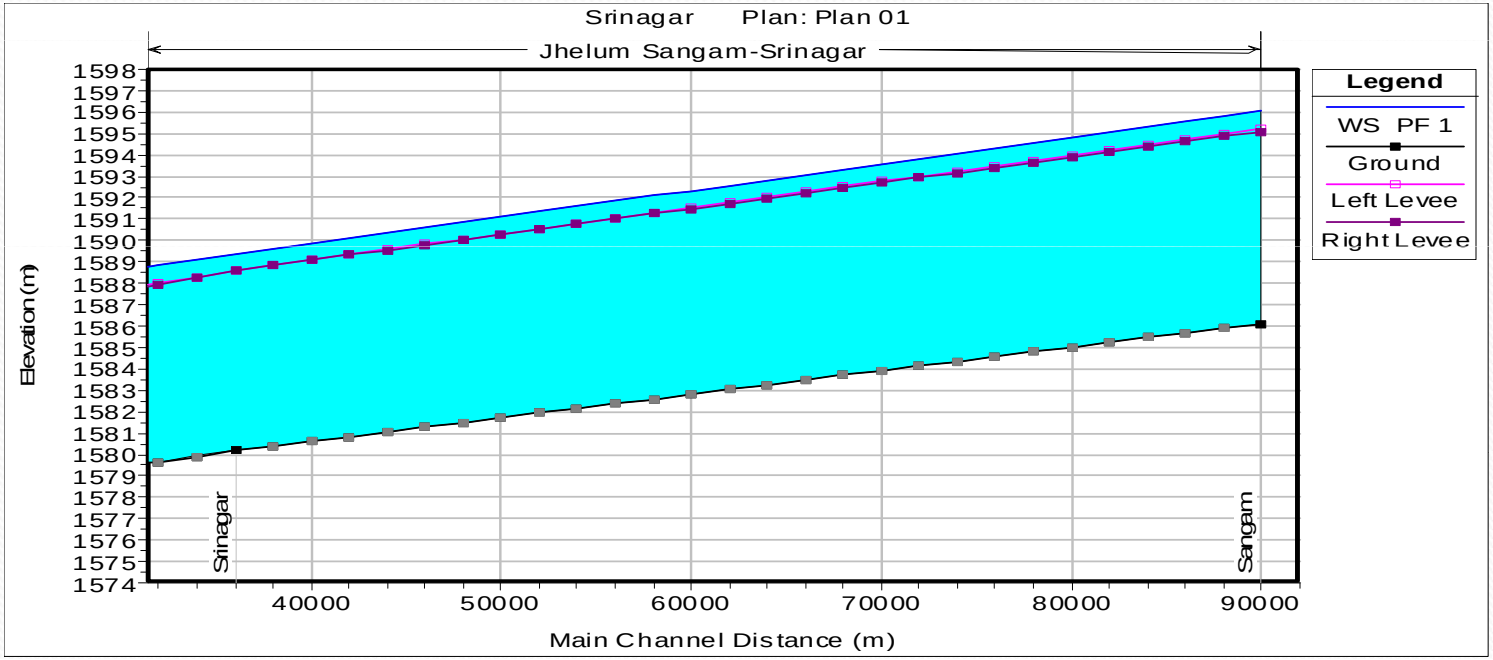
# Estimated flood at Srinagar



# Overtopping of river banks



# Findings

- The extreme rainfall was the main cause of the flooding in J&K. The district level normal monthly rainfall in the drainage area of Jhelum river is about 70 mm, while the rainfall during 3-7$^{th}$ Sep 2014 was about 303 mm resulting about 332% more rainfall than normal.

- The estimated flood at Srinagar is about 3200 cumec against the Jhelum carrying capacity of 900 cumec. This resulted overtopping of embankments

- Due to bowl shape of terrain around Srinagar the effective warning time available between Sangam and Srinagar will be hardly 3 hours

- The mild slope (1/10000) of river Jhelum between Sangam and Wular lake makes the area susceptible to flooding in case of extreme rainfall events, as the flood water will be drained out with a very small velocity

# Thank You