NEW ENGINEERING CHALLENGES CAUSED BY EUROPEAN ENVIRONMENTAL JURISDICTION ON THE EXAMPLE OF A FLOOD PROTECTION BASIN IN GERMANY

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ABSTRACT

With the introduction of the European Union (EU) Water Framework Directive (WFD), the status of surface waters in the EU had to be assessed according to ecological and chemical criteria. In addition, the Natura 2000 campaign has designated a large amount of protected areas in the EU, in which impacts that are unavoidable have to be compensated, accordingly. For large dam projects this fact leads to severe compensation requirements.

In consequence, the above-mentioned legal situation for today's major dam projects results in an intensive planning and design stage as well as intensification of environmental expertise, especially with regard to the avoidance and minimization of intervention as dictated by the prevention of deterioration by the WFD. Deterioration prevention embraces all possible affected ecologic aspects for which single one, such as surface and groundwater, the construction or, here, the dam project must not cause any deterioration.

By means of a case study for a flood protection reservoir in a nature protected area in Germany, the presented paper illustrates the difficult and iterative planning process of a major dam project in respect of up-to-date environmental jurisdiction.

Several expertise and expert opinion needed to be prepared, e. g., in order to quantify possible negative effects on morphodynamics, groundwater, and water quality parameter. Hand in hand with the intensive and long planning periods the validness of the basic data is a matter of discussion, since environmental survey and mapping data are frequently outdated and needed to be up-dated.

The paper also describes the technical structures and measures which are design to cope with the environmental requirements, such as fish passable conduits, groundwater flow windows in the subsoil sealing, special operation regulations, etc.

1. INTRODUCTION

1.1 Development of European and German environmental laws

Modern environmental legislation was initiated in the early 1970s by an increasing public environmental awareness (Wegner, 2009). A representative legal document of this process is the Federal Nature Conversation Act (German: Bundesnaturschutzgesetz) and the first environmental action program of the European Economic Community (EEC - predecessor of the EU) for Europe.In consequence of the introduction of the Environmental Impact Assessment (EIA) Directive in 1985 (85/337 / EEC) and in particular subsequently with the introduction of the Habitats Directive in 1992 (92/43 / EEC), national environmental legislation and laws were revised and amended.

The last elementary step for the environmental legislation, in particular the water law, was the adoption of the WFD in 2000 (2000/60 / EG), which was incorporated into German national law with the amendment to the Water Resources Act in 2009.

The content and effects on hydraulic engineering projects of the individual laws and directives mentioned above are explained in detail in section 2.2 of this paper. Table 1 provides an overview of the development of national and European water and nature protection laws.

Table 1 : Overview of the development of national and European water and nature protection laws

Step	Time	European Directive	German law
1.	1970's	First environmental action program	Federal Nature Conversation Act
2.	1980's	Environmental Impact Assessment (EIA)	Environmental Impact Assessment Act
3.	1990's	Habitats Directive	Amendment of enviromental laws
4.	2000's	Water Framework Directive (WFD)	

1.2 Floods and flood protection in Germany

There are three main types of floods in Western Europe: river floods, storm surges (at the coast) and urban flash floods (heavy rainfall events). The present paper deals exclusively with river floods.

River floods occur primarily after melting snow in the low mountain ranges and in the Alps and after prolonged rainfall during corresponding macro weather situations or in a combination of both. Due to the cultivation of and development along rivers and floodplain landscapes, assets, settlements, etc.have emerged continuously since the first major river training measures on the Upper Rhine more than 150 years ago.

This development results in considerable flood risks and vulnerability and requires effective but complex flood protection concepts and measures for the protectionassets and human lives in the river basin. A distinction can be made between two different approaches for flood protection: decentralized flood protection like flood retentionreservoirsand areal retention in the catchment and technical local measures such as levees, flood protection walls, mobile systems and so on.

1.3 Floods on the Selke River

The case study that is presented in this paper is located at the Selke river basin. TheSelke Riveroriginates in the Harz Mountains, a mountain range in the middle part of Germany, and flows into the Bode River in the flatlands northeast of the Harz Mountains (Fig. 1). The rivers Selke and Bode are a part of the Elbe catchment.

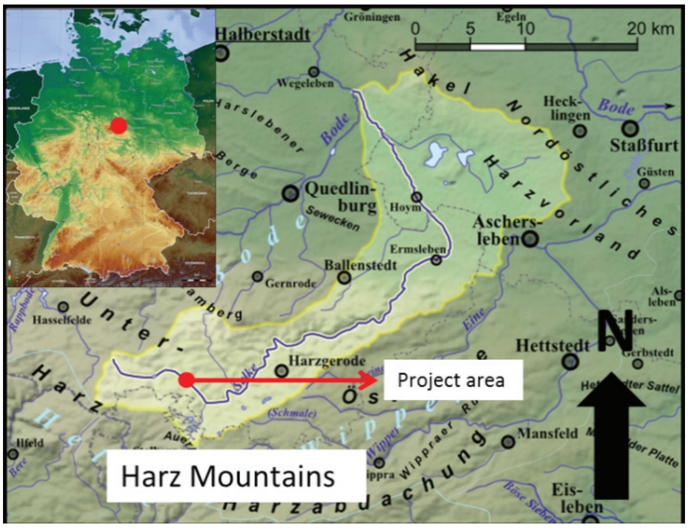

Figure 1 : Catchment area of the Selke River (Source: Wikipedia)

The valley of the Selke River is narrow and, therefore,lacks natural flood retention potential. The flood discharge are developing rather quick and frequently caused flooding with the corresponding harm in the past.

Recent floods occurred in 1994, 2002, 2011 and 2013. The greatest flood since starting of level measurements on the Selke Riversince 1921 occurred in 1994. The flood caused great economic damage. Afterwards, a flood protection concept was developed for the Selke River, which shall guarantee protection up to floods that statistically occur every 100 years (HQ_{100}) by means of various flood protection measures on the Selke Riveritself and its tributaries. One of those measures is the flood retention reservoir Straßberg, as discussed in this paper.

2. ENVIRONMENTAL ASPECTS AND FLOOD PROTECTION

2.1 General

Flood protection measures generally require a large amount of land. In particular this is valid for decentralized flood protection projects. Since there is naturally a high pressure of land utilization in Western Europe, usually areas are barely available and conflicting interests of various stakeholders have to be balanced. Landscaped areas (fields and meadows) as well as nature-like floodplains and floodplain forest with very high environmental value are usually the only available place for effective flood retentions dams. A specific impact on nature-sensitive areas is therefore usually unavoidable.

Due to this unavoidable impact elaborate and comprehensive environmental impact assessment (EIA)studies have to be prepared for flood retentions and protections projects in Europe. This is particularly valid for Germany since Germany is among the few countries of Europe which fully respects and is trying to fulfil the environmental legislation.

2.2 Requirements of environmental and water laws

2.2.1 *Approval procedures in Germany*

It is important to know that German water law provides two different approval procedures: planning approval procedure and a simple licensing procedure.

Planning approval procedures have to be carried out for "space-relevant" projects. Generally, the specific laws, e.g. the Water Resources Act, dictate whether a project is "space-relevant" or not. But for special cases, when the circumstances are not completely defined by law, the competent licensing authority defines the type of procedure.

With the decision for a planning approval procedure, the owners are granted substantial rights, e. g. also the right to expropriate. In addition to the general participation of the technical authorities, the planning approval process for planning approval requires public participation and publishing of the project documents.

2.2.2 *Environmental impact assessment (EIA)*

With the EU's EIA directive, the national EIA law stipulated for the very first time that an environmental impact assessment have to be carried out in order to issue a permit, provided that the protective subjectsspecified in the EIA law have to be significantly impaired.The EIA law distinguished the following subjects (Table 2):

Table 2 : Protected subjects of the EU's EIA directive

Protected subjects of the EU's EIA directive		
Man (human health)	Soil	Surface area
Animals & Plants	Climate & Landscape	Other material subjects
Biodiversity	Culture heritage	

The environmental impact study enables the licensing authority and the public to evaluate whether the expected impact is well-balanced and can be accepted.

2.2.3 *Water Resources Act and Water Framework Directive*

The Water Resources Act (WRA) regulates, among other topics, the use of water bodies and in particular sets requirements that have to be complied with during use. For example, the WRA stipulates that river training works always require a planning approval procedure since the discharge situation is affected. Flood retention reservoirs and dams, as in the case study, are subject to a planning approval procedure.

Since the introduction of the WFD, the WRA has also enforced the regulations of the WFD. In addition to the general requirement that planned project should not worsen the flood situation upstream and downstream, the project must not adversely affect the river basin management plans set out in the WFD. The aim of the WFD's management plans is the good ecological and chemical status of the water body. The status is assessed using defined criteria in relation to typed reference water.Projects that can in principle deteriorate the conditions of the water cannot be approved ("no deterioration", see section 2.3).

2.2.4 *Habitats Directive and Natura 2000*

TheConservation of Wild Birds Directive(2009/147 / EC, former 79/409 / EEC) and the Habitats Directive induced the designation of a Europe-wide, coherent network of protected areas, which are embraced by the term Natura 2000. The conservation areas contain habitats for protected species subsumed in so-called habitat types.

If an impact on a protected area is unavoidable due to a project, the existing habitat types have to be functionally and close-by compensated. For projects the finding of adequate compensation areas is not easy. The compensation of certain habitat types represents a considerable obstacle for the realization of a project due to complicated approval conditions.

2.2.5 *Protection of species*

Another component of an EIA is species protection. Species protection is based on the Federal Nature Conversation Act. There, endangered species are listed under specially or strictly protected species. The list is based on the Habitats Directive and international directives. As part of the environmental planning process, the existing species are mapped and the potential project impact is assessed.

Problems arise if strictly protected species are affected which does not only refer to ban to killing or physical harm but also includes the disturbance of the living habits especially during breeding season.

2.2.6 *Landscape Management Plan*

Another study which needs to be prepared according to the Federal Nature Conservation Act is the Landscape Management Plan.In the Landscape Management Plan, the avoidance, minimization and compensation measures are described and planned basing on the findings of the aforementioned environmental studies. With the plan approval decision, the defined measures in combination with the defined areas are binding.

2.3 European Court Decision in 2013 for the Weser River Training Works

A critical change of the environmental requirements for the assessment of environmental impact for hydraulic engineering projects occurred with the introduction of the WFD. The WFD was interpreted for the first time at the highest judicial level by the judgment of the European Court of Justice in 2013 on the training works of the Weser River inGermany. This led to the so-called “no deterioration” dictates.

However, the jurisdiction of the European Court of Justice specifies the requirements. It also defines the deterioration status of quality components. At the same time, it describes how deterioration can be determined. The deterioration is pegged to a lower threshold value. Consequently in order to prove that there is no deterioration, the quality components defined in WFD have to be specified or determined quantitatively. This is particularly necessary if an exception is required based on Article 4 (7), which can be guaranteed if no alternative is (reasonably) available and the project serves public interest.

Therefore this jurisdiction has a fundamental impact on hydraulic engineering projects and the planning process. In order to guarantee legal security forthe project, groundwater modeling and, if required, water quality and sediment transport modeling in addition to the surface water modeling are required.

For critical projects a complete set of self-consistent studies need to be incorporated in the project permission documents. Hence, planning periods are especially for controversial projects critically extended and experts’ disputes have to be settled by court decision.

The presented case study was caught in this trap which affected the complete time schedule and required an elementary revision of the EIA starting from mapping until the definition of compensation measures.

3. CASE STUDY: FLOOD RETENTION PROJECT STRASSBERG

3.1 General project description

The flood retention project “Straßberg”is located on the Selke River and it is a backbone of the complete flood protection concept for the Selke valley.

The Selke River is a 64.4 km long river in the north of Germany. It originates in the Harz Mountains and flows into the Bode River (see also section 1.3 of the paper). The project area is in the upper reaches at kilometer 58 (from the mouth) of the river.

The Harz Mountains are sparsely populated. The upper Selke valley is quite natural and is legally protected as a national nature conversation area and as a Habitats protection Natura 2000 area (see Figure 1).

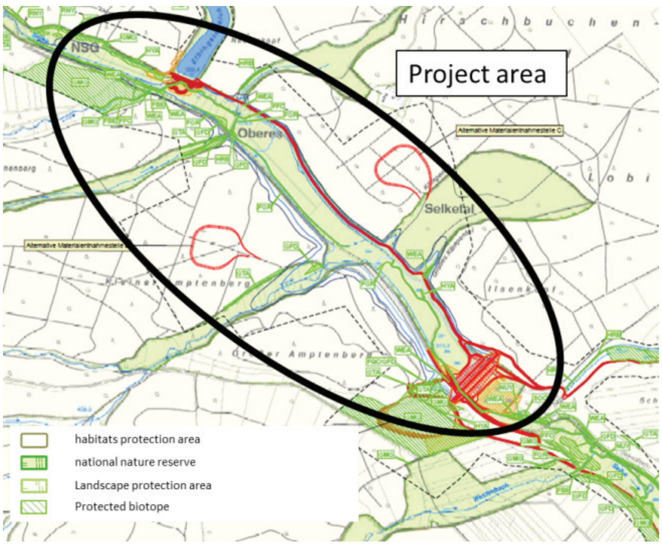

Figure 2 : Protected areas within the vicinity of the project (Source: BCE/TSB)

In addition, the project area is located in a landscape protection area. The "Selketalbahn" train crosses the project area and also the dam axis. The "Selketalbahn" train is an important tourist infrastructural asset for the economically underdeveloped region in East Germany.

The catchment area of the Selke River at the location of the Straßberg flood retention reservoir is approx. 46 km².

3.2 Design of the flood protection reservoir and dam

The dam of the flood protection reservoir is planned as rockfill dam with a center sealing, subsoil grouting, a base sealing(Figure 4) and a so-called combination structure made of concrete hosting some conduits and the spillway (see Figure 3). The main parameters of the flood protection reservoir and dam are given in Table 3.

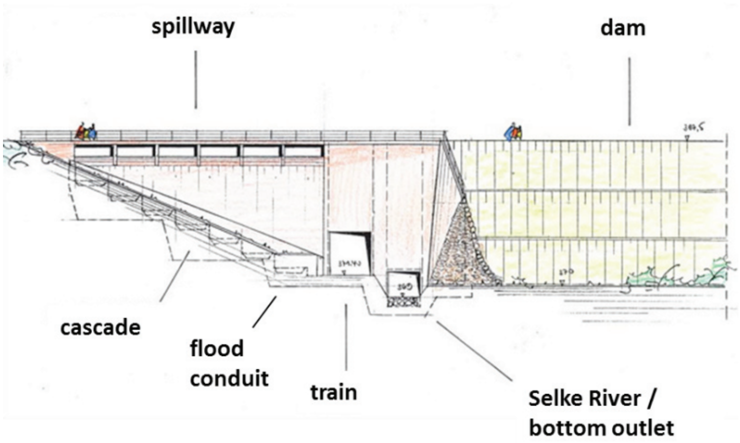

Figure 3 : View on the dam of the flood protection reservoir Straßberg (Source: BCE/TSB)

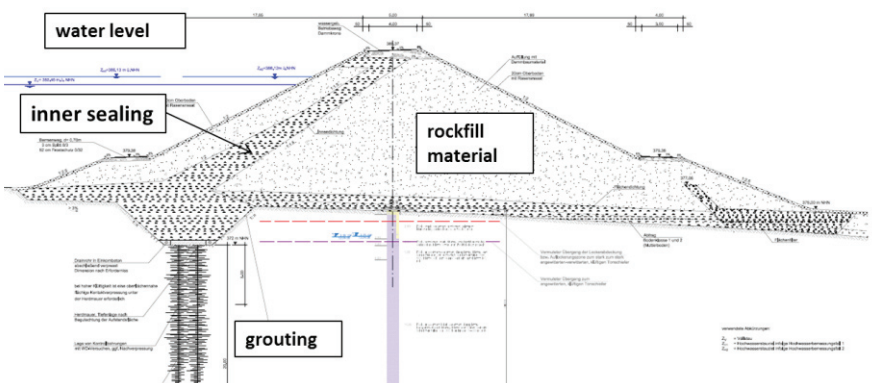

Figure 4 : Cross section through the dam of the flood protection reservoir Straßberg (Source: BCE/TSB)

Table 3 : Main parameters of the flood protection reservoir Straßberg

Basic Data	
Water body / river	Selke
Catchment area	46 km²
Flood retention volume	approx. 2.54 Mio. m³
Height of the dam	19,69 m
Type of flood retention reservoir	Green / dry basin
Flood retention design discharge (inflow) for HQ_{100}	25,73 m³/s
Max. outflow for HQ_{100}	9,0 m³/s
Safety flood discharge (inflow) for $HQ_{10,000}$	66,21 m³/s
Max. outflow (with spillway discharge) for $HQ_{10,000}$	44,21 m³/s

The flood protection reservoir is planned as a so-called green, dry reservoir. This means that the reservoir starts impounding when the outflow is greater than a flood that occurs statically every 5 years (HQ_5) and usually there is not water in the reservoir except in the river section.

Below a discharge of HQ_5 the outflow is regulated by thenormal discharge outlet/bottom outlet, which is incorporated in the combination concrete structure (see figure 3). The outlet passage is designed so that the consistency for fishes is given up to 300 days a year. If the discharge exceeds HQ_5, the flood protection reservoir is changing to controlled operation stateand the gate of normal discharge conduits / bottom outlet is closed and the flood conduit takes over.

The outflow discharge to downstream can be throttled via the operating gates at the flood conduits. The maximum discharge of those conduits is 9 m³/s. It is controlled by sluice gates. The floodoutlet is also integrated into the combination concrete dam structure.

Another conduit that is integrated in the combination concrete dam structure is the railway tunnel. The "Selketalbahn" train crossed the dam through the tunnel. When the dam is operated during flood and the water level reaches the rails, the railway operation is stopped and the tunnel is closed with a sluice gate. Since this occurs statistically only once in five years, this is not a significant impact on the railway operations, but the complete project was discussed with the railway owner and a mutual agreement could be gained.

The flood reservoir capacity is designed for flood that occurs statistically every 100 years. If the corresponding storage level is exceeded, the cascade spillway is starting operation. The spillway is also integrated in the combination concrete dam structure and it shows a cascade downstream for effective energy dissipation.

3.3 Project history

The project design worksstarted in 2004 with the preparation of the final design which was completed only 1 to 2 years. Meanwhile, thedetailed design and nature conservation planning were carried out between 2005 and 2009. In 2009, the owner submitted the planning documents for the so-called "completeness check" to the approval authorities.

During the first project period the amendment to the Water Resources Act was published. As a result, the licensing authority had to take into account the new requirements from the WFD (see section 2.2). In consequence thelicensing authority demanded somemodifications. A new mapping of flora and fauna habitat was required since the validity of mapping results were set to maximum 5 years in the new regulations.

In 2013 again after a complete revision and after the preparation of many new documents as part of the environmental studies and assessment the planning documents were submitted to the licensing authority and the planning approval procedure was initiated. In this timethe court decision regarding the Weser River of the European Court of Justice was published. The decision opened up opportunities for legal claims and critics of the project because, as was state of the art at this time, not all quality components of the WFD were considered correspondingly and not as required quantitatively. Thus, the environmental part of the planning was not up to date anymore and not togo for a legal risk during the project approval procedure the owner decided to revise the planning documents in form of a first supplement.

Statements and investigations, in particular on water quality, were supplemented and a study of alternatives demonstrated the correctness of the selected project solution.

The first supplement to the plan documents was completed in 2018 and the documents were submitted again, the third time. For the time being, minor revision works are ongoing mainly concerning the compensation measures and private property issues. Selectedexperts' studies that were carried outduring the whole planning process are presented below.

3.4 Surface Water Modeling

The hydrological parameters for the project area were determined using a precipitation-runoff model. Various rain events were considered. The peak runoff was determined for a centenary rain event with rain duration of 9 h and the greatest volume with rain duration of 72 h (compare Table 3, Figure 5). A flood rooting model was prepared. The characteristic values for the flood discharge that were determined are listed in Table 3. The determination of the design outflows and the legal requirements for the regular outflow, the water and operating outlet as well as the spillway was designed accordingly.

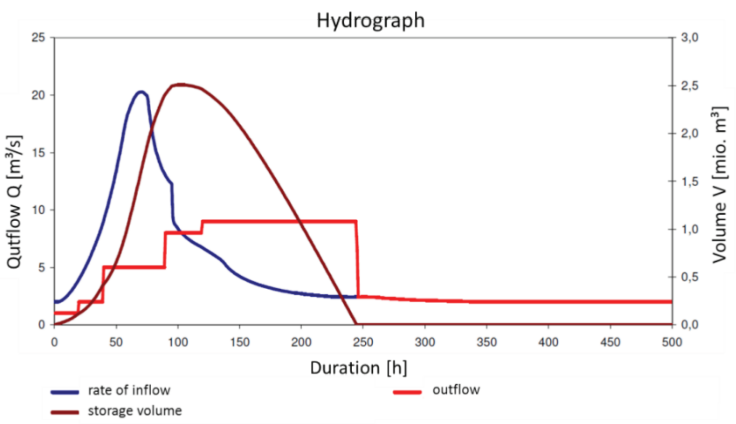

Figure 5 : Hydrograph of inflow, outflow and reservoir volume of the flood protection reservoir Straßberg

The bottom of the outlet structures is covered with river bed substrate. To ensure fishpassability, the bed is also partly covered by rock baffle/riprap. Due to the changes in the existing technical guidelines on fish passability during the long planning process, the design still needs a future adaptation before the implementation phase. For instance, during a period of 300 days per year the minimum and maximum flow depths and flow velocities which are acceptable for the selected fish types have to be guaranteed. During flood the bed substrate maybe be damaged and needs to be rehabilitated afterwards which is also considered to be acceptable in consideration of the expected impoundment flood incidents every 10 years.

3.5 Groundwater Modeling

An essential requirement resulting from the WFD is the determination of the impact on the groundwater regime. In order to be able to make statements on this, a numerical groundwater model was prepared. The model required complex underground investigations within the entire potential area of influence (Figure 6). In addition, sufficient pumping tests had to be carried out, too, in order to have a reliable data base.

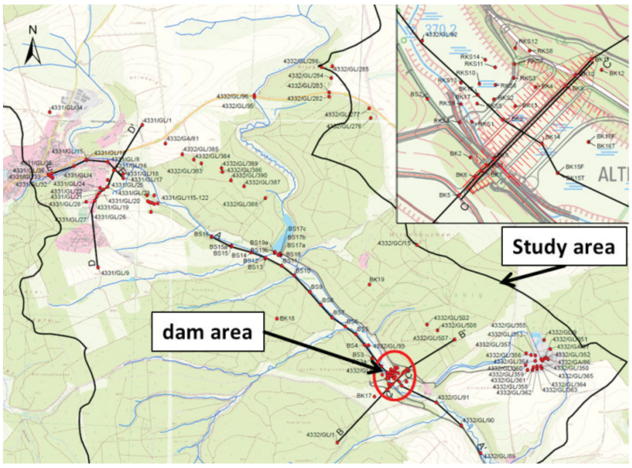

Figure 6 : Underground exploration measures in the project area (Source: BCE/TSB)

After all the necessary data have been collected, they were implemented into the hydrogeological model. From this the groundwater balance was derived and a groundwater table plan was created. In the end, the groundwater flow could be mapped and implemented in the groundwater model.

After the implementation of the groundwater flow data, the model was calibrated on measured and calculated groundwater tables. The existing status was modelled and could be verified after the calibration by independent modeling scenarios. After the model (FEM) was updated with the dam structures including dam body, underground sealing, drainage bodies, rock quarry, etc. the design/operation stage was modelled and compared to the existing situation.

The subsoil sealing and the excavation for the rockfill dam showed aclear influence on the groundwater situation. Therefore, groundwater flow windows were considered as a countermeasure.

The model was able to show that groundwater flow windows in the subsoil sealing of the order of 10 percent can significantly reduce the effects of the sealing on the groundwater situation, so that negative effects on the average groundwater conditions could be evaluated as minimal and acceptable. In addition, the expected decrease of the groundwater level due to the excavation within the rock quarry could be quantified and also evaluated as acceptable.

As a future component of the monitoring of the dam project, a groundwater monitoring concept was defined and integrated in the approval documents, with which the results of the model and any deviations that may occur can be detected during operations and enables to perform countermeasures.

3.6 Morphological/Sedimentation Modeling

The construction of the flood retention reservoir and the associated flooding of the Selke River during flood affect the natural sediment transport behavior. This can lead to sedimentation or erosion.

The sediment loadoriginating in the catchment area of the Selke River were determined using a combined approach from the USLE soil erosions model (Schwertmann et al., 1987) and the SDR sediment delivery model (Behrendt et al., 2000). The empirical approach assumes that soil is mainly eroded from agricultural land. The erosion potential on these areas could be determined with sieve tests to 4.8 t/ha/a and is therefore classified as high according to DIN 19708.

A large part of the eroded soil remains in the catchment area, therefore the SDR approach assumes that on average approx. 20% of the eroded soil is transported into the water and to the reservoir. The expected sediment load into the reservoir was estimated to reach around 525 t/a. Assuming a areal distribution of the sediments a sedimentation rate of 1.4 mm/a was determined.

Sediment management measures weredescribed and defined in the landscape management plan. It was recommended that if the sedimentsare harmful for the vegetation in the reservoir, it should be removed mechanically. A close monitoring is required.

3.7 Water Quality Modelling

The flood protection reservoir is operated as a “green, dryreservoir”. This means that vegetation is flooded during the impounding of the reservoir. This leads to oxygen depletion and thus a decrease in the oxygen concentration/content in the water. In order to assess the effects of oxygen depletion, a model and expertise were prepared.

The water quality during the impounding was analyzed using a numerical model simulation. This was done using the DYRESM (Dynamic Reservoir Simulation Model) program system from the Center for Water Research, University of Western Australia (Perth). The program part CAEDYM (Computational Aquatic Ecosystem Dynamics Model) calculates the chemical-physical reactions in the water body as well as the exchange with the free surface and the interaction with the sediment. The main focus was on the oxygen balance.

The depletion rate is determined by the existing vegetation and was previously determined in laboratory tests. Other basic input data were long-term temperature and water quality parameters of the Selke River. The summer of 2003, which was particularly very hot in the project area, was chosen as the reference period for the selection of implemented water quality parameters. This reflectsthe worst case.

The simulation showed that the reservoir may be stowed for a maximum of 10 days so that the oxygen content in the reservoir water does not drop below a critical value for the fish. The control of the reservoir has been adjusted accordingly or takes place in operation so that the accumulation time is not exceeded (see Figure 5).

4. CONCLUSION

Due to the EU environmental directives (Habitats Directive, WFD) and due to the decision of the European Court of Justice in 2013, which legally confirms the goals of the WFD for a major river project in Germany, natureprotectionin Europe obtained an extremely strong position. This enables project opponents and environmentalists to take action against projects which show even minor deficits in environmental planning.

The protection of nature and the environment in Europe and especially in Germanyis undoubtedly a serious task, one of the decisive challenges of the future and a valuable chance.However, the strict regulations create difficult obstacles for project developers and owners, although, the projects such as flood retentions dams, serve the common good.

For such projects, the required, in particular experts’ studies, planning effort has multiplied. This means not only higher planning costs but in particular significantly longer planning periods.Nevertheless, there are still considerable legal risks for the project, even when the planning quality and content is due and reliable. This is due to the fact that the effects of a project sometimes only can be modeled taking certain assumptions which results in more or less accurate result with a high quantitative variation. From these results reliable statements can hardly be derived.Counter studies may show different results just by changing minor input values basing on other assumptions.

Another considerable risk for such projects is simply the long planning periods and the associated risk that lwas, codes and guidelinesare changing. Additionally, court decisions may also change the legal framework unexpectedly. Adapting the planning to up-to-date legal framework again takes a lot of time and can extend the planning process so that the up-to-dateness of basic data, in practice a value of 5 years is considered to be applicable,is no longer given. This again leads to the requirement of updates of the planning documents and so on. A vicious circle against which the responsible parties and institutions in Europe still have to find a practical way for project realization without weakening the honorable goals of nature and environmental protection.

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