<u>Revised Terms of Reference</u>

Heavily Modified Waters in Europe
Case Study on the Elbe River

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PART I

1 Preface (1 page)

Within the scope of the European project "Identification and Designation of Heavily Modified Water Bodies under the Water Framework Directive" 25 Case Studies in eleven member states are realised. The aim is the development of assessment criteria for the designation of heavily modified water bodies in contrast to natural surface waters.

As the normative definitions of heavily modified waters in the Water Framework Directive are widely interpretable, and the quality requirements for heavily modified waters are minor compared to natural surface waters, the project is dealing with the determination of uniform quality levels to be implemented in Europe. Thus, the approach includes the assessment of the ecological situation and the specification of quality targets ("high status" for natural waters respective "maximum ecological potential" for heavily modified waters). To identify measures, to improve the ecological situation and finally to achieve the given quality target Germany scenarios in the river basins Elbe, Lahn and Seefelder Aach were examined.

2 Summary Table (2 pages)

Below is a summary table on the case study of the Elbe River.

	Item	Unit	Information
1.	Country	text	Germany
2.	Name of the case study (name of water body)	text	Elbe River
3.	Steering Committee member(s) responsible for the case study	text	Dr. Ulrich Irmer, Dr. Bettina Rechenberg, German Federal Environmental Agency (UBA)
4.	Institution funding the case study	text	German Federal Environmental Agency (UBA)
5.	Institution carrying out the case study	text	Institute of Water Resources Research and Management, University Kassel
6.	Start of the work on the case study	Date	01.05.2000
7.	Description of pressures & impacts expected by	Date	30.10.2000
8.	Estimated date for final results	Date	30.04.2002
9.	Type of Water (river, lake, AWB, freshwater)	text	River
10.	Catchment area	km^2	80.000 (in Germany, gauging station Zollenspieker)
11.	Length	km	1091,47
12.	Mean discharge	m^3/s	720 m^3/s (gauging station Neu-Darchau)
13.	Population in catchment	number	15.000.000
14.	Population density	$Inh./km^2$	182
15.	Modifications: Physical Pressures / Agricultural influences	text	Navigation, Floodprotection
16.	Impacts?	text	Impact Group “ Navigation ”: More than 10 % of the length bank impairments. Impact Group “ Flood protection ”: Instructure for flood protection along entire river
17.	Problems?	text	Industrial discharges (local); Municipal discharges; Navigation; River channel in extended sections only moderatly regulated
18.	Environmental Pressures?	text	Tourism
19.	What actions/alterations are planned?	text	Decreasing navigable depth up to 10-30 cm Breakthrough of bank impairments and harbor-basins Maintenance of buildings and maintenance measures for the river

20.	Additional Information	text	
21.	What information / data is available?	text	German River Habitat Survey, inventories of fish and benthic invertebrate fauna
22.	What type of sub-group would you find helpful?	text	
23.	Additional Comments	text	

3 Introduction (2 pages)

3.1 Choice of Case Study

The case study “Elbe River” has been chosen as one of four case studies in Germany treated in the framework of the European project on “heavily modified water bodies”. These stream systems differ with respect to its size (middle, large and very large sized [Elbe River]), geography/topology, main uses and main pressures.

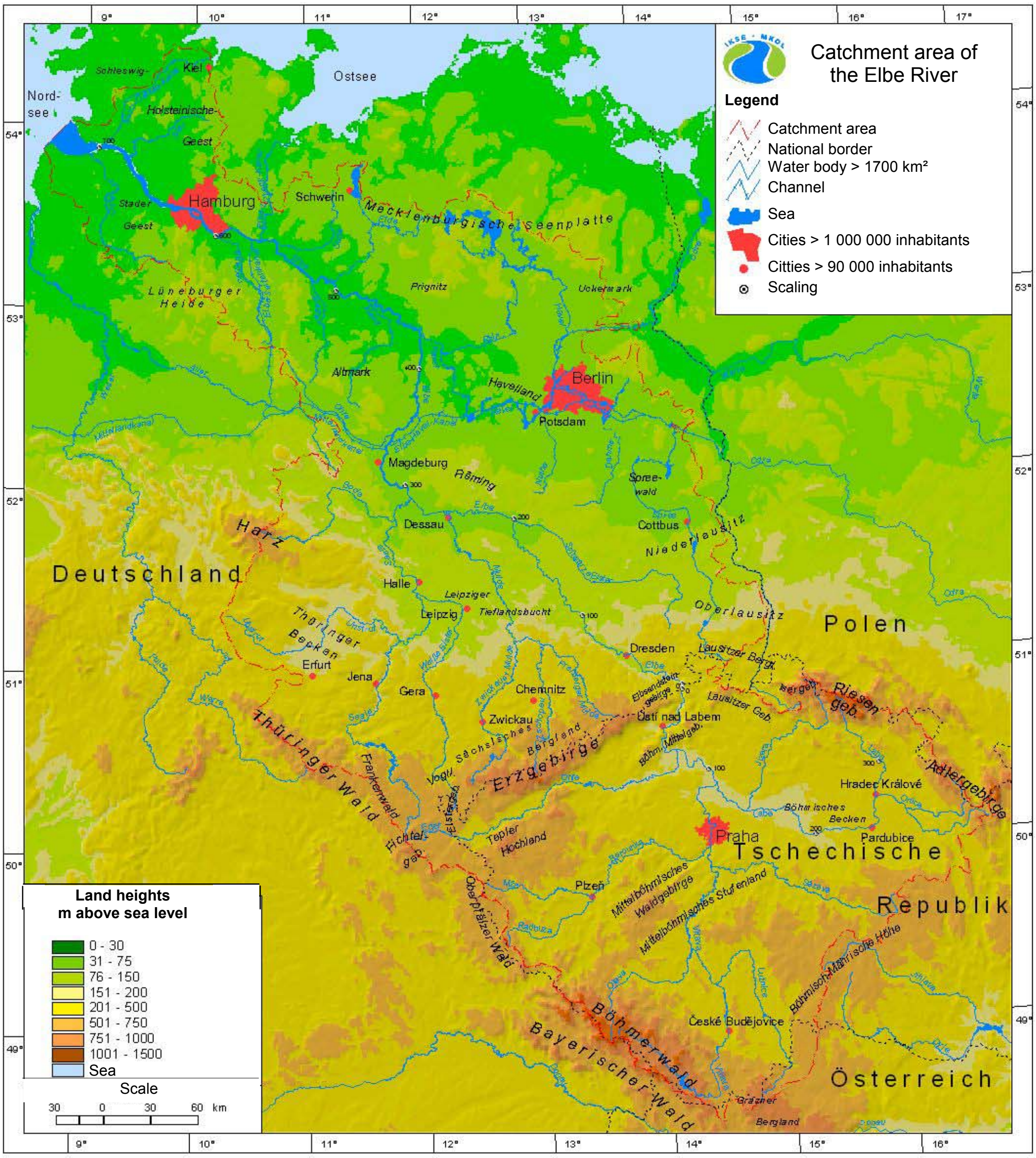
Substantial data from earlier and actual studies on the Elbe River collected by official measurements of departments and ministries of the federal states, International commission for the protection of the Elbe River and “Working group Elbe” are available, for example

- water quality: physical and chemical parameters, nutrient loads with regard to catchment areas, water quality modelling
- hydromorphology: assessment by the special method "survey mapping" of parameters in the framework of the German River Habitat Survey (Elbe River), an assessment with mapping in the field is made at present
- biology: various investigations of fish fauna, benthic invertebrate fauna and other aquatic organisms and also examination on flora, vegetation and fauna of river banks and flood plains
- flood protection: stocktaking of the flood protection level in the catchment area of the Elbe River, flood protection concept for the Elbe River
- stocktaking of weirs

3.2 General Remarks

The large-sized river basin of the Elbe is situated in the North-Eastern Part of Germany. The Elbe River rises in the “Riesengebirge” at 1384 m above sea level. The entrance of the Elbe River into the Federal state of Sachsen is defined as km 0. For navigation purposes it begins in the frontier on the left bank, since the Elbe River forms the common boundary on a length of 3,43 km. The scaling for water-management is different and slain from the boundary in the Czech republic upstream to the source. Below the “Elbsandsteingebirge” the Elbe River passes the city of Wittenberg in a northwest direction. Here it leaves the low mountain range, crosses the pre-aged hill country, passes the lowland in the north of Germany and finally the original stream valley of Breslau next to Bremen. North of Magdeburg the Elbe River turns towards north-northeast. Direction on reaches the Elbe River the North Sea at Cuxhaven-Kugelbake/Friedrichskoog-Spitze (km 727.7) (IKSE 1994) (see figure 3.2.1).

The Elbe River is the forth biggest river (after Donau, Rhein and Weichsel) of the central and west-europe. About 65 % (96.932 km²) of the catchment area is located in Germany, 33 % (50.176 km²) in the Czech Republic, 0,62 % (920 km²) in Austria and 0,16 % (240 km²) in Poland (see figure 3.2.1) (IKSE 2001).



References: Federal Institution for hydrology, Koblenz

Czech hydraulicmeteorological institute, Prag

International commission for the protection of the Elbe River, Magdeburg

Digital landscape model 1:1000 000 – DLM 1000 of the institute for applied geodesy

Figure 3.2.1: Topographic map of the catchment area of the Elbe River (differently references)

4 Description of Case Study Area (3 pages)

4.1 Geology, Topography and Hydrology

Commencing at the source of the Elbe River in the "Riesengebirge" up to the border profile of Germany/Czech republic the flow distance amounts 367,95 km, the pertinent catchment area covers a surface of 51.393,6 km² (IKSE 1994).

Corresponding to the natural local conditions the Elbe river can be subdivided into three sections: upper, middle and down-stream. The upstream Elbe river comprises from the spring in the "Riesengebirge" (1384 m above sea level) till the crossing to the lowland from the northern Germany at Schloss Hirschstein (Elbe river km 96 below the Czech republic and Germany boundary) among Meißen and Riesa. In this section the length is about 460 km. Till the estuary of the Moldau (Vltava) at Mělnik the catchment area of the Elbe River increases to 13714 km². Important tributaries are the Orlic river (2037 km²) from the "Adlergebirge" and the Jizera river (2193 km²) from the "Isergebirge" (see figure 3.2.1). The Moldau River is the largest tributary from the Elbe River. Her catchment area comprises about 28090 km² which is twice the size of the adjacent catchment area of the Elbe River at their confluence. The Eger River (5614 km²) has her source in the "Fichtelgebirge" and drains mainly the south of the "Erzgebirge" (Ore Mountains). After the spring from the Bìlina River (1073 km²) and the Ploučnice River (1193 km²) another twelve rivers with major catchment areas between 150 and 400 km² are flowing to the upstream Elbe River.

The middlestream section of the Elbe River comprises from Schloss Hirschstein till the weir Geesthacht (Elbe river km 585,9) and is about 490 km long. Major tributaries the Schwarze Elster River (5541 km²) follows the Mulde River (7400 km²). The Mulde River and her headwaters drain the largest area from the "Erzgebirge". About 389 km² of her catchment area is located in the Czech Republic. The Saale River (24079 km²) arises in the "Fichtelgebirge" and incorporates the Unstrut River (6343 km²), the Weiße Elster River (5154 km²) and the Bode River (3298 km²). Nearly 100 km² of the catchment area of the Saale River is located in the Czech Republic. Below Magdeburg the following tributaries enter the midsection of the Elbe River: Ohre River (1747 km²), Havel River (24096 km²), Aland River (1864 km²), Elde River (2990 km²), Jeetzel River (1928 km²) and Sude River (2253 km²). About 69,5 km² of the catchment area from the Havel River is located in the Czech Republic.

The catchment areas of the biggest six rivers form the middle and upstream sections of the Elbe River are the Moldau River, Eger River, Schwarze Elster River, Mulde River, Saale River and Havel River (see figure 4.1.1) (IKSE 2001).

The downstream section of the Elbe River from the weir Geesthacht to the estuary into the North Sea at Cuxhaven-Kugelbake (Elbe River km 727,7) is about 142 km long (IKSE 2001). The catchment area of this section is about 13255 km². Important tributaries are Ilmenau River (2852 km²), Stör River (1780 km²) and Oste River (1712 km²). Also the North Sea-Baltic Sea Channel belongs to the catchment area of the Elbe River (see figure 4.1.1).

References: Federal Institution for hydrology, Koblenz

Czech hydraulicmeteorological institute, Prag

International commission for the protection of the Elbe River, Magdeburg

Figure 4.1.1: Catchment area of the six main tributaries of the Elbe River (differently references)

The catchment area of the Elbe River and her main tributary, the Moldau River, is drained preponderant in the bohemian upland. This area is dominated by high proportions of mountains and hills. The present river network is the result of the erosion and accumulation activity of the rivers as a function of the intensity of the geotectonic movements of the earth's crust and of the character of the geological background (IKSE 1994).

Regarding the geological characteristics of the catchment area the Czech Elbe River passes five distinctive zones while the German Elbe River passes further zones specified in table 4.1.1 (IKSE 1994).

Table 4.1.1: Geological zone-classification (IKSE 1994)

Number of zone	**name of the sections border**	**characteristic**
I	source - Vrchlabi[1] (348,86)	Bedrock of the "Riesengebirge"
II	Vrchlabi[1] - Vestřev[1] (348,86-326,05)	Permian basin underneath the giant mountains
III	Vestřev[1] - Malé Žernoseky[1] (326,05-56,07)	bohemian chalk basin
IV	Malé Žernoseky[1] - Děčin[1] (56,07-12,50)	Low mountain range, vulcanic with a chalk basin
V	Děčin[1] - national border of Czech Republic (12,50-0,00)	Elbe River sandstone of the bohemian chalk basin with “Dioriten” and “Metamorphiten”
VI	zone Schmilka[2] - Dresden[2] - Meißen[2] - Riesa[2]	rocks of the east "Erzgebirge" in the west, “Elbsandsteingebirge” in the south and the east, “Lausitzer Granodioritgebirge” in the east

Table 4.1.1: Geological zone-classification (continued) (IKSE 1994)

Number of zone	name of the sections-border	characteristic
VII	zone Riesa² - Torgau² - Wittenberg² - Aken²	Bedrocks and pleistocene coverage and tertiary rocks at the south and south/west edge, moraines end of the "Fläming" and pleistocene high areas in the north and north/east
VIII	below Aken²	pleistocene high areas

[1] = cities in Czech Republic

² = cities in Germany

In the area of the upper stream Elbe River in the zones I and II (see table 4.1.1) the geomorphology is characterised through predominantly erosion processes and the feed of the developed till. Mainly above the local erosion basis the zone III can be characterised by the transportation and at least by the sedimentation of the till. In the zones IV and V deep valleys are formed as local erosions-basis with a characteristic slow depth-erosion and transportation of till (IKSE 1994).

With the break-through of the Elbe River in the "Elbsandsteingebirge" the river eroded the entire rock sequence of the cretaceous period. Between Pillnitz (km 43,0) and Coswig (km 73,0) the "Lausitzer" granite forms the eastern steep hillside. Northeast closes on the bedrock (carboniferous period) of Meissen, the last obstacle for the Elbe River before its entrance into the North German lowland. Below Meissen (km 83.0) the Elbe River flows through the morainic landscape coined by the ice ages and achieves at Hirschstein (km 96.0) and Diesbar (southern of Riesa) the north German lowland. Rock again touches the Elbe River with the permian period rocks at Magdeburg (km 326.0). Near to Magdeburg the Elbe River flows at the foot of the ice peripheral locations of the "Plankener" and "Warthestadium", and it continues to flow through the "Saale" moraine (Quaternary period) towards Havelberg (km 423.0) along the eastern moraine of the stage of Brandenburg from the "Weichsel" glaciation. The original stream-land of the middle and downstream Elbe River became created by the meltwater stream of the two last interglacial periods (after KEMPE 1992). According to these geological conditions the river bed of the Elbe River on German area consists only in the highest run of rock and rubble. Downstream the grain size of the bed-forming materials constantly decreases from rough gravel over gravel and sand to the fine sand. Only the tributaries from the mountains supplies boulderous solids to the main stream and forms at their estuaries crushed stone cones (>Schotterkegel). The sediment discharge is indicated following measurements from the thirties specified in Dresden with 36.000 m³ per year, at Magdeburg with 300.000 m³ per year and in Boizenburg with 541.000 m³ per year. The downstream Elbe River crosses an after-ice-age original stream-land, which is filled up i.e. with silt of fine sand. Drilling results point to deeper zones in addition, peat, sand, rough gravel and boulder clays. With increasing depth the material becomes more coarse-grained (from the silt to the fine sand). The current in the downstream section of the Elbe River caused a sole existing essentially from sands (IKSE 1994).

Based on its flow parameters and its regime code the Elbe River belongs to the Central European rain-snow-type. Typical floods occurs in times of the thaw in the low mountain ranges in the spring. Floods in the summer are rarer after appropriate precipitation. The means of the flow in the profile at the state border Germany/Czech republic amounts to 315 m³/s (mean discharge) and at the delta into the North Sea to about 877 m³/s (mean discharge). At the confluence of Elbe and Moldau the Elbe has a flow of 105,877 m³/s (mean discharge) (IKSE 1994).

The highest middle precipitation in the upstream section of the Elbe River on Czech area approximate to 894 mm/year (station: Jaroměř). The middle precipitation in the upstream section of the Elbe River on German area is about 667 mm/year (station: Dresden). In the area to the middlestream section of the Elbe River the highest measured middle precipitation is about 711 mm/year (station: Neu-Darchau) (IKSE 2001).

4.2 Socio-Economic Geography and Human Activities in the Catchment

About 24,5 million Humans live in the catchment area of the Elbe River. In the Czech part of the Elbe area, which constitutes about two thirds of the area of the Czech republic, there are about 6 million inhabitants. That corresponds approximately two thirds to the total population of the Czech republic (IKSE 2001). In the German part of the catchment area of the Elbe River live about 18.5 million humans, with about *182* inhabitants per square kilometre. This corresponds to the total population of Germany in approximately 23 %. In the catchment area of the Elbe River, partially completely or partly, about ten states of the German Federal Republic with the following numbers of inhabitants are associated with the Elbe River: Sachsen 4,3 million, Brandenburg 2.1 millions, Berlin 3.4 millions, Sachsen-Anhalt 2.7 millions, Niedersachsen 0.9 millions, Mecklenburg-Vorpommern 0.3 millions, Hamburg 1.7 millions, Schleswig-Holstein 1.1 millions, Thüringen 1.7 millions and Bayern 0.3 millions inhabitants (see figure 4.2.1). The most densely populated areas in the catchment area of the Elbe River are Berlin with 3,47 Mill., Hamburg with 1,71 Mill., Prague with 1,21 Mill., Leipzig with 0,488 Mill., Dresden with 0,477 Mill., Halle with 0,290 Mill., Chemnitz with 0,278 Mill. and Magdeburg with 0,265 Mill. Inhabitants (status 1994) (IKSE 1995).

The land area of the catchment area of the Elbe River consists of 29 % forested land, 7 % urban areas, 61 % Agricultural areas and 1,5 % Water surface (BEHRENDT et. al. 1999).

References: Federal Institution for hydrology, Koblenz

Czech hydraulicmeteorological institute, Prag

International commission for the protection of the Elbe River, Magdeburg

Figure 4.2.1: Federal states in the catchment area of the Elbe River

(differently references)

The Elbe River and its tributaries are mainly used for the withdrawal of drinking water treatment (bank filtration), the supply by process water for the industry and the supply by irrigation water for the agriculture (IKSE 1995). In the year 1992 became in the newly-formed German states (without East-Berlin) about 41 % (486 Mill. m³) water promoted for the potable water supply from surface water including bank filtrate and enriched groundwater. However, in the German states Niedersachsen, Schleswig-Holstein and Hamburg the potable watersupply used from bank filtrate, artificial infiltrate or by direct withdrawal from watercourses does not play a significant role in the catchment area of the Elbe River (IKSE 1995).

4.3 Identification of Water Bodies

Corresponding to the natural local conditions the Elbe River has been subdivided into three distinct water bodies: upper, middle and downstream (see chapter 3):

The **upstream** section of the **Elbe** River comprises from the spring in the “Riesengebirge” (1384 m above sea level) till the crossing to the lowland from the northern Germany at Schloss Hirschstein (Elbe river km 96 below the Czech republic and Germany boundary).

The **middlestream** section of the Elbe River comprises from Schloss Hirschstein to the weir Geesthacht (Elbe river km 585,9).

The **downstream** section of the Elbe River commencing at the weir Geesthacht is till her estuary in the North Sea at the sea border near Cuxhaven-Kugelbake (Elbe River km 727,7)

The river basin has been described according to the WFD Annex II, 1.2 system A (table 4.3.1). It is part of the ecoregion no. 14 “central flat country” and no. 9 " central low mountain range" (WFD Annex XI) at “upper-altitude to lowland” and “very large size”. The geology is classified as limy.

Table 4.3.1: Description of the Elbe Basin according to system A, WFD Annex II, 1.2. “Ecoregions and surface water body types”

Descriptors	**Description**
Ecoregion	Central flat country and central low mountain range (Annex XI WFD)
Altitude	upper-altitude to lowland
Size	very largely
Geology	limy

PART II

5 Physical Alterations (5 pages)

5.1 Pressures and Uses

Initial interventions into the ecological system of the Elbe River and its floodplains were measures for flood protection, the melioration and finally measures for the creation and upgrading of the infrastructure for navigation. Structural measures like continuous dyke construction works at the Elbe River are verified already in the 12th Century (Meyerhoff u. Petschow 1996). The continuous dyke construction works and thus the cutting off from large original floodplains became more importantly. As a consequence the Elbe River has been straightened for the improvement of flood protection and in the following centuries with the further urbanisation adjacent cities. In the 20th century followed further dyke construction works, the estuary -removal from the tributaries and the building of shut-off units within the estuaries areas of the tributaries, which can be closed at flood-times of the Elbe River (IKSE 2001).

Written vouchers indicate the use of the Elbe River and its larger tributaries in the sixth century and later in the tenth and eleventh century for raft- and ship- traffic (IKSE 1994, GABRIEL 1996). Since the beginning of the 19th century the navigation and rafter experienced a systematic increase. Since the turn of the century vehicles with over 1000 t carrying capacity operated on the Elbe River.

Today the entire German Elbe River is a national waterway; upstream Hamburg the river represents an inland waterway, downstream a sea-traffic dominates. Today stretch is certified for single-vehicles up to 110 m length and about 11 m wide, coupled tugboats on the upper Elbe River up to 137 m and on the middle Elbe River to 170 m length (FAIST 1994).

On the basis of suitable criteria (see table 5.1.1) an evaluation took place with respect to determined loads. As main physical pressures on the Elbe Basin navigation and flood protection are identified (see marked fields in table 5.1.2). In the context of the available information/data we have selected two specific parts from the middle and upper section of the Elbe River which are representative for the identified main pressures. The first considered section belongs to the upper section of the Elbe River and comprises from the national border of Germany (km 0) to the city of Pirna (km 34). In this section the main pressure is navigation. The second considered section in the middle Elbe River with the main pressures "flood protection" and “navigation” comprises the city of Magdeburg (km 326,5) and the weir at Geesthacht (km 585,9).

So far the data represent an outline of the significant pressures and other uses upon the morphology of the water body of the Elbe River (table 5.1.3).

Table 5.1.1: Criteria for the identification of significant pressures on surface-waters (LAWA 2001, modified and completed)

Pressures/Uses	significant	not significant
Navigation	1. > 10 % impounded river length at mean low water flow 2. navigation of passengers, goods-traffic, national waterway 3. not passable artificial barriers with a height > 30 cm 4. Proportion of river length with discharge acceleration with - Ratio profile depth to profile width ≥ 1:4, - Bank (single or both sides) ≥ 10 % total length with bank impairments **and** - Longitudinal profile ≥ 70 % stretched or straightened	1. ≤ 10 % impounded river lengthat mean low water flow 2. recreational uses, motor boats, rowboats and canoes 3. artificial barriers with a height ≤ 30 cm, passable artificial barriers with a height > 30 cm respectively 4. Proportion of river length with discharge acceleration with - Ratio profile depth to profile width < 1:4; - Bank (single or both sides) < 10 % total length with bank impairments **and** - Longitudinal profile < 70 % stretched or straightened
Flood Protection	1. flood-protection structures (dams, dykes) located within a strip up to 100 m at the potential floodplain along the river and directly connected with the river or located within a strip of 40 % of the adjacent potential flooded riparian zones **and** - > 50 % dyke construction works at the free-flowing river length	1. flood-protection structures (dams, dykes) located within a strip up to 100 m at the potential floodplain along the river, located at least outside of 40 % of the adjacent potential flooded riparian zones**and** - ≤ 50 % dyke construction works at the free-flowing river length

Table 5.1.1: Criteria for the identification of significant pressures on surface-waters (continued) (LAWA 2001, modified and completed)

Pressures/Uses	significant	not significant
Hydropower generation	1. > 10 % impounded river length at mean low water flow 2. not passable artificial barriers with a height>30 cm 3. Proportion of river length with discharge acceleration with - Ratio profile depth to profile width ≥ 1:4, - Bank (single or both sides) ≥ 10 % total length with bank impairments **and** - Longitudinal profile ≥ 70 % stretched or straightened 4. Intermittent flow regulation with flow spills	1. ≤ 10 % impounded river lengthat mean low water flow 2. artificial barriers with a height ≤ 30 cm, passable artificial barriers with a height > 30 cm respectively 3. Proportion of river length with discharge acceleration with - Ratio profile depth to profile width < 1:4; - Bank (single or both sides) < 10 % total length with bank impairments **and** - Longitudinal profile < 70 % stretched or straightened 4. flow regulation without spills
Agriculture/Forestry	1. tillage and grassland > 50 % of the river length 2. special crops > % of the river length 3. not passable artificial barriers with a height > 30 cm 4. > 50% of the entire river length in the rural landscape is impaired in the adjacent land zone	1. tillage and grassland ≤ 50% of the river length 2. special crops ≤ % of the river length 3. artificial barriers with height ≤ 30 cm, passable artificial barriers with height > 30 cm 4. 50% of the entire river length in the rural landscape is agriculture-like impaired in the adjacent land zone

Table 5.1.1: Criteria for the identification of significant pressures on surface-waters (continued) (LAWA 2001, modified and completed)

Pressure	significant	not significant
Water supply	1. Extraction > 10 % of mean low water flow 2. Fluctuated discharge = 10 % of mean water flow 3. No minimum discharge (according to respective land regulations) in rivers 4. without recharge > 0,1 mean low water flow per single installation and > 0,5 mean low water flow total 5. with recharge > 0,3 mean low water flow per single installation	1. Extraction ≤ 10 % of mean low water flow 2. Fluctuation discharge < 10 % of mean water flow 3. minimum discharge (according to respective land regulations) in rivers 4. without recharge ≤ 0,1 mean low water flow per single installation and ≤ 0,5 mean low water flow total 5. with recharge ≤ 0,3 mean low water flow per single installation
Urbanisation	1. urban areas > % of the river length 2. > 50% of the entire river length are urban with bank fixation	1. urban areas ≤ % of the river length 2. ≤ 50 % of the entire river length are urbane with bank fixation

Table 5.1.2: Assessment and classification of the resulting impacts on the water body "Elbe"

Pressures & Uses	Selected Sections of the Elbe River	
	upstream * **(km 0 - km 34)**	**middlestream *** **(km 326,5 - km 585,9)**
Navigation		
Flood Protection		
Hydropower generation		
Agriculture/ Forestry		
Water supply		
Urbanisation		

* > the data are not related to the catchment area, them refer only to the River and its adjacent surfaces

Table 5.1.3: Specification of the main physical pressures and other uses on the basis of selected sections in the case study " Elbe " (differently references)

Pressures & Uses	Selected sections of the Elbe River	
	upstream * **(km 0 - km 34)**	**middlestream *** **(km 326,5 - km 585,9)**
Navigation	National waterway, goods-traffic, navigation of passengers and recreation: motor boats, uses recreational	National waterway, uses in slight extent: recreational and navigation of passengers passable weir at Geesthacht with a height > 30 cm
Flood Protection	non-existent	Dyke construction along the entire distance
Hydropower generation	non-existent	non-existent
Agriculture/ Forestry	tillage and grassland ≤ 50% of the river length	tillage and grassland ≤ 50% of the river length
Water supply	For the Elbe River there are no significant water abstractions identified so far.	For the Elbe River there are no significant water abstractions identified so far.
Urbanisation	≤ 50 % of the entire river length are urbane with bank fixation	≤ 50 % of the entire river length are urbane with bank fixation
References	KOLBE (2001), IKSE (1999), IKSE (2001), BfG (2001), IKSE (1995), SCHWELER (2001), LÖFFLER (2001), LfW (2001), GRUNDMANN (2001)	

* > the data are not related to the catchment area, them refer only to the River and its adjacent surfaces

The Elbe River is also used for recreation, tourism and fishing. The effects on the morphology and biology of these uses are local.

5.2 Physical Alterations

The development of the littoral areas and the floodplains of the Elbe River were influenced by human beings since the first settling. The most extensive alterations in the Elbe River were in particular due to the navigation (canalisation of the river), to the flood protection (channel regulation - modification of the route and the river bed) and to the extension of the water-economic use of the river (establishment of weirs and dams) (IKSE 1994). The guarantee of a regular navigation on the Elbe River led gradually to a canalisation or adjustment of the river bed of the upper Elbe River. The natural dynamics of the longitudinal profile and its floodplains within the area of the Czech republic were removed by the consistent canalisation and the building of more numerous weirs (IKSE 1994). The canalisation of the longitudinal profile led in sub-sections of the upper Elbe River to punctures of the meander, to separately river elbows, to the modification of the aquatic ecological system of a running river towards a slowly flowing river and to modifications of the level from the groundwater, in particular in the area of the weirs.

The original length of the Czech section of the Elbe River (422,91 km) was shortened by the adjustment of around 55 km towards the present length of 367,95 km, i.e. a loss of approximate 13 % of the original length (IKSE 1994). In order to generate a deeper channel obstacles like e.g. islands and river-divisions were removed, while banks were fixed with cross - and longitudinal constructions (ROMMEL 2000). The channel regulations of the upper section of the Czech Elbe River had strong influence on the longitudinal profile in this area and the loss of adjacent rivers, brooks and ox-bow-lakes. Floodplain forests were flooded regularly.

The decrease of the flooding volume at given times is a consequence of the enlargement of the riverbed near to Jaroměř. The original average soundings by flooding of max. 1.5 m lowered itself on the present depth of 0,8 m. The accelerated water discharge from the catchment area means a decrease of the retention volume at flood times from originally about 362 Mill. m^3 on today about 102 Mill. m^3.

The traffic-water-construction works of the last 150 years represent a cut also in German area of the upper Elbe River. The onward extension of the Elbe River in the framework of the traffic-water-construction resulted in the typical islands and stream-divisions. As complete consequence, alluvial deposit of smaller waters loss were determined in the dyke-riparian surroundings. Further channel regulations and the attachment of the riverbed prevented an emergence of new ox-bow lakes (IKSE 1994, ROMMEL 2000).

The effects of the measures for the upgrading of the upper and middle section of the Elbe River concerning to the waterway construction are more unequivocally than the effects of measures of the flood protection (cf. JÄHRLING 1992). Dyke construction works limited the actual flood-dynamics of the Elbe River only regionally. Afterwards it came in the today's governmental district of the city Magdeburg to a reduction of the former active floodplains on about 16 % (IKSE 1994). By the loss at retention surfaces particularly in the valley with close river hose the flood situation was intensified, whereby it came again and again to breaking of the dykes. Here erosion trough developed land laterally the locations of fracture. The following riparian zones were silted up. The dykes, which were kept permanent against the erosion attack of the Elbe River, formed at the same time a development boundary for the run-migration and for run-expansion of the river. On the other hand at some places the dyke lines were adapted to the changed run-geometry. In the years 1881 and 1890 bottlenecks were eliminated by redeployment near the city Storkau, while large old meanders were separated with dykes between 1843 and 1881 in the section Elbe River km 515 to 520 by advancement. The table 5.2.1 below shows the development of some water structures of the Elbe River on the basis of the years 1776 and 1992.

Table 5.2.1: Confrontation of waters structures 1776 and 1992 for Elbe River-km 475 - 583 (out ROMMEL 2000)

Structure-feature	**year 1776**	**year 1992**
Length of the section	about 106 km	108 km
Width of the Elbe River (incl. the width of the islands, if within the profile) 1992 between the banks	max. 850 m average 420m at least 130 m	max. 550 m average 340m at least 230 m
Width of the Elbe River (without islands) 1992 between the head of the groynes	max. 750 m average 380m at least 130 m	max. 430 m average 220m at least 150 m
Width variation (with/without islands)	6,5/5,8	2,4/2,9
Islands and banks (with vegetation/without)	55 (30/25)	21 (2/19)
Length of the run of the Elbe River with islands	32 km	7,65 km
Island area (with vegetation/without)	ca. 6 km², (4,1 km²/1,70 km²)	ca. 1 km² (0,7 km²/0,4 km²)
Length of the amphibious zone around the islands	ca 70 km	ca 20,4 km
Regulation buildings	27 groynes	ca. 1680 groynes

Table 5.2.1: Confrontation of waters structures 1776 and 1992 for Elbe River-km 475 - 583 (continued) (out ROMMEL 2000)

Structure-feature	year 1776	year 1992
Tributaries - without connection to the Elbe River	62	112
Tributaries - with connection to the Elbe River (total length/average)	40 (52,9 km/1,3 km)	28 (23,7 km/0,8 km)

In Germany there is a procedure to assess physical alterations on a water body. Therefore a survey on the present quality state the "structural quality of water" is mapped as it has been done with "biological quality of waters". The structural water quality becomes a generally applicable assessment basis in projects of river renaturation, river development planning, assessment of river development projects, as well as in assessing river-damaging interventions. The methodology is applicable to landscape and urban areas. For survey maps at Federal-State or national levels, the results of the mapping campaign in the field can be aggregated on any desired scale. The results may also be utilised in the framework of programmes, specialised plans and development concepts at Federal-State or regional levels.

The term water structure is understood here as all spatial and material differentiations of the riverbed and its riparian zones as far as they are hydraulically, morphologically and hydrobiologically effective and relevant to the ecological functions of the river and the floodplain. The measuring scale oft he assessment is the present-day potential natural state of the water. It is the state that would establish itself after abandoning of all existing uses of the river and its floodplain and after the removal of all buildings there. The best assessment (Quality class 1) is oriented at this overall concept. Because this state may be different depending on the regional landscape and size of the river, different assessment references, so called overall concepts of regional landscapes are applied to the major types of water bodies.

The determination of the structural water quality is an assessment process. It bases on an objective and reproducible inventory of the structural elements of the river and its riparian zones by means of a predefined system of parameters. Altogether 25 single parameters are covered. These are particularly assessment-relevant indicators of the ecological functionality of the longitudinal profile (i.e. "curvature of the stream", width variability"). The determination of the structural water quality is made in seven levels. The results of the assessment are shown in maps of structural water quality (LAWA 2000). Besides mapping in the field, a special method for "survey mapping" is being developed. This method is based on the analysis of available maps, aerial imagery and other data without direct data acquisition in the field. The results of the assessment of some sections of the upper and middlestream section of the Elbe River developed with the special method "survey mapping" shows figure 5.2.1. At present an assessment of the Elbe River with mapping in the field is made.

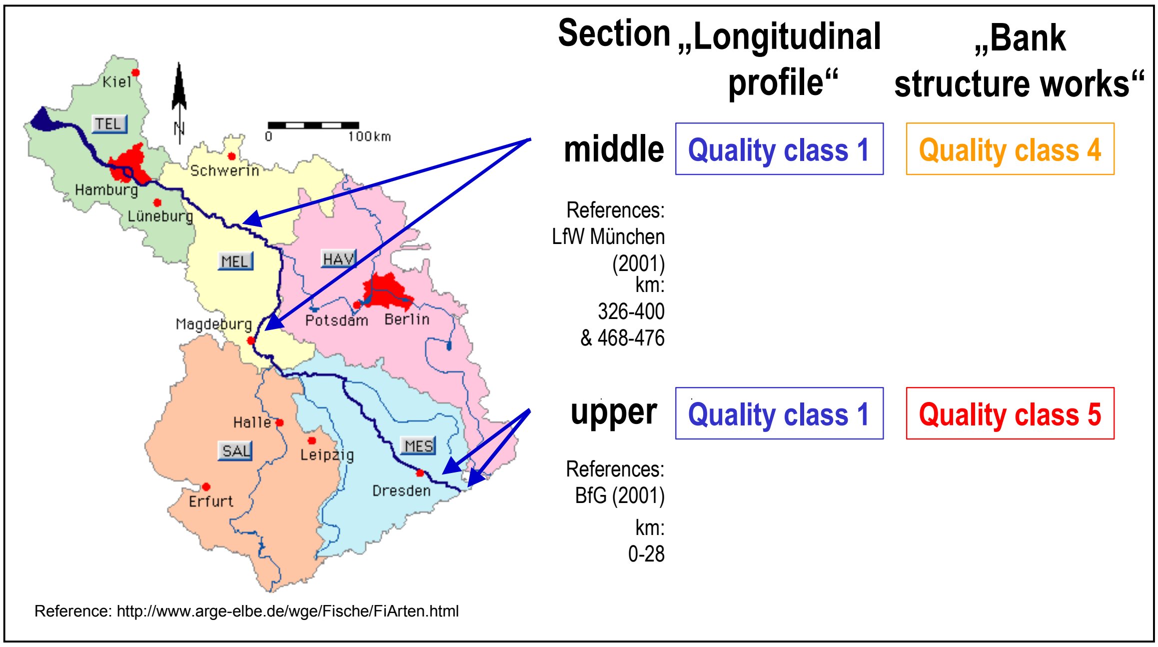


Figure 5.2.1: Quality classes of water structure from sections of the upper and middlestream Elbe River (differently references)

The quality classes in figure 5.2.1 are adapted to the classes of Annex V WFD. So quality class 2 can be equate to "good ecological status".

5.3 Changes in the Hydromorphological Characteristics of the Water Bodies and Assessment of Resulting Impacts

Since the 17. Century the natural flood area of the middle Elbe River was reduced substantially. This caused a loss of more than 2,3 billion m³ retention volumes at a 100-annually flood. Consequences of this development are above all the acceleration of flood waves and increase of vertex. The vertex increase near the city Lutherstadt Wittenberg approximate about 10 cm and near the city Wittenberg ca 50 cm (IKSE 2001).

In the area of the upper Elbe River in Czech area in the context of the waterway construction numerous weirs were established. So between Usti nad Labem - Strekov and Chvaletice (km 40.4 - 212.3) the river became a chain of "flowing through storage reservoirs". The consequence is the rise of the groundwater level above the weirs and its dropping below the weirs. The effect of the modification of the biotope is the loss of the original Flora and Fauna towards a microbiota of a standing water. In German area of the upper section of the Elbe River are for the improvement of the channel conditions of the Elbe River in accordance with the federal traffic route plan 1992 up to the year 2012 instead of weirs construction measures (groyne, covering and control units as well as resoling thresholds with partial supplement) intended (IKSE 1994).

The channel regulation and the constriction of the stream through tail units, deck-works and breakwaters causes an elevated flow velocity and therefore a bigger slope of the stream. The consequence is a lower riverbed through sole-erosion up to the attitude of the new equilibrium (BRETTSCHNEIDER 1982). This equilibrium was not achieved especially in the course of 100 years in the upper section of the middle Elbe River at many positions. The river bottom has sunk about up to 2 m. This process has not stopped in the last 30 years (DOMS et al. 1990). The enormous deep erosion represents a today's main pressure of the Elbe River (IKSE 1994).

The Elbe River extension has led caused by the decrease of the course to a diminution of the self-cleaning-route. Important is the loss at ecologically valuable flat-water-areas, at sand - and grit-benches, current-calmed zones and cols. Therefore, these flat-water-areas gets lost by weirs like for example upside of the weir of Geesthacht or get impaired in their function. The effects of the weir at Geesthacht takes up to Lauenburg. The tailback causes a special hydrologic conditions. Low surface discharges decrease the flow velocity. The result is a increased sedimentation (IKSE 1994). Altogether there is a loss of biologically desired morphological variety in the cross - and longitudinal-profile. As part-substitute for the loss at current-calmed flat-water-areas, the breakwaters - and tail unit-fields originated with the stream-extension are from particular value for the ecosystem of the Elbe River today (SPOTT 1994, IKSE 1994).

The increasing adjustment of the river in 19. Century affected immensely the flood valley in the upper Elbe River. The original animal and plant communities were destroyed to a large extent and replaced from fewer specific, type-poorer secondary companies (km 286.75 to km 56,07 on the Czech area). The primary forests are only in its types sorted available, which are threatened further by the following factors (IKSE 1994):

- Modification of the ground-water level and the removal of vital periodic flooding
- Construction measures at the watercourse and its environment
- Transformation of flood forests in fewer productive forests

Despite of all human activities (dyke construction works, channel regulation, groundwater lowering) in the German area the upper section of the Elbe River zones land laterally the dykes are often still ecologically meaning surfaces. Sections of the river have intact flood typical flora and fauna (IKSE 1994).

5.4 Discussion and Conclusions

For the evaluation of the determined loads suitable criteria are to consult. Currently significance criteria are compiled in the context of the LAWA-committee "Surface waters and coastal waters" following the WFD annex II. Presently the significance criteria are available in a concept. They were examined in modified and completed form in the case study " Elbe ". Within this framework not the entire catchment area but the water body was regarded. That leads to the fact that only due to the development to a national waterway the use "navigation" at the middle Elbe River is significant (see table 5.1.2). At the middle Elbe River the navigation of passengers and recreational are represented to a small extent. Weirs were not built at the water body of the Elbe River up to the weir near the city Geesthacht (section: middle km 326,5). The longitudinal profile of the middle section of the Elbe River was evaluated by the Federal Institution for Water Research (BfG) Koblenz with "very well", whereby the fourth criterion according to table 5.1.2 is eliminated. Thus in this section the use "navigation" is nevertheless evaluated as significant. Within a total catchment area-referred analysis many weirs with a height more than 30 cm have to be considered, which are established among others for the navigation in the tributaries of the middle Elbe River. The classification of the use “navigation” in the section of the middle Elbe River as significant would be more univocal.

These aspects shows clearly up the meaning of the regarded scale in a catchment area. Further model sensitive parameters represent the significance criteria. The entire result of a conclusion analysis and finally the designation of water bodies as heavily modified substantially depends on these parameters.

6 Ecological Status (7 pages)

6.1 Biological Quality Elements

The geomorphologic and hydrological situation has a close relationship to the ecological characteristics of a water profile. As a cause for the modification in the type spectrum of the aquatic partnerships and the partnerships in the bank and floodplains priority the various human influences are to be addressed, e.g. adjustment work on the longitudinal profile and on the tributaries to improve the navigation conditions and water pollution (IKSE 1994, ARGE-ELBE 1995). Further influences are overfishing and bringing in allochthan types (ARGE-ELBE 1995).

For an ichthyological classification of the profile of a river abiotic and biotic factors of the paragraph which can be judged are necessary. The most important abiotic factors are the average downward gradient, the flow rate, the width of the riverbed, the bank structure, the character and composition of the sole and the physical and chemical condition of the water. Important biotic factors are the qualitative and quantitative composition of the makroinvertebrate communities, the presence of a water vegetation and the fish fauna.

Important abiotic factors regarded in this case study are the depth of profile and the bank structure. Regarded important biotic factors are the qualitative and quantitative composition of the makroinvertebrate communities and the fish fauna. The estimation was made in the context of the Elbe River by available data of the makroinvertebrate communities and fish fauna. The evaluation of the makroinvertebrate communities was realised by the Potamon Typie Index (PTI) according to the demand of the Federal Institution for Water Research (BfG) Koblenz (cf. SCHÖLL and HAYBACH 2001) and the evaluation of the fish fauna by the ichthyofaunistical procedure of the ARGE Elbe Hamburg (cf. ARGE-ELBE 2000). If an insufficient data basis does not permit the application of the procedures mentioned, the ecological status has been evaluated by means of the saprobic index or selected parameters to the fish stock.

The upper section of the Elbe River in the Czech republic is largely canalised. The water-stands are regulated by a multiplicity of weirs. The weirs subdivides a river and cause other life-communities in the water. In addition, the biotope-structures and life-communities are influenced in considerable dimensions (IKSE 1994). By the partial missing of fish stairs in this area the spectrum of the euryhalinen types is accordingly poor.

The effects of the extension measures on the different life-communities on German area of the Elbe River can be appraised heavily because of former examinations with the object to verify the abundance of the life-communities are hardly available for the individual stream-precincts. However in the area of the middle section of the Elbe River a natural meadow landscape with valuable life-communities gets remained despite of flood construction works, river-regulation and groundwater-mould. This applies also to the area of the upstream section of the Elbe River in Czech area (IKSE 1994). Nevertheless in the upper Elbe River in Germany some sections euryhaline fish types are missing. However in the area of the middle section of the Elbe River some of these fish types were proven, which must be moved up from the downstream Elbe River. The weir at "Geesthacht" is no hindrance for the migration of fishes (see chapter 6.3) since 1998. Therefore the absence of the euryhalinen fish types in the upper section of the Elbe River on German area is attributed for lack of suitable spawn substrates. On the other hand the fishes cannot look up its potential places to spawn and residence area because of many weirs in the tributaries of the upper section and in the middle section of the Elbe River. Thus the demand for a better river continuity should extend also to the areas of the tributaries in the catchment area. (ARGE-ELBE 1995).

In the middle-area after clearance of the former floodplain forests grassland - also tillages dominates on both sides of the Elbe River. The agriculturally used floodplains are shaped by grasslands of the stream valleys with different societies accordingly the utilization-intensity and the water-regime.

The method-Elbe-area offers stream valleys typical habitats for numerous insects and amphibians. The weir of Geesthacht has an effect on the water body up to the area of the city Lauenburg, so that the river assumes biological circumstances of a re-accumulated water. The ecosystem reacts to the water quality and the meteorological influences, for example through a climbing bioactivity (autotrophy components). The same is applied to the weirs embossed sections of the Elbe River of the Czech republic (see before).

After declining of the sewage-burden at the Elbe River the previous and further improved condition of the banks will be able to integrate a multifarious aquatic life-community again (IKSE 1994).

6.2 Physico-Chemical Elements

The Elbe River is in its order of magnitude one of the most strongly loaded rivers of Europe. In 1989 the water condition corresponded to that of the Rhine River in the times of maximal loads at the beginning of the 70's (IKSE 1995). Beginning with the term of 1990 the water condition of the Elbe River clearly improved. In particular in the new Lands of the Federal Republic and the Czech republic this improvement is mainly a result of the locally new building and development of industrial wastewater treatment plants or the link of many industrial companies to these plants (ARGE-ELBE 2001). By decommissioning of undertakings or reduction of the industrial production it came to further lowering of the river loads (IKSE 1995).

In table 6.2.1 the development of the water condition at the metering station Schnackenburg (Elbe km 474.5) is represented. The reduction of the sewage-content was referred to the years 1993 and 1989 because of the similar discharge conditions.

In earlier years oxygen-concentrations under 1 mg/l temporary made the existence of many water organisms impossible and limited the self cleaning efficiency of the Elbe River (SPOTT 1994). In nower days the ecological standard value oriented on fishes was not fallen below 3 mg/l. After IKSE (1995) the solve oxygen concentration raised on about 54 % (see figure 6.2.1). Further the development of the loads at the metering station “Schnackenburg” shows up the reduction of the organic load about 40 %, the reduction of nitrogen and phosphorus in each case about 30 %. The heavy metals reduced on about 84 % (Hg) up to 22 % (Cad) as well as the hydrocarbon connections around 93% (chloroform) up to 10% (γ-HCH) (IKSE 1995).

Table 6.2.1: Development of the water condition at the metering station Schnackenburg (Elbe km 474.5) calculated from week mixed samples (IKSE 1995)

Parameters	Symbol	Unit of measure -ment	1989	1993	Changing 1993 to 1989 [%]
mean water flow - calendar year	MQK	m³/s	520	510	
Solved oxygen	O_2	mg/l	6,3	12,5	198,4
Biochemical oxygen-demand	BSB_5	mg/l	10,0*	5,5*	55*
Chemical oxygen-demand	CSB	mg/l	56	30	53,6
Total-nitrogen	$N_{total.}$	mg/l	8,5	6,1	71,8
Ammonium-nitrogen	NH_4-N	mg/l	2,4	0,08	3,3
Nitrate-nitrogen	NO_3-N	mg/l	3,9	4,4	112,8
Total-phosphorus	P_{total}	mg/l	0,66	0,34	51,5
PH	pH	-	7,5	7,9	105,3
Adsorbable organic halogen-connections	AOX	µg/l	100	40	40
Chloride	CL	mg/l	295	151	51,2

* Estimation of the BSB_5 from the BSB_7

The decrease of the concentrations and loads in the Elbe River strengthened the natural self cleaning processes in the river. The decrease of the pollution impact led to occurring alga blooms in the middlestream section of the Elbe River since the beginning of the 90's. In the waste water of chemical industries some sections of the Czech Elbe River and some tributaries (Bilina, Schwarze Elster, Mulde, Saale und Havel) further increased pollutant concentrations are available. Currently in the area of the sections upper and middlestream section of the Elbe River there is still coming on loads i.e. with arsenic, the heavy metals lead, copper, zinc and iron (ARGE-ELBE 2001). A special meaning in this connection have zinc and mercury because the loads data can be influenced by hydrologic conditions (SPOTT 1994, IKSE 1995). Therefore in the year 1994 in the sections upper and middlestream section of the Elbe River by several flood waves came to re-mobilization of heavy metals from the sediments of the groyne-fields. This showed up clearly with zinc and mercury (IKSE 1995, FURRER

1996). In despite of the aforementioned improvements of the load situation the Elbe River is still one of the strongest loaded rivers in Europe.

6.3 Definition of Current Ecological Status

The assessment of the current ecological status of the Elbe River based on two indicator groups: fish fauna and macroinvertebrate communities.

The evaluation of the fish fauna of the Elbe River has been implemented according to the ichthyofaunistical assessment procedure of the ARGE Elbe, Hamburg. Regarded areas were sections of the upper and middle Elbe River. The available data basis is specified into figure 6.3.1.

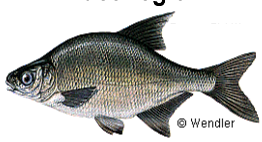
Total number of the catches:	172	
Number of catches with age structure:	79	
Acquisition period:	1994 to 2000	
Capture ranges (Elbe-km):	2-7 (Schmilka)	***Czech Republic***
	12-15 (Prossen)	↓
	80-87 (Meißen)	
	185-215 (Wittenberg)	
	300-340 (Magdeburg)	***German North Sea***

Figure 6.3.1: Data basis for the evaluation of the fish fauna at the Elbe River (BEHRENDT et. al. 1999)

Table 6.3.1: Criterion for an evaluation of the fish fauna by a procedure of the ARGE-Elbe (ARGE-ELBE 2000)

Evaluation area	Single criterion	Quality grade 2: „good status“
Type inventory	historically admitted types Guidance fish & Corollary fish types Migrate longdistance fish types	predominantly available (>>50%) completely available most represent
Abundance	Guidance fish Corollary fish types Rel. Proportion of d. lead /Corollary fish types	eu- to subdominant (>10% bis >2%) predominantly eu- to subdominant about 50%
Age structure	Guidance fish Corollary fish types	3 age groups in the balanced measure available 2 of 3 age groups available

In the procedure of the ARGE-Elbe an evaluation is made regarding to the type inventory, the abundance and the age structure of the currently fish fauna. On the basis of individual criteria the currently fish fauna can be assigned by defined quality grades of the ARGE-Elbe (ct. ARGE-ELBE 2000). In table 6.3.1 the single criteria of the evaluation areas above are mentioned. Further the table 6.3.1 shows the "good status" of the fish fauna , so called quality grade 2, defined by ARGE Elbe (2000). The results of this evaluation can be taken from the figure 6.3.2.



		Upper section (City Meißen) Barbel region	Middle section (City Wittenberg) Brace region
Stock	Historically admitted types:	Quality grade 3	Quality grade 3
Stock	Guidance fish & Corollary fish types :	Quality grade 1	Quality grade 1
Stock	Long distance migrational fish types:	Quality grade 3	Quality grade 3
Abundance	Guidance fish:	Quality grade 3	Quality grade 1
Abundance	Corollary fish types :	Quality grade 1	Quality grade 2
Abundance	Rel. Proportion G-/C-fish types:	Quality grade 3	Quality grade 1
Age	Guidance fish :	Quality grade 3	Quality grade 1
Age	Corollary fish types:	Quality grade 2	Quality grade 2

Figure 6.3.2: Results of the Evaluation of the fish fauna

Originally the fish fauna of the Elbe River (without *chondrostroma nasus*) consists in the area of the upper Elbe River about 44 and in the middle section of the Elbe River about 40 types. In nower days the fish types of the Elbe River has not changed hardly. Only comparatively few types disappeared. According to specifications from KNÖSCHE (1) (1998) a few types like *acipenser sturio l.*, *coregonus oxyrhynchus l.*, *alburnoides bipunctatus* and *pelecus cultratus* could not be proven any longer. In the years 1991 to 1993 no longer provable salmon (ARGE-ELBE 1995) occurs today regularly according to predicates of KNÖSCHE (1) (1998). Also the *salmo trutta trutta* settled again. KNÖSCHE (1) (1998) doubts however that these populations are originally residents in the Elbe River. The modification of the populations of the original fish fauna showed up fewer qualitatively than rather quantitative type. After old descriptions the Elbe River seemed to be coined by migrated fishes as *salmo salar*, *acipenser sturio l.*, *salmo trutta trutta*, *petromyzon marinus* and *lampreta fluviatilis*, *alosa alosa l.*, *platichthys flesus* and *lota lota L.* as well as by rheophile types as *barbus barbus*, *aspius aspius* among other things in addition, by which in German is called “euryök” fish type the *anguilla anguilla*. Today the fauna is characterized particularly by flexible types as *leuciscus rutilus, abramis brama, perca fluviatilis*, *leuciscus idus* and *blicca björkna* (KNÖSCHE (2) 1998). Likewise a clear increase of the *esox lucius* was registered. For the section of the section middlestream of the Elbe River some euryhaline types could be proven in 1995 (*anguilla anguilla* and *gasterosteus aculeatus*) (ARGE-ELBE 1995). For the most parts of the Elbe River the weir at Geesthacht takes a “key-role”. Since 1998 permits this weir the migrate fishes a crossing from the downstream Elbe River into the middle and upper section of the Elbe River where the natural cycle particularly closes. The still continuing regeneration shows up also in formerly high-grade loaded tributaries of the Elbe River. In the 1990 desolated "Schwarze Elster" River could be proven 26 fish types in 1997 (IKSE 1999). However in the German section upstream of the Elbe River the euryhaline types are mostly missing (ARGE-ELBE 1995).

The evaluation of macroinvertebrate communities has been made by means of specific indices: "Potamon-Typie-Index (PTI)" and saprobic index.

In the years 1992 and 1994 the Federal Institution for hydrology (BfG 1995) performed 13 investigations to record the macroinvertebrate communities of the Elbe River. The section Schmilka (km 0 German area) to Cuxhaven (km 729 German area) was examined. At the entire section altogether 218 types were proven, there from 46 are allotted to the *oligochaeta* and 45 to the *chironomidae*. The individual’s density is subjected strong fluctuations depending upon the regarded section of the Elbe River, position in the cross profile and seasonal aspect. The BfG (1995) indicates values between 0 and several 10000 individuals/m².

In the longitudinal section a natural arrangement of the microbiota is not to be detected. Generally the local differences due to the waters loads or to the influence of the supplies. The highest value was determined in the "Elbsandsteingebirge", the lowest below the city Hamburg in the zone of constantly changing salt concentrations. The structural shift of the communities is particularly remarkable in the section below the city Magdeburg. The reasons are unknown (BfG 1995). In this section the number of types and individual density of some groups of animals (*hirudinea*, *mollusca*, *insecta*) is decreased strongly.

In the cross profile the community occurs essentially find at the large misalignment-sturdy pouring stones of the banks. The number of types and individual density of the sessile and semi sessile macroinvertebrate communities are here largest, cause of the suitable settling substrates. The sole is settled only by a few types. The living conditions are unfavorable for the majority of the communities because of the increased movement of the riverbed material. In the area of the middle of the sole types like *oligochaeta* and *chironomidae* settled. These types have settled in deeper positioned layers of the sole, where the substrate is not in sequential motion (BfG 1995). SCHÖLL and HAYBACH (2001) showed similar results in their studies in the years 1992 and 1998. Figure 6.3.2 shows a relative continuous saprobic value about 2,3. However the PTI value was classified (status 1992) between 5 and 6 about the entire longitudinal profile of the upstream section of the Elbe River. In the year 1998 the PTI value near the city Magdeburg moves into the quality grade 2 (defined "good status"). After it the value changed strongly. In the lower section of the middlestream and downstream section of the Elbe River the PTI value is similarly. The observed improvement of the PTI value is here not so obvious as in the section before.

Original typical types of the Elbe River are e.g. communities from the group *mollusca*, *plecoptera*, *ephemeroptera*, *trichoptera* and *odonata* (BfG 1995). On the basis of these communities e.g. the regeneration of the Elbe River to its original status can be evaluated.

The temporal development detects a clear recovery of the communities of the Elbe River. Much occurring of some types of caddies fly (i.e. *hydropsyche contubernalis*), local proof of large shells (i.e. *unio pictorum*, *anodonta anatina*) shows, that the Elbe River is at the beginning of its regeneration. This phase is comparable with the situation at the beginning of the Rhine regeneration.

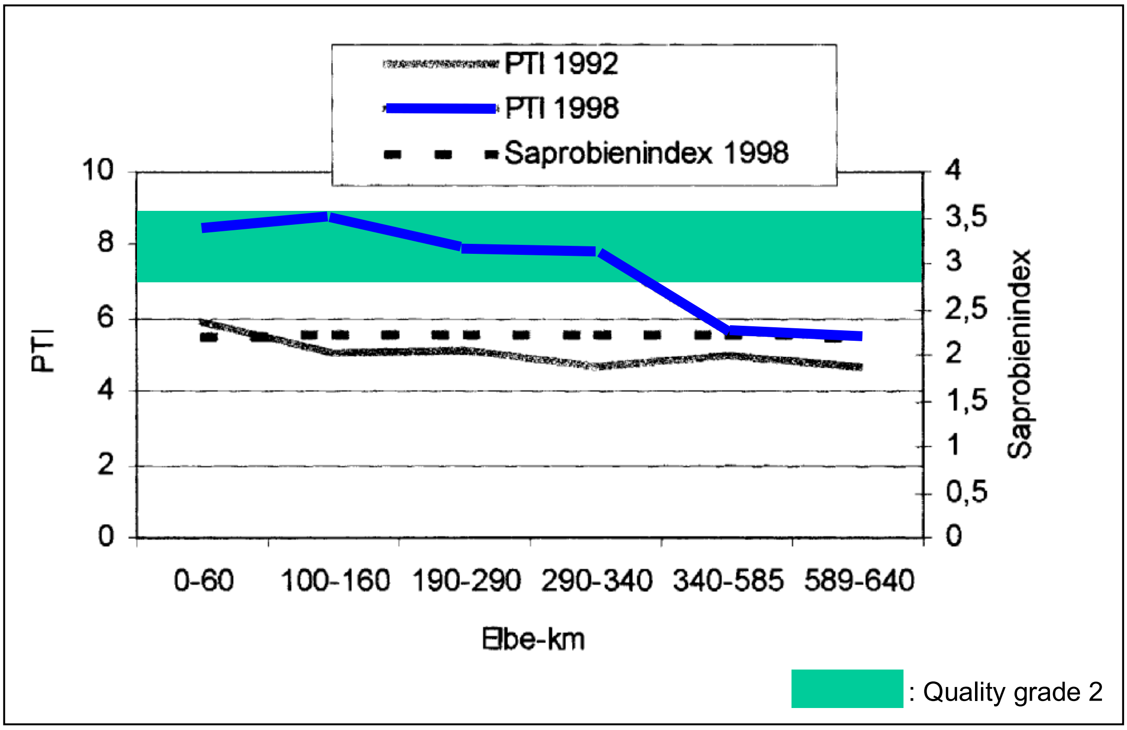


Figure 6.3.3: Evaluation of macroinvertebrate communities after SCHÖLL and HAYBACH (2001)

6.4 Discussion and Conclusions

The currently definition of saprobic index and PTI value like community structure, abundance, ratio of damageable comparing to robust species (see Annex V, WFD) was not considered. Further the evaluation was not oriented on the human uninfluenced original status. According to the requirements of the WFD we followed the assessment procedure based on saprobic index and corresponding quality classes (from 1 to 3) as suggested by RECHENBERG (2000).

Additionally we used the PTI value for the evaluation of the ecological status concerning the macroinvertebrate communities for the upper section of the Elbe River. Basis were the studies from SCHÖLL and HAYBACH (2001).

A weakness of the saprobic index is a primary limited evaluation of the pollution, which is not ideal for the assessment of the ecological status. In our case studies it was respectively used in default of adequate indices and assessment procedures. A problem is still to define the ecological status of streams with benthic macroinvertebrate fauna adequately.

7 Identification and Designation of Water Bodies as Heavily Modified (6 pages)

7.1 Provisional identification of HMWB

The process of the provisional identification of HMWB for the case study "Elbe" can be described in the three worksteps showed below. The worksteps were passed through in accordance to the "Terms of Reference":

Workstep (1): In the workstep "hydromorphologic impacts" the existing uses such as navigation, flood protection, hydropower generation, land use, water supply and urbanisation were examined. The effects of each use on the water body were specified. Based on suitable criteria an evaluation took place with respect to the determined loads (see table 5.1.1 up to table 5.1.3).

Workstep (2): The next workstep "ecological status" requires an evaluation of the biological status of the Elbe River. Concerning this a first estimation was made in the context of the Elbe River by available data of makroinvertebrate communities and fish fauna. The evaluation of the makroinvertebrate communities was realised by the Potamon Typie Index (PTI) according to the demand of the Federal Institution for Water Research (BfG) Koblenz and for the fish fauna the ichthyofaunistical procedure of the ARGE Elbe Hamburg. If an insufficient data basis does not permit the application of the procedures mentioned, the ecological status has been evaluated by means of the saprobic index or selected parameters to the fish stock.

Workstep (3): The designation process takes place according to a multi-level testing method, whose development is originated in the context of the international sub-group "navigation". The methodology up to the provisional identification is represented in figure 7.1.1. Thus the development of a "provisional negative/positive list" follows in accordance with the worksteps (1) and (2) after the stocktaking. This list contains specifications to the impacts of pressures on the hydromorphological and biological characteristics on surface waters. On the basis of suitable criteria the identification takes place from "significant" and "not significant" impacts. Table 7.1.1 shows a general negative/positive list as a function of the pressure "navigation". Significant impacts on the Elbe River become led provisional on the 1. negative list; not significant impacts are constituent of the 1. positive list. For the further representations and evaluations the section upper Elbe River is regarded exemplary. Figure 7.1.1 shows the specified negative/positive list concerning this river section. According to LAWA (2001) the criterion "*…Bank (single or both sides) ≥ 10 % total length with bank impairments*" is examined in connection with the criteria specified in the second point of the general negative list (see table 7.1.1). In order to analyse the meaning of the criteria from the negatives lists for the classification process of a river as heavily modified, an aggravation was made in this case study. Thus the criterion was considered independently of the other two criteria in the case study on the Elbe River.

Based on the provisional Negative list the upper Elbe River is designated provisional as heavily modified (identification).

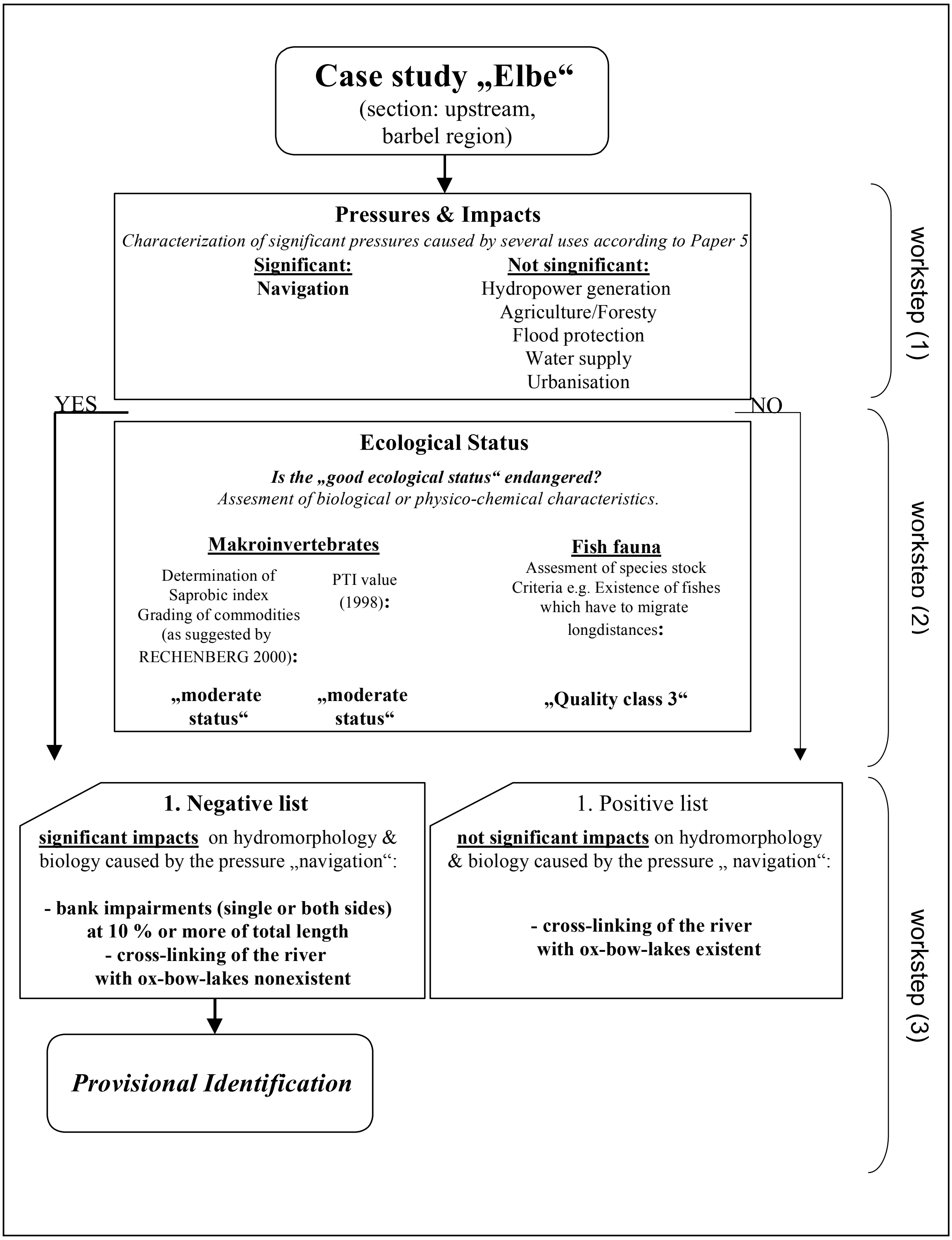


Figure 7.1.1: Process of the “Provisional Identification of Heavily Modified Water Bodies” concerning the subgroup “navigation”

Table 7.1.1: Effects on the quality of morphological structure of the river caused by the pressure "navigation" (LAWA 2001, modified and completed)

Negative list *i.e.* ***significant*** *impacts on hydromorphology & biology caused by the pressure "navigation"* *> provisional designation of the water body as heavily modified*	**Positive list** *i.e.* ***not significant*** *impacts on hydromorphology & biology caused by the pressure "navigation"* *> „good ecological status" available*
➢ > 10 % impounded river length at mean low water flow	➢ ≤ 10 % impounded river lengthat mean low water flow
➢ Proportion of river length with discharge acceleration with - Ratio profile depth to profile width ≥ 1:4 **and** - Bank (single or both sides) ≥ 10 % total length with bank impairments **and** - Longitudinal profile ≥ 70 % stretched or straightened **or** - cross-linking of the river with ox-bow-lakes nonexistent	➢ Proportion of river length with discharge acceleration with - Ratio profile depth to profile width < 1:4 **and** - Bank (single or both sides) < 10 % total length with bank impairments **and** - Longitudinal profile < 70 % stretched or straightened **or** - cross-linking of the river with ox-bow-lakes existent
➢ not passable artificial barriers with a height > 30 cm	➢ artificial barriers with a height ≤ 30 cm, passable artificial barriers with a height > 30 cm respectively

7.2 Necessary Hydromorphological Changes to Achieve Good Ecological Status

In order to finally prove a water body actually as heavily modified (designation), further test units are necessary (see figure 7.2.1). On the basis of the provisional 1. negative list measures are derived, to reduce use-conditioned impacts. The environmental objective is to achieve a good ecological status. In the context of an economic analysis the measures are examined regarding their possible significant adverse effects on pressures. In case the measures impair existing pressures “better environmental options" are submitted of an economic view. The determined measures are checked for their technical feasibility and financial proportionateness. According to the results of this economic analysis arises the so-called "2. Negative/Positive list". The 2. positive list contains the not significant impacts of the provisional 1. positive list. In addition come impacts, which were first classified as significant (cp. 1. negative list) and now reduced or even removed toward good ecological status assistanced by economically checked measures. Specified impacts on the 2. positive list do not lead to a designation of water bodies as heavily modified. It applies the environmental objective "good status".

All significant impacts caused by pressures, which cannot be modified or given up by economic proved measures remain on the 2. negative list. The determined impairments of the hydromorphological and biological characteristics of water bodies are accepted. Are there after the economic analysis still specifications on the 2. negative list, the water body or sections of the water body is to be designated as heavily modified. As environmental target the "good ecological potential" is to be aimed at.

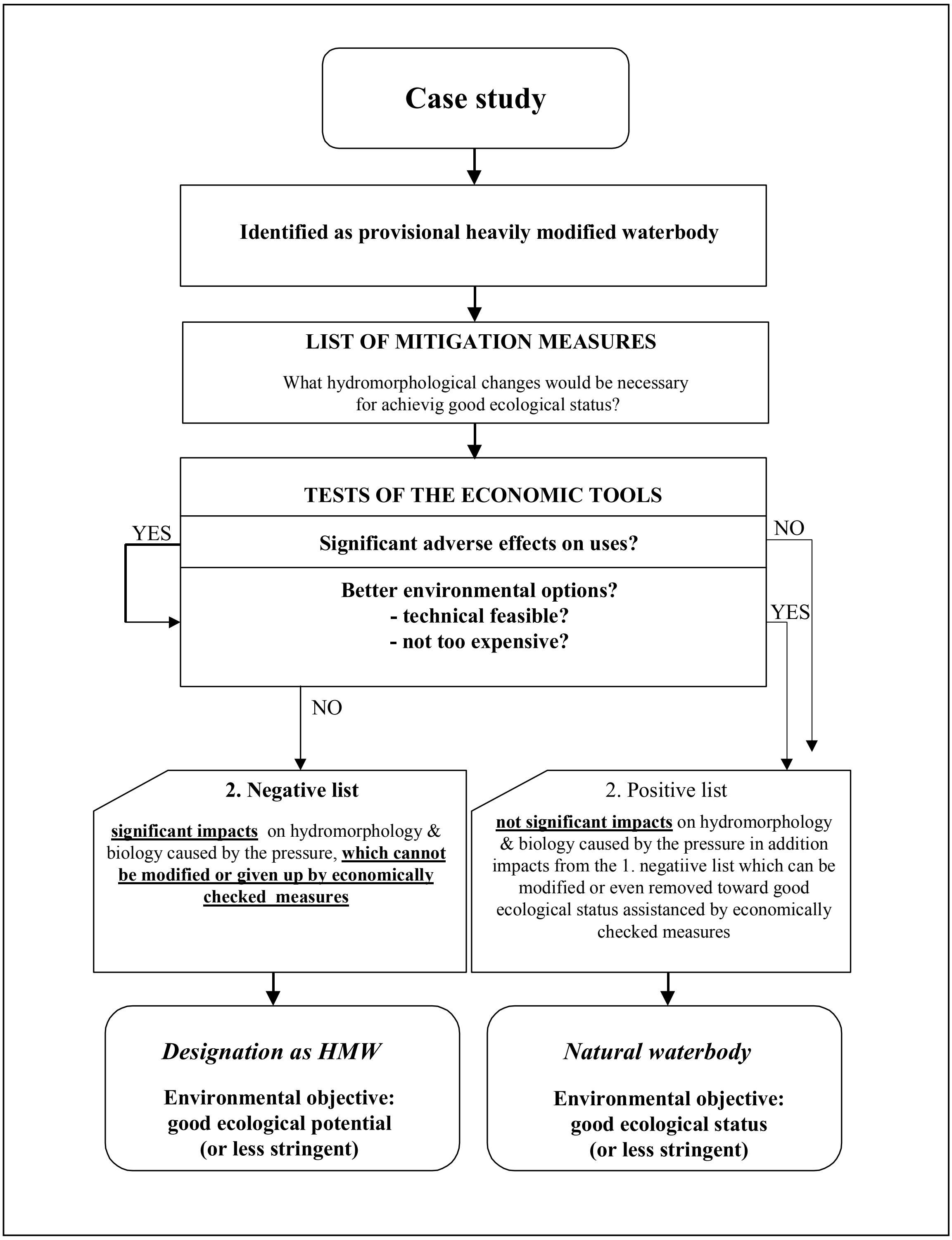


Figure 7.2.1: Further process of the "Identification of Heavily Modified Water Bodies" after designation as "Provisional Identification of Heavily Modified Water Bodies" concerning the subgroup "navigation"

For the further representations and evaluations the section upstream of the Elbe River is regarded exemplary. This section comprises from the national border of Germany (km 0) to the city of Pirna (km 34). As main physical pressure on this section of the Elbe Basin navigation is identified (see marked fields in table 5.1.2).

7.2.1 Required hydro-morphological changes and required measures to achieve the Good Ecological Status

As a general approach, two scenarios are assessed to achieve a good ecological status for the regarded section upstream of the Elbe River: a modification of the pressure (a less extreme scenario B) as well as an abandonment of navigation of passengers and goods traffic (as the most extreme scenario C) (tab. 7.2.1).

An abandonment of the use of the Elbe River as an national waterway is not necessary to achieve a good ecological status (see chapter 6). Therefore, only modifications of the use are taken into consideration.

Table 7.2.1: **Mitigation measures for the case study "Elbe" (section: upper Elbe River (km 0 – 34))**

	Pressure: Navigation		
	Scenario A	**Scenario B**	**Scenario C**
	Maintenance of navigation	**Modification of the navigation**	**Abandonment of navigation**
Action areas	*i.e. unrestricted use navigation further on*	*i.e. possible restriction of the use navigation for passengers and goods-traffic is taken in purchase*	*i.e. omission of the use navigation for passengers and goods-traffic incl. for the use established buildings and application factors*
Ecological continuum (Patency)	**-**	**-**	**-**
Hydromorphology	• Maintenance of extensive building and maintenance measures • Breakthrough of the bank impairments at approximately 1-2 % of the regarded river length to extend habitat-diversity	• Decreasing navigable depth up to 10-30 cm (Compliance with a max. fairway-depth app. 1,40 m at mean low water flow) • Breakthrough of bank impairments at approximately 1-2 % of the regarded river length to extend habitat-diversity • Maintenance of extensive building and maintenance measures	• Omission of navigation for passengers and goods-traffic • Omission of all harbor-basins. If possible: • unrestricted development of river devolution, • Extension of the riverbed, • Removement of bank and river bed impairments/sub natural formation
Catchment area	• Establishment of typical vegetation units floodplains (passive, active) • Breakthrough harbor-basins near the following cities: a) Königsstein – Halbestadt b) Prossen c) Pirna - Copitz • Cross-linking of the river by deepening the ox-bow-lakes Left-sided the river: a) above the city Königstein ("Beaver holes") b) 2 km below the city Königsstein (pool) Right-sided the river: c) above the city Bad Schandau (rests of pools)	• Establishment of typical vegetation units floodplains (passive, active) • Breakthrough of harbor-basins near the following cities: a) Königsstein – Halbestadt b) Prossen c) Pirna - Copitz • Cross-linking of the river by deepening the ox-bow-lakes Left-sided the river: a) above the city Königstein ("Beaver holes") b) 2 km below the city Königsstein (pool) Right-sided the river: c) above the city Bad Schandau (rests of pools)	• Establishment of typical vegetation units of floodplains (passive, active) • cross-linking of the river: Creation/Recreation and linking of ox-bow-lakes Reactivation of pristine river bows including linking of detached river bows

7.2.2 Impacts on water uses and significant adverse effects

Due to the proposed measures, a decrease of 10-30 cm in navigable depths is expected. Limitations of that amount will have impacts only on cargo ships. Effects on shipping routes for passengers and leisure purposes (which require less draught) are not predicted. The evaluation of effects focuses therefore only on the conveyance of goods.

Scenario B focuses on a modification of the pressure “navigation” and other morphological alterations for navigability purposes. Due to these measures, a development of natural hydro-morphology can be expected in the long-term. In this case, restoration is not related to investments, i.e. cause no capital costs. However, on a long-term basis costs can be saved. Scenario C causes costs for restoration measures by the removal or rebuilding of alterations. However, these costs relate not to the pressure navigation itself. Income losses due to the reduced navigability have to be estimated for both scenarios. The decrease in navigable depths increases the annual number of days on which a maximum use to capacity of the ships is not possible. Incomes are reduced in line with the decreasing amount of goods transported.

An estimation of the significance of the effects can focus on the economics of the business or on a regional level. Concerning the economics of the business the effects (reduced income) for the individual enterprise have to be quantified. Generally, it can be said that transport enterprises are not dependent on the Elbe and can therefore use other water routes as well. The Elbe River shows some special conditions for an national waterway compared to other water ways: a navigable depth on average of 2m and more is achieved only on 40-50% of days in the year and is characterised by extensive low water periods.

The estimated impact of decreasing navigable depth up to 10-30cm is that for 30-50% of the year, a mean (not a maximum) use of capacity of ships is not possible. Concerning present conditions, at these times income losses of 5-22% are expected. One has to keep in mind that on the Elbe, the average use to capacity of national waterway shipping is approx. 36%. This extent of utilisation is not necessarily associated with the navigable depth but with less demand compared to capacity.

On a regional view, the share of goods transported by cargo ships in the area of the Elbe is only approx. 1%, i.e. clearly below the German average of 12%. Inland navigation on the Elbe is therefore of secondary importance compared to the demand at a regional level.

In summary, it can be stated, that neither on an economic business view nor on a regional-economic view will the mitigation measures lead to a significant impact on the pressure “navigation”, since income losses are lower than 10% and the importance of inland navigation can be considered as marginal. The proposed restoration measures such as breakthrough of bank impairments cause no effects on the ‘use’ itself, therefore don’t have to be regarded within the assessment of the impacts on uses and disproportionate costs.

7.2.3 Impacts on the wider environment

A removal of riverbed reinforcements could lead to an erosion due to increasing flow velocity. Impacts on the ecosystem (particularly the flood plain) are possible as a consequence of an induced lowering of the ground-water level.

7.3 Assessment of Other Environmental Options

7.3.1 Identification and definition of the beneficial objectives served by the modified characteristics of the water body

The main beneficial objective served by the hydro-morphological changes of the water is transport. Additionally to the transport function navigation fulfils income and employment possibilities, but within the designation process the focus is put on shipment.

7.3.2 Alternatives to the existing ”water use“

Alternatives to achieve the same beneficial objective are the modification of navigation (local view) and, on a regional view, replacing this function with road or rail transport. An abandonment of navigation is not considered as necessary to achieve good status. Therefore it is not discussed as an alternative.

Only a replacement with existing transport is considered. Hence, the existing use is compared with the modification as the proposed alternative and discussed concerning the technical feasibility, the environmental effects and the costs. The technical feasibility of the restoration measures is given.

On a regional level, the replacement of navigation with road or rail transport is taken into account. There is an existing railway network along the river Elbe.

Different types of costs can be differentiated: on the one hand the investment costs for river restoration measures (i.e. puncturing of harbour-basins, breakthrough of bank impairments). These types of restoration measures cause no costs for the use ‘navigation’ or the beneficial objective ‘transport’.

On the other hand, there are costs relating to existing use: i.e. costs for foregone economic benefits due to ecological requirements. In the case of the Elbe River, an assessment of the costs with regard to the foregone benefits cannot be done within this investigation. It would require a detailed analysis of the operation costs, the freight charges and types of cargo ships.

Environmental effects

The negative effects of changes in river profile and morphology to allow shipping with a sufficient water depth are well-known: Increase of the flow velocity, a degradation of the channel, modification of the hydraulic regime, losses of biodiversity and habitats (above all flood plains) etc.. A restoration has accordingly positive environmental effects.

In the following table, the environmental effects (positive and negative) of different means of transport are compared. The ecological effects of the means of transport refer to the emission of pollutants, to the noise pollution and to the demand for surface area. In the comparison regarding emissions, railway transport has less environmental effects compared with inland navigation (related to energy consumption per transport unit). However, the quantity of transported goods have to be considered. The following table shows the amount of transported goods in the catchment area of the Elbe.

Table 7.3.2: Transport of goods along the Elbe River

in 1.000 t	**Railway**	**share**	**navig.**	**share**	**road**	**share**	**total**
Sachsen	19.053	4,53%	386	0,09%	400.852	95,37%	420.291
Sachsen-Anhalt	30.368	9,29%	7.239	2,21%	289.382	88,50%	326.989

According to these results, inland navigation is less environmentally harmful as measured by total emissions .

Inland navigation causes higher impacts of noise pollution compared to railway transport. The investigation which assessed the externalities of different means of transport was conducted in areas of higher population density. There are no specific results with regard to the catchment area of the Elbe. Therefore, the situation along the Elbe could not be evaluated exactly.

7.4 Designation of Heavily Modified Water Bodies

Based on the considerations and information above, the Elbe River should not be designated as heavily modified.

The impacts of the mitigation measures are not assessed as significant. Furthermore, considering the environmental effects in the case of the Elbe River, a replacement of navigation with rail transport is considered as the better environmental option. Hence, a restoration is related to benefits and the costs are not assessed as disproportionate. When one considers the negative impacts of channelisation for navigation purposes for ecosystems and compares the low costs (income losses) and low profitability of inland navigation, the Elbe River should not be assessed as heavily modified.

7.5 Discussion and Conclusions

With exact consideration the specified significant impacts of the general negative-list (see table 7.1.1) no effects are left on the negative list after conversion of the examined measures (compare chapter 7.1) in the case study Elbe. So the Elbe River would not have been designated as provisional heavily modified. This means that the “good ecological status” would have been achieved without conversion of the regarded measures. Exemplary for this case study the criteria were intensified to execute over thus an enhanced analysis. Thus considering the prevailing boundary conditions (Bilateral contracts between Germany and Czech republic, Federal Water Way Law) the list of mitigation measures which can be examined is reduced. Nevertheless the "good status" related to the biology can be achieved (compare chapter 6) after conversion of the examined scenario B.

In the case of navigation, the following issues have to be considered in the context of the designation process.

The present frame conditions of the uses have to be taken into account. For the Elbe River, it was shown that the extent of utilisation for transport purposes is rather low. Due to the extensive low-water periods the Elbe River is not always a suitable national waterway. Therefore, it is not sure that the restoration measures will cause adverse effects on the pressure at all. Probably only the amount of days will decrease in which the channel flow is sufficient for navigation. On a regional view, the Elbe River is of less importance for transportation and is not a profitable use. In the case of better site conditions, a higher navigability of the waterway and a greater demand of transportation, a different valuation is probable.

PART III

10 Conclusions, Options and Recommendations (5 pages)

10.1 Conclusions

10.1.1 Identification of water bodies, scaling

The very different characteristics within a river regarding morphological structures and pressures requires a subdivision into homogeneous sections (water bodies). This subdivision should be orientated primarily on the relevant pressures named in paper 5. A subdivision into several water streches with constant size as well as a subdivision according to administrative unities is unpracticable and not usefull. Also water bodies must not be too small, because the designation process is unpracticable and consequences such as operative monitoring of heavily modified waters require disproportionate effort.

Particularly large waters show different patterns of pressures along their longitudinal gradient (see case studies Lahn and Elbe). In many cases the headwaters represent widely undisturbed conditions while the downstream sections are more or less modified due to multiple anthropogenic uses. A subdivision according to the significant pressures will retrieve the upper, middle and downstream section in many cases as a result of the designation process. Where appropriate these sections may be differentiated in more detail. Small waters with relatively homogeneous pressures such as Seefelder Aach do not require a subdivision and can be treated as one water body.

A subdivision according to the relevant pressures will lead to meso-scaled units and water bodies. The german case studies indicate that water sections withmore than 40 kilometers in length and catchment areas up to ca. 1000 square kilometers are adequate.

10.1.2 Reference conditions

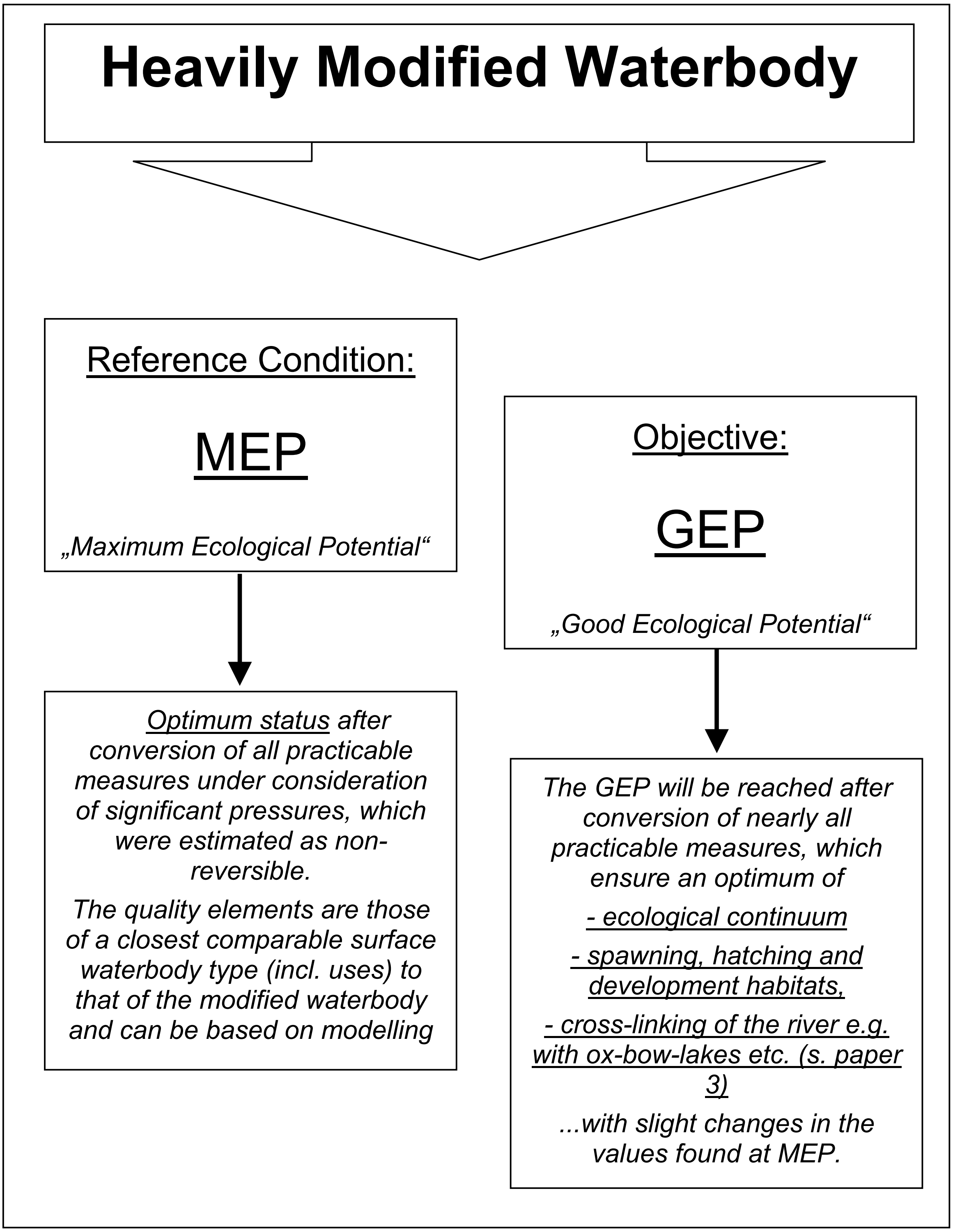
The definition of reference conditions on which status classification of HMWB is based is a difficult task and has not been solved in straightforeward approach. In our case studies we solely used natural waters as references which was proofed to be sufficient. There was no need to change the water type or even the water category. Even the upper Lahn River which is modified due to numerous impoundments (weirs, sluices) has been clearly identified as a running water.

The use of another HMWB as reference is not usefull according to our experiences.

10.1.3 Definition of MEP and GEP

For water bodies identified as being heavily modified, the reference conditions on which status classification is based, is called MEP.

Table 10.1.3: Maximum and Good Ecological Potential for Heavily Modified Waterbodies



HMWB have to meet certain minimum standards such as (see paper 3):

- River continuum

- Hydromorphological criteria (navigation, impoundments; see upper Lahn section and Elbe River)

10.1.4 Significant pressures / significance criteria

The designation of water bodies as being heavily modified substantially depends on the derivation of criteria for significant pressures and impacts, especially those which define physical alterations and damaged hydromorphology.

For the evaluation of the determined loads suitable criteria have to be applied. Currently significance criteria are compiled in the context of the LAWA-committee "Surface waters and coastal waters" following the WFD annex II. They were examined in modified and completed form in the case studies. Within this framework not the entire river catchment but the respective water body was regarded. That leads to the fact that despite of the development towards a national waterway, the use “navigation” may not be identified as being a significant pressure without specified properties (see case study “Elbe”). For this river weirs were not built over extended stretches of the water body and the longitudinal profile was evaluated as being "very good", while the fourth criterion according to table 5.1.2 is eliminated. Thus in this section the use "navigation" is not evaluated as being significant.

Within a total catchment area- analysis including tributaries numerous weirs with a height more than 30 cm have to be considered, which are established - among others - for navigation purposes. According to table 5.1.2 the use "navigation" would be classified as significant in these cases.

Another eventuality is a river not developed towards a national waterway, but is managed with the same boundary conditions. According to LAWA (2001) three criteria are examined in connection with each other. If two criteria are eliminated because of being in “good status” and one criterion is fulfilled, the river would not be designated as being “Provisionally Heavily Modified”.

These aspects clearly show the relevance of meaningful scales in a catchment area.

10.1.5 Quality elements

Quality elements for heavily modified water bodies are the same as for natural waters.

The four case studies clearly showed shown that despite of given significant pressures the analysis of the biological status does not inevitably lead to the designation as being a HMWB. Therefore the final designation of water bodies as being heavily modified should not be based on the river morphology alone. The biological status is the decisive factor for the designation of water bodies as heavily modified.

10.1.6 Designation as HMWB oder minor objectives

The question, how to handle waters/water bodies with disturbed river continuum and loss of migratory fish species, is still open. Numerous rivers e.g. the upper Lahn and

Dhünn may have a "good status" according to the majority of biological quality elements, but populations of long distance anadromous fish species, e.g. salmons, sea trouts and lampreys are missing due to barriers in downstream stretches. These water bodies must not designated as being heavily modified (see Terms of References), but "minor objectives" obtain.

10.1.7 Relation of HMWB and natural waters

In our study „Clarification of the EU WFD to heavily modified surface water bodies" we have examined four rivers (Elbe, Lahn, Seefelder Aach and Dhünn) which differ in size, ecoregion and pressures and in so far can be seen as being representative for a wide range of conditions. None of the rivers and river sections has been designated as being heavily modified although they show significant hydromorphological alterations. This emphasises the fact that even significant physical alterations do not inevitably lead to the designation of a water/water body as being heavily modified. IN this respect the negative/positive lists of specified pressures were proved to be useful for decision processes.

10.2 Options and Recommendations

1. Identification of water bodies should be based on significant pressures supported by positive/negative lists with specified characteristics (see paper 5).

2. Regarded scale: meso scaling is sufficient and adequate.

3. Reference conditions for HMWB should be derived from natural waters. If necessary the category or type of water body may be changed.

4. HMWB have to meet certain minimum standards such as river continuum and a set of hydromorphological properties (see paper 3).

5. For the definition of MEP only natural waters should be used as references. MEP should be derived from natural references.

6. The analysis and the final designation of water bodies as being heavily modified substantially depends on significance parameters for categories of pressures. These have to be applied carefully and specific for each category.

7. The biological status (not river morphology) is the decisive factor for the designation of water bodies as being heavily modified. Chemical status is an important, but independent feature and boundary condition without consequences

for the designation result.

8. For waters/water bodies with disturbed river continuum, missing anadromous fish species, but being biologically in “good status” for other quality elements minor objectives obtain.

9. Significant physical alterations do not inevitably lead to the designation of a water/water body as being heavily modified. Therefore, they may be designated as being “provisionally heavily modified” and ecological status may be evaluated using relevant indicators either based on existing data or operational monitoring.

10. For Germany (and potentially other countries with comparable population densities and infrastructure) numbers of waters/water bodies which have to be straightforwardly designated as being “heavily modified” may be rather the exception than the rule.

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