

# The flood protection concept in Kvam, Norway

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## INTRODUCTION

This abstract presents a case from the settlement Kvam in the valley Gudbrandsdalen in Southern Norway which was hit by severe floods in May / June 2011 and 2013. The case demonstrates prevention through land use planning and relocation as well as structural protection with a diversity of elements, including bed load control and water retention. The responsibilities for flood warning and local preparedness is briefly presented.

## BACKGROUND

Kvam is located on an alluvial fan where the tributary Veikleaa enters the main River Gudbrandsdalslaagen. The settlement has approximately 800 inhabitants.

The river Veikleaa, with a catchment of 100 km<sup>2</sup>, responds very quickly to heavy rainfall, in particular in the spring before the ground frost thaws. The river carried large amounts of bed load during the 2011 and 2013 floods. Both lateral erosion and landslides from the valley slopes contribute to the sediment load. On the alluvial fan, the sediment is deposited. Some 150 000 m<sup>3</sup> of deposited material was removed after each of these floods.

During both flood events, the river Veikleaa caused severe damage to buildings and infrastructure from erosion, mass deposition and flooding. The situation was quite dramatic and several inhabitants had to be evacuated in a hurry. Luckily no people were killed or injured.

## LAND USE PLANNING - FLOOD SAFETY LEVEL

In accordance with the Planning and Building Act and Technical Regulations, new development requires safety against a 200-year flood. This also applies to the reconstruction of the destroyed houses. The municipality has therefore banned further development in the hazard zone within Kvam, until sufficient protection is in place. The Norwegian Water Resources and Energy Directorate (NVE) supports the municipality in

planning, implementing and financing protection works. Norconsult AS and Dr. Blasy - Dr. Øverland Beratende Ingenieure GmbH & Co. has been engaged as consultants in Kvam. The municipality has made a detailed land use plan for the protection works. The updated hazard zones will also be implemented in the municipal master plan. A national debate was raised about the laws and regulations related to reconstruction and relocation after flood events. Particular attention was given to the regulations related to insurance and the funding possibilities for relocation of buildings to safe ground. A new scheme has been established, allowing NVE to support relocation instead of protection, if protection is too expensive. In Kvam, both protection and relocation has been applied.

## THE PROTECTION SCHEME

The protection scheme for Kvam aims to protect 160 residential houses, shops, private and public offices, national highway E6, national railway and other infrastructure.

The design flood is an event with recurrence interval of 200 years. The greatest challenge is the control of sediment load. Both retention of bed load and water (flood peak reduction) has been considered.

The scheme includes the following elements:

- Restoration and upgrading of the river channel through the settlement Kvam. Length 1600 m. Designed for a 200 year flood, including a safety margin of 1 meter. 25 thresholds to prevent vertical erosion. 150 m of concrete flood walls. Footpaths along the river. Finished October 2014.
- Retention of bed load. Three retention dams has been planned. Dam no 1, with a height of 5 m and a capacity of 6000 m<sup>3</sup>, is completed. Dam no 2, with a height of 12 m and capacity of 100 000 m<sup>3</sup> is now being projected. Due to its size dam no 2 is subject to strict dam safety



Figure 1. Retention dam no 1, length 60 m. May 2014 (discharge 10 m<sup>3</sup>/s; Foto: NVE)

regulations related to planning, construction and maintenance.

- Retention of water. The possibility to reduce the flood peak by establishing two retention basins in the upper part of the catchment has been considered. The calculated effect is a reduction of the flood peak for the design flood from 69 m<sup>3</sup>/s to 40 m<sup>3</sup>/s.
- Relocation of county road.
- Relocation of some of the most flood prone buildings.

### FLOOD WARNING AND LOCAL PREPAREDNESS

The municipalities are responsible for local preparedness, and are obliged according to the Civil protection Act to perform risk analyses as basis for their preparedness plan. As floods in Kvam is a major threat in this municipality, the plan should include preparedness for evacuation of the population in situations where the protection level might be exceeded. As basis for this, monitoring and flood warning is important. NVE runs a 24/7 national flood warning service, delivering flood warnings at regional level. All flood warnings, as well as land-

### KEYWORDS

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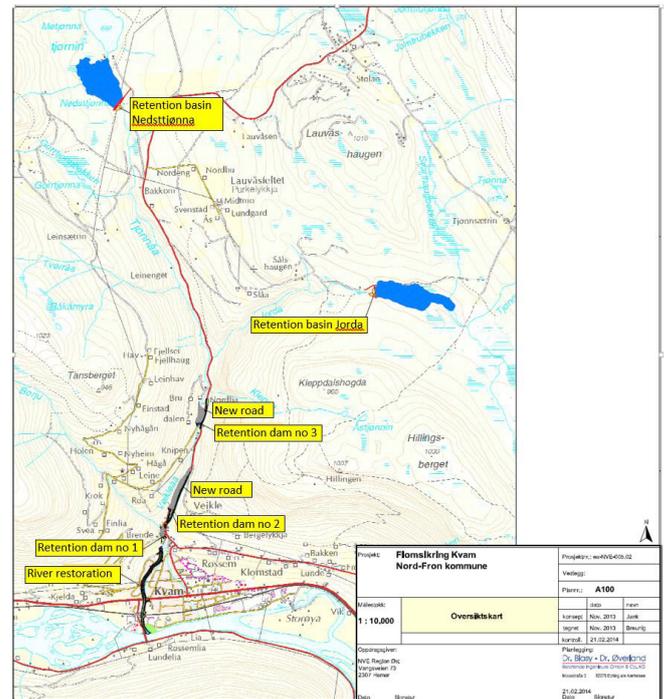


Figure 2. Overview map with the different elements of the protection scheme (Planned by Dr. Blasy - Dr. Øverland, Beratende Ingenieure GmbH & Co.)

slide warnings, are presented at the web portal [www.varsom.no](http://www.varsom.no). As the catchment of the River Veikleaa is small and responds quickly to heavy rainfall, the municipality should also monitor precipitation as part of their local preparedness.

### EXPECTED PROGRESS AND RESULTS

The follow-up after the flood events in Kvam has provided valuable input to the management of floods at both local and national level. The protection scheme is still ongoing. The building of retention dam no 2 is planned to start in May 2016, after which the required safety level for new buildings is expected to be met. For NVE, new insight will be gained in complex projects including sediment control.