DHI CASE STORY

MODEL-BASED MANAGEMENT OF RIVER GUDENÅ

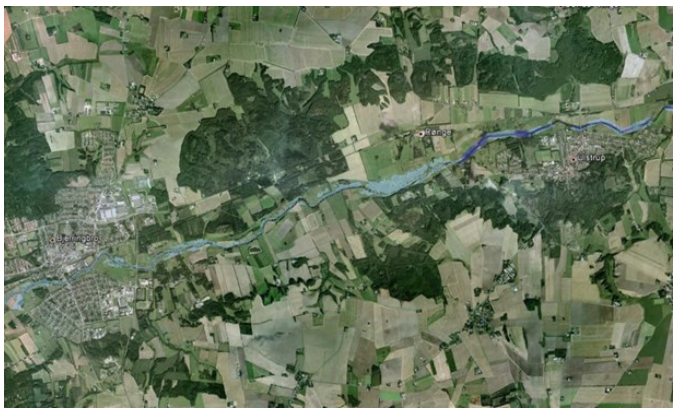
Enabling efficient flood risk mapping, forecasting and river regulation

In recent years, water levels in the Gudenå River have been steadily rising. These rises, combined with climate change-induced higher rainfall intensities have sparked concerns about future flooding risks. In order to identify and implement new river management/maintenance measures, we developed an integrated hydraulic model based on our MIKE by DHI software suite components. In so doing, we helped the authorities conduct effective river mapping and flood forecasting and develop more efficient river regulation and maintenance schemes. Our tailored, user-friendly modelling tools and services now help them plan and manage the river better.

WATER LEVELS ON THE RISE

River Gudenå – the longest river in Denmark – flows through several municipalities and cities. The river is regulated and water levels are controlled for sections of the river and its extensive lake complex.

In recent years, complaints from riparian land owners about the rising water levels in the river have become more frequent. Water levels have risen prominently due to significant increases in aquatic weed densities and increasing discharge. Due to habitat concerns, weed cutting has been restricted, intensifying the problem. As a result, flooding occurs for longer periods during both the summer and winter seasons. The region also faces higher rainfall intensities due to climate change. As such, serious concerns about increased flood risks and damage have sparked initiatives on identification and implementation of new river management measures and maintenance procedures.



Gudenå River and forecasted flood extents

SUMMARY

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Silkeborg, Viborg and Favrskov municipalities, Denmark

CHALLENGE

- Rising water levels and increased flood risks in the Gudenå River
- Difficulty in identifying appropriate flood and environmental protection measures
- Need to map flood risk along the river to prepare adequate climate change adaptation plans
- Need to evaluate, develop and implement river maintenance and management alternatives
- Need to provide the public with reliable forecast of water levels and flood maps

SOLUTION

- An integrated hydrological model of the river and river basin (MIKE SHE–MIKE11)
- Specifically designed web front ends to serve the purpose of water level forecasting and scenario analysis

VALUE

- Efficient river regulation and river maintenance schemes
- Real-time information and three-day prognoses of lake and river water level forecasts
- In-house, web-based and easy-to-use model scenario tool designed for staff needs
- Efficient mapping of flood risks and river 'bottlenecks' – local contraction in the river, controlling the rate of flow
- Flood risk mapping as a requirement of climate change adaptation plans

LOCATION / COUNTRY

Gudenå, Denmark

As part of these initiatives, we developed a survey data-based hydraulic model in combination with an integrated catchment model for the Gudenå River. This model – based on our MIKE by DHI software suite components (MIKE SHE and MIKE 11) helped simulate water levels and flood extents.

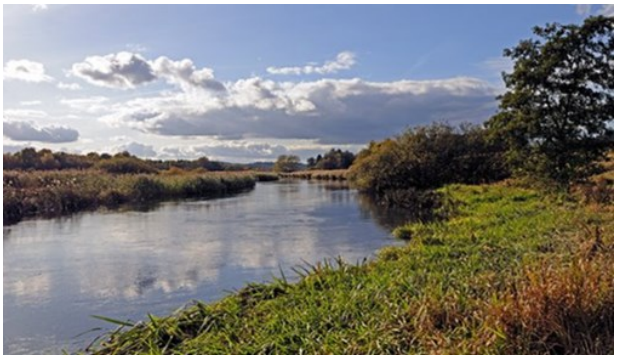
UPSTREAM FLOODING, DOWNSTREAM CHALLENGE

When water storage capacity is exceeded, released upstream volumes flood downstream residential areas, agricultural land and roads. In such cases, both urban and rural property along the river is subjected to flood damages from upstream Silkeborg to the Gudenås discharge into the sea at downstream Randers. As such, solving the upstream flooding problem by releasing excess water may relieve local problems but give rise to severe downstream challenges.

In order to ensure flood protection both upstream and downstream of the Gudenå River, it is necessary to coordinate both planning and operational modes of the river management. This in turn requires a common platform and tool. Our on-line forecast system and river management scenario tool facilitates collaboration between municipalities and helps finding joint solutions by showing impacts along an approximately 50 km reach of the river.

ON-LINE FORECASTING

The water level forecasting model runs automatically. The latest on-line rainfall data, hydrometrical data and weather forecasts are collected and used in the three-day forecast. Using data assimilation, qualified forecasts showing flood inundation maps of the river valley and lake shores are produced and presented on public web sites. The service also includes highlighting critical water levels at individual land owners (specific addresses, houses or properties) and roads. Overview maps and zoom facilities to focus on individual properties help to provide the information in an easily understandable form.



River Gudenå

WORST CASE SCENARIOS AND CLIMATE ADAPTATION

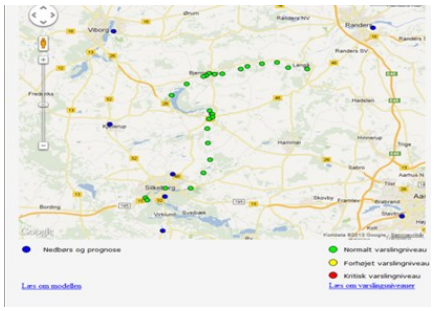
The local authorities are also responsible for flood protection and are required to formulate a climate adaptation plan for flood prevention. Consequently, flood mapping is an integral part of the web-based scenario tool. A simple user interface supports 'worst case' scenario formulations which include factors such as:

- choice of season
- initial conditions of river and basin
- upstream inflow
- rainfall
- roughness associated with a specified maintenance level

Specifically with respect to climate change, authorities are required to carry out extreme flow condition scenarios corresponding to 5-, 10-, 20-, 50- and 100-year return periods for present conditions (2010) and future conditions (2050). The model outputs – in terms of maximum depth inundation maps – are used in flood risk assessments with the aim of outlining flood prone areas to be protected through climate adaptation measures.

For river Gudenå, the upper reaches receive relatively large inflows from the upstream basin. As per current practices, lake water levels need to be maintained at constant levels by releasing water rather than storing excess water. The capacity to discharge flood water at Silkeborg city will be limited by cross sectional dimensions of the downstream river and the flow resistance due to aquatic vegetation. Further downstream, the Tange Lake created for hydropower purposes offers very limited protection for downstream reaches due to its limited volume and the release operation aiming at maximising power production, not to offer flood protection.

Results show that for extreme flows, the water level rise in the upstream city of Silkeborg and associated flooding is restricted to areas near the lake shore. Further downstream however, maximum water levels and frequencies suggest that the most vulnerable houses on the flood plain may become uninhabitable unless investments are made to prevent climate change-induced deterioration.



Overview of warning levels in the on-line environment

CLIENT TESTIMONIAL

> *"The water level forecasting is impressive and very useful in serving a number of different purposes and the public interest in river Gudenå water levels as experienced by citizens and land owners."*
> *Poul Hald Møller—Silkeborg Kommune*

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