

Flood inundation maps

Mapping of flood prone areas in Norway

Background – major flood in 1995

After a major flood in south eastern Norway in 1995, a governmental commission gave several recommendations in order to reduce flood damage in the future. The damage in 1995 amounted to about 1.8 billion NOK (200 mill USD). The average annual cost of flood damage in Norway is about 200 mill NOK. One of the recommendations from the commission on flood protection measures was to produce flood inundation maps for the areas with the largest damage potential.

Definition

Flood inundation maps present the area prone to flooding at one or more floods with given return periods.

Why produce flood inundation maps?

The overall objective of the mapping is to reduce flood damages, through improved land use planning and emergency preparedness. The main target groups are municipalities and county officials, who are responsible for land use planning and emergency planning at local, respectively county level.

The flood inundation map represents a tool to achieve:

- Improved land use planning with respect to flood hazards.

A sensible use of flood prone areas is in Norway regarded as the best way of keeping the damage potential at a reasonable level. Improvement in land use planning with respect to risk of flooding is among the most important measures to achieve this goal.

- Improved flood warning and emergency preparedness

The maps will be useful in emergency planning and action connected to flood situations. The basis data and model results from the mapping will make quantitative flood forecasting possible, i.e. forecasting of water levels locally. Flood inundation maps can be generated related to the forecasted flood levels, allowing quick assessment of the potential impacts of a given flood. The maps will simplify rescue operations such as evacuation, and give background



New shopping centre, flooded during the 1995 flood. The flood resulted in a recognition of the need for improved land use planning in flood prone areas and improved emergency preparedness. Photo: Fotonor

information when setting priorities to other actions.

- Improved flood protection plans

National standards

NVE has defined guidelines for land use planning and flood protection in flood prone areas. The acceptable flood risk is differentiated in relation to hazard type (risk of life, risk of economic loss) and type of assets to be protected. Domestic buildings for instance, should be safe against flooding up to 100 years floods, while industry and important infrastructure should be safe against at least 200 years floods.



Sandbagging during the major flood in 1995. Flood inundation maps are useful for emergency planning and action, such as evacuation, construction of temporary levees etc. Photo: NVE

The flood inundation map project

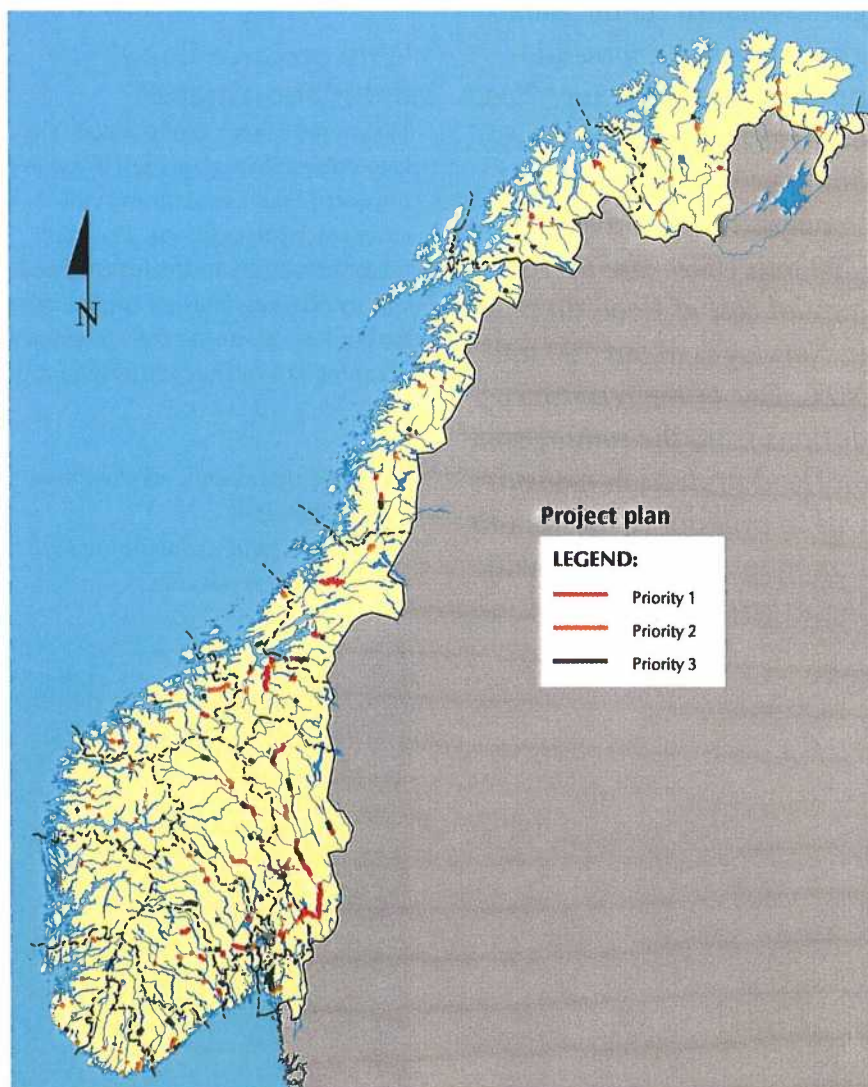
- Includes the areas in Norway with the largest damage potential
- The plan is to map 188 river stretches, covering 1750 km river length in 168 municipalities.
- Total cost is estimated to 8 mill USD
- Project period: 1998-2007

The flood inundation map project was started by NVE (Norwegian Water Resources and Energy Administration) in 1998. NVE is manager of the project and NVE professionals also do most analyses. Other organisations such as the Norwegian mapping authority and private consultants participate with basis data. The municipalities are active partners in the mapping process and contribute with local information on water levels in previous flood events as well as measurements during floods within the project period.

Production method

The maps are produced digitally, to make the users able to make their own presentations in combination with other information, using their own tools.

High accuracy mapping was chosen, in order to make the users able to use the results in land use planning with-



hout further analyses.

Land surface is represented by a DEM (Digital Elevation Model) based

on detailed elevation data and the riverbed is represented by surveyed cross sections. Expected accuracy of the DEM is +/- 30 cm.

Through flood frequency analyses and hydraulic simulations water levels for 10, 20, 50, 100, 200 and 500 years floods are calculated. Expected accuracy of the computed water levels is +/- 30 cm.

Inundated areas are determined using GIS (Geographical Information System).

Historic events related to other known hazards in the river system, such as ice jams, ice run, erosion, debris flows etc, are identified based on information from local informers and archives, without trying to relate the events to statistical probability.

The final results from each river reach are delivered to the users both as a report with paper maps and as digital data. The presentation is standardized at scale 1:15000 with cross sections, levees etc marked. Water levels for all computed floods are presented both in a table and in a graph (longitudinal profile).

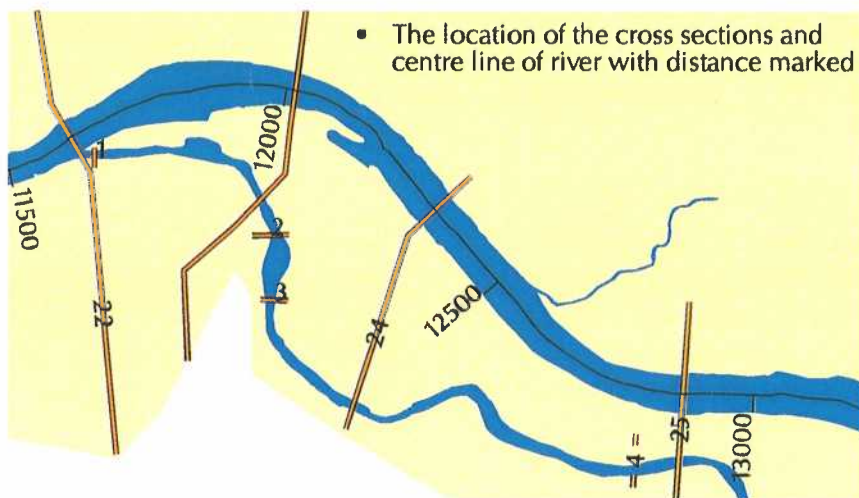
Flood estimation

- Basis data are long term water stage observation series from hydrometric stations and catchment characteristics
- Discharges are estimated for all projects within a catchment, based on flood frequency analyses
- The result is the best coherence between discharge and return period

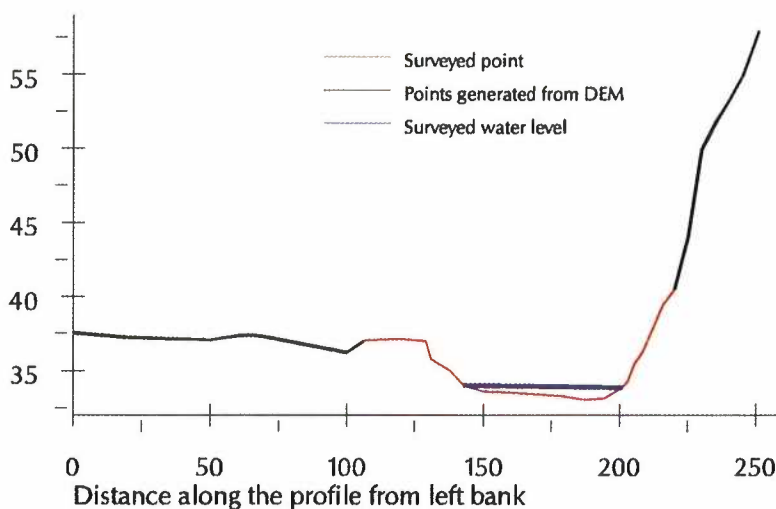
Flood elevation profiles

- Basis data are cross sections and discharges from the flood estimation
- Flood profiles are calculated in hydraulic simulation programmes (MIKE 11 or HEC-RAS)
- The result from the hydraulic simulations is water level in each cross section

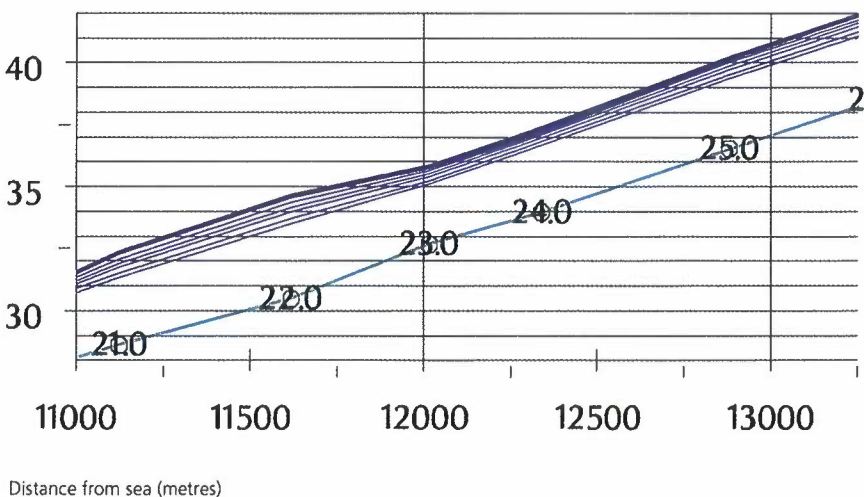
Flood elevation profiles



Cross Section No. 24



Flood profiles for all estimated floods



The Norwegian Water Resources and Energy Directorate (NVE) is subordinated to the Ministry of Petroleum and Energy, and is responsible for the administration of Norway's water and energy resources.

The goals of NVE are to ensure consistent and environmentally sound management of water resources, promote an efficient energy market and cost-effective energy systems, and contribute to the economic utilization of energy.

NVE plays a central role in organizing contingency measures against floods and other emergencies related to water-courses, and is in charge of maintaining power supplies under emergency conditions nationwide. NVE takes part in

R&D and international cooperative efforts in relevant fields, and is the national competent authority on hydrology. NVE headquarters are in Oslo, with regional offices in Tønsberg, Hamar, Førde, Trondheim and Narvik.

Newsletter from
Norwegian Water
Resources and
Energy Directorate

Land surface model

- A digital elevation model (DEM) with high resolution (5-10 meters) and vertical accuracy (± 30 cm) is made by generating TIN models for all elevation data.
- Base map data: detailed elevation data of terrain as well as other available elevation data (roads, levees, water contour etc)

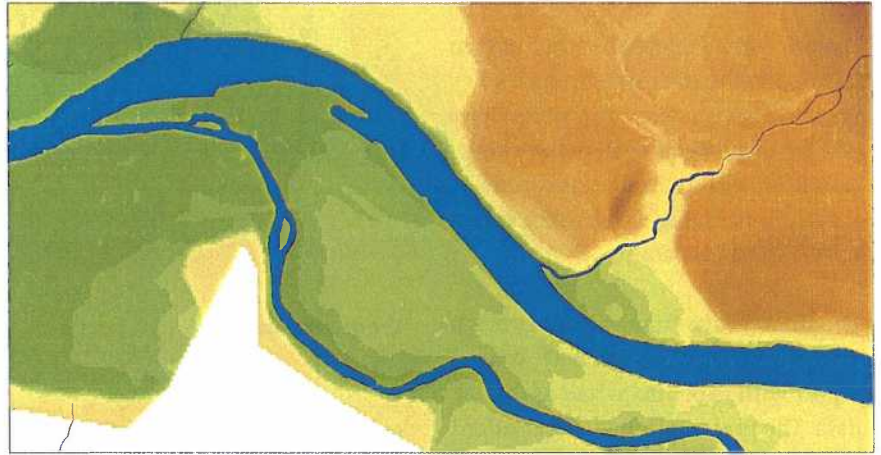
Flood surface

- Flood surface derived from TIN based on flood elevation in cross sections from the hydraulic simulation
- The inundated areas are identified by subtracting the DEM from the flood surface, resulting in positive values in inundated areas.

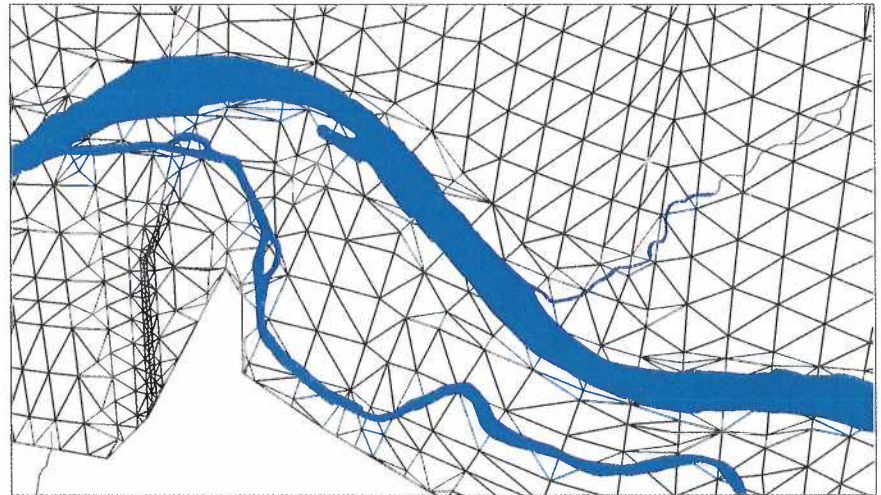
Flood inundation map

- Map presentation: Inundated areas in blue. Areas without direct connection to the river (behind levees, culverts etc) are marked with diagonal shade, since these areas have a different probability for flooding compared to the areas in direct connection to the river.
- Base map: detailed digital maps (scale 1:1000), surveyed cross sections

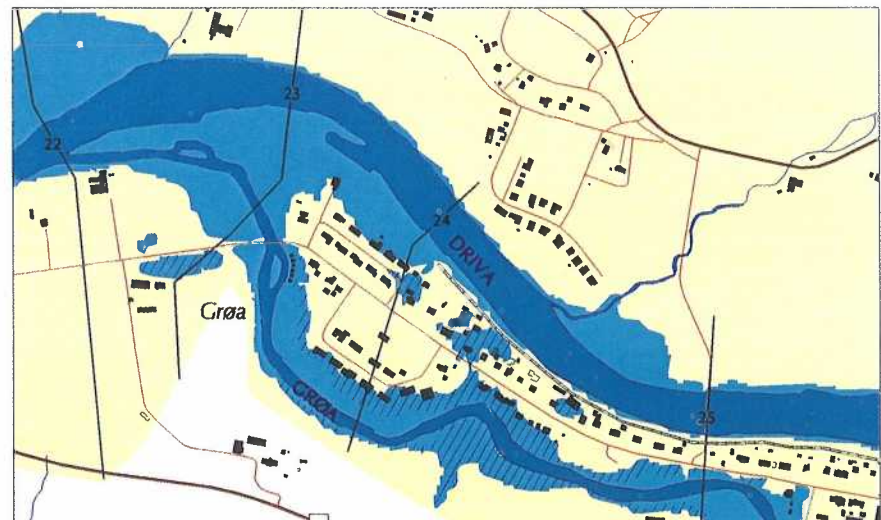
Land surface model



Flood surface model



Flood inundation map



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