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International Commission for the Protection of the Danube River

Internationale Kommission zum Schutz der Donau

The Danube River Basin District

River basin characteristics, impact of human activities and economic analysis required under Article 5, Annex II and Annex III, and inventory of protected areas required under Article 6, Annex IV of the EU Water Framework Directive (2000/60/EC)

Part A – Basin-wide overview

Short: "Danube Basin Analysis (WFD Roof Report 2004)"

//// Deutschland //// Österreich //// Bosna i Hercegovina //// Bălgarija //// Hrvatska //// Ceská republika //// Magyarország //// Moldova //// România //// Srbija i Crna Gora //// Slovensko //// Slovenija //// Ukraïna ////

The complete report consists of Part A: Basin-wide overview, and Part B: Detailed analysis of the Danube river basin countries

18 March 2005, Reporting deadline: 22 March 2005

Prepared by
International Commission for the Protection of the Danube River (ICPDR) in cooperation with the countries of the Danube River Basin District.

The Contracting Parties to the Danube River Protection Convention endorsed this report at the 7th Ordinary Meeting of the ICPDR on December 13-14, 2004. The final version of the report was approved 18 March 2005.

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Mario Romulic, Croatia

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List of Abbreviations

a.s.l.	above sea level
AEWS	Accident Emergency Warning System
AOX	Adsorbable Organic Halogens
AP	Action Programme
APC EG	Expert Group on Pollution, Prevention and Control
AQEM	The development and testing of an integrated assessment system for the ecological quality of streams and rivers throughout Europe using benthic macroinvertebrates (EU-Project)
ARS	Accident risk spots
AT	Austria
AWB	Artificial Water Bodies
BAT	Best available technology
Bd	Band
BG	Bulgaria
BOD	Biochemical Oxygen Demand
BR	Biosphere Reserve
BSC	Black Sea Commission
CCO-Mn	Chemical Oxygen Consumption
CEE	Central and Eastern Europe
CIS	Common Implementation Strategy
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COD	Chemical Oxygen Demand
COD-Cr	Chemical oxygen demand (dichromate method)
COD-Mn	Chemical oxygen demand (manganesedichromate method)
CORINE	Coordination of information on the environment - CORINE land cover
CP	Contracting Party
CPOM	Coarse Particulate Organic Matter
CS	Serbia and Montenegro
CZ	Czech Republic
daNUbs	Nutrient Management in the Danube Basin and its Impact on the Black Sea
DBSC	Danube-Black Sea Canal
DDNI	Danube Delta National Institute for Research and Development
DDT	Chlorinated Organic Insecticides-1,1,1-Trichloro-2,2-bis-(4'-chlorophenyl) ethane
DDT	Dichlorodiphenyltrichloroethane
DE	Germany
DEF	Danube Environmental Forum
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved oxygen
DOC	Dissolved Organic Carbon
DPRP	Danube Pollution Reduction Programme
DRB	Danube River Basin
DRBD	Danube River Basin District
DRBMP	Danube River Basin Management Plan
DRP	Danube Regional Project
DRPC	Danube River Protection Convention
DTD	Danube-Tisza-Danube (Canal)
EC	European Commission
ECO EG	Expert Group on Ecology
Econ ESG	Expert Sub-group on Economics
Eds	Editors
EEA	European Environment Agency
EEC	European Economic Community
EG	Expert Group
EMIS EG	Expert Group on Emission
EPER	European Pollutant Emission Register
EQS	Environmental Quality Standards
EU	European Union
FAO	Food and Agricultural Organisation of the United Nations
FAOSTAT	Database of the Food and Agriculture Organization of the United Nations
FP EG	Expert Group on Flood Protection
FP	Flood Protection
FPOM	Fine Particulate Organic Matter
GDP	Gross domestic product
GEF	Global Environment Facility
GES	Good Ecological Status
GIS ESG	Expert Sub-group on Cartography and GIS
GIS	Geographical Information System
GWP	Global Water Partnership
HMWB	Heavily Modified Water Body
HPP	Hydro-Power Plant
HPS	Hydroelectric Power Station
HR	Croatia
Hrsg	Herausgeber (Editor)
HU	Hungary
IAD	International Association for Danube Research
IAWD	International Association of Water Supply Companies in the Danube River Catchment Area
IBA	Important Bird Area
ICPDR	International Commission for the Protection of the Danube River
IHD	International Hydrological Decade
IHP	International Hydrological Programme of the UNESCO
IRCM	Institutul Roman de Cercetari Marine, Constanta
IUCN	International Union for the Conservation of Nature
JAP	Joint Action Programme
JDS	Joint Danube Survey

km	kilometre
MHQ	mean high flow
MLIM EG	Expert Group on Monitoring, Laboratory and Information Management
MLIM	Monitoring, Laboratory & Information Management
MNQ	mean low flow
MONERIS	Modelling Nutrient Emissions into RIver Systems
MoU	Memorandum of Understanding
MQ	mean flow
N	Nitrogen
na	not available
NGO	Non-governmental Organisation
OECD	Organisation for Economic Cooperation and Development
OJ	Official Journal
OM	Ordinary Meeting
P	Phosphorus
PAHs	polycyclic aromatic hydrocarbons
PAMNC	Poarta Alba – Midia Navodari Canal
PIAC	Principal International Alert Centre
POPs	Persistent Organic Pollutants
PPP	Purchase power parity
PRTR	Pollutant Release and Transfer Register
PS	Permanent Secretariat
RBI	River Basin Initiative
RBM EG	Expert Group on River Basin Management
RBM	River Basin Management
REC	Regional Environmental Center for Central and Eastern Europe
RefCond	Reference Conditions
rkm	river kilometre
RMRI	Romanian Marine Research Institute
RO	Romania
RR	Roof Report
Si	Silica
SI	Slovenia
SK	Slovak Republic
SWG	Standing Working Group
t	ton
TEN	Trans-European Transport Networks
TNMN	Transnational Monitoring Network
TOC	Total Organic Carbon
TP	Total Phosphorus
TS	Technical Support
TV	Target value
UBA	Umweltbundesamt (Federal Environment Agency)
UN/ECE	United Nations Economic Commission for Europe
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USGS	United States Geological Survey
VOCs	volatile organic compounds
Vol	Volume
WFD	Water Framework Directive
WRI	Water risk index
WWF	World Wide Fund for Nature
WWTP	Waste Water Treatment Plant

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1. Introduction

1.1. Aim of the report

This report responds to reporting obligations of the Water Framework Directive 2000/60/EC (WFD) under Article 5, Annex II and Annex III regarding the first characterisation and analysis of the Danube River Basin District. In addition, information is given on progress related to Article 6 and Annex IV for setting up an inventory of protected areas in the river basin district, as well as on progress related to Article 14 regarding public information and consultation.

This report is the second report to the European Commission on the progress of implementation of the WFD. The first report dealt with the reporting obligations under Article 3.8 and Annex I related to the delineation of the Danube River Basin District, the identification of the competent authorities for WFD implementation and on the international coordination arrangements for international river basin districts. The WFD Roof report 2003 (see explanations in Chapter 1.2) was completed on 26 April 2004 and sent to the Commission on 22 June 2004.

Annex II and III of the Directive stipulate the analysis of environmental and economic characteristics including the assessment of significant anthropogenic pressures and impacts in surface waters and groundwater. This analysis forms the basis for the assessment of the status of surface waters and groundwater in Europe and illustrates, which water bodies are "at risk" of failing the environmental objectives. The future developments of monitoring networks and of the programme of measures will be based on the results of this analysis.

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and in the development of river basin management plans.

This report therefore has different addressees:

– the countries in the Danube river basin, this report being the common basis for river basin management on the basin-wide scale,
– the European Commission, to inform on the progress of WFD implementation, and
– all interested parties as well as the general public, to inform about the results of the first analysis of the Danube River Basin District and to prepare for the consultation process.

1.2. Structure and contents of the report

The Danube River Basin is the second largest river basin of Europe covering territories of 18 states including EU-Member States, Accession Countries and other states. In addition to the Danube River Basin the Danube River Basin District (DRBD) includes some of the Black Sea coastal catchments (see Chapter 2.1). Due to the large number of states and the coordination requirements in the DRBD (see Chapter 2.3) the report on the DRBD has been divided into two parts. Part A (roof report) gives the basin-wide overview; Part B (national reports) gives all relevant further information on the national level as well as information coordinated on the bilateral level (see Figure 1).

The International Commission for the Protection of the Danube River (ICPDR) is the implementing body under the "Convention on Cooperation for the Protection and Sustainable Use of the Danube River" (Danube River Protection Convention, DRPC) and serves as the platform for coordination to develop the Danube River Basin Management Plan (DRBMP). The ICPDR has a coordinating and supporting function, but does not report on its own.

Each EU Member State will send the Roof report (Part A) together with its own national report (Part B) to the European Commission. In addition, the ICPDR will informally send to the European Commission a copy of the Roof report and a copy of the national reports (Part B) of those countries, which are (currently) not obligated to report to the European Commission (Bosnia i Herzegovina, Bulgaria, Croatia, Moldova, Romania, Serbia and Montenegro, and Ukraine). This approach was also undertaken for the delivery of information required according to Art. 3 (8) and Annex I WFD.

Structure of the report for the Danube River Basin District[1] *FIGURE 1*

Part A:	Roof report coordinated by the ICPDR	
Part B:	National reports	
	GERMANY	EU-Member State
	AUSTRIA*	EU-Member State
	CZECH REPUBLIC	EU-Member State
	SLOVAK REPUBLIC**	EU-Member State
	HUNGARY	EU-Member State
	SLOVENIA	EU-Member State
	CROATIA	Accession Country
	BOSNIA I HERZEGOVINA	Other
	SERBIA AND MONTENEGRO***	Other
	BULGARIA	Accession Country
	ROMANIA	Accession Country
	MOLDOVA	Other
	UKRAINE	Other

including bilateral coordination:
** with Switzerland and Italy,*
*** with Poland*
**** with Albania and Macedonia*

Part A – Roof report

The Roof report gives the basin-wide overview on issues requiring reporting under WFD. It provides information on the main surface waters, which are shown in the Danube River Basin District overview map (Map 1) and the important transboundary groundwaters shown in Map 15.

The Roof report includes, in particular, an overview of the main pressures in the DRBD and the related impacts exerted on the environment. The overview includes effects on the coastal waters of the Black Sea as far as they are part of the DRBD, since their status could be a reason for designating the whole DRBD as a sensitive area.

The analysis is based on available data resulting from past and ongoing programmes and projects and a hierarchy of information used has been defined (see Chapter 1.3). The contents of the Roof report results from the work of the ICPDR expert groups and has been approved by the ICPDR at its Ordinary Meetings. The issues referred to in the basin-wide overview will be the basis for the preparation of the Danube River Basin Management Plan by the end of 2009.

The Roof report intends to give an overview of the situation in the Danube river basin district as a whole and to set the frame for the understanding of the detailed national reports. The Roof report is therefore comparatively brief. Detailed information is given in the national reports.

Part B – National reports

The National reports give all relevant further information on the national level as well as information coordinated on the bilateral level. Transboundary issues not covered by the ICPDR are solved at the appropriate level of cooperation e.g. in the frame of bilateral/ multilateral river commissions. The national information is given in addition to the information in Part A.

1 *This figure reflects the situation at the time of reporting (March 2005).*

Interplay between Part A (Roof report) and Part B (National reports)

The Roof report addresses those issues of Annex II, III and IV WFD relevant on the basin-wide scale, i.e. information concerning the

1. Analysis of surface waters (Annex II, 1.)
2. Analysis of groundwaters (Annex II, 2.)
3. Economic analysis (Annex III)
4. Inventory of protected areas (Annex IV)

In addition, an overview will be given on steps undertaken on the basin-wide level for public information and consultation. Table 1 shows which information which will be given in which part of the report.

Regarding Annex II – 1. Analysis of surface waters

The Roof report gives an overview for the following surface waters:

– the Danube and its tributaries with a catchment size of > 4 000 km^2,
– all lakes and lagoons with an area of > 100 km^2,
– the main canals,
– transitional and coastal waters.

A summary of the relevant information on surface waters will be given in Part A. Detailed information will be in Parts B.

Regarding Annex II – 2. Analysis of groundwaters

Groundwaters are generally of local or regional importance and are described in detail in the national reports. The Roof report gives an overview for important transboundary groundwater bodies according to the following criteria:

– all transboundary groundwater bodies > 4000 km^2,
– transboundary groundwater bodies < 4000 km^2, if they are very important; the identification as important has to be bilaterally agreed. The agreement must include the criteria for the importance, e.g. socio-economic importance, groundwater use, impacts, pressures, interaction with aquatic eco-systems.

Regarding Annex III – Economic analysis

The Roof report addresses three issues:

– assessment of the economic importance of water uses,
– projection of trends of key economic indicators and drivers up to 2015, and
– assessment of current levels of cost recovery of water services.

The assessment of current levels of cost recovery of water services and the cost-effectiveness of measures is not analysed on the basin-wide level as these issues are primarily of national importance. This report gives some general considerations on the issue, but the actual analysis will be contained in the National reports (Part B).

Regarding Annex IV – Inventory of protected areas

The protected areas for drinking water abstraction, for economically significant aquatic species, for recreational waters and the nutrient-sensitive areas (including vulnerable zones) are generally not of trans-boundary importance. These inventories have been set up nationally and are dealt with in the national reports.

Wetlands play an important role in the Danube River Basin and many of them are transboundary and under international protection. Therefore, an inventory of protected areas for species and habitats has been set up where the maintenance or improvement of the status of water is important for their protection. The protected areas selected for the basin-wide overview have been defined as follows

– an international protection status (RAMSAR and World Heritage Convention, UNESCO/ MAB and/or IUCN category II or Natura 2000 site), and
– a size of > 1,000 ha.

The National reports address all issues listed in Annex II and III WFD.

Issues covered in Part A (Roof report) and Part B (National reports) *TABLE 1*

	Part A Roof report	**Part B** National reports
Article 5 and		
ANNEX II – 1. ANALYSIS OF SURFACE WATERS		
1.1 Surface water categories	X	X
1.2 Ecoregions and surface water types	X	X
1.3 Establishment of type-specific reference conditions	X	X
1.4 Identification of pressures	X	X
1.5 Assessment of impacts	X	X
ANNEX II – 2. ANALYSIS OF GROUNDWATERS		
2.1 Initial characterisation	X	X
2.1 Further characterisation		X
2.3 Review of the impact of human activity	X	X
2.4 Review of the impact of changes in groundwater levels		X
2.5 Review of the impacts of pollution on groundwater quality	X	X
ANNEX III – ECONOMIC ANALYSIS		
(a) Analysis of water uses incl. levels of cost-recovery for water services	X	X
(b) Judgements of most cost-effective combination of measures in respect of water uses		X
Article 6 and		
ANNEX IV – INVENTORY OF PROTECTED AREAS		
1. (i) for abstraction of water intended for human consumption		X
1. (ii) for protection of economically significant aquatic species		X
1. (iii) as recreational waters, incl. areas designated as bathing waters		X
1. (iv) nutrient-sensitive areas, incl. areas designated as vulnerable zones		X
1. (v) for protection of habitats or species where the maintenance or improvement of		
the status of water is important for their protection	X	X
Article 14		
PUBLIC INFORMATION AND CONSULTATION	X	X

1.3. Status of the report and disclaimer

This report is the first comprehensive characterisation and analysis for the entire Danube River Basin, in which all 13 Danubian countries cooperating under the DRPC have participated. The nature, the extent and the quality of the available data and information varies considerably in relation to the issues and the countries concerned. All countries of the Danube basin have committed themselves to develop jointly a Danube River Basin Management Plan by the end of 2009, and, as a first step, provide the required information for this report. Some of the experiences while compiling the report are listed below and should be born in mind when reading and interpreting the report.

The key objective was to compile comparable data and information throughout the basin and to generate the level of detail or aggregation required for the assessment of transboundary and basinwide issues. Thus, for surface water, data collection focused mainly on the Danube River and, in most cases, on the main rivers and lakes as identified in the DRBD overview map. For groundwater, the focus was on the important transboundary groundwater bodies. A more detailed level of the analysis will be presented in the national reports. Hence, this report should only be read and interpreted in conjunction with the national reports. Where inconsistencies may have occurred, the national report may provide the latest up to date information since they have been finalised several months after this report. In other words, some of the data presented in this report were presented as a first approximation or at a different level of aggregation but the finally agreed result on the national level was only becoming available after the final date of data delivery for this report as mentioned below.

The report is mainly based on available data. Wherever possible, the following hierarchy of information has been used:

1. data that has previously been collected in the context of the ICPDR, e.g. results of the TransNational Monitoring Network (1996-2000), the ICPDR Emission Inventory (status 2002) or the results of the Joint Danube Survey[2] conducted in 2001;
2. data and information officially delivered by the competent authorities of the DRB countries (collected by the ICPDR in templates or questionnaires) during the preparation of the report (data mostly from 2004) based on agreed criteria;
3. other published data and information.

The reference of the data sources has been included, in particular for material used from the third category. Whenever a reference is missing, it can be assumed that the data fall under the second category. The maps generated for this report are either produced by the ICPDR on the basis of data sources categories 1 or 2, or maps from other sources have been used and clear reference is provided.

In some cases, national data, which were available only for one or few countries, have not been used if there were alternative published data from other sources for the entire Danube basin, e.g. generated through modelling tools. On one hand, the advantage of such an approach is that largely comparable data, e.g. generated through modelling, for the DRBD can be presented. However, this approach leads to a number of consequences, which have to be born in mind when interpreting the findings of this report:

1. Official national data have not been used and may, in some cases, differ from the Danubewide data set. If the modelled data had been replaced by the national data only for some countries, the level of comparability would have decreased. Hence, more emphasis was given on the relative quantitative levels rather than the correct absolute values.
2. In particular, results used in this report stemming from models (e.g. MONERIS) are focussed on a Danube-wide scale and in a generic way, these results have not been used to derive conclusions for particular countries or regions. The assumptions of the model and the input data are not fully reproduced in this report but are published in secondary literature. Some countries may not agree with the estimations of such models, in particular when a more detailed analysis has been carried out on the national level. However, it was appropriate to draw conclusions from the modelling results for a comparison on the basin-wide scale.
3. Natural conditions may vary, and thereby significantly influence the results of the modelling, e.g. data used in MONERIS for the upper part of the Danube basin was based on a wet period, which included a major flood event. This has led to the overestimation of nutrient loads for this area.

In summary, the results of modelling and other publicly available data and information have only been used if they provided added value to the report and only generic conclusions have been drawn on the basis of those data. In most cases, it was an indication that official and comparable data for the Danube basin do not yet exist.

For some issues it was possible to get expert input through support of the UNDP/GEF Danube Regional Project[3]. The contribution of the Danube Regional Project consisted of

- conducted studies for the characterisation of surface waters and groundwater (development of a typology of the Danube River, study on hydromorphological alterations in the DRB); Agricultural policy study as a contribution to the pressure and impact analysis; Contributions to the economic analysis; and the development of a Public Participation Strategy;
- specialised workshops for capacity building and for coordination/harmonisation of WFD implementation amongst DRB countries;
- data collection via templates and questionnaires, drafting of specific chapters of this report, and preparation of DRBD maps for WFD topics through consultants input.

2 *ICPDR (2002).*
3 *United Nations Development Programme / Global Environment Facility Project: "Strengthening the Implementation Capacities for Nutrient Reduction and Transboundary Cooperation in the Danube River Basin".*

As regards reporting obligations under the Water Framework Directive for EU Member States, this report together with the national report will comprise the package of information sent to the European Commission in order to enable an assessment of the compliance and conformity with the Directive. Given the situation of data availability described below, this report on its own may not be sufficient to completely fulfil the requirements of the Directive, in particular when pragmatic approaches or generalisations had to be applied on the basin-wide level in order to come up with a first screening analysis within the very short available time frame.

Moreover, the harmonisation of approaches and methodologies throughout the basin is only at the beginning. In some areas, harmonisation and comparability of data is already advanced (e.g. the TNMN) or harmonised work was carried out for the purpose of this report (e.g. the typology for the Danube river). In other areas, it was necessary to rely completely on national approaches and thereby presenting data based on a diversity of approaches. Whenever harmonised criteria are being used in the report, the thresholds should be interpreted as significant in the transboundary and basin-wide context of the Danube river basin. Given the immense size of the DRBD, it seems evident that criteria determining significance in the sense of the Water Framework Directive are likely to be much more stringent. Thereby the report only identifies the "major" problems, more stringent criteria in line with the Directive and protecting much smaller water bodies (e.g. lakes smaller than 100 km^2 or groundwater bodies smaller than 4000 km^2) must be used in the national reports. The data concerning transboundary watercourses was bilaterally harmonised.

In view of the above, the delivery of data from EU Member States[4] and Candidate Countries[5] in the Danube River Basin District[6] was satisfactory, even though there is still considerable divergence in the level of detail and availability of data from upstream to downstream. As regards the other Danubian countries, the situation during the preparation of the report was as follows:

Serbia and Montenegro – after becoming a full Contracting Party to the Danube River Protection Convention in August 2003 – has developed a detailed timetable to complete the necessary work for the 2004 report by the end of 2004.

Bosnia i Herzegovina is in the process of internal reorganization of the water management sector to meet requirements of the Water Framework Directive and has begun work to prepare the needed information.

Croatia has also reoriented its water management in line with the WFD, has undertaken most tasks needed and provided the majority of the information required for this report.

Moldova is attempting to meet the requirements of the WFD and has progressed jointly with Romania, with whom Moldova shares a border, in undertaking the necessary work to prepare the necessary information collection and assessment for reporting under WFD.

Ukraine is at the beginning of preparing the necessary internal structures and management arrangements for WFD implementation and has discussed with the ICPDR and the UNDP Danube Regional Project potential assistance in capacity building related to this issue. No timetable for completing tasks or meeting requirements has yet been developed.

All of the countries have, however, progressed with the work necessary and have attempted to organize their internal structures to meet the requirements of the Water Framework Directive.

This report is based on data delivered by the Danube countries by 8 November 2004. Data that has been compiled after this date will only be contained in the national reports. Where data was not delivered by the countries other data sources were used where they were available. Other sources than the competent authorities of the Danube River Basin have been clearly identified in the report.

As regards countries with a share of less than 2000 km^2 in the DRBD, Austria, Slovakia, and Serbia and Montenegro have endeavoured to establish appropriate coordination with these neighbours. Italy and Switzerland have submitted geographical data for this report. Poland delivered data to the Slovak Republic, through the Transboundary Commission established in the frame of bilateral agreement between the Slovak Republic and Poland. Albania and Macedonia communicated the competent authorities for water management issues.

In conclusion, this first assessment reflects the current level of preparation for a harmonised, integrated river basin management. The extent, the quality and the degree of harmonisation of the data will improve with future reviews and updates of the characterisation and analysis making later assessments more comprehensive and robust. Notwithstanding, this first analysis is an outstanding milestone and provides a sound basis for the next stages of the implementation of the Water Framework Directive, in particular the development of the monitoring programmes and the river basin management planning process. To this end, the identified gaps and deficiencies will guide the followup activities after finalisation of this report, in line with the principles identified by the EU Common Implementation Strategy for the Water Framework Directive.

4 Austria, Czech Republic, Germany, Hungary, Slovakia, Slovenia.
5 Bulgaria, Romania (note: Croatia has become a new EU Candidate Country in June 2004 when the most part of the preparatory work was finalised).
6 Only referring to those 13 Danubian countries, which have a share of the Danube River Basin District larger than 2000 km^2.

2. The Danube River Basin District and its international coordination arrangements

Most of the information given in this chapter is taken from the Danube Roof Report 2003 (Art. 3.8 and Annex I), but is provided here to help readers use this report as an alone-standing document.

2.1. Delineation of the Danube River Basin District

The Danube River Basin is the second largest river basin of Europe[7] covering 801,463 km² and territories of 18 states including EU-Member States, Accession Countries and other states that have not applied for EU Membership. According to Article 3.3 of the WFD *"Member States shall ensure that a river basin covering the territory of more than one Member State is assigned to an international river basin district"*. Where a river basin district extends beyond the territory of the Community, the WFD requests the Member State or Member States concerned to *"endeavour to establish appropriate coordination with the relevant non-Member States, with the aim of achieving the objectives of this Directive throughout the river basin district."* (Art. 3.5 WFD). The main objective of WFD implementation is the development of a Danube River Basin Management Plan.

The International Commission for the Protection of the Danube River (ICPDR) is the implementing body under the "Convention on Cooperation for the Protection and Sustainable Use of the Danube River" (Danube River Protection Convention, DRPC) and serves as the platform for coordination to develop and establish the Danube River Basin Management Plan (DRBMP).

The Danube River Basin District has been defined in the frame of the work of the ICPDR. It covers 1) the Danube River Basin, 2) the Black Sea coastal catchments on Romanian territory, and 3) the Black Sea coastal waters along the Romanian and partly the Ukrainian coast.

Area of the Danube River Basin District *TABLE 2*

	Territory	Official area [km²]	Digitally determined area [km²]*
Danube River Basin (DRB)	18 countries (see Table 3)		801,463
Black Sea coastal river basins	Romania	5,198	5,122
Black Sea coastal waters	Romania and Ukraine		1,242
Danube River Basin District (DRBD)			807,827

* *For the purpose of comparison the areas were calculated using GIS on the basis of the DRBD overview map. The value for the Black Sea coastal river basins differs slightly from the official data, since other methods of calculation have been used.*

7 *The area of the DRB was determined digitally with GIS. If other sources are consulted this value may vary slightly, because other methods of calculation have been used.*

Map 1 shows the geographical coverage of the Danube River Basin District as well as the competent authorities. The outer boundary of the Danube River Basin District was defined taking into consideration the hydrological boundaries of the surface waters and groundwater. In a few small places the district boundaries of groundwater and surface waters are not aligned (Germany, Slovenia, Serbia and Montenegro, Bosnia i Herzegovina, and Bulgaria). Details can be found in the respective national reports.

In addition to the Danube River Basin, the small coastal basins of the Black Sea tributaries lying on Romanian territory between the eastern boundary of the DRB and the coastal waters of the Black Sea have been included in the Danube River Basin District. Here also lies the Danube-Black Sea Canal (Canal Dunarea-Marea Neagra), which diverts part of the water of the Danube River directly to the Black Sea. These coastal catchments were included in the DRBD, because they influence the coastal waters along the Romanian coastline.

The coastal waters of the DRBD extend along the full length of the Romanian coastline and along part of the Ukrainian coast up to the hydrological boundaries of the Danube River Basin. The Romanian coastal waters were included in the DRBD, because the water quality and the morphology of the seashore are substantially influenced by the Danube River. The Romanian coastal waters are delineated at 1 nautical mile from the baseline, which is defined along 9 points within the territorial sea of Romania as laid down in the Romanian Law No. 17/1990, modified by Romanian Law No. 36/2002. A detailed description of the coastal waters is contained in the Romanian national report (Part B). The Ukrainian coastal waters are not defined by Ukrainian law. For WFD implementation the coastal waters are defined in line with Art. 2.7 WFD at 1 nautical mile from the baseline.

The coastal waters of Bulgaria are not included in the DRBD, since their characteristics are substantially influenced by rivers on Bulgarian territory flowing into the Black Sea and by processes in the Black Sea itself. Bulgarian coastal waters are assigned to the Bulgarian Black Sea River Basin.

Danube River Basin District - Overview *MAP 1*

2.2. States in the Danube River Basin District

18 states have territories in the Danube River Basin District. Besides Austria, Germany, and Italy, five additional Danube countries have become EU Member States on May 1, 2004. At the time of reporting, three other Danube countries are in the process of accession and are preparing to fulfil the complete body of EU legislation in order to become EU Members. Seven states have not initiated a formal process to join the EU (see Table 3).

For the EU Accession countries the WFD is part of the 'acquis communautaire'. By the time the deadline for the completion of the River Basin Management Plan is reached in December 2009 probably two more Danube countries, Bulgaria and Romania, will have become EU Members. Croatia has officially become an Accession Country in April 2004 and will begin its accession negotiations in 2005. Although these countries have no reporting obligations until they become EU-Member States, they are cooperating in the frame of the ICPDR to implement the necessary steps just as the other Non-EU States.

States in the Danube River Basin District

TABLE 3

State	ISO-Code	Status in the European Union*
Albania	AL	-
Austria	AT	Member State
Bosnia i Herzegovina	BA	-
Bulgaria	BG	Accession Country
Croatia	HR	Accession Country
Czech Republic	CZ	Member State
Germany	DE	Member State
Hungary	HU	Member State
Italy	IT	Member State
Macedonia	MK	-
Moldova	MD	-
Poland	PL	Member State
Romania	RO	Accession Country
Serbia and Montenegro	CS	-
Slovak Republic	SK	Member State
Slovenia	SI	Member State
Switzerland	CH	-
Ukraine	UA	-

* *The table reflects the situation at the time of reporting (March 2005).*

Table 4 shows the coverage of the states in the DRB and the estimated population in the basin. The territory of Hungary is 100 % within the basin. Romania, the Slovak Republic and Austria lie almost completely within the DRB (96 – 97 % of state). Countries sharing < 2000 km² are (in descending order by size) Switzerland, Italy, Poland, Albania and Macedonia. Romania contributes by far the largest population in the DRB (more than 26 %), followed by Hungary, Germany, and Serbia and Montenegro with nearly equal percentages of the total population in the DRB (11 – 12 %).

The Danube River Basin has a rich history with a strong cultural heritage. This is also reflected in the large number of ethnic groups in the basin and the large number of languages still spoken (at least 17 official languages in the DRB). The official languages of the ICPDR are English and German; English is the language used.

Coverage of the states in the Danube River Basin (DRB) and estimated population

(data source: Competent authorities in the DRB unless marked otherwise) *TABLE 4*

State	Code	Official coverage in DRB [km²]	Digitally determined coverage in DRB [km²]*	Percentage of DRB [%]	Percentage of DRB in state [%]	Population in DRB [Mio.]	Percent of population in DRB [%]
Albania	AL		126	< 0.1	0.01	< 0.01	< 0.01
Austria	AT		80,423	10.0	96.1	7.7	9.51
Bosnia i Herzegovina	BA		36,636	4.6	74.9	2.9	3.58
Bulgaria	BG		47,413	5.9	43.0	3.5	4.32
Croatia	HR		34,965	4.4	62.5	3.1	3.83
Czech Republic	CZ	21,688		2.9	27.5	2.8	3.46
Germany	DE		56,184	7.0	16.8	9.4	11.60
Hungary	HU	93,030		11.6	100.0	10.1	12.47
Italy **	IT	565		< 0.1	0.2	0.02	0.02
Macedonia	MK	109		< 0.1	0.2	< 0.01	< 0.01
Moldova	MD		12,834	1.6	35.6	1.1	1.36
Poland	PL	430		< 0.1	0.1	0.04	0.05
Romania	RO	232,193		29.0	97.4	21.7	26.79
Serbia and Montenegro***	CS		88,635	11.1	90.0	9.0	11.11
Slovak Republic	SK	47,084		5.9	96.0	5.2	6.42
Slovenia	SI	16,422		2.0	81.0	1.7	2.10
Switzerland	CH		1,809	0.2	4.3	0.02	0.02
Ukraine	UA		30,520	3.8	5.4	2.7	3.33
Total			(801,463)	100		81.00	100

* *For the purpose of comparison the coverage of the states was calculated using GIS based on the DRBD overview map. These values differ slightly from the official data of some countries, since other methods of calculation have been used.*
** *Data source: Autonomous Province of Bozen – South Tyrol.*
*** *According to the 2002 census the population in Serbia and Montenegro without the provinces of Kosovo and Metohia is 7.668.000 inhabitants. On the territory of Kosovo and Metohia the last census was in 1981. On the basis of this census and OEBS data the estimated population of Kosovo and Metohia in the Danube river basin today is about 1.300.000 inhabitants.*

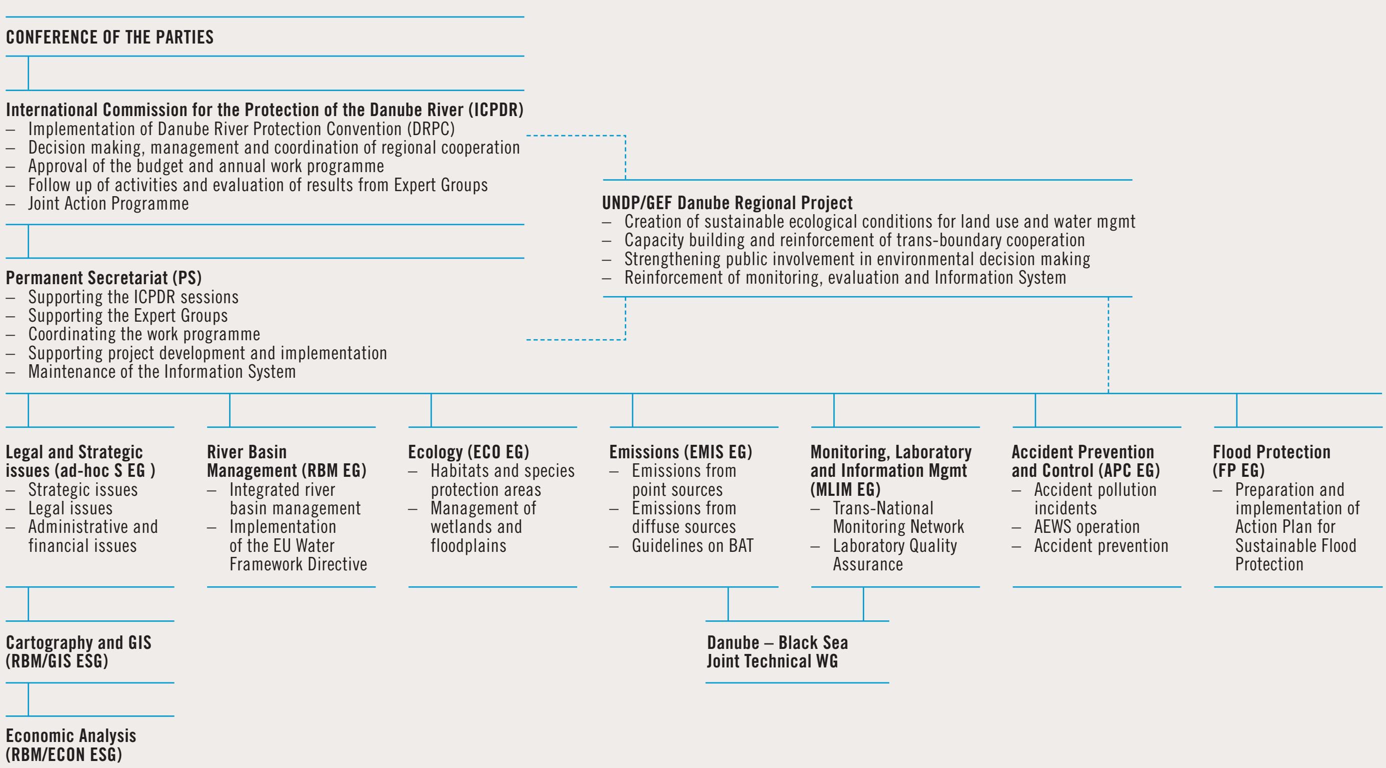
2.3. International coordination of WFD implementation

2.3.1. Coordination at the basin-wide level

The Danube River Protection Convention forms the overall legal instrument for cooperation and transboundary water management in the Danube River Basin. The main objective of the convention is the sustainable and equitable use of surface waters and groundwater and includes the conservation and restoration of ecosystems. The Contracting Parties cooperate on fundamental water management issues and take all appropriate legal, administrative and technical measures, to maintain and improve the quality of the Danube River and its environment. Austria, Bosnia i Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Moldova, Romania, the Slovak Republic, Slovenia, Serbia and Montenegro, Ukraine and the European Community are Contracting Parties to the DRPC.

To facilitate the implementation of the DRPC, the Danubian countries agreed that with its entry into force the ICPDR is established. The ICPDR is therefore the framework for basin-wide cooperation (see Figure 2).

Organisational Structure under the Danube River Protection Convention *FIGURE 2*



At its 3rd Ordinary Meeting on November 27-28, 2000 in Sofia the ICPDR made the following resolutions:

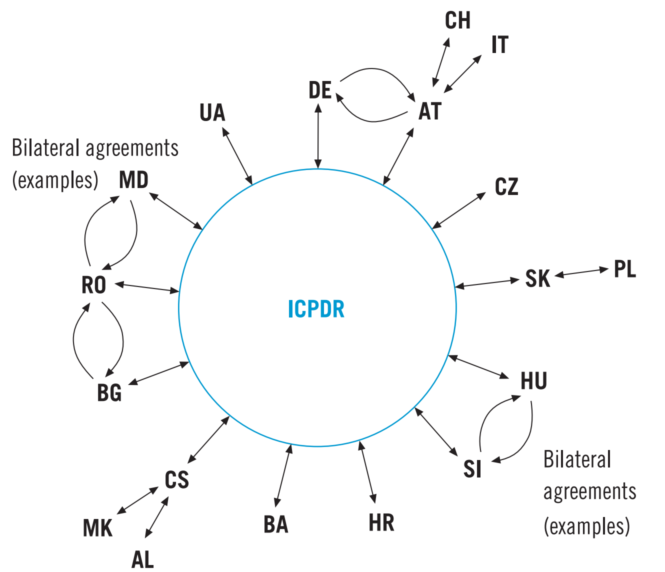
- The ICPDR will provide the platform for the coordination necessary to develop and establish the River Basin Management Plan for the Danube River Basin.
- The Contracting Parties ensure to make all efforts to arrive at a coordinated international River Basin Management Plan for the Danube River Basin in line with the requirements of the WFD.

In the ICPDR all Contracting Parties support the implementation of the WFD in their territories and cooperate in the framework of the ICPDR to achieve a single, basin-wide coordinated Danube River Basin Management Plan. The ICPDR President has addressed the other DRB countries not cooperating under the DRPC to commit themselves to cooperate with the ICPDR to achieve a basinwide coordinated DRBMP. Poland, Switzerland, Macedonia and Albania have offered their support. From Italy no response was received. On the operational level, it is the obligation of the Contracting Parties to ensure the necessary coordination with their DRB neighbours not cooperating under the DRPC.

The River Basin Management Expert Group was created to prepare and coordinate the necessary activities for the implementation of the WFD. All countries cooperating under the DRPC are represented in the River Basin Management Expert Group. The group jointly agrees on the necessary actions for the development of the Danube River Basin Management Plan, e.g. the development of a strategy for establishing the RBM Plan, development of the roof report to the European Commission or identifying needs for harmonisation of methods and mechanisms (see Figure 3).

The Danube countries cooperating under the DRPC report regularly to the ICPDR on the progress of WFD implementation in their own states. These national reports serve as a means for exchanging information between the states and for streamlining the implementation activities on the national level. At each of its Ordinary Meetings and Standing Working Group Meetings[8] the ICPDR deals with the step-wise implementation of the WFD in the Danube River Basin and takes the necessary decisions.

Coordination mechanisms for WFD implementation in the Danube River Basin (for bilateral agreements only some examples are shown; a full list is contained in **Table 5**) *FIGURE 3*



8 See the Convention on Cooperation for the Protection and Sustainable use of the Danube River (Danube River Protection Convention).

2.3.2. Bilateral and multilateral cooperation

The ICPDR serves as the platform for coordination in the implementation of the WFD in the Danube River Basin District on issues of basin-wide importance. Transboundary issues not covered by the ICPDR are solved at the appropriate level of cooperation e.g. in the frame of bilateral/multilateral river commissions. Local issues remain a national task. Generally, coordination will take place at the lowest level possible so that the coordination via the ICPDR can be limited to those issues necessary on the basin-wide level.

Bilateral agreements are in place between almost all states in the Danube River Basin District, but it is important to note that these agreements were not *"established in order to ensure coordination"* as stated in WFD Annex I, 6. These are generally older treaties that deal with specific issues of transboundary cooperation, which in many cases includes water management issues. Some of these agreements have been adapted to cover issues related to WFD implementation, but generally they are only used as the platform for coordination needed to fulfil the requirements of the WFD.

Table 5 gives an overview of the existing agreements that are being used for WFD implementation. There are cases where no formally approved bilateral agreements and commissions implementing them exist, but regular meetings serve to facilitate cooperation.

Overview of bilateral agreements and bilateral cooperations for WFD implementation in the Danube River Basin District *TABLE 5*

	AL	AT	BA	BG	CH	CS	CZ	DE	HR	HU	IT	MD	MK	PL	RO	SI	SK	UA
AL						X												
AT					(X)		X	X		X	(X)					X	X	
BA									X									
BG						X							X		X			
CH		(X)																
CS	X			X						X					X			
CZ		X						X						X			X	
DE		X					X											
HR			X							X						X		
HU		X				X			X						X	X	X	X
IT		(X)																
MD															X			X
MK				X														
PL							X										X	X
RO				X		X				X		X						X
SI		X							X	X								
SK		X					X			X				X				X
UA										X		X		X	X		X	

X = formal agreement between neighbouring states, (X) = bilateral cooperation without formal agreement

2.3.3. Competent authorities

The competent authorities for WFD implementation are designated by the states. The link between these on the basin-wide level is ensured through the ICPDR and its Contracting Parties. The ICPDR serves as the platform for coordination for the implementation of the WFD in the Danube River Basin District on issues of basin-wide importance. The competent authorities are listed in Table 6 and also shown in Map 1.

List of competent authorities in the Danube River Basin District *TABLE 6*

Albania
Ministry of Environment
Rruga e Durresit 27
AL-Tirana

Austria
Federal Ministry for Agriculture, Forestry, Environment and Water Management
Stubenring 1
A-1012 Wien

Bosnia i Herzegovina
Ministry of Foreign Trade and Economic Relations
Musala 9
BiH-71000 Sarajevo
and
Federal Ministry of Agriculture, Water Management and Forestry
Marsala Tita 15
BiH-71000 Sarajevo
and
Ministry of Agriculture, Forestry and Water Management of Republika Srpska
Milosa Obilica 51
BiH-76300 Bijeljina

Bulgaria
Ministry of Environment and Water
22 Maria-Luisa Blvd.
BG-1000 Sofia

Croatia
Ministry of Agriculture, Forestry and Water Management
Ulica grada Vukovara 220
HR-10000 Zagreb

Czech Republic
Ministry of Environment
Vrsovická 65
CZ-10010 Praha 10
and
Ministry of Agriculture
Tesnov 17
CZ-117 05 Praha 1

Germany
Bavarian State Ministry for Environment, Public Health and Consumer Protection
Rosenkavalierplatz 2
D-81925 München
and
Ministry for Environment and Transport Baden-Württemberg
Kernerplatz 9
D-70182 Stuttgart

Hungary
Ministry of Environment and Water
FŒ utca 44-50
H-1011 Budapest

Italy
No information

Macedonia
Ministry of Agriculture, Forestry and Water supply
Department for Water Management and Water Supply
Ul. Leninova 2
MK-1000 Skopje
and
Ministry of Agriculture, Forestry and Water supply
Ul. Skupi bb
MK-1000 Skopje

Moldova
Ministry of Ecology, Construction and Territorial Development
9 Cosmonautilor St.
MD-2005 Chisinau

Poland
Ministry of Environment
Ul. Wawelska 52/54
PL-00922 Warszawa
and
Regional Water Management Authority
Ul. C.K. Norwida 34
PL-50950 Wroclaw
and
Regional Water Management Authority
Ul. J. Pilsudskiego 22
PL-31109 Kraków

Romania
Ministry of Environment and Water Management
12 Libertatii Blvd., Sector 5
RO-04129 Bucharest
and
National Administration "Apele Romane"
6 Edgar Quinet St., Sector 1
RO-010018 Bucharest

Serbia and Montenegro
Ministry of Agriculture, Forestry and Water Resources Management of the Republic of Serbia
Nemanjina 22-26
CS-11000 Beograd

Slovak Republic
Ministry of the Environment
Námestie L' Stúra 1
SK-81235 Bratislava

Slovenia
Ministry of the Environment, Spatial Planning and Energy
Dunajska 48
SI-1000 Ljubljana

Switzerland
Bundesamt für Wasser und Geologie (BWG)
Abt. Wasserwirtschaft
CH-3003 Bern
and
Bundesamt für Umwelt, Wald und Landschaft
Abt. Gewässerschutz und Fischerei
CH-3003 Bern

Ukraine
Ministry for Environmental Protection of Ukraine
35, Uritskogo str.
UA-03035 Kyiv

3. General characterisation of the Danube River Basin District

This chapter gives a general overview of the Danube River Basin District and serves as background information for the detailed analysis according to Art. 5 and Annex II and III WFD, which is described in **Chapter 3, 4, 5, 6 and 7.**

3.1. Geographic characterisation

The Danube River Basin[9] is the second largest river basin in Europe after the Volga covering 801,463 km^2. It lies to the west of the Black Sea in Central and South-eastern Europe (see Figure 4). To the west and northwest the Danube River Basin borders on the Rhine River Basin, in the north on the Weser, Elbe, Odra and Vistula River Basins, in the north-east on the Dnjestr, and in the south on the catchments of the rivers flowing into the Adriatic Sea and the Aegean See (see Map 2).

Due to its geologic and geographic conditions the Danube River Basin can be divided into 3 main parts.[10]

- The Upper Danube Basin reaches from the sources in the Black Forest Mountains to the Gate of Devín, to the east of Vienna, where the foothills of the Alps, the Small Carpathians and the Leitha Mountains meet. The area covers in the north the Swabian and Frankonian Alb, parts of the Oberpfälzer, the Bavarian and the Bohemian Forests, the Austrian Mühl- and Waldviertel, and the Bohemian-Moravian Uplands. South of the Danube lie the Swabian-Bavarian-Austrian Alpine Foothills as well as large parts of the Alps up to the water divide in the crystalline Central Alps.
- The Middle Danube Basin covers a large area reaching from the Gate of Devín to the impressive gorge of the Danube at the Iron Gate, which divides the Southern Carpathian Mountains in the north and the Balkan Mountains in the south. The Middle Danube Basin is confined by the Carpathians in the north and the east, and Karnic Alps and the Karawankas, the Julian Alps and the Dinaric Mountains in the west and south. This circle of mountains embraces the Pannonian Plains and the Transsylvanian Uplands.
- The Lower Danube Basin covers the Romanian-Bulgarian Danube sub-basin downstream of Cazane Gorge and the sub-basins of the Siret and Prut River. It is confined by the Carpathians in the north, by the Bessarabian Upland Plateau in the east, and by the Dobrogea and Balkan Mountains in the south.

Due to this richness in landscape the Danube River Basin shows a tremendous diversity of habitats through which rivers and stream flow including glaciated high-gradient mountains, forested midland mountains and hills, upland plateaus and through plains and wet lowlands near sea level.

3.2. Climate and hydrology

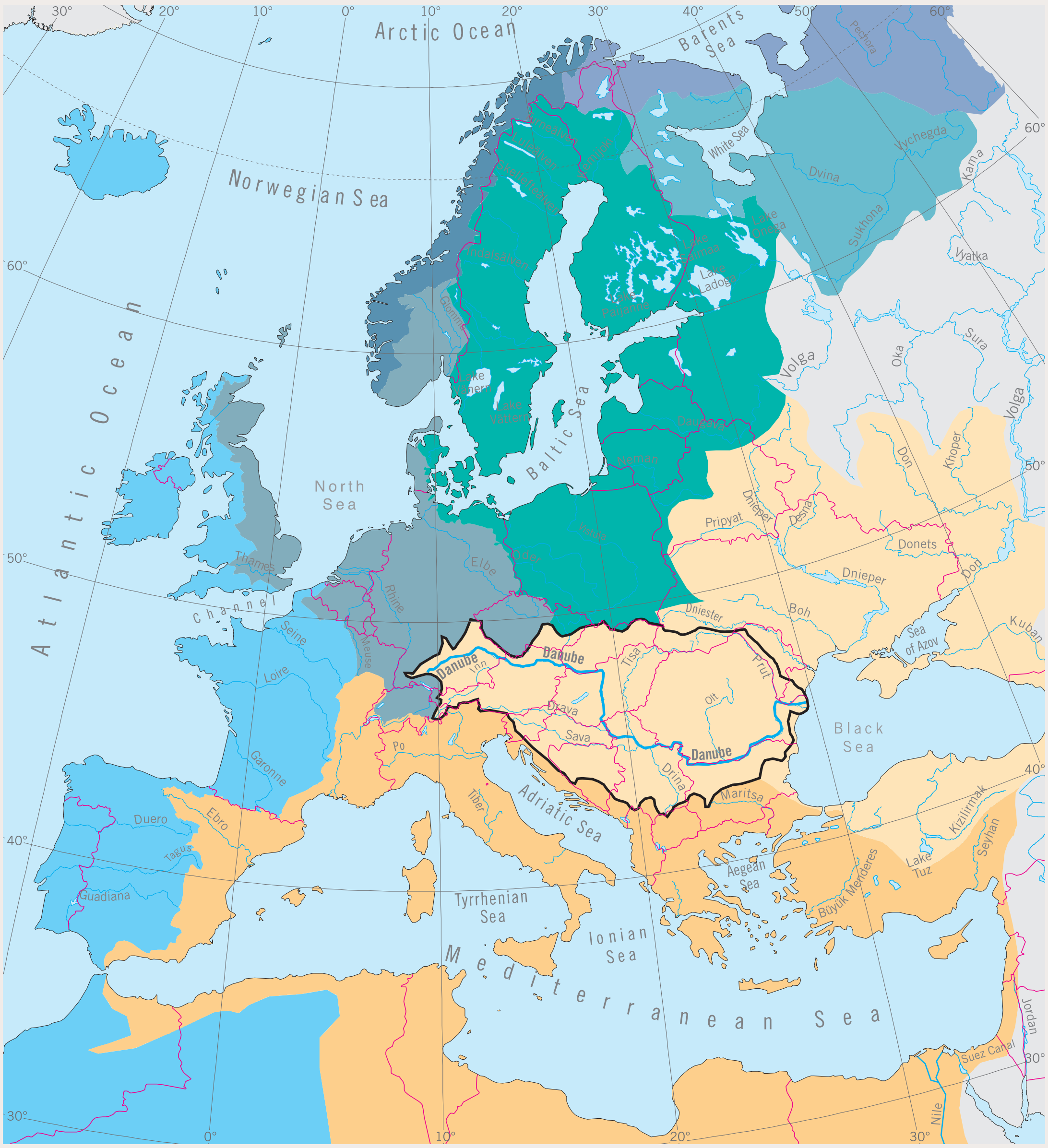
Due to its large extension from west to east, and diverse relief, the Danube River Basin also shows great differences in climate. The upper regions in the west show strong influence from the Atlantic climate with high precipitation, whereas the eastern regions are affected by Continental climate with lower precipitation and typical cold winters. In the area of the Drava and Sava, influences from the Mediterranean climate, can also be detected[11]. The heterogeneity of the relief, especially the differences in the extent of exposure to the predominantly westerly winds, as well as the differences in altitude diversify this general climate pattern. This leads to distinct landscape regions showing differences in climatic conditions and in the biota, e.g. the vegetation. The precipitation ranges from < 500 mm to > 2000 mm based on differences in the regions (Map 3). This in turn has strong effects on the surface run-off and the discharge in the streams.

9 *The area of the DRB was determined digitally with GIS. If other sources are consulted this value may vary slightly, because other methods of calculation have been used.*

10 *STANČIK et al. (1988).*

Location of the Danube River Basin in Europe

FIGURE 4



The Danube River Basin in Europe
Drainage basins of regional seas

0 500 km

- White Sea
- Barents Sea
- Baltic Sea
- Norwegian Sea
- Mediterranean Sea
- Black Sea and Sea of Azov
- Atlantic Ocean
- North Sea
- not classified

Source: European Commission, adjusted for ICPDR, 2004

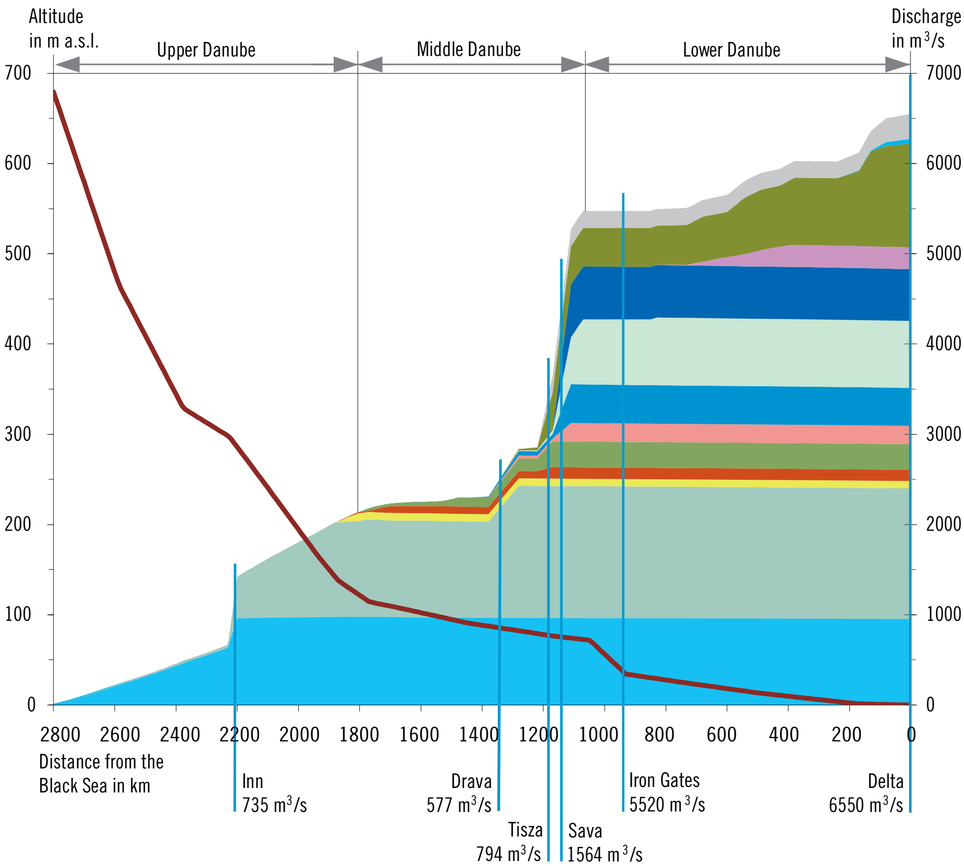
Danube River Basin District - Relief and Topography

MAP 2

Danube River Basin District - Annual Precipitation

MAP 3

Longitudinal profile of the Danube River and contribution of water from each country (in %) to the cumulative discharge of the Danube (in Mio m³/year), based on data for 1994-1997 using the Danube Water Quality Model[11] *FIGURE 5*



Discharge per country: m³/s	%	
279	4,3	Ukraine
49	0,7	Moldova
1151	17,6	Romania
243	3,7	Bulgaria
574	8,8	Bosnia i Herzegovina
741	11,3	Serbia and Montenegro
421	6,4	Croatia
202	3,1	Slovenia
283	4,3	Hungary
125	1,9	Slovak Republic
81	1,2	Czech Republic
1448	22,1	Austria
952	14,5	Germany
		Elevation
6551	100,0	

The hydrologic regime of the Danube River, in particular the discharge regime, is distinctly influenced by the regional precipitation patterns. This is well illustrated in Figure 5, which shows the surface water contribution from each country to the cumulative discharge of the Danube. Austria shows by far the largest contribution (22.1 %) followed by Romania (17.6 %). This reflects the high precipitation in the Alps and in the Carpathian mountains. In the upper part of the Danube the Inn contributes the main water volume adding more water to the Danube than it has itself at the point of confluence of the two. In the middle reach it is the Drava, Tisza and Sava, which together contribute almost half of the total discharge that finally reaches the Black Sea.

3.3. The Danube River and its main tributaries

The Danube rises in the Black Forest (Schwarzwald) in Germany at a height of about 1,000 m a.s.l. and receives its name at the confluence of Brigach and Breg in Donaueschingen. Interestingly, the Danube loses about half its discharge to the Rhine basin through underground passages in its upper course near Immendingen (reduction from 12 to 6 m³/s). The Danube flows predominantly to the south-east and reaches the Black Sea after 2,780 km where it divides into 3 main branches, the Chilia, the Sulina, and the Sf. Gheorghe Branch. At its mouth the Danube has an average discharge of about 6,500 m³/s. The Danube Delta lies in Romania and partly in Ukraine and is a unique “World Nature Heritage”. The entire protected area covers 675,000 ha including floodplains, and more than 600 natural lakes larger than one hectare, and marine areas. The Danube is the largest tributary into the Black Sea.

Some of the largest tributaries of the Danube are characterised below. Their key hydrologic characteristics are listed in Table 7 (catchment areas have been calculated digitally for the purpose of comparison):

11 Developed during the Danube River Pollution Reduction Programme in 1999, UNDP/GEF (1999b).

The Danube and its main tributaries (1st order tributaries with catchments > 4,000 km^2) in the order of their confluence with the Danube from the source to the mouth (data source: Competent authorities in the DRB unless marked otherwise)

TABLE 7

River	Mouth at Danube [rkm]	Length [km]	Size of catchment [km^2]*	Average discharge [m^3/s]	Time series for discharge values
Danube	0	2,780	801,463	6,460	(1914-2003)
Lech	2,497	254	4,125	115	(1982-2000)
Naab	2,385	191	5,530	49	(1921-1998)
Isar	2,282	283	8,964	174	(1926-1998)
Inn	2,225	515	26,130	735	(1921-1998)
Traun	2,125	153	4,257	150	(1961-1999)
Enns	2,112	254	6,185	200	(1961-1999)
Morava/March	1,880	329	26,658	119	(1961-1999)
Raab/Rába	– **	311	10,113	88	(1901-2000)
Vah	1,766	398	18,296	161	(1931-1980)
Hron	1,716	278	5,463	55	(1931-1980)
Ipel/Ipoly	1,708	197	5,108	22	(1931-1980)
Sió***	1,498	121	9,216	39	(1931-1970)
Drau/Drava	1,382	893	41,238	577	(1946-1991)
Tysa/Tisza/Tisa	1,214	966	157,186	794	(1946-1991)
Sava	1,170	861	95,719	1,564	(1946-1991)
Tamis/Timis	1,154	359	10,147	47	(1946-1991)
Morava (CS)	1,103	430	37,444	232	(1946-1991)
Timok	846	180	4,630	31	(1946-1991)
Jiu	694	339	10,080	86	(1921-2003)
Iskar	636	368	8,684	54	(1936-1998)
Olt	604	615	24,050	174	(1921-1995)
Yantra	537	285	7,879	47	(1936-1998)
Arges	432	350	12,550	71	(1914-2003)
Ialomita	244	417	10,350	45	(1915-2003)
Siret	155	559	47,610	240	(1921-2003)
Prut	132	950	27,540	110	(1928-2003)

* *For the purpose of comparison the size of the catchments was calculated using GIS on the basis of the DRBD overview map. These values may differ slightly from the official data, because other methods of calculation have been used.*
** *The Raab/Rába flows into the Mosoni Duna, an arm of the Danube, at rkm 14.*
*** *Sió River is the outflowing river of Lake Balaton, which has in itself a catchment area of 5,737 km^2. The total catchment area of Lake Balaton and Sió River is 14,953 km^2.*

The Tysa/Tisza/Tisa River basin is the largest sub-basin in the Danube River Basin (157,186 km^2). It is also the longest tributary (966 km) of the Danube. By flow volume it is second largest after the Sava River. The Tysa/Tisza/Tisa River basin can be divided into three main parts:

- the mountainous Upper Tysa in Ukraine (upstream of the Ukrainian-Hungarian border),
- the Middle Tisza in Hungary (receiving the largest tributaries: Bodrog River and Slaná/Sajó River collecting water from the Carpathian Mountains in Slovak Republic and Ukraine as well as the Somes/Szamos River, the Crisul/Körös River System and Mures/Maros River draining Transylvania in Romania), and
- the Lower Tisa (downstream of the Hungarian border with Serbia and Montenegro, where it receives the Bega/Begej and other tributaries indirectly through the Danube – Tisza – Danube Canal System).

The Sava River is the largest Danube tributary by discharge (average 1,564 m^3/s) and the second largest by catchment area (95,419 km^2). It rises in the western Slovenian mountains and passes through Croatian lowland before forming the border between Croatia and Bosnia i Herzegovina. Continuing through Serbia and Montenegro it reaches its confluence with the Danube in Belgrade. Its main sub-tributaries are Krka, Kolpa/Kupa, Una, Vrbas, Bosna, Drina and Kolubara.

The Inn is the third largest by discharge and the seventh longest Danube tributary. At its mouth in Passau, it brings more water into the Danube than the latter itself. However, its catchment area of 26,130 km^2 is only nearly half as big as the Danube at this point. The main tributary of the Inn is the Salzach River.

The Morava/March River is a left hand tributary of the Danube. Its catchment area of 26,658 km^2 covers parts of the Czech Republic, Slovak Republic and Austria. In terms of geological structure, this basin forms a boundary between the Bohemian Highlands, the Carpathians and the Pannonian Province. It is an ecologically valuable area with high diversity of species and landscape types.

The Drau/Drava is the fourth largest (41,238 km^2) and fourth longest Danube tributary (893 km). It rises in the Southern Alps in Italy but is the dominant river of southern Austria, eastern Slovenia, southern Hungary and Croatia. Main Austrian sub-tributaries are Isel, Möll, Lieser and Gurk, and the Mur/Mura with its mouth at the Croatian-Hungarian border.

The Velika Morava in Serbia and Montenegro is the last significant right-bank tributary before the Iron Gate, with a catchment area of 37,444 km^2. The Velika Morava is formed by the confluence of two rivers, the Južna/Southern Morava draining the south-eastern part of Serbia, together with the Nišava River and Zapadna/Western Morava draining the south-western part of Serbia together with the Ibar.

The Prut River is the second longest (950 km) and the last tributary of the Danube, with its mouth just upstream of the Danube Delta. Its source is in the Ukrainian Wood Carpathians. Later it forms the border between Romania and Moldova. Main sub-tributaries are Ceremosh, Derelui, Volovat, Baseu, Corogea, Jijia, Chineja, Ciugur and Lapusna.

3.4. Important lakes in the Danube River Basin District

In the Danube River Basin there are a multitude of natural lakes. Most of them are small, but some are also very large, with areas of several square kilometres. The middle Danube region shows some characteristic steppe lakes, of which the most prominent ones are Neusiedlersee / Fertő-tó and Lake Balaton. A characteristic lake type of the lower Danube basin is the Liman Lake[12], of which several are situated to the north of the lower Danube. Ozero Ialpug in Ukraine is a liman-like lake that has been blocked off by levees of the Danube River.

Lakes selected for the basin-wide overview are those larger than 100 km^2 (see Table 8).

Neusiedler See / Fertő-tó

Neusiedler See / Fertő-tó is located in the east of Austria and shared with Hungary. It has a total surface area of 315 km^2 (at a defined water level), of which 240 km^2 are located in Austria and 75 km^2 in Hungary. A fluctuation in the water level of the lake of +/- 1.0 cm means a change in the lake surface of up to 3 km^2. More than half of its total area consists of reed beds; in certain parts the reed belt is 3 to 5 km wide. In the past the lake had no outflow and therefore extremely large fluctuations of its surface area were recorded.

Neusiedler See / Fertő-tó has an average natural depth of 1.1 m, its maximal water depth is 1.8 m. In its history it has dried out completely several times. Later the Hanság Main Canal was built as the lake outlet. Since 1965 the water level is stabilised by the outlet sluice based on an agreement of the Hungarian-Austrian Water Commission in 1965 (water level in April-August: 115.80 m a.s.l., October-February: 115.70 m a.s.l., transition periods March and September: 115.75 m a.s.l.). The main surface water input is through precipitation on the lake surface, secondly by Wulka River, Rákos Creek and other smaller tributaries. Inflow due to groundwater is close to negligible. Due to its low depth the lake is quickly mixed by wind action and therefore naturally turbid. The lake water is characterised by a high salt concentration.

12 *Liman lakes are enclosed shallow flooded river estuaries that have been separated from the sea by narrow sandbars.*

Lake Balaton

Lake Balaton, situated in the western part of Hungary, is a large shallow lake with a surface area of 605 km^2 (official data) and an average depth of 3.6 m. The shape of the lake is slender with a length of 77.8 km and a width of 7.7 km on average. The narrowest point is the Tihany Strait. Here the accelerated lake current erodes the bottom sediment up to more than 10 m depth. The catchment area of the lake is 5,188 km^2 excluding the surface of the lake itself. Out of the many water courses that enter the lake River Zala is the most significant, contributing 45 % of the catchment area.

The southern shore is characterised by a gently deepening, velvety quicksand due to its lotic conditions. Reed belts cover major parts of the southern shore and the area around Keszthely Bay. Due to its shallow waters the lake responds quickly to changes in air temperature and solar radiation. During the summer it is not rare that the water temperature exceeds 25˚ C, while in winter the lake freezes. For management purposes the lake is usually subdivided into four basins, namely Keszthely-, Szigliget-, Szemes- and Siófok basins, from west to east.

Ozero Ialpug

For Ozero Ialpug no information is available.

Razim-Sinoe Lake System

The Razim-Sinoe Lake System is a complex system consisting of several large brackish lagoons separated from the sea by a sandbar (see Figure 6). Every year thousands of tons of alluvial deposits are carried into the Delta by the Danube resulting in a constant reshaping of the river banks and sandbars.

Lacul Razim has a surface area of 392 km^2 (520 km^2 including Lacul Golovita and Lacul Zmeica). Lacul Razim is fed from several sources: the Danube – Sf. Gheorghe arm through Dranov and Dunavat Channel as well as Babadag Lake through Enisala Channel. The catchment area of Babadag Lake is 924 km^2. Razim Lake is predominantly influenced by water from the Danube and much less from the Babadag and Razim catchments.

Lacul Sinoe is the only lagoon along the Romanian seashore. It covers 162 km^2 at the southern end of the Razim-Sinoe complex. The hydrological character of Lacul Sinoe has changed over time. Originally it was a bay of the Black Sea, which was gradually cut off by natural sandbar formation. In 1975 to 1977 hydrological works were performed that resulted in the closure of the Black Sea connection of the Razim-Sinoe complex. The only connection remaining between the Sinoe Lagoon and the Black Sea today is the Periboina Channel. Since that time the lagoon has experienced an increased inflow of freshwater through Lake Razim and the natural inlets connecting it to the Danube River. During the last 25 years of freshwater inflow Lacul Sinoe has turned into an oligohaline lake.

The main lakes (with a surface area > 100 km^2) in the Danube River Basin
(data source: Competent authorities in the DRB unless marked otherwise)
TABLE 8

Lake	Country(ies)	Surface area [km^2]	Average depth [m]	Maximum depth [m]
Neusiedler See / Fertő-tó	AT, HU	315	1.10	1.80
Lake Balaton	HU	605	3.60	10.60
Ozero Ialpug*	UA	149	na	na
Lacul Razim / Razelm	RO	392	2.05	3.50
incl. L. Golovita and L. Zmeica	RO	520	na	na
Lacul Sinoe / Sinoie	RO	162	1.25	2.30

** The size of the surface area was calculated using GIS on the basis of the DRBD slightly from the official data, because another method of calculation has been used.*

3.5. Major wetlands in the Danube River Basin District

Floodplain forests, marshlands, deltas, floodplain corridors, lake shores and other wetlands are essential components in the Danube River Basin's biodiversity and hydrology. The Danube River Basin extends into five of the eight Biogeographical Regions of Europe: the Alpine, the Continental, the Pannonic, the Steppic and the Black Sea Region. Each of these shows characteristic wetlands, some of them are protected, others not. Many of the larger wetland areas are transboundary in nature. The wetlands in the Alps and Carpathians also represent valuable drinking water reserves for millions of people.

The current extent of wetlands in the DRB is only a remnant of the former wetland systems. The 13 most important wetland complexes in the Danube River Basin are described below (see also Map 16 and Chapter 6 of this report).

The Donauauen National Park (Austria) with approximately 11,000 ha of floodplain forests, riparian habitats and side-arms between Vienna and Hainburg represents the last intact floodplain of the upper Danube. Together with the Floodplains of the Lower Morava and Dyje (Austria, Czech Republic and Slovak Republic) it forms a transboundary "wetland of international importance" and was declared as a trilateral Ramsar Site. On the Czech side, it is partly a biosphere reserve and World Heritage Site; protected nature reserves and landscapes exist in all three countries. The area contains extended floodplains and lowland steppe river habitats along the former Iron Curtain. Extended old hardwood forests and the largest wet meadow complex in Central Europe form an inter-connected wetland area of 25,000 ha in three countries.

The Neusiedlersee and Fertő-Hanság (Austria and Hungary), a transboundary National Park since 1993, and World Heritage Site since 2003, is a 30,000 ha shallow steppe lake area with a huge reed belt, adjacent small soda lakes and traditional pastures. It is one of the most important resting sites for migrating birds in Europe. Protected landscape areas, including small nature reserves, form the Szigetköz and Zitny Ostrov Floodplain Complex (Hungary and Slovak Republic), an extended meander zone around the low water bed of the Danube.

As a part of the Duna-Drava National Park, established in 1996, the Gemenc-Béda-Karapancsa Wetlands (Hungary) represent an exceptional example of a large old floodplain with big meanders, oxbow lakes, marshland and extended hardwood forests. This Important Bird Site (Black Stork, Sea Eagle) with a total area of 47,000 ha is also an excellent fish spawning ground.

Kopacki Rit (Croatia) with some 30,000 ha between the Drava and the Danube is one of the richest and most dynamic floodplains of the Danube River Basin. It has extended floodplain forests (willow, poplar and oak), floodplain lakes, ponds, extensive reed beds and marshes and was already designated as a Ramsar Site and a Nature Park (IUCN category I b and V). It was further proposed as part of a transboundary Biosphere Reserve along the Drava and Mura rivers. 100 days flooding per year and the abundance of food and underwater vegetation makes Kopacki Rit, after the Danube Delta, the most important fish-spawning ground along the entire Danube.

Just opposite Kopacki Rit lies the wetland complex of Gornje Podunavlje (Serbia and Montenegro) with 19,648 ha of floodplain habitats. This spatially and ecologically unique complex with its mosaic of water, marsh, swamp, meadows, bush and forest ecosystems is characterised by a high biodiversity and significant number of threatened, rare, endemic and relict species.

A special case are the middle and lower Drava-Mura wetlands (Slovenia, Croatia, Hungary) forming an intact bio- and landscape corridor of 380 km from the alpine foothills up to the Pannonian Lowlands on the Danube. Although there are already some nature reserves and other protected areas, most of the area has remained unprotected. The floodplain corridor covers 60,000 ha and forms a unique living space especially for migratory freshwater species and alpine pioneer species living on sand, gravel bars and islands as well as for forest species and mammals such as river otter and beaver.

The Sava wetlands extend through Croatia, Serbia and Montenegro, and Bosnia i Herzegovina. The Nature Park Lonjsko Polje constitutes the largest wetland in Croatia and covers an area of more than 100,000 ha. Obedska Bara is the largest wetland in Serbia within this system and has an extent of more than 30,000 ha.

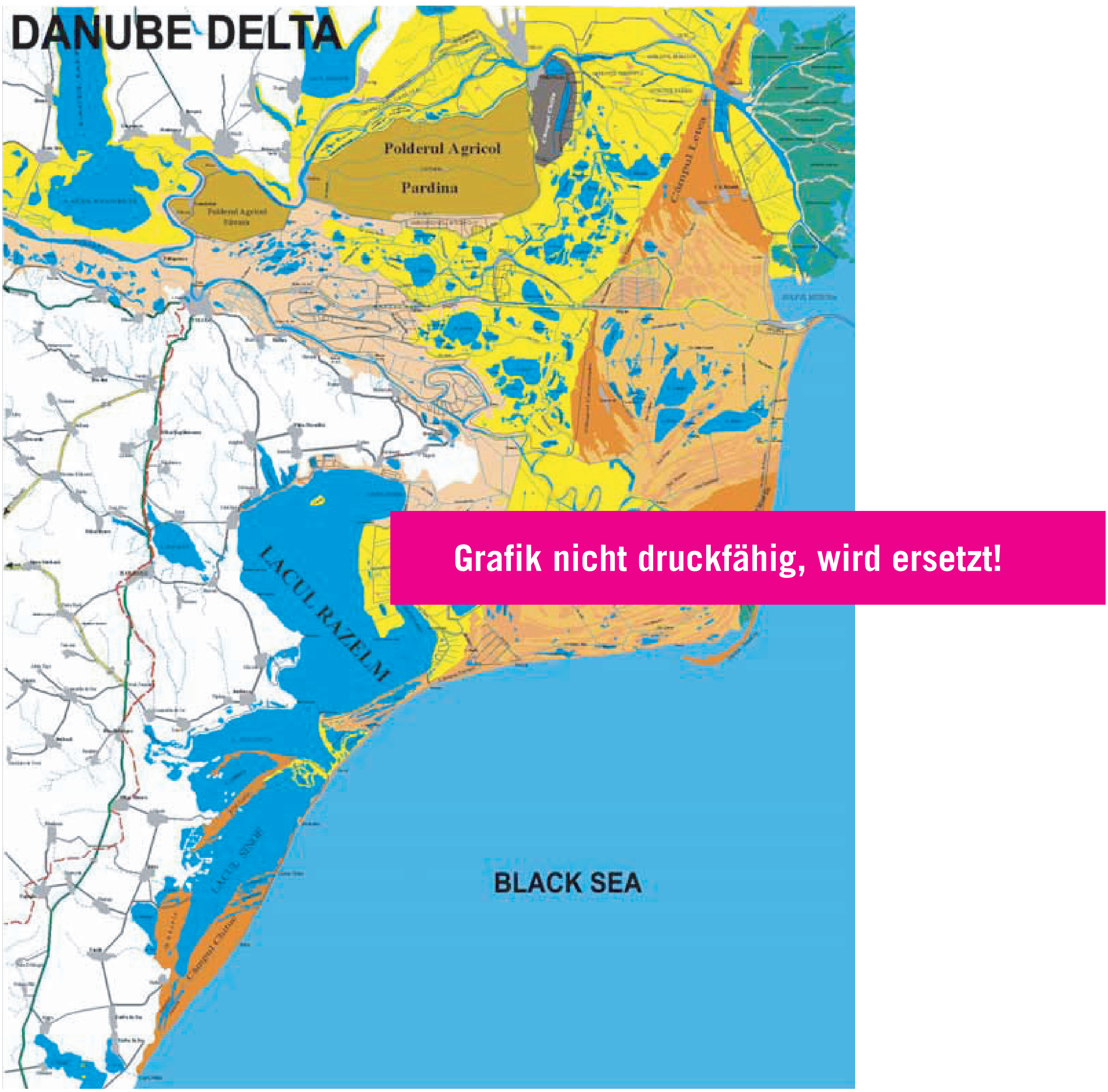
A mosaic of Ramsar Sites, Important Bird and Landscape Protection Areas, Biosphere Reserves and also non-protected areas can be found along the wetlands of the Upper and Middle Tisza River. The Ecsedi Lap Complex (Ukraine, Slovak Republic, Romania, and Hungary) forms a riverine ecocorridor which is 400 km long and has a size of 140,000 ha. On the lower Tisza, the Stari Begej- Carska Bara Ramsar Site at the confluence of the Begej and the Tisza River is the most valuable wetland area.

A major wetland complex for Europe is the Lower Danube wetlands (Serbia and Montenegro, Romania, Bulgaria, Moldova, and Ukraine) with a size of approximately 600,000 ha. They are also a mosaic of protected areas including Ramsar sites, Biosphere Reserves, World Heritage Site (Srebarna Lake) and National/Nature Parks (e.g. Balta Mica a Brailei). Most important are the Bulgarian islands at Belene, the Kalimok marshes, the lower Prut floodplains and liman lakes in Moldova. Together with the Danube Delta this area is one of the world's most important ecoregions for biodiversity.

The Lower Prut floodplains (Romania and Moldova) are 147 km long and have a size of 19,153 ha with adjoining floodplain terraces and river-cliffs with ravines. Up to the confluence of Prut and Danube the floodplain is up to 6 km wide, and includes meadows and riverine forests; the aquatic biodiversity is high especially in the floodplain lakes Beleu (1,700 ha) and Manta (complex of interconnected lakes).

The Danube Delta (80 % Romania and 20 % Ukraine) with a size of 675,000 ha is the most important wetland in the Danube River Basin. It was designated as a transboundary UNESCO World Heritage Site and Man and Biosphere Reserve, has 2 Ramsar Sites, a national park and some nature reserves. The Danube Delta includes the largest reed bed in the world (180,000 ha) and a complex of three large river arms, floodplain forests, inner lakes, natural and man-made channels, sand dunes and coastal biotopes (see Figure 6). It has globally important breeding, feeding and resting areas for pelicans and 300 other birds, for sturgeons, the river otter and many other endangered species.

The Danube Delta FIGURE 6



3.6. Important canals for navigation

Main-Danube Canal

Location

With a length of 171 km the Main-Danube Canal connects the River Main at Bamberg with the River Danube at Kelheim in Germany thereby linking the Danube with the Rhine river basin. The altitude difference between the top of the canal in the franconian Jurassic and the Main is approximately 175 m. The altitude difference between the top of the canal and the Danube is approximately 68 m. To overcome this altitude difference, 16 sluices were necessary. The Canal is 55 m wide and 4 m deep.

History of its construction

The idea of a continuous waterway between the Main and the Danube dates back to Charlemagne in 793, who made the attempt to build a 2 km long ditch between Altmühl and the Swabian Rezat, yet failed to complete it. In the following centuries, this idea was brought up several times but it was never fully realised.

The Bavarian King Ludwig I established a continuous waterway – the "Ludwig-Main-Danube-Canal". However, the Canal did not achieve acceptance because of competition with the railway, its narrow width and its insufficient development in the Main and the Danube. The construction of the current Main-Danube Canal started in 1960 and was completed in 1992.

Important uses

Besides navigation, the diversion of water from the Altmühl and the Danube in the Regnitz-Main-area is of particular importance. The diversion aims at:

- improvement of low water availability in northern Bavaria,
- improvement of the water quality and the ecological status in the Main area,
- flood protection in the Altmühl valley downstream of Gunzenhausen,
- improvement of the regional structure and creation of new jobs in the tourism sector, and
- enrichment of the landscape with water and near-natural areas.

Danube-Tisza-Danube Canal System

Location

The Danube-Tisza-Danube (DTD) Canal System is situated in the Vojvodina province of Serbia. The DTD System is divided into two practically independent parts, in the Backa and in the Banat region. In Backa, the main canals receive water from the Danube River gravitationally (up to 72 m^3/s) and by pumping (33 m^3/s). In the Banat region, the main canals are fed from the Tisza River (120 m^3/s) and intercepted rivers (Old and Navigable Bega, Timis, and a few minor). The biggest canals of the DTD System are used for navigation. These include 330 km of navigable canals, which enable the navigation of 1,000 t vessels.

The economy in the area is based mainly on agriculture and related industry. Many industrial plants and larger settlements are located on the main canals.

History of its construction

From the ancient times people in these areas made great efforts to protect their properties from frequent flooding and prevent water-related diseases. Organized works started in the eighteenth and nineteenth century. Canals were excavated to drain swamps and enable navigation: the Bega Canal for the drainage of the Central marsh (4,000 km^2), the Teresia Canal in the Banat region, and the Danube-Tisza Canal in the Backa region. After the Second World War, the existing canals were connected into a multipurpose water management system. Its design started in 1947 and the project was finished in 1977 with the completion of the dam on the Tisza. These developments changed Vojvodina from a swampy and uninhabited area to a densely populated and developed part of Serbia.

Important uses

The DTD multi-purpose system fulfills the following tasks: (a) Flood protection, (b) Drainage of excess interior waters and routing of drainage waters through the main canals towards the Danube and the River Tisza, (c) Convey of water for the irrigation of agricultural land, (d) Water supply of industry and fisheries, (e) Navigation, (f) Receiving and convey of wastewater (wastewater discharge of 40 million m^3/year), (g) Abstraction of water from the Danube and the River Tisza to improve water quality, and (h) Recreation, sports and tourism.

Danube-Black Sea Canal

Location

The Danube-Black Sea Canal (DBSC) is situated in Romania. It takes its waters from the Danube upstream of the town Cernavoda, and flows into the Black Sea at Agigea. It is 64.4 km long. From the Poarta Alba Locality, the canal has a 32.7 km long branch (Poarta Alba – Midia Navodari Canal, PAMNC), which flows into the Black Sea at Navodari. The catchment area of both canals is 939.8 km^2. Table 9 includes information on the hydrology of the DBSC and its branch PAMNC.

History of its construction

The main purpose of the Danube-Black Sea Canal (DBSC) is to decrease the navigation distance to the Black Sea. The works began in 1975 and were completed in 1987. The canal locks are situated at Cernavoda, Agigea, Ovidiu, and Navodari, separating thus the canals in distinct reaches. Part of the Carasu Valley, which was a tributary to the Danube River, was used in order to dig the DBSC. The construction of the branch PAMNC began in 1983 and was completed in 1987.

The tributaries of the DBSC are characterised by torrential flow regime. In order to mitigate the maximum flows and to decrease the sediment transport, 34 reservoirs were constructed.

Important uses

The main uses of the canals DBSC and PAMNC are the following: (a) Navigation (maximum weighcarrying capacity of the canal is 70 million t/year), (b) Water supply, (c) Nuclear power generation (Cernavoda Nuclear Power Plant), (d) Hydropower generation (Agigea Micro-Hydroelectric Power Plant), (e) Irrigation, (f) Flood defence, (g) Drainage, and (h) Receiving effluent discharges from the Cernavoda Nuclear Power Plant (thermic pollutant), municipal wastewater and industrial effluents.

3.7. Groundwater in the Danube River Basin District

The hydrological basins drain directly or indirectly towards seas with little or no tide, slow renewal processes and sensitive ecosystems. Most of the renewable water resources come from rivers that have significant hydrological variability. The water resources in the DRB show a large variability in terms of groundwater quantity. Nonetheless, they share common characteristics.

Besides porous aquifers there are many karstic aquifers in the DRB. Due to their high permeability karstic aquifers are highly vulnerable to contamination. The percolation time for contaminants is very short and therefore natural purification processes are very limited. For selected countries such as Bulgaria, Croatia, and Serbia and Montenegro, groundwater resources represent as much as 30 % of total internal renewable water resources.

A large number of transboundary aquifers exist in the region. Not much is known at present about the availability of groundwater or potential extraction capacity in many countries, although aquifers are the main sources for drinking and industrial water.

Hydrological characteristics of DBSC and PAMNC *TABLE 9*

Hydrological characteristics	DBSC	PAMNC branch
Flow variation [m^3/s]	800 (1 % probability) - 220 (94 % probability)	32.8 - 51
Water level difference between the intake and the outlet [m]	11.5 - 3.75	7.5 - 8.1
Flow velocity [m/s]	0.3 - 0.9	0.13 - 0.23
Water depth [m]	8.4 - 4.5	-
Width [m]	90	50

4. Characterisation of surface waters (Art. 5 and Annex II)

According to Annex II 1.1 WFD *"Member States shall identify the location and boundaries of bodies of surface water and shall carry out an initial characterisation of all such bodies …"*. Details on the implementation of the requirements of the WFD are given in this chapter.

4.1. Identification of surface water categories

The first step in the analysis is the identification of the surface water categories. According to Annex II 1.1.(i) WFD "The surface water bodies within the river basin district shall be identified as falling within either one of the following surface water categories – rivers, lakes, transitional waters or coastal waters – or as artificial surface water bodies or heavily modified surface water bodies."

The following surface waters have been selected for the basin-wide overview and are therefore dealt with in the Roof report:

- all rivers with a catchment size of > 4 000 km²
- all lakes and lagoons with an area of > 100 km²
- the main canals
- transitional and coastal waters.

These surface waters are shown on the Danube River Basin District overview map (see Map 1). The surface water body categories have been identified on the national level. A brief description of these waters is given in Chapter 4.1. A list of all rivers and lakes selected for the basin-wide overview is contained in Annex 1.

4.2. Surface water types and reference conditions

For each surface water category, the relevant surface water bodies within the river basin district need to be differentiated according to type (Annex II 1.1 (ii) WFD). The Directive foresees the use of System A (a defined set of descriptors) or System B (a set of obligatory and a set of optional descriptors) for the development of surface water typologies.

As mentioned in Chapter 1.3 the state of implementation of WFD varies strongly between the countries in the Danube River Basin. This is especially true for the development of surface water typologies and the definition of their reference conditions. Germany, Austria, the Czech Republic, the Slovak Republic, Hungary, Bulgaria and Romania have finalised their surface water typologies in line with the requirements of the WFD. Slovenia, Croatia, Serbia and Montenegro, and Moldova have started the development of their typologies. They have focussed on the surface waters dealt with in the Roof report and will further develop their typologies for other surface waters afterwards. The latter countries have provided information on drafts of their typologies in order to make a basin-wide overview of the current status of development possible. Deviations between this report and the National Reports of these countries may occur, since the finalised typologies will only become available after finalisation of this report.

4.2.1. Ecoregions in the Danube River Basin District

Fauna and flora show different geographical distributions depending on the natural characteristics of the environment. To account for these differences the WFD requests the definition of surface water types and the development of type-specific ecological classification systems to assess the status of water bodies. Ecoregions are regions of similar geographical distribution of animal species. They are therefore an important basis for the definition of biologically relevant surface water types. These have been delineated by ILLIES[13] and are used in Annex XI WFD.

The Danube River Basin District covers nine ecoregions or parts thereof (see Table 10). Some countries have shares of several ecoregions, e.g. Austria, and Serbia and Montenegro each have parts of five ecoregions on their territory in the DRBD. Ecoregion 11 (Hungarian Lowlands) has an importance due to its location in the middle of the basin. Eight DRB countries have territories in this ecoregion (Figure 7). For the transitional and Black Sea coastal waters, Romania and Bulgaria have proposed to define a new ecoregion: "the Black Sea ecoregion". A detailed description of this ecoregion will be included in the National reports of these countries.

13 ILLIES (1978)

Ecoregions in the Danube River Basin

TABLE 10

Ecoregion	Countries with territories in the DRB
4 – Alps	Germany, Austria, Slovenia, Italy, Switzerland
5 – Dinaric Western Balkan	Austria, Slovenia, Croatia, Bosnia i Herzegovina, Serbia and Montenegro, Albania
6 – Hellenic Western Balkan	Serbia and Montenegro, Albania, Macedonia
7 – Eastern Balkan	Serbia and Montenegro, Bulgaria, Macedonia
9 – Central Highlands	Germany, Austria, Czech Republic
10 – The Carpathians	Austria, Czech Republic, Slovak Republic, Poland, Serbia and Montenegro, Romania
11 – Hungarian Lowlands	Austria, Czech Republic, Slovak Republic, Slovenia, Hungary, Croatia, Serbia and Montenegro, Romania
12 – Pontic Province	Romania, Bulgaria, Moldova, Ukraine
16 – Eastern Plains	Romania, Moldova, Ukraine

Location of the Danube River Basin in Europe

FIGURE 7

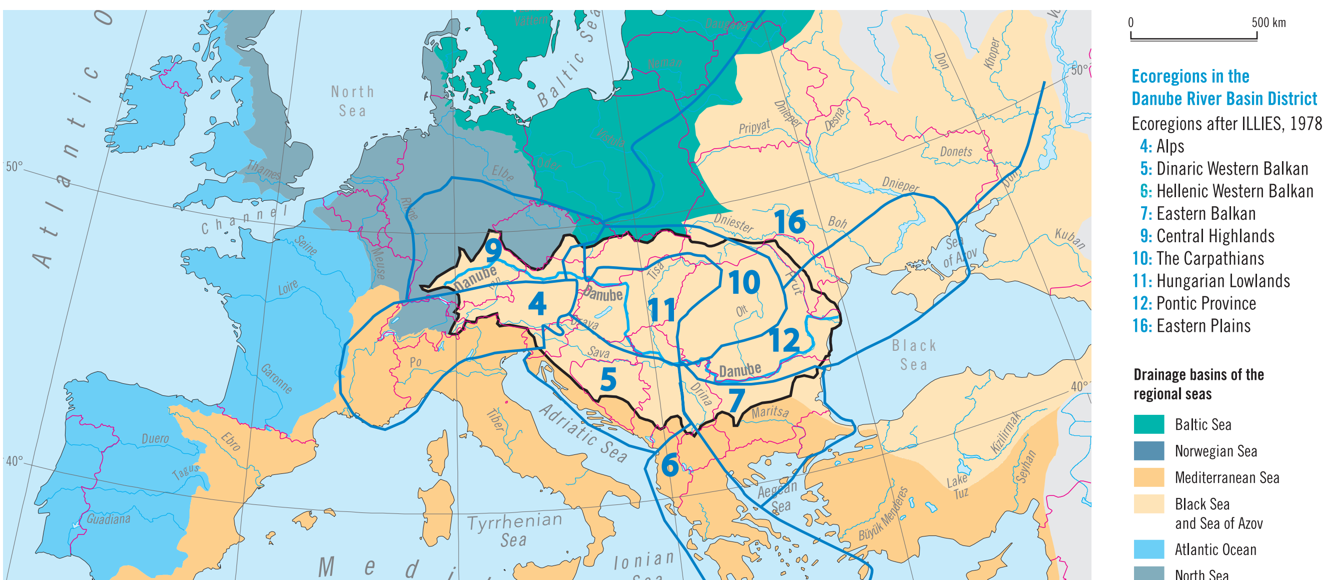


Figure base: European Commission, adjusted for ICPDR, 2004 by *FLUVIUS*

In several countries (Germany, Austria, Croatia, Hungary and Romania) the ecoregions have been divided into smaller geographical regions to address differences in river types based on different landscape features or differences in the aquatic communities.

Hungary has subdivided ecoregion 11, Hungarian Lowlands, into five sub-ecoregions based on the topography and the (hydro-)geochemical character of the region. Croatia has specified five sub-ecoregions on its territory discerning differences in fluvial topography, geomorphology and riparian vegetation. Romania has introduced a new sub-ecoregion within ecoregion 10, the Carpathians. This sub-ecoregion is the Transylvania Plateau, an inner mountain area that shows differences in altitude, geomorphology and in the macroinvertebrate communities. In Germany, "river landscape units" have been defined as sub-ecoregions based on geological and geographical features. In Austria, abiotic and biotic characteristics were used to define a total of 15 "bioregions" as sub-divisions of ecoregions.

4.2.2. Rivers

4.2.2.1. Typology of the Danube River

The typology of the Danube River has been developed in a joint activity by the countries sharing the Danube River[14]. The Danube typology therefore constitutes a harmonised system used by all these countries. The Danube flows through or borders on territories of 10 countries (Germany, Austria, Slovak Republic, Hungary, Croatia, Serbia and Montenegro, Bulgaria, Romania, Moldova and Ukraine) and crosses four ecoregions (9 – Central Highlands, 11 – Hungarian Lowlands, 10 – Carpathians, and 12 – Pontic Province). The Danube typology was based on a combination of abiotic factors of System A and System B. The most important factors are ecoregion, mean water slope, substratum composition, geomorphology and water temperature.

Ten Danube section types were identified (see Table 11). The ten Danube section types are defined below. The morphological and habitat characteristics are outlined for each section type. In order to ensure that the Danube section types are biologically meaningful, these were validated with biological data collected during the Joint Danube Survey, a longitudinal survey conducted in August/September 2001 (see Annex 3).

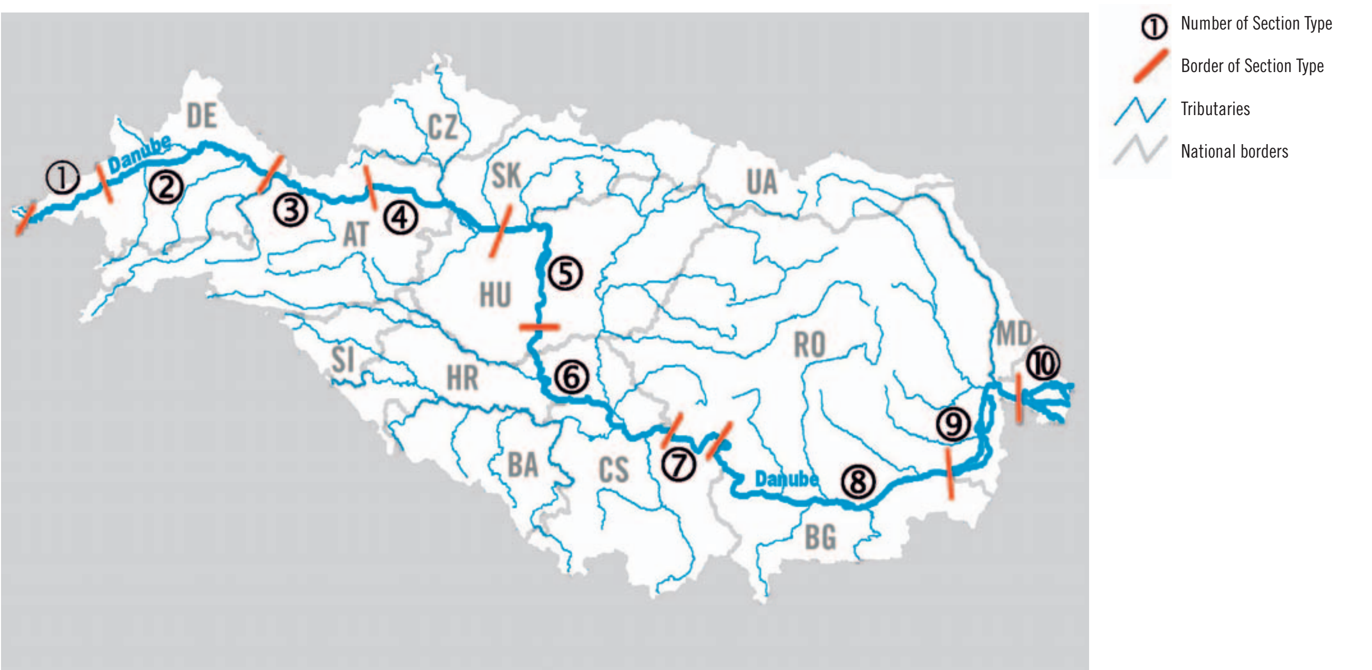
Definition of Danube section types *TABLE 11*

Section Type 1:	Upper course of the Danube	rkm 2786:	confluence of Brigach and Breg – rkm 2581: Neu Ulm
Section Type 2:	Western Alpine Foothills Danube	rkm 2581:	Neu Ulm – rkm 2225: Passau
Section Type 3:	Eastern Alpine Foothills Danube	rkm 2225:	Passau – rkm 2001: Krems
Section Type 4:	Lower Alpine Foothills Danube	rkm 2001:	Krems – rkm 1789.5: Gönyű/ Kližská Nemá
Section Type 5:	Hungarian Danube Bend	rkm 1789.5:	Gönyű/ Kližská Nemá – rkm 1497: Baja
Section Type 6:	Pannonian Plain Danube	rkm 1497:	Baja – rkm 1075: Bazias
Section Type 7:	Iron Gate Danube	rkm 1075:	Bazias – rkm 943: Turnu Severin
Section Type 8:	Western Pontic Danube	rkm 943:	Turnu Severin – rkm 375.5: Chiciu/Silistra
Section Type 9:	Eastern Wallachian Danube	rkm 375.5:	Chiciu/Silistra – rkm 100: Isaccea
Section Type 10:	Danube Delta*	rkm 100:	Isaccea – rkm 20 on Chilia arm, rkm 19 on Sulina arm and rkm 7 on Sf. Gheorghe arm

* *Within this section the Danube divides into the three main branches of the Danube Delta.*
Each arm also has transitional waters with the following limits: Chilia arm: rkm 20 – 0, Sulina arm: rkm 19 – 0, Sf. Georghe arm: rkm 7 – 0.

14 *This activity has been supported by the UNDP/GEF Danube Regional Project.*

Danube section types; the dividing lines refer only to the Danube River itself *FIGURE 8*



4.2.2.2. Typology of the tributaries in the Danube River Basin District

The typologies of the Danube tributaries were developed by the countries individually. Workshops enhanced the exchange of information between the countries and allowed for a streamlining of approaches. In addition, stream types relevant on transboundary water courses were bilaterally harmonised with the neighbours. Information on river typologies or drafts of river typologies was available from Germany, Austria, Czech Republic, Slovak Republic, Hungary, Slovenia, Croatia, Bulgaria and Romania. Romania has helped Moldova with the development of the river typology for the Prut River, and Moldova has confirmed the typology. Most countries in the Danube River Basin (Germany, Austria, Slovak Republic, Hungary, Slovenia, Croatia, Romania) have applied System B (Annex II, 1.2.1 WFD). Only the Czech Republic and Bulgaria have used System A.

The common factors used in all DRB typologies are ecoregion (described above), altitude, catchment area and geology.
Their use in the DRBD is described below.

Altitude

In general, the class boundaries suggested in Annex II WFD have been applied in the DRB countries. Both Austria and Slovak Republic include an additional altitude class for watercourses higher than 1500 metres. Since the typology system of Croatia accounts for the main rivers only two altitude classes are defined. A 500 metres-class boundary is set up by Austria, Serbia and Montenegro, and Romania.

Catchment area

The size classes of System A are generally applied. Austria, Hungary and Serbia and Montenegro have introduced other class boundaries than those suggested in the Directive. The Austrian system has an additional class boundary at 500 km^2 and one at 2500 km^2. Hungary has established overlapping class boundaries in order to take account of continuous changes in nature that do not stop at fixed borders. Serbia and Montenegro has defined an additional catchment area boundary at 4000 km^2. Bulgaria has no rivers with catchment areas of more than 10,000 km^2 and has therefore dropped this class.

Geology

The Directive identifies three main categories for geology: siliceous, calcareous and organic. These have been refined by some countries, e.g. by Austria and the Slovak Republic. Croatia has added the category “mixed geology”. The Czech Republic does not make use of the category “organic”.

Table 12 gives an overview of the class boundaries used by the DRB countries for the common descriptors altitude, catchment area and geology.

Countries using System B have used a number of optional factors to further describe the river types. River discharge, mean substratum composition and mean water slope are most frequently used (Table 13). The Romanian system relates the river discharge to the catchment area. Serbia and Montenegro has used mean substratum composition as a descriptor in their stream typology. In Austria, watercourses are classified according to the Strahler System for stream order. River basin and intermittent flow are optional parameters of the Slovenian scheme. Romania uses mean air temperature, precipitation and yearly minimum specific monthly flow with 95 % probability as an indicator of temporary streams among others. The only optional factor of the German system is the delineation of the River Landscape Units, which is based on several abiotic and biotic features. Biocoenotic parameters are considered in Austria, Slovak Republic and Romania.

Obligatory factors used in river typologies (System A and B)

TABLE 12

Descriptor	Country	Class boundaries					
altitude	Germany		0-200 m		200-800 m	> 800 m	
	Austria		0-200 m	200-500 m	500-800 m	800-1500 m	> 1500 m
	Czech R.		0-200 m		200-800 m	> 800 m	
	Slovak R.		0-200 m		200-800 m	800-1500 m	> 1500 m
	Hungary	0-100 m	100-200 m	200-500 m	> 500 m		
	Croatia*		0-200 m	> 200 m			
	Slovenia**		0-200 m		200-800 m	> 800 m	
	Serbia and Montenegro		0-200 m	200-500 m	500-800 m	> 800 m	
	Romania		0-200 m	200-500 m	500-800 m	> 800 m	
	Bulgaria		0-200 m		200-800 m	> 800 m	
catchment area	Germany	10-100 km^2		100-1000 km^2		1000-10,000 km^2	> 10,000 km^2
	Austria	10-100 km^2	100-500 km^2	500-1000 km^2	1000-2500 km^2	2500-10,000 km^2	> 10,000 km^2
	Czech R.	10-100 km^2		100-1000 km^2		1000-10,000 km	> 10,000 km^2
	Slovak R.***			< 1000 km^2	> 1000 km^2		
	Hungary	10-200 km^2			100-2000 km^2	1000-12,000 km^2	> 10,000 km^2
	Croatia[1]			100-1000 km^2		1000-10,000 km^2	> 10,000 km^2
	Slovenia[2]	10-100 km^2		100-1000 km^2		1000-10,000 km^2	> 10,000 km^2
	Serbia and Montenegro	10-100 km^2		100-1000 km^2	1000-4000 km^2	4000-10,000 km^2	
	Romania	10-100 km^2		100-1000 km^2		1000-10,000 km^2	> 10,000 km^2
	Bulgaria	10-100 km^2		100-1000 km^2		1000-10,000 km^2	
geology	Germany	siliceous		calcareous		organic	
	Austria	cristalline		tertiary and quaternary sediments		flysch and helveticum	limestone and dolomite
	Czech R.	siliceous		calcareous			
	Slovak R.	siliceous rock of neo-volcanics		siliceous rock of other geologic formations		calcareous	
	Hungary	siliceous		calcareous		organic	
	Croatia[1]	siliceous		calcareous		organic	mixed
	Slovenia[2]	siliceous		calcareous		organic	
	Serbia and Montenegro	siliceous		calcareous		organic	
	Romania	siliceous		calcareous		organic	
	Bulgaria	siliceous		calcareous		organic	

** This is a very first draft of type-specific sections of Croatian main rivers. The Croatian typology will be subject to future revision in accordance with national verification and bilateral harmonisation processes with neighbouring countries.*
*** Only valid for large rivers.*
**** The river typology is not based on strict boundaries of catchment area. Rivers > 1,000 km^2 make up individual types; definition of types for smaller rivers is based on ecoregion, altitude and geology.*

Optional factors used in river typologies by countries using System B *TABLE 13*

Descriptor	Country	Class boundaries					
mean annual discharge	Austria	> 0-5 m^3/s	5-10 m^3/s	10-50 m^3/s	> 50 m^3/s		
	Croatia		< 10 m^3/s	10-300 m^3/s	300-1000 m^3/s	1000-10,000 m^3/s	> 10,000 m^3/s
	Romania	< 3 l/s km^2	3-30 l/s km^2	> 30 l/s km^2			
mean substratum composition	Hungary	middle-fine	coarse				
	Croatia	loam	Clay	silt	sand	gravels	boulders
	Serbia and Montenegro	fine (clay, silt, sand, gravel)		medium (sand, gravel, cobbles)		coarse (gravel, cobbles, boulders)	
	Romania	clay	silt	sand	pebbles	boulders	blocks
mean water slope	Slovak R.*			< 2 ‰	2-5 ‰	5-50 ‰	> 50 ‰
	Croatia	> 0-0.1 ‰	0.1-0.5 ‰	> 0.5 ‰			
	Romania				< 10 ‰	10-40 ‰	> 40 ‰
Strahler system	Austria			seven different stream orders			
river basin	Slovenia*	Danube	Adriatic				
intermittent flow	Slovenia*	yes	no				
mean air temperature	Romania	< 0 °C	0-8 °C	> 8 °C			
precipitation	Romania	< 500 mm	500-800 mm	> 800 mm			
yearly minimum specific monthly flow with 95% probability	Romania	< 1 l/s km^2	0.3-2 l/s km^2	> 2 l/s km^2			
"river landscape unit"	Germany	46 in total, aggregated to larger biocoenotic units					
"bioregion"	Austria**	15 in total					
zoogeographical division	Slovak R.	Poprad area	Upper Vah area	Tisza area	Danube area		

* *only large rivers*
** *Large rivers (Danube, Morava, Thaya, Rhine and the alpine rivers) are defined as "special types".*

In total, 216 stream types have been defined for the Danube River Basin District. Annex 2 gives a complete list of all stream types that have been identified so far. 131 of these stream types are relevant on the DRBD overview scale (see Table 14). This includes the 10 section types for the Danube River. Most of the stream types (45) are located in the Hungarian Lowlands (ecoregion 11). 24 stream types are situated in the Carpathian Mountains (ecoregion 10). In some ecoregions only few stream types were identified (ecoregion 5, 7 and 16). The latter mainly cover territories of countries still developing their river typologies. Therefore, these numbers will increase in the future.

Due to the overview nature of this report most stream types relevant on the basin-wide scale cover large and very large rivers. The geology is siliceous in about 2/3 of all stream types and calcareous in about 1/3. Only very few stream types were identified as being of organic nature. About half of the stream types are located in the lowlands (altitude < 200 m). About 10 % of the stream types are located above 800 m. About 40 % of the remaining types are at mid-altitude.

4.2.2.3. Reference conditions

Annex II 1.3 (i) WFD prescribes, that for each surface water type, type-specific hydromorphological and physico-chemical conditions shall be established representing the values of the hydromorphological and physico-chemical quality elements specified for that surface water type at high ecological status. Type-specific biological reference conditions shall be established, representing the values of the biological quality elements for that surface water type at high ecological status.

Number of stream types defined on the DRBD overview level

TABLE 14

Country	Number of stream types
Tributaries	
Germany*	6
Austria	17
Czech Republic	8
Slovak Republic	17
Hungary	12
Slovenia	9
Bosnia i Herzegovina	-
Serbia and Montenegro	8
Croatia	12
Bulgaria	6
Romania*	23
Moldova	3
Ukraine	-
Total number on tributaries	121
Danube River	10
Total number for DRBD	131

* *including sub-types*

On the basin-wide level, the Danube countries have agreed on general criteria as a common base for the definition of reference conditions (see Table 5). These have then been further developed on the national level into type-specific reference conditions.

The definition of reference conditions was based on the following approaches:

- spatially based approach using data from monitoring sites, or
- approach based on predictive modelling, or
- definition of temporally based reference conditions using either historical data or palaeo-reconstruction, or
- use of expert judgement (where none of the above methods was possible).

Spatially based reference conditions and expert judgement were the two methods predominantly used in the DRBD. Methods were also combined to derive reference conditions.

Use of spatially based data from monitoring sites

The method is based on the use of existing sites of high ecological status. In the DRBD (as in other European river basins) only few reference sites are available, which fulfil all criteria mentioned in Table 15. Especially in the lowlands, and for large rivers, undisturbed reference sites do not exist anymore. Therefore, the description of reference conditions was based on best available sites for these types. This method was used by all countries to describe the reference conditions for the fish fauna.

Use of expert judgement

In addition to spatially based reference sites, most countries applied expert judgement for deriving reference conditions of benthic invertebrates and for phytobenthos.

Historical reconstruction

Historical data were frequently applied to define reference conditions for fish communities and for macrophytes.

Predictive modelling

Predictive modelling was used to define macrozoobenthos reference conditions in the Czech Republic. Germany used this approach for defining the physico-chemical aspects of the reference conditions.

Biological quality elements

As for the biological elements, the description of reference conditions was generally based on benthic macroinvertebrates. The following variables were used: taxonomic composition, abundance, diversity, and the ratio ‘sensitive to insensitive taxa’. Austria also defined type-specific reference values for the Saprobic Index and for multimetric indices. Romania added type-specific values for the Saprobic Index.

Basic criteria for defining reference conditions (harmonised basin-wide) *TABLE 15*

Basic statements	Reference conditions must be reasonable and politically acceptable.
	Reference sites have to include important aspects of "natural" conditions.
	Reference conditions should reflect no or minimum stress.
Land use in catchment area	Influence of urbanisation, land use and forest management should be as low as possible.
Stream and habitats	Reference sites should be covered by natural climax vegetation or unmanaged forests.
	No removal of coarse woody debris.
	No bed or bank fixation.
	No obstructions that hinder the migration of organisms or the transport of bed material.
	Only minor influence due to flood protection measures.
Bank and floodplain vegetation	Bank and floodplain vegetation should be present to allow lateral migration.
	Hydrology and water management
	No alteration of natural discharge regime.
	No or only minor alteration of hydrology by dams, reservoirs, weirs, or sediment retaining structures affecting the site
	No alteration of regime due to water diversion, abstraction, and no pulse releases.
Physico-chemistry	No point source of organic pollution.
	No point source of nutrient pollution.
	No sign of diffuse pollution inputs.
	No acidification.
	No liming.
	No alteration of natural thermal regime.
	No salinisation.
Biology	No significant impairment of the indigenous biota by introduction of animals and plants (e.g. in the frame of fish farming).
Lake morphology	Morphological alterations do not influence biodiversity and ecological functioning.
Biomanipulation	No biomanipulation (e.g. in lakes).
Recreation uses	No intensive recreational use.

Reference values for fish have been used by all countries (except Slovenia) but different indicative parameters were applied:

- taxonomic composition and abundance of fish fauna (Germany, Czech Republic and Moldova; Romania has used taxonomic composition without using abundance)
- abundance of fish fauna (Germany, Czech Republic and Moldova)
- age structure (Austria and Slovak Republic)
- ratio of sensitive to insensitive species (Austria)
- fish diversity (Czech Republic, Slovak Republic)
- biomass, habitat guilds, reproduction guilds or share of reproducing species, and a fish index (Austria).

For the biological element, 'macrophytes and phytobenthos', different approaches were used for each organism group: for macrophytes, the taxonomic composition of the reference communities was defined by Germany, Slovak Republic and Moldova. Moldova also used abundance of macrophytes. For phytobenthos, taxonomic composition and abundance were used by all DRB countries. Austria has defined reference values for the trophic index based on phytobenthos.[15] Romania has defined reference values for Saprobic Index.

Reference conditions for phytoplankton were described by the same four countries named above. Germany only defined taxonomic composition. Slovak Republic, Romania and Moldova added information on the abundance of species. Biomass was used a reference criterion in Moldova and Romania (for naturally eutrophic streams). The Slovak Republic and Romania both used phytoplankton diversity. In addition, Romania used the Saprobic Index.

The hydromorphological and physico-chemical reference conditions for rivers were defined by Germany, Austria, Czech Republic, Slovak Republic and Romania.

The reference conditions of the Danube River have been developed in a uniform approach together with the typology of the Danube River. A first draft of the reference conditions is available and may be found in Annex 3. These will need further revision and validation.

15 ROTT et al. (1999).

4.2.3. Lakes

4.2.3.1. Lake types

The lake typologies were developed individually in the Danube countries. Five lakes have been selected for the basin-wide overview. These are situated in Austria, Hungary, Romania and Ukraine. Only one lake is transboundary in nature (see Table 16).

Information on lake typologies, or drafts of lake typologies, was available from Austria, Hungary and Romania. All these countries implemented System B (Annex II, 1.2.2 WFD). The common factors used in these lake typologies are the obligatory factors of System B: altitude, depth, surface area and geology. In addition, ecoregion was used in the typologies of these countries. The class boundaries defined in System A were generally used. How these factors were applied is described below.

In the Austrian lake typology two additional altitude classes were introduced (800-1800 m and > 1800 m). The factor geology was further differentiated into the following categories: crystalline, tertiary and quaternary sediments, flysch and helveticum, and limestone and dolomite. Regarding depth, only two classes were used: < 15 m and > 15 m. For the further characterisation of lake types Austria used lake mixing characteristics, acid neutralising capacity, water level fluctuation as well as biological elements (fish, phytoplankton and macrophytes). The Hungarian lake typology covers only lakes of less than 200 m altitude. The mean water depth is classified in the categories less than 1 m, less than 1.5 m (intermittent lakes), 1-3 m, less than 4 m (oxbow lakes) and 3-15 m. Three lake size classes are applied in the Hungarian typology: 0.5-10 km², 10-100 km² and more than 100 km². The hydro-geochemical character is differentiated in the categories calcareous, calcareous-organic, calcareous-salinic, and salinic. Additional factors are the permanency of the lake and oxbow character. The Romanian typology follows the class boundaries of System A. Lake surface area is differentiated in five size classes: < 0.5 km², 0.5-1 km², 1-10 km², 10-100 km² and > 100 km². The lake typology is currently being further developed to cover biological elements as well.

Table 16 indicates the lake types for lakes relevant on the basin-wide scale. All lake types are calcareous by geology and dominated by sandy and muddy substratum. They are all oblong in shape and very shallow. Lacul Razim / Razelm is less than 3 metres deep and has monomictic mixing characteristics. Neusiedler See / Fertő-tó is characterised as the last and most western member of the so-called steppe-type lakes in Europe. It has a mean water depth of 1.1 m and is holomictic. Lake Balaton is a very large steppe-type lake. It has a mean water depth of 3.6 m and is polymictic. A typological description of Ozero Ialpug is not available.

Lakes selected for the basin-wide overview and their types *TABLE 16*

Lakes > 100 km²	Country/ies	Type of lake	Ecoregion	Altitude class	Depth class	Size class	Geology
Neusiedler See / Fertő-tó	AT, HU	large shallow, salinic steppe-type lake	11	lowland: < 200 m	< 3 m	> 100 km²	calcareous
Lake Balaton	HU	very large shallow steppe-type lake	11	lowland: < 200 m	3-15 m	> 100 km²	calcareous
Ozero Ialpug	UA	na	12	na	na	> 100 km²	na
Lacul Razim /Razelm	RO	lowland, very shallow, calcareous, very large lake type	12	lowland: < 200 m	< 3 m	> 100 km²	calcareous

4.2.3.2. Reference conditions

As for rivers, the Directive (Annex II 1.3 (i) WFD) prescribes, that for each surface water type, type-specific hydromorphological and physico-chemical conditions need to be established representing the values of the hydromorphological and physico-chemical quality elements that have been specified for that surface water type at high ecological status. Type-specific biological reference conditions shall be established, representing the values of the biological quality elements for that surface water type at high ecological status.

The reference conditions were developed individually by the countries. In Hungary and Romania the definition of reference conditions is still being developed. The methods most frequently applied were spatially based methods, the use of historical data, and expert judgement. Hungary also used historical data and palaeo-reconstruction for phytoplankton and physico-chemical conditions to define reference conditions in its lakes.

A comparison shows that similar approaches are being applied. While Austria has finalised the definition of reference conditions, Hungary and Romania are still in the process of development. All countries are basing their assessment on species composition, abundance and the diversity of species. In some cases, additional parameters were used (e.g. age structure, biomass, ratio of sensitive to insensitive species). Table 17 gives an overview for which quality elements reference conditions are being defined.

Quality elements used to describe reference conditions of lakes *TABLE 17*

Quality element	Austria	Hungary	Romania
Hydromorphological conditions	-	x	x
Physico-chemical conditions	x	x	x
Phytoplankton	x	x	x
Macrophytes	x	x	-
Phytobenthos	-	-	x
Benthic invertebrates	-	x	x
Fish fauna	x	x	-

4.2.4. Transitional waters

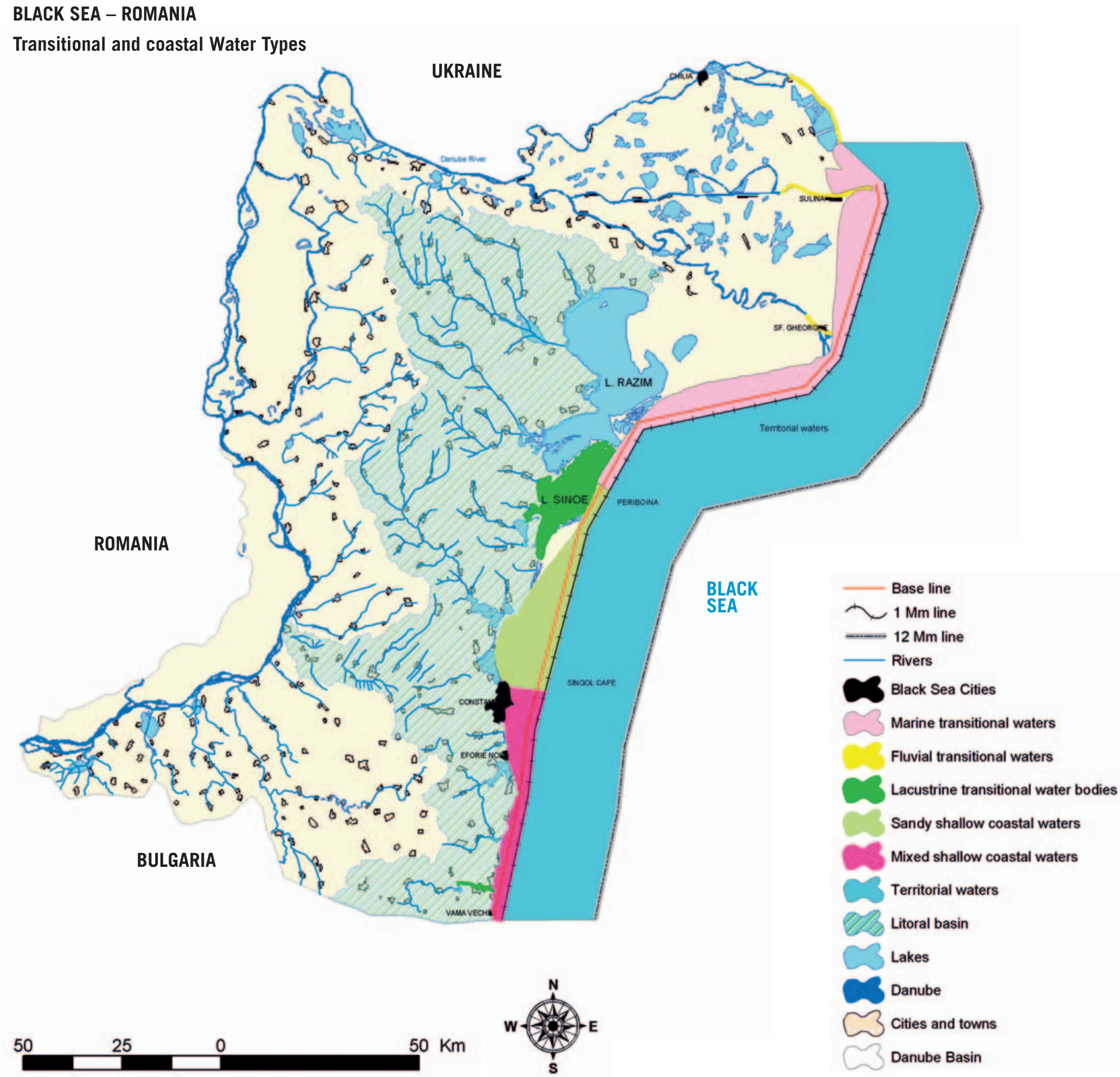
"Transitional waters are bodies of surface water in the vicinity of river mouths, which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows" (Art. 2 6. WFD). The transitional waters of the DRBD are located in the Danube Delta in Romania and Ukraine. In this area, the arms of the Danube are influenced by marine water of the Black Sea. In addition, transitional waters are located on the Romanian coast of the Black Sea. Lacul Razim and Lacul Sinoe are originally marine waters that have gradually been cut off from the Black Sea by sandbars. In the 1970s the remaining connection to the Black Sea has been closed through hydrological works. Today, Lacul Sinoe is a transitional water (lagoon), which still receives marine water at very high tides. Lacul Razim is no longer influenced by marine water and has turned into a freshwater lake (see also Chapter 3.4.).

For the development of the typology of transitional waters the following obligatory and optional parameters of System B were used:

– ecoregion
– salinity
– flow velocity of fluvial water
– wave exposure
– mixing characteristics
– mean substratum composition
– tidal range
– depth
– current velocity of marine water
– mean water temperature
– turbidity
– ice coverage duration

Location of transitional and coastal water types

FIGURE 9



The transitional waters are differentiated into fluvial, lacustrine and marine transitional waters (see Table 18). The marine transitional waters are strongly influenced by the Danube, which has an average discharge of about 6,500 m³/s. The freshwater of the Danube is generally transported southwards along the Romanian coast with the predominant southward coastal current. Figure 9 shows the location of the transitional and coastal water types. A detailed description of the transitional surface water types and their reference conditions are given in the National report of Romania.

Types of transitional waters in the Danube River Basin District *TABLE 18*

Transitional water	Type
Danube River – Chilia arm	transitional fluvial type
Danube River – Sulina arm	transitional fluvial type
Danube River – Sf. Gheorghe arm	transitional fluvial type
Lacul Sinoe	transitional lacustrine type
Black Sea coastal waters (northern sector) – Chilia mouth to Periboina	transitional marine type

4.2.5. Coastal waters

The coastal waters of the DRBD are located in the coastal area of the Black Sea in Romania and Ukraine.

For the development of the typology of coastal waters the following obligatory and optional parameters of System B were used:

- ecoregion
- salinity
- current velocity
- mean water temperature
- turbidity
- mean substratum composition
- ice cover duration
- tidal range
- depth
- wave exposure
- mixing characteristics

Two coastal water types have been defined for the coastal waters in the DRBD. The location of these coastal water types are depicted in Figure 9. A detailed description of the types as well as the definition of the reference conditions is given in the National report of Romania (Part B).

Types of coastal waters in the Danube River Basin District *TABLE 19*

Coastal water	Type
Periboina – Singol Cape	sandy shallow coastal water
Singol Cape – Vama veche	mixed shallow coastal water

4.3. Identification of surface water bodies

According to Annex II 1.1 WFD *"Member States shall identify the location and boundaries of bodies of surface water …". "A body of surface water means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water"* (Art. 2. 10. WFD).

Water bodies need to be clearly identified. Certain rules apply for their delineation. For this initial characterisation water bodies may also be aggregated to form groups of water bodies of similar character. The surface water categories have been identified in Chapter 4.1. The water bodies described here refer to the Danube River Basin District overview map (see Map 1), i.e. to those relevant on the basin-wide level. All other water bodies are dealt with in detail in the National Reports (Part B). Croatia, Bosnia i Herzegovina, Serbia and Montenegro, Moldova and Ukraine have not finalised the identification of water bodies.

4.3.1. Water bodies in rivers

44 water bodies have been identified on the Danube River. Two of these are shared by the Slovak Republic and by Hungary. The number of water bodies on the Danube varies per country, e.g. on the German part of the Danube 15 water bodies were delineated, on the Bulgarian part only one. This means that the size of the water bodies also varies significantly. The smallest water body on the Danube is only 7 km long, the longest is 487 km. Table 20 gives an overview of the number of water bodies identified on rivers. So far, 485 water bodies have been identified on the tributaries on the overview scale. Romania has the largest number of water bodies but also the largest part of the basin (29 %). The mean length of water bodies is 55 km on the tributaries, on the Danube it is 140 km. Map 4 gives an overview of surface water bodies identified on the basin-wide level.

Table 21 give an overview of the criteria used for the delineation of water bodies. A change in type is the most frequent reason for the separation of water bodies as well as a change in pressure, in particular a change in the degree of pollution. Also, changes in the hydrological regime and in morphology were frequently used criteria.

Number of water bodies on rivers on the DRBD overview scale *TABLE 20*

	DE	AT	CZ	SK	HU	SI	HR	BA	CS	BG	RO	MD	UA
Danube River	15	6	-	3*	4*	-	2	-	9	1	6	na	na
Tributaries	42	74	29	43	57	11	12	na	42	11	161	5	na

** Two of these water bodies are shared by SK and HU.*

Criteria for the delineation of water bodies in rivers *TABLE 21*

	DE	AT	CZ	SK	HU	SI	HR	BA	CS	BG	RO	MD	UA
Change in surface water category	x	x	x	x	x	-	x	na	x	-	x	x	na
Change in type	x	x	x	x	x	x	x	na	x	x	x	x	na
Change in pressure													
- pollution	x	x	x	x	x	x	-	na	x	x	x	x	na
- alteration of hydrological regime	x	x	x	x	x	x	-	na	x	x	x	x	na
- change in morphology	x	x	-	x	x	x	-	na	x	-	x	x	na
- fisheries	-	-	-	x	-	-	-	na	-	x	x	x	na

4.3.2. Water bodies in lakes

Lakes were generally delineated as one water body (Neusiedlersee / Fertő-tó, Lake Balaton, Lacul Razim). The delineation of the water bodies for Ozero Ialpug is not available.

Danube River Basin District - Surface Water Bodies *MAP 4*

4.3.3. Water bodies in transitional and coastal waters

Romania has delineated five transitional water bodies and three coastal water bodies in the DRBD (see Figure 10). For all water bodies changes in pressures were used for the delineation of water bodies (Table 22 and Table 23). In addition, the criterion "provisionally identified heavily modified water body" was used on the Sulina arm of the Danube River and on the coastal water Singol Cape – Eforie Nord.

Transitional water bodies and reasons for their delineation *TABLE 22*

Transitional water bodies	pollution	alteration of hydrological regime	changes in morphology	fisheries
Danube River – Chilia arm	x	-	x	-
Danube River – Sulina arm	x	-	x	-
Danube River – Sf. Gheorghe arm	x	-	x	-
Lacul Sinoe	x	-	x	-
Black Sea coastal waters (northern sector) – Chilia mouth to Periboina	x	x	x	-

Coastal water bodies and reasons for their delineation *TABLE 23*

Coastal water bodies	pollution	alteration of hydrological regime	changes in morphology	fisheries
Periboina – Singol Cape	x	x	x	-
Singol Cape – Eforie Nord	x	x	x	-
Eforie Nord – Vama veche	x	-	x	-

4.3.4. Heavily modified water bodies (provisional identification)

The provisional identification of heavily modified water bodies (HMWB) is part of the characterisation of the River Basin District and the identification of distinct water bodies as defined in Annex II of the WFD. However, the provisional identification of HMWB is discussed in detail in Chapter 4.6 because it is closely related to the analysis of hydromorphological pressures and impacts. Chapter 4.6 provides an overview of the provisionally identified HMW sections which meet basin-wide agreed criteria.

4.3.5. Artificial water bodies

The identification of artificial water bodies (AWB) is part of the characterisation of the River Basin District as defined in Annex II of the WFD. This subchapter describes the AWB selected for the basin-wide overview. These are the three main navigation canals of the Danube River Basin District, which are shown Map 4: the Main-Danube Canal, the Danube-Tisza-Danube Canal System, and the Danube-Black Sea Canal.

Table 24 includes information on the main characteristics of the three canals. All three are used for navigation, two of them (the Danube-Tisza-Danube Canal and the Danube-Black Sea Canal) additionally serve the purpose of flood protection. In addition, the Danube-Black Sea Canal is highly urbanised.

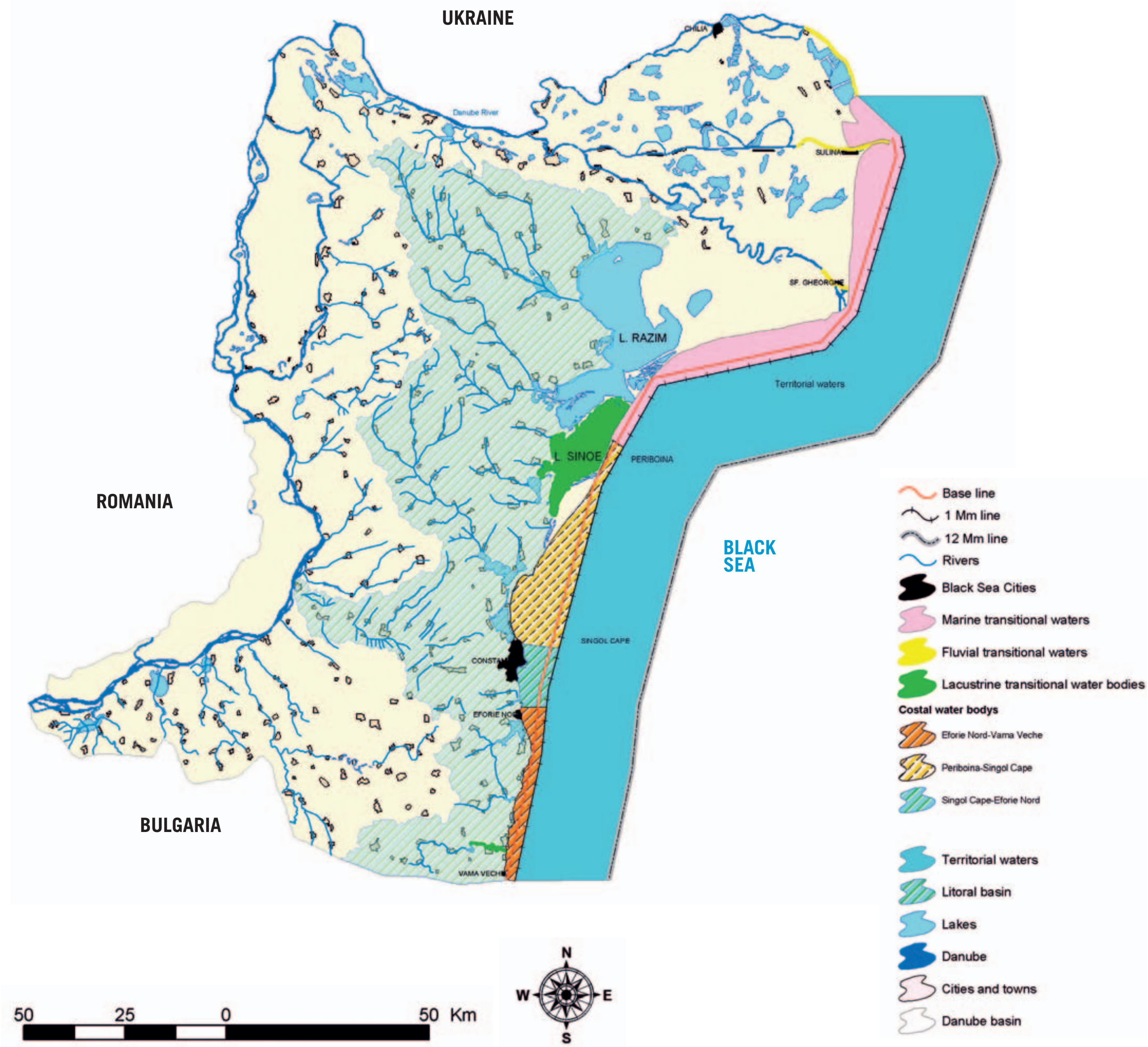
All other AWBs are dealt with in the national reports.

Transitional and coastal water bodies in the Danube River Basin District

FIGURE 10

BLACK SEA – ROMANIA

Transitional and Coastal Water Bodies



Artificial water bodies relevant on the basin-wide scale

TABLE 24

Name	Country	Length [km]	Area [km²]	Main uses
Main-Danube Canal	DE	171		Navigation
Danube-Tisza-Danube Canal (DTD)	CS	695	20,000 (canal system)	Navigation, Flood protection, Drainage
Danube-Black Sea Canal (DBSC) incl. the Poarta Alba-Midia-Navodari Canal (PAMNC)	RO	64.4 (PAMNC: 32.7)	939 (catchment)	Navigation, Flood protection, Urbanisation

4.4. Identification of significant pressures

The WFD requires information to be collected and maintained on the type and magnitude of significant anthropogenic pressures, and indicates a broad categorisation of the pressures into:

- point sources of pollution,
- diffuse sources of pollution,
- effects of modifying the flow regime through abstraction or regulation, and
- morphological alterations.

Any other pressures, i.e. those not falling within these categories, must also be identified. In addition, there is a requirement to consider land use patterns (e.g. urban, industrial, agricultural, forestry) as these may be useful to indicate areas, in which specific pressures are located.

The pressures and impacts assessment follows a four-step process:

1. describing the driving forces, especially land use, urban development, industry, agriculture and other activities which lead to pressures, without regard to their actual impacts;
2. identifying pressures with possible impacts on the water body and on water uses, by considering the magnitude of the pressures and the susceptibility of the water body;
3. assessing the impacts resulting from the pressures; and
4. evaluating the likelihood of failing to meet the objective.

In this first analysis, the list of pressures and the assessment of impacts on a water body, and possibly on up- or downstream situated water bodies, includes the identification of all potentially important problems. This is then followed by a screening according to certain criteria, which determine what 'significant pressure' means.

While pressures from point sources may result e.g. from a large number of different human activities (e.g. households, industrial activity, power generation, agriculture, forestry, fish farming, mining, navigation, dredging, etc.) only those pressures are addressed here that have significant impacts on the basin-wide level. Therefore, some activities with only local effects such as mining will not be discussed in this report. Detailed information can be found in the National Reports.

The ICPDR Emission Inventory covers at present the emissions in the Danube River Basin and still has to be complemented by the emissions in the remaining part of the Danube River Basin District. The inventory is the key data base for the assessment of emissions from point sources on the basin-wide level. It includes the major municipal, industrial and agricultural point sources and identifies the total population equivalents of the municipal waste water treatment plants, the industrial sectors of the industrial waste water treatment plants, and the types of animal farms for the agricultural point sources. In addition, it includes information on the receiving water and data on some key parameters of the effluent such as BOD, COD, P and N.

In Chapter 1.3 it was already indicated that the results derived from models should be interpreted and used with caution. In particular, the results presented in the Chapter 4.4.1 and 4.4.2 which were derived from the application of the MONERIS model, are not consistent with national data despite several rounds of improvements. It was not possible to finally assess and agree the quality and accuracy of the basic datasets used for the calculations. Therefore, the assumption and base data used are not necessarily approved by the countries concerned.

However, the MONERIS work represents the latest and best possible attempts to present comparable data on nutrient pressures from point and diffuse sources for the Danube basin. The results have been presented in several publications and are going to be part of the final report of the daNUbs project of 2005[16]. Despite considerable efforts to ensure the consistency of the results with the final daNUbs report, the sections represent the state-of-play on 8 November 2004. Thereafter, certain model calculations have been updated and published (see BEHRENDT et al. 2005 and SCHREIBER et al. 2005).

The ICPDR is committed to improve the quality and consistency of the input data by, in particular, collecting and using latest official and comparable national datasets, and, if necessary, to further develop the MONERIS model. An updated and officially authorised inventory of pressures from point and diffuse sources of nutrient pollution will be available by the end of 2006 as an important basis for preparing the detailed programme of basin-wide nutrient reduction measures as part of the Danube River Basin Management Plan.

16 *daNUbs (2005).*

4.4.1. Significant point source pollution (overview)

4.4.1.1. Data availability

The analysis of the point source pollution in the Danube river basin district requires the availability of complete inventories of point sources with data of high and homogenous quality covering the whole catchment area. This analysis is based on the ICPDR Emission Inventory. More detailed information is available in the national reports.

The criteria for the identification of the significant point sources for the basin-wide overview are given in Table 25. These criteria refer especially to substances mentioned in Annex VIII WFD, to the Urban Waste Water Treatment Directive (91/271/EEC), to the Integrated Pollu-tion Prevention and Control Directive (96/61/EC) and to the Dangerous Substances Directive (76/464/EEC).

Within this report the focus of the analysis is on the significant point sources of pollution. Table 26 gives an overview of the significant point sources identified in the Danube River Basin. The locations of the significant point sources are shown in Map 5. Annex 4 provides a list of all identified significant point sources in the Danube River Basin District.

The point source pollution is not only due to significant sources. Therefore, the results on the significant sources have to be compared with the total emissions from point sources. The ICPDR has prepared inventories for point source emissions for the reference years 2000 and 2002. These include municipal sources (2000 only existing waste water treatment plants; 2002 untreated and treated municipal sources), industrial and agroindustrial (only 2002) point sources.

Definition of significant point source pollution on the basin-wide level *TABLE 25*

Discharge of		Assessment of significance		
Municipal waste water				
any municipal waste water from	agglomerations with < 10,000 PE	not significant		
	WWTPs with < 10,000 PE			
untreated municipal waste water from	agglomerations with > 10,000 PE	significant		
only mechanically treated municipal waste water from	WWTPs with > 10,000 PE	significant		
mechanically and biologically treated municipal waste water without tertiary treatment from	WWTPs with > 100,000 PE	significant if at least one parameter is exceeded:		
		– BOD* > 25 mg/l 02		
		– COD* > 125 mg/l 02		
		– N_{total}** > 10 mg/l N***		
		– P_{total}** > 1 mg/l P		
Industrial waste water		significant if at least one parameter is exceeded:		
		– COD*** > 2 t/d		
		– pesticides**** > 1 kg/a		
		– heavy metals and compounds*****:	As_{total}	> 5 kg/a
			Cd_{total}	> 5 kg/a
			Cr_{total}	> 50 kg/a
			Cu_{total}	> 50 kg/a
			Hg_{total}	> 1 kg/a
			Ni_{total}	> 20 kg/a
			Pb_{total}	> 20 kg/a
			Zn_{total}	> 100 kg/a
Waste water from agricultural point sources (animal farms)		significant if at least one parameter is exceeded:		
		N_{total}****** > 50,000 kg/a		
		P_{total}****** > 5,000 kg/a		

WWTP = waste water treatment plant
** according to Table 1 of the EU Urban Wastewater Treatment Directive, 91/271/EEC*
*** according to Table 2 of the EU Urban Wastewater Treatment Directive, 91/271/EEC*
**** equivalent to 13 mg/l N in Germany, due to 2h-composite sample monitoring*
***** threshold as in the EMIS inventory for industrial discharges 2000*
****** thresholds water in kg/year as in the EPER*
******* threshold as in the EPER (EMIS inventory for point agricultural sources 2002)*

The inventory for the reference year 2002 includes 987 municipal, 306 industrial and 62 agroindustrial point sources. The inventory of the point sources includes also the significant point sources according to Table 25. The list of significant point sources therefore represents 24 %, 56 % and 34 % of the municipal, industrial and agroindustrial point sources respectively of the 2002 inventory. Unfortunately, however, the inventory of point sources for 2002 does not include the pollution from priority substances for all locations. In addition, the impact analysis within this report (see Chapter 4.5.1.3), as well as the analysis of the diffuse sources of emissions into the Danube river system, is using data from the year 2000. For these reasons the following analysis has mainly used the existing list of significant point sources and the point source inventory for the reference year 2000.

Because both inventories do not include all point sources, these results will also be compared with the total point source pollution of nutrients given by SCHREIBER et al. (2003) and BEHRENDT et al. (2005). Within the framework of the research project "Harmonised Inventory of Point and Diffuse Emissions of Nitrogen and Phosphorus for a Transboundary River Basin"[17] the database of the point source pollution for the nutrients was enlarged by additional data for Germany, Hungary and Slovak Republic. Because in 2004 Austria also provided a complete set of the municipal point sources, the database used for this report is larger than the ICPDR Emission inventory. As part of the daNUbs project[18] this database was used to estimate the development of the point source pollution in recent decades. With regard to organic point source pollution the ICPDR Emission inventory is the exclusive database. The estimation of the point source pollution of other substances is on the other hand based only on the overview of the significant point sources.

Significant point sources of pollution in the Danube River Basin District according to the criteria defined in **Table 25** *TABLE 26*

		DE	AT	CZ	SK	HU	SI	HR	BA	CS	BG	RO	MD	UA
Municipal point sources:	WWTPs	2	5	1	9	11	3	10	3	4	6	45	0	1
	Untreated wastewater	0	0	0	2	1	3	16	15	14	31	14	0	0
Industrial point sources		5	10	10	6	24	2	10	5	14	4	49	0	5
Agricultural point sources		0	0	0	0	0	1	0	0	0	0	17	0	0
Total		7	15	11	17	36	9	36	23	32	41	125	0	6

** Two of these water bodies are shared by SK and HU.*

Danube River Basin District - Significant Point Sources of Pollution *MAP 5*

17 SCHREIBER et al. (2003).
18 daNUbs (2005).

4.4.1.2. Contribution of sub-basins to the total point source pollution of the Danube

Point source pollution from organic substances and nutrients

Table 27 shows the results of the point source inventory for the main sub-catchments of the Danube river basin district for the year 2000 (missing values for COD, BOD, N and P for individual municipal waste water treatments and agricultural point sources were replaced on the country averages of the ratios of COD/BOD, N/BOD and N/P). The selection of the sub-catchments is based on the results of the Transboundary Analysis within the Danube Pollution Reduction Program[19] and is not related to a possible subdivision of the Danube river basin within the framework of the WFD.

Additionally the table includes the results of the estimated point source discharges for nitrogen and phosphorus estimated by SCHREIBER et al. (2003). The base for this study was data on the total point source nutrient emissions from municipal waste water treatment plants (WWTPs) of Germany, Austria, Slovak Republic and Hungary. For the other countries the total point source discharges were estimated from the ICPDR Emission Inventory and additional data for total national point source emissions[20].

If the main point source discharges of the ICPDR Emission Inventory are taken into account the total organic pollution from point sources into the river system of the Danube in 2000 was about 420 kt/a BOD (COD data for Serbia and Montenegro were not available and could also not be estimated). The point source discharges of nutrients were 125 kt/a (N) and 20.1 kt/a (P) according to the ICPDR inventory for 2000.

If it is taken into account that the inventory includes only a portion of the total organic point source discharges the total organic point pollution of the Danube river system was about 560 kt/a BOD in 2000. If the same correction is made for the nutrients the total pollution the total nutrient pollution by point discharges was about 167 kt/a N and 26.8 kt/a P, respectively. These estimations are to a large extent consistent with the estimation of the modelling done for 388 sub-catchments of the Danube basin.[21]

If the results of the point source pollution of organic substances and nutrients for the inventory are compared with the pollution caused by the significant sources (see Table 27) the portion of the contribution from the main sources is very different for the different substances. Table 27 includes, in addition to the 15 sub-catchments of the Danube river basin, the significant point sources for the coastal zone of the Black Sea in Romania, which form part of the Danube basin river district.

For COD, the significant point sources account for 82 % of the total COD for all point sources in the emission inventory. For BOD, the significant point sources account for only 48 %. The difference between the organic pollution indicated by COD and BOD should not be so significant. For this reason it can be assumed that one of the databases is incomplete and leads to biased assessments. Further clarification is needed.

A comparison of the significant point source emissions with the complete list of point sources in the emission inventory illustrates that only few point sources are responsible for about half of the point discharges into the Danube River system. From this it can be concluded that reduction of emissions (organic substances and nutrients) from these sources would lead to a remarkable reduction of the total point source pollution.

Table 28 shows population specific point discharges within the sub-catchments of the Danube and for the total Danube basin. Table 28 allows a comparison on the present state of the treatment of organic pollution and nutrients within the sub-catchments. It is necessary to consider that these data are based on the total population in the sub-catchments and not on the population connected to WWTPs. The lowest discharge of organic pollution was found in the sub-catchments of the Upper Danube, Austrian Danube, and Morava, where the specific organic pollution of BOD is only about 10 % of the Danube average. Specific organic pollution above the Danube average is indicated for the catchments of Sava, Banat-Eastern Serbia, Velika Morava and Mizia-Dobrudzha.

19 UNDP/GEF (1999c).
20 SCHREIBER et al. (2005).
21 SCHREIBER et al. (2005).

Municipal, industrial and agricultural point source discharges of COD, BOD, total nitrogen and phosphorus* *TABLE 27*

Sub-catchment	COD t/a	BOD t/a	N t/a	P t/a
Municipal sources				
01 Upper Danube	3,100	550	2,200	80
02 Inn	1,037	160	288	30
03 Austrian Danube	604	130	248	14
04 Morava	898	100	189	20
05 Váh-Hron	14,899	4,248	2,102	349
06 Pannonian Central Danube	94,759	32,304	11,618	1,495
07 Drava-Mura	14,970	5,802	2,291	418
08 Sava	83,649	37,102	6,005	1,358
09 Tisza	37,507	14,327	4,883	1,029
10 Banat-Eastern Serbia	13,261	4,247	2,679	619
11 Velika Morava	na	na	na	na
12 Mizia-Dobrudzha	64,057	29,149	5,064	1,254
13 Muntenia	59,917	29,861	15,602	1,844
14 Prut-Siret	25,314	9,869	2,751	215
15 Delta-Liman	744	272	50	4
16 Romanian Black Sea Coast	10,297	2,801	910	87
Municipal sources Total DRBD	425,013	170,922	56,880	8,816
Industrial sources				
01 Upper Danube	7,346	49	20	8
02 Inn	8,469	375	305	20
03 Austrian Danube	4,825	196	12	9
04 Morava	1,911	136	130	19
05 Váh-Hron	8,294	2,681	96	4
06 Pannonian Central Danube	16,424	3,515	352	13
07 Drava-Mura	29,718	6,083	185	52
08 Sava	33,965	6,772	310	374
09 Tisza	16,622	3,315	331	32
10 Banat-Eastern Serbia	1,158	120	20	2
11 Velika Morava	na	na	na	na
12 Mizia-Dobrudzha	9,244	na	na	na
13 Muntenia	16,173	5,166	2,312	5
14 Prut-Siret	4,456	903	136	1
15 Delta-Liman	982	na	24	15
16 Romanian Black Sea Coast	842	242	390	na
Industrial sources Total DRBD	160,427	29,555	4,625	555
Agricultural sources				
07 Drava-Mura	2	1	na	1
08 Sava	191	41	107	3
09 Tisza	2,263	579	749	na
10 Banat-Eastern Serbia	357	104	57	16
13 Muntenia	2,040	1,085	881	57
14 Prut-Siret	285	1,074	326	5
15 Delta-Liman	901	206	na	na
Agricultural sources Total DRBD	6,039	3,089	2,121	82

** from significant sources according the criteria of Table 25 (based on ICPDR Emission Inventory data of 2002)*

Specific point source discharges of COD, BOD, total nitrogen and phosphorus from municipal waste water treatments (WWTPs), direct industrial discharges, and agricultural point discharges in the sub-catchments of the Danube.* TABLE 28

Sub-catchment	CODs g/(Inh·d)	BODs g/(Inh·d)	Ns_{inv} g/(Inh·d)	Ps_{inv} g/(Inh·d)	Ns_{calc} g/(Inh·d)	Ps_{calc} g/(Inh·d)
01 Upper Danube	9.5	1.2	3.5	0.2	3.8	0.3
02 Inn	20.2	3.9	3.9	0.4	3.6	0.5
03 Austrian Danube	11.8	1.4	2.8	0.2	3.4	0.3
04 Morava	10.8	1.8	3.5	0.4	4.9	0.5
05 Vah-Hron	26.0	9.1	7.1	0.6	4.2	0.4
06 Pannonian Central Danube	35.8	18.8	5.3	0.6	6.7	1.0
07 Drava-Mura	44.2	12.5	5.2	0.8	4.1	0.7
08 Sava	52.3	28.6	4.0	1.0	4.8	1.2
09 Tisza	14.4	8.3	2.7	0.5	3.5	0.5
10 Banat-Eastern Serbia	17.8	68.5	12.4	2.7	10.4	2.4
11 Velika Morava	n.a.	24.9	3.3	1.1	3.3	1.1
12 Mizia-Dobrudzha	64.6	30.2	6.4	1.6	6.7	1.5
13 Muntenia	17.3	10.0	4.1	0.7	4.5	0.9
14 Prut-Siret	15.1	5.9	2.1	0.2	2.4	0.3
15 Delta-Liman	15.6	8.4	4.3	0.5	3.7	0.6
Total DRBD	23.9	14.0	4.2	0.7	4.5	0.8

* *Ns, Ps_{INV} – based on the ICPDR Emission Inventory data for 2000; Ns, Ps_{CALC} – results of the MONERIS application for this report*

For nutrients the situation is not so clear. This is because additional waste water treatment in WWTPs, and lower proportion of the population connected to WWTPs, lead to lower specific nutrient discharges. For this reason, in addition to the Upper Danube, Inn, Austrian Danube and Morava catchments, the lower sub-catchments of the Danube and the Tisza are also characterised by low specific nutrient discharges. The catchments with the highest specific nitrogen discharges are Vah-Hron, Pannonian Central Danube, Drava-Mura, Banat-Eastern Serbia and Mizia-Dobrudzha. For phosphorus the situation is also dependent on the existing use of P in detergents. Therefore the highest specific P discharges were found for the Sava, Banat-Eastern Serbia, Velika Morava and Mizia-Dobrudzha.

Within the Upper Danube, Austrian Danube and partly the Inn the point source discharges are considerably lower due to significant elimination of organic pollution and nutrients especially in municipal and industrial WWTPs.

If the criteria of the Urban Waste Water Directive (91/271 EEC) are used as a delimiter for the treatment efficiency, a large potential for the reduction of the point source discharges exists for the sub-catchments of the middle and lower Danube.

An overview on the significant sources of point discharges for the COD, BOD and the nutrients is given for the countries in the Annex 4.

Point source pollution from other substances and nuclear power plants

The database of the significant sources does not include enough data on other substances that an estimation of these pollutants for the whole Danube River Basin as well as for the sub-catchments can be given. For some countries, such as Germany, only qualitative numbers are presented. For most of the countries, the data are partially or totally missing. For Romania the list of significant point source pollution includes at least data for the heavy metals.

In addition, 8 nuclear power plants are located within the Danube River Basin District (see Map 5). Emissions of organic substances, nutrients and other substances into the river system should not exist from this energy source or should be insignificant. Emissions of radio nuclides have not been presented and should not occur.

4.4.2. Significant sources of nutrients (point and diffuse) including land use patterns

4.4.2.1. Introduction

Whereas the load of substances from point discharges can be measured or calculated from measured concentrations and flows, the emissions of substances from diffuse sources cannot be measured. For small watersheds the loads can be estimated but for medium and large river catchments the estimation of the diffuse source pollution is only possible by mathematical modelling. This is done using land use, hydrological, soil and hydrogeological data collected in a Geographical Information System (GIS) as well as statistical information for different ad-ministrative levels.

The definition of significant sources of pollution for the diffuse emissions is a very complex theme. This is especially the case for large transboundary river basins such as the Danube. The main problem is to distinguish between areas with low and high levels of diffuse pollution. These levels are not only dependent on anthropogenic factors such as land use and land use intensities, but also on natural factors such as climate, flow conditions and soil properties. These factors influence the pathways of the diffuse nutrient emissions and the retention and losses on the way from the origin to the inputs into the river system. Absolute values of the significant diffuse source of pollution are also difficult to define. This is because the level of the intensity of land use as the main indicator for the diffuse emissions into the river is also dependent on the population density in the catchment area.

Criteria for estimating the significant diffuse sources, which ignore the natural and basic anthropogenic conditions, are not reliable for distinguishing between significant and insignificant levels. Therefore, a number of uncertainties need to be taken into account when analysing the data (see Chapter 4.8.2).

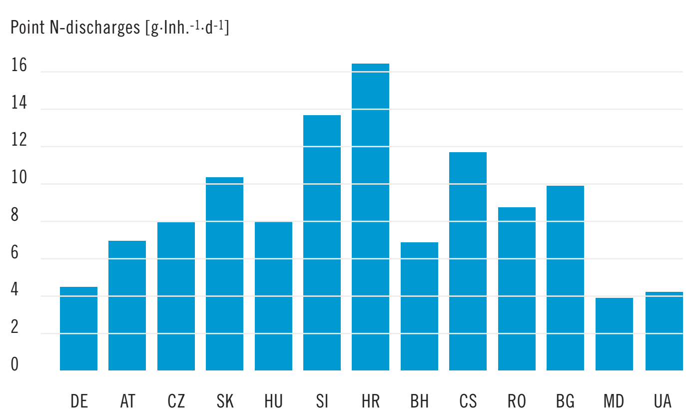
The following chapters present the analysis of the point and diffuse nutrient emissions for the Danube river basin, but not for the Danube river basin district. Such an analysis should be done in the future.

4.4.2.2. Present state of the nutrient point discharges

The total nutrient point discharge into the Danube was about 134.2 kt/a nitrogen and 22.7 kt/a phosphorus in the year 2000[22]. Figure 11 and Figure 12 show the difference in the present state of the specific nutrient point source discharges within the Danube countries. For these figures the estimated point discharges of nutrients for the individual countries were divided by the population in the countries, which is connected to sewer systems. For nitrogen it is shown that the lowest point N discharges are in Germany with 4 g/(Inh.·d) per connected inhabitant followed by Austria, Ukraine and Moldova. It is likely that the low N discharges for the latter two countries are due to inconsistent data for the population connected to waste water treatment plants, or to low nitrogen discharges from the point sources in the inventory. The lowest N discharges per capita were found for Germany and Austria, this corresponds to the highest N-elimination in WWTPs. For some countries the specific N discharges are higher than the assumed N emission per inhabitant of 12 g/(Inh.·d). This is due to the present low level of nitrogen removal in most of the WWTPs of these countries and the additional fact that the point source database includes industrial discharges emitted into the river indirectly (via sewer system) and directly (industrial point sources).

The picture for phosphorus presented in Figure 12 is similar to that for nitrogen (Figure 11), but the differences between the countries are much larger. This is due to the fact that the specific P point discharges reflect, not only the state of the P elimination in waste water treatment plants, but also the existing use of phosphorus in detergents, and discharges from direct industrial sources. This is the reason that the specific P emissions are above 2.5 g/(Inh.·d) for Slovenia, Croatia, and Serbia and Montenegro. The medium level P emissions between 1 and 2 g/(Inh.·d) were found for the Slovak Republic, Hungary, Bosnia i Herzegovina, Romania and Bulgaria. Beside Germany and Austria, the specific point P discharges are also below 1 g/(Inh.·d) for Czech Republic, Moldova and Ukraine. This is due to the fact that some WWTPs have additional P elimination. The relative low specific P emissions for Ukraine and Moldova are likely due to the same reasons as pointed out for the low nitrogen values.

Inhabitant-specific N discharges from point sources
(total load divided by total population in the state)
in the Danube countries for the period 1998 to 2000;
results of the MONERIS application for this report *FIGURE 11*



22 SCHREIBER et al. (2003).

4.4.2.3. Land use patterns and agricultural indicators

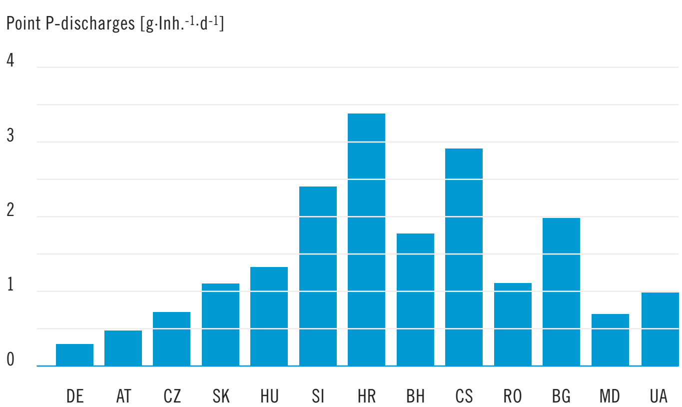
The Danube basin is characterized by large gradients of anthropogenic and natural indicators, which are important for affecting nutrient inputs into the river system. One indicator for the level of the diffuse emissions of substances can be the land use within the basin and its regional distribution.

Figure 13 gives an overview of the portion of differing land uses, arable land, grassland and pasture, forest and other kinds of land use, related to the total area of the Danube countries. The use of these country averages does not allow a calculation of an average for the total Danube river basin. The figure shows an increase of the share of arable land, and a decrease of forest, from the upper to the lower part of the Danube. Because most countries (Hungary is the exception) have only a portion of their territory in the Danube catchment, the estimation of a Danube average for the land use pattern is not possible using data on the country level. In addition, it must be considered that the average land use for the countries can deviate from the status within the parts of the countries only in the Danube basins. This is due to the inhomogenous distribution of land use within the countries.

Another source of information on land use patterns in the Danube River Basin is the available CORINE land cover map. This data is not yet available for Croatia, Serbia and Montenegro, Ukraine and Moldova. SCHREIBER et al. (2003) tried to fill this gap by transferring the USGS land cover map into the classes of CORINE. A similar procedure was applied for Map 6 covering the whole Danube River Basin District. As shown by information from SCHREIBER et al. (2005) for Bosnia i Herzegovina, such a transfer can lead to substantial deviations for land use patterns. The advantage of using the land use patterns according CORINE is that it contains the higher segmentation for the land use classes, and the possibility to estimate the land use for the river basin, as well as the sub-catchments.

Figure 14 shows the land use patterns for those parts of the countries within the Danube basin and the average for the whole Danube. If both figures are compared, it is obvious that the estimated portions of the arable land are higher based on CORINE data.

Inhabitant-specific P discharges from point sources* *FIGURE 12*

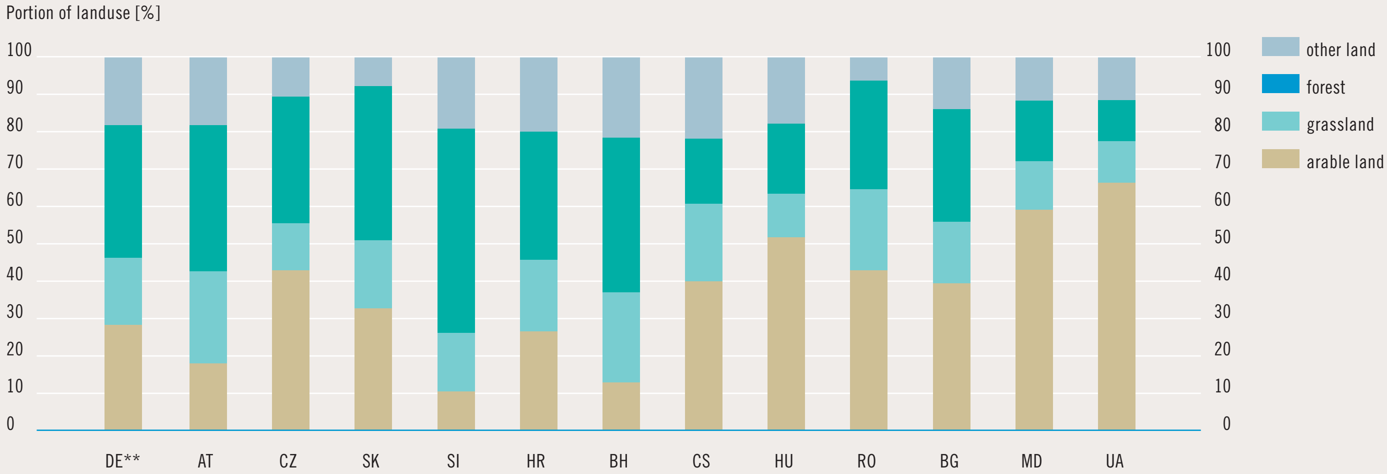


* *(total load divided by total population in the state) in the Danube countries for the period 1998 to 2000; results of the MONERIS application for this report*

Danube River Basin District – Land Use *MAP 6*

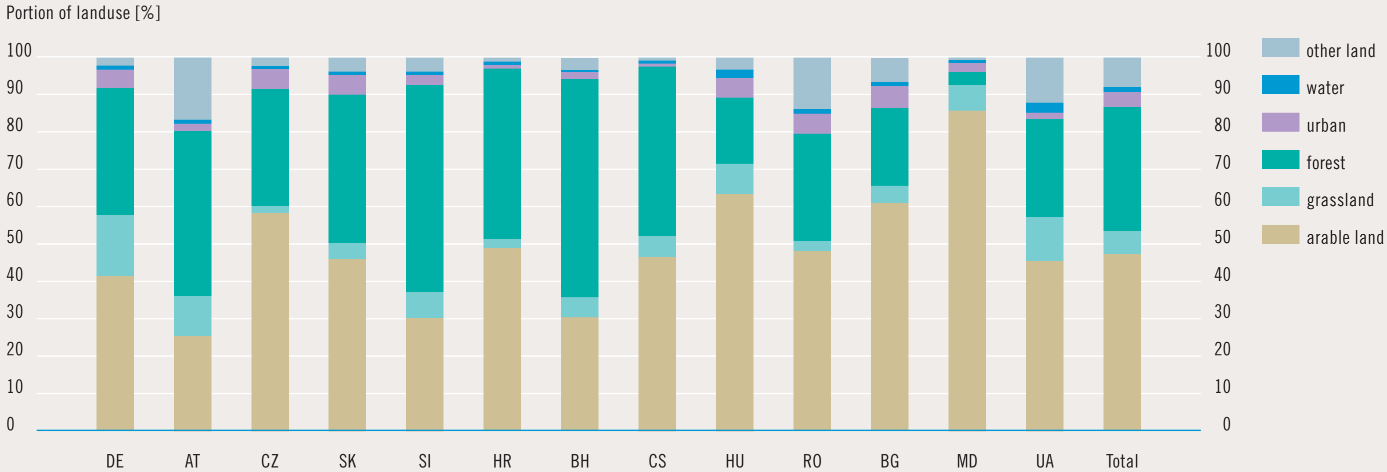
These differences are due to the different classification systems being used. The national statistics represent the actual uses of land whereas the CORINE data reflects the cover of the land according to the classification of satellite images. Because the resolution for the classification of CORINE is 25 ha, this procedure leads further to an overestimation of the dominant land cover (arable land and forest) and an underestimation of the other classes. For the total Danube the share of the land use is: arable land 47.4 %, grassland and pasture 6.2 %, forest 33.5 %, urban areas 3.9 %, surface water area 0.9 % and other areas including open land, wetlands and glaciers 8.0 %.

Portion of land use types in the total area of the Danube countries for the period 1998 to 2000* *FIGURE 13*



** The data source FAO the exception is Germany.*
*** DE represents the land use for Baden-Württemberg and Bavaria according to the German Federal Statistical Office for the same period.*

Portion of land use types at the parts of countries within the Danube basin and the average for the total Danube according to CORINE land cover map and transferred USGS land cover map (source: SCHREIBER et al. 2003) *FIGURE 14*

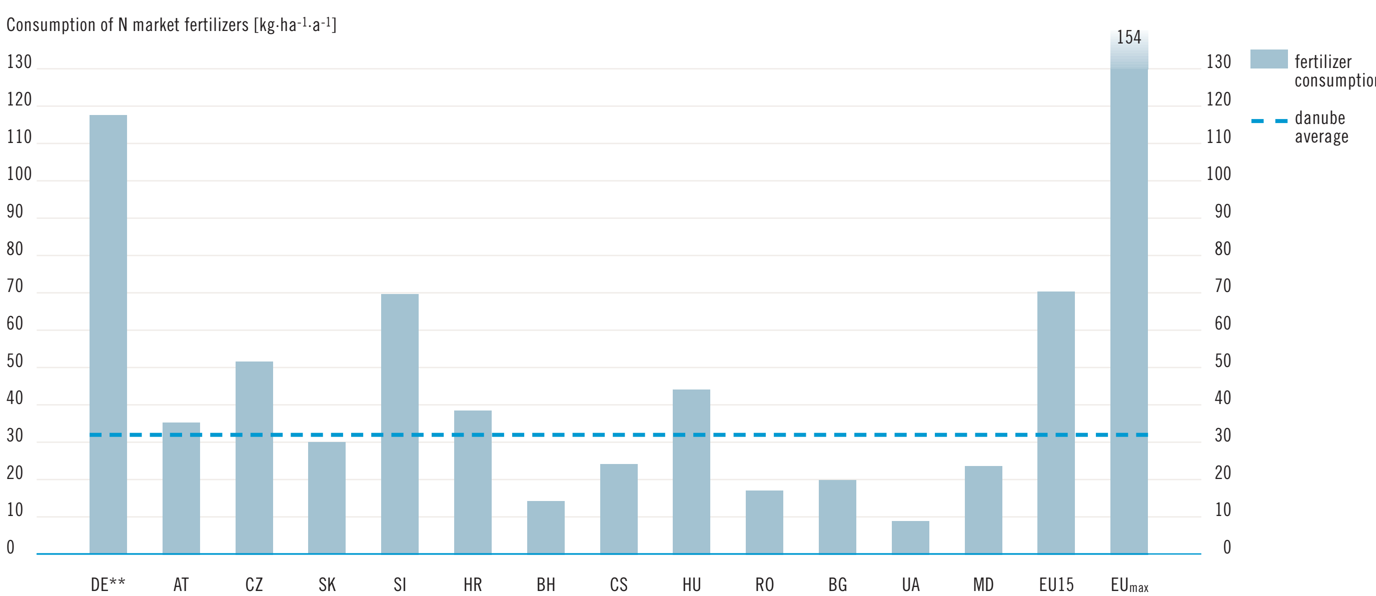


Besides being influenced by the land use it self, the level of the emissions into the surface waters of a river system is also dependent on the intensity of the land use. Because agricultural activities are a main source for the diffuse nutrient emissions into the river system, it is important to show differences in intensity of use on a unique database. Statistical data for the countries is the best way to do this. Figure 15 shows the consumption of nitrogen fertilizer used in agriculture of the Danube countries. The source of the data is the FAO agricultural statistics for the individual countries for the years 1998 to 2000.[23] For Germany the information is not from the national level but from the "Länder" of Baden-Württemberg and Bavaria where the data of BEHRENDT et al. (2003) was used based on the GERMAN STATISTICAL YEARBOOK (1999 to 2001). The figure includes also the average value for the 15 countries of the EU (before May 2004), and the maximum value reached within the set of countries. Further the area weighted average for the Danube basin is given.

From Figure 15 three groups of countries can be distinguished. Germany, Slovenia and Czech Republic are the countries with a consumption of mineral nitrogen fertilizer of more than 50 kg/(ha·a) N, although there is a large difference between the amount of use in the three countries.

In the second group of countries (Austria, Slovak Republic, Croatia and Hungary) the use of mineral fertilizers in agriculture is low to moderate, between 25 and 50 kg/(ha·a) N. In all other countries the level of mineral fertilizer consumption is significantly below 25 kg/(ha·a) N. The area weighted average of consumption of N fertilizer was estimated as 31.4 kg/(ha·a) N for the Danube basin. Comparison with the average of the EU15 countries shows that the level of fertilizer consumption in the Danube basin is less than half this amount. The maximum of N fertilizer consumption reached in the EU15 countries is five times higher than the average in the Danube basin.

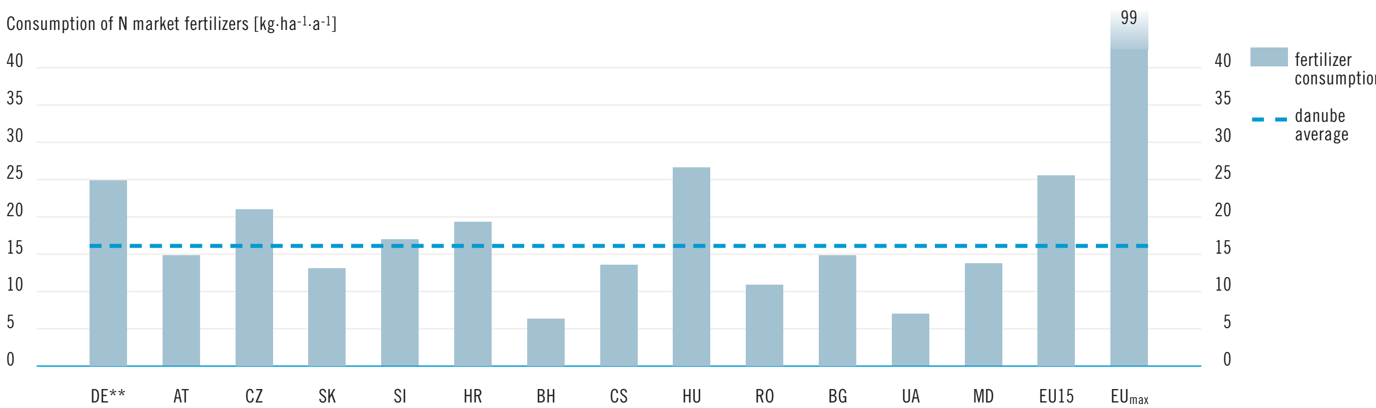
Consumption of nitrogen market fertilizers in the Danube countries
within the EU 15 countries, and EU maximum value in the period 1998 to 2000 * *FIGURE 15*



** The bars represent the consumption of nitrogen market fertilizers per agricultural area of the Danube countries.*
*** The data given for DE** represents the average N fertilizer consumption of the German "Länder" Baden-Württemberg and Bavaria. The database is the national statistics published by the statistical offices of the countries or by FAO*

23 FAO (2004).

Consumption of nitrogen market fertilizers per inhabitant in the Danube countries
the EU 15 countries, and EU maximum value in the period 1998 to 2000 * *FIGURE 16*



** The bars represent the consumption of nitrogen market fertilizers per inhabitant living in the Danube countries.*
*** DE represents the average N fertilizer consumption of the German "Länder" Baden-Württemberg and Bavaria. The database is the national statistics published by the statistical offices of the countries or by FAO.*

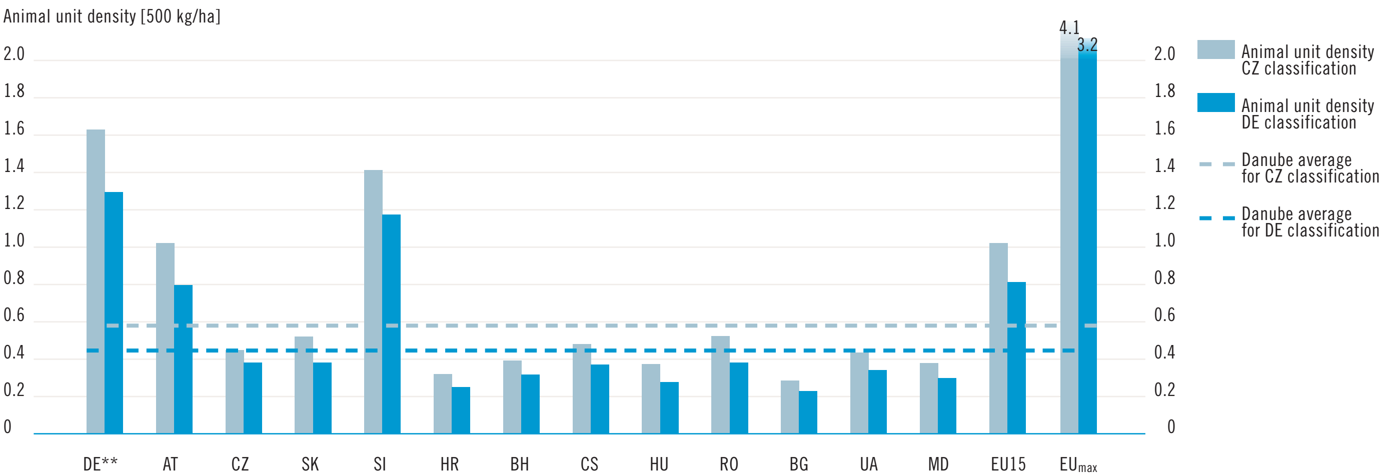
If N fertilizer consumption is calculated per inhabitant living in the countries a different picture emerges (see Figure 16). The deviation between the countries, with exception of Bosnia i Herzegovina and Ukraine, is lower. The Danube average is 16.6 kg/(Inh.·a). This is only 64 % compared to the average of the EU 15. The EU 15 maximum is also 4.5 times higher than the average of the Danube basin.

In addition to the application of mineral fertilizer, the number of livestock is an indicator for determining land use intensities that affect diffuse nutrient inputs. Figure 17 shows the livestock density as animal units per hectare agricultural area for the Danube countries. The animal unit (AU) corresponds to a live weight of 500 kg. Coefficients used for the conversion of animals of various types into the animal unit differ from state to state. In Figure 17 and Figure 18 the coefficients common in the Czech Republic and Germany, respectively are applied for the purpose of comparison. A systematic deviation is found when using the different equivalents. The animal unit number calculated with the German equivalents is on average only 79 % of the number found for the Czech equivalents. Figure 17 includes the average for the total Danube basin for both kinds of animal units, as well as this indicator for the average of the EU 15 countries, and the maximum of these countries.

The countries with a density of 1 or 0.8 animal units per hectare and more are Germany, Austria and Slovenia. All other countries have a livestock density lower than 0.5 animal units. The reason for these low densities is that in most countries of Eastern Europe there has been a strong reduction of livestock numbers after the changes of socio-economic conditions around 1990. The average density of animal units in the Danube basin is only 55 % of the EU 15 average. The maximum of the EU 15 countries is more than 7 times higher than the average of the Danube basin.

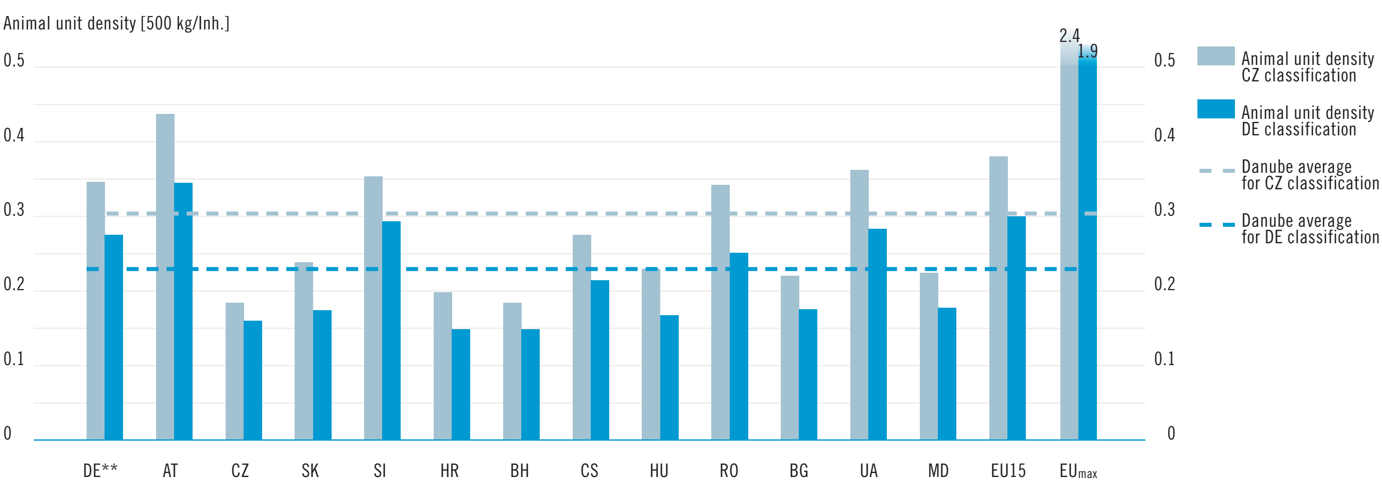
The deviation between the countries for the livestock density is much lower if this indicator is calculated as animal units per inhabitants living in the countries (see Figure 18).

Animal unit density per agricultural area in the Danube countries for the period 1998 to 2000 * *FIGURE 17*



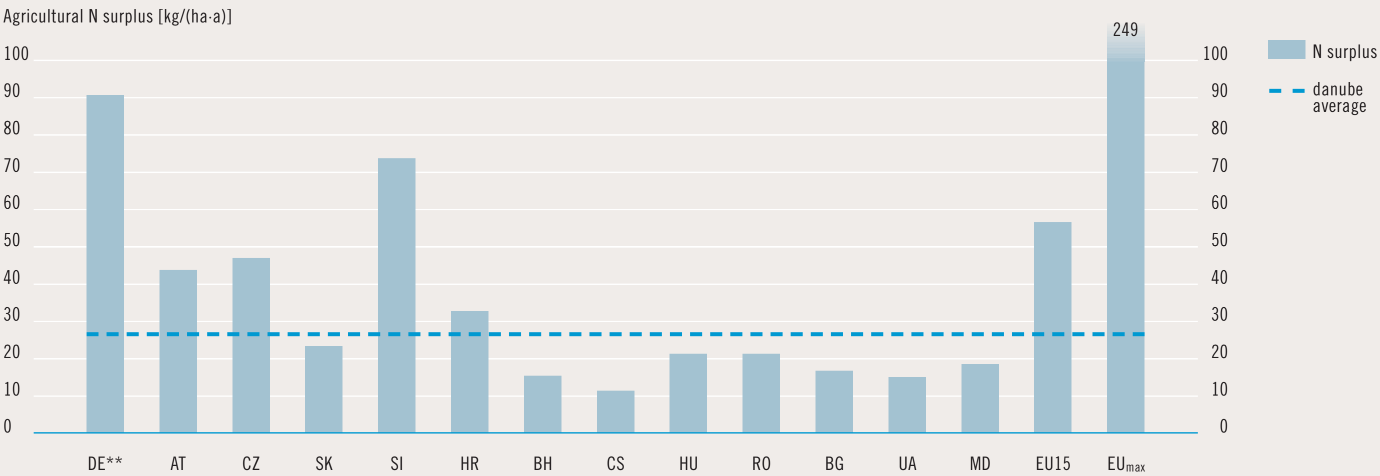
* *The bars represent the animal units per agricultural area in the Danube countries.*
** *The data given for DE* represents the animal unit density of the German "Länder" Baden-Württemberg and Bavaria. The database is national statistics published by the statistical offices of the countries or by FAO, equivalents for Czech Republic and Germany were used)*

Animal units per inhabitant in the Danube countries for the period 1998 to 2000 * *FIGURE 18*



* *The bars represent the animal units per inhabitant in the Danube countries.*
** *The data given for DE represents the inhabitant-specific animal unit density of the German "Länder" Baden-Württemberg and Bavaria. The database is national statistics published by the statistical offices of the countries or by FAO, equivalents for Czech Republic and Germany were used.*

Nitrogen surplus per agricultural area in the Danube countries for the period 1998 to 2000* FIGURE 19



* *Data sources: SCHREIBER et al. (2003), based on data of FAO and national statistics for the German "Bundesländer"; data source for EU15 and EU_{max}: FAO (2004). The data of these sources are not directly comparable, but give a general indication.*

The group of countries with a value above the Danube average includes Romania and Ukraine. The average of the Danube is between 75 and 80 % of the livestock density of the EU15 but about 8 times lower than the EU15 maximum. This is due to the lower population density within the Danube than in the EU15 countries.

Consumption of mineral fertilizer and livestock density are the major sources of information on nutrient inputs from agriculture. If the inputs by atmospheric deposition, seeds and for nitrogen N-fixation, and the outputs by harvested crops are taken into account, then the nutrient surplus on agricultural area can be calculated. The procedure for this calculation can differ from country to country and within the countries. The results presented in Figure 19 are for all Danube countries using the OECD procedure. The coefficients used for the transfer of the different livestock excreta and crops into nitrogen and phosphorus are the ones used in the Czech Republic. As shown by SCHREIBER et al. (2003), the N surplus can differ within a minor range if the coefficients or procedures of other countries were applied. It should be pointed out that the application of different sets of coefficients for the individual countries would lead to systematic differences and consequently to incompatibilities of the data.

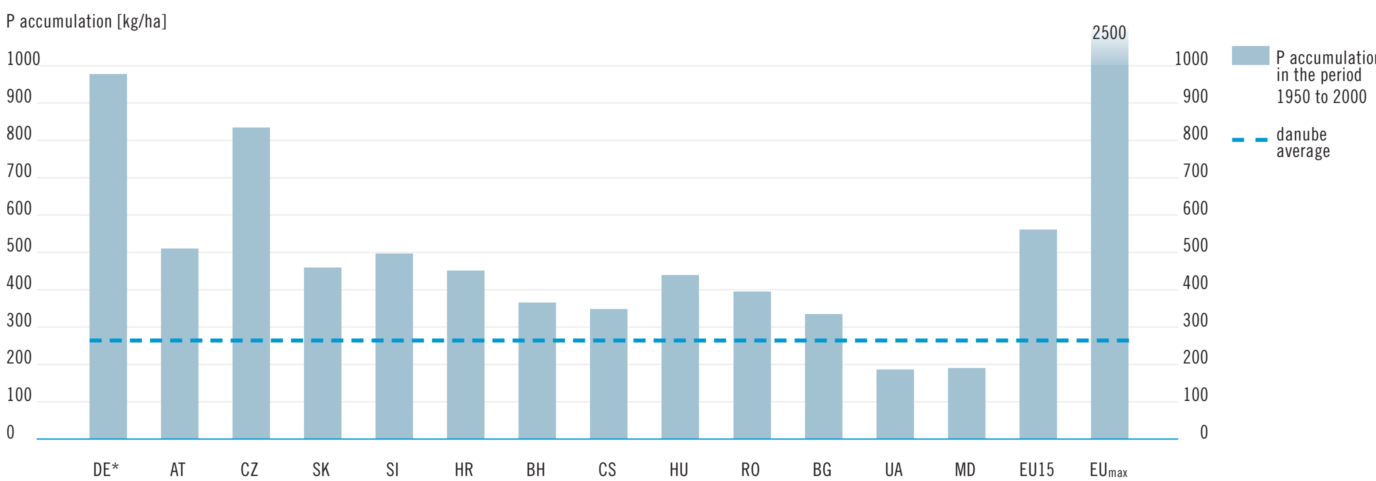
The high animal density, and the large consumption of mineral nitrogen fertilizer, is the reason that Germany and Slovenia are also the countries with the highest nitrogen surplus per hectare agricultural area (see Figure 19). The level of the N-surplus was 91 and 74 kg/(ha·a) N respectively for the period 1998 to 2000.

From Figure 15 and Figure 17 a higher difference in the N-surplus between Germany and Slovenia could be expected, but higher specific nitrogen outputs by harvested crops partly compensate for the larger fertilizer consumption and higher animal density in Germany. For the second group of countries (Austria, Czech Republic and Croatia) the estimated N-surplus is moderate, between 30 and 50 kg/(ha·a) N. The level of the N-surplus of all other countries is below 25 kg/(ha·a) N. Figure 19 presents the wide variation in nitrogen surplus between countries and indicates that the potential for nitrogen inputs into the surface waters of the Danube from countries also varies widely.

The area weighted average of the N surplus within the Danube basin was estimated as 27 kg/(ha·a). In comparison to the EU15 countries this level of N surplus is only about 47 %. The maximum of the EU15 countries is more than 9 times higher than the average of the Danube basin.

Because the annual phosphorus surplus on agricultural area is large part accumulated in the soil, one main indicator for diffuse P emissions into the river system is the longterm P accumulation on the agricultural area. This indicator provides a basis for determining the P emissions by erosion and surface runoff into the river system. Figure 20 shows the estimated P accumulation on the agricultural area of the Danube countries.

Phosphorus accumulation on agricultural area in the Danube countries for the period 1950 to 2000* *FIGURE 20*



* *for data sources see Figure 19*

According to Figure 20 the highest P accumulation was estimated for Germany and Czech Republic. For these countries, the P-accumulation of agricultural soils is about the double of the value for the most of the other countries. Moldova and Ukraine have an estimated P-accumulation, which is half that of most countries.

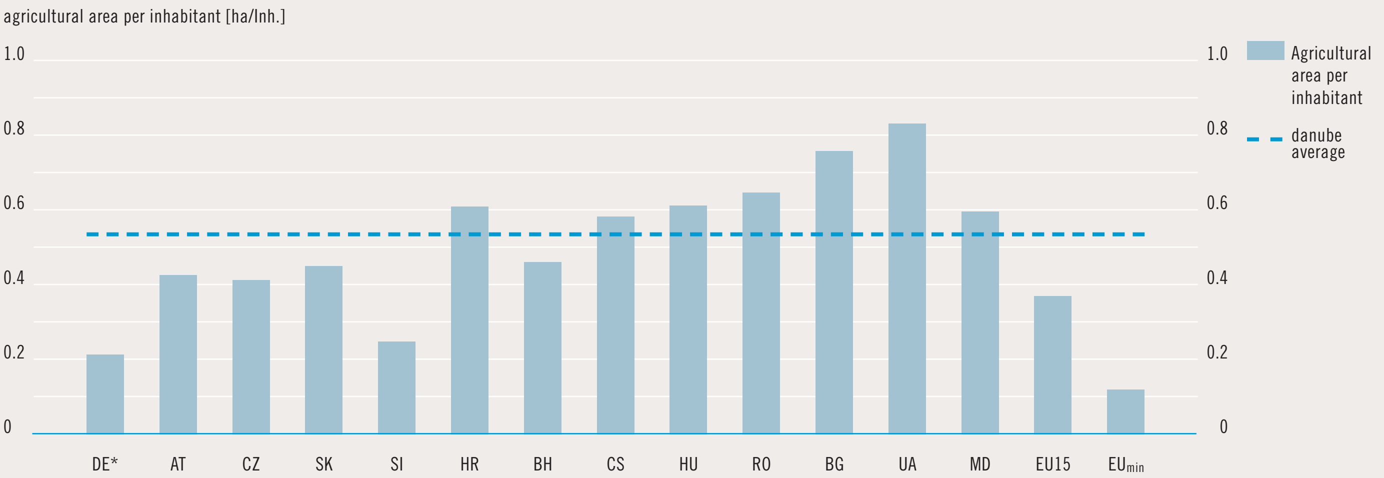
The nitrogen surplus on the agricultural area, as well as the long term P accumulation on this area, reflects the differences of the intensity of land use. The interpretation of the consequences of these differences between countries involves more than examining the agricultural sector. The level of agricultural intensities in the countries is also dependent on the people living in the region. If consideration is given to this factor then the results will change.

Figure 21 shows the agricultural area per inhabitant living in the countries. The figure shows that the agricultural area per inhabitant is the lowest in Germany and Slovenia, where only a little more than 0.2 ha per inhabitant are used for agriculture. A second group of countries has an inhabitant-specific agricultural area of about 0.6 ha/inh. or more (Croatia, Serbia and Montenegro, Hungary, Romania, Bulgaria, Ukraine and Moldova). This is at least three times higher than for Germany and Slovenia. The Danube average is 0.54. This is about 50 % higher than the EU15 average and more than 4 times higher than the minimum reached within the EU15 countries.

From this, the nutrient surplus per inhabitant can be calculated (see Figure 22), which shows that the behaviour regarding nutrients is much more similar in the countries than may be deducted from the previous graphs.

Agricultural area per inhabitant*

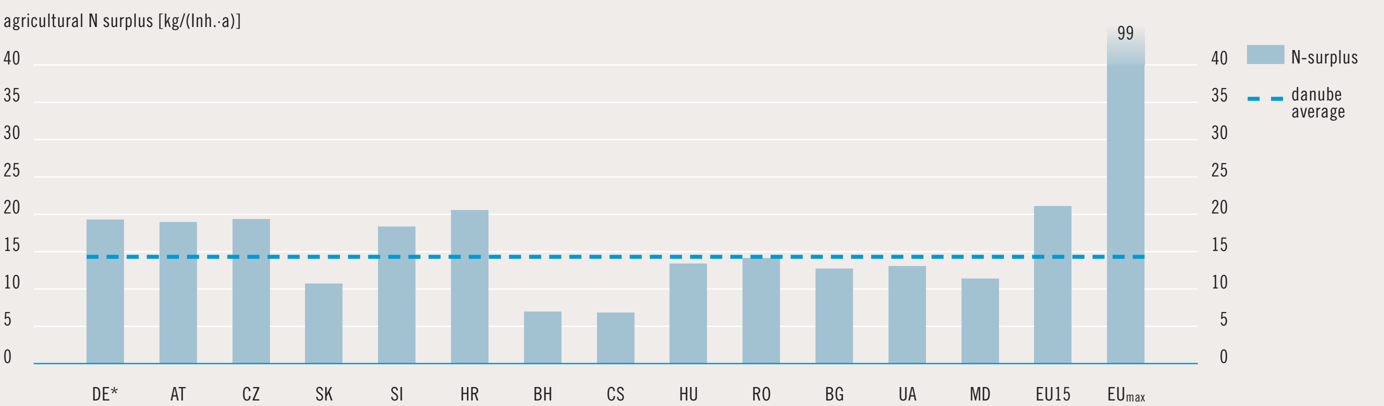
FIGURE 21



* *living in the Danube countries, the EU15 countries, the minimum in the EU15 countries, as well as the population weighted average for the Danube basin for the period 1998 to 2000. (Data sources: see Figure 19)*

Nitrogen surplus per inhabitant and year in the Danube countries for the period 1998 to 2000*

FIGURE 22



* *Data sources: see Figure 19*

Figure 22 shows that one reason for the very high N surplus in Germany is that Germany has a high population density in comparison to most of the other Danube countries. If this is taken into account, the variation of the agricultural intensities is much lower. The N surplus per inhabitant and year is very similar in Germany Austria, Czech Republic, Slovenia and Croatia (about 20 kg/(inh.·a)). The second group of countries (Slovak Republic, Hungary, Romania, Bulgaria, Ukraine and Moldova) has an N surplus of 10 to 15 kg/(inh.·a). Only for Bosnia i Herzegovina as well as Serbia and Montenegro the N surplus per inhabitant is below 10 kg/(inh.·a). The average of the N surplus per inhabitant within the Danube basin was estimated as 14.7 kg/(inh.·a) N. This value corresponds to 67 % of the EU15 average and is about 7 times lower than the EU15 maximum.

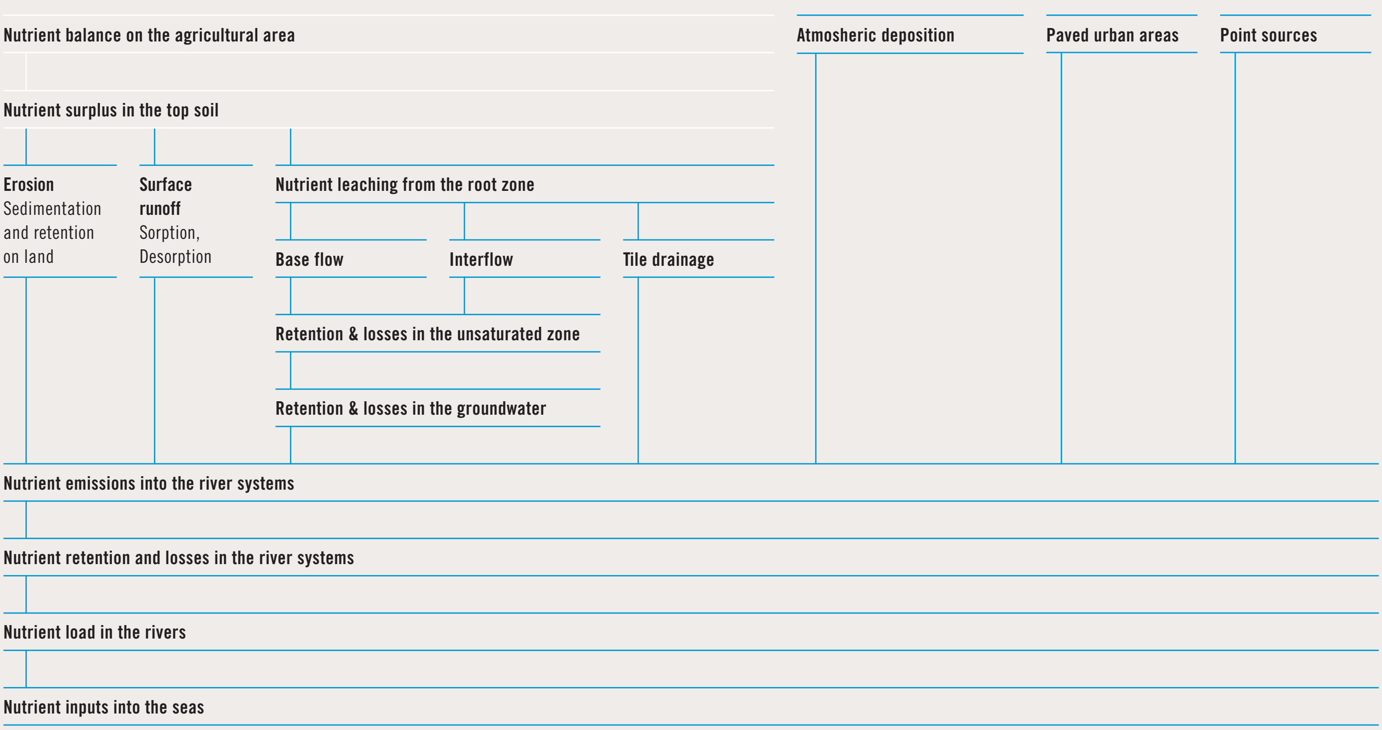
4.4.2.4. Diffuse nutrient pollution

Applied method

Since comparable data on diffuse nutrient pollution are not available on the basin-wide scale (see also Chapter 1.3), the analysis of the diffuse nutrient pollution was undertaken by applying the model MONERIS (MOdelling Nutrient Emissions into RIver Systems). This model was developed for the estimation of the nutrient emissions in German river systems[24] and has recently been applied for the total basin of the Danube.[25] A detailed description of the model, and the results for the Danube for the time period 1998 to 2000, is presented by SCHREIBER et al. (2005).

Figure 23 gives an overview of the pathways and main processes used in the model. The basic inputs into the model are data on discharges, data on water quality of the investigated river basins, a Geographical Information System (GIS) integrating digital maps and statistical information for different administrative levels. The sum of the diffuse nutrient inputs into the surface waters is the result of different pathways realized by several runoff components. Distinction between the inputs from the different runoff components is necessary. This is because the nutrient concentrations within the runoff components and the processes within these runoff components are different. Consequently MONERIS takes seven pathways into account: point sources, atmospheric deposition, erosion, surface runoff, ground-water, tile drainage and paved urban areas.

Pathways and processes used in MONERIS *FIGURE 23*



24 BEHRENDT et al. (2000).
25 SCHREIBER et al. (2003).

Along the pathway from the source to emission into the river, substances are governed by manifold processes of transformation, retention and loss. To quan-tify and forecast the nutrient inputs in relation to their source requires knowledge of these transformation and retention processes. The use of a GIS allows a regional differentiated quantification of nutrient emissions into river systems. The EU research project daNUbs is currently verifying these.

Because the discussion on possible indicators and the criteria for determining significance for diffuse source pollution has not yet been completed, the current situation of diffuse nutrient emissions and relative differences between regions are shown in the following paragraphs.

The results, which are presented here focus only on the nutrients and use the results of the modelling of the nutrient inputs into the Danube basin published by SCHREIBER et al. (2003).

The following chapters present the analysis of the estimated point and diffuse nutrient emissions for the Danube river basin, but not for the Danube river basin district. This means that the Black Sea coastal catchments, which are included in the Danube river basin district, are not included in the analysis with the MONERIS model. Such an analysis should be done in the future.

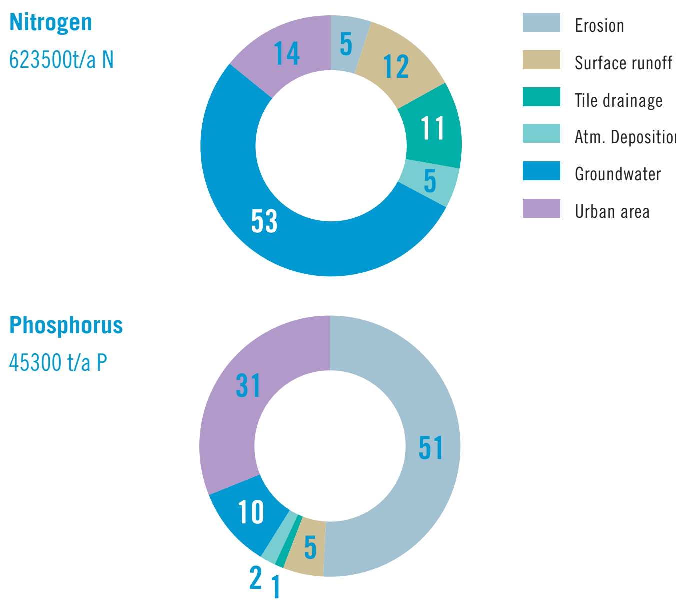
Significant diffuse nutrient pollution by pathways

Based on the data on the indicators described above, and further input data, the model MONERIS calculates the diffuse nutrient emissions from six different diffuse pathways into the river system of 388 sub-catchments of the Danube basin.

For each pathway of diffuse sources, the model takes into account the special natural conditions, which determine the retention and losses from the origin to the point of input into the river systems. The large gradient of these conditions leads to high variation in the retention and losses. The consequence is that the human input to the environment (as shown in Figure 15 to Figure 22) will be decreased to a different extent within the sub-catchments. Especially in the sub-catchments of the upper Danube, the retention is lower than in the other sub-catchments. For this reason the specific diffuse nitrogen emissions are higher due to natural conditions. On the other hand the retention is – also due to natural conditions – higher in Central and Lower Danube. In combination with moderate or low human pressures, these conditions lead to lower specific diffuse N-emissions. As shown in Figure 24 the total diffuse nutrient pollution into the Danube river system was estimated to be 624 kt/a nitrogen and 45.3 kt/a phosphorus. The average area-specific emission discharge into the whole river system (total load divided by total area of river basin) over all diffuse pathways is therefore 7.8 kg/(ha·a) for nitrogen and 0.56 kg/(ha·a) for phosphorus.

Diffuse nutrient pollution by pathways for the total Danube river systems for the period 1998 to 2000

result of the MONERIS application for this report *FIGURE 24*



The respective shares of the other types of diffuse phosphorous emissions into the river system are smaller compared with the ones for nitrogen. The sub-catchments with high precipitation and high altitude or slope are the catchments with the highest specific inputs. Figure 24 shows the contribution of the different diffuse nutrient pathways for the Danube.

It is clear that two pathways contribute about half of the diffuse nutrient inputs into the river system – groundwater for N and erosion for P. For both nutrients the pollution from surface runoff and urban areas are the next major dominant pathways. Tile drained areas are important for nitrogen; inputs via groundwater are important for phosphorous. According to SCHREIBER et al. (2003) the contribution from the different diffuse nutrient pathways varies significantly within the Danube basin. The effect is that the total diffuse nutrient emissions into the Danube river system also show large differences.

The sources of nutrient pollution by human activities

A portion of the diffuse nutrient emissions into the Danube river system is caused by natural conditions and independent from human activities. This portion is the natural background. SCHREIBER et al. (2003) estimated the amount of the background emissions of the nutrients for the Danube and the sub-catchments. If this background (for the total Danube about 61 kt/a nitrogen 6.5 kt/a phosphorus) is taken into account in calculating the diffuse nutrient emissions, it is possible to separate the portion of the emissions from human activities from the total nutrient pollution.

After separating the nutrient pollution of the Danube into human sources and background sources, four main sources can be identified – background, point sources, agricultural diffuse sources, and other diffuse sources such as nutrient inputs from urban area and atmospheric deposition by NO_x. The contribution of phosphorous and nitrogen emissions from these sources is shown in Figure 25 and Figure 26.

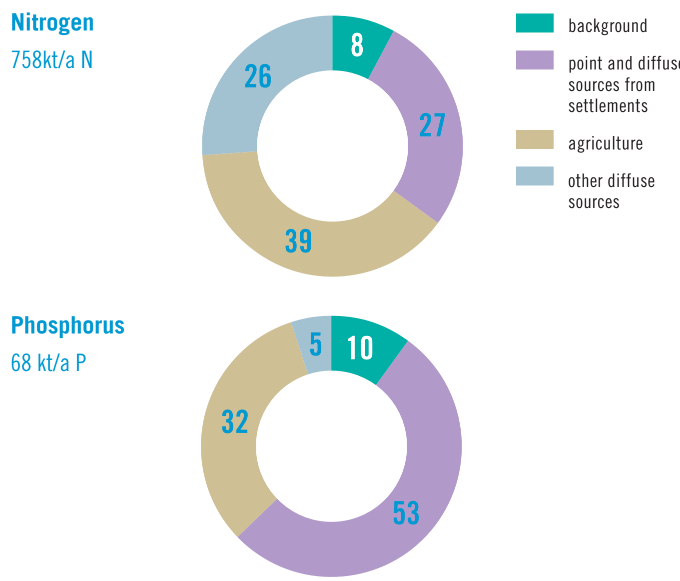
In general, the portion of point sources to the total nutrient emissions is higher for phosphorus than for nitrogen. The share of background contributions is higher for phosphorus than for nitrogen. That means that the total human influence on the nutrient pollution of the Danube is much higher for phosphorus than for nitrogen.

The relation between different human sources/activities to the total emissions is important to monitor. For the Danube basin the share of the different human sources compared to the total nutrient pollution is shown in Figure 25.

The total amount of nutrient pollution was in the period 1998 to 2000 about 758 kt/a nitrogen and 68 kt/a phosphorus. The Figure shows that for both nutrients the pollution is far from the background conditions (Background: 8 % for N; 10 % for P). The portion of the other sources is different for both nutrients. For nitrogen it was found that diffuse agricultural sources are the dominant source of pollution (39 %) at the present time. In contrast, the dominant sources for phosphorus are the point and diffuse emissions from urban settlements. This source contributes only 27 % of the total emissions for nitrogen. For nitrogen the pollution by other diffuse sources due to atmospheric deposition of NO_x are also important and can not be neglected. Due to the differences of human pressures in agriculture, as well as in the natural conditions, the regional distribution of agricultural diffuse nutrient pollution varies significantly.

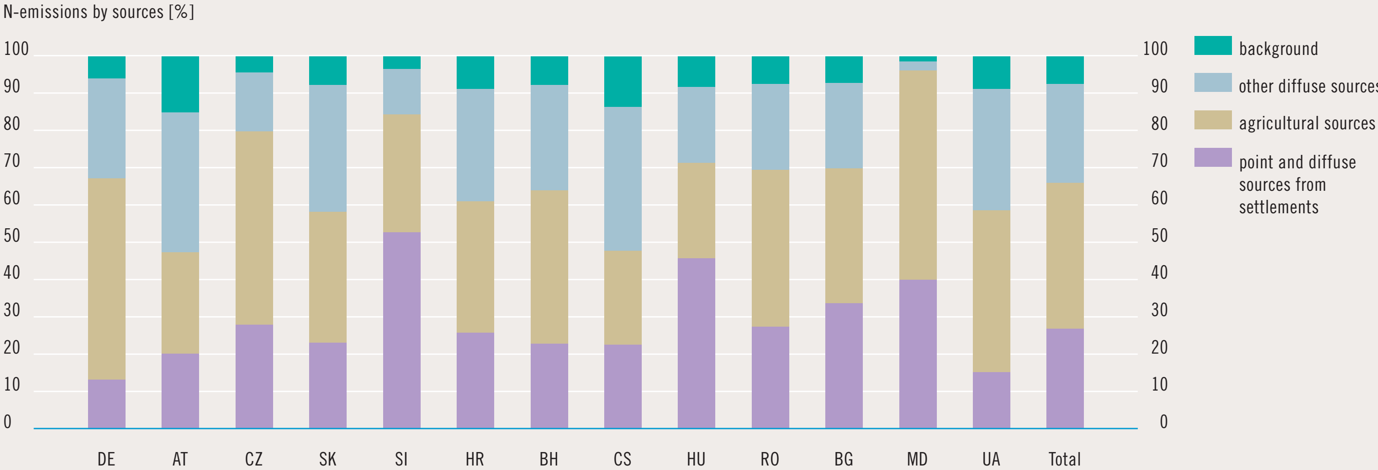
The contribution of the natural background, point and diffuse emissions from urban settlements, agricultural diffuse inputs and other diffuse sources to the total N and P emissions is shown for the areas of the countries within the Danube basin in Figure 26 and Figure 27. The figures show clearly that the present state of the nutrient pollution of the Danube is due to different sources in the different countries. Whereas in the countries Hungary and Serbia and Montenegro the N emissions from urban settlements are the dominant sources, it was found that the other diffuse N emissions mainly due to atmospheric deposition of NO_x are the dominant source for Austria and Bosnia i Herzegovina. For all other countries the N emissions caused by agricultural activities represents the major source. For phosphorus, the point and diffuse emissions from urban settlements are the major source of pollution with the exception of Germany and Austria where agriculture shows the largest share. This finding also reflects the different state of the waste water treatment within the Danube countries. In a number of countries the share from agricultural sources and from urban settlements is equally high (CZ, SK and UA). In the other DRB countries, agricultural sources for P emissions rank second, with the exception of Moldova, where the share of P from agricultural sources is higher than that for settlements (see Figure 27). Figure 28 and Figure 29 show the deviation of the specific diffuse agricultural nutrient emissions from the average for the total Danube basin for the considered sub-catchments. For nitrogen (average of the specific diffuse agricultural emissions is 7.2 kg/(ha·a) agricultural area) there is a clear tendency for agricultural emissions to decrease from the upper part of the Danube to the lower part. This means that a reduction of the agricultural diffuse pollution in the upper part of the Danube would lead to higher effects for the Danube than in the lower part.

Total nutrient emissions by human sources and background values for the Danube river basin in the period 1998-2000;
result of the MONERIS application for this report *FIGURE 25*



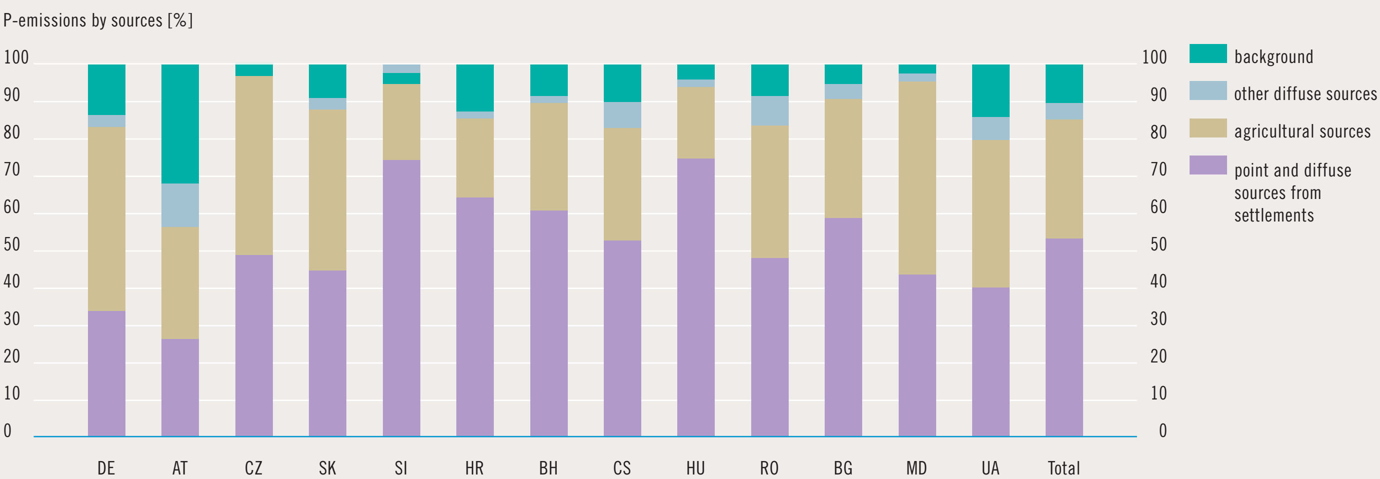
Total N emissions by human sources for area of the countries within the Danube basin in the period 1998-2000

result of the MONERIS application for this report *FIGURE 26*



Total P emissions by human sources for area of the countries within the Danube basin in the period 1998-2000

result of the MONERIS application for this report *FIGURE 27*



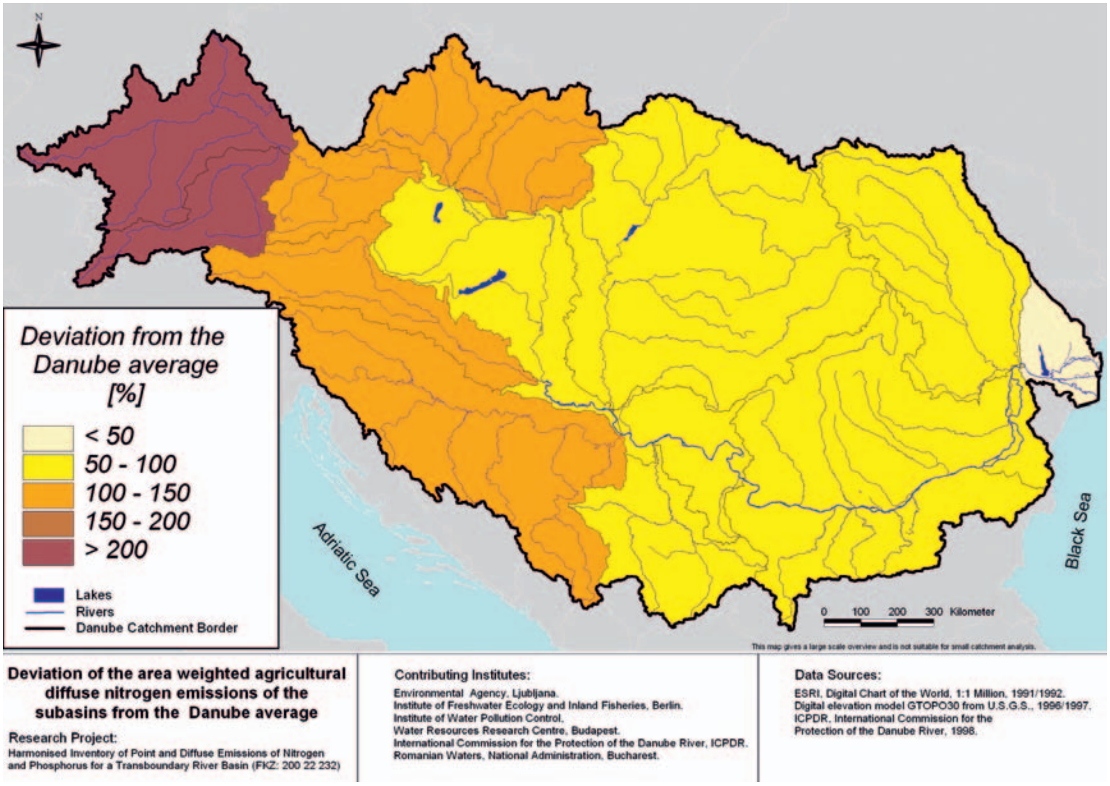
The situation for phosphorus is somewhat different. Because erosion from arable land is the main source of the agricultural diffuse pollution, it can be expected that sub-catchments with a high portion of arable land and mountainous areas have a higher emission from this source than the average of the Danube.

It should be noted that the information related to agricultural diffuse nutrient pollution should be treated as general estimates. This is because there is a need to take into account the problem of the spatial resolution of the statistical data and the incomplete harmonized data for the land use, as well as the discrepancy of the data sources. The land use patterns given by CORINE are for some countries much different to that of the statistical sources. This is in part due to the fact that CORINE does not include a separation into used and unused agricultural area. For the phosphorus emission calculations it should be noted that erosion into water, the main source of emissions, is based on a raw map of the soil losses in Europe. A new soil loss map is in preparation but at present not yet available.

Deviations of the specific total diffuse nitrogen pollution from agricultural activities

in the main sub-catchments of the Danube from the average for the period 1998-2000

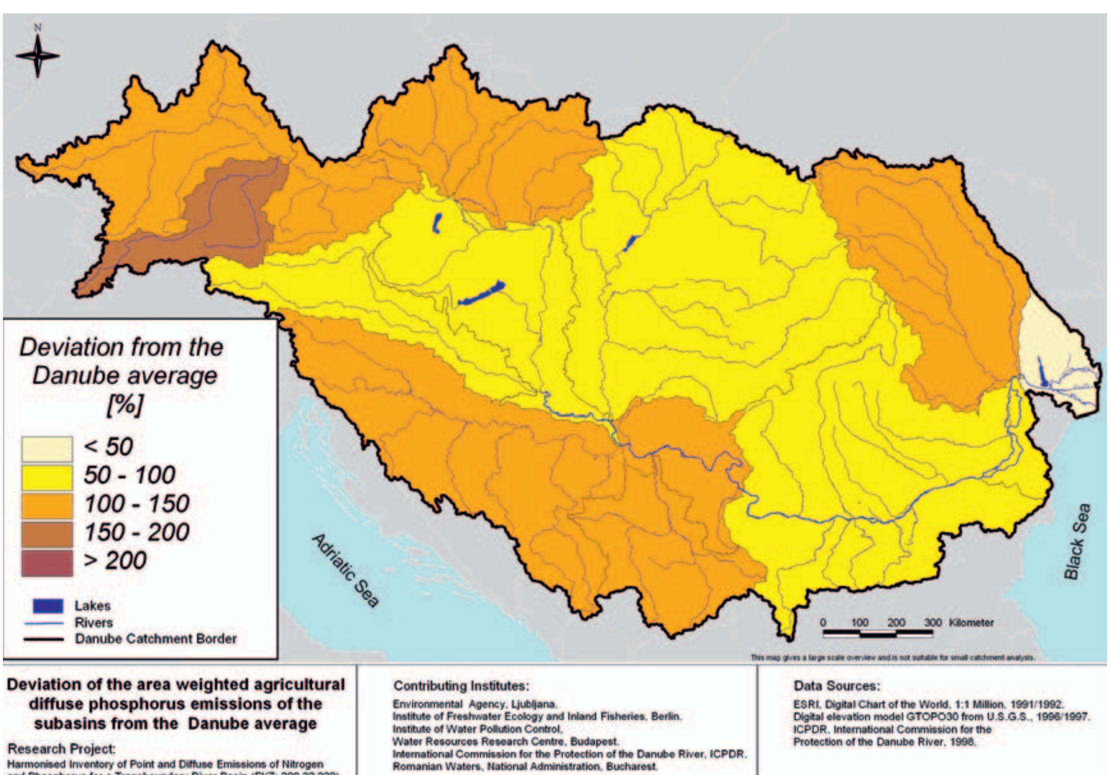
FIGURE 28



Deviations of the specific total diffuse phosphorus pollution from agricultural activities

in the main sub-catchments of the Danube from the average for the period 1998-2000

FIGURE 29



4.4.2.5. Historical development of the diffuse source nutrient pollution into the Danube River system

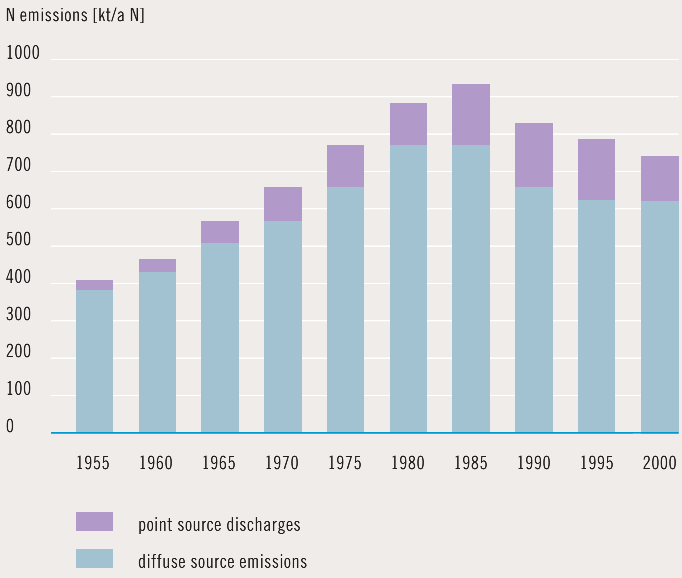
A historical look at the development of the Danube nutrient emissions from point and diffuse sources over the last 50 years has been prepared based on the results of the present situation, and a reconstruction by means of the model MONERIS (SCHREIBER et al. 2005, BEHRENDT et al. 2005). Figure 30 and Figure 31 show the results.

According to Figure 30 the diffuse source pollution of nitrogen is about doubled in the period in the 1950s to the mid of 1980s. In the 1990s this pollution is reduced by about 23 % mainly due to the reduction of the land use intensities as represented by the N-surplus on agricultural areas. The reduction of the nitrogen surplus is much larger, especially for the countries in the middle and lower part of the Danube, than the reduction of the diffuse nitrogen sources. This is due to the differences in the residence time in the groundwater and the different retention rates for nitrogen in the unsaturated zone and in the groundwater. The large residence times in the groundwater are responsible for the fact that a further reduction of the diffuse nitrogen emissions can be assumed in the next years if the N-surplus will remain on the present level.

The present level of the diffuse nitrogen emissions into the Danube river system is about 1.8 times higher than in the 1950s. One reason for the change of the total nitrogen emissions is the change of the point source discharges. The increase from the 1950s to the end of the 1980s is approximately a factor 5 and the decrease within the 1990s is about 20 %. This is due to a decrease in the number of industrial discharges in the lower Danube countries after the political changes and substantial improvement of waste water treatment especially in Germany and Austria.

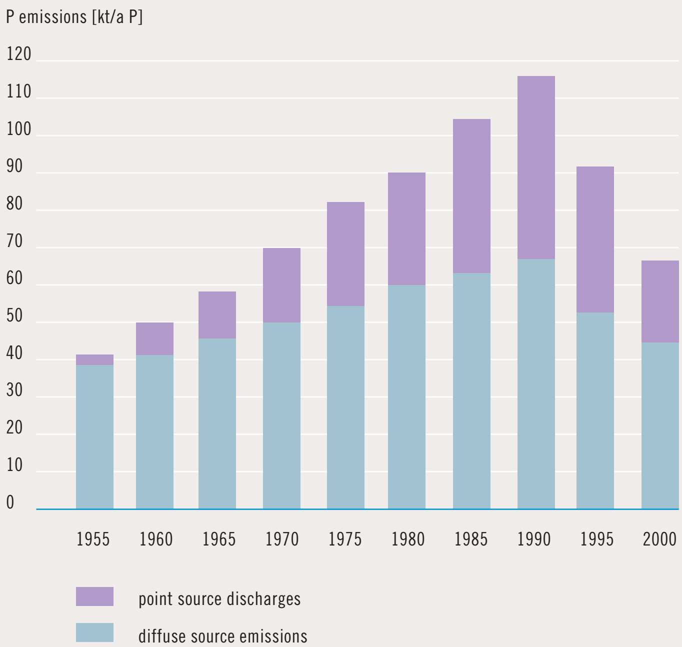
For total N-emissions, it was found that the present state is a factor of 1.8 higher than in the 1950s but about 23 % lower than in the late 1980s.

Temporal changes of the nitrogen emissions
into the total Danube river system for the years 1955 to 2000
(see also **Chapter 4.5.1.3**)* *FIGURE 30*



** result of the MONERIS application for this report*

Temporal changes of the phosphorus emissions
into the total Danube river system for the years 1955 to 2000
(see also **Chapter 4.5.1.3**); * *FIGURE 31*



** result of the MONERIS application for this report*

For phosphorus the changes in the amount of diffuse source pollution is much lower than for nitrogen. This is because, other pathways (erosion and surface runoff) are more responsible for the diffuse P emissions into the river system. In addition, the main indicators for the diffuse P emissions as a portion of arable land were changed in the past to a lesser extent than the N-surplus.

Further it should be noted that important pa-rameters for changes of diffuse P emissions by erosion over time, such as the change of the field size in the different regions of the Danube basin, are not available up to now.

If these uncertainties in the database and for the modelling are taken into account, the present level of diffuse P emissions into the Danube river system is probably more than 20 % above the level of the 1950s.

Changes in the amount of point source discharges of phosphorous are much higher than for the diffuse sources. For P, an increase by a factor of 4.6 was estimated from the 1950s to 1990.

This development in the amounts of P from point sources is the result of two overlapping effects – increase of the use of P in detergents and an increase in connection of population to sewers and WWTPs. The de-crease of the point P emissions is due to the replacement of P in detergents to a high proportion and the increase of P elimination in WWTPs. The consequence is that the reduction of point P emissions is more than 50 %. The present level in the upper Danube is already in the range of the 1950s. The change of the total P emissions is larger than for nitrogen. A reduction of about 40 % during the 1990s was estimated and the present level of the total P emissions is a factor 1.6 higher than in the 1950s. The reconstruction of the historical changes of the sources of nutrient pollution in the Danube shows that in the last decade a substantial reduction of nutrient pollution was reached in the Danube.

4.4.3. Other significant diffuse source pollution

Diffuse pollution results from broad-scale activities linked to the land use itself, and the land use intensities in both the urban and rural environments. This includes, for example, the application of fertiliser, forestry, inappropriate cultivation which can cause problems by increasing soil erosion on the effected land, livestock units on pastureland; handling and transport of oil, chemicals, raw materials and products, run-off from impermeable surfaces of roads, and urban and industrial areas. Industrial activities may generate diffuse pollution including oils and hydrocarbons, sediment, phosphorus, iron, acidifying pollutants through atmospheric emissions, and chemicals such as solvents. Dispersed settlements and atmospheric depositions (mostly caused by transport and traffic) also fall into the category of diffuse pollution.

The disposal of waste heat from industry or power generation processes can cause deterioration of water quality or alterations of the sedimentary environment and water clarity. These can lead to increased growth of microalgae and other nuisance flora.

Water pollution from navigation is linked to several diffuse sources. These include poorly flushed waterways, boat maintenance, discharge of sewage from boats, storm water runoff from parking lots, and the physical alteration of shoreline, wetlands, and aquatic habitat during construction and operation. A significant amount of solvent, paint, oil, and other pollutants potentially can seep into the groundwater or be washed directly into surface water. Many boat cleaners contain chlorine, ammonia, and phosphates – substance that can harm plankton and fish. Small amounts of oil released from motors and during refuelling activities contain petroleum hydrocarbons that tend to attach to waterborne sediments. These persist in aquatic ecosystems and harm the bottom-dwelling organisms that are at the base of the aquatic food chain. The discharge of sewage and waste from boats can degrade water quality.

Article 16 WFD sets out a strategy against the pollution of water and outlines the steps to be taken. WFD Annex 10 specifies 33 priority substances, which need to be taken into account when assessing the chemical status of surface waters. One third of these are pesticides. The WFD requests that the priority hazardous substances are phased out in the next 20 years after adoption of appropriate measures. The Directive also requests to identify additional chemical pollutants if they are of specific concern in the river basin district. For the Danube River Basin District the following four heavy metals have been identified in addition to the 33: Arsenic, Chromium, Copper and Zinc.

Additional pesticides that need special attention are mentioned in the following EU legislation:

- POPs Convention[26]:
  aims at the elimination or restriction of persistent organic pollutants (POPs),
- EU Authorisation under Directive 91/414/EEC[27] and 79/117/EEC[28]:
  only 2 of the Danube priority pesticides are fully registered in the European Union and listed in Annex I of Council Directive 91/414/EC. For three of the priority pesticides, registration will expire or has already expired and seven are still in the re-authorisation process. According to Directive 79/117, use of two of the priority pesticides is banned in the EU.

4.4.3.1. Analysis of priority pesticides used in the Danube River Basin District

The use of pesticides has declined significantly in most of the countries of the DRB since the political changes and the sector reforms of the early 1990s. These have disrupted the process of modernisation, specialisation and intensification of agricultural production.

Unfortunately, comparable data is not available for the whole Danube River Basin District, but FAOSTAT provides data for the CEE countries. The data of FAOSTAT shows a strong decline in pesticide use in the CEE countries to about 40 % of 1989 levels. This compares with a relatively small decrease in EU Member States during the same period. There are indications, however, that the use of pesticides in the CEE region is increasing again. Of concern is especially the fact that the expected economic development in the region may lead to a further increase of pesticide use.

Table 29 presents a summary of the national pesticide consumption according to the FAO statistics for seven of the Danube countries. The FAO database does not include data for the other Danube countries. The table shows that the total use of pesticides varies between 0.5 and 3.8 kg/ha agricultural area, and that, in general, herbicides are used most followed by fungicides and bactericides. A harmonised overview on pesticide consumption for all Danube countries is not possible at present.

Consumption of pesticides (in t/a)
in some Danube countries and specific pesticide consumption (kg per ha agricultural area and year) in the year 2001* *TABLE 28*

	DE	AT	CZ	SK	HU	SI	RO
Pesticide category	t/a	t/a	t/a	t/a	t/a	t/a	t/a
Fungicides and bactericides	7,912	1,336	1,050	537	1,637	921	2,802
Herbicides	14,942	1,436	2,590	2,136	3,149	362	3,960
Inorganics	1,959	99	272	0	684	504	0
Insecticides	1,255	0	157	175	298	81	1,110
Rodenticides	80	1	162	34	20	19	0
Total	26,148	2,872	4,231	2,882	5,788	1,887	7,872
Pesticide consumption	kg/ha·a	kg/ha·a	kg/ha·a	kg/ha·a	kg/ha·a	kg/ha·a	kg/ha·a
Specific pesticide consumption per ha agricultural area and year	1.53	0.82	0.99	1.18	0.94	3.77	0.53

** according to the FAO database on agriculture*

26 Stockholm Convention on persistent organic pollutants (POPs Convention).
27 Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market, OJ 1991 L 230/1.
28 Council Directive 79/117/EEC of 21 December 1978 prohibiting the placing on the market and use of plant protection products containing certain active substances, OJ 1979 L 33/36.

An additional source of information on pesticide use within the Danube countries is the report “Inventory of Agricultural Pesticide Use in the DRB Countries”[29]. The data collected presents a picture of the situation at the national level for eight countries (CZ, SK, HU, HR, BA, CS, MD and UA). An analysis has shown that 29 priority chemicals are used in the Danube River Basin in pesticide products. Of these only three priority pesticides are authorized for use in all of the DRB countries, while seven priority pesticides are not authorized in any of the countries.

Although pesticide use is currently relatively low in the DRB countries the risks of pesticide pollution remains:
– Priority pesticides, as well as other pesticides, are frequently detected in surface water and groundwater in the DRB and pose a serious hazard to the environment and human health.
– Seven priority pesticides are not authorised in the Danube countries; some of them continue to be of concern because of the existence of old stockpiles and residues in soils and sediments.
– The uncontrolled and illegal trade of pesticide products lead to the use of banned pesticides (e.g. DDT) by farmers.

An overall estimation of pesticide use in the Danube catchment is not possible. Detailed information is given in the national reports of the countries.

4.4.4. Significant hydromorphological alterations

According to Annex II, 1.4 WFD the Members States are requested to carry out an:
– “Estimation and identification of significant water abstraction for urban, industrial, agricultural and other uses,
– Estimation and identification of the impact of significant flow regulation, including water transfer and diversion, on overall flow characteristics and water balances, [and]
– Identification of significant morphological alterations to water bodies.”

These three categories of hydrological and morphological alterations are strongly interrelated and have therefore been summarised as “hydromorphological alterations” in the context of this report.

In addition, the separation of the pressures and the impacts resulting from hydromorphological alterations poses difficulties. Physical alterations of the environment may have severe impacts on the abiotic sphere as well as on the ecology and the ecological status of the ecosystem. The evaluation of hydromorphological alterations in combination with biological assessment is a new territory for the Danube River Basin countries as it is for many countries in Europe. In the past decades, biological monitoring of rivers in the Danube River Basin has focused mainly on detection of effects due to organic pollution (often referred to as “classical” biological water quality monitoring). Although information on hydrology and morphology has been recorded in many countries (e.g. Romanian Water Cadastres, German LAWA ‘Strukturgütekarte’), interrelationship between hydromorphological alterations and ecological status of rivers was hardly considered. Being an innovative subject, only a few countries have already developed systems / criteria to integrate hydromorphological alterations into the ecological assessment (see national reports). Therefore, this chapter deals primarily with the abiotic/physical effects of hydromorphological alterations whereas Chapter 4.5.1.4 focusses on the biological and ecological impacts. Nonetheless, the separation of the two is not always easy so that some overlap is unavoidable.

Three main hydromorphological driving forces have been determined as most relevant on the basin-wide scale: hydropower generation, flood defence and navigation. Gravel and water abstraction as well as outdoor recreation activities and fisheries have been identified as being of minor or local importance.

Map 7 presents information on dams (for hydropower generation as well as water abstraction purposes), flood defence/river regulation and navigation for the Danube and the main tributaries. The specific details may be found in Annex 5 on the
– free flowing sections,
– length of impounded sections and associated dams (especially of hydropower plants),
– strongly regulated sections characterised by artificial banks and/or dikes along the main river,
– navigable sections and harbours.

The following descriptions provide an overview of the main hydromorphological alterations displayed in Map 7. Morphological alterations are often undertaken for more than one use and often overlap with each other (e.g. river canalisation for flood protection and navigation). At present overall quantitative information on single pressures related to the driving forces is not available.

Danube River Basin District – Major Hydraulic Structures MAP 7

29 UNDP/GEF (2004).

4.4.4.1. Hydropower generation

The major pressures of basin-wide importance resulting from hydropower use are

- disruption of the longitudinal river continuity by artificial in-channel structures,
- alteration of the hydraulic characteristics.

Other important pressures[30] are

- other alteration of the river course and channel form,
- disruptions of lateral connectivity,
- alteration of the hydrological (discharge) regime,
- possible effects on drinking water supply due to sedimentation processes.

The interruption of the longitudinal continuum occurs as a consequence of the existence of several chains of hydropower plants in the Danube itself and along many tributaries. Over 700 large dams / weirs exist on the DRB main tributaries. A large number of these dams and weirs impound the rivers on which they are built. Impoundments change hydromorphological conditions by modifying water depth and river width, changing flow characteristics (reducing flow velocity) and interrupting natural sediment transport as well as the migration way of biota (see Chapter 4.5.1.4). Not all of the dams displayed in the map are constructed for hydropower generation, some of them are built for water abstraction, e.g. on the Danube downstream Budapest or the Cunovo weir, which diverts water to the Gabcikovo hydropower plant. The upper part of the Danube was ideal for building hydropower plants that operate in running mode due to advantageous slope conditions ranging between > 1 ‰ and 0.4 ‰. In the first approximately 1000 rkm – from the source down to Gabcikovo – 59 dams are present, many of them built decades ago. In this section, the Danube is interrupted by a dam and accompanying impoundment on average every 16 km. Only very few stretches can still be characterised as free-flowing. These sections are Vohburg-Weltenburg and Straubing-Vilshofen in Germany, and Wachau and Vienna-Bratislava in Austria.

Downstream of Bratislava three more hydropower plants exist, which interrupt the free-flowing conditions. The first of these, the Gabcikovo dam system, operating since 1992, diverts approximately 80 % of the Danube river water into a side-canal and the reservoir. The remaining 40 km of the original river bed are affected by a lack of water. The diversion and the flood protection works affect the surrounding wetlands on both sides of the Danube (see Chapter 4.5.1.4).

What major effects hydropower dams can have is illustrated on the special case of Iron Gates I and II (see textbox page 76).

Hydromorphological effects as described for the Iron Gate case study can also be seen on other large hydropower dams such as Gabcikovo Hydropower Plant. The impacts on the aquatic environment of these dams on the Middle and Lower Danube are described in Chapter 4.5.1.4.

In total, the Danube is impounded on approximately 30 % of its length. The above mentioned chain of hydropower plants in Austria and Germany as well as the Iron Gate section are provisionally identified Heavily Modified Water Bodies, because the water body shows "substantial change in character", which is widespread, permanent and affecting both hydrological and morphological characteristics (for details Chapter 4.6).

Chains of hydropower dams are also present in the main tributaries of the Upper Danube, which originate in mountainous areas, such as Iller, Lech, Isar, Inn, Salzach and Enns. River Lech for example, is impounded on over 90 % of its length by 32 dams. 29 out of these operate by hydropeaking, an operating mode used at various impounded mountainous tributaries (e.g. Inn, Salzach, Enns). Hydropeaking and pulse release cause special problems. Water from different smaller brooks or tributaries is often diverted through pipelines into large reservoirs, leading to residual flow and droughts in river beds. Water is then released by pulses several times per day resulting in non-natural water level fluctuations. On the Danube such fluctuations can be observed approximately down to Melk. Tributaries in the middle and lower DRB with steeper gradients such as the Mura, upper parts of the Sava and Drava, Olt, Arges and Bistrita are also influenced by numerous hydropower dams built on these rivers. The Olt, for example, is impounded by a chain of 24 hydropower dams over the last 307 km of its total length of 615 km.

30 Information on major pressures due to MOOG & STUBAUER (2003).

Pressures from hydromorphological alterations Case study: Iron Gates I and II on the Danube River

History of the modifications:

Iron Gate I and II, located in the transboundary area of Romania and Serbia and Montenegro, impound the Danube up to Novi Sad. The Iron Gate I dam was completed in 1972. The hydropower plant (HPP) operation regime is adjusted to the hydraulic/hydrologic conditions on the mouth of the Nera river (rkm 1,075) at the end of the common part of the Danube. The HPP operates as run-off-river, covering peak demands, which is enabled by the Iron Gate II reservoir (completed in 1985). The operating rules of the HPP were gradually changed from the initial phase (impoundment up to 7,500 m^3/s) to the present (impoundment up to 11,500 m^3/s).

Geography and hydrology:

Reservoirs have variable height of water levels and extent of backwater zone that depend on the inflow and the power-plant operation. At low flow the backwater zone extends up to the Danube River for 310 km (up to Novi Sad), into the Sava River (100 km) and the Tisza River (60 km), and many small tributaries. At high flow the backwater zone extends to rkm 1,075. The average volume is 3.5 109 m^3, and the surface area of the reservoir is on average 330 km^2. The Iron Gate II reservoir is 80 km long; the average volume is 0.8 109 m^3, and its area is 79 km^2. The average annual discharge is 5,550 m^3/s for both dams. There are two distinct parts of the Iron Gate reservoir: the lowland areas upstream of the mouth of the Nera river (rkm 1,075), and the downstream reach in the Iron Gate Gorge. The latter part has a very rich archaeological, historical and tourist potential, and the Nature Park Iron Gates was established to protect its special natural habitat.

Important uses:

- Hydropower: Iron Gate I is the most important hydropower plant (HPP) on the Danube River, with installed power 2 x 1,050 MW, and average energy output 2 x 5,250 GWh/year. The characteristics of the Iron Gate II HPP are 2 x 270MW and 2 x 1,320 GWh/year, respectively.
- Navigation: Navigable conditions on the formerly very dangerous Djerdap section of the Danube are completely improved, and navigation is possible all over the year. From Belgrade (rkm 1,170) to the Iron Gate II (rkm 863), the Danube is a VII class waterway according to the ECE classification (ECE/TRANS/SC.3/131), while upstream it is a VIa class waterway.

Significant physical alterations constructed to serve the uses of water at the Iron Gate I and II dams:

- The Iron Gate I dam consists of two symmetrical parts, each comprising a navigation lock, earthen non-overflow dam, a hydropower plant (with 6 turbines) and concrete gravity overflow dam (14 spillways, each 25 m wide, with double table-gates, enabling evacuation of a 1,000 year flood). The dam is 60 m high and 1,278 m long. The hydropower plant (HPP) head is 21-35 m, with an installed capacity of 8,700 m^3/s.
- The Iron Gate II system consists of two dams: one on the main Danube channel (30 m high, 1,003 m long, with concrete overflow part, HPP plants and CS navigation lock) and one on the Gogos branch (with overflow dam and HPP). The hydropower plants are equipped with 20 turbines. The HPP head varies from 5 to 12.75 m, according to the river flow.

Significant changes linked to the physical alterations:

- Changed hydromorphological conditions. The Iron Gate I reservoir provides a daily and sometimes weekly flow regulation. Water velocities are considerably reduced in comparison to the natural river regime. The low water level is elevated 33 m at the dam, and 2.5 m about 230 km upstream (near Belgrade). The high water level is 19 m higher at the dam, while 132 km upstream it is nearly the same as natural.
- Reduced sediment transport capacity, followed by sediment deposition, which mostly occurs between the Iron Gate I dam and km 1,075 (in the CS-RO part of the reservoir). Particularly intense sedimentation is present in one part of the gorge (between km 970 and km 1,003). Deposits are composed of fine silt and sand, covering the rocky riverbed and former floodplains. Sediment deposition induced the gradual increase of high water levels upstream, reducing the safety of the existing flood protection system.
- Raised ground water table in the lowlands of the Serbian territory, which endangers many settlements, industrial, municipal and transportation facilities, as well as the agricultural production in the riparian belt.
- Increased forming of ice and decreased ice transport capacity in the upstream parts of the Iron Gate I reservoir.

Dams and weirs have an important effect on natural sediment transport. Studies in Germany have shown, that a former load of 180 000 tons per year from the River Lech into the Danube decreased to nearly zero by 1960. The same can be said for River Inn, where a former 540 000 t/a of sediment transport was decreased to 180 000 t/a by 1960 and is today nearly zero[31]. Interruption of sediment transport has two important effects. Upstream of a dam the sediment is retained and often has to be extracted or flushed out during floods to maintain river depth for hydropower generation and navigation. For example, gravel extraction of approximately 15 000 m^3/a is necessary on the River Traun on the impounded section of Abwinden–Asten in Austria, which acts as a sediment trap[32]. In the backwater zone of the Iron Gate, 325 million tons of sediment accumulated between 1972 and 1994, and fill 10 % of the entire reservoir capacity.

Downstream of dams the loss of sediment transport requires artificial donation of material to stabilise the river bed and to prevent incision. This is the case downstream of the Freudenau dam where addition of 160 000 m^3 bed load per year is required[33]. Immediately downstream of the Iron Gate Dams, incision of the riverbed is monitored, as a result of change of flow and sediment regime. The overall reduction of sediment transported by the Danube over long-term leads to intensive erosion on unregulated banks and islands in the Lower Danube region, e.g. Tcibtriza-Island, Belene Island, Garla Mare, Calafatul Mic or Cama-Dinu. Increasing coastal erosion along the 244 km stretch of the Romanian seashore between Musura arm and Vama Veche, an area which represents 6 % of the total Black Sea seashore, is also partly caused by reduced sediment transport by the Danube. Recent measurements (1980 - 2003) of erosion processes at the sea-land interface have indicated that erosion is more accentuated in the northern area of the seashore (Sulina – Vadu).

4.4.4.2. Flood defence measures

Most of the larger rivers in densely populated areas are characterised by anthropogenic modifications for flood protection and to secure land for urban development. In many cases, hydro-engineering structures have multiple purposes often resulting in changes of the river character, e.g. straightening of a meandering or anabranching river. These changes affect not only the river itself but larger areas of the valley floor.

Major systematic regulations for flood defence and navigation purposes began in Austria in the 19^{th} century. On the present territories of Hungary, Serbia and Montenegro, Bulgaria and Romania first dike systems for flood protection along the Danube were already built in the 16^{th} century, but were intensified in the 19^{th} and 20^{th} century. The former extensive floodplains with numerous side arms and backwaters were largely altered into canalised and straightened waterways with distinct river bank reinforcement. As a consequence, today only less than 19 % of the former flood plains in the Danube basin, compared to the situation 150 years ago, remain. The area of floodplain affected by river regulation/flood defence is large – in Hungary for instance 2.12 million ha were diked.

These facts point out the basin-wide importance of river regulation works and flood defence measures. The major pressures resulting from flood defence are “alteration of the river course and channel form/profile”, “flood defence dams, set-back embankments, dykes”, “alteration of the hydrological/hydraulic characteristics” and “alteration of the bank vegetation and banktop land use”. Compared to pressures resulting from hydropower generation, where the disruption of the longitudinal continuity is most important, flood defence measures affect mainly the lateral connectivity.

In the upper part of the Danube in particular, river regulation works for flood defence often go hand in hand with alterations due to impoundments. The effects of these alterations on the river overlap with one another. For example, on the rivers Inn, Salzach and Enns chains of hydropower plants are built and almost the entire river stretches are strongly regulated. On the Inn, for example, less than 20 % can still be classified as free-flowing which means not impounded or not strongly regulated.

The Danube itself is regulated along over 80 % of its length. Due to hydraulic works aimed at navigation improvement oxbows have been locked or filled up, and major floodplain complexes separated from the natural hydrological conditions of the Danube. Discontinuity between the river and its accompanying floodplains reduces the hydrological connectivity leading to changes in frequency and duration of floods and degradation of the former floodplains. The examples for loss of flood plains are manifold. In the 19^{th} and 20^{th} century, altogether 15-20,000 km^2 of the Danube floodplains were cut off from the river by engineering works[34]. On the Tisza River drainage projects reduced a formerly large floodplain to a very narrow one, resulting in an 84 % loss, from 7542 km^2 to 1215 km^2. The meandering river bed was shortened by 32 % by river regulation works. Today, the Tisza can be classified as strongly regulated along more than 70 % of the total river length.

31 BANNING (1998).
32 SCHIMPF & HARREITER (2001).
33 SCHIMPF & HARREITER (2001).
34 KONOLD & SCHÜTZ (1996).

In the Sava River area, in particular in the area of the Nature Park Lonjsko Polje, there is an example of possible co-existence between the complex solution of flood control and conservation of natural, landscape and cultural values of national and international importance.

In the Danube Delta, more than 100,000 ha (most of them temporarily flooded areas) were embanked. It must be noted that between 1994 and 2003 about 15 % of the area with embankments have been re-connected to the natural influence of water, through ecological restoration works. In the Razim-Sinoe system coastal area, an amount of 23,500 ha have been embanked. The separation of the main river from the backwaters results in a loss of habitats, which affects the aquatic fauna and flora (see Chapter 4.5.1.4).

Large dikes and disconnected meanders and side-arms also reduce the dynamics of the groundwater by suppressing the exchange of surface and groundwater. This is important for re-newing river bank filtrate used for drinking water supply.

4.4.4.3. Navigation

Navigation routes in the DRB are restricted to the Danube itself and the lower portions of some tributaries (see Map 7). Regulation works for navigation in the Upper Danube region started already in the 19th century and led to a straightening and shortening of the main Danube bed and creation of one main channel for navigation. In Lower Austria for instance, lateral dams were built between 1898 and 1927 to narrow the river width. In Hungary, the Danube was shorted by cutting-off meanders from 472 km to 417 km.[35]

At present the Danube is navigable from Ulm down to the Danube Delta. From Kehlheim (rkm 2411) to the Delta the Danube serves as an international waterway. These 2411 km are equivalent to 87 % of the Danube's length. 78 harbours[36] are located on the Danube between Kelheim and the Black Sea. Therefore, navigation is of multilateral importance.

In the upper part of the DRB, navigable tributaries are Morava (about 30 % of its total length), Raba (29 km at the mouth) and Váh (71 km, equals 20 % of the river length). The Drava is navigable on approximately 20 % of its length. The Tisza River is used as a waterway from the Ukrainian-Hungarian border to the confluence with the Danube, which is over 70 % of the total river length. Some Tisza tributaries are navigable on shorter sections: Bodrog (Hungarian stretch and 15 km in the Slovak Republic), Mures (25 km, which corresponds to less than 5 % of its total length), Körös (115 km in Hungary) and Bega (117 km in Romania and Serbia and Montenegro, which is over 48 % of the total river length). On Sava, navigation is possible on over 50 % of the river starting from Croatia down to the mouth in Serbia and Montenegro.

Additional artificial waterways were built along the Danube for transport purposes. These include the Main-Danube Canal in Germany providing a link to the Rhine and the North Sea, the Danube-Tisza-Danube Canal System in Serbia and Montenegro, and the Danube-Black Sea Canal in Romania. A detailed description of these waterways is given in Chapter 3.6.

The (hydro)morphological alterations constructed for navigation purposes are manifold and often overlap with changes from hydro-power impoundments and flood protection. These include building weirs with sluices, regulation, canalisation and bed stabilisation. Unfortunately detailed quantitative information about pressures resulting from navigation in the DRB is currently not available.

One of the main pressures resulting from navigation is the effects related to channel maintenance. Sediment excavation and flushing of areas is undertaken where sediment accumulates and hampers navigation. Studies have shown that on the Austrian Danube, up to 60 % of the river bed deepening in several sections downstream Vienna was caused by increased regulation and dredging activities for securing waterway transport[37]. Yet, a recent ruling by the Austrian Supreme Water Authority only permits dredging in the Danube, if no more than 50 % of the dredged material is used for structural measures on the river banks and the rest of the material is deposited in the river such that it can be continuously mobilised by the flow of the river.

In the lower Danube region, lateral river bed erosion dislocates the navigation channel in the Danube. Additional river training works as well as dredging of shallow fords to maintain the minimum shipping depth are carried out. In the Danube delta, dredging is also an important problem. Already at the beginning of the 20th century, but especially in the last decades canals were dredged in the interior of the Delta. The total length of artificial water channels in the Delta created by dredging amounts to over 1,700 km, which is as much as the total length of natural water courses.

Other pressures related to navigation are e.g. alterations of the river course or disruption of the lateral connectivity by detaching side arms, tributaries and wetlands, have been described earlier. Environmental impacts resulting from navigation are mentioned in Chapter 4.5.1.4.

35 IHD (1986).
36 via donau (2004).
37 BERNHART et al. (1987).

4.4.4.4. Water transfer and diversion

Water transfer and diversion is generally an issue of local or regional importance and dealt with in the national reports (Part B). Nonetheless, it should be mentioned that in one case water is diverted from the Danube basin into another river basin (district). Through the Main-Danube-Canal water is abstracted from the Bavarian part of the Danube River at Kehlheim and diverted to the Rhine River Basin (see Map 7).

Background information: In Bavaria, the water resources are subject to highly varied conditions. Whereas Southern Bavaria is rich in water due to his high precipitation, water is short in supply in large parts of Northern Bavaria (Franconia). At times of low discharge, there is three times more water available per inhabitant in the Danube region in comparison to the Main region. For this reason, a supra-regional compensation system has been created between Southern and Northern Bavaria, i.e. between the Danube and the Main region. Depending on the needs and the discharge of the Danube up to 20 m^3/s or 125 Mio m^3/year are transferred to the Main i.e. Rhine river basin.

With the transfer, the following principal objectives are achieved:

- improvement in the quality of the water at times of low discharge,
- compensation for evaporation losses caused by the operation of the thermal power stations,
- reduction in the number of floods in the valley of the middle Altmühl in summer.

The water is transfered via two separate routes:

- water from the Danube is pumped to Lake Rothsee via the Main-Danube-Canal, from where it is distributed as the need arises,
- water from the Altmühl is collected in Lake Altmühlsee, then transferred to Lake Brombachsee and used in times of water shortage.

4.4.4.5. Future infrastructure projects

In addition to the significant degradation of the Danube and its tributaries caused by existing hydromorpological alterations, a considerable number of projects on navigation, hydropower and flood defenses are at different stages of planning and preparation. A non-exhaustive list of such future projects is enclosed in Annex 6.

One prominent set of projects with Danube-wide importance are included in the Trans-European Networks (TENs) agreed by the European Union[38]. The projects related to the Danube aim at reducing the "bottlenecks" in the Danube, in order to increase capacity of navigation and thereby shifting transport from the roads to the waterways. Whilst this certainly has a favourable impact on the reduction of greenhouse gases from transport, these projects may have a negative impact on the Danube since they are affecting the last free-flowing sections.

The pressures and impacts that result from all these envisaged projects are similar to those described in Chapters 4.4.4.1, 4.4.4.2 and 4.4.4.3). In addition to these severe ecological impacts (including the effects on drinking water supplies) from these future hydro-engineering projects, other pressures are likely to increase as well, e.g. the pollution loads from navigation (e.g. oil spills, antifouling agents, etc.) are likely to increase as well due to the significant increasing of shipping.

Although, to date, it is not possible to quantify the overall pressures and impacts of these projects, it is possible that the implementation of projects will lead to a deterioration of the current status of the water bodies affected. Hence, these projects fall under Article 4, Paragraph 1 (a). In order to respect the requirements of the Water Framework Directive, such projects must fulfil the conditions set out in Article 4, in particular the provisions for new modifications specified in Article 4, Paragraph 7 which require that:

"(a) all practicable steps are taken to mitigate the adverse impact on the status of the body of water;
(b) the reasons for those modifications or alterations are specifically set out and explained in the river basin management plan required under Article 13 and the objectives are reviewed every six years;
(c) the reasons for those modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the objectives set out in paragraph 1 are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development, and
(d) the beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option."

In addition, the effects of these modifications on other water bodies should be avoided (cf. Article 4 (8)).

In consequence, these future projects must be subject to an Environmental Impact Assessment and/or a Strategic Environment Assessment during the planning phase which takes account of the pressures and impacts to the aquatic environment and ensures that the above-mentioned conditions are met. If these assessment cannot justify the use of the derogations introduced in the WFD, these projects would result in breaching the objectives of the Directive. Hence, all the stretches for which such projects are envisaged (based

38 Decision No 884/2004/EC of the European Parliament and of the Council of 29 April 2004 amending Decision No 1692/96/EC on Community guidelines for the development of the trans-European transport network (Text with EEA relevance), OJ 2004 L 167/1.

on list in Annex 6), the current analysis must identify them as being "at risk of failing the objectives of the Water Framework Directive" unless it can be demonstrated that there is no deterioration of status.

Depending on the scale of the above-mentioned project, it is possible that significant transboundary effects will occur. The International Commission for the Protection of the Danube River should be used by the Danube countries as a platform to facilitate and promote information exchange and transparency with regard to the possible transboundary impacts of projects, plans and programmes affecting the aquatic ecosystem, and thereby also contributing to commitments under the Espoo Convention[39].

4.4.5. Other significant anthropogenic pressures

4.4.5.1. Accident Pollution

To prevent the surface waters from pollution caused by accidents it is necessary to establish an efficient basin-wide warning system and to adopt the appropriate precautionary measures to minimize the risk from accident pollution. In the past the ICPDR put strong efforts to the sector of accident prevention and control by establishing an Accident Emergency Warning System as well as by developing the effective accident prevention policy.

Accident Emergency Warning System (AEWS) of the Danube River Basin

The need for an accident emergency warning system is recognized in Article 16 of the Convention on Cooperation for Protection and Sustainable Use of the Danube River. The general objective of the system is to increase public safety and protect the environment in the case of an accidental pollution by providing early information for affected riparian countries. The first stage of the Danube AEWS came into operation in April 1997 in Austria, Bulgaria, Czech Republic, Croatia, Germany, Hungary, Romania, Slovak Republic and Slovenia. Ukraine and Moldova entered the system in 1999; Bosnia i Herzegovina, and Serbia and Montenegro are joining at present.

AEWS system set-up and tools

In the participating countries so-called Principal International Alert Centres (PIACs) have been established. The main function of these centres is to propagate the warning message at the international level.

Each PIAC has three basic units:
- the Communication Unit, which sends and receives warning messages,
- the Expert Unit, which evaluates the possible transboundary impact of an accident,
- the Decision Unit, which decides about international warnings.

PIACs have 24-hour attendance at the communication unit.

The procedures for the AEWS operation are described in the International Operation Manual, which is translated into the national languages of the Danube countries. Satellite communication with Information Processing System and faxes were established with the support of the Phare programme and are used for the fast transmission of the messages. The Expert Unit uses the database of dangerous substances to evaluate the possible impact to the environment and the Danube Basin Alarm Model to assess and forecast the transfer of pollutants in the river network.

AEWS operation

The Danube AEWS is activated in the event of transboundary water pollution danger or if warning threshold levels are exceeded (see Annex 7). The AEWS operation has been tested many times during various Danube alerts. Since the official start of its operation in May 1997, 37 accidents were registered by AEWS until December 2003. The most frequent pollutant was oil in 48.6 % of cases. The cause of an accident was identified only in 12 cases. A significant proof of the efficiency of AEWS was done during the Baia Mare and Baia Borsa spill accidents on the Tisa River in January and March 2000. A sound operation of the system enabled timely activation of measures preventing larger damages of the Tisa River ecosystem.

AEWS development

A substantial upgrade of AEWS is being carried out to make the whole system more effective and cost-efficient. The satellite-based communication is being replaced by a web-based communication using Internet and SMS messages to be an integral part of the ICPDR information system (Danubis). Simultaneously, the AEWS supporting tools (Danube Basin Alarm Model and database of dangerous substances) are continuously improved. Importance is given to regular trainings and experience exchange of the PIAC's staff to support the proper operation of the AEWS.

At present, the system deals only with accident spills but it is planned to extend the system activities in the future to ice and flood warning.

ICPDR Accident Prevention

The environmental disasters caused by the cyanide accident in the Tisa River Basin on 30 January 2000 proved that inadequate precautionary measures at Accident Risk Spots (ARS) could lead to massive harmful effects to humans as well as to the environment. Consequences of such events lead to significant economic impacts on entire regions. The lessons learned out of the cyanide spill are that the ICPDR has to pay attention to a better prevention as well as to a better preparedness for such accidental events.

39 Convention on environmental impact assessment in a transboundary context (ESPOO-Convention).

Therefore, the prevention activities of the ICPDR are focussed to following key elements:

1. To identify the ARS in the Danube River Basin
2. To establish the respective safety measures minimizing the risk potential.

The general structure of this strategy is demonstrated below:

ICPDR ACCIDENT PREVENTION

- **ARS-Inventory**
  - **Industrial Sites**
    - WRI-Methology
  - **Contaminated Sites**
    - M1-Methology
- **Safety Measures**
  - **Recommendations**
    - Basic Safety Requirements
    - Safety against Floods
    - Safety of CS
  - **Checklists**
    - CS
    - Industrial ARS

ARS-Inventory

The ARS Inventory is subdivided into two main parts:

1. Industrial Sites (ongoing activities)
2. Contaminated Sites (closed-down waste disposal sites and industrial installations in flood-risk areas)

In both cases a specific methodology was developed to

(i) identify potential ARS and

(ii) establish a ranking system to evaluate a real risk.

For ARS based on industrial activities the ICPDR developed a method for evaluation of potential risk. The methodology used was based on the transposition of amounts of hazardous substances stored in a particular site into the Water Risk Class 3 – equivalents (according to a German assessment system). From the sum of WRC 3 – equivalents a so-called WRI (water risk index – a logarithmic unit) was calculated to evaluate the overall risk potential of the site. Application of this procedure resulted in preliminary ranking of potential Accident Risk Spots in the Danube River Basin. The ARS inventory was finalized in 2001 for most of the Danube countries and updated in 2003 with the contributions of Austria and Bosnia i Herzegovina (see Map 8).

The floods of August 2002 highlighted the problem of inundation of landfills, dump sites and storage facilities where harmful substances are deposited. Transfer of toxic substances into the water may occur posing an additional threat to the environment. Therefore, in addition to the ARS Inventory based on ongoing industrial activities it was decided to prepare an inventory of contaminated sites related to closed-down waste disposal and industrial installations in flood prone areas. To enable preassessment of contaminated sites a special so-called M1-Methodology was elaborated. This methodology is used as a tool for a screening and preliminary ranking of suspected contaminated sites with regard to their risk potential. After this pre-ranking, further assessment using flood probabilities will have to be carried out (see Map 9).

Finally, it has to be stressed that, at present, both inventories and related maps reflect only potential dangers; the actual danger to the environment can only be determined on the basis of safety measures that have been put in place including a thorough site analysis. This will predominantly be a national task still to be performed.

Safety Measures

The philosophy of water protection, as seen in relation to industrial installations in developed industrial countries is based on the assumption that the potential hazard to water bodies can be compensated by comprehensive technological and organisational safety precautions.

An evaluation of the quality and quantity of prevention, or of the safety rating of the ARS concerned, is therefore one of the major future tasks of the ICPDR.

Danube River Basin District – Potential Accident Risk Spots *MAP 8*

Danube River Basin District – Old Contaminated Sites in Potentially Flooded Areas *MAP 9*

For this purpose two major instruments are used by the APC EG:

- Recommendations for safety guidelines as supporting instruments for the Danube member states to improve the current standard of safety measures and
- Application of existing and development of new checklists to control the implemented safety measures at existing ARS.

Concerning safety recommendations the ICPDR is building up on the work and experience of other river commissions.

Two important documents were elaborated by the ICPDR:

- "Basic Requirements for installations handling water endangering substances"
- "Safety Requirements for contaminated sites in flood-risk areas"

The application of existing and the development of new checklists to control the realized safety measures at existing ARS is related to this work. The "Checklist-methodology", which was developed by the German Federal Environmental Agency (Umweltbundesamt, UBA) on the basis of the safety recommendations of the International River Commissions of the Rhine and the Elbe River was proved to be the best solution to check and improve the technical safety level. Using this methodology it is possible to identify for the accidental risk spots all necessary safety measures applicable in a short-, medium- and long-term basis for fulfilling the safety standards of the EU. The ICPDR recommended the use of this methodology in the Danube countries. In the near future the ICPDR will focus on the development of a checklist for "Safety requirements for contaminated sites in flood-risk areas".

4.4.5.2. Fisheries

Fisheries are mainly important locally and in some places may still constitute an important source of income. At present, no data is available for the Danube basin on an overview scale. Where relevant this information will be given in the National Reports (Part B).

The issue has been addressed in this report since there are some significant impacts on aquatic species such as the sturgeon or the sterlet that are of basin-wide interest (see Chapter 4.5.1.4 and 4.5.1.5).

4.4.5.3. Invasive species

Results of hydrobiological surveys carried out along the Danube River indicated already that permanent colonization of new species is going on. Large scale engineering activity and river training works on the original European river systems resulted in a complicated water network consisting of interconnected canals and highly regulated water bodies that facilitated shipping and transporting all around Europe. The increased volume of the traffic between continents resulted in the exchange of several faunal elements, too. This was never observed before in European water bodies, due to geographical barriers.

Most of the factors influencing the faunal exchange process originate in human activity such as water engineering, traffic along the European and the intercontinental water network. Additionally, artificial introduction, natural colonization processes due to the transmission of other species or the increased spreading ability of the given species itself play an important role in this phenomenon.

The temporal and spatial processes of the faunal exchange between the different parts of Europe and the other continents are well documented mainly by German and Dutch scientists. According to several authors[40] there are different possibilities for non-indigenous species to invade new rivers in the continent. Two main directions of frequently observed colonization are described: East-West for the pontocaspic and West-East for the Northwest European taxa. However, some pontocaspic species could reach the western part of Europe via the northern Dnjepr-Pripet-Bug-Weichsel-Netze-Oder river chain that is connected to the Mittellandkanal in Germany. This means that some pontocaspic species could have reached the upper stretches of the Danube from the Rhine.

Some countries in the DRB have sufficient data about invasive species, but in the majority of the Danube countries data sources or information on neozoa and neophyta is not available. A new investigation on the significance of alien animal and plant species (neobiota) in Austria[41] informs that 46 animal species, 35 plant species, and 6 fungus species can be regarded as invasive or potentially invasive species. They cause problems mainly in river floodplain forests and in riverine wetlands.

40 BIJ DE VAATE & KLINK (1995), BRINK VAN DEN et al. (1989), BRINK VAN DEN et al. (1990), BRINK VAN DEN et al. (1993), FOECKLER (1987), FONTES & SCHÖLL (1994), KINZELBACH (1995), KOTHÉ (1968), SCHLEUTER et al. (1994), SCHLEUTER & SCHLEUTER (1995), TITTIZER et al. (1993), TITTIZER et al. (1994), TOBIAS (1972), WITTMANN (1995), SCHÖLL et al. (1995), TITTIZER (1996a), TITTIZER (1996b).

41 ESSL & RABITSCH (2002).

Neozoa

Macrozoobenthos

Few Neozoa species are well known in the different sections of the Danube River since the beginning of the 20th century *(Viviparus viviparus, Dreissena polymorpha)*. Many species originated from the vicinity of the Black Sea and migrated westwards. Several ponto-caspic taxa started to occur on the upper section only from the middle of the 20th century *(Hypania invalida, Lithoglyphus naticoides, Theodoxus danubialis, Dreissena polymorpha, Corophium curvispinum, Jaera istri)*. Others could reach the upper stretch from the Black Sea closed to the end of the 20th century only *(Cordylophora caspia, Valvata naticina, Chaetogammarus ischnus, Dikerogammarus villosus)*.

At present there are not so many species that arrived from the Western European region, such as the Rhine River or the Atlantic coast *(Potamopyrgus antipodarum, Theodoxus fluviatilis, Corbicula fluminea, C. fluminalis, Eriocheir sinensis)* but their number will most probably increase in the future.

The velocity of the colonization can be very different, similarly to the different survival or reproduction strategies of these animals. Recent international surveys (ICPDR 2002) indicated that there are some major changes concerning the Neozoa species added to the original Danubian biota. The Chinese Pond Mussel *(Sinanodonta woodiana)* is expanding slowly from the middle Danube to the upper and the lower section stretch since the 1960s. The snail *Theodoxus fluviatilis* was found in the Hungarian Danube stretch first in 1987 at Budapest. At present this snail species has an enormously abundant population on this relatively polluted Danube section. Additionally, it should be mentioned that similar expansion is registered on the Tisza River to upstream direction, too.

Corbicula fluminea reported from the Rhine[42] was observed first in the Hungarian section in 1999 together with *C. fluminalis* in the vicinity of the Nuclear Power Plant of Paks[43]. The latter species was found only at Paks. *C. fluminea* was wide spread on the lower Danube during the JDS Survey and only one occurrence data was detected upstream Budapest, at Sturovo (SK). Further data in 2002 and 2003 increased very quickly between the Danube Belt and Mohács (Hungary). The first occurrence of this Asian mussel was registered from the Szigetköz floodplain in 2003 as the uppermost Hungarian data. Today this mussel species is the most common one is the middle Danube.

The first data of the Chinese Woolcrab *(Eriocheir sinensis)* from Austria and Hungary were collected in the end of 2003 very near to each other. This indicates another important change on this section that could have serious consequence on the original composition of the biota. This species represents an example of the West-East direction of the expansion.

All of these additional occurrences indicate that the permanent increase of the number of new non-indigenous members has to be taken in consideration.

Fish species

Having in mind that factors, such as riverbed regulation, land reclamation, construction of water gates, change of the water flow, pollution, habitat degradation, overfishing of native species can provide conditions that favour alien species it is necessary to control or eradicate them, not only from protected areas, but from all the natural and semi-natural aquatic ecosystems. Serious upstream expansion of some pontocaspic fish species is known in the Danube also that represents more and more characteristic elements of the given river stretch *(Neogobius fluviatilis, N. melanostomus, etc.)*.

From the beginning of the twentieth century eight alien fish species *(Aristichthys nobilis, Carassius auratus gibelio, Ctenopharyngodon idella, Hypophthalmichthys molitrix, Ictalurus nebulosus, Lepomis gibbosus, Micropterus salmoides, Pseudorasbora parva)* have been found in the Serbian section of the Danube River. Some of them occurred in these waters as a consequence of imprudent introduction upstream and downstream from the Serbian section of the Danube, and some were intentionally introduced, at first, in the fishponds, and then in the running and stagnant waters.

Neophyta

River bank vegetation and floodplains of the Danube and its tributaries belong to those habitats which are most endangered by invasion of nuisance species when they are suppressing local aquatic communities and altering natural habitats. In the upper part of the Danube there are currently 15 invasive plant species that are effecting and changing the habitats in a drastic form.

A rapid distribution of certain neophytes in the riparian and water vegetation can be perceived *(e.g. Aesclepias syriaca, Amorpha fruticosa, Elodea canadensis, Impatiens glandulifera, Solidago canadensis, and S. gigantea)*. Czech Republic confirms the problem of neophyta especially in wetlands along rivers. In addition, there are problems with *Fallopia japonnica, Impatiens glandulifera,* tree species in floodplain forests *Negundo aceroides (= Acer negundo), Ailanthus altissima, Fraxinus pennsylvanica,* and others, which are supported by activities of foresters (clear-cuttings).

42 KINZELBACH (1991).
43 CSÁNYI (1998-1999).

Mario Romulic, Croatia

4.5. Assessment of impacts on the basin-wide level

The assessment of impacts on a water body requires quantitative information to describe the state of the water body itself, and/or the pressures acting on it. The timetable for completing the first pressure and impact analysis and reporting their results is very short. The first analysis therefore relies heavily on existing information on pressures and impacts and on existing assessment methods.

The TransNational Monitoring Network (TNMN) constitutes the main data source on water quality of the Danube and its major tributaries. The TNMN was formally launched in 1996, and aims to contribute to the implementation of the Danube River Protection Convention. The Contracting Parties cooperate in the field of monitoring and assessment with the aim to harmonise or make comparable their monitoring and assessment methods, in particular in the field of river quality.

The main objective of the TNMN is to provide a structured and well-balanced overall view of the pollution status as well as of the long-term development of water quality and pollution loads in terms of relevant determinands for the major rivers in the Danube River Basin (for list of determinands see Annex 8). The international aspect of TNMN is of high importance.

The TNMN monitoring network is based on the national surface water monitoring networks. For selection of TNMN sampling profiles following criteria were applied:

- site located just upstream/downstream of an international border
- site located upstream of confluences between Danube and main tributaries or main tributaries and larger sub-tributaries (mass balances)
- site located downstream of the largest point sources
- site located according to control of water use for drinking water supply

The selection procedure has led to establishment of a final list of 61 TNMN monitoring locations in the Phase I. At the initial stage, the territory of Yugoslavia was not included into the network due to war conditions, but Serbia and Montenegro joined the TNMN in 2001 increasing thus the number of TNMN sampling sites to 79 (Figure 32). On the other hand, it must be pointed out that from Bosnia i Herzegovina no data has been provided so far, Ukraine provided data only for 1998 and 1999. Moreover, the data on several parameters (especially micropollutants) have not been reported for many other downstream sites. The minimum required sampling frequency is 12 times per year for the chemical determinands in water and two times per year for the biological parameters.

The assessment of pollution loads in the Danube River is necessary for estimating the influx of polluting substances to the Black Sea and for providing an information basis for the policy design.

The TNMN load assessment programme started in 2000 and it provides an evaluation of the pollution load for the following determinands:

- BOD5
- ortho-phosphate-phosphorus
- total phosphorus
- chlorides (voluntary)
- inorganic nitrogen
- dissolved phosphorus
- suspended solids

There are 23 sampling stations in the TNMN load assessment programme with a requirement of a minimum sampling frequency of 24 times per year. Moreover, valid daily flow data must be available for the load assessment station. The quality of the TNMN data is regularly checked by a basin-wide analytical quality control programme (QUALCO-DANUBE). The results of this programme are reported annually. To evaluate the data collected by the TNMN an interim water quality classification scheme was developed that exclusively serves the presentation of current status and assessment of trends of the Danube River water quality (i.e. it is not considered as a tool for the implementation of national water policies).

In line with the implementation of the EU Water Framework Directive TNMN is going to be revised in 2005-2006 to ensure a full compliance with the provisions of the WFD.

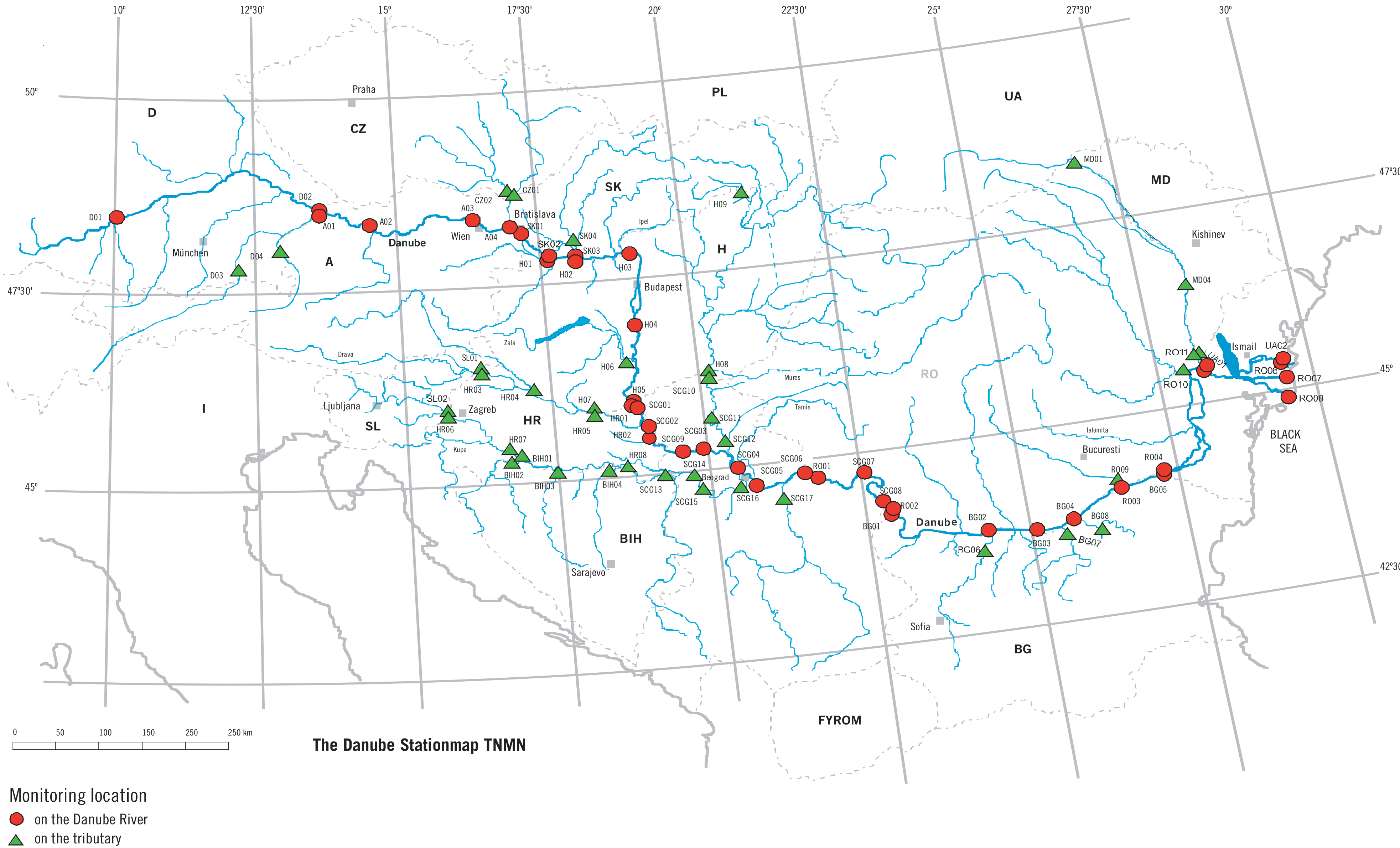
The multiple uses of surface waters by human activities (discharge of partially treated/untreated waste waters, water abstraction, hydropower generation, agricultural irrigation, navigation etc.) can affect natural abiotic as well as biotic characteristics of surface waters and negatively impact aquatic community. Consequently, the risk assessment is based on both significant pressures and their impacts on the aquatic ecosystem.

Overall, different pressures can be identified, each of them having the potential to impact the status of surface water bodies:

- Point source pollution (e.g. from urban and industrial wastewater treatment plants or waste management sites). Impacts on the status of surface water bodies may result from the input of organic substances, nutrients and hazardous substances.
- Diffuse source pollution (e.g. from agricultural and urban land use activities). Impacts on the status of surface water bodies can result from the input of organic substances, nutrients and hazardous substances.
- Hydrological alterations (e.g. water abstraction, hydro-peaking, flow regulation). Impacts on the status of surface water bodies may result from changed hydrological conditions.
- Morphological alterations (e.g. impoundments, weirs, bank reinforcements, channelisation). Impacts on the status of surface water bodies may result from hydraulic engineering measures altering the structural characterisation of surface waters.
- Any other pressures which might be identified.

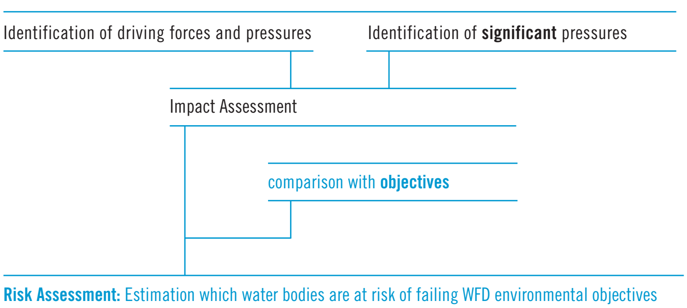
TNMN stations in the Danube river basin

FIGURE 32



The risk assessment is based on a 4-step procedure (Figure 33). In a first step, the driving forces and its related pressures are identified. Secondly, the significant pressures are determined. Thirdly, the environmental impacts are assessed. In the last step, the risk of failing to reach the environmental objectives is estimated by comparing the current status of the water body to the environmental objectives of the Directive. This estimation is based on available data and is not the ecological classification.

Procedure for the estimation of the risk of failure to reach the environmental objectives of the WFD *FIGURE 33*



The pressures and impacts described in Chapter 4.4 and 4.5 are the basis for estimating the risk of failing to reach the WFD environmental objectives by 2015 (Chapter 4.7).

4.5.1. Impacts on rivers

The analysis of the water quality in rivers is based on the

- Five-year Report on Water Quality in the Danube River Basin Based on Trans-National Monitoring Network, 2003;
- Joint Danube Survey Database;
- Joint Danube Survey – Technical Report of the International Commission for the Protection of the Danube River, 2002;
- A Synthesis of Activities in the Framework of “Bucharest Declaration 1985 -1997”; and the
- TNMN Database 1996-2000.

4.5.1.1. Impacts from organic pollution

The organic pollution is the result of contamination of water with organic substances originating both from natural and anthropogenic sources. The natural organic matter occurring in water stems mainly from soil erosion and decomposition of dead plants and animals; it is relatively insoluble and slowly decomposed. Organic compounds originating from various human activities belong to the most frequent pollutants discharged into rivers.

Rather critical status of the Danube water quality in eighties forced the Danube countries to act jointly in implementing the integrated transboundary water management. The first steps towards a basin-wide water quality assessment and protection have been done in 1985 when the Bucharest Declaration was established as a new frame for regional cooperation. The monitoring network created under the Bucharest Declaration started to operate in 1988. It consisted of eleven monitoring sites located on the border sections on the main stream of the Danube River. Within the Bucharest Declaration monitoring the parameters characterizing the organic pollution were grouped under the name “dissolved oxygen regime”. This group contained following determinands: dissolved oxygen concentration and saturation (DO), biochemical oxygen demand (BOD_5), chemical oxygen demand (both by $KMnO_4$ and $K_2Cr_2O_7$ - COD-Mn and COD-Cr). The agreed monitoring frequency was 12 times per year.

In the nineties the Danube cooperation was strengthened and led to signing of the Danube River Protection Convention in 1994. Under DRPC the Transnational Monitoring Network was created that is described in detail elsewhere. For the characterization of the organic pollution TNMN took over the dissolved oxygen regime parameters from the Bucharest Declaration monitoring.

The assessment of organic pollution has been based on the “Five-year Report on Water Quality in Danube River Basin Based on Trans-National Monitoring Network, 1996-2000”.

Link to pressures

It is clear that the status of the water ecosystem as well as the impacts depend on the type of pressure. Point and diffuse sources of the organic pollution are recorded within the ICPDR in form of the emission inventories of industrial and municipal discharges in the Danube River Basin. These inventories are updated regularly to provide a sound overview of emissions of organic matter into the waters.

In this chapter the status of the water ecosystem is presented based on the results of the TNMN and the extent of the impact is based on tools and criteria agreed within the ICPDR.

Status of water

The assessment methodology refers to the classification of the surface water quality in accordance to an interim classification system developed for TNMN. In this classification system five quality classes are used for the assessment, with target value being the limit value of class II. The class I should represent the background concentrations hence the reference conditions. The classes III - V show “non-compliance”and the limit values are usually 2 - 5 times the target values. They should indicate the extent of the exceedence of the target value and should help to recognise the positive tendency in water quality development.

The basis for the water quality assessment agreed by the MLIM EG is 90 %ile (c90) for each considered determinand (90 percentile method has the advantage that extreme values caused by exceptional conditions or measuring errors are not taken into account, but still represents “unfavourable” situation that occurred in monitoring site in a year). For the dissolved oxygen the higher concentrations mean a better situation, which is opposite to all other determinants and from this reason it is considered that the best descriptor for dissolved oxygen content is the 10 %-ile data.

In the assessment of the water quality 57 out of 61 TNMN sampling profiles are included, for which the data were available. 31 sites are located on the main stream of the Danube River and 26 on the important tributaries included in the TNMN.

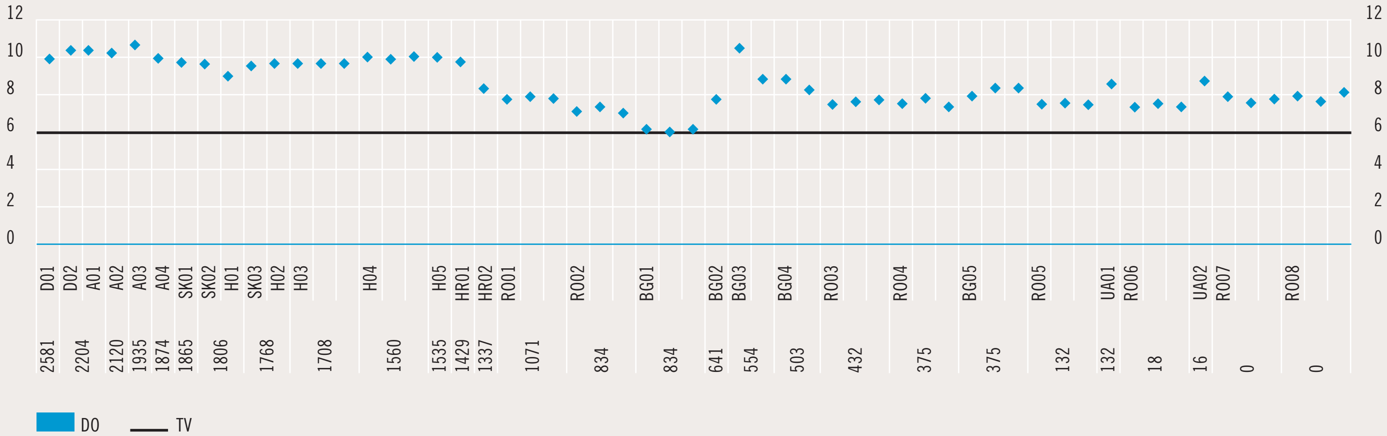
The c90 values are presented in a way indicating the compliance with the “target value” used in the TNMN classification system.

Dissolved oxygen

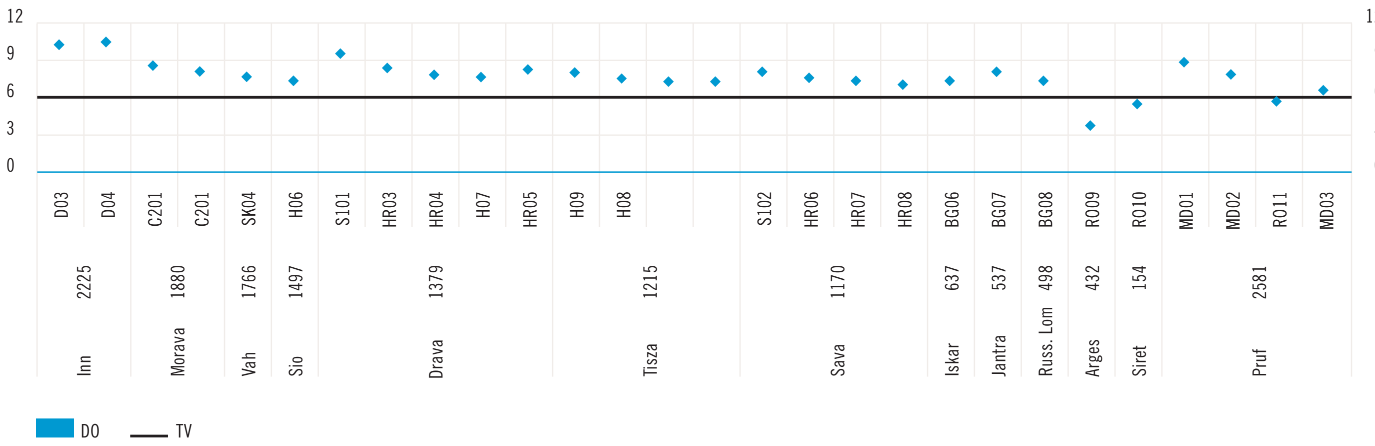
Because oxygen that is dissolved in water is far less abundant then the oxygen in the air, the actual amount of oxygen present in water is an important water quality parameter. As a general rule, the less oxygen dissolved in water the worse is the water quality. Low oxygen levels in water are caused mainly by the discharges of inadequately treated or untreated wastewater. This leads to a growing microbiological activity and hence to the depletion in dissolved oxygen. Low oxygen concentration results in a decrease in plant and animal species and a deterioration of water quality.

According to TNMN data from 1996-2000, the dissolved oxygen concentrations varied from 4.5 mg/l O_2 to 10.6 mg/l O_2 in the Danube River and from 2.1 mg/l O_2 to 11.5 mg/l O_2 in tributaries that are part of the TNMN. This is a rather positive situation, with only 7.4 % of values below the quality target (6 mg/l O_2) in the Danube River and 8.6 % in tributaries.

Dissolved Oxygen – Spatial distribution of mean values of c10 for 1996 - 2000 data against the limit of Class II (TV - target value) – **the Danube River.** Contrary to the other determinands, in the case of dissolved oxygen the “above target value” means a favorable situation *FIGURE 34*



Dissolved Oxygen – Spatial distribution of mean values of c10 for 1996 – 2000 data against the limit of Class II (TV- target value) – **tributaries.**
Contrary to the other determinands, in the case of dissolved oxygen the "above target value" means a favorable situation *FIGURE 35*



Summarizing the spatial distribution of the mean values of DO - c10 data for 1996 - 2000 for the Danube River and the major tributaries (Figure 34 and Figure 35), the following statements can be done:

- A decreasing tendency of the dissolved oxygen content downstream the Danube River was recorded; To a certain extent this is a natural phenomenon caused by reduced aeration and elevation of water temperature
- In the upper Danube section, the dissolved oxygen values increase from Danube-Neu Ulm (rkm 2581) to Danube-Wien-Nussdorf (rkm 1935). In this stretch, all concentrations are above 8.5 mg/l and no value is below the target limit which indicates a positive situation;
- In the middle stretch, the oxygen concentrations are slightly lowers then those in the upper part. A uniform pattern is present along this stretch, with no value below the target limit;
- Decreased concentrations appeared in the areas influenced by the two major reservoirs (Gabcikovo – slight decrease at rkm 1806 and Iron Gates – a significant decrease downstream of rkm 1071);
- In the lower part only three values were below the target value at rkm 834;
- In the tributaries, the dissolved oxygen content generally decreases from those located in the upper area to those located in the lower part;
- While only a slight deviation from Class II occurs in the Siret and the Prut River, a critical situation was observed in the Arges River having a mean value of less than 4.0 mg/l O_2, which is the limit value for Class V. This is mainly due to the absence of a waste water treatment plant for a municipality with more than 2 million inhabitants.

The above-mentioned results are in good correlation with the conclusions of the Joint Danube Survey[44].

Biochemical Oxygen Demand

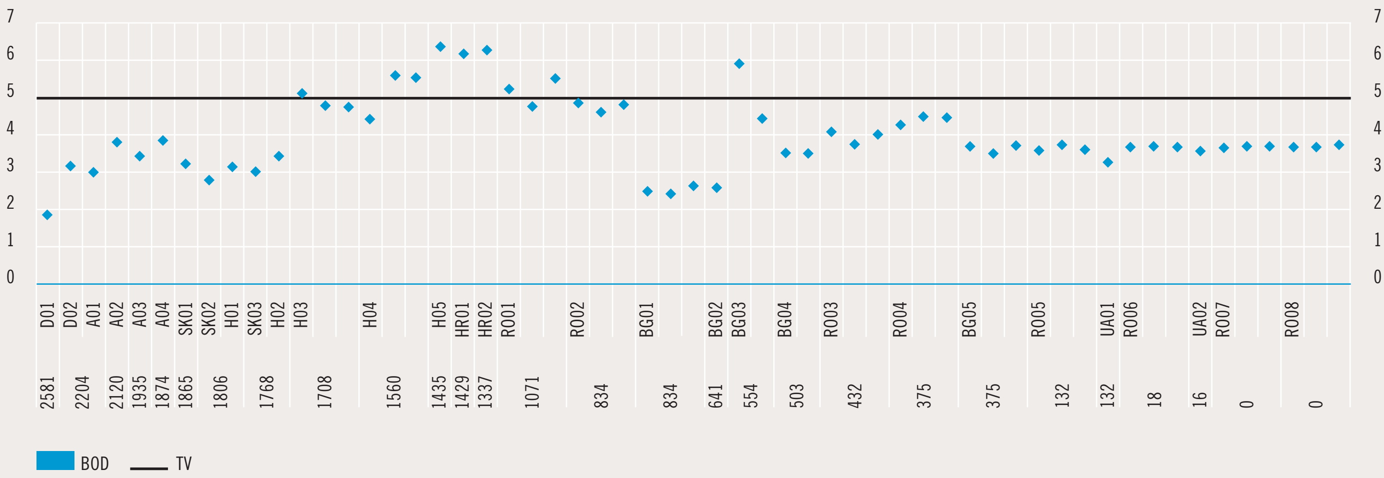
BOD_5 characterizes the oxygen demand arising from biological activities. High BOD_5 values are usually a result of organic pollution caused by discharges of untreated wastewaters from treatment plants, industrial effluents and agricultural run-off. Generally, it can be said that BOD concentrations less than 2 mg/l O_2 are indicative of relatively clean rivers and concentrations higher than 5 mg/l O_2 are signs of relatively polluted rivers.

According to TNMN data, BOD5 values varied during 1996 – 2000 in a range of 1.4 – 8.2 mg/l O2 in the Danube River and 1.8 – 60.5 mg/l O2 in the major tributaries. This means that 13.3% of values were above the target value (5 mg/l O2) in the Danube River (mainly in the middle and in the lower sections) and 35.9% in the major tributaries.

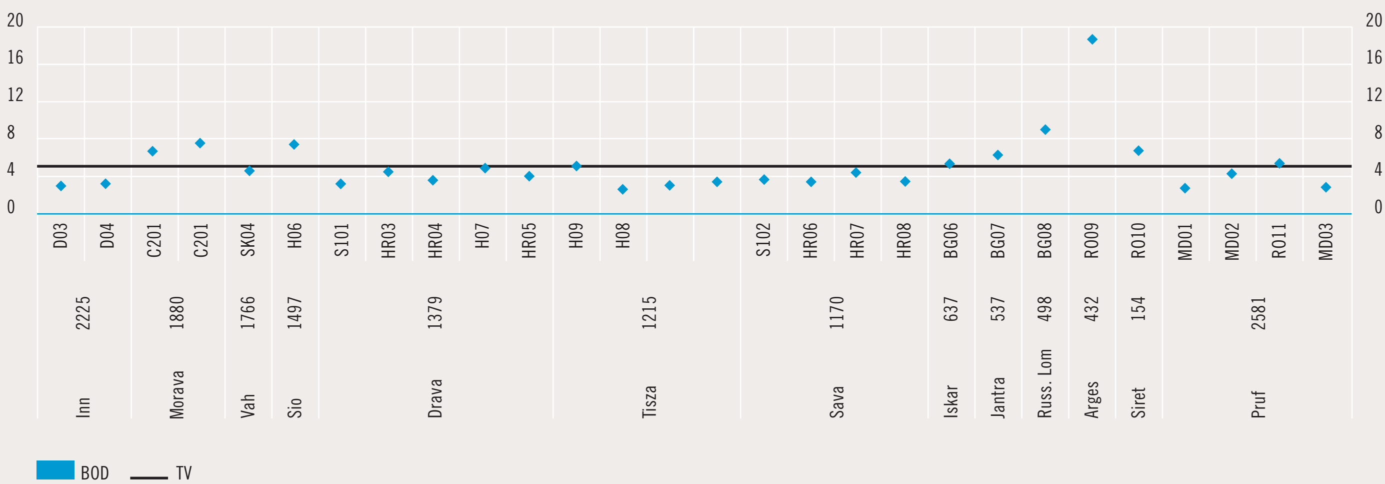
The spatial distribution of the mean values of BOD_5 - c90 data in 1996 - 2000 in the Danube River (Figure 36) shows that the profile is relatively scattered, with a concentration maximum located in the middle stretch of the Danube. In the tributaries (Figure 37), the BOD_5 values indicate a higher content of biodegradable organic matter occurring in the Morava, Dyje and Sio in the upper and middle Danube section and in the Yantra, Russenski Lom, Arges and Siret in the lower Danube. It should be pointed out that the maximum BOD5 value was found in the Arges river as a consequence of the pressure from a big municipality discharging insufficiently treated wastewaters into this tributary.

44 ICPDR (2002).

Biochemical Oxygen Demand – Spatial distribution of mean values of c90 for 1996 - 2000 data against the limit of Class II (TV - target value) – **the Danube River.** The values above the TV show unforable situations *FIGURE 36*



Biochemical Oxygen Demand – Spatial distribution of mean values of c90 for 1996 - 2000 data against the limit of Class II (TV - target value) – **tributaries.** The values above the TV show unforable situations *FIGURE 37*



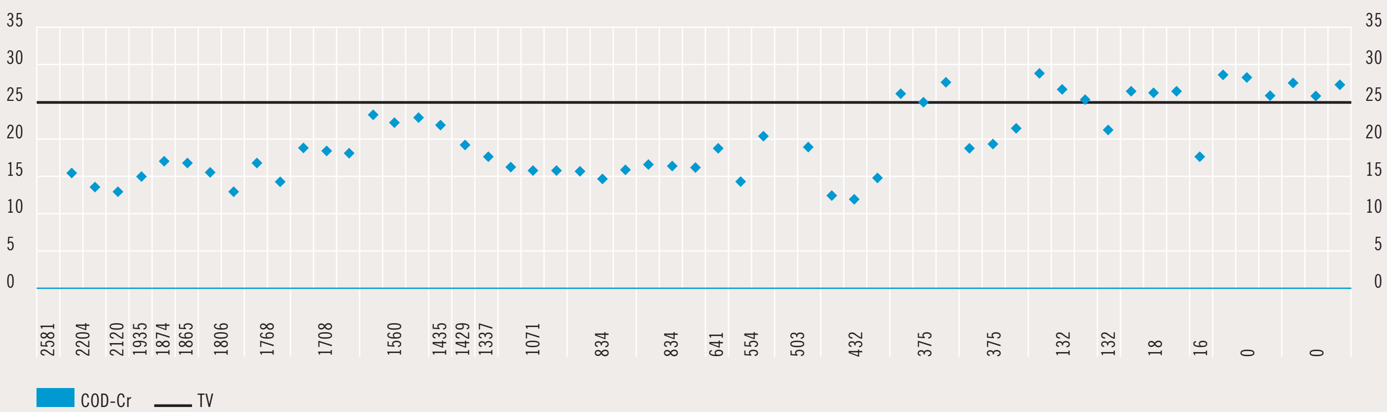
Chemical Oxygen Demand

Chemical Oxygen Demand (COD) informs on the demand of the oxygen needed for the oxidation of organic substances. Similar to BOD_5, high COD values adversely affect the aquatic environment. According to the oxidizing agens applied two different COD methods are distinguished: COD-Cr (oxidation by dichromate) and COD-Mn (oxidation by permanganate). Although in the TNMN both methods are used, in this report only COD-Cr was chosen for the assessment because of its higher oxidation ability (oxidizes 90-100% of the organic substances). It is generally considered that concentrations of COD-Cr less than 10 mg/l O_2 are indicative of relatively clean rivers, while concentrations above 25 mg/l O_2 indicate an organic pollution.

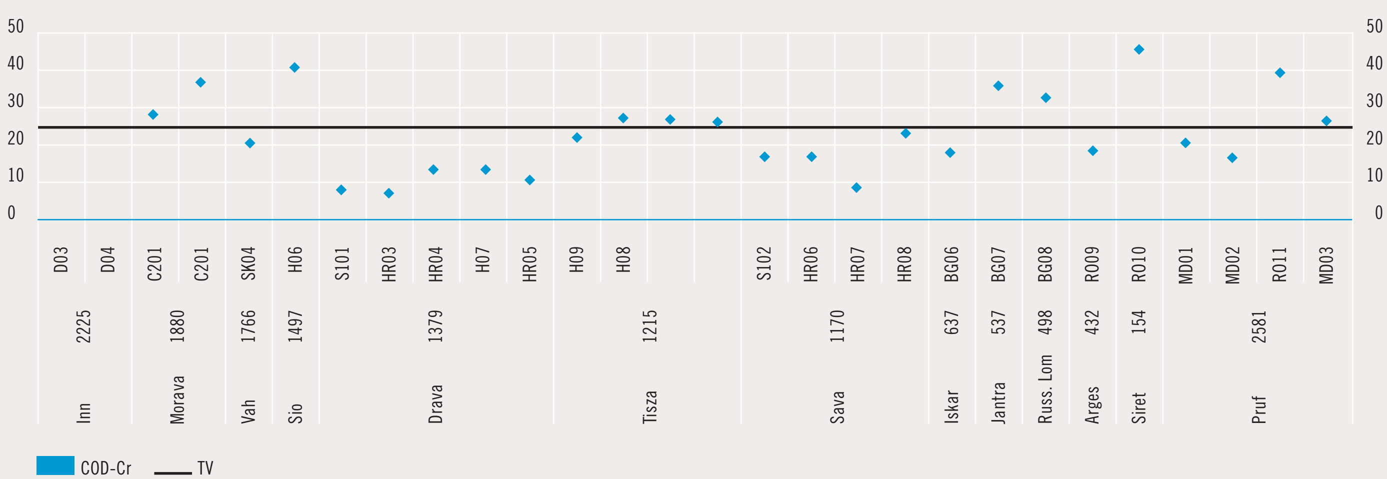
According to TNMN c90 data in 1996 - 2000, the COD-Cr values varied between 2.9 mg/l O_2 and 58.0 mg/l O_2 in the Danube mainstream and between 6.3 mg/l O_2 and 90.4 mg/l O_2 in the major tributaries. 22.4% of the samples from the Danube and 39.7% samples from the tributaries were above the TNMN target value (25 mg/l O_2).

The spatial variation of the mean values of COD-Cr - c90 data for 1996 - 2000 along the Danube River shows a relative scattered profile, caused by inhomogeneous data available from the same cross sections (yearly variation of COD-Cr is much higher in the lower Danube section than in the upper and middle reaches). An increase of COD-Cr from upper to lower Danube is visible (Figure 38), with values exceeding the target limit (TV= 25 mg/l O_2) in the lower Danube stretch. The target value was exceeded also in many Danube tributaries (Figure 39). The most significant non-compliance on a long-term basis was recorded in Dyje, Sio, Yantra, Russenski Lom, Siret and Prut.

Chemical Oxygen Demand (COD-Cr) – Spatial distribution of mean values of c90 for 1996 - 2000 data against the limit of Class II (target value) – **the Danube River.** The values above the TV show unfavorable situations *FIGURE 38*



Chemical Oxygen Demand (COD-Cr) – Spatial distribution of mean values of c90 for 1996 - 2000 data against the limit of Class II (target value) – **tributaries.** The values above the TV show unfavorable situations *FIGURE 39*



Impact assessment

As the benthic invertebrates are sensitive to the presence of the organic compounds in water, the analysis of macrozoobenthos in the aquatic ecosystem provides useful information on the impacts of organic pollution.

The results of the macrozoobenthos analysis presented in this chapter are based on the biomonitoring procedures agreed within the ICPDR. A so-called saprobic index system is based on a classification of water quality using seven biological quality classes (Table 30) Similar to the chemical water classes, water quality class II (moderately polluted) indicates the general quality objective. It must be pointed out that this procedure is not fully compatible to the type-specific biological monitoring as requested by the WFD.

It must be stressed that the presented saprobic indices (Table 31) are rather heterogeneous owing to the differences in national methodologies and that a lot of data is missing due to gaps in national monitoring programmes.

Viewing the results presented in Table 31 it is apparent that the Danube and most of its tributaries belong to the classes II – II/III (α – β mesosaprobity).

Macrozoobenthos was analysed also during the JDS and the results obtained showed that:

- The saprobity of the Danube varied between water quality class II (moderately polluted) and II/III (critically polluted). Taking into account that the saprobic index is also influenced by the habitat structure (for example, comparison of free-flowing stretches to impounded areas), the Danube showed good water quality (class II) all the way to Budapest.
- Downstream of Budapest, where the Danube passes through the Hungarian Lowlands, water quality often decreased to class II-III, indicating significant organic pollution. Taking into account the high chlorophyll-A values as well as the extreme over-saturation with oxygen in this reach, secondary pollution caused by an elevated phytoplankton biomass, which usually leads to an increase in saprobity, was clearly recognisable.
- Downstream of Belgrade to the Iron Gate reservoir, water quality varied between class II and II-III. Signs of pollution began to appear, and there were significant differences in the saprobity of the samples collected from the left and right banks of the Danube, which seemed to be due to the pollution effects of the discharging tributaries. Only the impounded reach upstream of the Iron Gate Dam showed saprobity values below the limit for water quality class II.
- In the Lower Danube reach, especially down-stream of big cities, discharges seemed to result in an increase in the level of destruents, bacteria and detritus feeders; even toxic effects see-med to exist. On the right bank of the Danube, for example at Vrbica/Smiljan, no invertebrates were present on rocks and pebbles, and the very fine-grained, reduced sediment was predominantly inhabited by a few oligochaetes and chironomids. Comparing the Upper and Lower Danube in terms of the sum of abundances, the lower section of the Danube was clearly marked by a significant decrease in biodiversity. Arms and tributaries of the Danube were found to be more polluted than the River itself and even reached water quality class III (strongly polluted) or higher. The Moson-Danube arm and the dammed Rackeve-Soroksar arm were found to be critically polluted (water quality class II-III). The Schwechat, the Drava and the Tisza could be placed between class II and II-III. The mouths of the Váh, Velika Morava, Yantra, Siret and Prut tributaries are critically polluted (water quality class II-III).
- The Sió even reached water quality class III. No macroinvertebrates were found – probably due to toxic effects – in the Iskar, Olt and Arges tributaries which exceeded the limit of water quality class III and represented the worst quality conditions identified during the Survey. Due to the problems in implementation of macro-invertebrates assessment procedures for the lower part of the Danube River (along the Romanian stretch) the evaluation of the organic pollution was made based on phytoplankton communities that has been monitored for many years (**Table 32**). The assessment of primary producers is important for the lower part of the river and gives information on pollution impact, water quality and ecosystem health, together with other biotic communities data. The information based on phytoplankton complements the information based on macro-invertebrates. The classification of water quality (with seven classes) is similar as for macrozoobenthos.

Classification scheme of water quality according to saprobic index *TABLE 30*

CLASSIFICATION SCALE	I.	I.-II.	II.	II.-III.	III.	III.-IV.	IV.
	unpolluted	low polluted	moderately polluted	criticaly polluted	strongly polluted	very high polluted	extensively polluted
	≤1,25	≤1,75	≤2,25	≤2,75	≤3,25	≤3,75	>3,75

Annual mean Saprobic Index based on macrozoobenthos (TNMN stations 1997 - 2000)

TABLE 31

D - Danube site (rkm)	T, T/T Tributaries (site)	Saprobic index (macrozoobenthos) 1997	1998	1999	2000
D01-Neu-Ulm (2581); D		2,40			
	D04-Salzach (Laufen); T/T		2,12	2,03	2,25
	D03-Inn (Kirchdorf); T		1,86	1,77	1,85
D02-Jochenstein (2204); D			2,26	2,27	2,19
A01-Jochenstein (2204); D		2,11	2,09	2,00	2,19
A02-Abwinden-Asten (2120); D		2,08	2,03	2,00	2,00
A03-Wien-Nussdorf (1935); D		1,93	2,19	2,00	2,20
A04-Wolfsthal (1874); D		2,14	2,15	2,10	2,20
	CZ02-Dyje (Pohansko) T/T	2,40	2,20	2,13	2,16
	CZ01-Morava (Lanžhot) T	2,71	2,30	2,23	2,15
SK01-Bratislava (1869) ; D		2,08	2,04	2,54	1,98
SK02-Medveďov/Medve (1806); D		2,12	2,09	2,18	1,99
H01-Medveďov/Medve (1806); D			2,20	2,18	2,00
SK03-Komárno/Komárom; D (1768)		2,11	2,12	2,27	2,11
H02-Komárno/Komárom; D (1768)			2,25	2,27	2,10
	SK04-Váh (Komárno); T	2,70	2,45	2,42	2,26
H03-Szob (1708); D			2,11	2,24	2,26
H04-Dunafoldvar (1560); D					
	H06-Sio (Szekszard-Palank) T				2,38
H05-Hercegszanto (1435); D					
	H07-Drava; T (Dravaszabolcs)				
HR01-Batina (1429); D					
HR02-Borovo (1337); D					
	HR03-Drava; T (Varazdin)				
	H09-Sajo (Sajopuspeki); T/T				
	H08-Tisza (Tiszasziget); T				
	SL01-Drava (Ormoz); T		2,34	2,35	2,52
	HR04-Drava (Botovo); T				
	HR05-Drava; T (D.Miholjac)				
	SL02-Sava (Jesenice); T		2,57	2,32	2,36
	HR06-Sava (Jesenice)*; T	2,60	2,80	2,50	2,24
	HR07-Sava (us.Una)*; T Jasenovac	2,70	2,40	2,50	2,03
	BIH01-Sava; T (Jasenovac)				
	BIH02-Una(Kozarska); T/T Dubica				
	BIH03-Vrbas(Razboj); T/T T/T				
	BIH04-Bosna; T/T (Modrica)				
	HR08-Sava*; T (ds.Zupanja)	3,70	2,90	2,60	2,34

** In Croatia the list of saprobic indicators was changed after 1999, so the results of 2000 are not comparable to the data of 1997-1999.*

Annual mean Saprobic Index based on phytoplankton (TNMN stations 1997 - 2000) *TABLE 32*

	Saprobic index (phytoplankton)			
D - Danube site (rkm)	1997	1998	1999	2000
R001-Bazias (1071); D	2,03	1,86	1,83	2,06
R002-Pristol/Novo Selo ; D Harbour (834)	2,12	1,92	1,88	
R004-Chiciu/Silistra (375); D	2,07	2,02	2,08	1,96
R005-Reni-Chilia/Kilia arm; D	2,08	2,11	2,11	2,17
UA01-Reni-Chilia/Kilia arm; D				
R006-Vilkova-Chiliaarm/Kilia; D arm		2,08	2,06	2,17
R007-Sulina-Sulina arm ; D			2,05	2,13
R008-Sf.Gheorghe arm; D Gheorghe arm			2,03	2,32

Regarding the phytoplankton results along the Romanian stretch of the Danube (1071 – 0 km), the range of the saprobic index varied between 1.88 (Reni, 1996) to 2.32 (Sf. Gheorghe arm, 2000). The average value for 5 years and for all TNMN Romanian sections was 2.02. The observed tendency was a slight increase of the saprobic index from Bazias (1.97) and Gruia (1.91) to the Danube Delta direction (2.10 – Valcov, 2.09 – Sulina, 2.17 – Sf. Gheorghe).

The Saprobic values based on phytoplankton in the lower Danube and the values based on macro-invertebrates for the upper and middle parts of the Danube River are not fully comparable, since the assessment is based on different parts of the process of biodegradation: The macrozoobenthos indicates the degree of decomposition of organic matter and degree of oxygen depletion, phytoplankton indicates the degree of primary production, which results from nutrients stemming either from the process of decomposition or from other point or diffuse sources.

Almost the same pattern of water quality assessment is provided by the Joint Danube Survey data. Thus, the results obtained show that the saprobity of the Danube varied between water quality class II (moderated polluted) or II/III (critically polluted).

4.5.1.2. Contamination with hazardous substances

The EU Water Framework Directive explains in its Article 2 the term ‘hazardous substances’ as substances or groups of substances that are toxic, persistent and liable to bio-accumulate; and other substances or groups of substances which give rise to an equivalent level of concern. Exposure to excessive loads of hazardous substances can result in a series of undesirable effects to the riverine ecology and to the health of the human population. Hazardous substances may affect organisms by inhibition of vital physiological processes (acute toxicity), or they may cause effects threatening population on a long-term basis (chronic toxicity).

If a substance is persistent, i.e. its degradation process exceeds certain time span, it remains in the environment and leads to a continuous and/or long-term exposure. Substances with a high lipophilicity that enter the water environment tend to accumulate in a solid phase and in living organisms. That is why it is necessary to investigate all compartments of the riverine ecosystem before a contamination by hazardous substances can be assessed. It is necessary to emphasize that only a thorough assessment of in-stream pollution by hazardous substances enables designing of the effective protection measures. This assessment is performed by appropriately tailored monitoring programmes.

Principles of monitoring and assessment

The ICPDR monitoring activities concerning hazardous substances are based on two complementary approaches: (i) regular monitoring of a water column via Transnational Monitoring Network (TNMN) and (ii) complex investigation of the whole river by occasional surveys. The TNMN has been operating since 1996 and produces a basin-wide database of hazardous substances on annual basis. In 2001 a longitudinal monitoring survey (Joint Danube Survey) was organized. The results of the survey provided a complex picture on contamination of water, sediments, suspended solids and biota by heavy metals and organic micropollutants.

To assess the extent of contamination of the aqueous environment by the hazardous substances the environmental quality standards (sometimes referred to as target values) have to be derived. Until now, the quality standards for particular substances were included in the environmental legislation in the Danube countries. However, these national lists of priority substances were not harmonized on a basin-wide scale. Therefore, to evaluate the data collected by the TNMN an interim water quality classification scheme was developed by the ICPDR (see Annex 9). This scheme serves exclusively for the presentation of the current status and the assessment of trends of the Danube River water quality (i.e., it is not considered as a tool for the implementation of national water policies). The border of the class II in the TNMN classification is referred to as a target value for good water quality. The TNMN classification has been applied for the evaluation of TNMN results and the related impact assessment in this chapter.

In November 2001 the Decision No 2455/2001/EC of the European Parliament and of the Council amended EU WFD by establishing the list of priority substances in the field of water policy. Altogether 33 priority substances are listed in this document, which has been accepted by the ICPDR as a basis for establishing the Danube List of Priority Substances. At present, the environmental quality objectives are being developed by the EC Expert Advisory Forum on Priority Substances (EAF PS) for all EU WFD priority substances. It is necessary to point out that the WFD's normative definitions for ecological status and potential clearly describe the conditions required for the specific pollutants at good status/potential. In such case the concentrations of specific pollutants should not exceed the environmental quality standards set in accordance with Annex V, Section 1.2.6 of the Directive. If one or more of the specific pollutants do not meet the required conditions (even if the biological quality elements do) the overall ecological status/potential will be moderate. In the other words for the hazardous substances the WFD classification is based on a one-out all-out principle.

Link to pressures

The data on releases of hazardous substances in the Danube River Basin is relatively scarce, the Emission Inventories provide only very limited information. According to the Inventory of Agricultural Pesticide Use, performed in 2003 within the UNDP/GEF project, the use of pesticides has declined significantly in most of the countries of DRB. Data from the FAOSTAT database show a strong decline in pesticide use in the CEE countries to about 40% of 1989 levels compared to a relatively small decrease in EU Member States during the same period. The most applied pesticides are Atrazine, 2,4-D, Alachlor, Trifluralin, Chlorpyrifos and copper containing compounds. There are indications, however, that the use of pesticides in the CEE region increases again and that this tendency might be accelerated after the enlargement of the EU.

Status of water

Heavy metals

Within the TNMN eleven heavy metals are regularly analyzed in water both as total and dissolved forms (however, for dissolved heavy metals, the data have been available only since 1998 and only for certain reaches of the Danube River). Out of these, eight heavy metals are of a particular importance due to the fact that they are considered as priority substances for the Danube River Basin – four of them are listed in the list of Priority Substances included in Annex X of the EU Water Framework Directive (Cd, Pb, Hg and Ni) and the other four belong to priority substances specific to the Danube River Basin (As, Cu, Cr and Zn).

For most of the monitored heavy metals the general pattern of their occurrence is an increase from the upper to the lower part of the Danube (see the example for Cadmium in Figure 40). The only exception is manganese, for which the maxima were observed in the middle Danube. As for the tributaries – the content of heavy metals is elevated in many of them, especially in those located in the lower Danube. A necessary issue still to be clarified in the future is the determination of natural background concentrations to be used for setting of region-specific quality standards. Due to the geomorphologic conditions the natural occurrence of heavy metals in the Danube River Basin varies.

Temporal trends of Cadmium in the Danube River *

FIGURE 40

** The full data is contained in ICPDR (2001).*

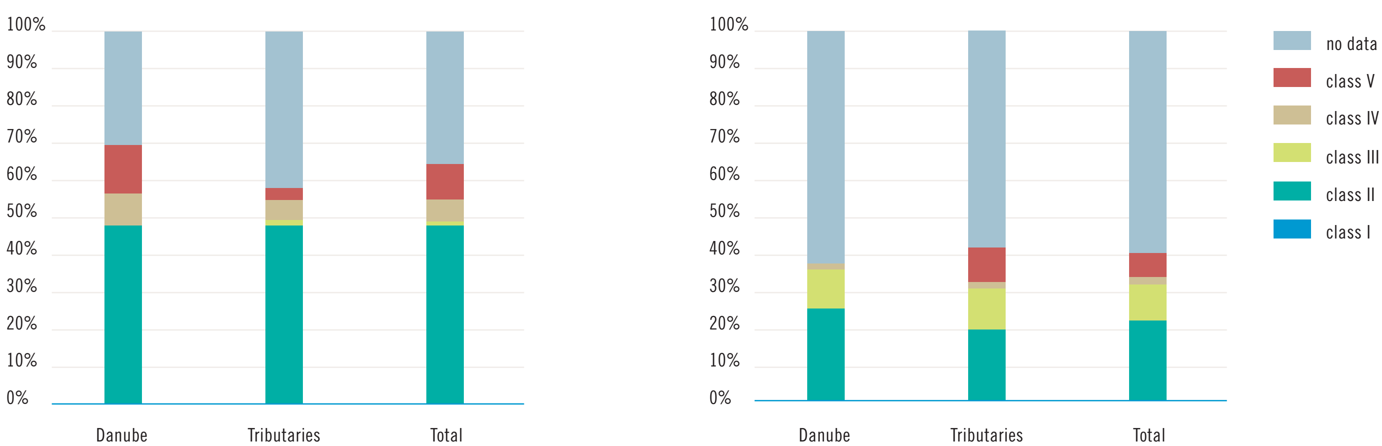
Based on the evaluation of TNMN data from years 1996 – 2000 using the interim classification the following conclusions can be drawn on the content of the total heavy metals:

– the content of lead, copper and cadmium in the Danube mainstream is rather high having 57 % of the results for lead and copper and 47 % of the results for cadmium above the target limit; the situation in the tributaries is slightly better – 53% results exceeded the target value for lead, 22 % for copper and 32 % for cadmium (target value for total Cu is 20 µg/l, for total Pb is 5 mg/l and for total Cd is 1 mg/l).
– due to the lack of data for mercury in the lower Danube a comprehensive picture cannot be given, however, it is worth mentioning that altogether 63 % of the results from tributaries were above the ICPDR limit of 0.1 mg/l.
– pollution of the Danube mainstream and its tributaries by arsenic, chromium, nickel and zinc can be considered as low. However, the lack of data for these heavy metals in the lower Danube section has to be mentioned.

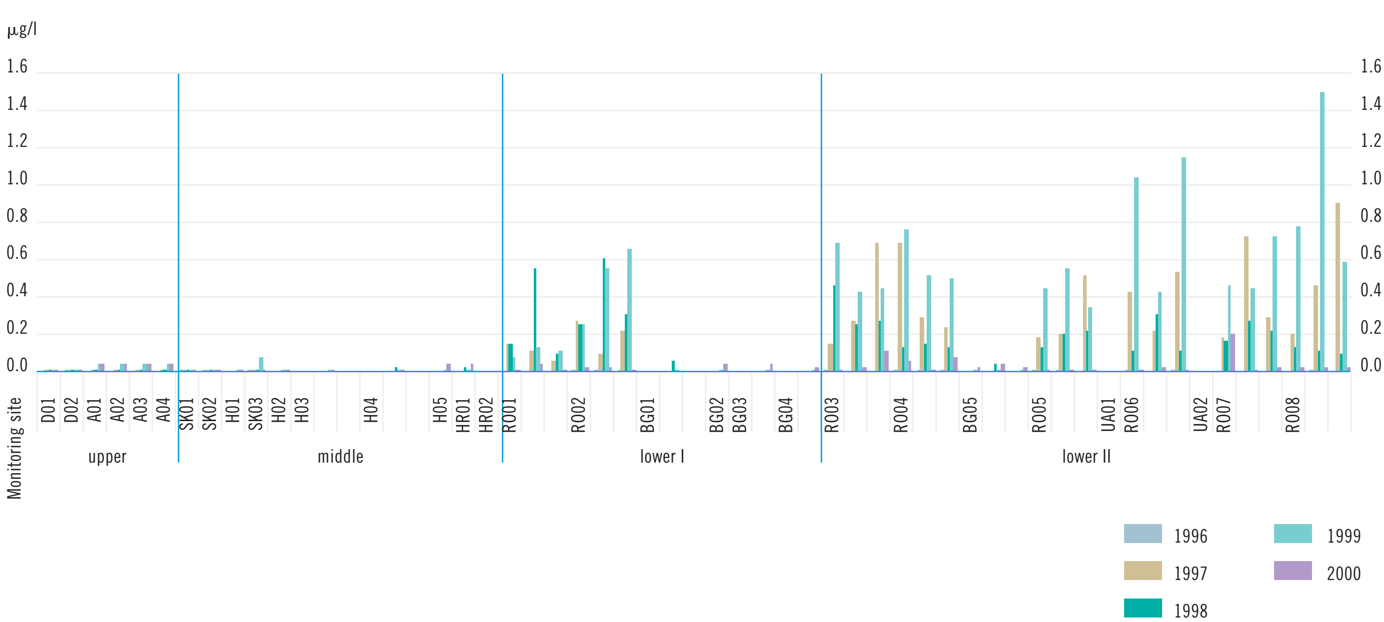
The overview of classification of the TNMN results from the year 2001 for cadmium and mercury is shown in Figure 41.

During the Joint Danube Survey a variety of elements (Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni and Zn) was determined in water samples, sediments, suspended solids and mussels from the Danube River and its tributaries. While for chromium and lead relatively low concentration levels were detected all other metals showed elevated concentrations in at least one of the investigated matrices, particularly in the lower stretch of the Danube (downstream of the Sava River confluence). Tributaries with the highest excess in heavy metal concentrations in water included the Rusenski Lom, the Iskar and the Timok River. In sediments, concentrations of arsenic, cadmium, copper, nickel, zinc and lead (in tributaries only) were found to be above the applied quality targets at more than one-third of the sampling points (German quality targets were used for this evaluation). Despite a significant decrease in arsenic, chromium, mercury, lead, nickel and zinc in core sediment samples of the Iron Gate, their surface concentrations are still significant.

TNMN Water quality classes for cadmium and for mercury in 2001 *FIGURE 41*



Temporal trends of pp'-DDT in the Danube River on the basis of field data collected during the JDS (compare also Figure 49) *FIGURE 42*



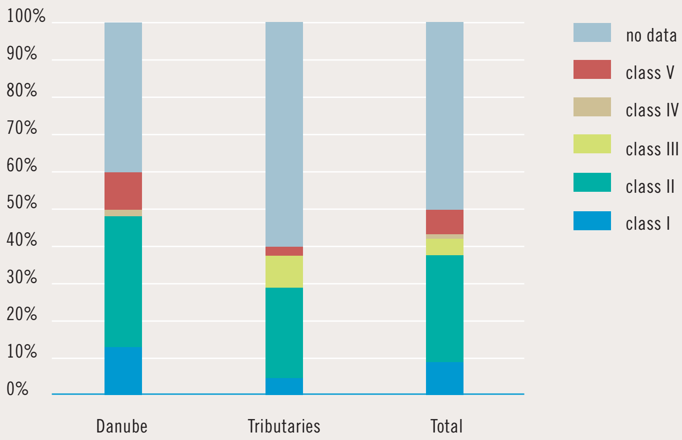
Organic micropollutants

Lindane, pp'-DDT, Atrazine, chloroform, carbon tetrachloride, trichloroethylene and tetrachloro-ethylene are the organic micropollutants regularly monitored in water in the frame of the TNMN programme. In general, the data collected so far exhibit rather large variation due to big differences between reported limits of detection in various Danube countries.

The organochlorine pesticides (Lindane and pp'-DDT) show an analogous increasing profile from the upper to the lower Danube (see Figure 42). As regards exceeding of the ICPDR interim targets the situation is worse for pp'-DDT: 71 % of the Danube samples and 54 % of the samples collected from tributaries contained more than 0.01 µg/l of this analyte. In case of Lindane the limit value of 0.1 µg/l was exceeded in 24 % of the Danube samples and in 9 % of the samples from tributaries.

From 1996 to 2000 the concentrations of the polar pesticide Atrazine were found below the detection limits at most of the monitoring sites along the Danube River. The target limit of 0.1 µg/l was exceeded only in 13 % of the Danube samples. The tributaries were more contaminated with Atrazine with approx. 30 % of values above the quality target. The highest concentrations of Atrazine during that five-year period were found in the tributaries Sio and Sajo. The overview of classification of the TNMN results for Atrazine in the year 2001 is shown in Figure 43.

TNMN Water quality classes for Atrazine in 2001 *FIGURE 43*



For the volatile organic compounds (VOCs), data are available for the upper and middle Danube only. Chloroform was the most often detected VOC in the Danube River Basin during 1996-2000. It exceeded the interim target of 0.6 µg/l in about one third of the collected samples. Significantly lower contamination was recorded for tetrachloroethylene – only about one tenth of the samples were above the target value of 1 µg/l. The situation was even better in the case of tetrachloromethane and trichloroethylene. Only in 2% of the samples from the tributaries the target value of 1 µg/l was exceeded. In the Danube mainstream no elevated concentrations of tetrachloromethane and trichloroethylene were observed during 1996-2000.

The Joint Danube Survey was focused on the analysis of a wide variety of hazardous organic substances in different compartments of the riverine ecosystem.

As for polycyclic aromatic hydrocarbons (PAHs), the concentration of 2 mg/kg was exceeded in 17 samples only and none of the samples reached 20 mg/kg. The concentration of PAHs in mussels showed an increasing trend downstream to the Danube Delta. Moreover, the highest concentrations of PAHs were measured in mussels collected from tributaries in the Middle Danube reach.

The contamination of the Danube and its main tributaries with volatile organic compounds was found very low during the JDS. High air and water temperatures during sampling might be a decisive factor for low concentrations of VOCs in this case.

Out of 23 polar pesticides investigated during the JDS, only Atrazine and Desethylatrazine could be found along the Danube in the average concentrations of around 0.05 µg/l. It was only in a few samples that the interim Danube quality target (being equal to that one set by the Rhine Commission) was exceeded. The few higher Atrazine results were mainly found in the tributaries. The maximum value for Atrazine was found in the Sava River (rkm 7 from the confluence to the Danube; 0.78 µg/l) and it affected the Danube River downstream of its confluence with the Sava.

During the Joint Danube Survey altogether 63 suspended matter samples and 187 sediment samples (including 26 core samples) from the Danube River and its major tributaries and arms were analyzed for the EU WFD compounds para-tert-octylphenol, 4-iso-nonylphenol, di[2-ethylhexyl]phthalate, pentachlorophenol, pentabromodiphenyl ether and tributyltin. Pentabromodiphenyl ether and pentachlorophenol were not found in the investigated samples, while tributhyltin was present only at low concentrations. Para-tert.-octylphenol was found only in bottom sediments; significant concentrations of 4-iso-nonylphenol and di[2-ethyl-hexyl]phthalate were found in bottom sediments as well as in suspended solids (from a few µg/kg up to more than 100 mg/kg) indicating the relevance of these compounds as an indicator of industrial pollution in the Danube River. Most of the elevated concentrations of nonylphenol were found in the Serbian section of the Danube. The use of alkyl-phenol-containing surfactants in this region was considered as a potential cause of the increased contamination. In the sediment core samples decreasing concentration profiles of the EU WFD compounds from the old to the new sediment layers were usually detected.

A special JDS task was focused on the search for unknown organic compounds, which are not included in the regular monitoring programmes and were not directly searched for during the Survey. Altogether 96 organic compounds were identified in the Danube water. The most ubiquitous compounds involved phthalates, fatty acids, aliphatic chlorohydrocarbons and sterols. In addition to these compounds, the following groups were observed: aliphatic and aromatic hydrocarbons, phenols, hydroxy- and keto-aliphates and aromates, benzothiazoles and other sulphur and nitrogen-containing compounds, organophosphates and a limited number of herbicides.

Impact assessment

The identification of the results surpassing class limits of the TNMN is of a pure informational nature, as these class limits are not based on harmonised quality standards needed for hazardous substances within the River Danube Basin. Classifying according to TNMN must in any case not prejudice the assessment as performed by Member States under Article 5 of the WFD. Under this assumption the Danube Basin States agree that – for the first risk assessment report – the TNMN quality criteria may be applied as a pragmatic solution.

Heavy metals

As mentioned above for a sound assessment of anthropogenic contamination by heavy metals the determination of natural background concentrations must be performed for setting of region-specific quality standards. The process of setting the respective quality standards for EU WFD priority substances is currently underway, thus, for a preliminary impact assessment the TNMN classification can only be applied.

Reviewing the 1996 – 2000 TNMN data the assessment of the risk separates the heavy metals into several groups.

Cadmium and lead can be considered as the most serious inorganic microcontaminants in the Danube River Basin. Their target values are slightly exceeded in several locations in the middle Danube and seriously exceeded in most of the sampling sites of the lower Danube. The situation in the case of cadmium is critical (Figure 40). The target value is substantial exceeded in many locations downstream rkm 1071 (values mostly 2-10 times higher than the target value). The pollution of the lower Danube by cadmium and lead can be regarded as a significant impact.

For mercury the data is missing from more than 40 % of locations. Moreover, from almost half of monitoring sites reporting the results no quality class indication was possible because the limit of detection of the analytical method used was higher that the target limit. So, the overall picture on mercury is incomplete focusing predominantly on the upper and middle Danube. Viewing the available data, the elevated concentrations of mercury in the Danube mainstream and its tributaries in the upper and middle section are quite frequent. It can be stated that mercury is the only heavy metal for which the target limit was exceeded even in the upper Danube section.

Copper is a very common element naturally occurring in the environment. Its concentration increases significantly downstream the Danube. Most of the exceeding values (up to several times the target value) were detected in the lower section of the river (including tributaries). In the middle part the only significant occurrence of copper was detected in the Tisza River.

The pollution of the Danube River and its major tributaries by nickel, zinc and arsenic is rather low with the elevated profile only in the lower section. For zinc the non-compliance with the target value in the lower Danube was not very frequent, the limit was exceeded by 20 – 100 %. Nickel concentrations in the whole Danube River did not go over the target limit during 1996 – 2000. Arsenic levels in the upper and middle Danube section do not pose any significant risk. The problem is the lack of the data from the lower Danube, where elevated concentrations were observed. In general, the risk stemming from these three elements can be looked upon as low.

Organic micropollutants

The major problems in assessing the results on organic micropollutants are the lack of the data (especially from the lower section), high detection limits not matching with the environmental quality standards and a high uncertainty of analytical results. These all factors must be taken into account when formulating any statements on existing risk.

For the two monitored persistent pesticides – p,p'-DDT and Lindane – the observed profile of occurrence is similar – relatively low amounts in the upper and middle sections and the elevated concentrations in the lower section. However, the substantially lower target value for p,p'-DDT makes this substance a critical issue for the lower Danube and the respective tributaries as the non-compliance factor in these areas reaches the order of two magnitudes. This means that despite a high uncertainty the level of pollution by p,p'-DDT is significant and gives a strong indication of potential risk of failure to achieve a good status taking into account the one-out all-out rule. An important fact in this case is that p,p'-DDT is a pesticide banned in Europe and it is likely that the contamination stems from the past loads. However, the Inventory of Agricultural Pesticide Use reports on uncontrolled and illegal trade of pesticide products leading to the use of banned pesticides (e.g. DDT) by farmers so this pollution source should be checked if possible.

A magnitude higher TNMN target value for Lindane suppresses the extent of non-compliance for this pesticide. Thus, the situation is not as negative as for p,p'-DDT. However, it is foreseen that the environmental quality standard for Lindane that will be set by the WFD may be substantially lower that the TNMN target value. In such case the probability of risk of failure to achieve a good status would be much higher and the situation similar to that for p,p'-DDT.

The postemergent herbicide Atrazine, despite its banning in the upper Danube area, belongs to the most applied pesticides in the Danube River Basin. This makes Atrazine detectable especially in the middle and lower Danube section including the tributaries. Extremely high concentrations were found in the Sio and the Sajo. The elevated concentration of Atrazine in the Sava triggered the alarm in the ICPDR Accident Emergency Warning System in 2003. Even though it is still not clear what will be the EQS set by the WFD, Atrazine belongs to significant pollutants of the Danube River and its tributaries.

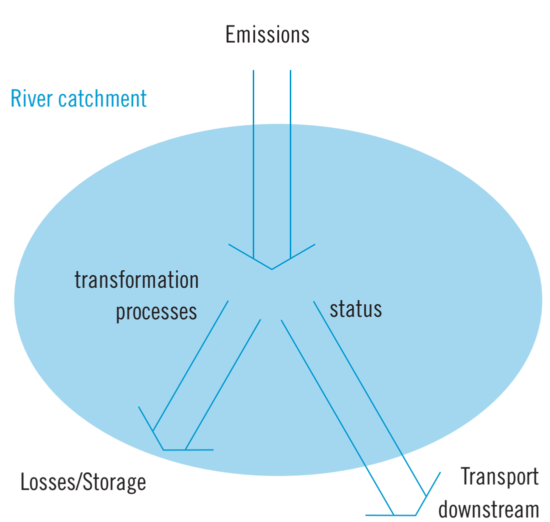
The detected concentrations of volatile organic compounds indicate that this group of pollutants is of lower relevance for the Danube River Basin. Even though chloroform, being the most frequent VOC representative, exceeded the target value in about one third of the results primarily from the middle section (data from the lower section are missing) the non-compliance was not very significant. The exceptions were several high values reported for the Slovak part of the basin. However, comparing these high results with the substantially lower obtained by the JDS it can be concluded that the high values of chloroform sporadically found in the Danube River or its tributaries can indicate that sources of pollution were still not sufficiently under control (of course assuming that the analysis of chloroform was not influenced by an error).

4.5.1.3. Impacts from nutrient loads

This paragraph discusses the impacts from the emissions of nutrients in the Danube Basin District (see Chapter 4.4). The impact assessment starts from the moment that the emitted nutrients reach the surface waters in the catchment (see Figure 44). In the surface waters, the nutrients undergo a range of transformation processes, which together with the emissions determine the status of the surface waters. Some of the transformation processes result in loss or (semi-) permanent storage of nutrients in the catchment. The remaining nutrients are transported downstream, eventually towards the Danube Delta and the Black Sea.

The present paragraph discusses the emissions (pressures), the status of the surface waters and the impacts. The focus is on the transboundary, large scale impacts. The impacts on the national level are discussed in Part B.

Schematic representation of the nutrient balances in the surface water network *FIGURE 44*



The present analysis requires the availability of data of high and homogenous quality, covering the whole catchment area. The time scale of the issue requires data over a long period of time, at least several decades. There is not one individual data set with sufficient temporal and spatial coverage. For this reason, gaps and inconsistencies in the existing data sets have been addressed by using mathematical models to interpret the data (see remarks on the use of models in Chapter 4.4).

Link to pressures

Chapter 4.4 provides an overview of the emissions of nitrogen and phosphorus to the Danube Basin District surface waters, which represent the pressure responsible for the impacts discussed here. The subdivision of these emissions over different pathways is relevant in this respect: the emissions stem from point sources (municipalities, industry and agriculture) and from diffuse sources (erosion and surface runoff, ground water inflow and atmospheric deposition). From the diffuse sources, a part has a natural origin, while the rest is of an anthropogenic nature, mostly related to agriculture. The applicable emission control measures are different for the different pathways. Furthermore, the impacts also have some relation to the emission pathways. For example, the phosphorus emitted by WWTP's has a higher bio-availability than the phosphorus stemming from the erosion of the soils.

Present status

Nutrient concentrations in the Danube River and its tributaries

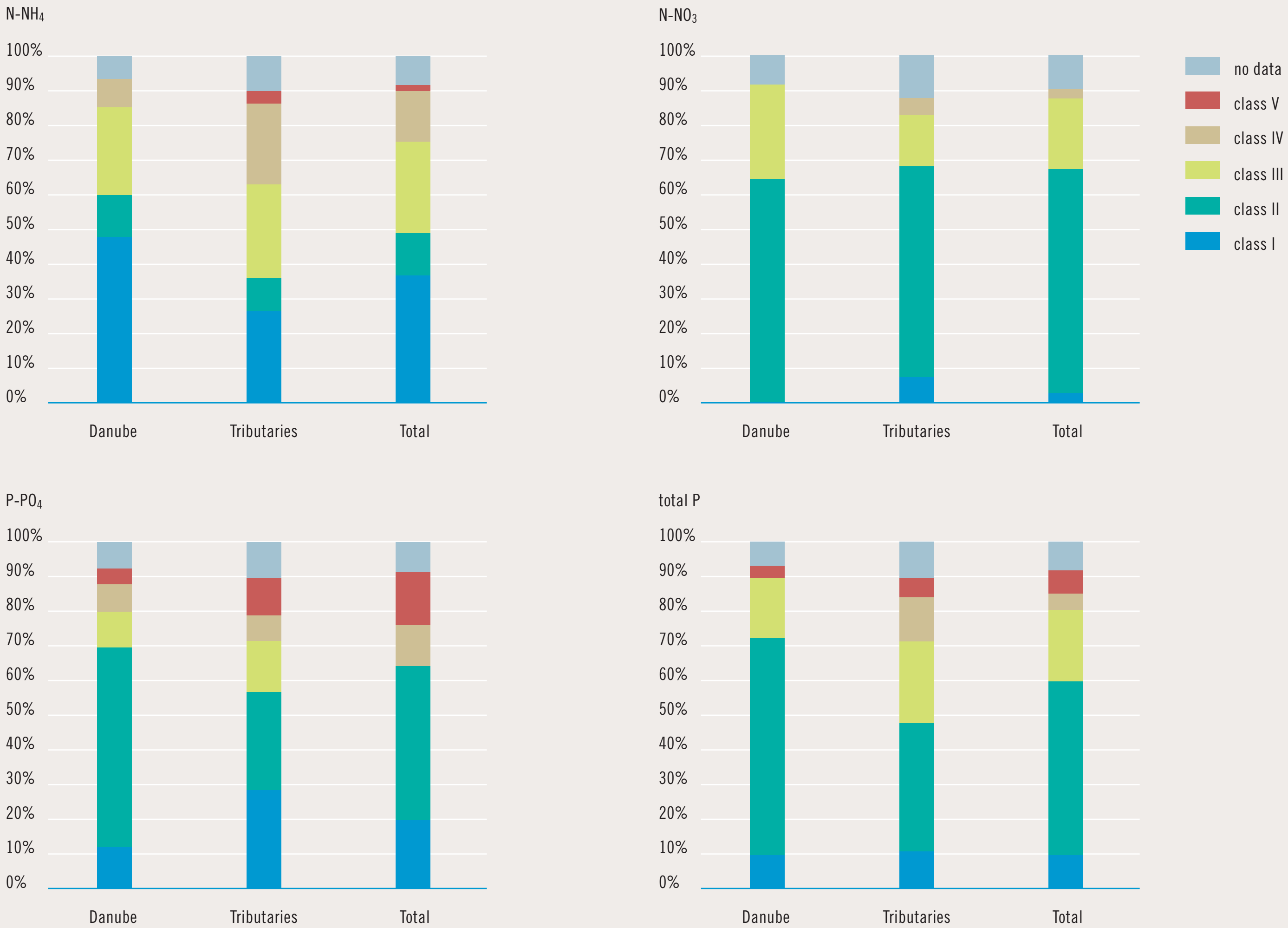
The nutrient concentrations in the Danube River and its tributaries are discussed on the basis of the TNMN results. These represent the larger transboundary rivers. For the smaller water bodies reference is made to Part B.

The 2001 TNMN Yearbook[45] presents the current status (2001) in an aggregated form, indicating the classification of the observed concentrations in 5 classes. Class I represents the lowest concentrations and Class V represents the highest values. The upper limit of class II represents a Target Value[46]. The summary charts for different nutrient species are presented in Figure 45.

These graphs indicate that for most of the stations sufficient data are available (only about 10 % is classified as "no data"). The percentage of stations satisfying the Target Value varies between 50 % and 65 % for the different parameters. It should be noted that the analysis concerns yearly averaged concentrations.

45 ICPDR (2001).
46 This is an existing classification system. It should not be confused with the WFD Good Ecological Status criteria for these water bodies. To determine the Ecological Status, a system with type specific class boundaries is required.

Overall assessment of present nutrient concentrations (on the basis of TNMN data from the year 2001) *FIGURE 45*



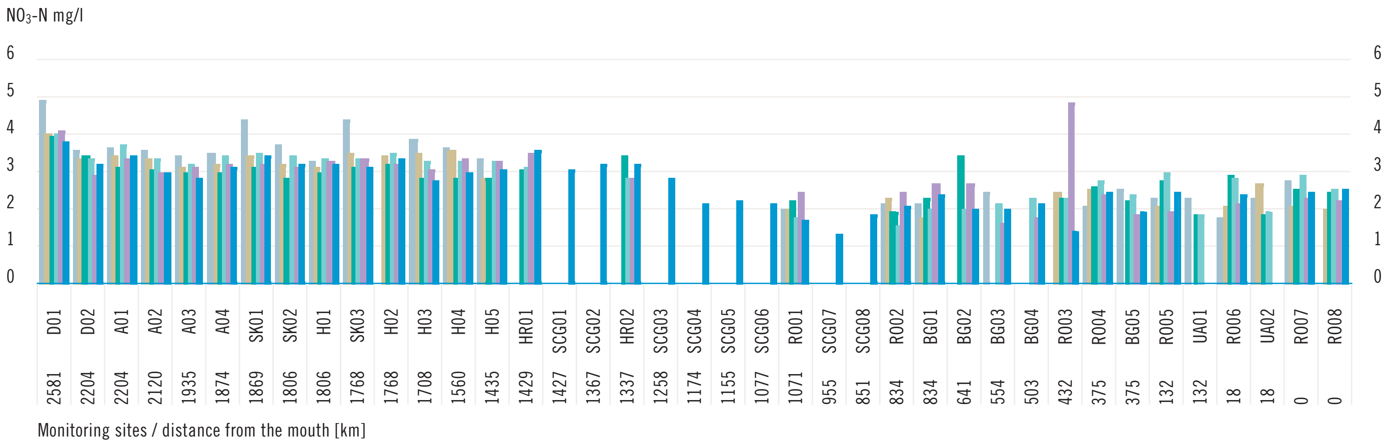
By inspecting the observed concentrations for individual stations along the Danube River and its tributaries, additional information can be obtained. Figure 46 and Figure 47 present such information for nitrogen in nitrates[47] and for total phosphorus, for the years 1996-2001. These graphs show clearly that the highest levels are observed in the tributaries and not in the Danube itself. A clear spatial trend along the Danube can not be observed for total phosphorus. For nitrates such a trend exists, but it is not representative for total nitrogen.

47 Nitrates represent an important species of nitrogen, but it may not be considered representative for the total nitrogen content of the river, since ammonium and organic nitrogen are not included.

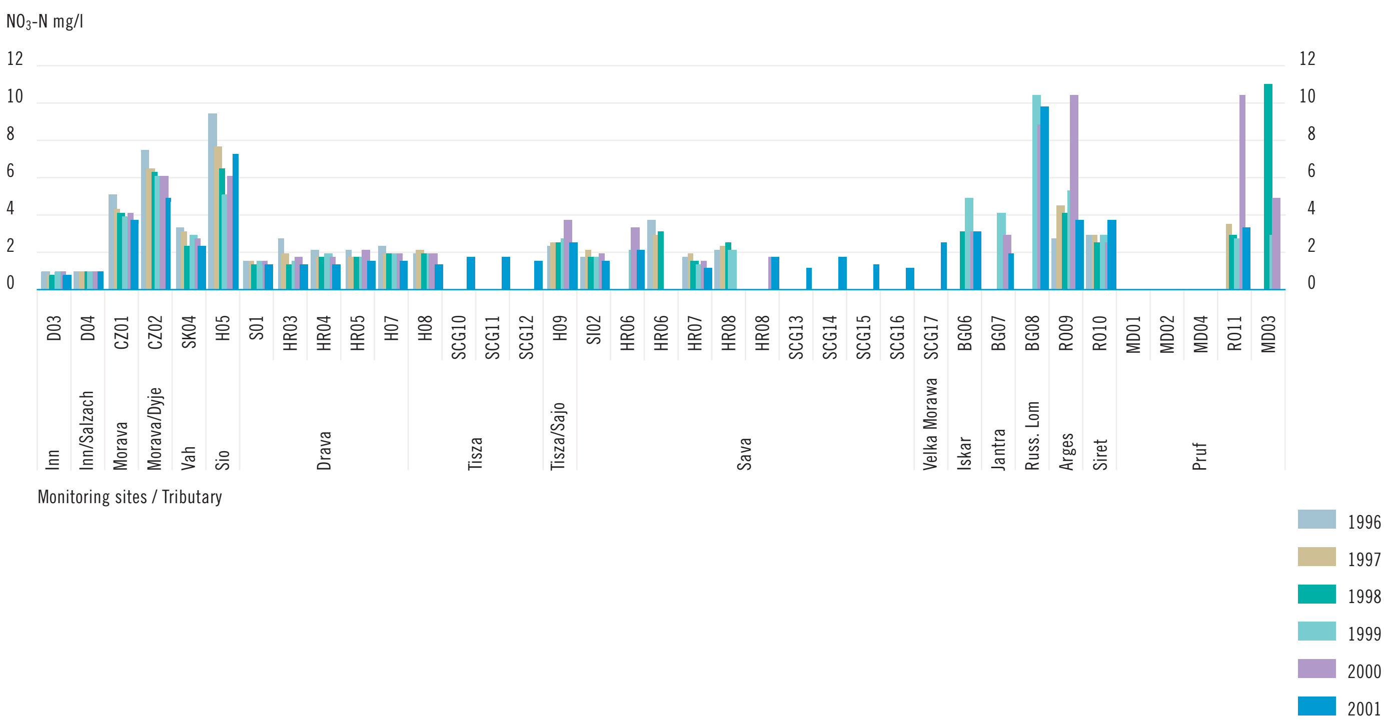
Temporal and spatial trends of nitrate concentrations

(data for the years 1996-2001; figures from TNMN Yearbook 2001; ICPDR 2001) *FIGURE 46*

Temporal trends of nitrate-nitrogen in Danube River

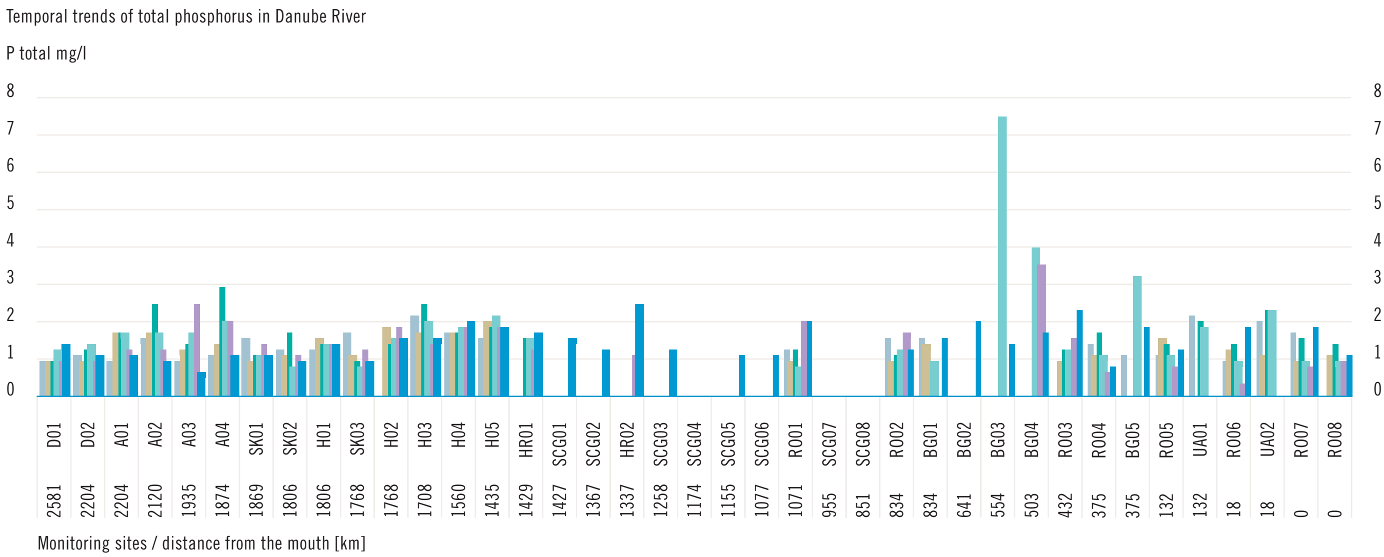


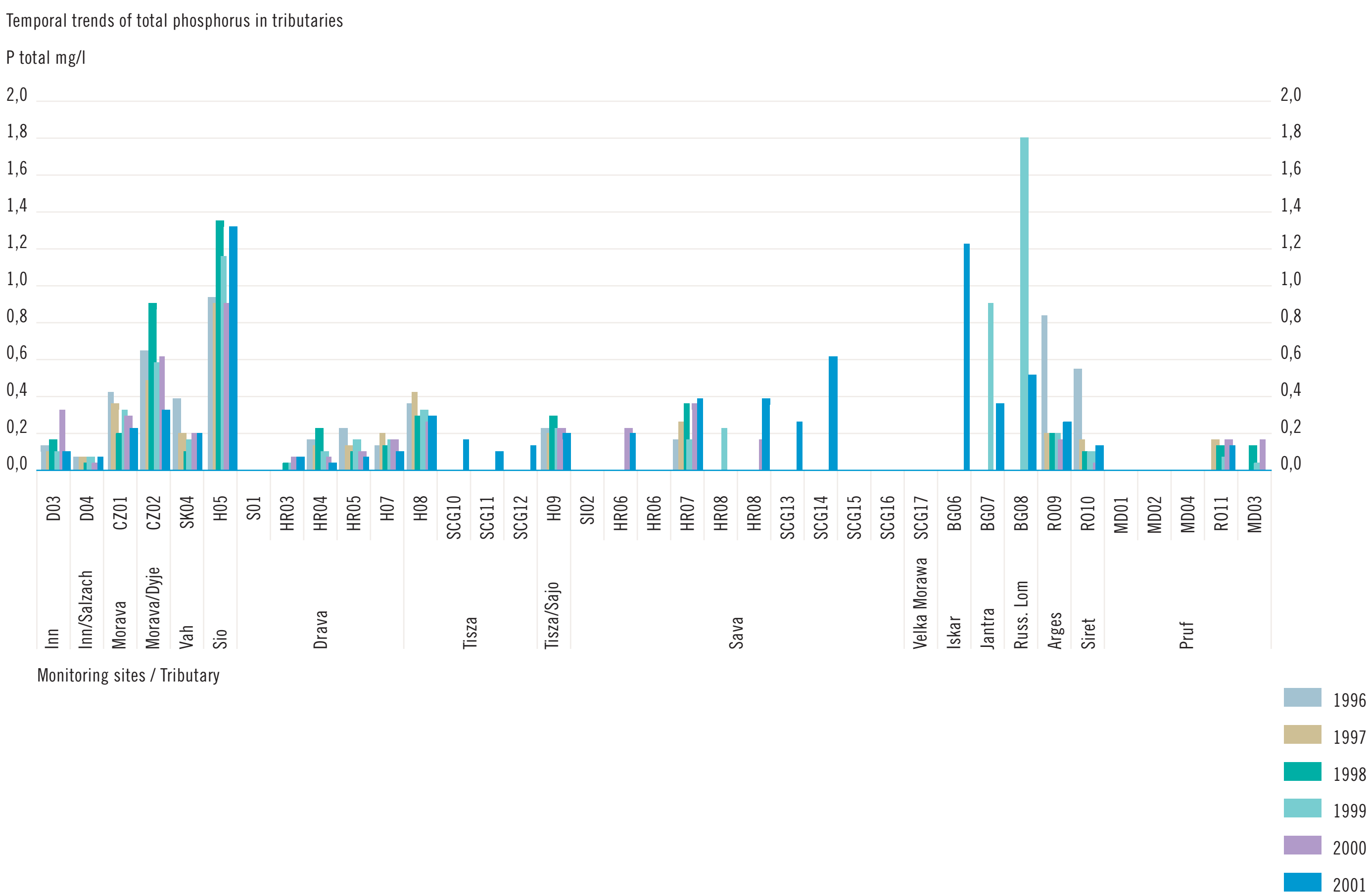
Temporal trends of nitrate-nitrogen in tributaries



Temporal and spatial trends of the concentration of total phosphorus

(data for the years 1996-2001; figures from TNMN Yearbook 2001; ICPDR 2001) *FIGURE 47*

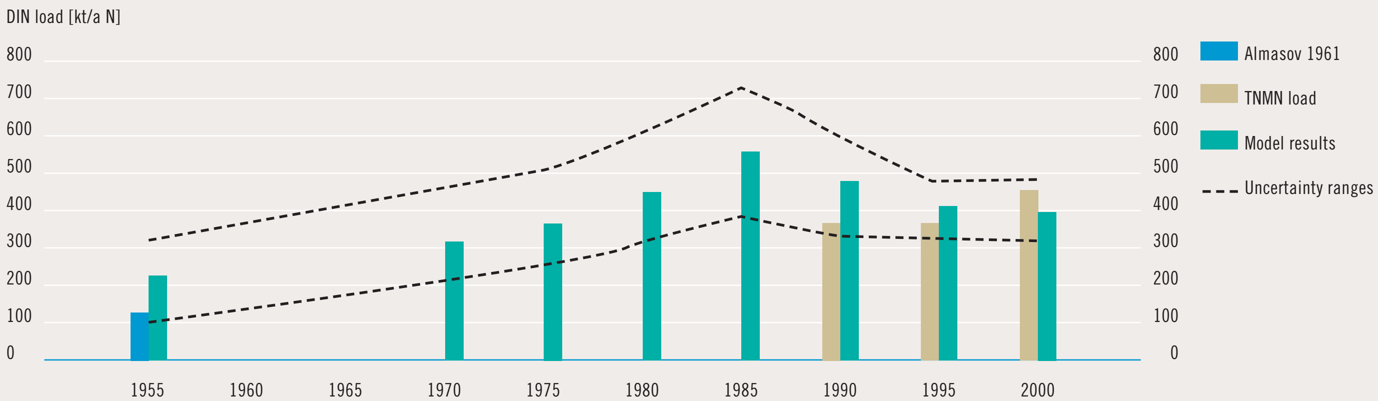




Historical development of the Danube nutrient loads

The historical development of the Danube nutrient loads over the last 50 years has been reconstructed by means of mathematical modelling with MONERIS, since it can not be derived from field data alone. Figure 48 shows the result.

Historical development of nutrient loads in the Danube River for dissolved inorganic nitrogen (top) and total phosphorous (bottom) based on modelling results with MONERIS; the estimates refer to the Danube River before it enters the delta *FIGURE 48*



The green bars represent the model results from MONERIS. The dashed lines represent the uncertainty ranges, estimated by expert judgement. The purple and red bars represent the available field data: historical data reported by Almasov in 1961, data collected by the Danube countries in the framework of the TNMN and the Buch rest Declaration ("TNMN load").

the purple and red bars >>

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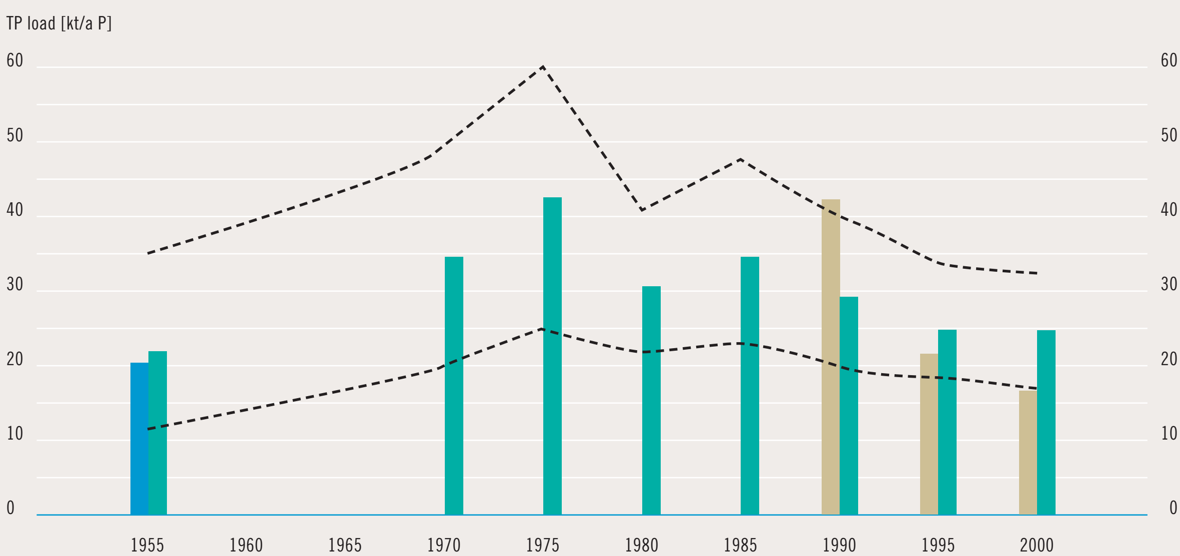


The green bars represent the model results from MONERIS. The dashed lines represent the uncertainty ranges, estimated by expert judgement. The purple and red bars represent the available field data: historical data reported by Almasov in 1961, data collected by the Danube countries in the framework of the TNMN and the Bucharest Declaration ("TNMN load").

The river loads of Dissolved Inorganic Nitrogen (DIN) show an increase from 1950 onwards up to a maximum in the mid 1980s. The increase is about a factor of 2.5 for DIN. In the 1990s, the river DIN loads decrease again for DIN (~ - 27 %). Compared to the 1950s the present DIN load is about 1.9 times higher. This increase of the river load is the result of the increase of the anthropogenic emissions of nitrogen to the river system.

The change of the load of Total Phosphorus (TP) is determined by two factors. As with DIN, the development of the emissions plays an important role. Another relevant factor is the construction of the Iron Gate dams in the second half of the 1970s, which introduces a strong P storage in the backwater area of the dams (see impact assessment below). Therefore, the highest TP load was estimated for the mid of the 1970s, just before the Iron Gate was established. A second maximum occurs in the mid of 1980s due to the emission maximum. The highest TP load around 1975 is about a factor of 1.9 higher than the 1950 load. The TP loads decrease in the 1990s (~ - 29 %). Compared to the maximum in the mid 1970s, the TP load is reduced by about 42 %. The TP load of 2000 is only about 10 % higher than the 1950s load. That is due to the storage effect of Iron Gates area. Without this effect, the present TP load would be about 40 % higher than in the 1950s.

The Report "State of the Environment of the Black Sea, Pressures and Trends, 1996 - 2000", issued by the Black Sea Protection Commission[48], reports substantially lower values for the Danube River load of inorganic nitrogen around the year 2000. The reason for this discrepancy is not fully understood, and is subject of study (e.g. in the EU research project daNUbs).

The development of the annual nutrient loads shows a pronounced inter-annual variability, which is strongly influenced by hydrological differences. For example, the Danube discharge has been higher than average for 7 consecutive years in 1996-2002. This affects the nutrient loads to such an extent that human induced trends can very well be obscured by this hydrology induced variability.

The historical development of the river loads is the direct result of the historical development of the anthropogenic emissions of nutrients in the Danube River Basin District (see Chapter 4.4). The decrease of the loads in the past decade is partly the result of emission control measures in the basin. To a significant degree however, it is the result of the economic crisis in the former communist countries. This has caused a dramatic decrease of the application of mineral fertilizers, the closure of large animal farms (agricultural point sources) and the closure of nutrient discharging industries (e.g. fertilizer industry). In order to get a full picture of the nutrient pressures impacting the coastal waters of the DRBD an estimation is still needed of the nutrient loads stemming from the Romanian Black Sea coastal catchments that are part of the DRBD but have not been included in the current modelling of nutrient loads into the Black Sea.

48 BSC (2002).

Impact assessment

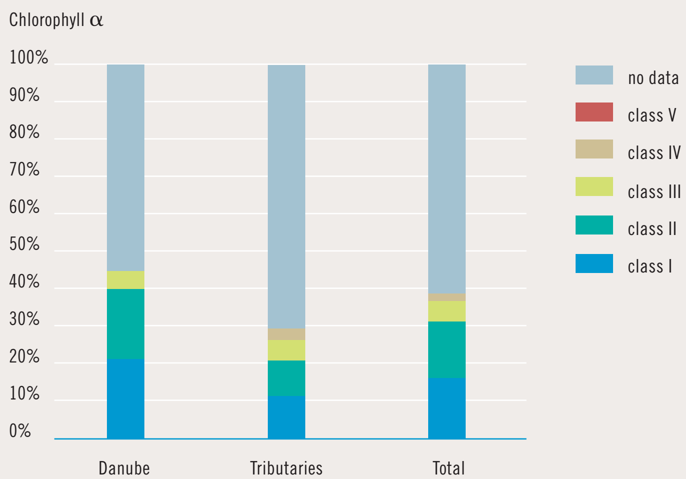
The most relevant impact of high nutrient loads is eutrophication. This is defined as *the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned*[49].

Impact on the Danube River and its tributaries

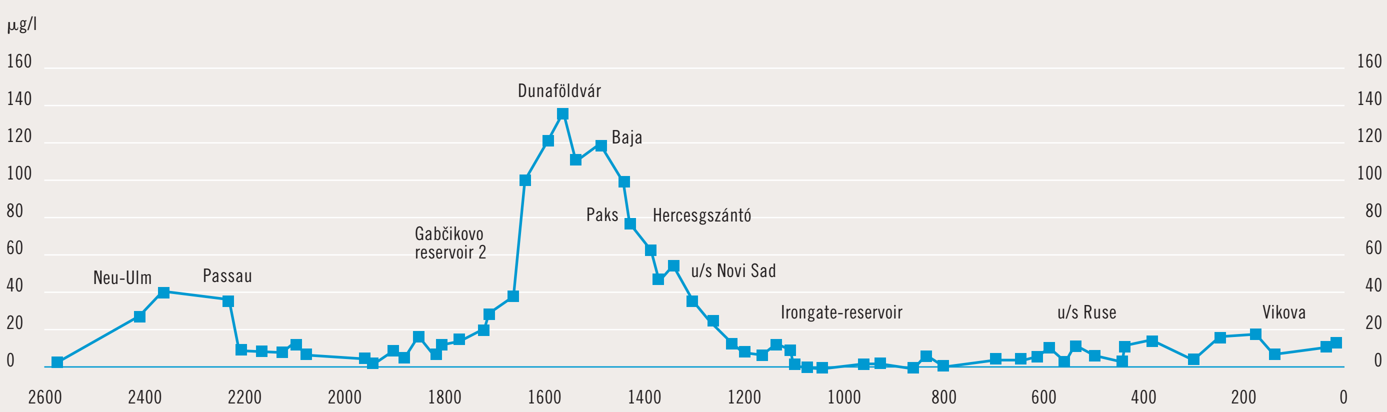
The eutrophication impacts in the Danube River and its tributaries are discussed on the basis of the TNMN results. These represent the larger transboundary rivers. For the smaller water bodies we refer to Part B.

The 2001 TNMN Yearbook[50] tries to assess the concentrations of chlorophyll-α. This parameter represents the amount of live phytoplankton in the surface water and is generally considered to be an indicator for eutrophication. The Yearbook presents the current impacts (2001) in an aggregated form, indicating the classification of the observed concentrations of chlorophyll-α in 5 classes. Class I represents the lowest concentrations and Class V represents the highest values. The upper limit of class II represents a Target Value[51]. The summary chart is presented in Figure 49. This graph indicates that there is a large data availability problem: more than 60 % of the stations are classified as "no data". The available data indicate eutrophication problems in the slow-flowing and relatively shallow reaches of the Middle Danube (in Hungary). The JDS results also point in this direction (see Figure 50). This survey in August-September 2001 indicated a strong algae bloom in the Hungarian part of the Danube.

Information related to the concentrations of chlorophyll-α in the Danube and its large tributaries, on the basis of TNMN field data from 2001 (compare also Figure 50) *FIGURE 49*



Concentrations of chlorophyll-α [µg/l] in the Danube River on the basis of field data collected during the JDS (compare also Figure 49) *FIGURE 50*



49 Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (UWWT-Directive).
50 ICPDR (2001).
51 This is an existing classification system. It should not be confused with the WFD Good Ecological Status criteria for these water bodies. To determine the Ecological Status, a system with type specific class boundaries is required.

Transboundary conveyance of nutrients in the Danube River and its tributaries

If we compare the total emissions of N and P in the Danube River Basin with the river loads to the Black Sea, we find that the river loads are substantially smaller. Apparently, the nutrients undergo *loss* or *storage* in the Danube Basin surface waters. Loss processes imply the permanent removal of nutrients from the hydrosphere, while storage processes are of a temporal nature: remobilisation may be relevant depending on the time scale under consideration. Due to the different nature of N and P, their fates in the surface waters are also different. For nitrogen mainly *denitrification* is relevant. This is a loss process taking place mostly on the interface between the water and the sediments. The process removes nitrogen from the hydrosphere to the atmosphere in the form of N_2 gas. For phosphorus on the contrary there is only (semi-)permanent storage in the aquatic sediments.

Loss and storage processes turn out to be concentrated in the small river systems, where there is an intensive contact between the water and the aquatic sediments. In this respect a natural river system with wetlands and floodplains is more efficient than a strongly canalised (artificial) one. The River Danube and its main tributaries play a minor role for nitrogen losses. In respect to phosphorus the Iron Gate backwater area represents a major storage area due to net sedimentation of P in particles. Recent research indicates that about 1/3 of the incoming load is semi-permanently stored. It can be expected that this storage function is limited in time (< 100 years).

The losses and storage of nutrients in the small scale river networks in the Danube Basin show strong geographical differences. This is the result of the natural morphological and hydrological gradients in the basin. Generally speaking, areas with a relatively high specific runoff[54] show relatively low losses and storage and consequently convey a relatively high share of the nutrient emissions downstream.

Some years ago, a Transboundary Diagnostic Analysis was carried out into the Danube River loads of nitrogen and phosphorus (Danube Pollution Reduction Programme, GEF-UNDP, 1999). Figure 51 shows the longitudinal profile along the River Danube of the in-stream load of N and P respectively. The load is subdivided over the countries of origin. Figure 5 provides a similar profile for the annual water volume.

The results show that certain countries contribute relatively strong to the annual water volume: as a result of the basin morphology and of the climatic conditions, the area specific run-off is high in those countries (e.g. Austria, Germany, Slovenia and Bosnia i Herzegovina). Other countries have a low area specific run-off (e.g. Hungary). These natural variations are reflected in the river load profiles for N and P. The areas with a high specific run-off have a relatively high contribution, while the areas with a low specific run-off have a relatively low contribution. The load profile for P shows a strong decrease in the Iron Gates area; due to the local point sink which was already mentioned above.

Climatic conditions

Climatic conditions have a distinct effect on the river hydrology, and significantly affect the impact assessment. For example, hydrologic variations may induce a variability of the nutrient concentrations (e.g. the high concentrations of P in the Danube Delta in the extremely dry year 2003). Furthermore, the Danube River nutrient loads to the Black Sea show a pronounced inter-annual variation influenced by the variability of the river discharge, which may be strong enough to obscure a man-induced trend.

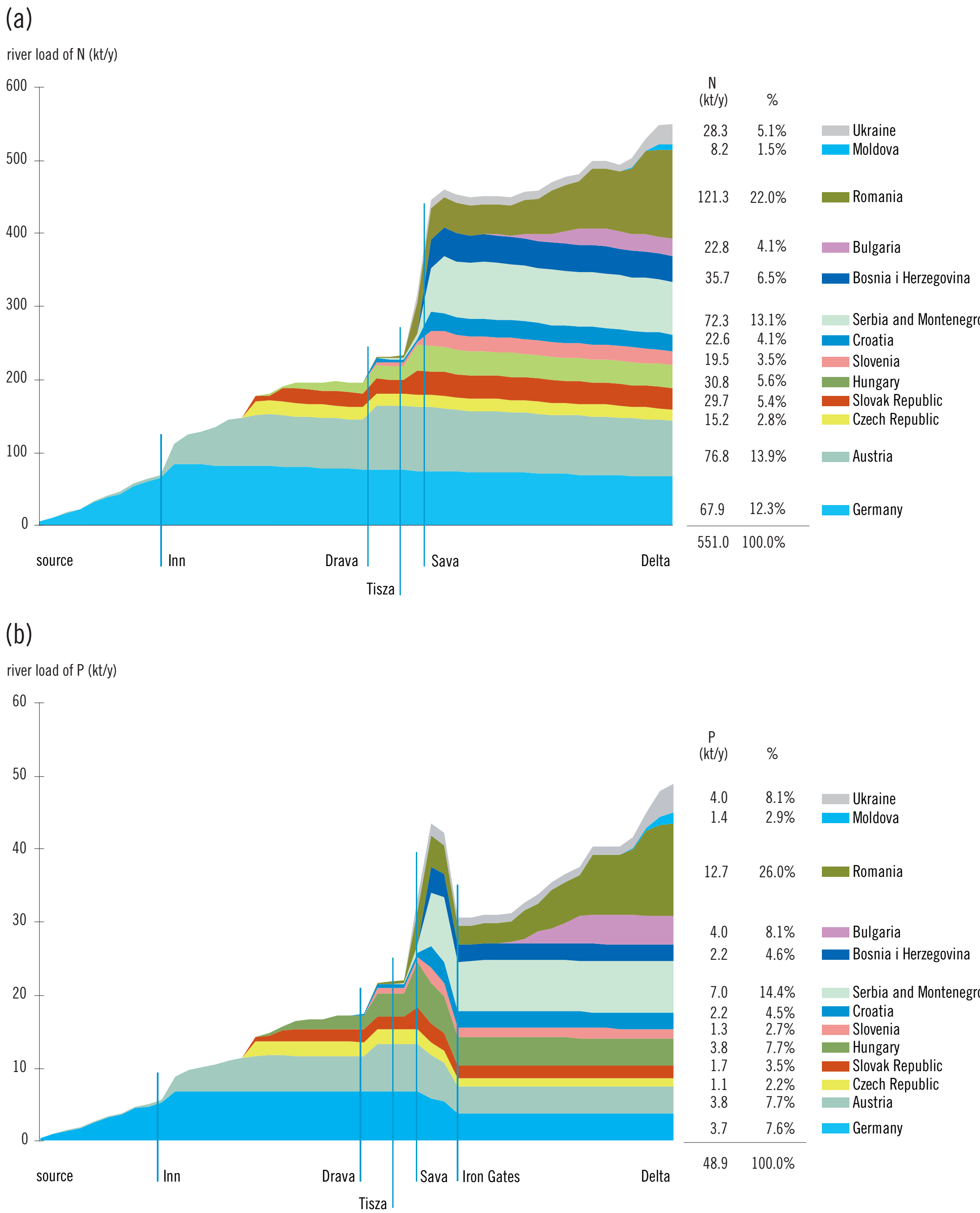
Future developments

The decrease of the Danube River nutrient loads in the last decade is partly a positive side-effect of the economic crisis in the middle and lower Danube Basin. The ongoing economic recovery will potentially result in increasing nutrient loads to the Black Sea. However, the economic development in these countries is a social necessity, even if an increase in the level of production probably will lead to an increase of nutrient emissions to the environment in the future. Therefore, the challenge is to compensate these possible increases by a decrease of emissions from point and diffuse sources and to level the increase of emissions.

From the present state of knowledge we can derive that future emission control efforts can best be concentrated on phosphorus (being the limiting nutrient). Furthermore, measures directed at dissolved P-compounds, which are easily available for algae growth, are most effective.

52 Specific runoff: river runoff generated per unit of surface area ($m^3/s/m^2$).

River load profiles of nitrogen (a) and phosphorus (b), subdivided over countries of origin – derived from simulations with the Danube Water Quality Model (DWQM) during the GEF-UNDP Danube Pollution Reduction Programme, 1999 UNDP/GEF (1999a) *FIGURE 51*



The introduction of P-free detergents, P-removal at municipal and industrial waste water treatment plants and the avoidance of agricultural point sources are such measures. In the same time, nitrogen removal from point sources (treatment plants) will play an important role in nitrogen management, as diffuse sources from agriculture in the Eastern Danubian countries are bound to increase as a result of the expected economic growth.

4.5.1.4. Impacts caused by hydromorphological alterations

Although a number of studies have been carried out on individual river stretches and special aspects of river degradation, a comprehensive assessment of the direct and indirect effects of hydro-morphological alterations in the DRB countries does not yet exist. Therefore, it is not possible to give an overview of the situation for the whole Danube basin. Instead examples will be given, which highlight the kind of impacts from hydromorphological changes that have occurred and allow the assumption that similar impacts have taken place in other parts of the basin where similar pressures from hydromorphological alterations exist.

Impacts from river regulation works

The Danube regulation works of the 19th century (since 1870 in the Austrian-Hungarian Monarchy, since 1895 in districts of the present Serbia and Montenegro) together with the nearly complete loss of sediment supply from the Upper Danube catchment in the 20th century (retained by a series of dams from the Alps down to Gabcikovo Hydropower Dam), increased the sediment deficit for the entire Danube up to the Iron Gate and even beyond. The result is an ongoing channel incision for long stretches of the Danube, e.g. on the Hungarian Danube of about 1 - 3 cm/a. On the Austrian Danube downstream Vienna, the river bed is eroding at a rate of 2.0 - 3.5 cm/a[53]. Connected water tables in the alluvial flood plain are reduced as well, sometimes in a magnitude of several meters. An example can be seen in parts of the upper Danube in Baden-Württemberg (rkm 2,670 - 2,655).

The meander cut-offs carried out to improve the navigation route (e.g. the Hungarian Danube was shortened from 472 km to 417 km) have changed the water table and resulted in a progressive silting of the many cut-off side-channels and oxbows. Most important flood-plain areas, such as the protected areas of Gemenc-Béda Karapancsa are slowly drying out. The local nature and water management authorities have started to halt this erosion and improve the water exchange by re-connecting the Gemenc floodplain area with the main channel and retaining more water in the side-arm system. The formerly rich fisheries can only thrive by restoring the migration routes and spawning areas in the floodplain[54].

During the last ten years the war and post-war impacts in former Yugoslavia inhibited the maintenance and reconstruction works in many areas of the Danube River. Between Baja (HU) and Belgrade numerous ecologically valuable bank segments and islands were therefore preserved or have even self-restored themselves over these past ten years[55].

Pronounced sediment accumulations occur behind the Iron Gate dams. Between 1972 and 1994, about 325 million tons of sediment were deposited, taking up 10 percent of the entire reservoir and resulting in a much reduced transport of suspended solids and soil sediments downstream of the Iron Gate. In the backwater of the Iron Gate, stretching upstream over 310 km (up to Novi Sad), the effects of the increased inner and outer colmation (clogging) have led to problems with the supply of drinking water in communities located along the impoundment.

Downstream of Bratislava from the impounded Danube 80 % of waters are diverted into the sealed Gabcikovo power side-canal. The remaining 20 % for the 40 km long section of the main river bed are too small to balance various effects: A drop of 2 - 4 m of the surface and groundwater table and resulting desiccation of bank forests; a loss of hydro-dynamics in the disconnected, artificially irrigated and impounded side-arm systems (altogether 8,000 ha on both sides of the river); absence of former morphological processes resulting in a disappearing of pioneer species, a reduced water quality and an overgrowing of former open or periodically inundated habitats.[56]

Specific impacts from dams and weirs (disruption of river continuity)

Impoundments lead to an alteration of the hydraulic characteristics of a river. A major problem associated with the interruption of the river continuum is the decrease of velocity and retention of sediment in the impounded stretches. As a consequence of reduced slope and current velocity, fine sediments cover the natural habitats of the bottom-dwelling organisms and clog the interstices in the bed sediments. This leads to a diminished flow of oxygen into the bed sediments and to a reduced recharge of the groundwater. These changes in flow and substrate composition affect the benthic invertebrates and the spawning grounds for fish. Typical rheophilic fish species, dependent on gravel and cobble as spawning habitats, such as *Thymallus thymallus, Chondrostoma nasus, Barbus barbus,* or *Hucho hucho* are especially affected during their spawning and larval phase. Another impact of reduced current velocity and changes in sediment composition in mountain streams is the loss of habitat for algae. *Hydrurus foetidus,* a typical winter species, is one of the most densely colonised habitats for benthic invertebrates[57]. Bottom-dwelling, rheophilic species feeding on algal and bacteria disappear and species typical for fine sediments can occur in masses (for example Tubificidae). As a result, typical benthic invertebrate communities are absent and the ecological integrity of such rivers is disturbed.

53 HANISCH & KORDINA (2004).
54 WWF (2002).
55 WWF (2002).
56 WWF (2002).
57 MOOG & JANECEK (1991).

Due to all these effects the self-purification capacity of the river may also be reduced. As an example, monitoring results on the Bavarian Danube show a change in water quality from class II to II/III after completion of the impoundments Straubing and Geisling in 1999, although discharge of waste water has been minimised. The impoundment changes the living conditions for all organisms – e.g. slower current velocity – and results in a change in river water quality due to intensified secondary production.

Migratory species are impacted by dams and impoundments that disrupt the longitudinal connectivity of rivers and streams. In-channel structures that exceed a certain height prevent or severely reduce the migration of certain aquatic species. Particularly some of the migratory fish species such as the sturgeon or the sterlet can no longer reach their spawning grounds, feeding and shelter areas.

One of the well-known impacts of the Iron Gate dams has been the extinction of sturgeons migrating in the middle and upper Danube basin after its construction[58]. The construction of the Iron Gate dams has changed the distribution of fish species. The migration path was cut for anadromous[59] species coming from the Black Sea into the Danube for spawning. Now, in Serbia and Montenegro, *Acipenser gueldenstaedti* (Danube or Russian sturgeon), *Acipenser ruthenus* (sterlet), *Acipenser stellatus* (stellate or starred sturgeon), *Huso huso* (beluga), and *Acipenser nudiventris* are present only downstream from the Iron Gate II. *Acipenser ruthenus* (sterlet) is present in all Serbian parts of the Danube, as well as its tributaries, such as the Sava, the Tisza and the Morava River.

Another example is known from the Inn River in Germany, where over 30 fish species were originally present. After the construction of the first impoundment at Jettenbach in 1921, professional fisheries on the river collapsed. Today, only two fish species are able to maintain their stocks by natural reproduction in this part of the river[60].

Effects of intermittent hydropower generation (hydropeaking)

Intermittent hydropower generation (hydropeaking) causes special downstream effects on the aquatic fauna. Water is released by pulses several times per day, which causes tremendous water level changes. These “artificial floods” damage the aquatic fauna, by sweeping them away during pulses and drying out in periods of retention. In the Austrian part of River Drau/Drava for example a reduction of 50 % of the fish stock, and 80 % of the benthic invertebrate community, has been attributed to peak operation in the Möll tributary and the impoundment of the Malta tributary[61].

Effects on riverine wetlands (disruption of the lateral connectivity)

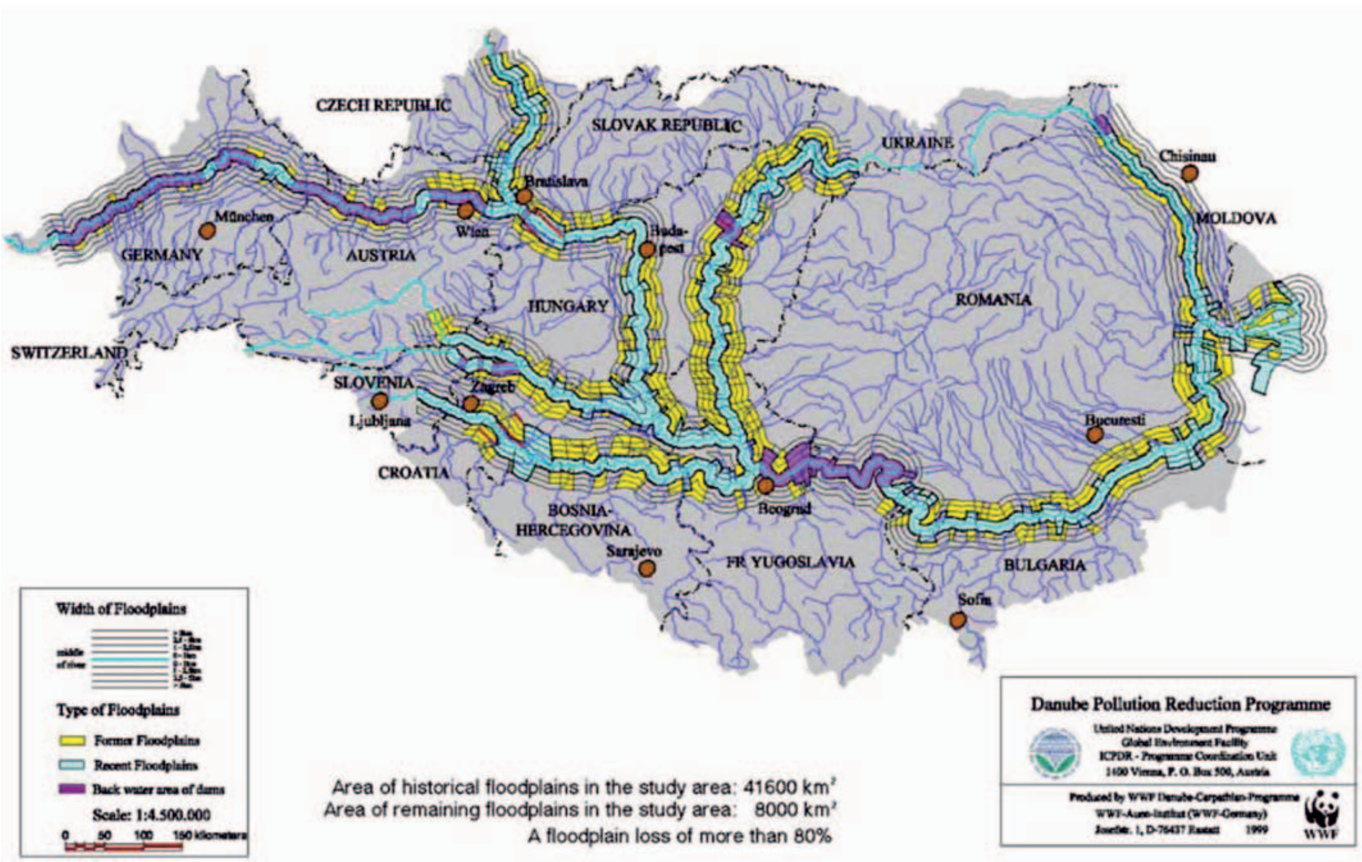
Wetland habitats in the Danube river basin have been drastically altered in the last two centuries. The main causes of wetland destruction have been the expansion of agriculture uses and river engineering works mainly for flood control, navigation and power production. Drainage and irrigation are also responsible for the drop in water levels and the loss of wetland and floodplain forests, leaving only a few natural forests. Compared to the 19th century less than 19 % of the former floodplains (7,845 km^2 out of once 41,605 km^2) are left in the entire Danube basin (see Figure 52)[62].

Since the 1950s, altogether 15-20,000 km^2 of the Danube floodplains were cut off from the river by engineering works. In the large plains of the middle and lower Danube (Hungary, Serbia and Montenegro, and Romania) extensive flood protection dike systems and drainage/irrigation networks were built up since the 16th century, but especially in the 19th and 20th century, and have caused a huge loss. For instance, in Hungary, 3.7 million ha were diked in and in Romania 435,000 ha.

58 REINARTZ (2002).
59 Anadromous species: species that spend their adult life in the sea but swim upriver to freshwater spawning grounds in order to reproduce.
60 WAIDBACHER & HAIDVOGEL (1998).
61 JUNGWIRTH (2003).
62 UNDP/GEF (1999d).

Symbolised view of floodplains in the Danube River Basin

FIGURE 52



In the Danube section between Romania and Bulgaria, dikes are usually only 200 to 300 m away from the main stream. Through this process, starting in the 16th century, the formerly extended floodplains along the Danube have been reduced drastically. Outside the dikes, natural succession processes from reed and marsh vegetation towards dry meadows but also forestation measures alter the habitat structure of the dynamic floodplain. These habitats, which are disconnected and partly far away from the Danube, are lost as spawning grounds for fish (pike, carp, etc.). Their loss contributed to the decline of fisheries in the lower Danube[63].

The complex system of riverine flood plains with its typical aquatic communities is dependent on constant changes in the duration, frequency and amount of floods. Elimination of these fluctuations inhibits regeneration of these habitats and siltation of backwaters cannot be reversed. Impacts on fauna and flora are significant. Typical fish fauna dependent on different habitat types during their life cycle (i.e. areas of refuge during floods and specific spawning and larval habitats) suffer from loss of habitats. Studies on the Middle Danube have shown that following the construction of flood control measures commercial fisheries have lost their importance. This factor is also apparently responsible for the decrease of fish catches in the Rajka and Budapest section of the Danube during the last two decades from over 300 tons in 1976 to approximately 50 tons in 1996.[64]
In the lower Danube the number of fish species has declined from 28 species before 1980 to 19 species today. Dominant species like the carp have been replaced by species of value for fisheries and have resulted in a decrease of fish catch from 6,000 t/a down to 2,500 t/a presently.

Impacts from navigation

Impacts from navigation often overlap with those of hydropower generation and flood defence, and are not very well studied. Special measures for maintenance of the navigation channel such as dredging affect the vertical connectivity. Benthic invertebrates inhabiting the river bottom and fish eggs are directly affected in areas of gravel extraction. Studies in Germany have shown that after the termination of gravel extraction typical benthic invertebrate communities re-establish themselves within two to three years[65]. From the mechanical point of view, regular ship traffic causes waves resulting in artificial changes of water level along the riparian zones. Consequences are the disturbance of reproduction habitats for fish and benthic invertebrates as well as de-rooting of aquatic plants. Fish larvae and young fish are affected by the wash of the waves. Another negative effect of ships' engines is the unnatural suspension of fine sediments which increases turbidity and reduces the incidence of light needed for plant and algae growth. Construction of harbours especially those with steep, artificial banks have adverse effects on the aquatic fauna and cannot be used as habitats[66]. German studies have shown that only half of the original species numbers and only 1/10 of the expected abundance can be demonstrated in such artificial surfaces[67].

Exploitation of sand and gravel and other activities leading to changes of gravel-dominated river bed can significantly affect the sturgeon population, which requires deep gravel-dominated habitats with a high water velocity during the spawning period. In addition, water pollution can impact negatively the functionality of spawning sites, the development of embryos and reduce the abundance of benthic invertebrates found in the diet of most sturgeons. And the increase of waves disturbs the biota on the river banks.

Expected impacts from future infrastructure projects

Based on the experiences described above it is likely that impacts from future infrastructure projects (see Chapter 4.4.4.5.) may result in similar impacts. This will depend on how these projects are implemented and the possibilities to reduce negative impacts should be explored to the fullest extent. Therefore, it is of paramount importance that an environmental impact assessment be carried out that includes the criteria of the WFD in order to ensure that these water bodies remain intact.

63 WWF (2002).
64 GUTI & KERESZTESSY (1998).
65 TITTIZER (1984).
66 KOVACECK et al. (1991).
67 TITTIZER & SCHLEUTER (1989).

4.5.1.5. Impacts from over-fishing

Sturgeons and paddlefish exhibit a very specific combination of morphological, habit and life history characteristics, which make them highly vulnerable to impacts from human activities, in particular to fisheries. The following information is based on the IAD Report "Sturgeons in the Danube River"[68].

Sturgeons and paddlefish belong to the class of bony fishes, the Osteichthyes with the subclass Actinopterygii containing the Chondrostei and the order of Acipenseriformes. The order of Acipenseriformes contains three families of which the family Acipenseridae (sturgeons) and Polyodontidae (Paddlefishes) are still represented by living species.

According to the IAD Report[68], out of six acipenserid species once native to the Danube Basin, only four still reproduce in the Lower Danube – *Acipenser gueldenstaedti* (Danube or Russian sturgeon), *Acipenser ruthenus* (Sterlet), *Acipenser stellatus* (Stellate or Starred sturgeon) and *Huso huso* (Beluga). *Acipenser sturio* and *Acipenser nudiventris* (Fringebarbel sturgeon) have possibly become extinct, while the stocks of anadromous[59] species *A. gueldenstaedti, A. stellatus,* and *H. huso* have been drastically decreased in the Lower Danube, as documented by catches. A remnant population of the resident form of *A. gueldenstaedti* still exists upstream of the Iron Gate dams.

The location of spawning sites of migratory species in the Lower Danube under the changed migration conditions, the exact status of stocks and their reproduction is still unknown. Stocks of the only true potamodromous[69] sturgeon species in the Danube, the sterlet *(A. ruthenus)*, depends on stocking in the Upper Danube. Due to improved water quality and temporary protection and stocking measures, the sterlet stocks have been increasing in the Middle Danube. In the Lower Danube, the stocks of the sterlet have been reduced to a minimum.

According to the available data, sturgeons are critically endangered in the Danube River Basin. Scientists indicate clearly that most species of sturgeon and paddlefish are endangered. However, it is rather difficult to exactly relate a threat for a given sturgeon species to a single cause or to a particular environmental impact.

It has been shown that migratory sturgeons have suffered from over-fishing in the Danube River – documented by a decline of stocks in the Upper and Middle Danube even before the construction of Iron Gate dams – as well as by the use of fishnets in the Danube delta, which do not allow those species to proceed further up the Danube to reach their natural spawning areas.

During the last century sturgeons used to easily reach the Bulgarian part of the river. The catch of those species was then about 23 - 45 tons per year. As a result of over-fishing and of other causes during the last 10 years, the number of sturgeon species significantly declined. For example *Acipenser sturio* disappeared about 50 years ago and there is no registered catch of *Acipenser nudiventris* since 20 years. Currently, natural spawning areas around the town of Vidin and Kozlodui are reached only by single specimen of *Huso huso* and *Acipenser gueldenstaedti.* The impact on sturgeon populations by marine fisheries is also documented.

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68 REINARTZ (2002).
69 Potamodromous species: migrating within rivers and streams

Some protection measures

Legislation in some countries prohibits over-fishing of species from the Danube and Black Sea during their spawning period (e.g. in Bulgaria from 20 April - 5 June). Fishing of individual specimen of sturgeons with a size smaller than 140 cm for Huso huso; 90 cm for Acipenser gueldenstaedti and 40 cm for Acipenser ruthenus is prohibited.

A common practice for reducing overexploitation is defining annual quota for the catch of sturgeon species. For instance, Bulgaria had in 2002 a quota to export 1,720 kg of Beluga caviar and 20 kg of Russian sturgeon caviar from natural sources. For 2004 the quota for export of caviar from Beluga was kept the same and for Russian sturgeon was not determined due to the unfavourable state of its population. Once determined, these quotas are being communicated by the Ministry of Environment and Water and the Executive Agency on Fishing and Aquacultures to Bulgarian license firms which process and export caviar. These firms are obliged in return to restock 120 fingerlings (weight over 15 grams) in the Danube for each kg of exported caviar. Annually, the Danube is restocked with about 40,000 to 60,000 fingerlings with a weight from 15 to 300 grams. Table 33 shows data on fish stocking of the Danube and on the catch of sturgeons in Bulgaria in 2001-2003.

Other measures, aimed at conserving and protecting sturgeons in Bulgaria, are the artificial fish farming of sturgeon species. Besides the artificial restocking of the Danube, the restoration of natural population could be supported by the designation of protected areas in the preferred spawning areas for sturgeons. In those parts of the river a prohibition for the catch of those species during the entire year could be imposed.

In Romania, the following measures are secured for the protection and development of fish populations:

– prohibition of fishing mainly in the spawning season, generally in the period 12 April - 10 June (the prohibition period can vary annually and is regulated by Ministerial Order);
– complete prohibition of fishing for some species in specific areas, e.g. for sturgeons and Danube shad in the Black Sea, in front of Danube River mouths, on a 5 km length to the open sea, and on a 2 km wide corridor, i.e. 1 km on the left side and 1 km on the right side of the Sfantu Gheorghe and Sulina arms' axis (Fishing Law 192/2001 and Order No. 207/24.03.2004);
– stocking of the Danube River with sturgeon offspring downstream of the Iron Gate II (according to the "Agreement between Popular Republic of Romania and Federative Socialist Republic of Yugoslavia" signed in Belgrade on 30 November 1963).

Fish stocking and catch of sturgeon in Bulgaria in 2001-2003 *TABLE 33*

	2001		2002		2003	
	Stocking with fish (kg)	Catch (kg)	Stocking with fish (kg)	Catch (kg)	Stocking with fish (kg)	Catch (kg)
Russian sturgeon	7,852	na	5,231	1,200	3,180	400
Beluga	na	300	na	9,900	90	5,600

4.5.2. Impacts on lakes and lagoons

4.5.2.1. Neusiedlersee / Fertő-tó

The lake water is characterised by a high salt concentration of more than 2,000 mg/l, an alkaline pH, and by high dissolved organic matter (COD) of natural origin. Dominant cat ions are Na^{+} and Mg^{++}, anions are HCO_3^{-}, SO_4^{2-} and Cl^{-}. The oxygen concentration in the open lake water is fairly good, in the water of the reed belt a lack of oxygen can be observed.

Eutrophication processes started in the 1970s. A gradual deterioration was observed during the early 1980s. A remarkable improvement of the nutrient levels occurred since the 1990s. This was the result of P-elimination in the waste water treatment plants built in the 1970s and 1980s and the introduction of P-free detergents in the 1980s. Buffer strips against soil erosion also contribute to this improvement. Neusiedlersee / Fertő-tó is at present only slightly polluted by point and diffuse sources. The lake is not affected by bacterial contamination and is therefore excellent for recreational use.

The reference state of Neusiedler See / Fertő-tó is mesotrophic. The present status is “mesoeutrophic”, which is shown by both the Austrian and the Hungarian monitoring results.

4.5.2.2. Lake Balaton

Hydromorphological alterations

The water level of the lake is regulated by the Sió Sluice, which was constructed in 1863 at the mouth of the Sió Canal, the only effluent of the lake. The artificial interventions had a significant influence on the ecological balance of Lake Balaton, they have altered the character of the landscape. The regulations have brought the elimination of marsh-lands and the arrangement of water-courses.

Chemical conditions

As a result of environmental regulations over the past decade a significant part of the treated wastewater is driven now to other water collection systems. By removing the phosphorus content the water quality has been positively influenced.

The chemical characteristics of the water can be considered stable including the characteristic anion and cation concentration. The calcium concentration is slightly reducing during the long axis therefore the water type is magnesium-calcium-hydrocarbon-containing. The pH value of the water of the lake is 7.8-8.8, slightly alkaline. It is suitable for recreational use. The dissolved oxygen content varies between 7.5 and 14.2 mg/l depending on the algal content and its activity. The ammonium and nitrate ion content of the lake is rather low. From the viewpoint of overall phosphorus concentration the Siófok and Szemes basins show excellent and good, while the Szigligeti and Keszthelyi basins good and acceptable water quality results. The phosphorus load has a positive impact on the chlorophyll-a concentration – that is the trophic status of the lake – therefore the reduction of phosphorus load has a major role in projects aiming at the water quality protection. Exchange of water between adjacent basins is extremely little. The eutrophication level aggravates towards the west.

Fish kills

There are two key dates in the recent history of the lake: the fish death in 1991 and the over-multiplication of algae in 1994. After the latter, the monitoring system of Lake Balaton was reviewed combined with a program-like determined activity aimed at the improvement of water quality and the fostering of the publicity of environmental data concerning the lake.

State

The present state of the lake is satisfactory, because in spite of decreasing water levels in the past years the water quality of the lake has not deteriorated. As mentioned above, the water level of the lake is regulated. Due to the rainy spring in 2004 the water level has reached the lower minimum water level, which means a slight increase, and the water quality is still good.

4.5.2.3. Ozero Ialpug

For Ozero Ialpug no information is available.

4.5.2.4. Razim-Sinoe lacustrine system

Link to pressures

The Razim Lake quality status is predominantly influenced by Danube discharge. Thus, the load from Danube is 105 times larger for BOD, 30 times larger for CCO-Mn, 57 times larger for dissolved substances, 350 times larger for total phosphorus and 140 times larger for total nitrogen in comparison to those from the Babadag and the Razim catchment area.

The Sinoe Lake is qualitatively influenced by water supply sources, represented by Razim – Golovita – Smeica, Nuntasi, Istria and Black Sea. Sinoe Lake is a transitional water body and meso-eutrophic.

The anthropic impact on Razim-Sinoe lacustrine system is due to (1) the nutrients content in Razelm and Sinoe lakes, owing to nitrogen and phosphorous from Danube and local pollution sources, (2) the hydraulic works.

Nutrients

Pollution sources from entire Danube River Basin, respectively the increasing on nutrients content and nitrogen in Danube at the end of '70 and in the next period 1980-1990, caused the increasing of the above elements in Danube Delta ecosystems, including the Razim-Sinoe lacustrine system.

Hydromorphological alterations

- A lot of complex works for fresh water supply of Razim lake has been carried out in 1903-1916, by dredging the Dunavat water channel and partially Dranov water channel.
- The Dranov water channel between Dranov Lake and Razim Lake was built in 1930-1940.
- The Golovita-Smeica and Golovita-Sinoe water channels were built in 1952-1960.
- The adjacent areas of Razim-Sinoe were embanked in 1961-1989.

Impact assessment

The eutrophication process and also the hydraulic works generated important changes for habitats and also on the level of main compartments of the trophic chain in lacustrine ecosystems.

(a) In 1979-1991, a decrease of 50% in the number of species was registered in the lacustrine ecosystems. These were frequently registered in previous years at phytoplankton communities level, together with a significant increase in biomass (Cure et al., 1980; Fetecau, 1992). A similar development was also noted for the zooplankton communities (Zinevici et al., 1990).

(b) A simplification of community structures was also registered for the ichtyofauna as a result of the following changes in the abiotic and biotic factors:

- Along with increasing of water phosphorus content, Cyprinidae species with larger demands for habitats (e.g. Abramis brama – bream) proliferated; beside the bream also Carrassius auratus, an exotic and invasive species, which last 20 years evolution was encouraged also by the eutrophication conditions, can be mentioned.
- A regression was registered for species with specific demands for habitat and food (zander and tench), which declined after 1970 and almost disappeared after 1980; zander is the only rapturous species with an industrial importance, which can adapt to eutrophication conditions and dispose of favorably environmentally conditions in Razim-Sinoe System, unlike the rest of Danube Delta.
- Despite of redressing trend for carp population, the habitat demands for spawn and evolution in Razim-Sinoe System are not been reached for two reasons:
  - In the Razim-Sinoe System coastal area, an amount of 23.500 ha have been embanked. This area represented spawning habitat, beside the floodplain areas (which constitute carp local reproduction sites);
  - The invasion of dominant species – *Carrassius auratus* – after 1970 restricts the success of the carp reproduction.

4.5.3. Impacts on the Danube Delta

Major impacts on the delta ecosystem result from the changes both in the upstream conditions (retained sediments, increased pollution loads) as well as from the changes in the delta itself. The most significant activities in recent decades have been the artificial extension of the natural channel network (doubling their length from 1910 to 1990 up to altogether 3,400 km) to improve access and the circulation of water through the delta, as well as the re-construction of wetlands into huge agricultural polders and fishponds. The many canals bring more fine sediments and nutrient-laden river water into the lake complexes than before (the water discharge flowing through the delta lakes increased from about 160 m^3/s in the 19th century to 620 m^3/s in the period 1981-1990). As a result, biodiversity (fisheries) declined and the fundamentally important natural water and sediment transport system has been altered, diminishing the delta's capacity to retain nutrients and pollutants. The new regime allows much of the nutrient-containing silt to pass directly through the main canals into the Black Sea.

Dredging is another important problem also here in the Danube Delta: In the delta of the Danube, the overall length of artificial water courses created by dredging amounts to 1,753 km – equal to the total length of the natural water network. New channels created for transport purposes, like the Caraorman Channel and the Mila 23 Channel, have changed the natural runoff of the water in the delta and cause an increase of sedimentation.

By 1990, one forth (974 km^2) of the Danube delta has been diked in, including 400 km^2 for agricultural purposes. The Tulcea-Sulina branch (81 km) is completely canalised with all former meanders and side channels being cut off, and its length reduced from 85 to 62 km. The 80 m wide navigation route has to be permanently dredged to secure a depth of 7.3 m. The southern Sfantu Gheorghe branch (109 km) is not used by sea ships but also affected by meander cut-offs since the 1960s (loss of app. 50 km) and by the ship waves destroying the unprotected banks.[70]

Other pressures and impacts on wetlands are gravel and sand excavation in many rivers of the DRB, contributing to the loss of riverine habitats and bed erosion, agricultural activities like drainage and irrigation systems, fishing and hunting and tourism.

4.5.3.1. Link to pressures

Nutrient concentrations

The nutrient concentrations in the Danube Delta area in the period 1996–2003 are as follows. For the Danube and its arms:

- The average concentrations of dissolved inorganic nitrogen are between 1-4 mg N/l;
- The average concentrations of total phosphorus are between 0.1–0.3 mg P/l. An increase has been recorded in 2003 at the stations Cotul Pisicii, Ceatal Chilia, Periprava and Sf. Gheorghe arm (average concentrations of 0.3 mg/l).

For the lakes of the Danube Delta:

- The average concentrations of dissolved inorganic nitrogen are similar to those in the Danube arms;
- The average concentrations of total phosphorus are between 0.1-0.5 mg/l, which is somewhat higher than those in the Danube arms. An increase has been recorded in 2003, with maximum values in the Somova (0.4 mg/l), Iacub (0.6 mg/l) and Sinoie lakes (0.5 mg/l).

The historical development of the nutrient concentrations in the Danube Delta can not be positively established[71].

Heavy metals

Regarding heavy metals, the Danube Delta quality over the period 1996-2003 according to the Romanian Assessment System of water and sediments quality 1146/2002 (5 quality classes) is as follows. In the Danube and its arms, the concentrations of iron, cadmium and lead correspond to quality classes IV and V in all monitoring sites. In general, zinc and nickel show average concentrations corresponding to class II. Manganese concentrations correspond to the classes III and IV, except 2003 when the concentrations of this metal correspond to class II.

In the Danube Delta lakes, the concentrations of iron, cadmium and lead were high, corresponding to quality classes IV and V. In general, zinc and nickel show average concentrations corresponding to class II. Lake Erenciuc presents an exception for nickel, since in 1999 values corresponding to quality classes III and IV have been recorded. The concentrations of manganese corresponded in general to water quality classes III and IV during the whole investigated period of time.

70 WWF (2002).
71 OOSTERBERG et al. (2000).

4.5.3.2. Impact assessment

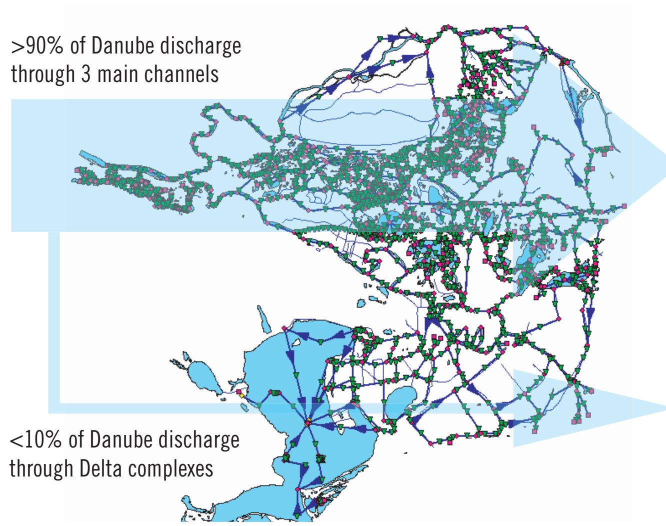
Impacts from hydromorphological alterations

The embankment of 85 % of the Danube floodplains for agricultural purposes, starting at the end of the 1950s, had effects also on the Danube Delta. The fish stock of the Danube Delta was based on a carp population, which had its spawning areas in the Danube floodplains. The carp population has shown a decline, and it was replaced by species with low economic values.

The embankment of more than 100,000 ha of mostly temporary flooded areas (wetlands), has led to the destruction of an area with an important role in the reproduction of fish and in the biology of aquatic bird species. A correlation between the dynamics of the embankment works and the dynamics of the cyprinidae biomass, which had their spawning habitats in these areas, has been noticed. In the period 1994-2003, about 15 % of the embanked area has been restored to the natural situation.

The building of dams on the Danube has reduced the migration way of marine migratory sturgeons in the Danube and has affected the number of spawning habitats. The spawning habitats downstream of the Iron Gates II dam ensured the continuity of the species, but the habitats are now limited to the last sector of the Danube with a length of 863 km. The construction of fish ladders for their upstream migration is not feasible, because even if the adults can migrate upstream, the downstream migration of their offspring is still inhibited by the present lake conditions in the backwater area of the dams.

Schematic representation of the distribution of water over the main Danube branches and the Delta complexes *FIGURE 53*



Impacts from nutrient loads

Role of the Danube Delta for the Danube river loads

Recent research, based on field data and state-of-the-art mathematical modelling (Danube Delta Model), has provided good insight into the water and nutrient balances of the Danube Delta. On average, more than 90 % of the water carried by the Danube River upstream of the Delta reaches the Black Sea via the 3 main Danube branches Chilia, Sulina and Sfintu Gheorghe. Less than 10 % enters the aquatic complexes of the Danube Delta and evaporates or finds its way to the Black Sea via smaller outlets (Figure 53).

The main branches effectively transport the nutrients in the Danube towards the Black Sea, without significant loss or storage. The nutrients in the < 10% of water that reaches the Danube Delta complexes are subject to loss and storage processes in the Delta. The Delta removes or stores about 1/3 of the incoming nutrient loads of nitrogen and phosphorus, while the remaining 2/3 is eventually transported to the Black Sea. Related to the total Danube River load, the loss and storage of N and P amounts 2-3 %. Thus, the loss and storage of nutrients is of negligible importance: the Danube River loads enter the Black Sea almost unaffected.

Impact of nutrient loads to the Danube Delta

The increasing nutrient concentrations of the Danube River, coming from the whole Danube River basin, have led to the intensification of eutrophication phenomena in the Danube Delta lakes after the 1980s, and to important changes in the structure of the flora and fauna communities. Regarding the fish communities, the decline or even the extinction of sensitive species has been recorded as a result of the reduced transparency water conditions.

These eutrophication impacts have been enhanced by another factor. Already at the beginning of the 20th century, but specifically in the last decades many canals were dredged in the interior of the Delta, with the purpose to let oxygen and nutrient rich water penetrate deeper into the Delta, to increase fish production and to improve navigation. Due to these canals and due to the change of the Danube water quality, more river-borne water, sediment and nutrients could reach the Delta complexes. In the last decade, a number of 13 canals were cut off or partially cut off in order to re-establish the natural flow regime.

4.5.3.3. Expected future developments

The decrease of the nutrient loads of the Danube River in the past decade may invoke the decrease of the eutrophication problems in the Danube Delta. Furthermore, due to the increasing attention for the restoration of wetlands and natural habitats it can be expected that the recovery of the Danube Delta floodplains and the restoration of original river beds will be an ongoing process. In this respect, the future intensity of the hydrological contact between the Danube arms and the Danube Delta will be a decisive factor for the water quality of the Danube Delta.

4.5.4. Impacts on coastal waters and the wider marine environment of the Black Sea

4.5.4.1. Assessment of status and impact

According to recent research, the Black Sea is affected by a combination of human interventions, occurring simultaneously in the Black Sea drainage basin and in the marine environment[72].

Nutrient concentrations in the Danube-influenced waters of the Black Sea

During 1960-1985, as a consequence of the intensification of the industrial and agricultural activities in the Danube River Basin, the Danube nutrient loads (N and P) to the Black Sea have increased significantly, followed by a quasi-constant level during 1985-1990 and by a significant reduction after the 1990s. The high nutrient concentrations in the Danube River have contributed to high nutrient concentrations in the Danube influenced coastal waters, with maximum values in 1987. After 1990, a reduction of the concentrations of inorganic N and P and an increase of the concentrations of inorganic Si occurred in the coastal waters (see Figure 54). Similar developments are reported for the other rivers flowing into the Black Sea (Dnipro, Bug, Dniestr), but the Danube represents by far the largest source of freshwater to the Black Sea.

Sediment transport

Another significant pressure is the reduction of the sediments discharged by the Danube as a consequence of the hydromorphological alterations in the river basin (see Chapter 4.4.4). Again, similar developments could be recorded in the other rivers flowing into the Black Sea.

Heavy metals

Regarding heavy metals and pesticides, the recorded concentrations in the surface water, the aquatic sediments and in the biota of the Black Sea do not present high levels. Elevated concentrations are recorded only locally, subject to the presence of specific sources.

Other pressures

Other relevant pressures to the Black Sea ecology are the irrational exploitation of fish stocks, and the invasion of the exotic species Mnemiopsis leydi into the Black Sea via shipping vessels. This comb jelly fish consumes fish eggs and larvae, as well as other small invertebrates.

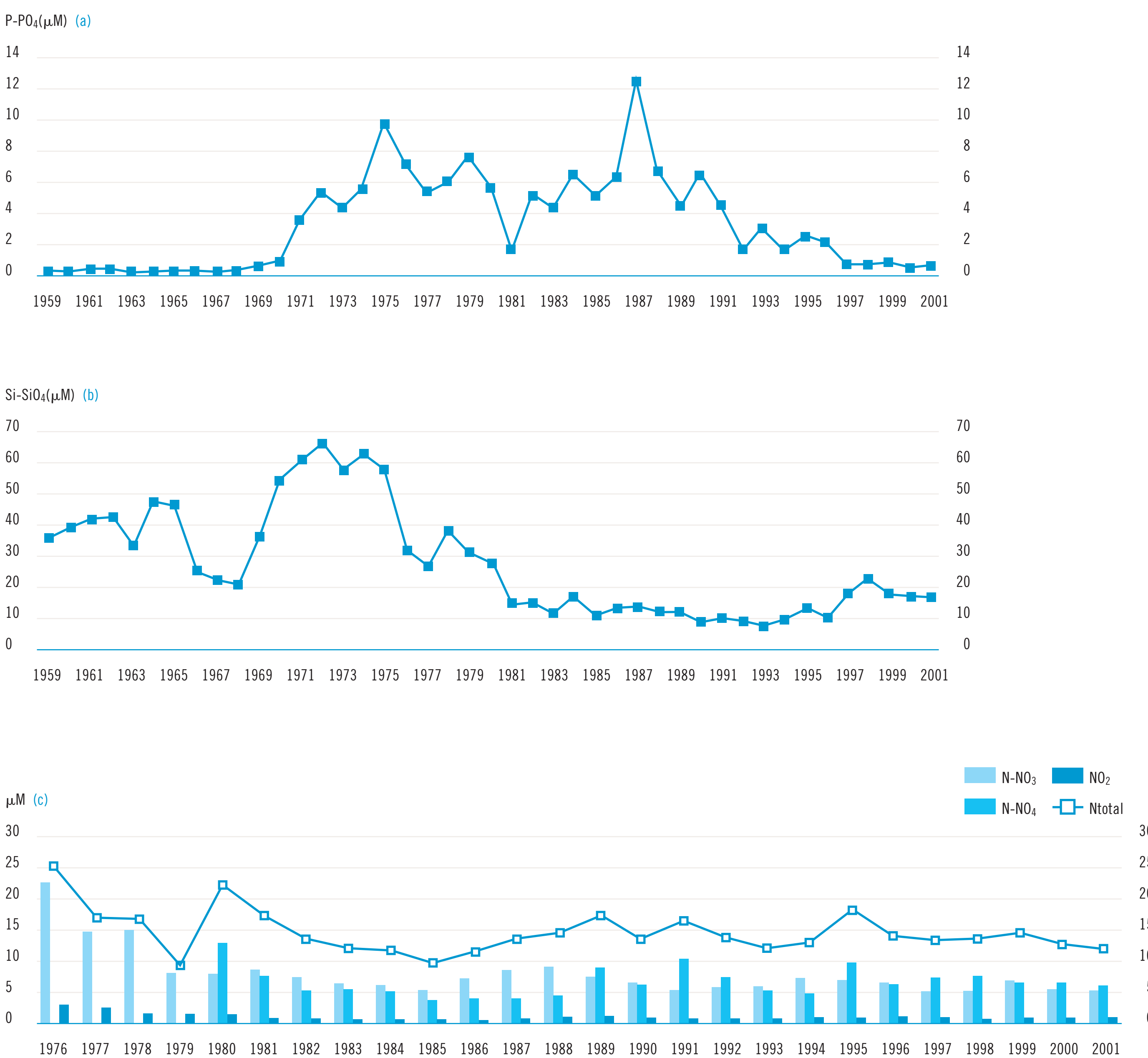
72 LANCELOT et al. (2002).

4.5.4.2. Impact assessment

Impact of nutrient loads to the Black Sea

A water quality analysis has indicated that the increasing concentrations of nutrients and organic matter in the coastal waters represented the main cause of the ecological imbalance of the Black Sea, especially in the Northern-Western and Western parts (which are relatively shallow and sensitive to eutrophication). In this area, the elevated Danube River loads of the 1980s and early 1990s have contributed to severe ecological problems. In addition, the discharges from other land based sources, e.g. from the Romanian Black Sea coastal basins, had to be taken into account. The high nutrient concentrations in the coastal waters, with maximum values in 1987, determined the excessive development of phytoplankton, with frequent algal blooms between 1974 and 1992: an expression of the eutrophication process of the coastal waters of the Black Sea.

The evolution of the inorganic nutrients concentrations (µM) in the Romanian coastal waters (Constanta monitoring site): phosphates (a), silicates (b) and inorganic nitrogen (c)* *FIGURE 54*

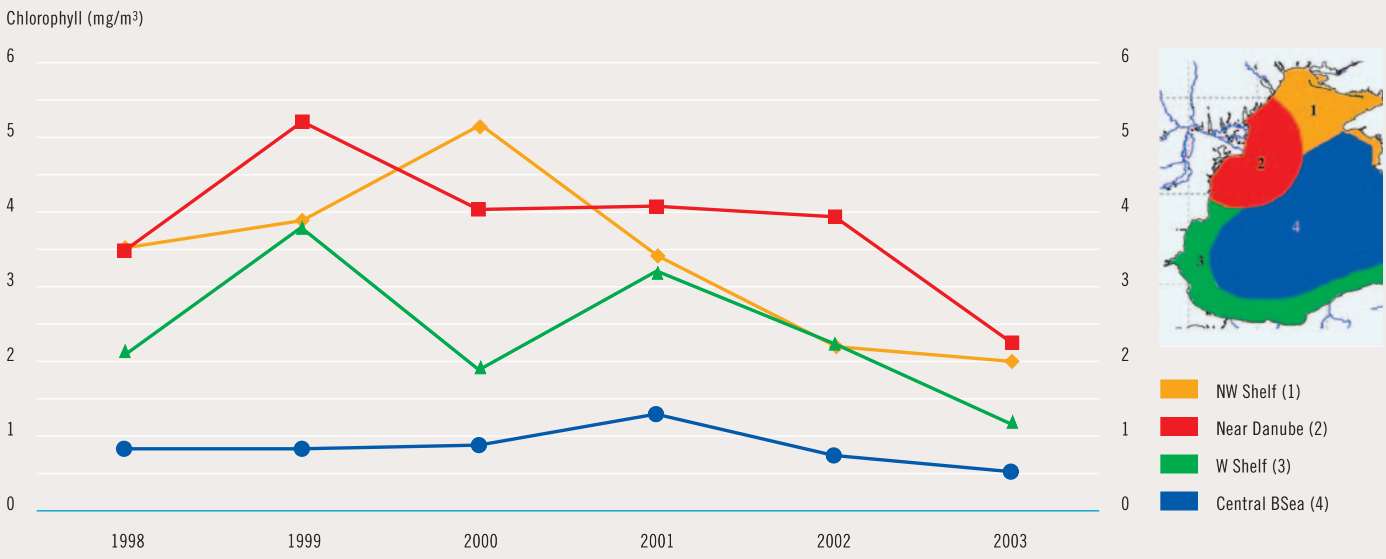


*(Source: "State of the Environment of the Black Sea, Pressures and Trends, 1996 - 2000")

The changes of the nutrient loads and their ratios in the coastal waters after 1990, and especially after 1995, have caused important changes in the marine phytoplankton composition: the percentage of diatoms which had been reduced from 92.3 % (during the 1960s and 1970s) to 29.3 % (during the 1980s and early 1990s) increased again after 1994.

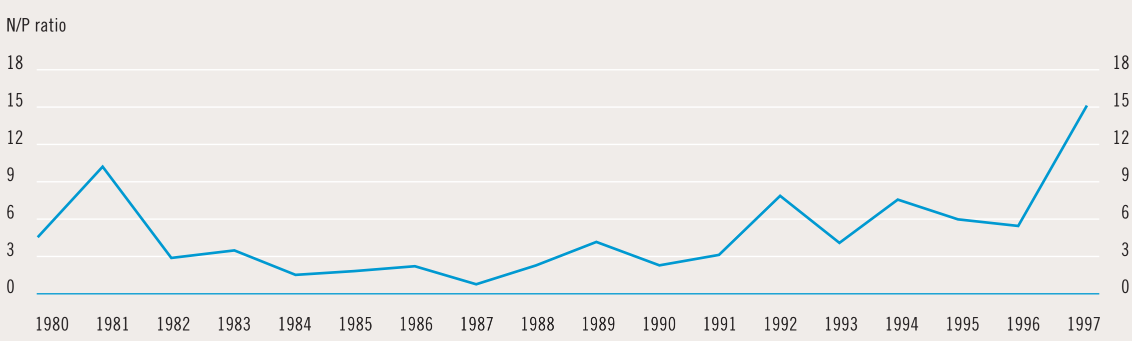
After the late 1980s and early 1990s some signs of a recovery of the marine ecosystem in the North-western Black Sea have been recorded, probably caused by reduced nutrient inputs from the Danube River and the Black Sea coastal catchments. The quantity of phytoplankton has decreased (see Figure 55). The concentration of phosphates in the marine waters affected by the Danube River has decreased, and the ratio between inorganic nitrogen and inorganic phosphorus indicates that phosphorus is now the limiting factor for algae growth (Figure 56). Furthermore, the diversity of the macro-benthos has increased significantly since 1996 (see Figure 57), although it is still lower than in the 1960s. In the 1970s and 1980s the zones of seasonal low oxygen concentrations (< 50 % of the saturation value) near the sediment in the North-western Black Sea were increasing (see Figure 58), which was a clear indicator of eutrophication. Recently, such zones have nearly completely disappeared from the Romanian coastal waters (see Figure 59).

Development of the phytoplankton biomass in different parts of the Black Sea
(derived by Horstmann and Davidov from field data collected in the daNUbs research project)* — *FIGURE 55*



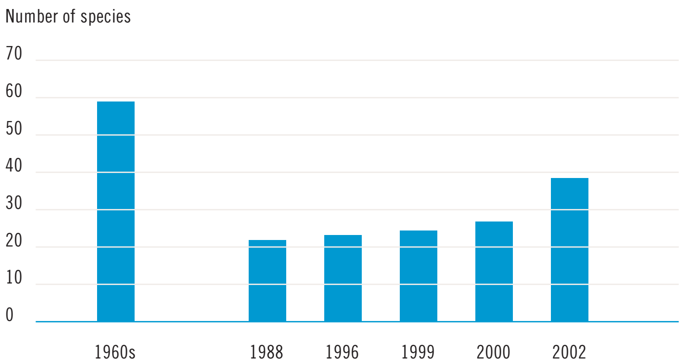
* *daNUbs (2005).*

Long term development of the N/P ratios in the Danube influenced waters off Constanta — *FIGURE 56*



Number of macro benthic species in front of the Danube delta*

FIGURE 57



**10 stations on 3 transects off Constanta, data from C. Dumitrache, IRCM Constanta*

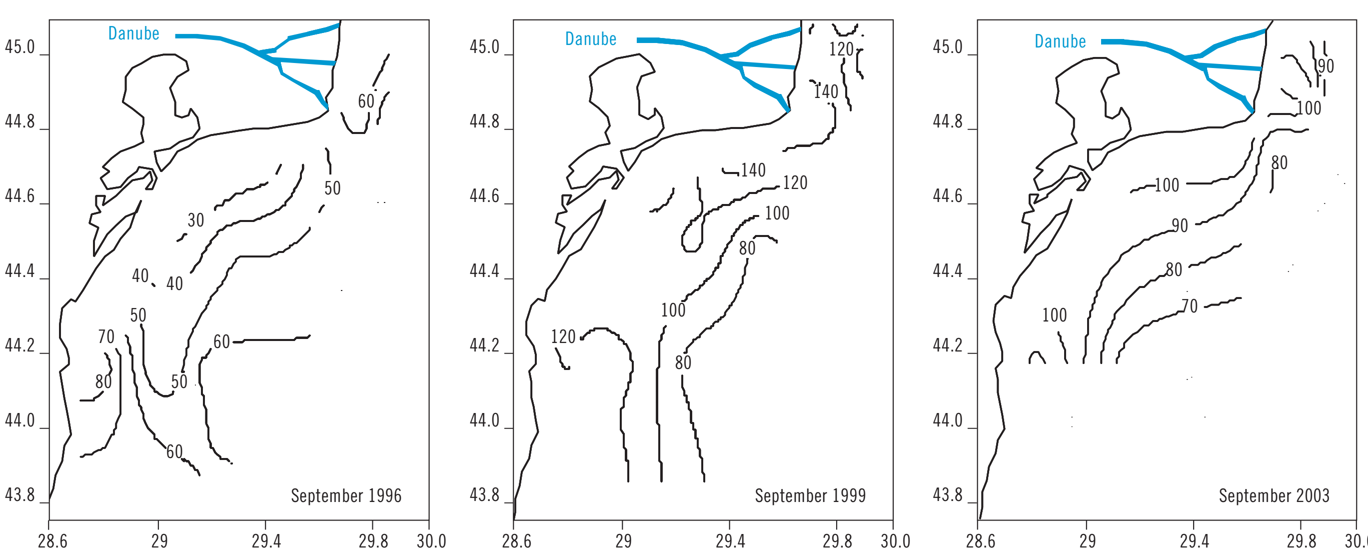
Development of seasonal areas of low oxygen concentration near the bottom on the north-western shelf of the Black Sea*

FIGURE 58

**(after ZAITSEV & MAMAEV 1997)*

Concentration of dissolved oxygen (expressed as % of saturation value) near the bottom on the Romanian shelf of the Western Black Sea *

FIGURE 59



**in September 1996, September 1999 and September 2003 (compiled in the daNUbs project from data collected by RMRI))*

Marine eutrophication in the Black Sea

Algae need light and nutrients (N, P, Si etc.) to grow. The biomass of algae is able to increase until either the light or one of the nutrients is no longer available. If the availability of one of the nutrients limits the growth of algae, this nutrient is referred to as the "limiting nutrient". The increasing inflow of nitrogen and phosphorus from the Danube and other rivers, represent a potential for the increased development of algae biomass. The relative amounts of N and P decide how much of this potential can be used, and which nutrient limits the growth of algae. Furthermore, the ratio of the nutrients and the solar energy availability influence the competition between the different algae species and the development of the aquatic food chain. Evidently, the intensity of fishing and the introduction of exotic species also play a role in this respect.

In general, a high share of diatom species within the algae community is considered a positive factor. Diatoms can develop as long as sufficient Si is available.

One of the consequences of the increased density of phytoplankton and the subsequent changes of the ecosystem is the occurrence of oxygen deficiency near the marine sediment, which is potentially very harmful to the benthic life. This is the result of episodes of strongly increased deposition of dead organic matter.

Coastal erosion

Coastal erosion affects the Romanian seashore over a length of 244 km (between the Musura arm and Vama veche), representing 6 % of the total length of the Black Sea seashore. The relief is represented by low shores (beaches, about 80 %) and high shores (cliffs, about 20 %).

An analysis of the erosion process at the interface sea-land, based on measurements from 1980-2003, has indicated that this process is more pronounced along the Northern sea-shore (Sulina-Vadu).

Loss of biodiversity

The high nutrients concentrations in the coastal waters of the past decades caused an excessive development of phytoplankton, with frequent algal blooms between 1974 and 1992.

The ecosystem of the Black Sea, including the Romanian sea shore, has undergone severe changes, regarding the species composition, populations and biocenoses, as a result of anthropogenic activities.

Quantitative and qualitative changes have occurred in the structure and functionality of the benthic and pelagic flora and fauna. Intense algae blooms and zooplankton blooms have been recorded, as well as a progressive reduction of the biodiversity, the simplification of the trophic webs and the reduction of bioproductivity.

The recent changes of the nutrient loads and their ratios in the coastal waters have caused important positive changes in the marine phytoplankton composition: the percentage of diatoms which had reduced from 92.3 % (during the 1960s and 1970s) to 29.3 % (during the 1980s and early 1990s) is increasing again after 1994.

During the last years a slow recovery of the marine ecosystem has been recorded, with a clear reduction of eutrophication indicators (see Chapter 4.5.1.3). The recovery of the equilibrium of the ecosystem and the increase of the biodiversity has been recently highlighted by the development of the benthic macro flora and by the re-appearance of some invertebrate species.

Endangered species along the Romanian sea shore

The Red List (updated in 2003 for the Romanian sea shore) is made up of 206 endangered species of macro algae, invertebrates, fish and marine mammals; special attention is paid to the Squalus acanthias, to the sturgeons (endangered owing to the conditions in the rivers of origin, to the conditions in the spawning habitats – the benthic area of the Black Sea and to over fishing) and to the 3 species of dolphins (Tursiops truncatus ponticus, Delphinus delphis ponticus and Phocoena phocoena relicta). In relation to rare species, a coastal protected area was established in 2000 between Vama Veche – 2 Mai, with a length of 7 km and a surface area of 5,000 ha. The rare organisms present in this area belong to the following classes: Crustacea, Chondrichthyes, Osteichthyes, Reptilia and Mammalia.

Fish stocks

The fish stocks have shown a pronounced decline. The fish catches have been dramatically reduced: at the level of the Black Sea, the catches were almost 3 times smaller in the early 1990s than they were in the 1960s and 1970s, on the Romanian sea-shore even 10 times smaller. In the early 1990s, out of 26 fish species of commercial interest annually captured in tens or hundreds of tons between 1960-1970, the commercial fishing of *Scomber scombrus, Trachurus mediterraneus, Thunnus thynus* and *Xiphias gladius* was stopped at the end of the 1970s. After the 1980s only 5 species (Sprattus sprattus, Engraulis encrasicolus, Merlangius merlangus euxinus, Neogobius melanostomus and Atherina boyeri) have had a commercial importance. As a consequence of the strong decline of the predator species, the small pelagic fish with a short life-time, in particular *Sprattus sprattus* and *Engraulis encrasicolus,* represented 80 % of the total fish catches.

Other impacts

Apart from the impacts mentioned above, the Romanian seashore is also subject to impacts from the following natural and anthropogenic processes:

– the deviation of the sediments carried along the seashore due to natural causes (Sahalin Island, the sand transfer from the beach to the lagoons) and due to some coastal works;
– the reduction of the mollusc populations (mussels) and implicitly of the sand quantity of biogenic origin;
– the intensification of the storm regime during the last decades;
∑ the rise of the sea level.

4.5.4.3. Expected future developments

The Danube River sediment load has decreased significantly in the past decades. There are no reasons to expect a recovery of this load in the near future.

The Danube River nutrient loads have undergone a substantial decrease in the last decade, especially for phosphorus. The possible increase of these loads in the future is driven by an economic development without proper pollution control measures and this represents a risk for failing to reach the good ecological status in the coastal waters.

4.5.5. Impacts on artificial water bodies

4.5.5.1. Main-Danube Canal

Due to relocation measures of the Altmühl and the intersection of moor areas, the construction of the Main-Danube Canal has had local impacts on the ecology.

4.5.5.2. Danube-Tisza-Danube Canal System

The largest impact on the biological and physico-chemical elements of the artificial water bodies within the Danube-Tisza-Danube Canal System results from wastewater coming from all larger settlements, industrial facilities, agriculture and fisheries. Wastewater is discharged into the canals and intercepted rivers in unpurified or inadequately purified state.

4.5.5.3. Danube-Black Sea Canal

The construction of the Danube-Black Sea Canal had a negative impact on the aquatic ecosystem of the Carasu River and the riverine areas.

The water quality of the two canals (DBSC and PAMNC) is mainly affected by wastewater discharges from the towns Medgidia and Poarta Alba and by the Danube River water quality. Certain indicators (dissolved oxygen, ammonia nitrate, chemical oxygen consumption (CCO-Mn), and chlorides) are recorded as exceeding the limits according to the quality standards.

The effluent discharge from the Cernavoda Nuclear Power Plant is a thermic pollutant for the water in the canals, which causes the decrease of the dissolved oxygen concentration and sometimes the occurrence of mist.

During the warm season, water eutrophication has been recorded in the two canals, as well as the development of macrophyte algae, especially in the canal branch PAMNC. The water from both canals has an insignificant impact on the Black Sea coastal waters.

4.6. Heavily modified surface waters (provisional identification)

"'Heavily modified water body' means a body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accordance with the provisions of Annex II." Art. 2(9) WFD.

This chapter provides an overview of selected provisionally identified heavily modified waters, which meet basin-wide agreed criteria. All other heavily modified water bodies (HMWB) are dealt with in the National reports of the countries (Part B).

The content of this chapter is based on data delivered by Austria, Germany, Czech Republic, Slovak Republic, Hungary, Slovenia, Croatia, Serbia and Montenegro, Bulgaria, and Romania. Data from the other Danube countries was not available.

4.6.1. Provisionally identified heavily modified waters on rivers

4.6.1.1. Approach for selecting heavily modified water bodies for the basin-wide overview

In order to provisionally identify heavily modified waters of basin-wide relevance it was agreed to identify heavily modified water (HMW) sections that fulfil a set of four criteria. A section can be provisionally identified as heavily modified if all of the four criteria are fulfilled.

The relevant provisions of WFD Annex II include the description of significant changes in hydromorphology (Annex II 1.4) and the assessment of whether the water body is likely to fail the good ecological status (GES) due to changes in hydromorphology (Annex II 1.5). In this context, the four basin-wide agreed criteria for selecting provisionally identified HMW sections in the DRBD are:

1. Size of water sections should be more than 50 km (a minimum of 70 % of the section should show significant physical alterations and hydromorphological impacts, i.e. it should be heavily modified).[73] AND
2. One or more of the following main uses which affect the DRBD via hydromorphological alterations should be present: hydropower, navigation, flood protection, urbanisation.
   The selection of these uses is based on the results of relevant research work of the UNDP-GEF Regional Danube Project, which identified the uses that may cause important hydromorphological pressures affecting the ecological status of the Danube River.[74] AND
3. One or more of the following significant physical alterations (pressures) should be present: dams/weirs, channelisation/straightening, bank reinforcement/fixation.[75]
   These alterations have been selected as the main significant physical alterations linked to the uses of criterion 2 above. AND
4. By expert judgement, it must be concluded that the section is "at risk" of failing to achieve GES due to changes in hydromorphology. According to the WFD, this "risk assessment" should be based on the assessment of significant physical alterations and the assessment of the ecological status. Due to the lack of appropriate biological data currently, indirect criteria based on physical parameters (expert judgement) were selected to conclude on the "risk".
   For the expert judgement, the criteria which are based on the impacts of the main hydromorphological pressures in the DRBD are the following:
   – not passable obstacles (weirs/dams) for migratory species,
   – change of water category (e.g. change of river to dammed reservoir),
   – impoundment with significant reduction of water flow,
   – disruption of lateral connectivity, and
   – other criteria which need to be specified.
   These expert judgement criteria allow to choose the most obvious provisional HMW sections.

73 Such a section may also include more than one physical alterations with a significant impact on hydromorphology (for example, a chain of consequent hydropower plants or weirs over a section of more than 50 km).
74 MOOG & STUBAUER (2003).
75 It is up to the individual countries to assess if these physical alterations are significant or not, based on their national approaches and as reported in their national reports (Part B of the 2004/5 report).

4.6.1.2. Provisional identification of heavily modified waters on rivers based on the agreed criteria

Map 10 shows the provisionally identified HMW sections meeting basin-wide agreed criteria, chosen according to the four criteria mentioned above. Annex 11 contains a list of all reported HMW sections meeting basin-wide agreed criteria, as well as information on their length, main uses, physical alterations and expert judgement for risk of failure to reach GES. Some of the HMW sections meeting basin-wide agreed criteria consist of chains of consequent HMW sections. In these cases, some of the individual HMW sections of such a chain can be shorter than the 50 km threshold of the basin-wide agreed criteria (see 1st criterion above).

A few Danube countries refer, as an exception, to an additional group of water bodies, which they defined as either 'candidate for HMWB', or 'probable provisionally identified HMWB'[76]. There is no detailed information available; therefore, this additional group of water bodies is not further described in the Roof Report but relevant information is provided in the national reports.

A large part of the Danube River and numerous tributaries of the DRBD are significantly affected by hydromorphological alterations, and therefore provisionally identified as HMW sections. The provisionally identified HMW sections on the Danube River meeting basin-wide agreed criteria are in total 2,089 km long, which is equivalent to 75 % of the Danube. The length of the provisionally identified HMW sections on the Danube differs in the upper Danube, the middle Danube and the lower Danube.[77] More than half of the upper Danube River is provisionally identified as heavily modified. The middle and the lower Danube are provisionally identified as 'heavily modified' to a slightly larger extent than the upper Danube.

The total length of the reported provisionally identified HMW sections on the tributaries is 6,382 km.

The Danube tributaries with reported provisionally identified HMW sections are the following:

- in the upper Danube: Lech, Isar, Inn, Traun, Enns, March/Morava, Thaya, Salzach,
- in the middle Danube: Raab/Rába, Rebnitz/Repce, Váh, Hornad/Hernád, Drau/Drava, Mur/Mura, Sava, Drina, Velika Morava, Zapadna Morava, Juzna Morava, Nisava, Timok, Crişul Alb/Fehér-Körös, Crişul Negru/Fekete-Körös, Barcãu/Berettyo, Zagyva, Tisza, Ipel'/Ipoly, Soroksári-Duna, Mosoni-Duna, Sió, Bodrog, Mureş/Maros, Hortobágy-Berettyó, Sebes-Körös, Kettös- Körös, Timis/Tamis, and
- in the lower Danube: Olt, Argeş, Ialomiţa, Buzãu, Bârlad, Prut, Jijia.

The four main uses affecting the DRBD via hydromorphological alterations are hydropower, navigation, flood protection and urbanisation. Navigation appears to be the most dominant use of the provisionally identified HMW sections on the Danube River followed by flood protection, urbanisation and hydropower (mentioned here in order of importance for the identified HMW sections) (see Figure 60). Regarding the tributaries of the DRBD, flood protection, urbanisation and hydropower appear as the main uses which affect hydromorphological status (see Figure 61), contrary to the Danube River where navigation is the dominant use.

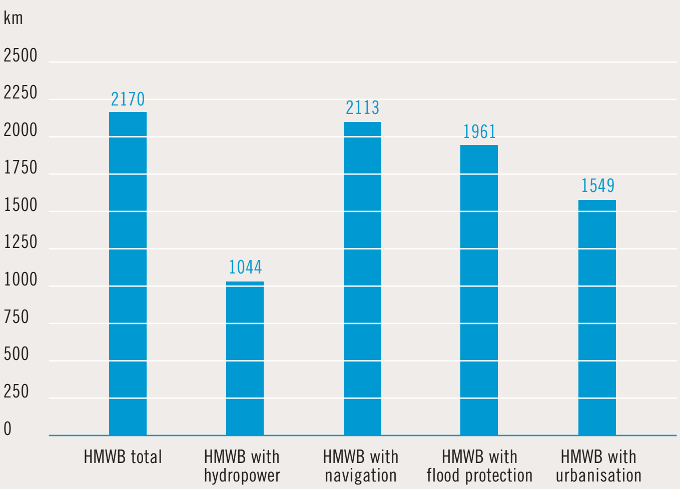
Danube River Basin District – Important Heavily Modified Surface Waters (provisional identification) *MAP 10*

76 For instance, Hungary marked provisionally identified HMW sections as either "candidate (1)" or "probable (2)" to reflect uncertainty in the HMWB provisional identification procedure due to limited biological data. In the Roof Report, these two aspects have been combined into one provisional HMWB status. A detailed overview is given in the Hungarian national report.

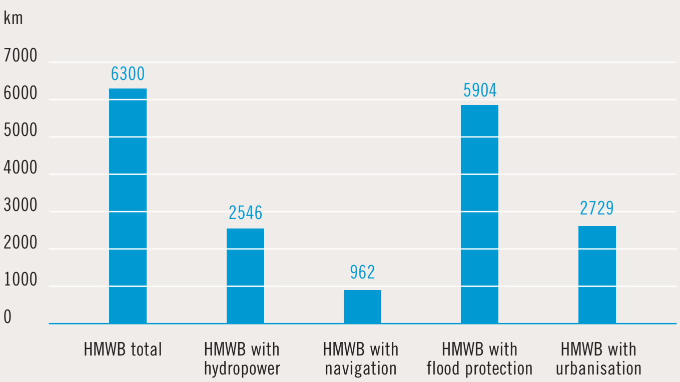
77 The upper Danube extends from the source to Bratislava in the Slovak Republic, the middle Danube from Bratislava to the Iron Gates dams (on the border of Romania and Serbia and Montenegro) and the lower Danube from the Iron Gate dams to the mouth (ICPDR (2004)).

The main significant physical alterations (pressures) which are linked to the provisional identification of HMW sections on the Danube River are dams and weirs, followed by bank reinforcement/-fixation and channelisation-/straightening (mentioned here in order of importance; see Figure 62). In the case of the tributaries, bank reinforcement/fixation is present as the main significant physical alteration of the HMW sections, followed by channelisation/-straightening and as the last by dams/weirs (see Figure 63). Chapter 4.4.4 gives a more detailed description of these physical alterations and of other hydromorphological alterations with a significant impact. Chapter 4.4.4 also refers to future developments in the DRBD which are linked to (new) hydromorphological alterations.

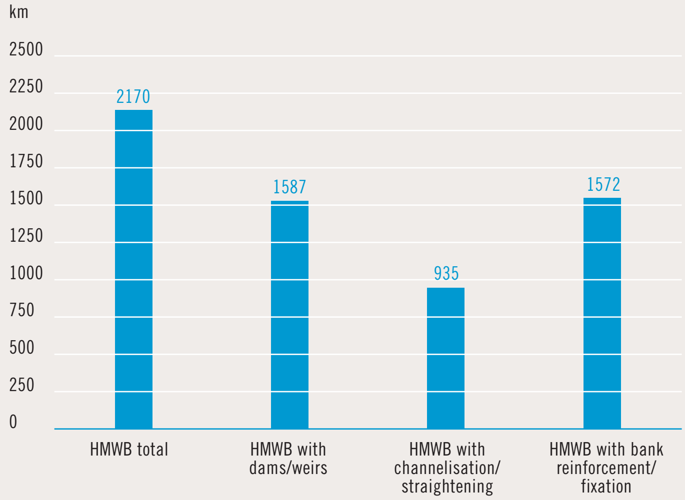
Main uses of the identified HMW sections on the Danube River *FIGURE 60*



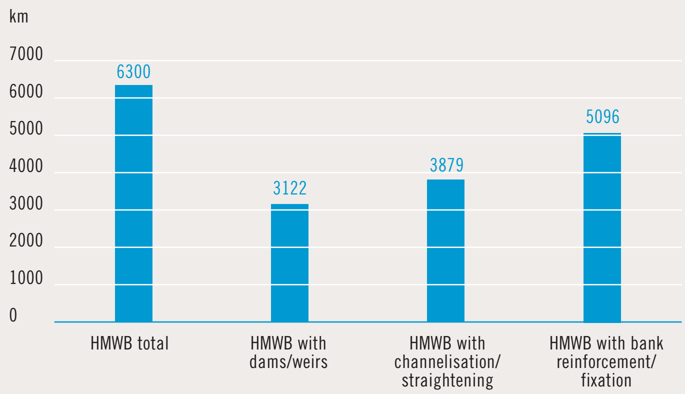
Main uses of the identified HMW sections on the tributaries of the DRBD *FIGURE 61*



Physical alterations of the identified HMW sections on the Danube River *FIGURE 62*



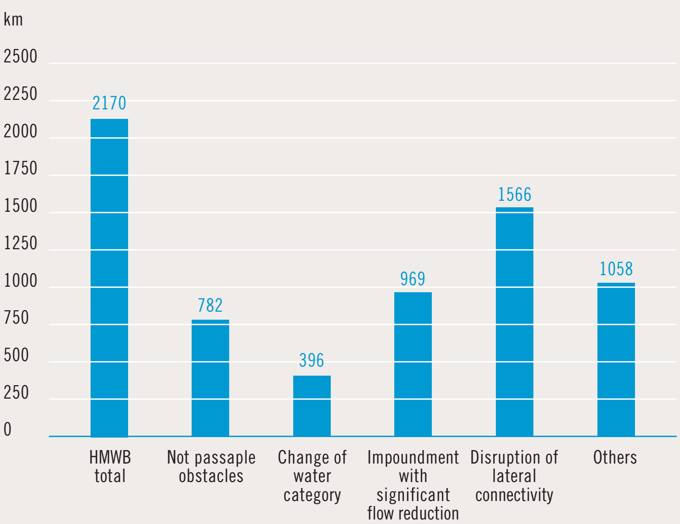
Physical alterations of the identified HMW sections on tributaries of the DRBD *FIGURE 63*



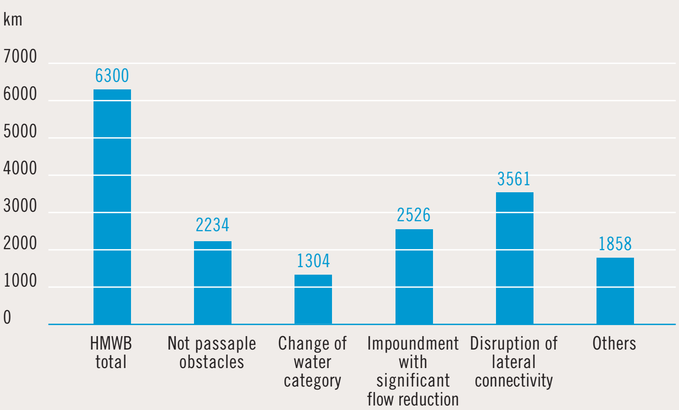
As already mentioned, several expert judgement criteria were used to assess whether sections are “at risk” of failing to achieve GES due to changes in hydromorphology and thereby should be provisionally identified as HMW sections meeting basin-wide agreed criteria. The three most commonly used expert judgement criteria for the HMW sections of the DRBD were: the disruption of lateral connectivity, the presence of impoundment with significant flow reduction, and the presence of obstacles, such as weirs and dams, which are not passable for migratory species (see Figure 64 and Figure 65). Dredging effects were also often considered in the expert judgement on sections of the Danube River.

An example on the process of selecting provisionally identified HMW sections, which meet the harmonised basin-wide criteria is provided for the Austrian upper Danube (see textbox).

Criteria used in expert judgement for the provisional identification of HMW sections on the Danube *FIGURE 64*



Criteria used in expert judgement for the provisional identification of HMW sections on the tributaries of the DRBD *FIGURE 65*



Application of the criteria for heavily modified water sections

Case study: Upper Danube in Austria

Over the last 125 years, the geomorphological properties of the upper Danube River in Austria have been changed significantly through dams and regulation. Human activities in this Danube section mainly include hydroelectric power generation and flood protection. Because of its approximately 0.43 ‰ average slope and high discharge, the Austrian part of the Danube is significantly used for hydropower. Since the early 1950s, 10 hydroelectric power plants have been constructed along this section of the Danube.

Further, activities of navigation, urbanisation, agriculture and recreation need to be mentioned. The history of river regulation in the Vienna section of the Danube is also closely related to urban development. The first regulation measures to increase the navigability of the major Danube arms date back to the 17th century. In the second half of the 18th century embankments were constructed on a large scale. Catastrophic floods in 1830 and 1862 increased the call for improved control. Thus, between 1870 and 1875, a straightened channel of 13 km was constructed.

In the Austrian upper Danube, two river sections are provisionally identified as heavily modified meeting the basin-wide agreed criteria:

- Section ATD1: This section is 165 km long (rkm 2203 – 2038, Jochenstein to the beginning of Wachau) and is affected by hydropower including seven hydroelectric power stations (HPS).
- Section ATD2: This section is 81 km long (rkm 2002 – 1921, Headrace of HPS Altenwörth to HPS Freudenau). This Danube section is also affected by hydroelectric power generation including three HPS. *The first criterion* for the selection of HMW sections meeting basin-wide agreed criteria is fulfilled for both sections of the upper Danube in Austria, since both are longer than 50 km.

According to the *second criterion,* the following main uses linked to hydromorphological alterations are present in these two sections in order of importance: hydropower generation, flood protection, navigation and urbanisation.

As required by the *third criterion,* the following physical alterations can be identified as having dominant impacts on the two HMW sections: dams (linked to HPS), channelisation/ longitudinal straightening (for flood protection, navigation, urbanisation), and bank reinforcement (for flood protection, navigation and urbanisation: e.g. dikes, transverse dikes).

Finally, by expert judgement *(fourth criterion),* it is concluded that the two sections are “at risk” of failing to meet the Good Ecological Status due to changes in hydromorphology. For the expert judgement, the following criteria were used:

- presence of not passable obstacles (weirs/dams) for migratory species, which result in the disruption of river continuity,
- presence of impoundment with significant flow reduction (damming effects),
- disruption of lateral connectivity due to river bed degradation and due to dikes.

4.6.2. Provisional HMWBs on lakes

Of the lakes dealt with in this report (lakes with a surface area > 100 km^2) Lacul Razim is the only lake that has been provisionally identified as a heavily modified water body.

4.6.3. Provisional HMWBs on transitional and coastal waters

Some parts of the transitional and coastal waters of the DRBD were provisionally identified as heavily modified water bodies. Information on these is provided in the National report of Romania, since they are of small size and therefore not addressed in this report.

Mario Romulic, Croatia

4.7. Risk of failure to reach the environmental objectives (overview)

National data and approaches are used for the national risk assessment, whereas the risk assessment on the roof level is based on the procedure described in Chapter 4.7.2. In the national risk assessment additional substances beyond those described in Chapter 4.7.2 may have been used. Therefore, results at the national level may differ from those given in the Roof report.

4.7.1. Approach for the risk assessment on surface waters

The WFD requests from the Member States to carry out an assessment of the likelihood that water bodies will fail to meet the environmental quality objectives by 2015. The objectives include both the overall objective to achieve good status by 2015, and possibly additional specific objectives that apply to protected areas as defined from other legislation. The objectives may also depend on the current status of the water body, since Member States must generally prevent any deterioration in the status.

Failure to achieve the objectives on surface waters may be the result from a very wide range of pressures, including point source discharges, diffuse source discharges, water abstractions, water flow regulation and morphological alterations. These and any other pressures that could affect the status of aquatic ecosystems must be considered in the analysis. The risk assessment is therefore based on information collected in the pressure and impact analysis.

In theory, evaluating the risk of failing the objectives should be a straightforward comparison of the status of the water body with threshold values that define the objective. In practice, this becomes more difficult, because the monitoring programmes and the ecological classification tools have not been fully established. Therefore, considerable data gaps exist and it is necessary to define interim thresholds based on expert judgement that are generally applicable in smaller geographical units. The risk assessment is based on the pressure and impact analysis and involves the steps illustrated in Figure 66.

From the pressure and impact analysis to assessing the risk of failure to reach the environmental objectives *FIGURE 66*

PRESSURE CRITERIA	IMPACT CRITERIA	RISK ASSESSMENT
Sigificant pollution or hydromorphological **Pressures** →	Defined thresholds for **impact assessment** →	**Likelihood, that WB will fall the objectives of the WFD**
Identification **Significant Pressure**	Identification **Significant Impacts**	

Pressure and impact criteria need to be defined in order to estimate if the identified pollution or hydromorphological pressures are significant and as a consequence impact the status of a surface water body. Such pressure criteria constitute defined thresholds e.g. concentrations of pollutants or thresholds related to morphological alterations. If a threshold is exceeded, then the water body is "at risk" and possible impact on the status is clearly defined. The same is true when applying the impact criteria, e.g. biological quality classes: If the defined impact criteria are exceeded, a water body is identified as being "at risk". The identification of a water body "at risk" means there is a likelihood that the water body will fail to achieve one of the objectives of the Directive.

This report provides information on significant pressures of transboundary and basin-wide importance. National reports identify significant pressures on a more detailed level using additional criteria. The risk assessment is based on both significant pressures and their impacts on the aquatic ecosystem as identified in Chapter 4.4 and 4.5. If assessments of ecological status classification in line with the requirements of Annex V WFD are already available, these may be used to determine if the water body is "at risk".

The WFD requires the achievement of the principal objectives – good status of surface waters and groundwater – by the end of 2015 at the latest, unless Art. 4.3 to 4.7 are applicable. Accordingly, the analyses of pressures and impacts must consider how pressures will likely develop prior to 2015 in ways that would place water bodies "at risk" of failing to achieve good status if appropriate programmes of measures were not designed and implemented. In the Danube River Basin, a prediction of the future development of significant pressures and their impacts is currently not possible. This is because of the significant economic changes under way and the lack of information on the changes. Therefore, the risk analysis is mainly based on the situation in 2004.

The risk assessment is linked with important follow-up actions, in particular the development of appropriate monitoring networks. The risk class will determine the necessary follow-up actions.

In the Danube River Basin the following three risk classes were defined:

– **"water body not at risk":** Based on the pressure/impact analysis it is estimated, that the investigated water bodies will reach the objectives set out by the WFD and are therefore "not at risk". No further characterisation or additional monitoring is needed. Nonetheless, attention should be paid to possible changes in pressures, which might cause deterioration. Water bodies "not at risk" can form part of the surveillance monitoring network that has to be set up by the end of 2006.
– **"water body possibly at risk":** This category of water bodies, are those for which not enough data is available. Due to the lack of sufficient data and/or high uncertainty of existing methods (e.g. low differentiation) it is possible that the objectives of the Directive will be failed. Further characterisation, analysis or investigative monitoring are necessary by the end of 2006. This is necessary to determine if these water bodies are "at risk" of failure or not. If they are finally classified as being "at risk", or the uncertainty remains, then these water bodies need to be included in the operational monitoring.
– **"water body at risk":** Based on the performed pressure/impact analysis it is estimated, that these water bodies are "at risk" of failing to meet the objectives set out by the WFD. No further characterisation or additional monitoring data are needed to finish the risk assessment. In order to assess the future status of the affected water bodies an operational monitoring network has to be operational by the end of 2006.

The data for this analysis was collected from the countries in the form of templates. Some of the countries were not able to deliver any data, either due to the short time available, or because the implementation of the WFD is not yet in an advanced stage, e.g. in most of the non-accession countries. If a country did not deliver any data, the water bodies were not assigned to any of the three risk classes. The entire area of the country was classified with the label "no data" in the maps.

Operational monitoring networks need to be established for the classes "at risk" and for those "possibly at risk" if further characterisation, analysis or investigative monitoring confirms that the water body is finally "at risk" or the uncertainty remains. The results of the risk assessment may also be used for the revision of the delineation of the water bodies.

4.7.2. Risk of failure analysis on rivers

The risk assessment is based on a combined evaluation approach considering both significant pressures and in-stream quality data. The risk analysis proceeds in a step-wise approach from disaggregated information to the aggregated analysis of the risk. The pressures and their resulting impacts are disaggregated into the following risk categories:

- Organic pollution
- Hazardous substances
- Nutrient pollution
- Hydromorphological alterations

Other kinds of risks were not identified on the overview level, but may be relevant in the National Reports. In many cases, water bodies are affected by multiple risks. Therefore, each of the risks is presented separately.

In general, criteria for risk assessment were developed on the national level (for details see National Reports), but for the overview some basic criteria were agreed to make the results comparable on the basin-wide level.

Risk assessment for organic pollution

If a water body is subject to a significant pressure from municipal, industrial or agricultural point sources (exceeding the limit values for organic pollution as identified in Chapter 4.4.1), then the water body is classified as being "at risk". The discharge of partially treated or untreated wastewater from urban areas is especially significant and does not meet the requirements of relevant EU legislation, in particular the EU Urban Wastewater Treatment Directive and the Directive for Integrated Pollution Prevention and Control (IPPC). Therefore, these water bodies were classified as being "at risk". This is particularly relevant in the middle and lower parts of the Danube basin.

For impacts from organic pollution the Saprobic Index (SI) utilizing benthic invertebrates was used. The following critical thresholds were defined at the basin-wide level for the category "at risk":

- Danube mainstream and lower parts of major tributaries: SI > 2.4
- all other tributaries with catchment areas > 4,000 km^2: SI > 2.25

Risk assessment for hazardous substances

Generally, there are substantial data gaps in both the pressure and the impact data. It was agreed that if a water body is subject to a significant pressure, which exceeds the limit values for hazardous substances as identified in Chapter 4.5.1.2, the water body is classified as being "at risk". For the risk assessment of impacts, the presence of hazardous substances from the ICPDR List of Priority Substances (i.e. EU List for Priority Substances plus Arsenic, Chromium, Copper and Zinc) in the water or sediments was used. The substances of the ICPDR List were screened by applying the national quality standards.

Risk assessment for nutrient pollution

It was not possible to define common criteria for risk assessment for nutrient pollution, on the basin-wide level, due to the heterogeneity of the surface water types. Therefore, countries applied national criteria. Almost all countries used chlorophyll a to define threshold values for the risk assessment. In some countries, threshold values for nutrients (phosphorus and nitrogen) were used as alone-standing criteria or as a supplement to chlorophyll a values. Special attention was given to the dislocation effects between the source of pollution and the impact area. The recognition of past high risk, lower current risk, and potential increase of risk in the future, was integrated in the analysis.

Risk assessment for hydromorphological alterations

No common criteria were defined for pressures from hydromorphological alterations. Therefore, countries applied nationally developed risk criteria. The classification proposed by MOOG & STUBAUER (2003) was used as a guidance. On the impact side, there is a general lack of data and of assessment methods. It was agreed that if the criteria for heavily modified water stretches on the basin-wide level are met (see Chapter 4.6), the water body is classified as being "at risk".

Final risk classification

The final risk classification into one of the risk classes "at risk", "possibly at risk", or, "not at risk", was based on the individual results of the applied pressure and impact risk criteria described above. A water body was classified as being "at risk", if at least one of the four risk categories had been identified. Water bodies where the data was insufficient were classified as being "possibly at risk" until more detailed information becomes available.

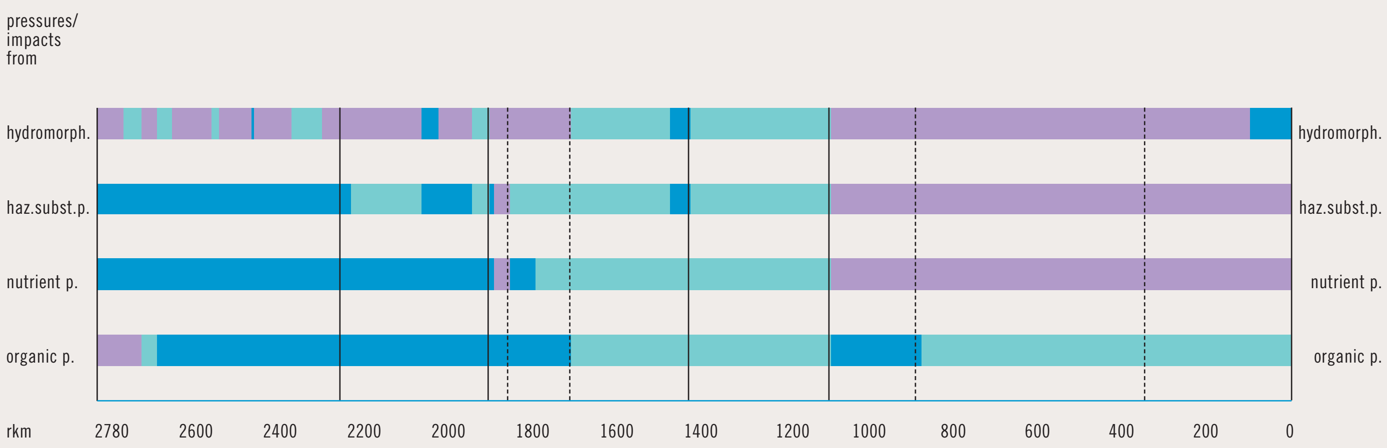
4.7.2.1. Results on the Danube River

The evaluations of the risk analysis for the Danube are based on the length of the water bodies that have been identified. The information about the risk of failure is presented in disaggregated form, i.e. evaluation of the single risk categories.

Data on the risk assessment are available for the total length of the Danube. Figure 67 illustrates for which reason the water body is at risk. The upper Danube, where chains of hydropower plants exist, is mainly impacted by hydromorphological alterations. Many of the water bodies in the upper Danube have also been provisionally identified as "heavily modified water bodies". The Middle Danube is classified as "possibly at risk" due to hazardous substances for the largest part. The Danube section shared by Slovakia and Hungary is classified as "at risk" due to hydro-morphological alterations. The part of the Danube shared by Croatia, and Serbia and Montenegro is "possibly at risk" in all categories since not enough data is available for a sure assessment. The lower Danube is "at risk" due to nutrient pollution and hazardous substances, and in large parts due to hydromorphological alterations. It is "possibly at risk" due to organic pollution.

Based on the data shown in Figure 67 the percentages of river length were calculated that are "at risk", "possibly at risk" and "not at risk". In total, 58 % of the Danube is "at risk" or "possibly at risk" due to organic pollution, 65 % due to nutrient pollution and 74 % due to hazardous substances. Large parts of the Danube (93 %) are "at risk" or "possibly at risk" due to hydromorphological alterations. As shown in Figure 67 a water body can be influenced by more than one risk category so that the actual risk can be even larger.

Risk classification of the Danube, disaggregated into risk categories. Each full band represents the assessment for one risk category (hydromorphological alterations, hazardous substances, nutrient pollution, organic pollution). Colours indicate the risk classes. *FIGURE 67*



4.7.2.2. Results on the Danube tributaries

The analysis does not yet cover a detailed risk assessment for all tributaries shown in the Danube River Basin District overview map (catchments > 4,000 km², see Map 1). Data on the risk of failure to reach the environmental objectives was available from Germany, Austria, Czech Republic, Slovak Republic, Hungary, Romania, Bulgaria (for Ogosta, Iskar and Yantra), and Moldova (only for Prut River). These results cover about 85 % of the tributaries (based on the length of the tributaries in comparison to the total length of tributaries, estimated to be about 18,850 km). For the other tributaries there was insufficient data available and these were therefore classified as being "possibly at risk". A basin-wide overview on the risk of failing to reach the environmental objectives of the Directive is given for organic pollution in Map 11, for hazardous substances in Map 12, for nutrient pollution in Map 13 and for hydromorphological alterations in Map 14.

The summary statistics show that 43 % of the tributaries are "at risk", or "possibly at risk" due to organic pollution. The upper Danube basin shows a comparatively low percentage of risk due to organic pollution (5 to 20 % of the length), while in the middle and lower Danube basin the percentage is much higher (ranging between 20 to more than 90 % of the length). 50 % of the Danube tributaries are "at risk", or "possibly at risk", due to nutrient pollution, and 36 % due to hazardous substances. Hydro-morphological alterations are responsible for 78 % of the tributaries being "at risk", or "possibly at risk", in the current analysis.

The overall risk assessment for Danube tributaries shows that 60 % are "at risk", and 27 % are "possibly at risk", of failing to reach the environmental objectives. 13 % are classified as being "not at risk". As mentioned above, these percentages were calculated based on the length of the water bodies.

Danube River Basin District – Risk of Failure to reach the Environmental Objectives – Organic Pollution *MAP 11*

Danube River Basin District – Risk of Failure to reach the Environmental Objectives – Hazardous Substances *MAP 12*

Danube River Basin District – Risk of Failure to reach the Environmental Objectives – Nutrient Pollution *MAP 13*

Danube River Basin District – Risk of Failure to reach the Environmental Objectives – Hydromorphological Alterations *MAP 14*

4.7.2.3. Discussion of results of the risk analysis on rivers

With respect to organic pollution the number of water bodies “at risk” is low in some areas, because of investments in wastewater treatment in the past decades, in particular in the upper part of the basin. On the other hand, the total share of water bodies “at risk” or “possibly at risk” is nonetheless fairly low given the high number of insufficiently treated wastewater in the middle and lower part of the Danube river basin. Thus, it is likely that the percentage may further increase when the application of the risk analysis approach is refined in the future. In light of the combined approach of the WFD the fulfilment of relevant EU legislation, e.g. the Urban Wastewater Treatment Directive (UWWT) and the Directive for Integrated Pollution Prevention and Control (IPPC) is a minimum requirement to reach the objectives of these directives.

In general, nutrient pollution of rivers, in particular in large rivers like the Danube, is much more uncommon than of lakes and coastal waters. The percentage gives an indication that there is a high level of nutrients in the system. In particular, slow flowing and impounded sections of the river are the areas where eutrophication problems may occur.

The analysis for hazardous substances is complex and uncertain because of the high number of pollutants that might be present in the aquatic ecosystem. The likelihood is that the percentage of water bodies in the DRBD “at risk” or “possibly at risk” will increase when more hazardous substances are monitored in the future.

The percentage of water bodies “at risk” or “possibly at risk” due to hydromorphological alterations is very high and reflects the level of human intervention in the Danube river basin in the past more than hundred years. However, some of these sections of the river will be designated as heavily modified water bodies in 2009. The risk assessment will then have to be carried out against the “ecological potential” not against the “ecological status” as it has been considered in this analysis of 2004. Moreover, it should be noted that the type and the extent of the hydromorphological pressures varies greatly between the upper, middle and lower part of the Danube river basin. In particular in the lower part of the Danube, the identified pressures may not be sufficient to identify the water bodies as heavily modified.

4.7.3. Risk of failure analysis on lakes

Within the Danube basin only a few lakes are larger than 100 km^2 and included as part of this report (see Chapter 4.2). Common risk criteria were not defined on the basin-wide level for lakes. The analysis described here is therefore based on the national assessments. Information on the risk of failure assessment is available for Neusiedlersee / Fertő-tó, which is shared by Austria and Hungary, for Lake Balaton in Hungary, and for Lacul Razim located near the Black Sea in Romania. Details on the risk assessment are contained in the respective National Reports.

Neusiedlersee / Fertő-tó is at present only slightly polluted by non-point and point source loads. Due to biological treatment and phosphate elimination in the waste water treatment plants built since the 1970s, and due to the introduction of phosphate-free detergents in the 1980s, considerable improvement was achieved in the nutrient levels of the lake, which have become visible in the 1990s. Based on the common Austrian-Hungarian assessment, the open water of the lake is now classified as “meso-eutrophic” again indicating that the current trophic situation is very near to the natural reference condition (mesotrophic). No other significant pressures (significant amounts of dangerous substances, significant hydromorphological changes) are observed that could cause a failure to achieve the environmental objectives. Therefore, Neusiedlersee / Fertő-tó is classified as being “not at risk”.

Lake Balaton is impacted by hydromorphological alterations resulting from the elimination of marshlands and changes in the water courses. The water level of Lake Balaton is controlled for recreational purposes. Lake Balaton is not a heavily modified water body. Nutrient pollution, especially the phosphorus loads, influences the trophic status of Lake Balaton. Eutrophication occurs particularly in the western part of the lake, but the nutrients have substantially decreased and the water quality has improved. The water quality of the lake corresponds to the bathing water standards. Lake Balaton is “possibly at risk” due to the mentioned hydromorphological alterations.

Lacul Razim is “at risk” of failure to meet the objectives due to nutrient pollution. No significant sources of hazardous substances could be identified but there is not enough data of sufficient quality to make a clear risk assessment for this risk category. Also, information regarding impacts from organic pollution and hydromorphological alterations is insufficient. Lacul Razim is also a provisionally identified heavily modified water body. Therefore, Lacul Razim is classified as being “at risk” due to nutrient pollution and “possibly at risk” due to organic pollution, hazardous substances and hydromorphological alterations.

4.7.4. Risk of failure analysis on transitional and coastal waters

The transitional waters in the Danube Basin are situated in the Danube Delta (lower parts of the three Danube branches), in Lacul Sinoe (lacustrine system), and in the marine transitional waters from the Danube-Chilia mouth to Periboina. The transitional waters are affected by a variety of different pressures and impacts (see Chapter 4.4 and 4.5). Among others, nutrient concentrations in the Danube River cause eutrophication and changes in the flora and fauna. To undertake the risk assessment the criteria for rivers were applied.

All transitional waters in the Danube branches are “at risk” of not meeting the environmental objectives due to the presence of hazardous substances and nutrient pollution. Additional risks may exist from organic pollution but the available data is insufficient for a clear assessment of the risk. Braţul Sulina, the middle branch, is “at risk” due to hydromorphological alterations. Therefore, all transitional waters in the Danube Delta are classified as being “at risk” for hazardous substances, “at risk” for nutrient pollution, and “possibly at risk” for organic pollution.

Lacul Sinoe shows significant effects from nutrient pollution. In addition, further pressures may exist due to organic pollution and hazardous substances. There is, however, currently not enough information available to make this assessment. Lacul Sinoe is therefore also classified as being “at risk” due to nutrient pollution and “possibly at risk” due to organic pollution and hazardous substances.

The marine transitional waters are “at risk” due to nutrient pollution and due to insufficient data on organic pollution and hazardous substances are “possibly at risk”.

The coastal waters of the Danube River Basin District are situated along the Romanian coastal zone of the Black Sea. They are divided into three water bodies. All three coastal water bodies are “at risk”. High nutrient loads from the Danube and the coastal river basins as well as coastal erosion on the Romanian seashore constitute significant pressures to the Black Sea coastal waters. The risk analysis showed that all three coastal water bodies are “at risk” due to nutrient pollution. In addition, the Singol Cape-Eforie Nord coastal water body is “at risk” due to hydromorphological alterations and also a candidate for heavily modified water body. The Eforie Nord-Vama Veche coastal water body is “possibly at risk” due to hydromorphological alterations. For the other risk categories there is not enough information available. Overall, all coastal water bodies have been classified as being “at risk” for nutrient pollution and “possibly at risk” for the other risk categories.

Details on the risk assessment on transitional and coastal waters are contained in the National Report of Romania.

4.7.5. Risk of failure analysis on heavily modified water bodies

The risk analysis for heavily modified water bodies was based on an estimation of the risk of failing to reach the good ecological status. The estimation of the risk of failure to reach the good ecological potential is strongly linked with the final designation of heavily modified water bodies and will be dealt with in the river basin management plan, i.e. will be finalised at the end of 2009.

4.7.6. Risk of failure analysis on artificial water bodies

The approach for the risk of failure analysis on artificial water bodies was based on national criteria. No data are available for this report.

4.8. Data gaps and uncertainties

A gap analysis has been carried out as regards missing or incomplete data encountered in the analysis described above. The following data gaps and uncertainties were identified.

4.8.1. Typology of surface waters and definition of reference conditions

The Danube typology and reference conditions have been jointly developed in a unified approach in cooperation with the countries concerned. Nonetheless further validation with biological data is necessary. The national typologies for surface waters have been developed independently by the countries. The countries in the middle and lower basin have benefited from the fact that the typologies in the upstream countries were developed at an earlier stage and have been used as an orientation for the development of their own. Therefore, similar approaches have been taken, but there has not been a unified or harmonised approach in the development of the national typologies.

Germany and Austria have finalised their national typologies including the bottom-up validation of the surface water types with biological data. Most of the new Member States and the Accession Countries have completed the development of the typologies based on abiotic variables, but generally these have not yet been validated with biological data at the time of finalising this report. The other Danubian countries[78] have in part begun with the development of surface water typologies, e.g. Serbia and Montenegro, and Moldova.

The countries in the Danube basin have agreed to use the 'general criteria for reference conditions' of the EU Guidance on reference conditions and this constitutes an important basic starting point for defining type-specific reference conditions in the countries. The type-specific reference conditions have not yet been defined by all countries in the basin. While the EU Member States and Accession Countries are quite advanced or have finalised the work, the other Danubian countries have largely not even started.

4.8.2. Significant pressures relevant on the basin-wide scale

In the future, the ICPDR emission inventory on point sources needs to be extended to cover the whole Danube River Basin District. Furthermore, it needs to be adapted to account for sources defined as "agglomeration" in the EU Urban Wastewater Directive. This would ensure the recognition of point source discharges from agglomerations, both with and without sewer systems or sewage treatment. In addition, the question of smaller agglomerations and their transboundary relevance should be addressed, given that nearly 40 % of the population is or will not be connected to large WWTPs in the coming years.

As regards the IPPC EPER database the publicly available data only includes Germany, Austria and Hungary. In general, all the other Danubian countries, which are or will be part of the EU, have submitted data in the context of the IPPC and the UWWT Directive negotiations. As this information becomes available it should be aligned with the ICPDR emission database.

For assessing diffuse sources the nutrient model MONERIS[79] serves as a basis for a comparative assessment of the pressures caused by nutrients in the Danube River Basin, but does not yet cover the coastal river basins of Romania. Calculated emissions as well as assessed loads are based on available data of significantly different quality, and time periods partly using very rough estimations. The information used often represents large scale aggregations derived from international statistics or surveys (e.g. CORINE Landcover). Regional, local and specific investigations respectively may strongly differ in results. Regarding emissions, for example, a later detailed investigation for the Bavarian part of the Danube River Basin shows substantially lower amounts for livestock (lower than 1,5 livestock unit/ha) and a noticeably smaller portion of arable land (less than 40 %) than used in MONERIS. Therefore, the calculated results differ in quality depending on the data sources and should be interpreted as a rough estimation.

The same is valid for the assessed immission loads that must be seen as a rough indicator, since the available data is not in all cases sufficient for such calculations. In addition, a longer time series of data is needed to minimize the effects of strong fluctuations in the hydrograph and its influence on nutrient loads. The balance period 1998-2000 represents for the upper Danube a wet time period including a flood event in 1999 in the German part of the Danube River Basin. In dryer years nutrient loads can be up to 20 % lower, in the extremely dry year 2003 the registered loads were even lower.

78 *Cooperating under the DRPC.*
79 *SCHREIBER et al. (2003).*

Calculated and assessed loads for phosphorous show a mean deviation of 30 % for the entire Danube River Basin (MONERIS report 2003). The authors have proposed to further develop the model focussing on a higher spatial resolution of the source data and on the adjustment of the approach for erosion assessments to local conditions. Also, for some tributaries located on Romanian territory the background loads were underestimated, e.g. for the Siret River.

Despite the mentioned limitations the results serve as a general assessment of the nutrient situation in the Danube catchment and the mouth of the river at the Black Sea. It is expected that the incorporation of the MONERIS model into the Danube Water Quality Model and the Danube Delta Model and the use of higher quality data will lead to an improved level of knowledge.

The MONERIS modelling results of the diffuse and point source nutrient emissions are dependent on the quality and the resolution of the available data in space and time. Because the quality of data varies within the Danube catchment, the results are only preliminary estimations and uncertain in a range of about 20 % for nitrogen (N) and about 30 % for phosphorous (P) for the total catchment. For the sub-catchments the level of uncertainty can be lower or higher depending on the data quality and the data resolution.

The ICPDR Emission Inventory was utilised for the estimation of point nutrient discharges, but this inventory only includes large point sources. Therefore, other, more complete inventories for point source nutrient discharges were additionally used for Germany and Austria (which have complete inventories) and for the Slovak Republic and Hungary (which have nearly complete, but partly inconsistent inventories).

To estimate diffuse sources of nutrient pollution a harmonised database is very important. This database should have the same spatial resolution as the data for the sub-catchments. While the establishment of a harmonised database for the DRB was largely possible (land cover data comparable to CORINE are missing for Croatia, Serbia and Montenegro as well as for Ukraine and Moldova), the spatial resolution is limited to the soil map (only FAO soil map; the existing EU soil map in the scale of 1:1,000,000 was not publicly available) and for the statistical data on agriculture as well as waste water management. This data was only partly available at the country level and not for the needed district level (NUT3).

There is a clear need for enlargement of the information to include the point and diffuse sources of nutrient emissions to the Danube basin river district, in particular:

– Improvement of the estimates on point and diffuse nutrient emissions will be possible if additional data can be provided in the ICPDR Emission Inventory for agglomerations less than 10,000 inhabitants, and on the connection degree of the population to sewers and WWTPs.
– Improvement of the model results related to diffuse nutrient emissions will be possible by using existing digital maps with higher spatial resolution, such as the European soil map (1:1,000,000), a detailed hydrogeological map (Danube Atlas) and the new digital elevation model (90 m grid).
– Improvement of the estimation of diffuse nutrient emissions by application of statistical data on the agricultural indicators (e.g. fertiliser use, harvested crops, livestock numbers) at a sub-national level for all Danube countries.
– Development of model approaches for the estimation of the point and diffuse emissions of other substances such as heavy metals.
– Development of new approaches to evaluate the diffuse emission pathways into the river system of the Danube based on the experiences and measurements in case studies.

4.8.3. Assessment of impacts on the basin-wide level

In view of the relatively brief history of the TNMN, and taking into account the complexity of the basin from a natural and socio-economical point of view, the achievements within the TNMN have been huge. Nevertheless, the TNMN needs further strengthening on the basis of feedback from the end users of the data. Improvements need to be achieved with respect to the reliability and the completeness of the data. Also, the consistency of data collected by TNMN with data from other sources needs attention (e.g. with data published by the Black Sea Protection Commission).

The analysis of the data on impacts from organic pollution has shown that there exist considerable data gaps. Of importance, not all countries measure all determinants. In the future, the following determinants should be measured regularly on all TNMN monitoring sites: Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC) and Adsorbable Organic Halogens (AOX). In addition, the quality of the data should be improved.

The biological impact assessments are not fully comparable between all countries. In the upstream and middle countries the assessment is based on macrozoobenthos, in the down-stream countries (BG, RO and UA) on phytoplankton. The Saprobic System in its current form is not in line with the ecological status assessment as required by Annex V WFD. It will therefore be necessary to develop ecological classification methods in line with the requirements of the WFD by all countries.

The lack of data on hazardous substances is a problem caused mostly by the deficiency of adequate analytical instrumentation in the downstream countries and the lack of legal instruments for obligatory measurements. An additional factor is the high costs of the trace analysis. Thus, for each hazardous substance included in the TNMN a substantial amount of data is missing (40 to 60 %) mainly from the lower section of the Danube.

Moreover, it is necessary to emphasize that out of the 33 priority substances identified from the Decision No. 2455/2001/EC only seven are included in the TNMN. Concerning the other 26 substances very limited basin-wide information is available. The major source of information is the Joint Danube Survey. Therefore, to achieve a reliable assessment of the risk of failure to reach the good status, a vast portion of information on the “new” substances must be collected. This is the task for the national screening surveys and the operative monitoring.

A frequent phenomenon in reporting the TNMN data on hazardous substances is that the limit of detection of the analytical method applied is higher than the environmental quality standard. In such cases no relevant information on a particular determinant can be achieved. In the cases that the detection limit is reported as a final result, all data are formally non-compliant, giving a false impression on the pollution situation.

The major methodological problem of environmental trace analysis is the reliability of data at low concentration levels. The level of uncertainty of the result required by the ICPDR is 30 %, in some cases this figure may be even higher. To ensure the quality of the data a basin-wide analytical quality control system is regularly organized by the ICPDR. The reports on the analytical quality are published annually and indicate the precision and accuracy of the results produced within the TNMN. One of the major recommendations made repeatedly is the need to improve the quality of analysis of micropollutants.

The analysis of the impact from nutrient loads on a basin-wide scale is ideally based on the availability of data of high and homogenous quality, covering the whole catchment area. Analysing the issue requires data over a long period of time. There is not one individual data set with such a temporal and spatial coverage. For this reason, the analysis presented herein is based on different existing data sets. The gaps and inconsistencies between the data from different origin have been addressed by expert judgement or by using mathematical models to interpret the data.

The TNMN is the key source of surface water quality data in the Danube Basin. Despite the huge achievements within the TNMN in its relatively short period of existence (since 1996), improvements are still necessary with respect to the reliability and the completeness of the data. This refers in particular to data for total nitrogen and silicates (completeness) and data for total phosphorus (consistency). In general, this fact introduces some minor uncertainty in the analysis. The lack of basin-wide data for chlorophyll-α creates a strong uncertainty as to the possible eutrophication in the Danube and its large transboundary tributaries.

High quality data with sufficient temporal and spatial coverage are not always available. The availability of data for organic nitrogen, for silica and for chlorophyll-α is poor, while the quality of the available data for phosphorus is not good. Furthermore, the consistency of data from different sources presents a major problem.

Long term data to detect temporal trends in the water quality and ecology of the Danube Delta are not available. Therefore, it is difficult to say if the decreasing concentration of phosphorus in the Danube River has already started to have an effect in the Delta.

The collection of data from the marine environment is a difficult and expensive exercise. As a result, the analysis of the impacts in the coastal waters and the marine environment of the Black Sea is necessarily based on data with a limited temporal and spatial resolution. Satellite imagery presents an additional source of high resolution data, but the number of parameters which can be observed is limited. However, based on recent marine research, we can be quite certain that there is indeed a positive development of the Black Sea. Year-to-year climatological variability and climatological trends are known to affect the marine ecology significantly. It is not clear whether favourable climatic conditions in the last decade have been supporting the recent positive development of the Black Sea.

Even if a large amount of data has been collected and quite a bit of research has been carried out, it is still not known in quantitative terms to what extent the Danube River nutrient loads have contributed to the deterioration of the Black Sea ecosystem, and to what extent the recent improvements have been the result of the reduction of the Danube River nutrient loads.

Furthermore, we do not exactly know the current Danube River nutrient loads: data for the organic fraction of nitrogen are sparse or lacking, data for total phosphorus have been found of limited reliability and the available data do not agree with respect to the loads of dissolved inorganic nitrogen.

Closing the existing data and knowledge gaps seems a logical next step. This includes a better understanding of the degradation of the ecological status in the north-western shelf of the Black Sea, starting from the early 1970s and into the middle of the 1990s, and the subsequent improvements in recent years. Especially, the role of the nutrient loads from the Danube River as well as from the Romanian Black Sea coastal basins in this process needs to be better understood.

The evaluation of hydromorphological alterations, in combination with biological assessment, is new not only for the countries in the Danube River Basin but also for many European countries. Biological monitoring of rivers in the Danube River Basin has up to now focused mainly on the detection of impacts due to organic pollution. The hydrological and morphological conditions have been surveyed in many countries, but the interrelationships between the hydromorphological conditions and the ecological status of rivers have hardly been considered. Only a few countries have already developed assessment systems or criteria to integrate impacts from hydromorphological alterations into the ecological status assessment. Due to the lack of information on the relevant drivers, the pressures and their impacts on the biota, no harmonised assessment system has been elaborated so far.

Several Danube countries do not yet have data on hydromorphological alterations or methodologies for the assessment of their significance. This should be an item of further research and of possible harmonisation of the approaches used in the different countries. Furthermore, more research is needed on the link of hydromorphological and biological elements in the context of the Danube region. This would also be relevant for monitoring the success of restoration measures.

For the provisional identification of the main heavily modified sections four basic criteria were chosen that would also allow non-Member States/non-Accession countries to follow the approach. Guidance was given on the application of these criteria. Nonetheless, countries may have interpreted them differently, e.g. as regards the assessment of significant physical alterations or the assessment of the risk of reaching the good ecological status, which in almost all cases had to be based on expert judgement. There is clearly a need for harmonisation and verification within the framework of the ICPDR. A more detailed methodological reasoning for the provisional identification of HMWB is provided in the national reports.

A few countries encountered a lack of data and introduced an additional category where a definitive decision on provisional identification of HMWB was not possible. This category was defined as either ‘candidate for HMWB’ or ‘probable provisionally identified HMWB’. Information on this category is provided in the respective national reports.

As regards the bilateral harmonisation, some countries were not able to finalise the bilateral agreement on some transboundary stretches. Such harmonisation has, for instance, taken place for the HMWB stretch on the Danube shared by Bulgaria and Romania. In the case of transboundary stretches between Croatia and Serbia and Montenegro, as a first step it has been agreed between them that in principle the water bodies are provisionally identified HMWB. Hungary has started its bilateral harmonisation with all its seven neighbouring countries. In this context, bilaterally harmonised data was provided by Hungary and the Slovak Republic.

Regarding invasive species data gaps exists in many Danubian countries. Experts for neobiota have been asked to submit information to the ICPDR referring on the basin-wide aspects.

4.9. Conclusions on surface waters

4.9.1. Surface water types and reference conditions

The development of surface water typologies and the definition of their (near-)natural reference conditions is a new approach, which requires a detailed scientific analysis of the geographical and physicochemical conditions of surface waters. In addition, it requires a validation with biological data for it to be biologically meaningful as stipulated by the Directive. This is a difficult task and requires iterative steps to arrive at a sound and practically useful system that serves as the basis for the ecological status assessment. The development of sound surface water typologies takes several years and the upstream countries having started earlier have provided guidance for the middle and lower Danube countries and shared their experiences. Therefore, similar approaches have been taken in Danube countries, but there has not been a unified or harmonised approach in the development of the national typologies.

Since it would not have been possible for any single country to develop a typology for the Danube River as a whole, a harmonised typology for the Danube River was developed with the help of international experts together with the countries concerned. The Danube typology has been developed in a combined approach applying the abiotic criteria mentioned in Annex II WFD and validating these with biological data. The definition of its reference conditions has been based on historical data.

Some of the national typologies have not yet been finalised, in particular the biological validation needs more time. Capacity building and sharing of experiences is now needed in the non-accession countries for a sound development of their surface water typologies. In a next step, the national typologies and reference conditions of the DRB countries will need to be harmonised on the basin-wide level. Preparatory work in this respect has already started.

4.9.2. Significant point and diffuse sources of pollution

The analysis of point sources of pollution is based on the ICPDR Emission Inventory. Within the Upper Danube and Austrian Danube and partly in the Inn sub-catchment, the point source discharges are low due to high elimination of organic pollution and nutrients especially in municipal and industrial WWTPs. Because the population is also connected to a high degree to municipal WWTPs the potential for further changes is low.

For all other sub-catchments, it can be assumed that the discharges from municipal WWTPs will increase as the connection degree of the population to WWTPs increases, unless this is counteracted by an increase of the treatment efficiency of the existing and planned municipal WWTPs.

There is a great need to revise the list of significant point sources, since it can not be assumed that other sources do not exist. In addition, the criteria for significant point source pollution need to be expanded to cover other substances relevant in the Danube river basin district.

The quality of the ICPDR emission inventory, as well as of the status of national information, has to be improved. In particular, information on the percentage of population connected to sewers, and data on concentrations of substances in the effluent of the municipal waste water treatment plants needs to be completed. This will allow getting consistent overviews and realistic estimates of the emissions, and consequently calculation of different scenarios for nutrient emissions.

The data presented in this report shows that despite some inconsistencies in the information, a large potential for further reduction of nitrogen pollution from point sources exists in the Danube river basin, if the efficiency of the existing WWTPs is increased to a level comparable to those of Germany and Austria. For both countries a further decrease of the point source discharges of N will not be possible, because they have nearly reached the targets prescribed by the EU Urban Waste-water Directive.

A further reduction of the point P discharges in the Danube can be expected in the future, if the existing WWTPs in the lower Danube countries reach a similar level of waste water treatment as in Germany and Austria. In the upper catchments, the diffuse sources from agriculture are more pronounced than in the lower part of the basin. Therefore, the potential for nutrient reduction in this area should be explored. Within the middle and lower Danube and the sub-catchments in this region the focus should be on point sources.

The following conclusions may be drawn from the existing data and information on pesticide use:

- The current low use of agricultural pesticides in the countries of the Danube River Basin represents a unique opportunity to develop and promote more sustainable agricultural systems before farmers become dependent again on the use of agro-chemical products.
- Seven priority pesticides are not authorised in the Danube countries. Despite this fact some of them continue to be hazardous due to old stockpiles and residues in soils and sediments.
- The priority pesticides 2,4-D, Alachlor, Trifluralin, Atrazine and copper compounds are heavily used pesticides in most of the Danube countries. They are mostly used in cereals, rapeseed and sunflower, maize and in orchards and vineyards.
- Priority pesticides as well as other pesticides are frequently detected in surface and ground water.
- ∑ Priority pesticides pose a serious hazard to the environment and human health. Most of them have already been regulated at the international and at the EU level.
- The selection of the most appropriate policy instruments for the DRB countries will depend on the establishment of a clear policy strategy for controlling pesticide pollution, together with clear policy objectives.
- There is a need for organised information on pesticide use in a standardised format across all Danube countries to monitor future trends. Efforts should be made to easily extract this information from other sources (i.e. FAO, EEA).

4.9.3. Impacts from organic pollution

The analysis of impacts from organic pollution is based on data collected in the frame of the TNMN. The TNMN is a monitoring programme for chemical and biological variables at 79 monitoring sites on the Danube and its major tributaries. An analytical quality control system (for chemical determinants) is in place to ensure the comparability of results. Setting up the TNMN among the 13 countries in the basin in 1996, and now carrying out routine monitoring can be seen as a considerable achievement.

The Danube shows an increase in organic pollution (expressed as BOD_5 and COD-Cr) from upstream to downstream, reaching its maximum between Danube-Dunafoldvar (rkm 1560, below Budapest) and Danube-Pristol/Novo Selo (rkm 834, just below the border of Serbia and Montenegro, and Bulgaria). Here the target values are frequently exceeded. In parallel, the dissolved oxygen concentrations show a decrease from the upper to the lower Danube, showing also clearly the influence of the two major reservoirs, Gabcikovo and the Iron Gates. The biological impact assessment is mainly based on the Saprobic System to detect biodegradable organic pollution. According to the Saprobic System, the Danube is classified as “moderately polluted” (Class II) to “critically polluted” (Class II-III).

The tributaries are in part highly polluted. This can be seen from highly elevated values for degradable organic matter (expressed as BOD_5) and for organic matter with low degradability (expressed by COD-Cr). In some tributaries also the oxygen content is significantly lower than in the main course of the Danube, e.g. in the Arges River.

The major cause of impacts from organic pollution is insufficient treatment of waste-water from the major municipalities. In many cases, waste-water treatment plants are missing or the treatment is insufficient. Therefore, the building of waste-water treatment plants will be a prime focus of the programme of measures, which needs to be developed in the frame of the river basin management plan by the end of 2009.

Additional steps should focus on the improvement of the Analytical Quality Control System and the development of ecological classification systems that respond to the requirements of the Directive.

4.9.4. Contamination with hazardous substances

Pollution loads of hazardous substances are significant although the full extent cannot be evaluated to date. Currently, there are only few data available for hazardous substances such as heavy metals and pesticides.

Cadmium and lead can be considered as the most serious inorganic micro-contaminants in the Danube River Basin. Especially critical is cadmium, for which the TNMN target value is substantially exceeded in many locations downstream of rkm 1071 (values mostly 2-10 times higher that target value). The pollution of the lower Danube by cadmium and lead can be regarded as a significant impact.

p,p'-DDT is a substance of special concern in the lower Danube. Here the very low TNMN target values are often exceeded in the order of two magnitudes. This means that despite a high analytical uncertainty the level of p,p'-DDT is significant and gives a strong indication of potential risk of failure to reach the good status.

For Lindane the results of the TNMN classification are not so alarming. It is however, foreseen that the environmental quality standard[80] that will be set by the EU may be substantially lower than the TNMN target value. In this case, the risk of failure to reach the good status will be much higher and the situation will be similar to that for p,p'-DDT. Some tributaries (Sió, Sajó and Sava) show random occurrence of high concentrations of Atrazine. The elevated concentration of Atrazine in the Sava triggered the alarm in the ICPDR Accident Emergency Warning System in 2003.

During the Joint Danube Survey significant concentrations of the EU WFD priority substances 4-iso-nonylphenol and di[2-ethyl-hexyl]phthalate were found in the bottom sediments as well as in suspended solids. The values ranged from a few µg/kg up to more than 100 mg/kg, indicating the relevance of these compounds as an indicator of industrial pollution in the Danube River.

Follow-up regarding hazardous substances should include:

- improvement of data quality:
  - Ensuring equal analytical capabilities in all TNMN laboratories,
  - Training of laboratory personnel (where necessary) in the analysis of "new" priority substances,
  - Implementing robust and sensitive analytical methods with detection limits 3-10 times below the environmental quality standards set by the European Commission.
- national screenings for EU WFD priority substances,
- joint longitudinal surveys focused – among others – on priority substances (e.g. the planned Joint Danube Survey II or the planned survey on the Sava),
- design of the monitoring programme for operational monitoring in line with Annex V WFD.

4.9.5. Impacts from nutrients

Like many large rivers, the impact of the high transboundary river nutrient loads in the Danube River Basin is the most critical in the receiving coastal waters of the Black Sea, however, pressures from the coastal river basins directly affecting the coastal waters of the DRBD need to be considered. In addition, there are indications that the middle Danube (rkm 1600-1200) may be sensitive to eutrophication as well.

The impacts from nutrient loads in the Danube River and its major tributaries is limited to some slow flowing and relatively shallow reaches, such as the middle Danube in Hungary. Other sections apparently are flowing too fast, are too deep or too turbid to develop eutrophication problems. The impacts on the Danube Delta and the Black Sea are discussed below.

The impact of nutrient emissions can be significant in smaller water bodies in areas with high emissions and/or low dilution capacities. Such impacts are often of a local nature, and they are discussed in national reports.

The strengthening of the TNMN in order to complete the basin-wide database and optimise its consistency is an ongoing effort. The collected data will be presented and analysed in a way that supports the upcoming steps in the implementation of the WFD.

So far, the comparison of data collected under the umbrella of the TNMN and data collected elsewhere has not been carried out systematically. It is strongly recommended to pay more attention to this aspect, which is particularly relevant for data collected by marine researchers in the transitional and coastal waters of the Danube River District.

80 *Decision No 2455/2001/EC of the European Parliament and of the Council of 20 November 2001 establishing the list of priority substances in the field of water policy and amending Directive 2000/60/EC (Text with EEA relevance), OJ 2001 L 331/1.*

4.9.6. Impacts on the Danube Delta

The Danube Delta has suffered significant impacts from anthropogenic pressures in the second half of the last century. For some impacts positive developments have been observed recently or may be expected in the near future. In the last decade the destruction of floodplains and wetlands has stopped and reconstruction projects have started to be implemented.

The fate of the Danube River and the Danube Delta are interlinked by water masses flowing from the river branches to the Delta aquatic complexes. At present, these flows amount on average of just less than 10 % of the Danube River discharge. The reduction of the Danube River concentrations of phosphorus may well have a positive effect on the eutrophication of the Danube Delta, now or in the near future. The Danube Delta is strongly affected by Danube waters, but the opposite is not true: the Danube Delta has a negligible effect on the Danube River nutrient loads.

It is recommended to monitor on a regular basis the water quality and the aquatic ecology of the Danube Delta, as well as the progress of restoration projects. It is important to carefully monitor the future hydromorphological and ecological changes in the Danube Delta.

4.9.7. Coastal waters and the wider marine environment of the Black Sea

Since the early 1960s, noticeable and well documented alterations have been observed at various trophic levels of the Black Sea ecosystem. Marine research carried out in the late 1990s[81] indicated that the changes of the ecosystem were the result of a combination of human interventions, occurring simultaneously in the Black Sea drainage basin and in the marine environment: (a) the manipulation of the hydrological regimes of the outflowing rivers, (b) the increasing discharge of nutrients from rivers and direct land-based sources, (c) the introduction of exotic species (such as the jellyfish *Mnemiopsis*), and (d) selective and excessive fishing.

The Danube nutrient loads are an important factor responsible for the deterioration of the Black Sea ecosystem. The ecosystem seems to have responded directly and positively to the recent reduction in the nutrient loads from the Danube and from the Romanian coastal basins. It thereby contributes to nutrient reduction in the Western Black Sea and signs of recovery have been observed in this area. However, nutrient loads are still significantly higher than in the 1960s. Jellyfish are still over-represented in the food-chain, and the fish stock is still out of balance. Nevertheless, from the point of view of the ecological status of the Black Sea possibilities for further reduction of the Danube River nutrient loads should be explored.

For reasons mentioned above, it is necessary to keep a close look at the Black Sea ecosystem and at the Danube nutrient loads entering the system. Experience from the past indicates that a possible increasing nutrient load can cause renewed ecological problems. The proper management of these loads will be a key issue in the next steps of the implementation of the WFD.

81 LANCELOT *et al.* (2002).

4.9.8. Hydromorphological alterations

The most important hydromorphological pressures are related to hydropower use, navigation and flood defence measures.

In the upper parts of the Danube chains of hydropower plants and navigation sluices interrupt the continuity of the river with the effect that only few free-flowing sections on the Danube remain, e.g. in the Austrian Wachau, a World Cultural Heritage Site. Also on the tributaries many dams and weirs have been constructed. Resulting impacts especially affect the migratory fish species that cannot reach their spawning grounds, feeding or refuge grounds in other parts of the river-floodplain system.

Iron Gates I and II on the middle Danube shared by Serbia and Montenegro, and Romania have dams 60 and 30 m high and backwaters reaching 310 km upstream on the Danube. Also the tributaries are strongly affected by backwaters reaching 100 km upstream on the Sava and 60 km upstream on the Tisza River, and also on many smaller tributaries. The Iron Gates have multiple effects on the Danube ecosystem. Flow rates are severely reduced and water levels considerably elevated (33 m at Iron Gate I during low water, 19 m during very large floods). The Iron Gates function in particular as sinks for nutrients and sediments with subsequent impacts on the Lower Danube and the Black Sea. Also, the groundwater tables are elevated considerably in the backwater areas endangering settlements, municipal and industrial facilities and agricultural activities, particularly in the Serbian lowlands.

Navigation occurs on nearly all parts of the Danube (except the uppermost section above Kehlheim) and the lower parts of its major tributaries. Construction and maintenance of the navigation channel, sluices and harbours have significant negative effects on the aquatic environment. Therefore, many stretches on the Danube have also been provisionally identified as heavily modified water bodies. The Lower Danube and many tributaries are also affected by hydromorphological alterations based on flood defence measures.

Follow-up should be initiated regarding the following points:

– Methods for the assessment of significant hydromorphological alterations need to be harmonised. A type-specific approach would be advisable.
∑ Further research is needed on the link between hydromorphological pressures and the response of the biota. Ecological classification systems should be developed in a way to also assess hydromorphological degradation. Common methods would be needed (e.g. common sampling method, common approach for the analysis and interpretation of results, stressor specific multimetric classification systems).
– Future monitoring networks need to include sites that are “at risk” of failing to reach the environmental objectives due to impacts from hydromorphological pressures.
– Migration pathways are needed on many barriers along the Danube and its tributaries. Species concerned are e.g. *Vimba vimba, Chondrostoma nasus, Lota lota, Alosa pontica* and *A. caspia normanni* as well as the sturgeons.
– Restoration of fish habitats should be carried out making best use of experience gained from previous restoration projects with similar measures in other parts of the Danube basin.

4.9.9. Important heavily modified surface waters

For the provisional identification of the most important heavily modified sections four basic criteria were chosen that would also allow non-Member States/non-Accession countries to follow the approaches used by EU Member States. For large parts of the Danube River and numerous tributaries such heavily modified sections have been identified. The most dominant use is navigation on the Danube River and flood protection on the tributaries. The main significant physical alterations are dams and weirs on the Danube River and bank reinforcements and fixations on the tributaries. These hydromorphological alterations with a significant impact on the rivers reflect the dominant uses of the heavily modified stretches in the Danube River Basin District.

Future projects for the further development of navigation and hydropower in the Danube River Basin District as well as flood protection measures should be considered with regard to their ecological effects and their implications for the future identification and designation of heavily modified water bodies.

4.9.10. Invasive species

Until now it is difficult to assess the possible pressures and impacts resulting from the invasion of alien species. Some scientific research already exists, but it is difficult to sort out human from natural changes and it remains unclear how this issue should be addressed with respect to the estimation of the risk of failure to reach the good status.

The significance of neobiota in the Danube will presumably increase in the coming years due to the fact that the Danube will become more and more important as a waterway and navigation contributes to the spreading of alien species. However, it is important to mention that currently there are no alien species, which can clearly be identified as a risk for reaching the good ecological status.

The overall relevance of alien species within the Danube River Basin should be further discussed in the European-wide context.

4.9.11. Risk of failure analysis

The Danube and its tributaries are to a large extent "at risk" or "possibly at risk" to fail to reach the environmental objectives set out by the WFD. Reasons for this risk in the upper Danube basin are mainly the hydromorphological alterations, which are also reflected in the fact that several stretches have been provisionally identified as heavily modified water bodies. From the Middle Danube region, currently only a limited data set is available. In the Lower Danube region, hydromorpho-logical alterations, organic and nutrient pollution as well as pollution from hazardous substances play an important role.

Regarding the lakes selected for the basin-wide overview in this report only Neusiedler See/Fertő-tó is "not at risk" of failing to reach the environmental objectives. Lake Balaton is "possibly at risk" due to hydromorphological alterations. Lacul Razim is "at risk" due to nutrient pollution and "possibly at risk" due to organic pollution, hazardous substances and hydromorphological alterations. It is also provisionally identified as a heavily modified water body. For Ozero Yalpug there is no information available.

The transitional and coastal waters are all "at risk" or "possibly at risk" to reach the environmental objectives, mainly due to nutrient pollution. More information is needed regarding organic pollution and hazardous substances.

Based on the results of this risk assessment follow-up actions will be needed. The focus will be on the adaptation of existing monitoring networks and programmes so they will be operational by the end of 2006. These will deliver data on both the national and the DRB scale. The data on the ecological and chemical status assessments from surveillance, operational and investigative monitoring sites will add to the knowledge on the current ecological and chemical status of the water bodies. Consequently, these assessments will verify the accuracy of the current risk estimations, which have been based only on available information.

Follow-up will have to focus in particular on transitional and coastal waters, as failing to reach the good status of these waters due to nutrients may result in costly measures basin-wide, e.g. obligatory tertiary treatment of waste-water, or stringent measures to further reduce nutrient inputs from agricultural sources. A first important step is to get a clear picture about the nutrient dependent relationships in the Black Sea ecosystem. The Memorandum of Understanding between the ICPDR and the ICPBS has already identified this as one of its key objectives.

In addition, the follow-up will need to fill data gaps regarding those water bodies, which were classified as being "possibly at risk" and those water bodies where no data is available. These water bodies will be reviewed using any additional information. The availability of the monitoring data and therefore certain knowledge on the status assessed by relevant quality parameters will further enable the preparation of the necessary measures to reach the WFD quality objectives by 2015.

Overall, the pressure/impact analysis has to be seen as a continuous process, which will result in the improvement of information on the status of water bodies and for river basin management.

5. Characterisation of groundwaters (Art. 5 and Annex II)

According to Article 2 of the EU Water Framework Directive (2000/60/EC) 'Groundwater' means all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. An 'Aquifer' means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater. Finally, a 'Body of groundwater' means a distinct volume of groundwater within an aquifer or aquifers.

Such groundwater bodies are subject to analyses and reviews as required under Article 5 and Annex II of the WFD. According to Annex II:

"Member States shall carry out an initial characterisation of all groundwater bodies to assess their uses and the degree to which they are at risk of failing to meet the objectives for each groundwater body under Article 4. Member States may group groundwater bodies together for the purposes of this initial characterisation. This analysis may employ existing hydrological, geological, pedological, land use, discharge, abstraction and other data but shall identify:

- *the location and boundaries of the groundwater body or bodies,*
- *the pressures to which the groundwater body or bodies are liable to be subject including: …*
  - *the general character of the overlying strata in the catchment area from which the groundwater body receives its recharge,*
  - *those groundwater bodies for which there are directly dependent surface water ecosystems or terrestrial ecosystems."*

According to paragraph 2.3 under Annex II for those bodies of groundwater which cross the boundary between two or more Member States further information on the impact of human activity on groundwaters shall be collected and maintained where relevant.

Groundwater in the DRB is of major importance and is subject to a variety of uses with the main focus on drinking water, industry, agriculture and spa and geothermal energy purposes.

A particular aspect reported by most countries is that shallow aquifers are at high risk of pollution in the short as well as long term as a result of uncontrolled use of fertilizers and chemicals as well as untreated sewage and leaching from contaminated soils. In some cases, groundwater sources cannot be used without prior treatment.

Concerning water utilization the following regional trends on water use can be noted. First, several countries have experienced a considerable decrease in water use as a result of the process of economic transformation. Second, most of the decline has been observed in the agricultural sector. Third, whereas in the past, agriculture was the largest water user, today water use in the industry sector has the largest share. Fourth, water withdrawal by the domestic sector has either remained unchanged or has experienced a slight increase as a result of increase in access to piped water supply[82].

Groundwater used as drinking water resource plays a major role in the DRB countries. This is reflected by the fact that up to 95 % of the public water supply of some countries is extracted from groundwater resources. Additionally, the proportion of the population which is self-supplied ranges from 11 % to 43 % in most of the countries[83]. This implies that many people use groundwater from their own private wells for drinking water purposes.

According to the reports of the WORLD BANK (2003a) and ALMÁSSY & BUZÁS (1999), the countries in the region depend mainly on groundwater sources to meet their drinking water needs, with the exception of Bulgaria, Czech Republic, Moldova and Romania. A conservative estimate is that about 60 % of the population in the DRB depends on groundwater sources. Therefore, the countries need to ensure that the groundwater is not overexploited and that the quality of groundwater is preserved.

Shared groundwater resources add another level of complexity. While many aquifers lie under the floodplains of large rivers, others do not correspond to surface watersheds, especially in the karstic regions of Slovenia, Croatia, and Serbia and Montenegro. In the karst, groundwater flow is rapid and it is highly vulnerable to pollution.

82 UNDP/GEF (1999b).
83 UNDP/GEF (2004).

All countries within the DRB haved stated that the water quality of many surface and groundwater bodies is not satisfactory[84].

The main reasons for the pollution of the water sources are:

- insufficient wastewater collection and treatment on municipal level,
- insufficient wastewater treatment at industrial enterprises,
- water pollution caused by intensive agriculture and livestock breeding,
- inappropriate waste disposal sites.

Existing and planned measures for pollution reduction concentrate on the most urgent objective to reduce the load from municipal wastewater. Although the intensity of agriculture has been declining since the early 1990ies (except for AT, DE) due to restructuring, future development might show an intensification of agricultural practices. Therefore, fertiliser and pesticide use will again be a threat to the groundwater resources in the DRB[85].

The information provided in the inventory on the implementation of the WFD performed in 2003 by the ICPDR/UNDP shows that in all of the responding eleven countries monitoring networks on water quantity and water quality exist.

The most important transboundary groundwater bodies

This report provides an overview of important transboundary groundwater bodies in the Danube River Basin.

They are defined as follows:

- important due to the size of the groundwater body which means an area > 4000 km^2 or
- important due to various criteria e.g. socio-economic importance, uses, impacts, pressures interaction with aquatic eco-system. The criteria need to be agreed bilaterally.

This means although there are other groundwater bodies with an area larger than 4000 km^2 and fully situated within one country of the DRB they are dealt with at the national level as they are not transboundary and not of basin wide importance.

The link between the content of the Roof Report and the national reports is given by the national codes of the groundwater bodies.

The importance of groundwater sources for associated ecosystems is dealt with in the national reports.

5.1. Location, boundaries and characterisation of groundwater bodies

Data on the location, boundaries and characterisation of important transboundary groundwater bodies were reported by eight countries. Three countries stated that they do not share any important transboundary groundwater body. For two countries data are currently not available.

Currently information on 11 important transboundary groundwater bodies with eight countries concerned (Germany, Austria, Slovak Republic, Hungary, Serbia and Montenegro, Bulgaria, Romania and Moldova) is available (see Map 15). One of the nominated important transboundary groundwater bodies is subject to trilateral meetings and agreements but is yet agreed on bilateral level.

Danube River Basin District – Important Transboundary Groundwater Bodies *MAP 15*

84 UNDP/GEF (1999b).
85 UNDP/GEF (2004).

5.1.1. Important transboundary groundwater bodies in the Danube River Basin District

Table 34 shows on the one hand where common borders between the countries in the DRBD are shared and along which important transboundary groundwater bodies have been nominated. On the other hand the number of nominated important transboundary groundwater bodies is presented. In some cases the harmonisation of designated transboundary groundwater bodies was difficult due to the different national methodologies that were used. In this case the neighbouring countries grouped the groundwater bodies into common groups (e.g. HU/SK). The boxes indicate the number of nominated important transboundary groundwater bodies of groups of groundwater bodies, if applicable. Furthermore it provides information on the bilateral agreements. The latter is indicated by the bold frame of the boxes. Empty white cells refer to countries where no information on important transboundary groundwater bodies is available. Different numbers of nominated bodies in one box or a missing bilateral agreement require further clarification.

Matrix of common borders and number of nominated important transboundary groundwater bodies or groups of groundwater bodies in the DRBD

TABLE 34

	AT	BA	BG	CS	CZ	DE	HR	HU	MD	RO	SI	SK	UA
AT					0 / 0	**1 / 1**		0 / 0			0 / 0	0 / 0	
BA				/ 0			/ 0						
BG				0 / 0						**2 / 2**			
CS			0 / 0				1 / 0	**1 / 1**		**1 / 1**			
CZ	0 / 0					0 / 0						0 / 0	
DE	**1 / 1**				0 / 0								
HR		0 /		0 / 1				0 / 0			0 / 0		
HU	0 / 0			**1 / 1**			0 / 0			**2 / 2**	0 / 0	**4 / 4**	0 /
MD										**1 / 1**			0 /
RO			**2 / 2**	**1 / 1**				**2 / 2**	**1 / 1**				0 /
SI	0 / 0						0 / 0	0 / 0					
SK	0 / 0				0 / 0			**4 / 4**					0 /
UA								/ 0	/ 0	/ 0			

	AT
DE	**1 / 1**

AT has nominated a transboundary GW-body at the border to DE.

BOLD FRAME: Transboundary GW-body reported as bilaterally agreed.

DE has nominated a transboundary GW-body at the border to AT.

Table 34 shows all the important transboundary groundwater bodies that have been nominated by the countries. Some of these have not yet been bilaterally agreed. Table 35 gives a list of the currently nominated and bilaterally agreed important transboundary groundwater bodies or groups of groundwater bodies with their key characteristics. The other groundwater bodies are dealt with in the national reports.

Nominated important transboundary groundwater bodies or groups of groundwater bodies in the DRBD *TABLE 35*

Code	Size [km²]	Aquifer Characterisation: Aquifer Type	Aquifer Characterisation: Confined	Main Use	Overlying strate [m]	Citeria for importance	Risk: Quality	Risk: Quantity
1-DE-AT	5,900	K	Yes	SPA, CAL	100-1000	Intensive use	No	No
2-BG-RO	26,903	F, K	Yes	DRW, AGR, IND	0-600	> 4000 km^2	No	No
3-RO-MD	21,626	P	Yes	DRW, AGR, IND	0-150	> 4000 km^2	No/Yes*	No
4-RO-BG	6,356	K, F-P	Yes	DRW, AGR, IND	0-10	> 4000 km^2	No/Yes*	No
5-RO-HU	6,553	P	Y/N*	DRW, IRR, IND	2-30	GW resource, DRW protection	No/Poss*	No/ Poss*
6-RO-HU	2,416	P	Y/N*	DRW, AGR, IRR	5-30	GW resource, DRW protection	No/Poss*	No
7-RO-CS-HU	28,608	P	Y/Y/N*	DRW, AGR, IND, IRR	0-125	> 4000 km^2, GW use, GW resource, DRW protection	No: RO/ Poss: CS/HU*	No: RO/ Yes CS/HU*
8-SK-HU	3,353	P	No	DRW, IRR, AGR, IND	2-5	GW resource, DRW protection	Poss/Yes*	No/Yes*
9-SK-HU	2,666	P	Yes	DRW,IRR	2-10	GW resource	Yes/Poss*	No
10-SK-HU	1,069	K,F	Y/N*	DRW, OTH	0-500	DRW protection, dependent ecosystem	No	No
11-SK-HU	3,601	F,K	Y/N*	DRW, SPA, CAL	0-2500	Thermal water resource	Poss	Poss

** not harmonised*

DESCRIPTION

Size	*Whole area of transboundary groundwater body covering all countries concerned in km^2*
Aquifer characterisation	*Aquifer Type: Predom. **P** = porous/ **K** = karst/ **F** = fissured.* *Multiple selection possible: Predominantly porous, karst, fissured and combinations are possible. Main type should be listed first.*
	*Confined: [**Yes** / **No**]*
Main use	***DRW** = drinking water / **AGR** = agriculture / **IRR** = irrigation / **IND** = Industry / **SPA** = balneology / **CAL** = caloric energy / **OTH** = other.* *Multiple selections possible.*
Overlying strata	*Indicates a range of thickness (minimum and maximum in metres)*
Criteria for importance	*If size < 4 000 km^2 criteria for importance of the GW body have to be named, they have to be bilaterally agreed upon.*
Risk	*Indicates whether a groundwater body is “at risk” of failing good status.* *[**Yes** = “at risk” / **No** = “not at risk” / **Poss** = “possibly at risk” due to insufficient data/knowledge]*

The detailed list can be found in Annex 12. Map 15 shows the nominated important transboundary groundwater bodies, if GIS information was available.

5.1.2. Summary description of the important transboundary groundwater bodies

The following summary provides relevant information on important transboundary groundwater bodies and the impacts of human activities on groundwaters. The national reports will contain more detailed information on the respective groundwater bodies and the detailed review of impact of human activity on groundwaters. The link between Roof Report and national reports is provided by the national codes of the groundwater bodies.

Criteria for delineation: The most frequent method applied for the delineation of the groundwater bodies is based on geological boundaries in combination with a hydrogeological approach. In some countries other criteria like importance for water supply, groundwater quality, water temperature or surface water catchment areas were additionally taken into account.

Geological overview: Limestone, sandstone, gravel and boulders and permeable fluvial sediments are the main components of the aquifers of the important transboundary groundwater bodies. Due to the different geological formations, the corresponding hydraulic conductivity of the aquifers, and the varying permeability of the overlying strata the aquifers are more or less protected. Geothermal groundwater bodies in limestone formations are also reported.

The majority of the reported aquifers are porous aquifers (6 out of 11). One groundwater body is stated as a karst aquifer whereas the rest is defined by a combination of karst, fissured and porous characteristics. Four groundwater bodies are confined and two bodies are not overlain by impervious or almost impervious formations. The remaining five groundwater bodies show both variations as they are situated in different horizons. The different kinds of the overlying strata reflect the geological formation of the aquifers. High permeable layers are also present as well as very impervious layers. While the geothermal groundwater bodies are covered by overlying strata up to 2500 m the aquifers in the fluvial sediments have almost no overlying strata. For 5 out of the 11 groundwater bodies the overlying strata ranges only from 0 to 60 metres.

Different horizons of groundwater bodies play a major role for the important transboundary groundwater bodies shared with Romania. The groundwater bodies are defined separately within different strata overlying each other in the vertical plane.

Groundwater use: For the majority of the important transboundary groundwater bodies main uses of groundwater are drinking water purposes followed by the use for agriculture and industry. Six bodies show the coexistent main uses of drinking water purposes and agriculture and five out of these six show them in combination with the main use for industry. However, in some of the groundwater bodies irrigation, spa and caloric energy are the main uses.

Pressures and impacts: Intensive agriculture and inadequate sewage and waste treatment are a major threat to the quality of the groundwaters. The effects of diffuse sources as well as point sources on the water quality are subject to further analysis in most of the countries. The mentioned pressures in combination with the high vulnerability of some aquifers require the development of groundwater protection strategies. Groundwater quantity is affected by groundwater abstraction for drinking water supply or industrial and agricultural purposes. The expected development of the future water demand has to be taken into account when identifying water exploitation and protection strategies.

Criteria for selection as ‘important’: The importance as groundwater resource and/or drinking water protection purposes are the most common criteria for the nomination (seven out of 11 bodies) of the groundwater bodies. The size-criterion which defines a transboundary groundwater body with an area > 4000 km^2 as important is the determining factor for four bodies. Intensive use, ecological criteria and geothermal potential were also listed as relevant criteria for defining the importance of a transboundary groundwater body.

5.2. Risk of failure to reach the environmental objectives (overview)

5.2.1. Approach for the risk of failure analysis on groundwater

The risk assessment is performed on national criteria both for quality and quantity. Hence the approaches are different. As a consequence the result of the risk assessment may differ for the national shares of an important transboundary groundwater body. The different methods for groundwater quality and groundwater quantity are summarized below.

The main components of the methodologies for assessing the risk of failure to achieve good chemical status are the available monitoring data on water quality, data on existing pressures and possible impacts, data on the overlying strata of the groundwater bodies and the corresponding vulnerability of the aquifer. Derived from the available data the evaluation can be carried out e.g. in a stepwise approach by using threshold values for each of the criteria and expert knowledge. However, the risk assessment methods are rather country specific and range from using combinations of the above mentioned data sets to focusing on interpreting water quality data.

The assessment of the risk of failure to achieve good quantitative status concentrates on the evaluation of changes in groundwater levels and estimating the available water resources taken into account information on groundwater abstraction. Being "at risk" is mainly defined by a threshold ratio of annual withdrawal rate and exploitable groundwater amounts. Hydrogeological and mathematical models are also used for assessing the risk by some countries.

5.2.2. Results of the risk analysis on groundwater

For many of the nominated important transboundary groundwater bodies the risk of failure assessment has not yet been harmonized. Four water bodies are definitely "not at risk" concerning the chemical status and this has been harmonized by the countries concerned. Seven out of the 11 important transboundary groundwater bodies are "possibly at risk" due to insufficient information.

The situation is more uniform for the risk assessment of the quantity status. Six groundwater bodies are "not at risk" of failing to meet the objectives. Five groundwater bodies are "possibly at risk".

For the reported important groundwater bodies no lower objectives were identified according to Article 4 and Annex II 2.4 and 2.5 with the exception of one country, which identified lower objectives for three groundwater bodies due to possible effects on associated terrestrial ecosystems and national protected areas.

5.3. Data gaps and uncertainties

Although some general information has been collected on transboundary aquifers e.g. in the frame of the UN/ECE Helsinki Convention Task Force on monitoring and assessment and at the EU level, the data collection for this report is the first time that data has ever been collected on groundwater in the Danube River Basin. Templates for reporting on groundwater bodies were prepared for a harmonised data collection.

Differences in the progress of WFD implementation in the Danubian countries have also become apparent in this part of the analysis. Countries used a broad spectrum of different approaches for the delineation of water bodies, their characterisation and for the assessment of the risk of failure to reach the good status. This entails the need for intensive bi- and multilateral co-operation to reach the harmonisation of data sets for transboundary groundwater bodies.

Data gaps and inconsistencies have become apparent in the underlying data resulting in uncertainties in the interpretation of the data. In addition, some countries have identified the need to expand the current monitoring networks to include monitoring stations along the national borders, where transboundary groundwater bodies are present. In some cases, countries have assessed the need to adapt their current monitoring programmes to collect better information on water quality and quantity.

At the moment no harmonised system for coding the different layers of groundwater bodies is available. The aspect of different groundwater horizons needs further discussion and clarification.

There is a need for further harmonisation of methods at the basin-wide level in particular as regards e.g. the procedure for the assessment of the risk of failure to reach the environmental objectives, both for groundwater quantity and quality. An analysis would be needed to check for differences in the national approaches. In addition, the interactions of groundwater with surface water or directly dependent ecosystems would need further attention.

5.4. Conclusions on groundwater

The main uses of the identified important transboundary groundwater bodies are drinking water supply, agriculture and industry. Some of these groundwater bodies show multiple uses mostly combining use for drinking water, agriculture and industrial use. Some groundwater bodies are also used for spas and caloric energy.

Intensive agriculture and inadequate waste and sewage treatment are a major threat to the quality of the groundwater. These pressures in combination with the high vulnerability of some aquifers require the development of groundwater protection strategies. Quantitative aspects of the groundwater resources are affected by intensive water management activities.

Regarding the quantitative status of these transboundary groundwater bodies none were estimated as being “at risk” of failing the environmental objectives. Six groundwater bodies are clearly “not at risk”. In three cases the data is insufficient and therefore additional monitoring is needed. Regarding the qualitative status none of the 11 identified important transboundary groundwater bodies is estimated unambiguously to be “at risk”. However, for seven of these bodies the assessment of the national shares varies in their results. For one water body the available data or knowledge is insufficient and it is therefore classified as “possibly at risk”.

The present report is based on an initial collection of available national information concerning important transboundary groundwater bodies. Further development may of course lead to changes of already defined important transboundary groundwater bodies. Improved knowledge may also lead to the definition of additional transboundary groundwater bodies.

Mario Romulic, Croatia

6. Inventories of protected areas (Art. 6 and Annex IV)

According to Article 6 WFD: *"Member States shall ensure the establishment of a register or registers of all areas lying within each river basin district which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water."*

Annex IV, 1. WFD indicates the different types of protected areas that shall be included:

(i) areas designated for the abstraction of water intended for human consumption under Article 7 WFD;
(ii) areas designated for the protection of economically significant aquatic species;
(iii) bodies of water designated as recreational waters, including areas designated as bathing waters under Bathing Water Directive (76/160/EEC);
(iv) nutrient-sensitive areas, including areas designated as vulnerable zones under the Nitrates Directive (91/676/EEC) and areas designated as sensitive areas under the Urban Wastewater Directive (91/271/EEC); and
(v) areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites designated under Directive 92/43/EEC and Directive 79/409/EEC.

The inventories referred to under (i) to (iv) have been set up nationally and are dealt with in the national reports. For (v) a basin-wide inventory has been set up for important water-related protected areas for species and habitats protection (for details see Chapter 6.1).

6.1. Inventory of protected areas for species and habitat protection

Annex IV, 1. (v) WFD refers to Natura 2000 sites that have been designated under the Habitats Directive (92/43/EEC) and Birds Directive (79/409/EEC). The designation process is based on the nomination of sites by the Member States. These are then subject to approval by the European Commission. The process of final designation of Natura 2000 sites has not yet been completed. Therefore, the selection of Natura 2000 sites is still preliminary.

Countries that are not EU Member States or EU Accession States are not part of the Natura 2000 process. Therefore, it was important to base this inventory on

– Natura 2000 sites for EU Member States (preliminary nomination), and
– Areas protected under international conventions.

International agreements include the Danube River Protection Convention, the UN/ECE Convention on transboundary water courses and international lakes, the Ramsar Convention on Wetlands, the World Heritage Convention as well as others. Provisions in some of these conventions are the basis for the designation of protected areas. Deteriorations or damage of these protected areas and their ecosystems can become subject to regulations of these conventions.

There are many classifications for protected areas; the globally important one for international nature conservation is the IUCN system with 6 categories; e.g. Category II defines the quality of the best-known type of protected area: the national park. The IUCN System also helps to compare areas protected under international law with those protected under national law by assigning them to an IUCN category.

Wetlands International maintains a comprehensive database, which describes all globally existing 1,300 Ramsar sites ("wetlands of international importance"). Through its "Man and Biosphere Programme" UNESCO has also set up a network of 391 reserves for the protection of wetlands including 59 sites, which are wetlands of international importance under the Ramsar Convention.

6.1.1. Approach for setting up the inventory

The ICPDR has compiled a draft inventory of the most important water-related protected areas for species and habitats (Status: October 2003). As mentioned above, the final selection of protected areas can only take place after the European Natura 2000 network has been completed. Therefore, countries were asked to inform at least about those protected areas of international importance, which shall be included in the future WFD inventory of protected areas, i.e. national parks, biosphere reserves, Ramsar sites and other important "water-related" national protected areas. Since the Natura 2000 nomination is a very delicate political procedure of great consequence, countries have been very reluctant in nominating pSCIs (proposed Sites of Community Interest according to the EU Habitats' Directive). Therefore, the present inventory provides only preliminary information in an ongoing process, but nonetheless forms an important basis for the elaboration of this inventory.

The draft inventory is based on sites officially nominated to ICPDR by the Danube countries and lists about 250 sites. Presumably, most of the protected areas in this inventory will be part of the coherent Natura 2000 network and will be included in the final inventory of protected areas.

6.1.2. Definition of important water-related protected areas on the basin-wide scale

The selection of protected areas for species and habitat protection for this inventory was based on the following criteria:

1. protected area of international ecological importance and integrity of the selected habitat representing a typical Danube basin ecosystem (river section – lake – fen/mire – spring or groundwater). Such areas can be small or large, even transboundary in nature (see **Annex 13**). Impounded rivers are excluded, even if there are important protected areas according to a national protection status and/or the presence of important bird communities (e.g. Danube at Iron Gate, Lower Inn).
2. size: area > 1,000 ha (only a few areas < 1,000 ha are listed, which are part of a complex of protected areas or if they have high ecological importance)
3. recognition as a protected area of basin-wide importance, e.g. areas protected under RAMSAR and World Heritage Convention, UNESCO/MAB and/or IUCN category II.

6.1.3. Establishment of the inventory with a core data set

The ICPDR has set up a core data set with connections to Natura 2000/Emerald and Ramsar inventories. The preliminary register includes the following information:

1. name of protected area (incl. code, in future with the EU-wide Natura 2000 code)
2. type of protected area
3. assignment to a sub-basin (Danube tributaries with catchment > 4,000 km^2)
4. area in ha
5. protected habitats and species (where available, or at least a short site description)
6. legal basis for designation of protected area (national, international).

Map 16 shows the more than 70 important water-related protected areas relevant on the basin-wide scale. These represent provisional national designations. The final designation depends on the approval by the European Commission.

It should be noted that many other wetlands in the DRBD deserve protection status. There are many examples of wetlands of international importance, which have not received an official status as a "Ramsar Sites" or as a protected area under European or national legislation. The Middle and Lower Drava-Mura wetlands (Slovenia, Croatia and Hungary) for example contain some nature reserves; some areas have been prepared for a nomination as a Natura 2000 area and a proposal for a transboundary Biosphere Reserve along the Drava and Mura rivers is under discussion.

Danube River Basin District – Important Water-related Protected Areas for Species and Habitat Protection MAP 16

6.2. Data gaps and uncertainties

The data sets have not yet been completed for all of the sites in the register. The timetable for the completion of the inventory of protected areas is based on the European Commission's progress in the establishment of the Natura 2000 network.

Additional data on wetlands can be found in national wetland inventories. Unfortunately, there are only few such inventories currently available in the DRB countries.

6.3. Conclusions on protected areas

80 % of the historical floodplain on the large rivers of the Danube River Basin has been lost during the last 150 years. Some of the remaining areas have either received protection status under different national or international legislation while others still remain unprotected. Many of the Danube basin wetlands are under pressure through navigation, hydropower and agriculture as well as from new infrastructure projects.

The inventory of protected areas can give geographical, technical and legal information on the situation, character and relevance of each protected area in the Danube River Basin. This is important basic information e.g. for preparing the River Basin Management Plan and its Programme of Measures.

Wetlands in the Danube River Basin play an important role in hydrological processes, in particular in flood prevention, recharging of groundwater as well as for habitat and species diversity. The DRB still contains a large variety of important wetlands.

The development of an inventory of protected areas for species and habitat protection (WFD Art. 6, Annex IV) is well under way. Many of them have already been designated as protected areas under EU law and under global conventions.The timetable for completion of the inventory is based on the European Commission's progress in the establishment of the Natura 2000 network.

At present, there are no protected areas along the Danube for the conservation of economically important species. Still, there are some areas along the Danube, which should be explored with regard to their potential as protected areas under the nature protection legislation.

There is also a need to elaborate an action plan for the sustainable use of the sturgeon, and for restoration of fish paths on the Danube and its tributaries. There are some international initiatives aiming at the protection of sturgeons with e.g. Romania, Russia, Georgia and Turkey. In 2001, the Black Sea Sturgeons Management Authority Group was established and a draft of a Regional Strategy for the conservation and sustainable management of sturgeon populations of the Black Sea and the Danube River was elaborated in accordance with CITES.

7. Economic analysis (Art. 5 and Annex III)

The Water Framework Directive (WFD) is one of the first environmental policy EC Directives, which explicitly integrates economic considerations into the process of achieving its objectives. According to the requirements stipulated in Article 5 and Annex III of the Directive, an economic analysis of water uses has to be carried out by 2004 on a river basin district scale. **All data refers to the year 2000 and to the part of the countries lying in the Danube River Basin if no other reference is given.**

7.1. Economic analysis of water uses (overview)

This section is divided into three distinct parts complementary to the requirements for the economic analysis due 2004:

– assessing the economic importance of water uses;
– projecting trends in key economic indicators and drivers up to 2015; and
– assessing current levels of the recovery of the costs of water services.

Severe difficulties appeared in the data gathering process as data collected by national statistical institutions are very rarely collected at the required scale, i.e. on a river basin district. Two different options of normalisation have been used for re-calculating data presenting the national situation on the Danube-level:

– using the population equivalent; i.e. the share of population living in the DRB in each country; or
– using the territorial/geographical equivalent; i.e. the share of the area being within the DRB.

The former option is used for the normalisation process of Table 36, Table 37 and Table 38 and the later one for Table 40 and Table 41, only in cases when countries did not deliver data on the required scale.

7.1.1. Assessing the economic importance of water uses

According to Article 5 and Annex III of the WFD, an economic analysis of water uses has to be carried out with the aim of assessing the importance of water use for the economy and assessing the socio-economic development of the river basin.

Table 36 presents basic socio-economic data covering all eighteen countries belonging to the Danube River Basin. As discussed above, the GDP and population figures presented are normalised using the population equivalent. In this case, a considerable difference in the GDP per capita figures can be recorded that shows a significant disparity in wealth. This big gap between the countries is reduced when GDP per capita figures are expressed in Purchase Power Parities (PPP).

General socio-economic indicators (data source: Competent authorities in the DRB unless marked otherwise) *TABLE 36*

	GDP (in bill national currency)	GDP (in million EUR)	Total population (million)	GDP per capita (in EUR per capita)	GDP per capita (in PPP EUR per capita)
Albania*	na	14	<0.01	1,390	na
Austria	2,732	198,611	7.7	25,795	25,521
Bosnia i Herzegovina*	na	3,493	2.9	1,204	na
Bulgaria	14	7,266	3.5	2,076	8,010
Croatia	99	12,942	3.1	4,175	7,460
Czech Republic****	520	15,247	2.8	5,461	13,226
Germany	557	285,075	9.4	30,321	29,215
Hungary	13,172	50,663	10.1	5,016	11,243
Italy**	780	403	0.02	20,225	22,457
Macedonia***	1	19	<0.01	1,921	6,020
Moldova*	na	394	1.1	358	na
Poland**	1	187	0.04	4,672	9,230
Romania	776,445	38,908	21.7	1,795	5,264
Serbia and Montenegro*****	983	8,628	9.0	959	na
Slovak Republic	898	21,077	5.2	4,059	11,157
Slovenia	3,523	17,182	1.7	9,892	14,696
Switzerland**	1	739	0.02	37,258	na
Ukraine***	9	1,840	2.7	686	3,706

* *2002; WORLD BANK (2003b).*
** *EUROSTAT (2004b).*
*** *2000; VIENNA INSTITUTE FOR INTERNATIONAL ECONOMIC STUDIES (2003).*
**** *2001*
***** *According to the 2002 census the population in Serbia and Montenegro without the provinces of Kosovo and Metohia is 7,668,000 inhabitants. On the territory of Kosovo and Metohia the last census was in 1981. On the basis of this census and OEBS data the estimated population of Kosovo and Metohia in the Danube river basin today is about 1,300,000 inhabitants.*

Based on the size of the GDP per capita figures, the eighteen Danube countries can be divided into three clusters. The first cluster (GDP per capita exceeding 20,000 EUR) composes of the three EU Member States Austria, Germany, Italy and in addition Switzerland; the second one of countries which joined the EU in May 2004; i.e. Czech Republic, Hungary, Poland, Slovak Republic and Slovenia, and in addition Croatia (GDP per capita between 2,000 EUR and 20,000 EUR). The remaining countries, i.e. the two EU Accession countries Bulgaria and Romania, as well as Albania, Bosnia i Herzegovina, Macedonia, Moldova, Serbia and Montenegro, and Ukraine constitute the third cluster based on GDP per capita figures (GDP per capita below 2,000 EUR). The composition of these clusters, in particular concerning the second and third cluster, is not so straightforward when GDP per capita figures expressed in PPP are considered.

Data and further information concerning the socio-economic situation in the five countries which are not contracting parties of the ICPDR have not been collected since the national share of population and/or the share of the geographical area belonging to the DRB can be neglected (i.e. less than 0.5 % of the national population lives in the Danube basin district in each country, while the geographical area which is part of the Danube district is less than 0.5 % of the total national area with the exception of Switzerland where this share is around 4.3 %). Furthermore, all these areas are lying in the country's mountainous regions without any significant economic development. The situation in these five countries is therefore no more considered in the following tables and discussions.

7.1.1.1. Characteristics of water services

Table 37 provides basic information regarding water services and illustrates the differences in terms of the connection rates of the population.

Water production, wastewater services and connection rates* (data source: Competent authorities in the DRB unless marked otherwise) *TABLE 37*

	Total water production (million m^3)	Water supply production Total supply (million m^3)	Water supply production Supply to households (million m^3)	Total collected wastewater (million m^3)	Population connected to public water supply (in %)	Population connected to public sewerage system (in %)	Population connected to wastewater treatment plant (in %)
Austria	2,066[a]	721[b]	na	1,024[c]	86.0[c]	87.0[c]	87.0[c]
Bosnia i Herzegovina	na	na	na	na	na	na	na
Bulgaria	4,174	3,760	168	410	99.0	67.9	42.9
Croatia	1,170	291	184	181	68.0	40.0	24.1[e]
Czech Republic	319	182	81[c]	1373	87.1	74.8	69.9
Germany[d]	3,770	704	459	1,404	98.4	93.3	92.7
Hungary	18,878	817	388	530	92.0	51.0	30.0
Moldova	na	na	na	na	na	na	na
Romania	7,689	2,410	1,642	1,229	62.6	48.0	27.0
Serbia and Montenegro[f]	2,568	1,233	555	683	69[g]	33[g]	14
Slovak Republic	405	293	175	487	82.9	54.7	50.0
Slovenia	na	669	109	na	85	53	30
Ukraine	na	na	na	na	na	na	na

* *The data for Austria, Romania, Slovak Republic and Slovenia have been reported on the national level. Only data of the columns one to four (total water production, water supply production – total and supply to households – and total wastewater collected) have been normalised based on population equivalent. The connection rates for these three countries are national figures.*

a 1993/94
b 2003
c 2002
d 2001
e 2004
f 1997
g 1991

The figures are showing relatively high rates for the connection of the population to public water supply. The rates are lower for the connection on to the public sewerage system and to wastewater treatment plant. The latter rate is low in Bulgaria, Hungary and Romania and Croatia.

Table 38 lists the total number of wastewater treatment plants distinguishing between mechanical, biological and advanced treatment plants. This table shows big differences considering that the majority of treatment plants (total capacity) in Austria and Germany are of advanced technology as compared to the situation in the new EU Member States and Bulgaria, Croatia, and Romania where biological treatment plants are predominant.

Wastewater treatment plants* (data source: Competent authorities in the DRB unless marked otherwise) *TABLE 38*

	Wastewater treatment plants		Mechanical treatment plants		Biological treatment plants		Advanced treatment plants	
	Total number (number)	Total capacity (1000 p.e.)	Total number (number)	Total capacity (1000 p.e.)	Total number (number)	Total capacity (1000 p.e.)	Total number (number)	Total capacity (1000 p.e.)
Austria[a]	596	17,405	0	0	83	1,298	513	16,106
Bosnia i Herzegovina	Na	na	na	Na	na	na	na	na
Bulgaria	18	2,842	6	156	11	2,627	1	59
Croatia[d]	30	2,180	14	1,300	16	881	0	0
Czech Republic	339	5,249	4	11	119	1,858	216	3,373
Germany[b]	795	18,607	0	0	479	5,868	316	12,738
Hungary	515	12,184	23	2,300	356	6,989	136	2,894
Moldova	Na	na	na	Na	na	na	na	Na
Romania[c]	328	9,552	99	2,023	224	6,580	6	949
Serbia and Montenegro	25	1,274	0	0	25	1,274	0	0
Slovak Republic[c]	327	na	21	na	291	na	15	43
Slovenia	100	1,199	6	321	80	419	14	458
Ukraine	Na	na	na	Na	na	na	na	Na

* *Total capacity data are only available in 1000m³/ day in Hungary and Czech Republic. The conversion in population equivalent (p.e.) has been done according to the international standard by applying the load of biologically degradable organic waste which has the five days oxygen demand (BOD5) of 60 grams and based on experience that the contamination of the communal wastewater is about 350 g/m³ leading to a factor of 1m³/day equals to 5.83 p.e. The data for Austria, Romania, Slovak Republic and Slovenia have been reported on the national level. All national data have been normalised based on population equivalent.*

a 2003
b 2001
c 2002
d 2004

Table 37 and Table 38 illustrate the challenges the middle and downstream Danube countries are currently facing. These countries have to make further investments into pollution reduction and environmental protection measures as required under the EC directives.

A more detailed analysis of the population connected to wastewater treatment plants in several of the Danube countries is shown in Table 39. The data show the situation on the national level distinguishing between the shares of the population connected to primary, secondary and tertiary wastewater treatment facilities as well as the total connection rate. The data show that the majority of the population in Austria and Germany were connected to tertiary wastewater treatment facilities. The wastewater of the majority of the population connected to wastewater treatment plants in the Bulgaria, Czech Republic and Hungary are treated in plants applying secondary treatment technology and it was equally distributed between primary and secondary treatment in Slovenia.

Population connected to wastewater treatment plants – data refers to whole country; data source: EUROSTAT (2004a) *TABLE 39*

	Total (in %)	Primary treatment (in %)	Secondary treatment (in %)	Tertiary treatment (in %)
Austria	86[a]	1[b]	17[b]	64[b]
Bosnia i Herzegovina	na	na	na	na
Bulgaria	38[a]	1[a]	37[a]	0[c]
Croatia	na	na	na	na
Czech Republic	68[a]	na	62[d]	na
Germany	91[b]	1[b]	6[b]	83[b]
Hungary	32[c]	2[c]	24[c]	6[c]
Moldova	na	na	na	na
Romania	na	na	na	na
Serbia and Montenegro	na	na	na	na
Slovak Republic	49[b]	na	na	na
Slovenia	30[d]	15[d]	15[d]	0[d]
Ukraine	na	na	na	na

a 2001
b 1998
c 2000
d 1999

Production of main economic sectors* (data source: Competent authorities in the DRB unless marked otherwise) *TABLE 40*

	Agriculture		Industry		Electricity Generation	
	Gross value added (in million national currency)	Share of GDP (in %)	Gross value added (in million national currency)	Share of GDP (in %)	Gross value added (in million national currency)	Share of GDP (in %)
Austria[a]	4,502	2.1	60,151	28.7	4,302	2.1
Bosnia i Herzegovina	na	na	na	na	na	na
Bulgaria	1,346	10.7	3,478	27.6	na	na
Croatia	9,600	9.7	19,983	20.0	706	0.7
Czech Republic[b]	20,822	4	192,643	37	18,253	3.5
Germany	3,268	1.2	80,643	28.9	na	na
Hungary	490,900	3.7	3,196,700	24.3	412,400	3.1
Moldova	na	na	na	na	na	na
Romania	86,967,167	11.1	214,431,081	27.3	22,366,461	2.8
Serbia and Montenegro	142,000	14.5	284,000	28.3	45,000	4.5
Slovak Republic	35,643	3.6	230,816	25	32,558	3.5
Slovenia	102,684	2.9	1,084,840	30.3	100,138	2.8
Ukraine	na	na	na	na	na	na

** The data for AT, RO, SK and SI have been reported on the national level. All national data referring to gross value added have been normalised based on territorial/geographical equivalent. However, the data presenting the share of the individual sector to GDP have not been changed; i.e. they are national shares.*
a 2002
b 2001

7.1.1.2. Characteristics of water uses

Differences in the economic structure of the Danube countries are shown in Table 40. The main differences arise from the varied importance of the agricultural sector. While in Bulgaria, Croatia and Romania around 10 percent of GDP is generated from agriculture, this share is between 1 and 3.7 percent in the remaining countries. The share of industry and electricity generation is more consistent between the countries which reported these data.

Table 41 on the generation of electricity in the Danube countries shows big differences in the mix of technologies used. Austria has by far the largest percentage of generated electricity based on hydropower (almost two thirds of total electricity generated). The share of hydropower is also relatively high in Croatia, Romania and Serbia and Montenegro (between 27 and 33 %) and more modest in Germany and the Slovak Republic. The contribution of hydropower is almost negligible in Czech Republic and Hungary. While the Czech Republic, Croatia, Hungary, Romania, and Serbia and Montenegro are relying heavily on conventional thermal power, Bulgaria and the Slovak Republic are reliant on nuclear power (the share of this technology is more than 50 % in the part of the country situated in the DRB).

Basic information relating to inland navigation in the Danube countries is shown in Table 42. These data must be observed in the context of the political instability of the western Balkan region in the 1990s. As a consequence of the recent conflict and instability in the West Balkan region the inland navigation between upstream and downstream countries was impaired. It can be further recorded that inland navigation is relevant only for some Danube countries as there is no commercial inland navigation in the countries on the fringe of the Danube River Basin.

Electricity generation in the DRB: total and electricity generation devided by origin*

(data refers to territory in DRB; data source: Competent authorities in the DRB unless marked otherwise) *TABLE 41*

			Electricity generated by origin		
	Total electricity capacity (MW)	Total electricity generated (1000 GWh)	Hydropower (in %)	Conventional thermal power (in %)	Nuclear power (in %)
Austria[a]	17,106	60	67.0	32.5	0.0
Bosnia i Herzegovina	na	na	na	na	na
Bulgaria	na	22	6.8	10.9	82.3
Croatia	1,129	3	33.0	67.0	0.0
Czech Republic[a]	4,000	11	5.5	53.3	41.3
Germany	na	na	na	na	na
Hungary	7,222	35	0.5	57.5	40.7
Moldova	na	na	na	na	na
Romania	21,401	51	28.5	61.0	10.5
Serbia and Montenegro	8,816	33	33	67	0.0
Slovak Republic	8,194	31	18.6	18.6	62.8
Slovenia	2,336	12	28.1	36.9	34.9
Ukraine	na	na	na	na	na

** The first two columns (total electricity capacity and total electricity generated) have been normalised for Austria, ,Romania, Slovak Republic and Slovenia using the geographical equivalent. However no normalisation procedure has been done for the columns showing the share of different generation technologies.*
a 2002

Inland navigation (data source: Competent authorities in the DRB unless marked otherwise) *TABLE 42*

	Quantity (1000 tons)	Number of harbours (number)
Austria	10,976	4
Bosnia i Herzegovina	na	na
Bulgaria	1,846	9
Croatia	1,045	4
Czech Republic	-	-
Germany[a]	4,279	4
Hungary	2,420	28[b]
Moldova	na	na
Romania	19,959	17
Serbia and Montenegro	3,796	na
Slovak Republic	1,607	na
Slovenia	none	none
Ukraine	na	na

a 2003
b 2001

Other water uses have not been considered as economically significant on the international, transboundary level currently. However, more detailed analyses of water uses, which are economically significant on the national level, can be found in the national reports.

7.1.2. Projecting trends in key economic indicators and drivers up to 2015

Assessment of key economic variables is significant for developing baseline scenario, particularly regarding the influence of these variables on the pressures and consequently the water status up to the year 2015.

As a result, the future trends in water supply and demand are of central importance for undertaking baseline scenarios. The anticipated growth rates of the main economic sector must also be taken into consideration.

The analysis shows that quantitative forecasts regarding future trends in total water supply and demand are not available in the majority of the Danube countries. Furthermore, qualitative predictions are demonstrating that there is no general trend discernible. Some differences in the trend forecasts can be recorded between Romania and the Czech Republic. A small increase in water supply and water demand is predicted in Romania, the opposite is expected in the latter country. More detailed analyses of the future development of these economic variables can be found in national reports (Part B). These analyses highlights the causes, rationales and underlying assumptions, such as changes in the connection rates, efficiency improvements in the water supply systems by reducing leakage rates, for these forecasts.

Similar problems with availability of data and information are encountered in the analysis of the expected growth rates for main economic sectors (Table 44). The forecasts of the overall growth rate as well as the rates for the different economic sectors illustrate the different economic situation of the countries. The growth rates of countries with the highest GDP per capita figures are smaller than for those with the lower GDP per capita figures. The former countries are expecting growth rates in the range of 2 percent per annum as compared with rates between 4 and around 9 percent.

National trends in total water supply and demand up to 2015 (data source: Competent authorities in the DRB unless marked otherwise) *TABLE 43*

	Trends in	
	Total water supply (in percent)	Total water demand (in percent)
Austria	constant	slightly fluctuating
Bosnia i Herzegovina	na	na
Bulgaria	15.3 (2010)	na
Croatia	slightly increasing	na
Czech Republic	79.6 % (base year 1996 = 100 %); i.e. decreasing	70 % (base year 1996 = 100 %);
i.e. decreasing		
Germany	constant	slightly decreasing
Hungary	has not been assessed	has not been assessed
Moldova	na	na
Romania	small increase	small increase
Serbia and Montenegro	na	na
Slovak Republic	110 (base year 2000 = 100)	128 (base year 2000 = 100)
Slovenia	na	na
Ukraine	na	na

National economic growth rates for main economic sectors (up to 2015)
(data source: Competent authorities in the DRB unless marked otherwise) *TABLE 44*

	Overall growth rate	Growth rates for the main economic sector		
	(in %)	agriculture (in %)	industry (in %)	electricity (in %)
Austria	2	na	na	na
Bosnia i Herzegovina	na	na	na	na
Bulgaria	until 2007: growth rate is expected to be between 5.1 and 5.5 % p.a.			
Croatia	5	< 5	5	4.5
Czech Republic	2.5	1.6	2.3[1]	
Germany	2	0.5	1.7	1
Hungary	4	na	na	na
Moldova	na	na	na	na
Romania	until 2008: an increase of around 5 % p.a. (GDP)			
Serbia and Montenegro	4	2.5	4.5	3
Slovak Republic	6	na	na	na
Slovenia	na	na	na	na
Ukraine	na	na	na	na

1 including electricity

7.1.3. Assessing current levels of recovery of the costs of water services

The appraisal of costs recovery levels of water services is in accordance with Article 9 of the WFD. As a result of differing economic, financial and institutional conditions in the Danube countries, the pricing systems also vary considerably among the countries. In addition, Danube basin wide relevance for cost recovery does not exist since often local communities have the responsibility for setting the price and the degree of cost recovery. The application of economic and environmental principles into price setting and the degree of application of cost recovery vary from one to another Danube country according to the specific legal and socioeconomic conditions. Furthermore, a number of influencing factors are to be considered when comparing water prices, costs, or level of cost recovery at the international level. The issue of cost recovery is therefore primarily an issue of national importance and will be dealt within Part B of the WFD roof report 2004. However, every effort should be undertaken in the future for compiling cost recovery levels for the Danube River Basin District.

7.1.4. Preparing for the cost-effectiveness analysis

The cost-effectiveness analysis will not be dealt with in the Part A of the WFD roof report. The WATECO guidance document recommends making preparatory steps in 2004. However, it is not a real requirement for reporting in 2004 and is not analysed on the Danube-wide level. Cost-effectiveness analysis is a future task and will be discussed in national reports (Part B).

7.2. Data gaps and uncertainties

Several gaps and uncertainties in the process of data gathering have been encountered. In general, there are large gaps in the availability of economic data in most of the DRB countries. Countries, such as Bosnia i Herzegovina, and Serbia and Montenegro, are currently in the process of establishing the necessary institutions for data collection and verification, so that economic data should become available in the future. Data from Moldova and Ukraine were not available. Additional efforts need to be undertaken in the cooperation with these countries. Data from all countries would be needed as a prerequisite for a complete economic analysis of the Danube River Basin District. For the trend analysis key economic variables are missing.

The accuracy of the data and variables is not always satisfactory due to several reasons. The data often is only available at the national level, therefore different levels of aggregation need to be used. In addition, the data is usually collected based on administrative units and not on the basis of river basins or sub-basins. This means that the data needs to be normalised. However, relevant information can get lost in the normalisation process in particular where information of high significance is in small basins as this information may not be significant on the national level.

7.3. Conclusions on the economic analysis of water uses

Following the publication of the national reports (Part B of the WFD Report 2004) an investigation of the national levels of recovery of the costs of water services should be carried out aiming to get a rather complete picture of these levels on the Danube River Basin District. This national information will be a useful input for the future analysis as required under the WFD, such as the cost-effectiveness analysis, and on assessing the economic/financial impacts of proposed programmes of measures.

8. Public information and consultation

The active involvement of the public is a core principle in sustainable water management. This basic fact was already recognised when the Danube River Protection Convention (DRPC) was signed on 29 June 1994 in Sofia, Bulgaria. The DRPC has already foreseen the involvement of the organised public in the framework of its implementation. To date, 10 organisations have taken this opportunity and have become observers to the ICPDR. These organisations include NGOs, organisations representing private industry, and intergovernmental organisations.

Organisations with observer status in the ICPDR

- Black Sea Commission (BSC)
- Danube Environmental Forum (DEF)
- Danube Commission
- Global Water Partnership (GWP)
- International Association for Danube Research (IAD)
- International Association of Water Supply Companies in the Danube River Catchment Area (IAWD)
- International Hydrological Programme of the UNESCO (IHP)
- RAMSAR Convention on Wetlands
- Regional Environmental Center for Central and Eastern Europe (REC)
- World Wide Fund for Nature – Danube-Carpathian Programme (WWF-DCP)

This cooperation, which grants observers the right to participate at ICPDR decision-making meetings and Expert Group meetings, has proven to be successful in ensuring that different aspects and approaches could influence and shape the current water management in the Danube River Basin.

This approach of involving the public has even been enhanced by the requirements of the EU Water Framework Directive (WFD). Despite the fact that these requirements lay within the responsibility of the EU Members States, the ICPDR – being the co-ordination platform for the implementation of the WFD on issues of basin-wide or multilateral concern - has taken this new challenge as a basis to reviewing its ongoing practice. The ICPDR started an active process towards defining a "Danube River Basin Strategy for Public Participation in River Basin Management Planning 2003-2009" and consequently developing an "ICPDR Operational Plan".

8.1. Strategy for public participation in river basin management 2003-2009

Based on Article 14 of the WFD, the objectives of this strategy are:

- To ensure public participation in the implementation of the WFD, especially concerning the development of the Danube River Basin Management Plan.
- To facilitate the establishment of effective structures and mechanisms for public participation that will continue operating beyond the first cycle of river basin management planning.
- To provide guidance to national governments on how to comply with their obligations under the WFD by providing practical support and guidance in addressing public participation.
- To inform key stakeholders about the structures for public participation and public involvement at the various levels.

The basic principles of the "Danube River Basin Strategy for Public Participation in River Basin Management Planning 2003-2009" were approved in June 2003.

One of the crucial elements of the "Danube River Basin Strategy for Public Participation in River Basin Management Planning 2003-2009" was the recognition of having public participation organised at various levels to assure meaningful inputs. Discussing the Danube River Basin, these levels are:

- international or "roof" level (Danube River Basin District)
- national level (the key "implementing" and management level)
- sub-basin level (transboundary or/and national)
- local level.

All four levels are required to assure the success of any activity at any single level. The "roof" level provides the framework for co-ordination throughout the river basin. There are differences between the levels depending on stakeholdership, types of activities, timetable of these activities, management and co-ordination needs.

8.2. ICPDR Operational Plan

As a next step, the activities at ICPDR level were developed in detail and summarised in the “ICPDR Operational Plan”. This plan as an overall framework and in particular the activities for 2004 were adopted in December 2003.

The Operational Plan provides a description of the activities at the roof level, including a timetable and a workplan. The Operational Plan is seen as a planning tool, which is regularly adjusted to the needs of the ICPDR.

For the first time ever, 13 countries of one large river basin embarked on the process in developing a coherent approach and to jointly develop tools for the public involvement.

The public participation activities of the ICPDR in 2004 are aimed at

– raising awareness about water management in general and about the Danube River Basin in particular,
– informing the public (including stakeholders and NGOs) about the WFD and the possibilities to participate in the process of its implementation;
– ensuring that organisational mechanisms for public participation are in place (in line with the national processes);
– involving the appropriate stakeholder groups;
– developing a network of public participation experts throughout the Danube River Basin,
– developing an effective media network to ensure the reach of a wider public.

8.2.1. Activities in 2004

8.2.1.1. Joining forces – a Network of Public Participation Focal Points

In order to secure that public participation activities are carried out in a concerted way throughout all Danube countries, the ICPDR developed a network of national public participation focal points. These focal points ensure that activities carried out on the ICPDR level are in line with and complementing the national public participation efforts.

8.2.1.2. Confidence building – WFD brochure and WFD on the internet

So far, little information on the implementation of the WFD in the Danube River Basin District is available. It is therefore of major importance to provide information about the WFD, its goals and the possibilities of getting involved in its implementation.

One of the tools is the WFD brochure for the general public, available in English as well as in the national languages, all following the same layout. The WFD brochure includes basic facts about the WFD and its implementation in the Danube River Basin, about the role of ICPDR and national governments as well as the provisions for public information and consultation. In addition, each “national brochure” includes information of national importance.

The second important tool is the ICPDR Information System (www.icpdr.org) with a special section on WFD implementation, providing access to all relevant documents. Links are available from the ICPDR Info System to the homepages of the respective Danube Basin Countries – and vice versa. This network of links provides easy access to information on the different levels.

8.2.1.3. Reaching the public – developing a media network

Transparent and direct information through dialogue is crucial for a successful cooperation. Updated information to the interested public about ongoing activities in the frame of the implementation of the WFD should raise awareness and stimulate people and organisations to take on responsibility in the process of river basin management planning.

With the assistance of the Danube Environmental Forum (DEF), the ICPDR established a network of journalists (print media, electronic media, TV) interested in water management and serving as multiplicator for WFD related issues throughout the basin.

8.2.1.4. Knowing your partners – a stakeholder analysis

In December 2003 a stakeholder analysis was carried out. Based on the findings, a decision on stakeholder involvement will be made to guarantee the successful implementation of the WFD.

8.2.2. Celebrating the Danube River Basin – Danube Day

It is important that water management is not only discussed by a circle of experts, but that the public is linked to the ongoing political discussions/decisions, especially if their outcomes affect people's daily life. Therefore, the ICPDR initiated the basin-wide celebration of Danube Day providing a platform for the inhabitants to demonstrate that they care for their river and that they take responsibility for its protection for future generations.

Celebrated for the first time on 29 June 2004 – at the 10th Anniversary of the signing of the Danube River Protection Convention – the Danube Day should be institutionalised and become a stable element in the schedules of ministries, NGOs and all other organisations caring and working for the Danube River Basin.

The general character of the Danube Day activities is light-hearted and celebratory and the Danube Day aims to:

– increase the awareness with citizens and stakeholders alike of sharing one river basin and depending on each other, stimulating "Danube solidarity" ("everybody lives downstream");
– provide a platform for communication with the public on the Danube River Basin and ongoing water management processes, as required by the WFD;
– inspire and motivate actions to maintain and improve the status of the water related ecosystems in the Danube River Basin.;
– promote the ICPDR and its contracting parties, and improve transparency and acceptance of integrated river basin management.

DANUBE DAY

Danube Day Logo:
Symbol of water movement and the connection of people.

Over 100 events and celebrations were held throughout the Danube river basin – all 13 Danube river countries contributed greatly to make Danube Day 2004 a success.

The International School Competition "Danube Art Master", also carried out in all 13 Danube River Basin Countries, reported more than 1000 contributions – the young generation was truly inspired by the Danube.

A Danube Day website was launched presenting information on activities in all the different Danube River Basin countries organised by different partners and linked to national websites providing information on Danube Day activities (**http://www.danubeday.org**).

Looking back on this very successful first Danube Day, there is a strong hope that the annual celebration of Danube Day will further stimulate "Danube solidarity" and become a vital link between the people sharing the river basin.

9. Key Conclusions and outlook

Some sections of the Danube River are still rather untouched ecosystems and, despite possible pollution problems, constitute a unique heritage to be preserved. In addition, the Danube River Basin still hosts many species and habitats of outstanding ecological value and unique importance for biodiversity. In particular the Danube Delta is of global significance. The future management of the river basin needs to ensure that the focus of measures is not only the restoration of affected water bodies but equally important is the preservation of those few areas that are still ecologically intact.

The current analysis shows that in the last two decades, considerable improvements in environmental conditions in the Danube basin have been made. Where investments, e.g. in wastewater treatment, have taken place, the improvement of the water quality is visible. However, a major part of pollution reduction can be attributed to the decline of industries and agricultural activities in the middle and lower parts of the basin since 1989. In these areas investments for a sustainable reduction of pollution levels has just started and will have to continue for another 10 to 20 years.

In surface waters, the loads of organic pollution are still unacceptably high in most of the Danube tributaries and in some parts of the Danube River. The considerable discharge of untreated or insufficiently treated wastewater from municipal, industrial and agricultural point sources is wide-spread, in particular in the middle and lower part of the basin. The indicators for impact from organic pollution show that the water quality is significantly affected, the major cause being insufficient treatment of waste-water from municipalities.

A significant reduction potential for organic pollution exists through the application of best available techniques for wastewater treatment facilities. Considerable efforts, in particular as regards financial investment will be necessary to reduce organic pollution to acceptable levels in some parts of the middle and lower basin. Financial programmes and initiatives from the EU and other international donors are already set up. The preparation of concrete projects and measures needs to be pursued without delay even well before 2009 since the successful resolution of this basic problem will be the first essential step to implement the Water Framework Directive and other relevant EU legislation. It will remain to be seen whether these load reductions will be sufficient to achieve the “good ecological status”, which are linked to organic pressures.

Overall, nutrient loads into the Danube basin have significantly decreased over the past 20 years, however, being still well above the levels of 1955. In the future this improvement in reduction of nutrient pollution may be lost, because of an increase in diffuse pollution from agriculture. Impacts from nutrients can mainly be seen in the receiving coastal waters of the Black Sea but also in many lakes and groundwater bodies throughout the basin. While in rivers nutrients generally cause fewer problems due to turbulent flow conditions, some slow flowing river stretches such as the middle Danube, impounded river sections, and lakes show effects of eutrophication.

In order to ensure the further reduction or at least stand-still of nutrient loads, the expected increase of diffuse sources needs to be compensated by the reduction of point source inputs. In addition to the investment strategies already described for dealing with organic pollution, the introduction of phosphate-free detergents throughout the Danube basin appears to be a cost-effective and necessary measure. Introducing such an instrument in a mandatory way could be undertaken at the EU level, however, options of voluntary instruments are already being explored in the context of the ICPDR.

As mentioned above, economic development in the middle and lower parts of the Danube region will inevitably increase diffuse nutrient inputs. It should be ensured that best environmental and agricultural practices are being developed and applied in order to create a sustainable agriculture in the long term. In this respect, there is still room for reduction of nutrient loads in the upper part of the Danube basin. The potential of the reformed EU Common Agricultural Policy should be fully explored in this regard.

Hundreds of hazardous substances are being used and released into the Danube river basin. Pollution from hazardous substances is significant although the full extent cannot be evaluated to date. There are only few data available for some hazardous substances such as heavy metals and pesticides, which indicate the transboundary scale of the problem. Cadmium and lead can be considered as the most serious heavy metals exceeding the target values considerably in many locations on the lower Danube. Also, pesticides show alarming concentrations in some tributaries and in the lower Danube. It will be necessary to improve the data base on pressures and impacts from hazardous substances, e.g. through further development of the existing inventories such as the European Pollutant Emission Register (EPER) to a comprehensive Pollutant Release and Transfer Register (PRTR). Despite the “knowledge gap” it is essential that measures for the introduction of “best available techniques” and “best environmental practices” are being developed without delay, otherwise it will be impossible to achieve “good ecological” and “good chemical status”. As mentioned above, many requirements and guidelines for appropriate measures exist in the European Union (e.g. the BAT reference documents under the IPPC Directive) and other international bodies, however, the appropriate investments need to be secured on the basis of a clear priority setting.

The extent of the hydromorphological alterations in the Danube basin has been significant over the past centuries. Such alterations include, *inter alia,* the building of dams, weirs and sluices, the canalisation of rivers and subsequent disconnection of their floodplains and old arms, erosion (incision) of the river bed and lowering of water tables with consequently higher flood risks. Some of these changes are irreversible, however, there is a potential for rehabilitation, which should be explored to the fullest extent. This is particularly the case, where floodplains could be reconnected with the main river thereby improving natural flood retention and enhancing fish migration to their natural habitats. In addition, migration path-ways would be needed on barriers on the Danube and most of its tributaries.

Due to these significant hydromorphological changes large parts of the Danube River and of numerous tributaries have been provisionally identified as heavily modified water bodies on the basin-wide scale. Dams and weirs on the Danube as well as bank reinforcements and fixations on the tributaries put these stretches “at risk” of failing to reach the “good ecological status”.

Future infrastructure projects such as planned hydropower developments and plans to expand navigation threaten the status of the riverine ecosystem on the Danube and its tributaries further, in particular, since some of these projects would affect the few remaining free-flowing sections of the Danube. It needs to be ensured that these future projects minimise environmental impacts in the Danube river basin and compensate inevitable environmental damage through appropriate mitigation measures.

The Danube River Basin contains a large number of wetlands offering unique habitats for a rich and diverse aquatic community. Many of these areas have high protection status such as the large wetland complexes protected under international conventions, others still deserve to be designated as protected areas, but have not been granted such status. 80 % of the historical floodplain on the large rivers has been lost during the last 150 years mainly from significant hydromorphological alterations, and many already protected areas deteriorate due to new human interventions. Still today, many wetlands are under pressure from navigation, hydropower plants, intensive agriculture and forestry as well as from new infrastructure projects. Wetland restoration can bring many benefits, in particular for flood protection. As a first step, an inventory of the most important water-related protected areas for species and habitat protection has been established for the Danube River Basin.

The Danube Delta has suffered significant impacts from anthropogenic pressures in the last 50 years. These were caused in part by high nutrient loads and heavy metals from the Danube. Nutrient inflow has led to eutrophication of the delta arms and its lakes; elevated concentrations of heavy metals occur especially in the delta lakes. In addition, severe hydromorphological alterations and intensive agriculture and forestry have led to the loss and deterioration of large areas of land formerly unused and interconnected within the delta. As a consequence species and habitat diversity has declined. The large number of hydraulic structures on the Danube and its tributaries has also considerably reduced the sediment transport thereby bringing the growth of the Danube Delta into the Black Sea in parts to a halt.

Although considerable restoration measures have been undertaken in the last decade new canalisation projects are still being planned and implemented. Sound environmental impact assessments need to be carried out and alternative solutions found in order to protect this unique natural heritage of global importance.

The coastal waters and the larger marine environment of the Black Sea have been strongly influenced by high nutrient loads from the inflowing rivers especially in the period up to the mid 1980s. Since then a significant reduction of nutrient input has taken place, but the nutrient level is still significantly higher than in the 1960s. The effects of reduced nutrient inputs are clearly visible particularly in the North-western Shelf of the Black Sea, which is shallow and therefore particularly susceptible to eutrophication. The marine ecosystem of the Black Sea is highly complex and strongly influenced not only from high nutrient loads from the Danube and other Black Sea tributaries but also from other pressures such as over-fishing and changes in the food web.

Groundwater is mainly used for drinking water supply and for agriculture. In some areas significant pressures result from over-abstraction, high nutrient levels infiltrating the groundwater as well as from hazardous substances originating from inadequate waste treatment. For these reasons a few important transboundary groundwater bodies are estimated to be “at risk” to reach the environmental objectives. Since many of the groundwater bodies are highly vulnerable special protection strategies are needed to ensure the sustainable use and protection of groundwater.

Finally, the economic aspects of implementing the Water Framework Directive need to be strengthened. Currently, economic data are being collected based on administrative boundaries, which are not in accordance with the hydrological boundaries of the river basins. It has become apparent that this is a problem throughout Europe, not only in the Danube River Basin. Best practices on assessing cost-effectiveness and introducing water pricing strategies should be shared.

This first analysis of the Danube River Basin District is based on available data and is the best result that was possible within the given time frame. It thereby reflects the current level of preparation of a harmonised and integrated river basin management analysis. The starting point and the availability of data is vastly different throughout the Danube River Basin District. The extent, the quality and the degree of harmonisation of the data will improve with future reviews and updates of the characterisation and analysis, which will make later assessments more comprehensive and robust. In order to achieve this goal, the dedicated process needs to be set up to improve the data base, in particular as regards data availability and comparability.

Such an improved knowledge base would include, inter alia, the development of:

– an improved emission inventory leading to a Pollutant Release and Transfer Register (PRTR) for the Danube river basin;
∑ an inventory of hydromorphological alterations and of HMWB;
– improved transboundary monitoring programmes, mainly for the purpose of “surveillance monitoring” of the ecological and chemical status;
– an inventory on the quality status of protected areas and, where appropriate wetlands;
– an inventory of transboundary groundwater bodies and their status.

In addition, a Strategic Plan has been developed for a common, consistent and harmonised Geographical Information System (GIS) for the Danube River Basin. It addresses organizational, technical and financial issues, defines a planning procedure, and explains strategies and concepts for this important management tool. The aim is to facilitate the movement and analysis of data in a structured and seamless manner.

Furthermore, the harmonisation of criteria and assessment methodologies needs to be pursued. An improved analytical quality control system is needed. In particular, the harmonisation of elements of the ecological quality assessment is essential, including the typology and reference conditions as well as the harmonisation of criteria for designating heavily modified water bodies, which would finally lead to carrying out a Danube intercalibration exercise in 2007/2008.

Next steps are to integrate the results of the pressure and impact analysis with the results of the economic analysis of water uses in order to develop a coherent and integrated programme of measures for the water bodies “at risk” of failing to reach the environmental objectives.

Public participation should be carried out on different levels depending on the scale of the issues being addressed. In a large transboundary river basin like the Danube there is an international dimension to public information and consultation. An Operational Plan for the international level has been agreed for 2004 and will be further developed for the following years.

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