DHI CASE STORY

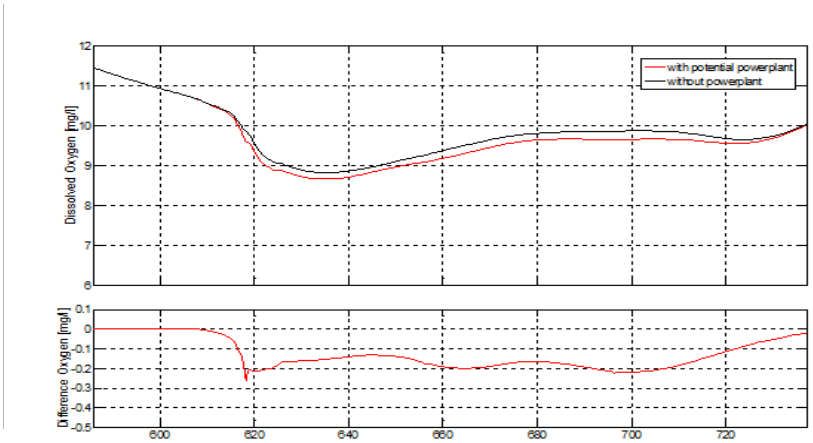
ENABLING SUSTAINABLE DEVELOPMENT ALONG THE ELBE RIVER

Hydraulic modelling to support planning and approvals for prospective power plants

Just downstream of the city of Hamburg, the tide-influenced part of the Elbe River has been witnessing low oxygen conditions, negatively impacting the fragile ecosystem. With new power plants planned along the river, several concerns were raised, related to the cooling water discharge from the power plants into the river and the consequent impact on the aquatic environment. To address these concerns, the adjacent federal states decided to develop a heat capacity plan. To help with this, we developed a hydraulic ecological model based on our MIKE by DHI software, which served as a potent instrument supporting authorities during the licensing procedures.

CHANGING OXYGEN CONDITIONS IN THE ELBE RIVER

The Elbe River is characterised by a high nutrient load, which enhances the growth of planktonic algae. The algae load is especially high in the river upstream of Hamburg. When the algae reach the deep navigational waters of the Port of Hamburg, the water column is too dark and deep for photosynthesis to occur. As a result, the bad light conditions hamper primary production. This causes the algae to starve and die. Thus, oxygen is consumed by bacteria which mineralise the dead



MIKE 11 comparison between the two scenarios

algae, thereby causing significantly low oxygen concentrations in this part of the

SUMMARY

CLIENT

Vattenfall Europe Wärme AG

CHALLENGE

- Low oxygen concentrations in Elbe River waters in the Port of Hamburg
- Further impacts to Elbe's ecology likely due to cooling water discharge from planned power plants
- Need to enable sustainable management of the power plants, without causing further damage to Elbe's aquatic ecology

SOLUTION

Ecological hydraulic model of the tidal part of the River Elbe using our MIKE by DHI (MIKE 11, MIKE 21 and ECO Lab) software

VALUE

- Enabling authorities and operators of power plants to estimate and evaluate the impact of cooling water discharge from new plants on the aquatic environment
- Making it possible to find optimal dimensions for using cooling water from rivers with respect to their ecological resilience
- Helping with the planning, approval and licening processes of new power plants along rivers
- Enabling sustainable development

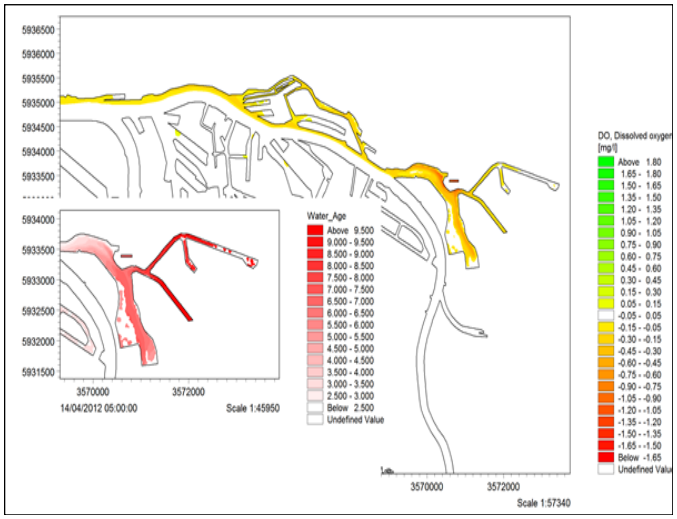
LOCATION / COUNTRY

Tidal Elbe, Germany

river. Especially in summer, when the oxygen concentration is naturally low, this causes many ecological problems, as the oxygen concentration sometimes falls below the critical levels of 6 mg/l. Often, dead fish can be found in summer floating along this stretch of the river. They can also block migratory fish on their way to spawning grounds.

SPECIAL CONSIDERATION WHEN PLANNING NEW DEVELOPMENTS

The purpose of the German Water Resources Act (amended in 2009) was to protect water bodies through sustainable water management. In keeping with the objective of the Act, it became necessary to prevent a further deterioration of the Elbe River's ecological and chemical status. The operation of new plants along the river would likely impact the fragile ecosystem. As such, harsh oxygen conditions needed special consideration when planning new developments here. This is because power plants utilise cooling processes which generally involve uptake from and discharge to the river. During the cooling water passage, the water is heated and a considerable amount of the plankton dies. Therefore the discharged water provides more material (detritus) for bacteria to mineralise and lower oxygen concentrations further.

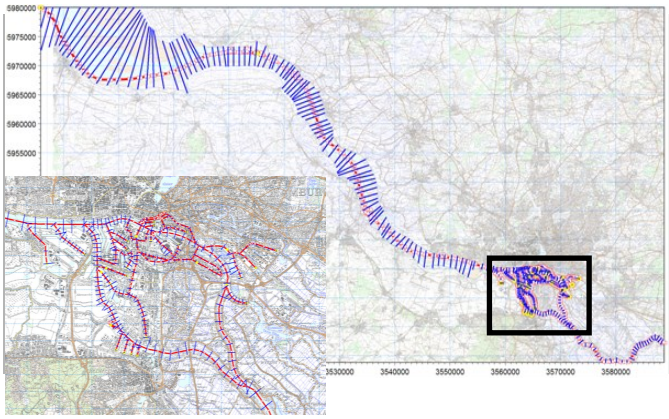


MIKE 21: impact on dissolved oxygen, Port of Hamburg

PREPARING A HEAT CAPACITY PLAN

In order to plan developments on the Elbe River sustainably, the adjacent federal states decided to prepare a new heat capacity plan. The plan was used to document not only the temperature changes, but also the ecological effects (such as changes in dissolved oxygen) in the Elbe Estuary with the help of numerical modelling over one representative year.

We helped by developing an ecological hydraulic model of tidal Elbe. It helped calculate the temperature and oxygen changes with respect to the ebb and flood tides as well as the time required for mineralisation of algae. The model encompassed all relevant biological and chemical processes



Model domain MIKE 11, between Geesthacht weir and the Northsea

which have an influence on dissolved oxygen (such as nutrient cycling, primary production, and the mineralisation of dead organic matter).

The model specifically focussed on processes that occur during the cooling water passage in power plants. During this passage, a considerable part of the plankton dies (due to stress and mechanical effects), which causes higher mineralisation rates after releasing the cooling water. Moreover the temperature is elevated, which augments all biological and chemical processes. As such, the mineralisation is faster, increasing the oxygen demand drastically and consequently lowering the oxygen concentration in water. Combined effects from more than one power plant could be analysed with the model.

HELPING TO EFFECTIVELY ESTIMATE THE IMPACTS ON THE ELBE RIVER

We carried out comprehensive oxygen and temperature studies for some existing power plants using our MIKE by DHI software. These included:

- one-dimensional (1D) models with MIKE 11
- detailed two-dimensional (2D) models with MIKE 21
- ECO Lab

Our model focussed on controlled modelling of all single cooling water channels and variables (such as maximum heating temperatures, oxygen saturation and plankton mortality).

During licensing procedures, our model served as a potent instrument for authorities and operators of power plants to estimate the impact of new plants on the aquatic ecosystem. With the help of our modelling studies, it was possible for them to outline optimal dimensions for the usage of cooling water from the Elbe River, with respect to ecological resilience. This in turn will help them sustainably plan new power plants and other developments along the Elbe River, without causing further damage to the aquatic environment.

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