Water Resource Management in Germany

Fundamentals, pressures, measures

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German Environment Agency (UBA)
Section II 2 Water and Soil
Postfach 14 06
06813 Dessau-Roßlau
Tel: +49 340-2103-0
info@umweltbundesamt.de
www.umweltbundesamt.de

Federal Ministry for the Environment, Nature
Conservation and Nuclear Safety
Division WR I 1
Post office box 12 06 29
53048 Bonn
https://www.bmu.bund.de

Authors:
J. Arle, H. Bartel, C. Baumgarten, A. Bertram, K. Blondzik, S. Brandt, F. Brauer, U. Claussen, H.P. Damian, D. Dieter, C. Galander, H. Ginzky, S. Grimm, M. Helmecke, K. Hofmeier, M. Hofmeier, W. Hülsmann, B. Kirschbaum, T. Knobloch, K. Koppe, J. Koschorreck, M. Krakau, W. Leujak, C. Mathan, V. Mohaupt, S. Naumann, C. Pickl, U. Pirntke, T. Rapp, A. Rau, J. Rechenberg, S. Richter, A. Roskosch, C. Sedello, A. Stoefen-O'Brien, M. Suhr, R. Szewzyk, A. Ullrich, U. Wachotsch, A. Walter, A. Weiß, S. Werner, C. Winde, G. Winkelmann-Oei , R. Wolter (all German Environment Agency)

Editors:
M. Helmecke (German Environment Agency, Section II 2.1)

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Contents

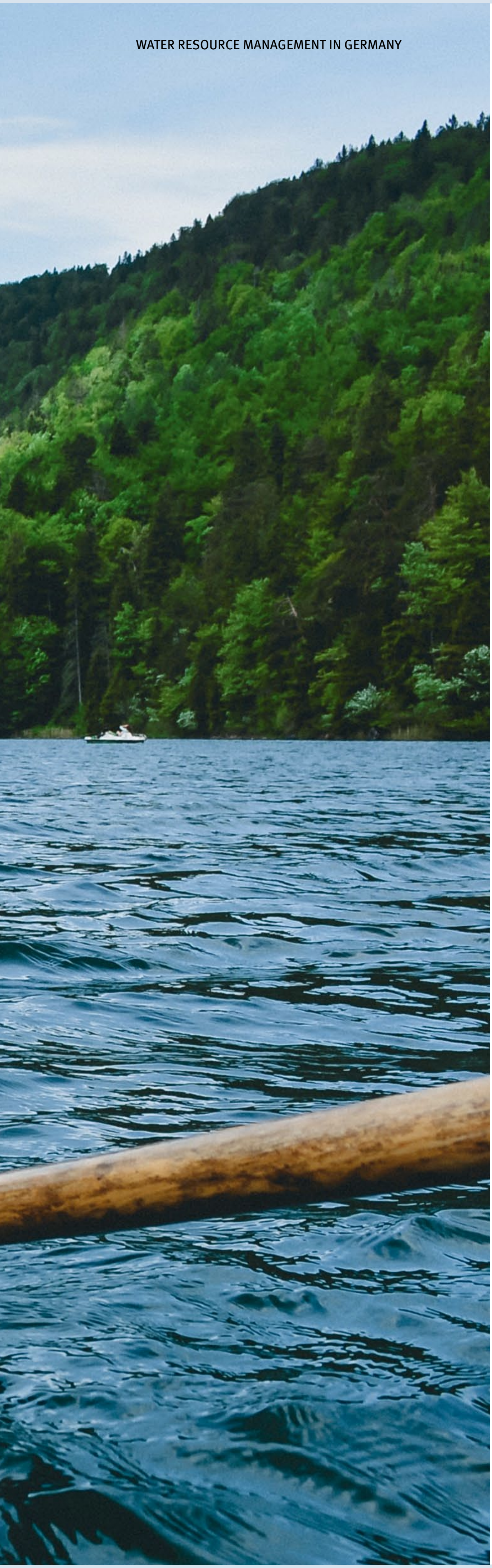
Contents

List of illustrations

List of abbreviations

AwSV	Ordinance on Installations for Handling Substances Hazardous to Water (Verordnung über Anlagen zum Umgang mit wassergefährdenden Stoffen)
BBodSchG	Federal Soil Conservation Act (Bundes-Bodenschutzgesetz)
BMBF	Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung)
BMEL	Federal Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft)
BMUB	Federal Ministry for the Environment, NatureConservation, Building and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit)
BMVI	Federal Ministry of Transport and Digital Infrastructure (Bundesministerium für Verkehr und digitale Infrastruktur)
BMWi	Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie)
BMZ	Federal Ministry for Economic Co-operation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
CAP	EU Common Agricultural Policy
CFP	EU Common Fisheries Policy
DAS	German Strategy for Adaptation to Climate Change (Deutsche Anpassungsstrategie an denKlimawandel)
DüV	Fertilisers Ordinance (Düngeverordnung)
DWD	German Meteorological Service (Deutscher Wetterdienst)
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
Floods Dir.	Directive 2007/60/EC on the assessment and management of flood risks
GAK	Community task to improve agricultural structure and coastal protection (Gemeinschaftsaufgabe der Verbesserung der Agrarstruktur und des Küstenschutzes)
GWP	German Water Partnership
HELCOM	Convention on the Protection of the Marine Environment of the Baltic Sea Area (also known as the Helsinki Convention)
HELCOM BSAP	Baltic Sea Action Plan
IMO	International Maritime Organization
INC	International Conference on the Protection of the North Sea
IPCC	Intergovernmental Panel on Climate Change
ISA	International Seabed Authority
LAWA	Working Group of the Federal States on Water Issues (Bund/Länder-Arbeitsgemeinschaft Wasser)
LAWA	Working Group of the Federal States on Water Issues (Bund/Länder-Arbeitsgemeinschaft Wasser)
LWG	Water Acts of the Länder (Landeswassergesetze)
MARPOL	International Convention for the Prevention of Pollution from Ships
MDG	Millennium Development Goals
MEPC	Marine Environmental Protection Committee
MSFD	Marine Strategy Framework Directive
MSY	Maximum sustainable yield
NASS	New Alternative Sanitation Systems
NFPP	National Flood Protection Programme
nrm	Non-relevant metabolites
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic (Oslo-Paris-Convention)
PAH	Polycyclic aromatic hydrocarbons
PBT	Persistent, bioaccumulative and toxic
PCB	Polychlorinated biphenyls
POPs	Persistent Organic Pollutants
PRTR	Pollutant Release and Transfer Register
RCP	Representative Concentration Pathways
SDG	Sustainable Development Goals
SECA	Sulphur Emission Control Area
SFM	Special framework plan for preventive flood protection measures
SLS	Slurry, liquid manure, silage
SRES	Emission scenarios as outlined in the “Special Report on Emissions Scenarios”
SRU	German Advisory Council on the Environment (Sachverständigenrat für Umweltfragen)
UBA	German Environment Agency (Umweltbundesamt)
UMK	Germany Conference of Environmental Ministers (Umweltministerkonferenz)
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
VAwS	Ordinance on Handling Substances Hazardous to Water (Verordnung zum Umgang mit wassergefährdenden Stoffen)
VOC	Volatile Organic Compounds
VwVwS	General Administrative Provision under the Federal Water Act on the Classification of Substances Hazardous to Water into Water Hazard Classes (Allgemeine Verwaltungsvorschrift Wassergefährdungsklassen)
WFD	Water Framework Directive
WGK	Water hazard classes (Wassergefährdungsklassen)
WHG	Federal Water Act (Wasserhaushaltsgesetz)
WPA	Water Protection Area

1 Introduction



1.1 Focus and structure of this brochure

Water is the basis for all forms of life. Streams, rivers, lakes, wetlands and seas provide habitats for a wealth of fauna and flora, and are also vital elements of the ecological balance and of our cultivated landscapes. In many regions, groundwater is the principal source of water supply, and an equally important habitat.

Water is a central resource and the most important element for our nutrition. We use water for food, for everyday hygiene, and for leisure activities. Water also represents an important economic factor, as a source of energy, transport medium and resource. Ensuring the effective protection and considerate use of our water resources is elemental to biological diversity and sustainability. As a vital public commodity, water is subject to comprehensive rules and regulations governing its management. Water legislation, economic instruments and other measures are designed to strike a good balance between economic and environmental interests.

This brochure offers a comprehensive insight into water resource management in Germany, and sets out to provide answers to the following questions:

- *Fundamental principles of water resource management in Germany:* What are the key concepts of national and international water policy and sustainable water resource management? (chapter 1)
- *Framework conditions of water resource management in Germany:* What are the main natural conditions, legal and institutional requirements, water sources and water uses among the relevant sectors in Germany? (chapter 2)
- *Pressures from water use:* What are the current challenges facing the handling of Germany's water resources? (chapter 3)
- What is the current status of Germany's lakes, rivers, streams, groundwater, coastal and marine waters? (chapter 4)
- *Measures to protect groundwater, surface waters, coastal and marine waters:* How do the instruments of German, European and international law and other measures in selected segments contribute to water protection? (chapter 5 and 6)
- *What are the new challenges facing water resource management* (chapter 7)
- Where can I find out more, and how can I contribute to water protection? (chapter 8)

To ensure systematic and comprehensive answers to these questions, the brochure is based on the international DPSIR approach, developed by the OECD in 1993 and updated by the European Environment Agency (EEA 2007). Its aim is to highlight the correlations between **D**riving Forces, **P**ressures, **S**tate, **I**mpact and **R**esponse.

Application of the DPSIR concept ensures that water use, the associated environmental impacts, the resultant water status, and the required water protection measures are thoroughly addressed.

We hope that this brochure will

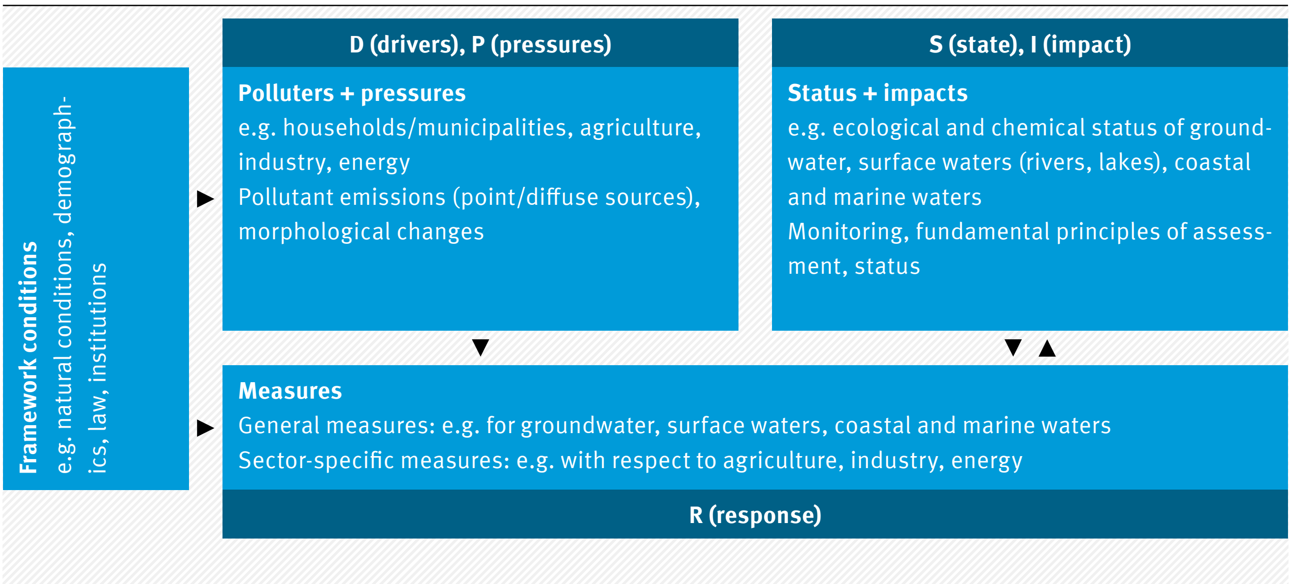
- Provide interested readers and specialists with a compendium of information on water resource management in Germany.
- Offer students and the media a reliable basis for academic work and reporting in this field.
- Supplement the range of information provided by the German Environment Agency and the Ministry for the Environment, Nature Conservation, Building and Nuclear Safety on water-related issues, and present existing, topic-specific brochures, themed web pages and water-related "environmental data" in a comprehensive and clustered way.

1.2 Fundamental principles of water resource management

Water is a basic necessity of life for people, animals and plants. As such, it is vital to ensure that it is handled sustainably and carefully. Water resource management has always endeavoured to strike an equitable balance between the various different water uses. The protection of ecosystem and biodiversity has been added in the recent past. Densely populated and highly industrialised regions with an adequate supply of water resources face different challenges then sparsely populated, rural, arid regions. With this in mind, a forward-thinking policy to protect our waters must focus on both water quality and water quantity, and provide mechanisms for controlling them.

Figure 1

Simplified implementation of the DPSIR approach in this brochure



Source: German Environment Agency

A sustainable water conservation policy should not only prevent imminent threats and restore any damage already caused, but above all should protect and conserve natural resources in a precautionary way.

Managing water from the source to the sea, with due regard for all usage aspects and the demands on ecosystems, is known as integrated water resource management. It is reflected in the planning and management tools, in the cooperation between authorities, and in the involvement of the general public.

In Germany, taking precautions to protect waters as a component of the natural balance and guaranteeing public water supply and public wastewater disposal are two of the central tasks of federal, Länder and municipal governments.

Thanks to Germany's climatic situation, water quantity problems have been rare. Now as ever, the principal concern is to improve water quality and waterbody structure.

In the years of reconstruction following the Second World War, water protection in both East and West Germany was unable to keep pace with the expansion of industrial activity. By the late 1960s and early 1970s, water pollution had reached alarming levels.

In the economically stronger West–the original Federal Republic of Germany–the national and regional authorities adopted a raft of measures which improved water quality quickly and sustainably. Industry in particular was called upon to take far-reaching action to reduce the extent of water pollution.

The construction of over 9,000 biological wastewater treatment plants in the public sector, alongside intensive treatment of wastewater and complementary in-house measures among industrial facilities, helped to substantially reduce emissions of oxygen-depleting organic wastewater constituents and pollutants into waters, with compelling success for the quality of surface waters.

In the wake of German reunification, one major task was to ensure the same level of environmental protection throughout the country. The technical standard of water supply and wastewater disposal in the five new Länder (former GDR) was well below that of the old Länder (FRG). The goal was therefore to raise standards in the new Länder and achieve uniformly high levels of environmental conditions throughout Germany.

While the high level of investment in the last 25 years has brought substantial improvements, water protection remains an ongoing task. The general context of the Federal Republic of Germany, i.e. its geographical situation in the centre of Europe, its high population density and high level of industrialisation, together with intensive industrial use, still necessitate special efforts in the field of water protection, also as a way of mitigating the emerging impacts of climatic change.

Despite the significant reduction in inputs of hazardous substances into Germany's waters, a number of persistent, toxic organic substances and heavy metals remain problematic. Some of them (e.g. fire retardants such as polybrominated diphenyl ether (PBDE)) have now become ubiquitous in Germany's waters. They are emitted into waterbodies via surface runoff and erosion from soils as well as discharge from wastewater treatment plants and other sources and are then far-spread by oceanic currents. Additionally, rising levels of organic micro pollutants, such as pharmaceutical residues, pesticides and other chemicals are being detected in Germany's waters. In the interests of health protection, and to protect the fauna and flora found in surface waters, hazardous substances must be kept away from all waters as far as possible. This is achieved via a well-equipped wastewater treatment plants, as well as via avoidance measures at the source (e.g. substance prohibitions or usage restrictions), and protective measures directly at the waterbodies themselves (such as riparian buffer zones).

Nutrient inputs are another problem. This is particularly evident in groundwater, the principal resource for our drinking water abstraction, with one in four groundwater bodies indicating excessing nitrate concentrations. In the North and Baltic Seas, but also in many lakes and slow-flowing rivers, high inputs of nitrogen and phosphorus, originating primarily from over-fertilisation in agriculture, have led to excessive algal growth and hence to various cases of oxygen deficiency and fish mortality.

Imposing stringent requirements on municipal and industrial wastewater treatment plants and offering financial incentives under the wastewater charges regulations, agreeing financial support for agricultural measures with the Länder, and adopting a continuity programme for Germany's waterways are just some of the many different measures implemented by the Federal Government to reduce pressures on our waterbodies. However, polluters must continue to redouble their efforts in the years ahead if Germany is to achieve both, the EU Water Framework Directive's (WFD) objective of good status of surface waters and groundwater and the EU Marine Strategy Framework Directive's (MSFD)[2] objective of good environmental status of marine waters. In particular, this means reducing the considerable inputs of nutrients from agriculture and improving waterbody morphology.

As an essential component of the hydrological cycle, and in the interests of ensuring drinking water supplies, groundwater merits particular protection. Measures to reduce nutrient and pesticide inputs from agriculture are extremely important. Precautions to prevent pollution associated with the handling of substances hazardous to water in industry and transport must establish a high level of protection. Action is still needed to reduce inputs from contaminated sites, civil and military legacy sites, and defective underground pipelines that pose a threat to groundwater. More recent threats to groundwater include underground activities such as gas fracking, geothermal installations, and the underground storage of CO_2. Here too, the German legislators have taken action to avert threats to groundwater.

In the long term, water resources must be carefully managed so as to

- Maintain or restore the ecological balance of surface waters, with particular regard for waterbody structures
- Achieve good chemical status of surface waters
- Achieve good quantitative and qualitative status of groundwater
- Guarantee reliable water supplies in terms of both quantity and quality
- Ensure that all other water uses serving public welfare continue to be possible.

In particular, the fundamental principles of water resource management policy are

- Priority of prevention
- Cooperation between all parties concerned
- Allocation of costs based on the polluter-pays principle and full cost recovery.

Water resource management in Germany changed with the entry into force of the new EC Water Framework Directive on 22 December 2000 and its implementation in Germany. Key elements of the WFD include:

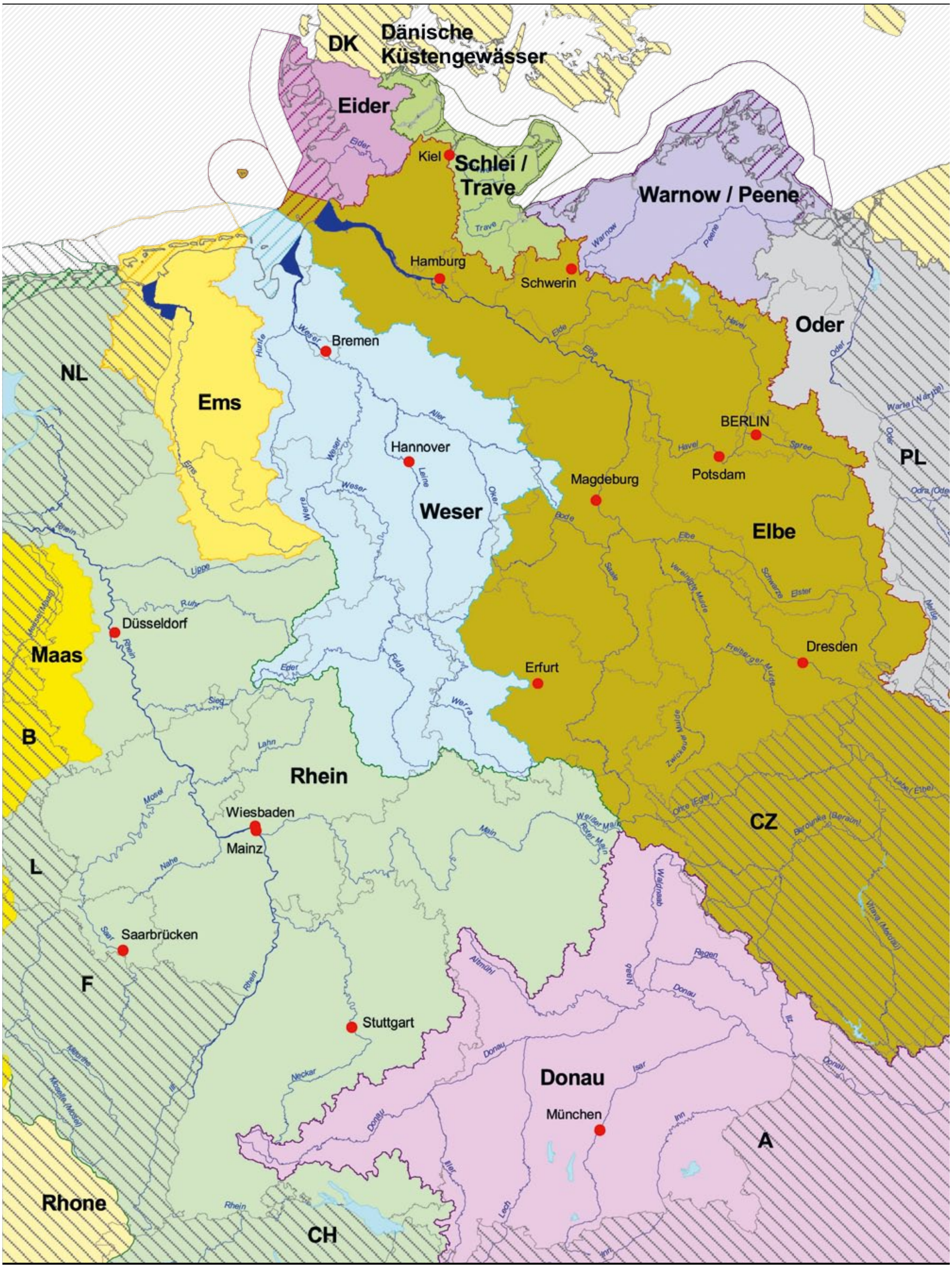
- River basin management in 10 catchment areas (Figure 2), i.e. the integrated management of groundwater and surface waters including lakes, estuaries (river mouths) and coastal waters
- An emphasis on waterbody ecology
- More national and international coordination
- The definition of biological, chemical and quantitative environmental objectives
- The obligation to prepare management plans and programmes of measures to improve the status of waterbodies
- Involving the general public in the planning processes

The MSFD, which entered into force on 4 July 2008, also contains similar and other elements, such as the incorporation of marine protection-related requirements on noise and litter. *Inter alia*, it obligates the Member States to cooperate in the regional Baltic and North Seas.

Transboundary cooperation to protect inland waters and the seas falls within the remit of the Federal Government's environmental policy work, since responsibility for and management of water does not end at territorial boundaries.

Figure 2

River basin districts in Germany



Sections of international river basin districts that lie outside the borders of the Federal Republic of Germany have been labelled for illustrative purposes only; this does not in any way affect the provisions of other countries and international agreements.
Map basis: Working Group of the Federal States on Water Issues (LAWA), Federal Agency for Cartography and Geodesy (BKG).

Source: German Environment Agency (UBA), 2004

1.3 Implementation of the UN's water-related sustainable development goals in Germany

At its General Assembly in New York on 25 September 2014, the United Nations (UN) adopted 17 sustainable development goals (SDGs)[3], plus a further 169 sub-goals. These reinforce the principles already adopted in 1992 in the Rio Declaration on Environment and Development, and the Millennium Development Goals (MDGs) adopted in 2000. The MDGs were supposed to have been met by 2015, but not all of them were. The SDGs, which entered into force on 1 January 2016, build on and develop the aforementioned principles and objectives, make them binding for all signatories, and are to be met by 2030. The SDGs are based on the principles of inter-generational justice, quality of life, social cohesion, ecological viability within planetary boundaries, and international cooperation. The UN has drawn up indicators for all goals and sub-goals, which the signatories should use to document their progress in achieving them. Germany's sustainability strategy[4] provides a pivotal framework for national implementation of the SDGs. Its targets and indicators must be updated accordingly.

Table 1

SDG goal 6 and sub-goals

SDG 6: Ensure availability and sustainable management of water and sanitation for all	
Goal 6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all.
Goal 6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.
Goal 6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated waste water, and significantly increasing recycling and safe reuse globally.
Goal 6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure the sustainable abstraction and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.
Goal 6.5	By 2030, implement integrated water resource management at all levels, including through transboundary cooperation as appropriate.
Goal 6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.
Goal 6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.
Goal 6.b	Support and strengthen the participation of local communities for improving water and sanitation management.

source: https://sustainabledevelopment.un.org/sdg6

Goals 6 and 14 are particularly relevant for water resource management.

Goals 6.1 and 6.2–access to safe and affordable drinking water and to adequate sanitation–have already been met in Germany and do not require further implementation. Thanks to the mechanisms prescribed by the WFD, which have been comprehensively implemented, goal 6.5 on integrated water resource management is also considered to have been met in Germany. Although this does not solve all waterbody-related problems, all relevant issues are being addressed and discussed with affected parties.

By contrast, further action is still needed in Germany if we are to meet the requirements of goal 6.3 concerning improved water quality and goal 6.6 on water-related ecosystems (such as rivers, lakes, groundwater aquifers and wetlands).

Goal 6.4 is intended to combat water scarcity and therefore calls for a significant improvement in the efficiency of water use throughout all sectors, and the sustainable abstraction and supply of freshwater. Germany has already documented significant progress in the abstraction of national water resources, but further efforts and practical concepts are still needed in order to reduce Germany's "water footprint" (chapter 3.1.1) in other countries.

Goal 14 formulates the requirements for the sustainable development and use of the oceans, seas and marine resources. Many of the subgoals, namely prevent and significantly reduce marine pollution from marine debris and nutrient pollution (14.1), strengthen the resilience of marine ecosystems (14.2), reduce ocean acidification (14.3) and stop overfishing (14.4), are also addressed by the MSFD and require further implementation efforts in Germany.

1.4 The human right to drinking water and basic sanitation

The "sanitary revolution"–the supply of safe drinking water and a functioning sewage system–is one of the most important medical achievements of modern times. While this "revolution" has been very effective in our part of the world, on a global scale, waterborne diseases, especially diarrhoeal infections, remain a huge health problem. The World Health Organisation (WHO) estimates that they are responsible for around 842,000 deaths each year. As well as the financial implications for the healthcare system, this also incurs high indirect consequential costs to those affected and their families.

According to recent estimates by the WHO and UNICEF, there are currently some 663 million people worldwide without access to safe drinking water.

Recognising the human right to water is often cited as a key pre-requisite for reducing waterborne diseases and their consequences. On 28 July 2010, the United Nations, with a large majority, declared access to safe drinking water and sanitation to be a universal human right.

Resolution 64/292 calls upon States and international organisations to provide financial resources through international cooperation, and to foster capacity-building and technology transfer to assist developing countries, in particular, in their efforts to provide safe, clean, accessible and affordable drinking water and sanitation for all. Germany has long been committed to this philosophy and supports the UN resolution. This is not binding in international law, nor is it individually enforceable, but it does have a major influence on the policies of individual countries and the UN.

Above all, guaranteeing a "human right to water" means ensuring personal, household and food hygiene through adequate water supplies, which in turn affords a good level of protection against waterborne (infectious) diseases. This human right does not include other forms of water use, such as adequate water for food production, maintaining families and livelihoods, environmental protection, recreation and relaxation, cultural and religious practices, nor does it extend to free access to water or distribution entitlements by neighbouring states. Measures to help implement the human right to water and sanitation are a key focal point of Germany's development cooperation work.

1 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ No. L 327, p. 1 ff.

2 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy, OJ No. L 164, p. 19 ff.

3 Resolution by the UN General Assembly of 25 September 2015: Transforming our world: the 2030 Agenda for Sustainable Development http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

4 https://www.bundesregierung.de/Content/DE/StatischeSeiten/Breg/Nachhaltigkeit/0-Buehne/2016-05-31-text-zum-entwurf-nachhaltigkeitsstrategie.html

663 million people worldwide still lack access to improved drinking water sources

2 Framework conditions for water resource management in Germany

2.1 Natural conditions

2.1.1 Climate and precipitation

Germany lies within the moderately humid climate zone, which is characterised by frequent weather changes and precipitation at all times of the year. The annual average precipitation is 789 mm (corresponding to 789 litres per square metre). The volume and frequency of precipitation varies within Germany and fluctuates between the seasons. More rain falls on the uplands and alpine regions than in the lowlands. In the North German Lowlands, the annual averages range between 500 and 700 mm, while the Central German Uplands receive 700 mm to 1500 mm per annum, and in the Alps annual precipitation can exceed 2,000 mm. Also, rainfall tends to decline from west to east. Across Germany as a whole, the summer half-years are on average somewhat wetter than the winter half-years. On average, 57% of annual precipitation falls in summer and 43% in winter.

2.1.2 Landscapes and waterbodies

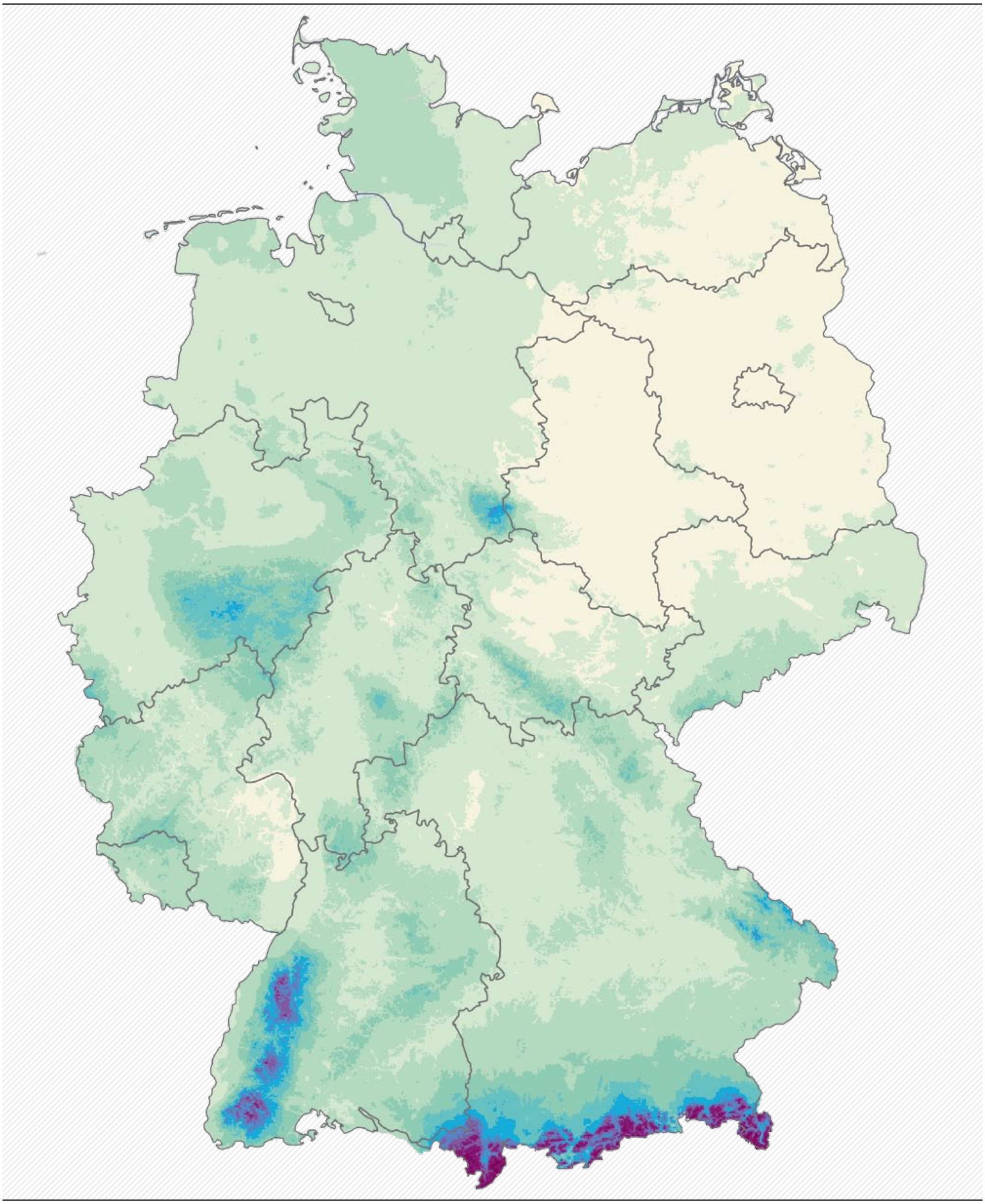
Geographically speaking, Germany is divided into three almost parallel landscape types from north to south: The North German Lowlands, the Central German Uplands, and the Alpine region, which is divided into the South German Alpine foothills and the Bavarian High Alps. These eco-regions also influence the composition of the type-specific aquatic biota[5].

Due to the Ice Age, the plain of the North German Lowlands between the North and Baltic Sea coasts and the Central German Uplands is characterised by hilly moraine landscapes with many lakes, as well as lowlands and glacial melt water valleys. Many areas of moorland and heath are found in the northwest.

The hills of the Central Uplands separate North Germany from South Germany. The uplands are morphologically subdivided into mountainous regions and valleys, the mountains reaching altitudes of between 700 m and 1,500 m.

Figure 3

Annual precipitation volume in Germany (reference period 1961–1990).



Precipitation volume in Germany

400–600 mm	800–1000 mm	1 200–1 400 mm	1 600–1 800 mm	2.000–2.500 mm
600–800 mm	1000–1 200 mm	1400–1 600 mm	1800–2000 mm	2.500–3.000 mm

Source: Data by DWD

Germany's landscape is characterised to a large extent by overland waterbodies. The diverse landscape of the South German Alpine Foothills includes a number of large lakes, and merges into the High Alps with their numerous mountain lakes further south. Germany's largest lake, Lake Constance, with an area of 535.9 km², is located in the Alpine region.

Large interconnected natural lake areas are also found in the North German Lowlands. These include Lake Müritz, the second-largest lake in the Federal Republic of Germany with an area of 109.8 km². There are eleven further lakes with an area of more than 20 km² each (Table 2).

The rivers and streams in Germany's ten river basins (see Figure 2), with a combined length of more than 400,000 km, flow into the coastal regions. The Rhine, Elbe, Weser, Ems, Maas and Eider river basins drain into the North Sea; the Oder and the waters of the Schlei/Trave and Warnow/Peene river basins flow into the Baltic Sea; and the Danube flows into the Black Sea.

For centuries, man has changed the hydrological, morphological and geochemical features of waterbodies for shipping, settlement, agriculture, flood protection and recreational purposes[7]. The impoundment of rivers with dams is one such example. The reservoirs created in this way have been part of the landscape in Germany for almost 100 years. They store water for drinking water and energy supply, are used for flood prevention, and often perform a valuable recreational role as well.

Germany currently has a total water area of 8,552 km², corresponding to around 2.4% of its territory, and the trend is rising: The overground mining of raw materials such as lignite, sand and gravel leaves a legacy of destroyed landscapes and residual pits. Their subsequent flooding has led to an increase in Germany's water area since 2000. Over the next few years, they will be joined by further lakes in the lignite pits. Once all the flooding is complete, lakes covering an area of 77 km² will be created in the Lausitz region of Brandenburg alone.

Germany's transport routes include around 7,300 km of canals, impounded and free-flowing rivers that function as federal waterways. Some 6,550 km of these are inland waterways and around 690 km sea transport corridors. 34% of inland waterways are free-flowing or regulated sections of river, 24% artificial

Table 2

Natural lakes with a surface area of more than 20 km²

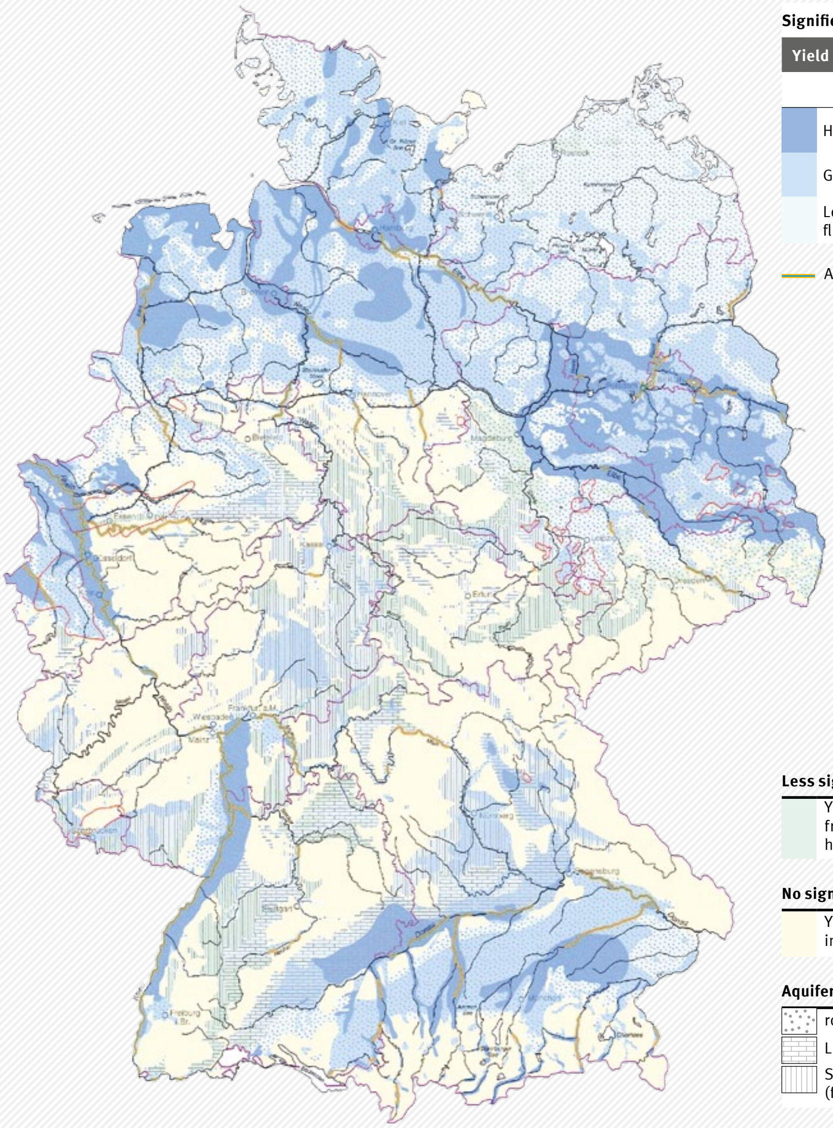
Lake	Land	Area in m²	Maximum depth in m
Lake Constance	Baden-Württemberg/Bavaria	535.9	254
Lake Müritz	Mecklenburg Western Pomerania	109.8	30
Chiemsee	Bavaria	77.0	73
Schweriner See	Mecklenburg-West Pomerania	61.5	52
Starnberger See	Bavaria	56.0	128
Ammersee	Bavaria	46.2	81
Plauer See	Mecklenburg-West Pomerania	38.4	26
Kummerower See	Mecklenburg-West Pomerania	32.5	23
Steinhuder Meer	Lower Saxony	29.1	3
Großer Plöner See	Schleswig-Holstein	29.1	56
Schaalsee	Mecklenburg-West Pomerania / Schleswig-Holstein	22.9	72
Selenter See	Schleswig-Holstein	21.4	36
Kölpinsee	Mecklenburg-West Pomerania	20.3	30

Source: LAWA in Statistisches Bundesamt (Federal Statistical Office), Statistisches Jahrbuch 2015, chapter 1 "Geografie und Klima"[6]. Date: 30/04/2015 waterways (canals) and 42% impounded. Natural habitats and contact with water meadows are often lost as a result of development and impoundment of the waterbodies. Where water is impounded, further problems can arise, such as algal bloom, sludge accumulation and oxygen deficiency.

Most overground waterbodies are fed by groundwater inlets. Overall, Germany is rich in groundwater supplies. However, the availability and quality of groundwater varies widely from region to region depending on geological, hydrological and hydro-chemical conditions. The largest coherent region with plentiful groundwater reserves is the North German Lowlands. Large groundwater supplies are also found in the Alpine foothills and in the Upper Rhine Rift.

Figure 4

Yield of groundwater resources in Germany



Significant groundwater resources

Yield	Possible abstraction	
	Individual wells	**Water works**
High yield	Generally › 40 l/s	Frequently › 5 hm³/a
Good yield	Generally 15-40 l/s	Generally 1-5 hm³/a
Low or fluctuating yield	Generally 5-15 l/s	Generally 0.2-1 hm³/a

Additional abstraction possibility from bank filtrate

Less significant groundwater resources:

Yield of wells generally › 5 l/s, high yields possible locally from wells and springs; usage restricted for technical and hygiene reasons

No significant groundwater resources:

Yield from wells generally › 2 l/s, local resources may be important for supply

Aquiferous rock:

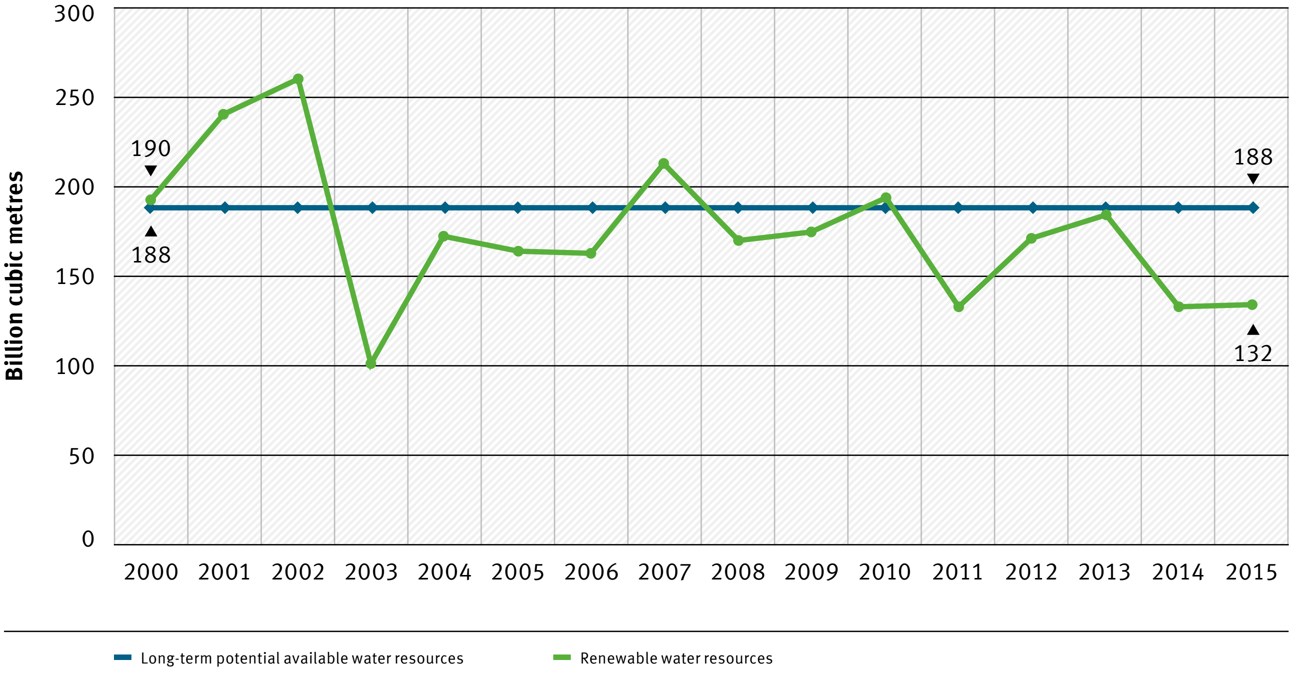
- rock: sand, gravel, tufa (porous aquifers)
- Limestone, dolomite, gypsum (karst aquifers)
- Sandstone, quartzite, basalt, lime-marlstone (fissured aquifers)

Mining regions

Source: Hydrologischer Atlas von Deutschland: Tafel 5.2 - Bundesanstalt für Geowissenschaften und Rohstoffe

Figure 5

Change in renewable water resources in Germany



Source: German Environment Agency[8], Data: German Federal Institute of Hydrology

2.1.3 North and Baltic Seas

The North Sea is a shallow marginal or shelf sea of the North-East Atlantic, covering an area of around 575,000 km². The average depth is 93 m, with a maximum depth of 725 m in the Norwegian Channel. Water exchange with the Atlantic occurs primarily via the open north side, and to a lesser extent via the English Channel as well. Depending on the geographical location, the average residence time for North Sea water is one or several years. In the coastal region, the water residence time is particularly long, due to the existing flow conditions. The North Sea is one of the most biologically productive marine regions in the world, with excessive concentrations of nutrient salts in some areas and a correspondingly high level of plant and animal production.

As an intracontinental marginal sea of the North Sea, the Baltic Sea is almost completely enclosed by land mass and has only a narrow, shallow connection to the North Sea (Sunde, Belte, Kattegat, Skagerrak). It covers an area of approximately 413,000 km², with an average depth of 52 m, and a maximum water depth of 459 m at Landsorttief. As a result of the minimal and irregular discharge of salt water from the North Sea and the high input of river water, the salt content rises from the Gulf of Bothnia (almost freshwater) to Skagerrak (almost seawater), making the Baltic Sea one of the largest cohesive areas of brackish water in the world. The water in the Baltic Sea has a residence time of approximately 25–30 years, with slower rates in the shallow western part, and longer rates in the deep basins of the central Baltic Sea.

2.1.4 Available water resources

The potential available water resources in Germany are 188 billion cubic metres, making it a country rich in water resources. Countries such as Sweden have similar water resources of 179 billion cubic metres available, while southern European countries, such as Romania, have considerably less available resources of around 42 billion cubic metres.

The available water resources are a variable of the regional water cycle, and comprise the quantity of groundwater and surface water theoretically available to use. The annually calculated renewable water resources, i.e. precipitation, evaporation and inflows to and outflows from Germany, provide the basis from which to calculate the potential available water resources as a long-term average, allowing statements to be made on water supply in Germany.

The available water resources remain comparatively stable over time. In certain years, however, there have been significant deviations in renewable water resources from the long-term average due to weather-related fluctuations–for example, 2002 was particularly wet and 2003 particularly dry (see Figure 5).

Although overall, the potential available water resources are adequate, there are also some regional differences in water availability in Germany, due to different climatic conditions.

The available water resources per capita are an initial indicator of whether the available water volume is in general adequate for water supply purposes. In Germany on average 2,292 m³ of water are available per person, per year. For its 82 million inhabitants this corresponds to a potential water volume of 6,279 litres per person, per day. However, there are regional and seasonal variations in the distribution of potential available water resources. For example, Brandenburg, with potential available water resources of just 3.7 bn m³ per annum[9] (1,484 m³/inh.*a) has significantly less water than Baden-Württemberg, with potential available water resources of 49 bn. m³ per annum (4,522 m³/inh.*a).

If we take a look at other regions of the world, it is clear that adequate water supplies for industrial and private purposes cannot be taken for granted. Usable water resources are extremely unevenly distributed throughout the world, leading to water stress or water scarcity primarily in arid regions. Some countries in North Africa and the Near East suffer from severe water scarcity, with between zero and a maximum of 500 m³ of water available per person, per year. By contrast, countries such as Canada have potential available water resources of more than 100,000 m³ per person, per year. The total global water resources are estimated at 1.4 bn km³, but 97.5% of this are salty seawater or brackish water. Only 2.5 % of the world's water volume is freshwater. However, as the bulk of freshwater supplies are bound by ice and glaciers, less than 1% of the total global water resources are directly usable.

2.2 Climate change

Scientists in the Intergovernmental Panel on Climate Change (IPCC) assume that human influence is causing global warming[10]. It is certain that a change in the global climate has emerged due to rising emissions of greenhouse gases worldwide.

2.2.1 Global climate change

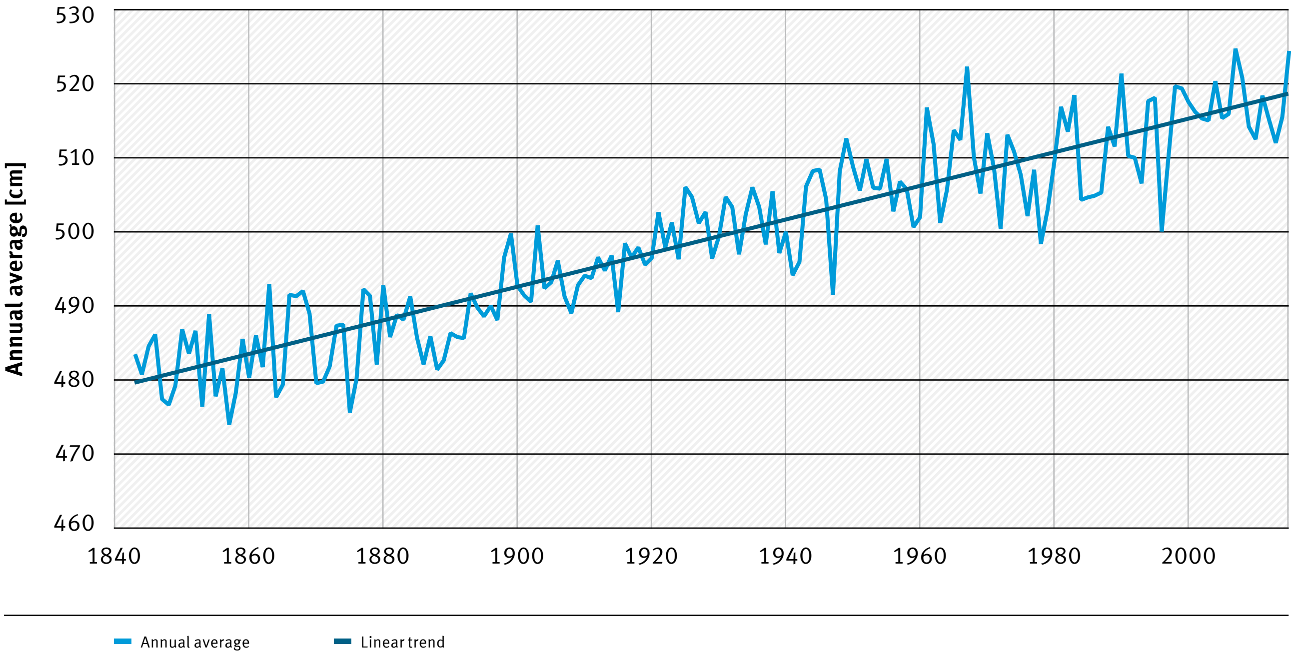
Between 1880 and 2012, the global average near-ground temperature rose by 0.85°C. In the northern hemisphere, the 30-year period from 1983 to 2012 was the warmest in 1400 years. On a global scale, the year 2016 was probably the hottest year since temperature records began, exceeding the previous high of 2015. Scientists anticipate a further global temperature increase of between 0.9°C and 5.4°C compared to pre-industrial levels by the end of the 21st century. Predictions vary depending on which emission scenario is used. Emission levels, in turn, depend on the underlying development assumptions, for example with regard to population, technology and climate protection. Limiting the rise in temperature between now and the end of the century to between 0.9 and 2.3°C requires a very ambitious climate policy.

Precipitation is also changing over the course of global warming, with major regional and seasonal variations. For example, in the last century, precipitation in Europe has increased by 6-8%. The regional divide is particularly striking. Northern Europe is experiencing a pronounced rise in precipitation at 20–40 %, whereas in southern Europe, winters are getting dryer.

Rising global temperatures are causing glaciers and ice shields to melt. For example, between 2002 and 2011, the ice mass of Greenland decreased by around 215 billion tonnes annually, compared to 34 billion tonnes each year in the 1990s. The melting of the glaciers and ice masses, coupled with the thermal exansion of seawater, have led to rising sea levels. Whereas sea levels between 1901 and 2010 increased by an average of 1.7 mm per year, in the last 20 years this has nearly doubled to 3.2 mm annually. In total, sea levels have already risen by 19 cm over the past century. Scientists anticipate a further increase of around 26 to 55 cm during the 21st century, even if considerable efforts are made to combat climate change. If emissions are not

Figure 6

Rising sea levels in the North Sea. Average sea level at the Cuxhaven Station 1843-2011



Source: Universität Siegen, Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime & Hydrographic Agency)

limited, sea levels are expected to rise by between 45 and 82 cm.

Rising average seawater temperatures are another direct impact of the global temperature change. For example, in the uppermost layer of the oceans up to a water depth of 75 metres, the water temperature increased by around 0.11 °C per decade over the period 1971 - 2010.

2.2.2 Climate change in Germany

Climate change analyses are based on the evaluation of measurement series from the past, while modelling is used to predict the future. Measurement series for temperature and precipitation began in Germany in 1881, and have therefore existed for 136 years. 30-year periods are used wherever possible in order to distinguish between climatic fluctuations that can occur from year to year, and genuine climate change. The period 1961-1990 is defined as a reference period, and comparative evaluations tend to refer to this period. In order to be able to make statements on future climate change in Germany, information from global climate models and regional models are transferred to smaller regions. Scientists use a range of scenarios and models in different computations to gauge climate development. The outcome is not just one temperature value for future development, but a range of values. Since all model results are equally probable, it is important to work with this range. As a result, all derived variables such as precipitation or discharge are likewise given as ranges.

Temperature change

Studies indicate that average annual air temperatures in Germany have risen by 1.4 °C during the period 1881 to 2015. A comparison of 30-year periods likewise indicates an increase in average temperatures. During the reference period (1961-1990), the average temperature was 8.2 °C, rising to 8.9°C in the 30 years between 1981 and 2010. 2014 was the warmest year in Germany since records began in 1881 (Figure 7)[11].

For Germany, the models predict a further increase in annual average temperatures of between 1.1 °C and 3.8 °C by the end of the century[12].

Change of precipitation

Precipitation fluctuates widely according to region and season. 2002 was the wettest year since 1881, with annual precipitation of 1018 mm. By contrast, 1959 was the driest, with only

551 mm. Within these major fluctuations, annual precipitation in Germany has increased by 83 mm or 11 % in the last 135 years compared to the reference period (1961 - 1990) (Figure 9). Whereas precipitation has remained almost constant in the summer months since 1881, in the winter months (December, January, February) it has increased by 48 mm or 27 %.

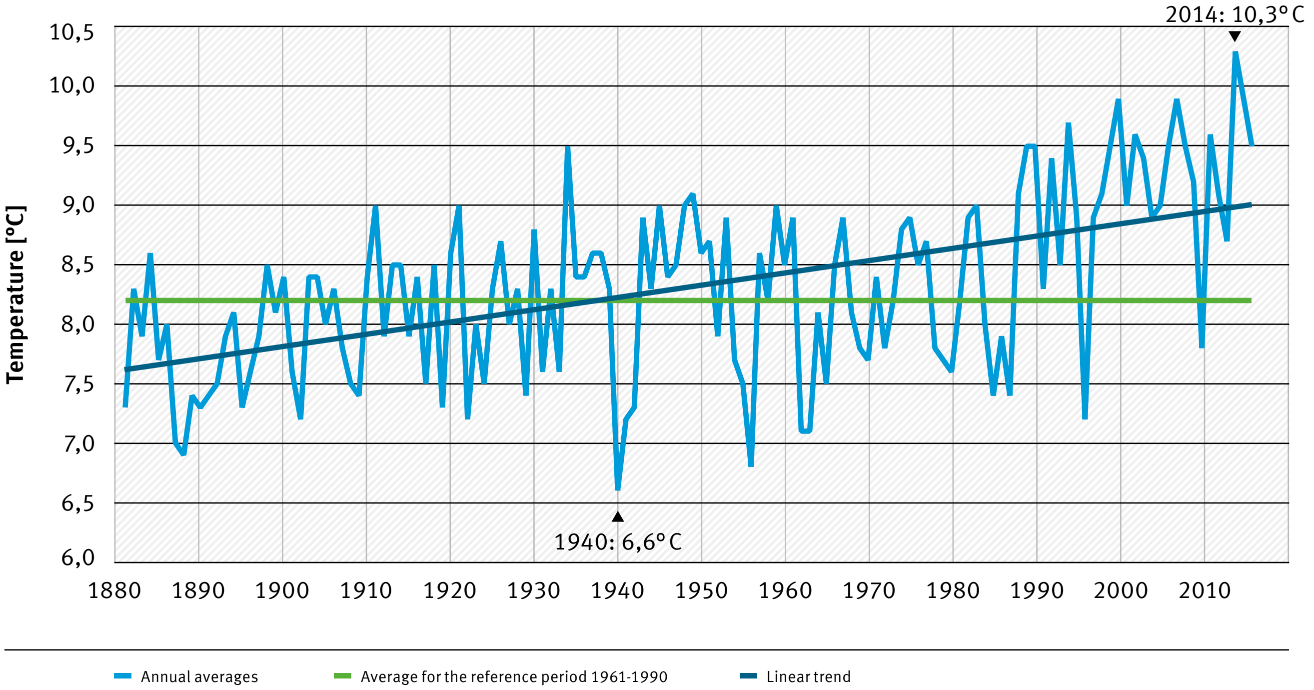
There are also differences between individual regions: In the east of Germany, annual precipitation has barely changed since 1881. The most visible change has been in the north-west, where the average annual precipitation has increased by 15 % and the winter precipitation by 31 %.

Precipitation will continue to change in the future. By the end of the century (2071 - 2100), annual precipitation in Germany is expected to increase by 9% compared to the period 1971 - 2000. This rise will be distributed evenly across all regions. By the end of the century, precipitation in the winter months could increase by 17 %, and decrease by between 4 % and 7 % in the summer months[13] (Figure 10).

Alongside average precipitation, the likelihood of extreme events occurring is also changing: The models indicate that the number of days with at least 10 mm to 20 mm or more precipitation per day will clearly increase.[14]

Figure 7

Annual average temperatures in Germany (area average from station measurements at a height of 2 m), 1881-2016



Source: DWD: Nationaler Klimareport (National Climate Report) 2016

Figure 8

Annual average mean temperatures and anticipated changes

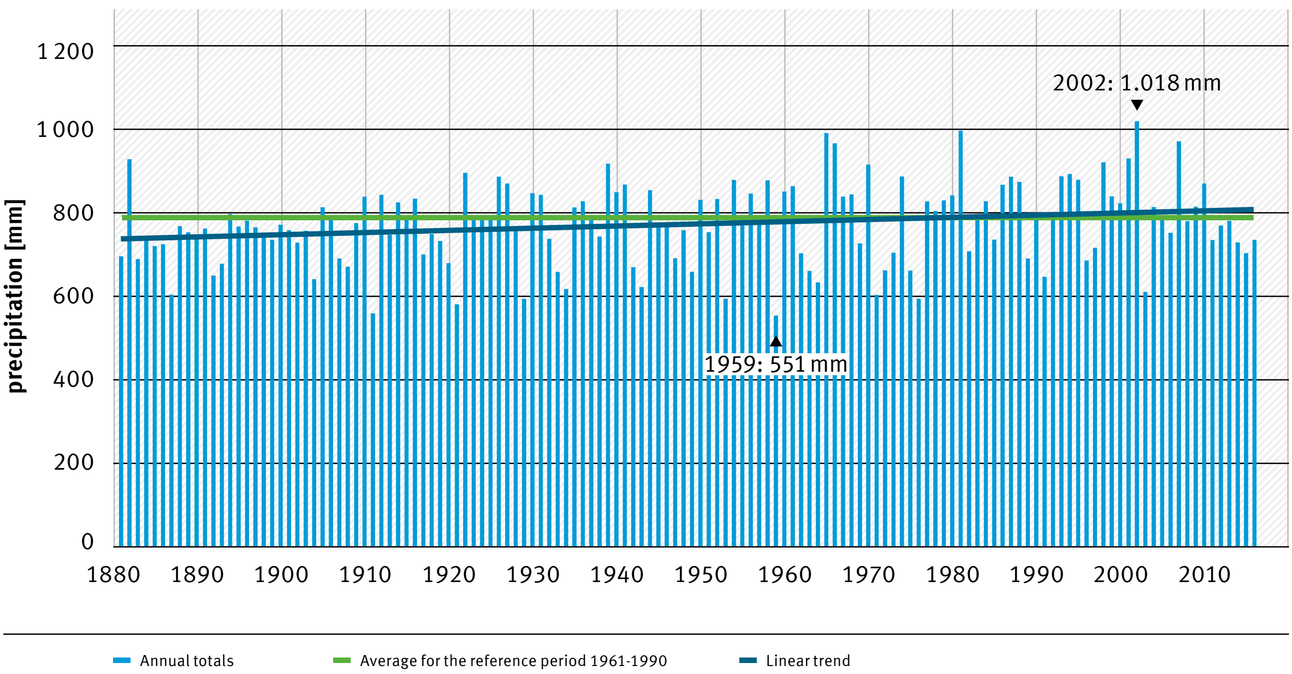
	1961 – 1990	1971 – 2000	2021 – 2050 (RCP2.6)	2021 – 2050 (RCP8.5)	2071 – 2100 (RCP2.6)	2071 – 2100 (RCP8.5)
Spring	7.7 °C	8.1 °C	+0.9 °C	+1.1 °C	+1.0 °C	+3.2 °C
Summer	16.3 °C	16.6 °C	+1.1 °C	+1.3 °C	+1.1 °C	+3.9 °C
Autumn	8.8 °C	8.7 °C	+1.1 °C	+1.6 °C	+1.2 °C	+4.1 °C
Winter	0.3 °C	0.8 °C	+1.0 °C	+1.4 °C	+1.2 °C	+4.1 °C
Year	8.2 °C	8.6 °C	+1.0 °C	+1.3 °C	+1.1 °C	+3.8 °C

Note: The period 1971 to 2000 is the reference period. RCP 2.6 = “Climate action scenario”, scenario RCP 8.5 = “Business as usual scenario” (i.e. emissions of greenhouse gases continue to rise unchecked)

Source: DWD: Nationaler Klimareport (National Climate Report) 2016

Figure 9

Time series of annual precipitation level in Germany (area average from station measurements), 1881-2016



Source: DWD: Nationaler Klimareport (National Climate Report) 2016

Figure 10

Seasonal averages of precipitation and anticipated changes

	1961 – 1990	1971 – 2000	2021 – 2050 (RCP2.6)	2021 – 2050 (RCP8.5)	2071 – 2100 (RCP2.6)	2071 – 2100 (RCP8.5)
Spring	186 mm	179 mm	+5 %	+8 %	+3 %	+13 %
Summer	239 mm	234 mm	−6 %	+7 %	−4 %	−7 %
Autumn	183 mm	191 mm	+3 %	+4 %	+1 %	+7 %
Winter	181 mm	183 mm	+7 %	+5 %	+4 %	+17 %
Jear	789 mm	788 mm	+2 %	+5 %	+2 %	+9 %

Note: The period 1971 to 2000 is the reference period. RCP 2.6 = "Climate action scenario", scenario RCP 8.5 = "Business as usual scenario" (i.e. emissions of greenhouse gases continue to rise unchecked)

Source: DWD: Nationaler Klimareport (National Climate Report) 2016

Changes in air temperature and precipitation affect water resources, such as the outflows of rivers, groundwater recharge or water temperature. Model chains are being developed as a way of modelling these changes. The results of regional climate models are used as input variables for specialist models, such as water balance models or hydraulic models of watercourses.

Changes in the hydrological balance

Groundwater recharge depends on the amount of precipitation and evaporation, which is influenced by temperature. Other influencing factors include the soil type, the geological structure, and the location of the groundwater aquifer in relation to other waterbodies. Human settlement and land use structure also influence the volume of rainwater seepage to form new groundwater.

Regional studies are carried out to investigate changes in groundwater recharge and groundwater supply. The challenge is to distinguish the influence of groundwater use from potential changes in groundwater supply caused by climate change. Water resource management under the Water Framework Directive defines good quantitative status of groundwater as an indicator of groundwater status. Measurement results to date have not yet indicated any impairments to groundwater as a result of climate change. Just under 96 % of groundwater bodies in Germany are in a good quantitative status (see chapter 4.1.2).

Regional differences in groundwater recharge already exist today. Groundwater recharge in the east of Germany is less than in western regions, while groundwater recharge in the south is particularly high. Assuming a "wet scenario", groundwater recharge across Germany will hardly change until the middle of this century. However, if we assume a "dry scenario", moderate decreases in the east and south-east of Germany become apparent[15].

Changes in river basins[16]

No changes in average discharges in the Rhine river basin are anticipated up to the middle of this century (2021 - 2050). However, average discharge in winter is increasing. In areas of the Rhine which are characterised by the snow regime, low water discharge will be rising. Where the discharge regime is characterised by winter rainfall, there are heterogeneous predictions regarding low water discharges. Average high water discharges are rising by up to 20 % due to higher winter precipitation, especially in the region of the Central German Highlands. By the end of the century, average and low water discharges during the summer months will decrease, while in winter, average discharges will tend to increase. Flood-critical threshold values will be exceeded more frequently by the end of the century.

In the Elbe river basin, the model results suggest that it will become slightly drier in the summer half of the year by the middle of the century (-15 % to +5 %). For the winter half of the year and for the annual average, no clear trends have been identified. Annual low water discharges will likewise show a non-uniform pattern. Model calculations suggest that by the end of the century, the average annual discharge and the average discharges in the summer half of the year will decrease (-30 % to +10 %). In winter, there is not even any uniform pattern for the more distant future. For low water discharges, the range will widen to -35 % to +10 %. Water levels will be more frequently below critical threshold values. No forecasts can be given for high water discharges, due to the high level of variability between decades, and the considerable influence of changes in water resource management in the catchment area.

In the Danube catchment area, projections of average winter discharges until the middle of the century vary. For the River Inn and the levels downstream of the Inn tributary, winter discharge levels are already expected to rise in the near future. In summer, discharges in the Danube river basin will decrease in general. Low water discharges along the Danube will also tend to decrease.

2.3 Demographics

The Federal Republic of Germany is a densely populated country in Central Europe. In 2015, around 82.2 million inhabitants were living on an area of 357,375.62 km². With a population density of 227 inhabitants per km², Germany is well above the European average of 116 inhabitants per km². Population densities vary widely between individual Länder. Berlin has the highest population density, with 3,891 inhabitants per km², while Mecklenburg Western Pomerania has the lowest, with just 69 inhabitants per km².

Despite the density of population and the high level of industrialisation, much of which is concentrated in particular geographical regions, over four-fifths of Germany's total area is used for agriculture and forestry. Agriculture accounts for 51.6% and woodland for 30.6%. 13.7 % of the area is used for settlements and traffic. Water accounts for only a small proportion of 2.4 %.

Demographic changes are transforming the population density and structure in Germany. By 2023, experts predict that population figures will be below 2013 levels (80.8 million inhabitants). By 2060, depending on the assumed level of immigration, between 67.7 and 73.1 million people are forecasted to be living in Germany. The age composition of the population is also changing. Whereas 20 to 64-year-olds currently (as at 2013) account for just over 60 % of the population at 49 million, this level will decrease from 2020, and will have fallen by 10 % by 2060. By then, only 34 to 38 million people will be in this age range. Also, by 2060 the proportion of over-65-year-olds will increase from around 20 % (2013) to 32–33 %, and the number of those over 80 years of age will double.

Demographic changes demand adaptations to our water resource management, particularly in settlements. In response to falling volumes of water use, for example, pipeline systems need to be converted to prevent stagnation in drinking water supplies and odour generation in the sewer systems. A higher proportion of elderly people will probably lead to greater consumption of pharmaceuticals, which may place growing pressure on wastewater treatment.

International agreements for marine protection include the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), which includes the North Sea

2.4 Legal framework conditions

Water is a vital and limited resource. There are legal provisions on its sustainable management, designed to protect waterbodies

- as an element of the ecosystem
- as a basic necessity for human life
- as a habitat for animals and plants
- as a usable commodity[17].

The tasks of water resource management are manifold and diverse, and the regulatory framework is equally extensive.

2.4.1 International water legislation

Many environmental problems, such as the greenhouse effect with its impacts on the global climate and hence the water balance, climate protection - and adaptation measures as well as the protection of coastal waters, marginal seas and oceans can only be addressed through global cooperation.

International agreements

Germany cooperates with numerous international organisations in the area of water protection, and is a Contracting Party to a wide range of international environmental protection agreements. Among them marine protection agreements such as the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter and the subsequent Protocol of 1996, MARPOL for the Prevention of Pollution from Ships, the Convention for the Protection of the Marine Environment of the North-East Atlantic including the North Sea (OSlo-PARis Convention–OSPAR), the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM) (see chapter 5.4) and the conventions for transboundary cooperation in the river basins of the Maas, Elbe, Rhine, Danube and Oder, each of which have set up Commissions to jointly address management issues[18].

UNECE Water Convention

The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE Water Convention) was adopted in 1992[19]. In Germany, the Convention has been in force since 1996[20]. 41 countries have signed up to the Convention (as of 2017).

The Water Convention focuses on integrated water resource management in the UNECE region, particularly the protection of transboundary waters, via the avoidance, control and reduction of transboundary pressures. It is also aimed at the appropriate, balanced use of water resources and the conservation and restoration of ecosystems. The UNECE contains general provisions on waterbody management, monitoring and research. It also regulates specific requirements for countries that share waterbodies or river basin districts, such as an obligation to set up coordination committees, to warn one another in case of accidents, and to notify one another of the impacts of any planned projects. Several river basin commissions in Europe are based on the principles of this Convention.

Since its entry into force, the UNECE Water Convention has evolved into an active mechanism for the transboundary management of waterbodies. It provides a platform for the exchange of experience and knowledge. For example, in 2009 and 2015, international workshops were held with experts from various UNECE countries on the challenges of flood risk management in transboundary river basins. As the selection and location of flood protection measures can adversely impact other riparian countries, the exchange of experience and knowledge on water resource management issues often provides the basis for farther-reaching agreements in river basins where political tensions exist.

Given the current threats to the quantity and quality of water resources (e.g. associated with the impacts of climate change), there is ever-growing interest in the Convention's work, even from non-ECE countries. In February 2013, this prompted the opening up of the UNECE Water Convention, and as of 1 March 2016, non-ECE countries may now also become Parties to the Convention.

The causes of water-related diseases include inadequate drinking water supply or wastewater disposal, poor water resource management or inadequate quality of bathing waters and swimming pool waters, and the inappropriate use of sewage sludge in agriculture. As a supplement to the UNECE Water Convention, the Protocol on Water and Health aims to improve the protection of public health from water-related diseases. Germany has been a Party to the Protocol since April 2007[21].

Within two years of becoming a signatory to the Protocol, Parties are required to define specific targets and objectives, tailored to their national conditions, for preventing, tackling and reducing water-related diseases in future.

UN Convention on the Law of the Non-Navigational Uses of International Watercourses

Germany is a Party to the United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses[22], adopted on 21 May 1997. This first ever universal water convention entered into force on 17 August 2014, 17 years after it was negotiated. Germany had already ratified the Convention in 2007.

The Convention aims to improve collaboration and consideration between littoral states and, in particular, to avoid and peacefully resolve intergovernmental conflict over limited freshwater resources.

2.4.2 Influence of EU water legislation

The European Union (EU) has been concerned with water protection since the 1970s. Since 2000, its central instrument in this regard has been the Water Framework Directive (WFD)[23]. Its material and procedural guidelines provide Member States with a legal framework for the management of EU waters.

The Directive's broad-based protective approach includes the protection of inland surface waters, transitional waters, coastal waters and groundwater. Its principal aim is to ensure good status of all waterbodies within the EU. As well as improving aquatic ecosystems, this also entails preventing any further deterioration. The WFD also pursues a strategy of sustainable water use based on the long-term protection of resources. This interpretation of water protection has both quantitative and qualitative dimensions, and combines an ecologically-focused approach with a water resource management-based, quantitative approach, with the aim of achieving a sensible balance between uses and protection.

The WFD includes the concept of river basin management as a system of trans-regional / transnational management based on river basin districts (Figure 2), which the Member States implement with a programme of measures and a management plan (see chapter 5.1).

The WFD is supplemented by its “daughter” directives (Groundwater Directive, Environmental Quality Standards Directive). Other key directives on water protection include the Marine Strategy Framework Directive (see 5.4), the Flood Risk Management Directive (see 5.5), the Industrial Emissions Directive (see 6.4.1), the Urban Waste Water Treatment Directive (see 6.1.2), the Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources (see 6.3.1), and the Bathing Waters Directive (see 6.8.2). EU Directives are binding for Member States, and must be transposed into national law. If national law is incompatible with the Directives, it must be repealed, tightened up or redesigned in line with EU guidelines.

Germany has transposed the requirements of the WFD fully to national legislation through its Federal Water Act, its Surface Water Ordinance and Groundwater Ordinance. The Länder are responsible for preparing the programmes of measures and management plans, and for enforcing regulations. Within Germany, the Federation and the Länder are jointly responsible for implementing the objectives of Directives, but vis-à-vis the EU, the Federation has sole responsibility.

Figure 11 shows the principal provisions of water resource management at EU level and the corresponding regulations at Federal Government level.

2.4.3 The Federal Water Act and its ordinances

The decisive national law relating to water resource management is the Federal Water Act (Wasserhaushaltsgesetz, WHG)[24], which legislates a regulated management of surface and groundwater in terms of their quality and properties, and to control human interventions into waterbodies. The Federal Water Act states that waterbodies, as a component of the ecosystem and as a habitat for fauna and flora, must be protected and managed in such a way as to serve the general public

Figure 11

Principal legal provisions of water resource management

<table>
<tr><th>Level</th><th colspan="6">Regulations</th></tr>
<tr><td rowspan="6">EU</td><td rowspan="2">Water Framework Directive (WFD)</td><td rowspan="3">Urban Wastewater Treatment Directive</td><td rowspan="6">Drinking Water Directive</td><td rowspan="6">Nitrates Directive</td><td rowspan="6">Flood Risk Management Directive</td><td rowspan="6">Marine Strategy Framework Directive (MSFD)</td></tr>
<tr></tr>
<tr><td rowspan="2">Groundwater Directive (GWD)</td></tr>
<tr><td rowspan="3">Industrial Emissions Directive (IED)</td></tr>
<tr><td rowspan="2">Environmental Quality Standards Directive (EQSD)</td></tr>
<tr></tr>
<tr><td rowspan="12">National</td><td rowspan="3">Federal Water Act (WHG)</td><td rowspan="4">Federal Water Act</td><td rowspan="12">Drinking Water Ordinance (TrinkwV)</td><td rowspan="6">Fertilizer Act (DüngG)</td><td rowspan="12">Federal Water Act</td><td rowspan="12">Federal Water Act</td></tr>
<tr></tr>
<tr></tr>
<tr><td rowspan="3">Groundwater Ordinance (GrwV)</td></tr>
<tr><td rowspan="4">Waste Water Charges Act (AbwAG)</td></tr>
<tr></tr>
<tr><td rowspan="3">Surface Waters Ordinance (OGewV)</td><td rowspan="6">Fertilizer Ordinance (DüV)</td></tr>
<tr></tr>
<tr><td rowspan="4">Waste Water Ordinance (AbwV)</td></tr>
<tr><td rowspan="3">Ordinance on Installations for Handling Substances Hazardous to Water</td></tr>
<tr></tr>
<tr></tr>
<tr><td>Länder</td><td colspan="6">Federal states’ legislation (laws/ordinances, licences, notices, monitoring)</td></tr>
</table>

Source: German Environment Agency

interest and, in harmony with this, must benefit the individual, while refraining from any avoidable impairments to its ecological function (precautionary principle). A high level of protection for the environment as a whole must be ensured.

The targets and management provisions of the Water Framework Directive are a central element of the Federal Water Act. The details set out in the "daughter directives" (EQS Directive, Groundwater Directive) have been transposed into statutory ordinances (Surface Waters Ordinance (Oberflächengewässerverordnung, OGewV), Groundwater Ordinance (Grundwasserverordnung, GrwV)). § 23 of the Federal Water Act (WHG) contains comprehensive powers for the Federal Government to adopt statutory ordinances on waterbody management in line with the management objectives. These powers offer the opportunity to detail the lean provisions in the WHG, and also serve the uniform nationwide implementation of EU law.

As a general principle, waterbodies[25] are managed by the government. All uses of water (such as the discharge of substances or the abstraction of water) are subject to official authorisation, apart from a few exceptions. This is intended to prevent impairments to the water regime and enforce a precautionary approach to water protection.

Generally speaking, permits are issued at the discretion of the responsible water authority (management discretion). In certain cases, this discretion is restricted to the protection of waterbodies. For example, a permit to discharge wastewater may only be granted provided certain minimum requirements are met. These minimum requirements, which reflect the best available technology and which are differentiated according to branches of trade and industry, are outlined in greater detail in the Federal Government's Wastewater Ordinance (see chapter 6.2.1).

Special provisions apply to installations that handle substances hazardous to water. Graduated according to the volume and degree of hazard posed by such substances, these are intended to eliminate the risk of disadvantageous changes to the waterbody's properties[26]. The new German Ordinance on Installations for Handling Substances Hazardous to Water (Anlagenverordnung zum Umgang mit wassergefährdenden Stoffen, AwSV) replaces the previously valid regulations at Länder level, and defines the requirements applicable to such installations and the procedure for classifying substances hazardous to water (see chapter 6.4.4).

Other key provisions in the WHG also regulate the construction and operation of wastewater treatment plants, the duties of water conservation officers, engineering measures on waterbodies, preventive flood protection, and the designation of water protection areas in the interests of water supply.

Next to the requirements of the WFD, the WHG also uniformly transposes the content of the Marine Strategy Framework Directive (MSFD) and the Flood Risk Management Directive (FRMD) into national law.

Surface waters

The management concept of the European WFD for surface waters is outlined in §§ 27 - 31, § 82 and § 83 of the WHG. These regulate the management objectives to be achieved for surface waters, as well as the required deadlines and admissible exceptions from the prescribed objectives and deadlines (see chapter 5.1).

The Surface Waters Ordinance (Oberflächengewässerverordnung, OGewV)[27] sets out the statutory provisions in greater detail and implements the Environmental Quality Standards Directive[28], the Directive laying down technical specifications for chemical analysis[29] and the EU Intercalibration Decision[30]. The OGewV is aimed at the coherent, comprehensive enforcement of EU law relating to the protection of surface waters.

The content of the Regulation includes:
- Nationwide regulation to ensure equivalent standards of protection for surface waters in Germany
- Requirements governing the characteristics of surface waters with uniform specifications on the chemical status (adoption of the Environmental Quality Standards Directive) and the ecological status (adoption and completion of the intercalibration decision on uniform requirements for biological quality elements, and the specification of national environmental quality standards for river

basin-relevant pollutants)
- Regulations governing the categorisation, typification and demarcation of surface water-bodies and defining reference provisions
- Provisions for conducting the audit and monitoring programmes, requirements governing the analysis techniques to be used, and quality management systems.

Groundwater
The specific management objectives to be met for groundwater are anchored in § 47 of the Federal Water Act (WHG). Groundwater must be protected nationwide, and its natural properties preserved. The Act standardises a ban on degradation and a requirement to preserve and rehabilitate, with regard to both the quantitative and chemical status of the waterbody. More specific provisions on achieving the management objectives may be found in the Groundwater Ordinance[31], which transposes the EU Groundwater Directive[32] into German law.

The content of the ordinance includes:
- criteria for the characterization, assessment, classification and monitoring of the groundwater status and for the identification and reversal of significant and sustained upward trends in pollutant concentrations in groundwater bodies,
- specification of threshold values for the assessment of chemical status,
- the aim of preventing and limiting the input of pollutants into groundwater and thereby preventing a deterioration in the groundwater status,
- preserving or restoring good quantitative and good chemical status,
- reversing significant pollutant trends.

Coastal and marine waters
Based on the provisions for surface waters, § 44 of the Federal Water Act (WHG) formulates management objectives for coastal waters. However, the scope of application is confined to those parts of coastal waters which, in accordance with § 7, paragraph (5), sentence 2 of the Federal Water Act, are assigned to one of the river basins that have been created for surface waters (Figure 2). With regard to chemical status, the entire portion of the sea up to the 12 nautical-mile limit is covered.

§§ 45a to 45l of the Federal Water Act transpose the requirements of the Marine Strategy Framework Directive (MSFD)[33] into national law. The management targets for marine waters are defined in § 45a, paragraph (1) of the Federal Water Act, and state that any further deterioration in the status of marine waters is to be avoided and good status achieved or maintained by 31 December 2020 (see chapter 5.4).

Other water-related legislation
Alongside provisions governing the use of waterbodies, the effective regulation of water resources must also serve other purposes, including economic ones. Over the course of time, numerous laws have arisen which affect water resource issues in a myriad of ways.

Wastewater Charges Act
The Wastewater Charges Act (Abwasserabgabengesetz, AbwAG)[34] regulates the levying of charges for the direct discharge of wastewater into a waterbody. By requiring direct dischargers to bear at least part of the costs associated with their use of the environmental medium water, the AbwAG translates the polluter-pays principle into practice. The charge is based on the quantity and toxicity of certain discharged constituents[35] (see chapter 6.1.1).

Federal Waterways Act
The Federal Waterways Act[36] covers Germany's inland waterways that are used for general traffic, and its lake waterways. It primarily concerns legal guidelines for waterways, but also contains some references to water legislation.

Act on the Environmental Compatibility of Washing and Cleansing Agents (Washing and Cleansing Agents Act)
The Washing and Cleansing Agents Act[37] sets out requirements governing the biodegradability of water-polluting washing and cleansing agents.

Water Organisation Act
The Water Organisation Act[38] regulates the organisation of public-law associations assigned responsibility for water resource management tasks in a defined area.

Act on the Assessment of Environmental Impacts
The Act on the Assessment of Environmental Impacts[39] covers water-related projects, such as large wastewater treatment plants or river engineering measures, the construction or expansion of which requires an environmental impact assessment or strategic environmental assessment.

Environmental Damages Act

The Environmental Damages Act[40] covers water damage as defined in § 90 of the Federal Water Act (§ 2, para. (1B) Environmental Damages Act). This states that any damage with significant adverse impacts on the waterbody status constitutes water damage within the meaning of the Environmental Damages Act.

German Penal Code

The Penal Code[41] regulates the criminality of deliberate and negligent water pollution, see § 324.

Legislation with a protective effect for water

Federal Nature Conservation Act[42]

Water legislation and nature conservation legislation both adopt an overarching environmental approach, as illustrated by the objectives of the Federal Water Act and the Federal Nature Conservation Act, as well as the definitions and provisions in both Acts. However, the management of waterbodies as an element of the ecosystem and as a habitat for fauna and flora, as outlined in the Federal Water Act, illustrates a potential conflict of interests between water protection and nature conservation, particularly with regard to the usage interests in waterbodies.

Federal Soil Conservation Act[43]

There is a close connection between soil and waterbodies. Soil conservation measures may have a water-protecting effect, at least indirectly. What is more, soil uses can restrict the water-related functions of soil (such as its filtering function).

Circular Economy Act[44]

The requirements governing the avoidance, recovery and disposal of waste set out in the Circular Economy Act also benefit waterbodies by ensuring that pollutant discharges into waters are minimised.

There are also other fields of law which contribute to avert potential threats to the hydrological regime other than water legislation itself. These include immission control legislation, chemicals legislation, regional planning legislation, radiation protection legislation, environmental protection-related agricultural legislation (such as the Fertiliser Ordinance) and construction legislation.

General environmental legislation spanning multiple fields and media, such as the Environmental Liability Act, the Environmental Appeals Act and the Environmental Information Act also plays a key role, and helps to protect waterbodies.

Health legislation such as the Infection Protection Act and, based on this, the Drinking Water Ordinance, likewise partially affects water legislation (see chapter 6.1.1).

2.4.4 Water legislation of the Länder and municipalities

The water-related provisions of the Länder (including Land Water Acts) complement the national provisions and serve to implement them. The Länder have made varying use of the right to deviate from national law (Federal Water Act) granted to them by Article 72, paragraph (3) of Germany's Basic Law.

The Land Water Acts are further complemented by various other regulations including ordinances and administrative provisions. The municipalities may likewise adopt binding provisions within their areas of sovereignty. Examples of such regulations include those concerning connection to public water supply and wastewater disposal facilities, discharges into wastewater facilities, the levying of cost-recovering fees, and charges for water abstraction.

2.5 Structures and cooperation in water resource management

2.5.1 Organisation of water resource management in Germany

Water protection is a joint task for the Federation, Länder and municipalities. Progressive water protection is reliant on pertinent cooperation between all levels of government. Whereas the municipalities are, on the one hand, part of the Länder level, on the other, they also have their own scope (right to self-administration) which is protected in constitutional law[45].

A distinction must be made between legislative powers, the competence to enforce regulations, and financial responsibility. The expenditure associated with exercising their duties is borne separately by the Federal Government and the Länder.

In the field of water management, concurrent legislation rests with the Federation[46], authorizing it to adopt detailed water resource management provisions such as those contained in the Federal Water Act (WHG). Alongside this, the Länder may only adopt provisions, provided and to the extent that the Federation has not completely exhausted its legislative competence, leaving scope for provisions by the Länder. Furthermore, the Länder may adopt alternative provisions from the provisions of the Federal Water Act, except for regulations governing materials and installations[47].

Organisation of water resource management within the Federal Government

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is responsible for regulating fundamental issues relating to water resource management in the relevant Federal legislation[48]. It also represents Germany's interests externally within the context of transboundary cooperation, and when formulating water protection regulations at EU level.

Environmental policy projects, programmes and opinions, particularly legislative initiatives, must be coordinated between the Federal Ministries concerned. The following Federal Ministries are the principal partners of the BMUB; to a certain extent, they also perform independent tasks in the field of water resource management:

The Federal Ministry for Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft, BMEL)

- The BMEL promotes water resource management projects in the rural sector, including flow regulation and flood protection measures. It is responsible for coastal protection of the North and Baltic Seas within the framework of the Joint Task for the Improvement of Agricultural Structures and Coastal Protection (GAK), and for fertiliser and plant protection legislation.
- *Federal Ministry of Health (Bundesministerium für Gesundheit, BMG)*: The BMG is responsible for matters of drinking water supply (drinking water quality as part of health care) and pool bathing water quality. It is also responsible for pharmaceutical licensing.
- *Federal Ministry for Transport and Digital Infrastructure (Bundesministerium für Verkehr und digitale Infrastruktur, BMVI):* The BMVI is responsible for the administration of Federal waterways and navigation. It is responsible for all matters relating to shipping and the carriage of dangerous goods on maritime and inland waterways. Together with the coastal Länder, it is responsible for combating the pollution of coastal waters with oil and other contaminants.
- *Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF)* The BMBF coordinates the Federal Government's research promotion efforts, and coordinates basic research, applied research, technological development and innovation, including the areas of water research and water technology.
- *Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie, BMWi).* The BMWi is responsible for those areas of the law affecting key framework conditions, including those in the water resource management sector, such as cartel and contract allocation law. It is also responsible for restructuring Germany's energy supply in favour of renewables, including hydropower.
- *Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, BMZ).* The BMZ is responsible for principles matters and coordination of all bilateral and multilateral German development cooperation, of which water resource management-related issues (such as a safe drinking water supply and wastewater disposal) constitute a key part.

In executing its tasks in the field of water resource management, the BMUB is assisted by the following Federal authorities and research institutions:

Subsidiary to the BMUB:

- German Environment Agency (Umweltbundesamt, UBA)
- Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN)
- Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS)
- Federal Office for the Safety of Nuclear Waste Management
- Federal Agency for Building and Regional Planning with the Federal Institute for Research on Building, Urban Affairs and Spatial Development

Subsidiary to the BMVI:

- Federal Institute of Hydrology (Bundesanstalt für Gewässerkunde, BfG)
- Federal Maritime and Hydrographic Agency (Bundesamt für Schifffahrt und Hydrologie BSH)
- Federal Waterways Engineering and Research Institute (Bundesamt für Wasserbau, BAW)
- German Meteorological Service (Deutscher Wetterdienst, DWD)

Subsidiary to the BMG:
- Federal Institute for Drugs and Medical Devices (Bundesinstitut für Arzneimittel und Medizinprodukte, BfArM)

Subsidiary to the BMEL:
- Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries (TI)
- Julius Kühn Institute, Federal Research Centre for Cultivated Plants (JKI)
- Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung, BfR)

Subsidiary to the BMWi:
- Federal Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe, BGR)
- Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und -prüfung, BAM)

Water resource management by the Länder

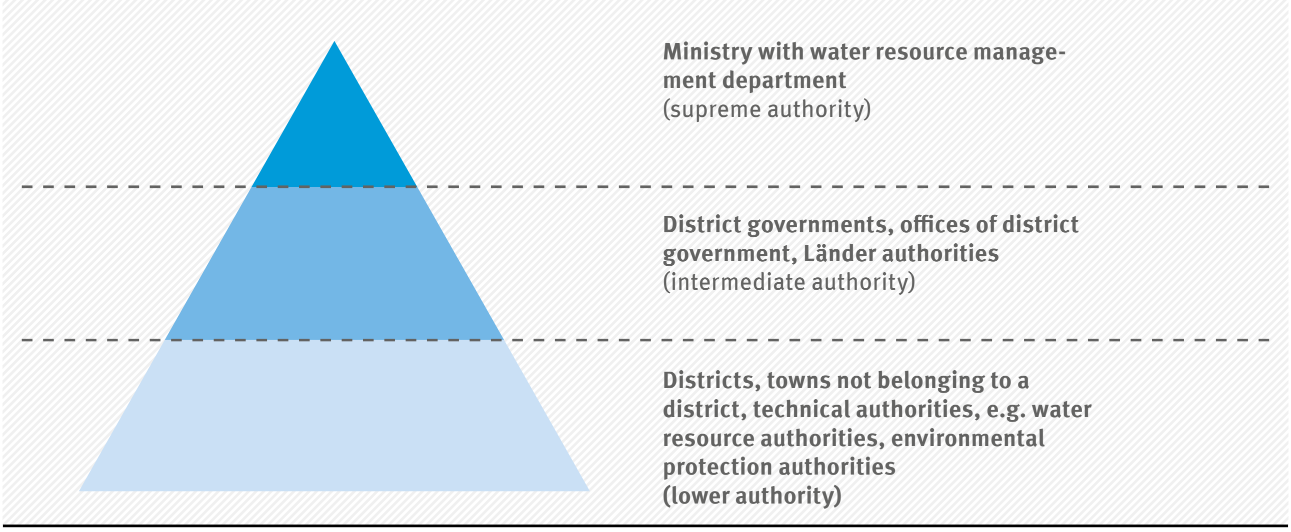
The enforcement of water resource management regulations is the responsibility of the Länder and the municipalities[49]. The Federal waterways are an exception to this rule: their maintenance and development vis-à-vis traffic requirements fall under the exclusive control and administration of the Federal Government. Some Länder have a two-tier structure with no intermediate tier. However, the majority of Länder follow a three-tier structure (Figure 12).

The assignment of tasks varies from state to state. Generally speaking, the Ministries are responsible for the control of water resource management and the implementation of overarching administrative procedures. They are also responsible for legislation at Länder level and the supervision of intermediate and lower water authorities. The intermediate authorities are involved in regional water resource management planning and important legislative procedures relating to water.

The lower water authorities are responsible for:
- Technical advice
- Monitoring of waters
- Licensing of facilities in and on waterbodies
- Approval of water use
- Authorisation to traverse non-navigable waters
- Approval of wastewater facilities and monitoring of wastewater discharges
- Processing notifications on the handling of substances hazardous to water

Figure 12

Three-tier administrative structure in water resource management



Source: German Environment Agency

- Receiving notices about water pollution
- Conducting waterbody and dyke inspections
- Ordering protection works when there is a risk of flooding
- Fines and compensation
- Asserting existing rights and authorisations
- Rainwater management

The so-called central Länder authorities, such as the State Institutes for Environmental Protection, Water Resource Management, Water and Waste, are also tasked with handling the extensive duties associated with water resource management. They perform technical functions such as hydrology, waterbody monitoring, water resource management planning, technical advice, and the preparation of technical guidelines. The central Länder authorities usually report directly to the most senior authorities, i.e. the ministries.

Working Group of the Federal States on Water Issues

The Federation and Länder have joined forces in the "Working Group of the Federal States on Water Issues" (LAWA) to coordinate shared issues. Cross-Länder and joint water resource management and water legislation issues are debated in LAWA, and solutions drawn up. The Länder mainly use LAWA recommendations as an implementation aid for enforcement[50].

Water resource management by the local authorities

The local authorities perform a number of important environmental protection-related tasks in enforcing the environmental legislation of the Federation and Länder. Their decisions help to shape the local environment for residents.

This public service is part of the local authority self-administration. It includes organising water supply, i.e. supplying the general public with drinking water and service water, and the disposal of wastewater. The local authorities levy charges on users (contributions and fees) to meet the associated costs.

The Federal Ministry of Transport and Digital Infrastructure is responsible for all matters related to shipping and transportation of dangerous goods on maritime and inland waterways.

To ensure the autonomous and effective implementation of water supply and wastewater disposal, the local authorities may draw on a variety of operating forms. For this reason, a highly differentiated supply structure has emerged in Germany. Public-law operating forms, such as publicly owned enterprises, municipal undertakings, public law institutions, special-purpose organisations and water associations, are most commonly involved in the completion of tasks. Some Länder have legislation allowing tasks to be transferred to a private company. It is important to ensure that a functioning water supply can be guaranteed in the general public interest.

Other key tasks of the local authorities include maintaining smaller waterbodies and development planning. Within the context of urban land use planning, local authorities can play a pivotal role in flood prevention, for example.

Associations and technical associations

In Germany, cooperation between local authorities in associations is essential in helping to ensure that water supply, wastewater treatment and waterbody maintenance are organised effectively from a technical and financial perspective. The associations vary in terms of their assigned tasks, their regional coverage and organisational form:

- Special-purpose organisations as associations under public law
- Water and soil associations as defined in the Water Organisation Act
- Water associations for river basins in the industrial region of Rhine/Westphalia on the basis of special legislation (e.g. Ruhr Association).

Various technical/scientific associations are also concerned with the objectives of water resource management. Scientists, associations and politicians (Federation, Länder, local authorities) are usually represented in these associations. These technical organisations have prepared numerous technical regulations, most of which are recognised and applied as generally accepted technical standards.

- *Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall* (German Association for Water, Wastewater and Waste, DWA)
- *Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau* (Federation of Engineers for Water Resource Management, Waste Management and Agricultural Engineering, BWK)
- *Deutsche Gesellschaft für Limnologie* (German Limnology Association, DGL)
- *Deutsches Institut für Normung* (German Institute for Standardisation, DIN), represented by the *Fachnormenausschuss Wasserwesen* (Water Sector Standards Committee, NAW)
- *Deutscher Verein des Gas- und Wasserfaches* (German Association of Gas and Water Experts, DVGW)
- Other associations representing large numbers of water utilities and wastewater disposal bodies include:
- *Verband kommunaler Unternehmen e.V.* (German Association of Local Utilities, VKU)
- *Bundesverband der Energie- und Wasserwirtschaft e.V.* (German Association of Energy and Water Industries, BDEW)
- *Allianz der öffentlichen Wasserversorger e.V.* (AöW).

Involvement of the public

Under the provisions of water legislation and administrative law, the general public may give its opinion in written or verbal form on large projects such as waterbody development projects.

In implementing the WFD, the competent authorities are required to encourage the active involvement of the general public in water resource management planning. The general public must also be given the opportunity to voice its opinion at three separate stages during the formulation of management plans. This requires the involvement, firstly, of the organised general public, i.e. all environmental protection organisations as well as all other interest groups (e.g. from industry, agriculture, shipping and tourism), as well as of each and every individual. The Floods Directive and the MSFD contain similar provisions on the involvement of the general public. At national level, these participation options are guaranteed by §§ 45 i, 79 and 85 of the Federal Water Act. For water resource management projects requiring an environmental impact assessment, members of the public affected by the project are additionally consulted within the context of this procedure.

Recent examples include:

- Information and network activities about the WFD by Grüne Liga.
- Support of and information about the “blue

ribbon" scheme for waterways by Naturschutzbund Deutschland e.V. (Nature and Biodiversity Conservation Union, NABU)
- Environmental education project about plastic litter in the sea by the youth wing of NABU e.V.

Support for environmental and nature conservation associations

The BMUB and UBA support environmental and nature conservation associations with a view to anchoring environmental policy concerns in society. The projects they support are designed to raise awareness of and encourage commitment to environmental protection and nature conservation. Attention is focused primarily on projects that address major topical issues, children's and youth's projects with wide-ranging effects, projects designed to promote environmental awareness and environmentally-friendly practices, and measures aimed at environmental advice and education. Associations that promote water protection projects represent an important target group in this respect[51].

2.5.2 Cooperation between the European Union and its Member States

Water protection is a transboundary challenge, and for this reason, cooperation between the Member States and the European Union is exceptionally important. Differences in environmental standards could hamper the free traffic of goods within the single European market.

As a Member State of the EU, Germany is both involved in the drafting of EU legislation and bound by it. As the EU institutions do not have their own enforcement competencies, the Member States are responsible for implementing EU law in practice. Within Germany, extensive coordination and representation efforts are needed, because the Federation is responsible for implementing EU law vis-à-vis the EU, while the Länder are responsible for enforcement within Germany.

Generally speaking, EU Directives do not become valid law until they have been transposed into national law. As EU regulations are often not comprehensive, Member States are at liberty to adopt their own regulations for unregulated areas. Furthermore, the Member States generally have the option of exceeding the EU regulations, i.e. enforcing more stringent environmental protection requirements, if an area is not conclusively regulated by EU law.

2.5.3 International cooperation

Germany cooperates with numerous international organisations on water protection, and is a Contracting Party to a wide range of international environmental protection agreements (chapters 1.4 and 2.1.4).

Germany's international cooperation with other countries on water resource management-related topics takes the form of political dialogues, administrative partnerships, and various forms of project cooperation. Alongside various EU instruments (Twinning[52], Taiex[53]), the BMUB also uses its Advisory Assistance Programme[54] and the Export Initiative for Environmental Technologies[55]. The partners and implementing organisations of project cooperation include government authorities, companies, and German water industry associations, such as the German Water Partnership initiative, environmental associations and international organisations such as UNECE, OECD and WHO.

Cooperation with Central and Eastern European countries and with EECCA countries[56]

Water resource management and water protection are key priorities in the Federal Republic of Germany's international cooperation with the countries of Central and Eastern Europe, the Caucasus and Central Asia. This includes sharing knowledge and experience, exchanging technology recommendations, and preparing environmental investments in a variety of bilateral and multilateral contexts. Apart from international conventions and their protocols (see chapter 1.4), this cooperation is based on EU Regulations and Directives, as well as bilateral government and divisional agreements with selected countries in these regions.

Germany is also actively involved in the EU water initiative "EUWI - Water for Life"[57]. This initiative adopts a partnership-based approach with national governments, donors, the water industry, NGOs and other interest groups. Its so-called National Policy Dialogues are designed to encourage to greater coordination and cooperation between various different players in the EECCA countries (Eastern Europe, the Caucasus and Central Asia: includes Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kurdistan, the

Republic of Moldavia, Russia, Tajikistan, Turkmenistan, the Ukraine and Uzbekistan), with the aim of improving water management and ensuring more effective development cooperation in the water sector.

German Water Partnership (GWP)

The water sector is a global future market. There is a huge demand for investment in proper water supply and wastewater disposal in Eastern Europe, in the newly industrialising countries of Asia and Central and South America, and last but not least, in developing countries. Furthermore, global demand for innovative solutions for the efficient use of scarce water resources, for example in industry and agriculture, will be increasing. The focus here is not solely on modified and innovative technology; but also on cooperation in solving water resource management challenges, as a key priority for Germany's development work.

The German water industry can offer wide-ranging expertise and technological solutions. For years, the German water industry and the political debate surrounding the modernisation of the German water industry have essentially agreed on the need to improve the German water industry's global image, raise its profile, and combine its wide-ranging skills and services more effectively.

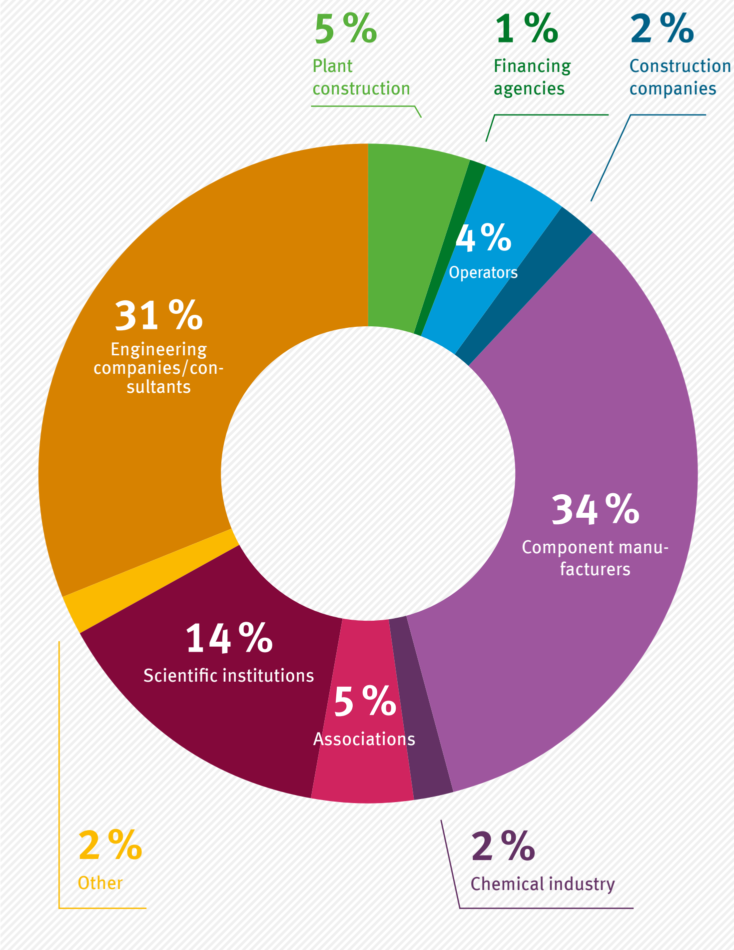
Against this backdrop, in April 2008 a group of dedicated representatives from the German water industry and water research sector, with the support of the Federal Government, set up the German Water Partnership.

GWP is a successful, innovative network with around 350 members[58] at present, made up of private and public-sector companies in the water sector, specialist organisations, and institutions from academia and research.

The German Water Partnership brings together the activities, information and innovations of the German water sector with a view to strengthening Germany's competitive situation on the international markets and working to resolve water resource management problems worldwide with an integrated, sustainable approach. Dedicated country forums draw up water resource management solutions tailored to that particular country, initiate community projects, and develop long-term contacts. In New Delhi, for example, the first energy-autarchic system for local drinking water supply was built by Autarcon GmbH in collaboration with its partner SolarSpring[59]. Countless other examples are presented on the respective country forums on the GWP website[60]. The German Water Partnership is a central point of contact for enquiries from abroad regarding the German water industry.

Figure 13

Membership composition of the German Water Partnership



Source: German Water Partnership, http://www.germanwaterpartnership.de/ as at September 2016

2.6 Organisation of water supply and wastewater disposal in Germany

2.6.1 Water supply

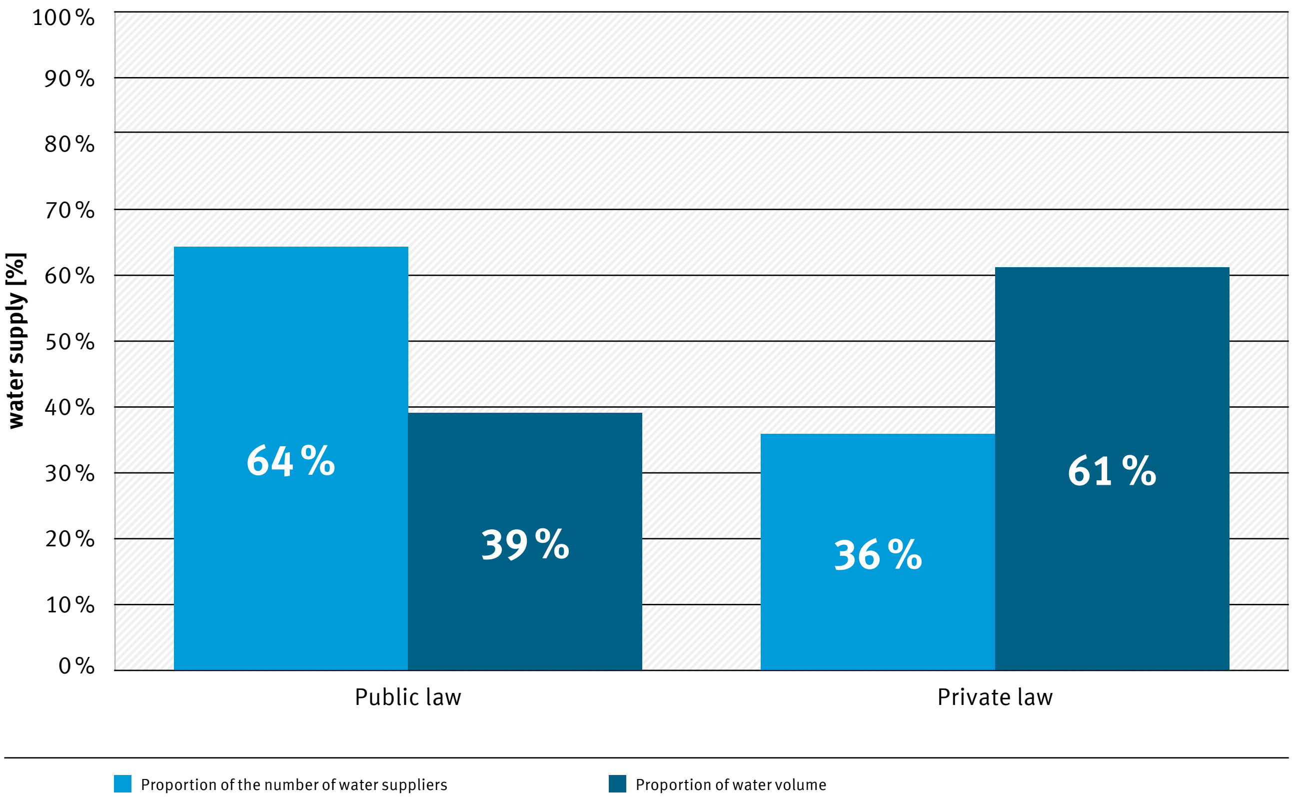
In accordance with the constitutions and/or water legislation of the Länder, drinking water supply is essentially the responsibility of local government, within the context of its public service mandate pursuant to Article 28, paragraph (2) of Germany's Basic Law. The municipalities and local authorities may exercise this duty in a sovereign capacity or else appoint private companies to do so on their behalf. In many cases, smaller towns and communities in rural areas form special-purpose organisations which often cooperate with similar organisations for both water supply and wastewater disposal. The basic aim of these special-purpose associations is to join forces and thus create more favourable business conditions combined with the necessary technical expertise in the management and execution of their work. These associations formulate targets for the water supply companies in their area and operate as supervisory bodies. Responsibility under public law therefore remains with local government (see also chapter 6.1.1).

In 2013, some 5,948 companies and operations were responsible for water supply in Germany[61]. Statistical surveys show that of these, 1,631 companies covered around 80% of the total volume of water transported by the public water supply system in Germany. In 2015, 64% were organised under public law and 36% under private law[62]. 61% of the water volume was provided by private companies (Figure 14).

The dominant form of organisation under public law is the special-purpose association (accounting for just under 19% of water volume) (Figure 15). Among organisational forms under private law, the mixed public/private company in the form of an AG/GmbH (18% of water volume) is the most common.

Figure 14

Forms of organisation under public and private law in public water supply



Source: BDEW-Wasserstatistik 2015 (based on: 1,631 companies) Water volume includes water abstraction plus water procurement

2.6.2 Wastewater disposal

Public wastewater disposal in Germany is a government task executed by municipalities and cities as a public responsibility (see 2.4.4 "Water resource management by the local authorities"). With just under 7,000 local authority wastewater management enterprises, the German wastewater sector is divided into extremely small units[63].

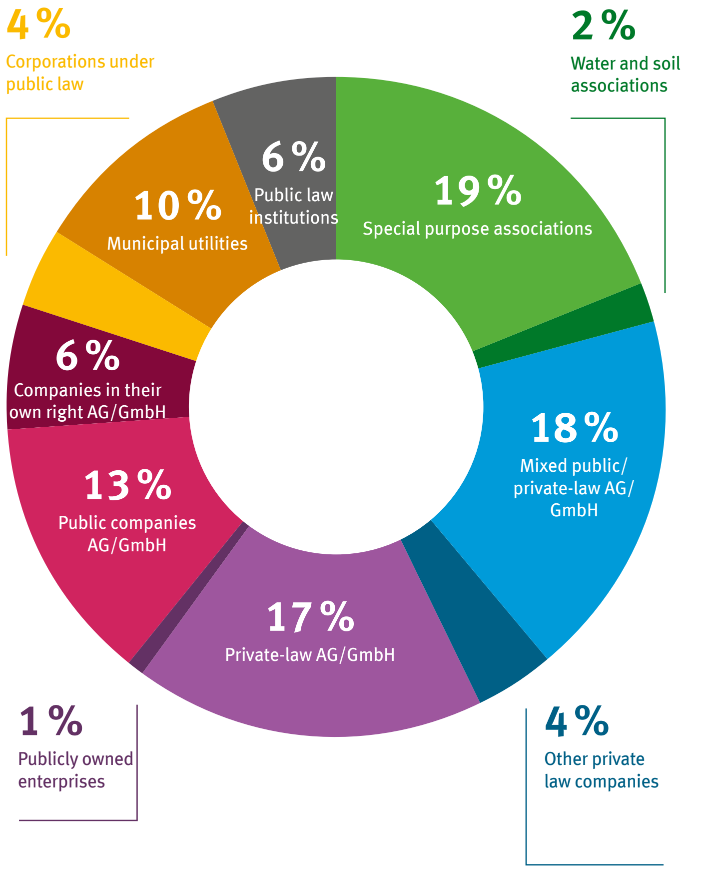
The potential operating forms are classified as follows:

- Publicly owned enterprise: Operated by the community within the context of general community administration
- Municipal utility: Operated by the community as a special asset with separate book-keeping
- Company in its own right: Enterprise under private law owned by the community.
- Operator model/cooperation model: Plant operation is transferred to a private contractor, while responsibility for the completion of tasks remains with the community. In Germany, a particular role is played by (usually) voluntary, in some cases Land-regulated cooperation between local authorities in associations, in order to ensure the efficiently structured organisation of water supply, wastewater treatment and waterbody maintenance from a technical and financial viewpoint, also with regard to waterbody conservation. These associations vary in terms of their assigned tasks, regional coverage and organisational form:
  - Special-purpose organisations as associations under public law
  - Water associations as defined by the Water Association Act or on the basis of special legislation (e.g. Ruhrverband (Ruhr Association)).

Wastewater disposal in Germany is predominantly carried out by public-law companies. They are dominated by municipal utilities, accounting for a share of 35%, together with special purpose/water associations of multiple local governments (single purpose association/ wastewater association) with 34% (as a percentage of inhabitants). Public-law corporations account for a further 16%. These are primarily found in the cities of Berlin and Hamburg[64]. Publicly-owned enterprises account for 7%.

Figure 15

Company forms in public water supply

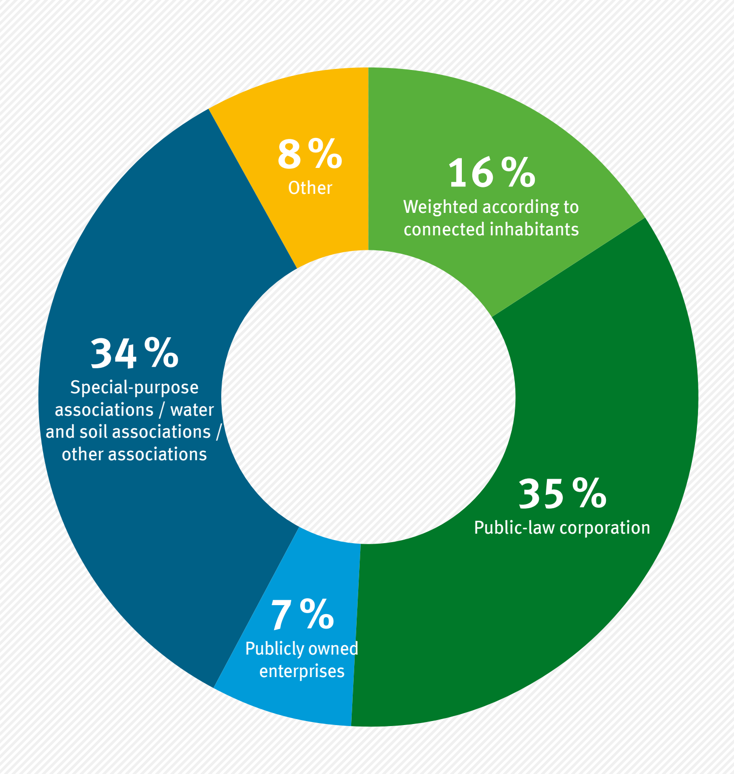


Source: BDEW-Wasserstatistik 2015 (based on: 1,631 companies)

Wastewater disposal essentially comprises two main tasks: wastewater discharge via the sewer networks or wastewater pumping trucks (so-called rolling sewers), and wastewater treatment in plants. Both tasks may be mandated to various companies by the local authority.

Figure 16

Organisational forms of wastewater disposal weighted according to number of inhabitants



Source: DWA-Wirtschaftsdaten der Abwasserbeseitigung 2014 (In: Branchenbild der deutschen Wasserwirtschaft 2015)

2.7 Water use in Germany

Over a multi-year average, Germany has at its disposal potential water resources of 188 billion m³ (see chapter 2.1.4). In 2013, the total volume of water abstracted was 25.1 billion m³. Statistically speaking, water abstractions are divided into the sectors public water supply, mining and manufacturing industry, energy extraction and agriculture.

The public water supply serves private households as well as small businesses such as doctors' surgeries, bakeries, solicitors' offices and hairdressers. Commercial clients, such as the retail sector and others e.g. schools, nurseries and hospitals, are also connected to the public water supply. The manufacturing sector includes factories producing all types of merchandise, such as food, drinks, clothing, pharmaceuticals, metals, vehicles etc. These businesses abstract water themselves, but also take water from the public network or from other businesses. For the most part, the energy supply sector abstracts the water it needs itself. Agriculture and forestry is considered a separate sector.

In 2013, industry, commerce and private households used 13.3% of renewable water resources in total.

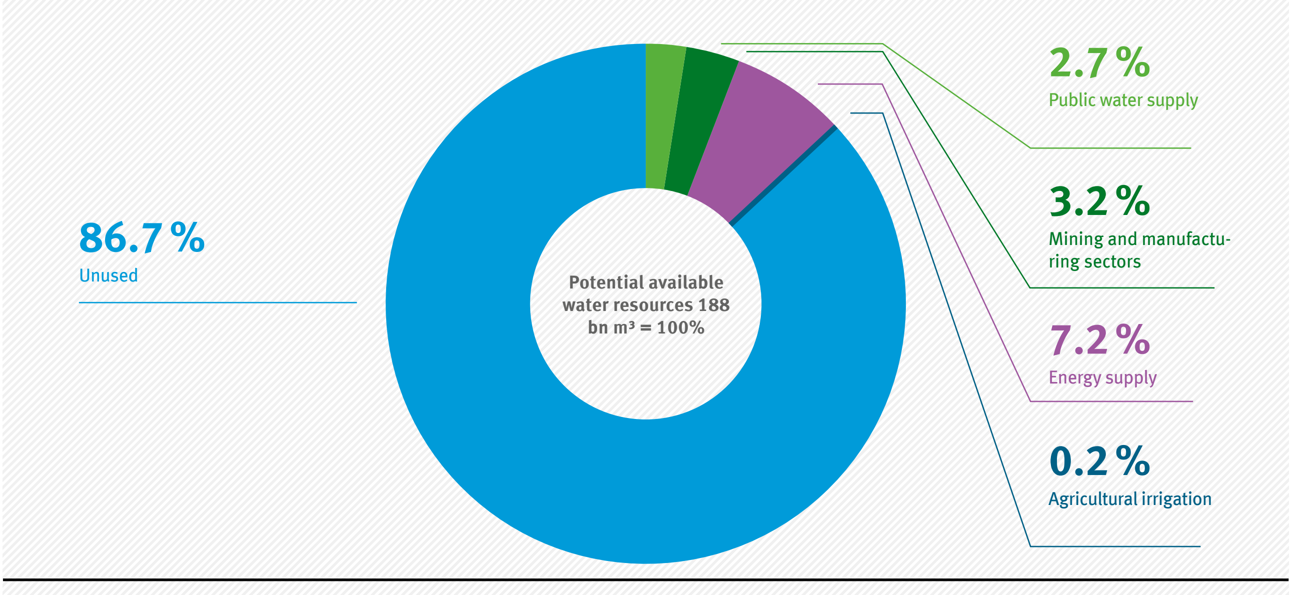
The largest volume of water was abstracted by energy suppliers in 2013 at 13.6 billion m³ or 7.2% of potential available water resources. The public water supply which supplies households and small businesses with drinking water only utilised around 3% of the potential available water resources, or 5 billion m³. The mining and manufacturing industries abstracted 6.1 billion m³ (3.2%). 0.3 billion m³ (0.2%) was attributable to agricultural irrigation. Other sectors abstracted significantly less water, for example, the sports, entertainment and leisure services sector with less than 0.02 billion m³.

Over the past 20 years, there has been a tangible reduction in the volume of water abstraction across all areas. Specifically, since 1991 water abstractions for the energy, mining and manufacturing sectors have decreased by 45%.

To enable a comparison of water abstractions between Länder, water abstraction for all sectors is expressed as a ratio of renewable water resources. If the usage level of water use exceeds 20 % of water resources, in an international comparison[65] this is referred to as "water stress". Excessive use of water resources not only has the potential to cause conflict between individual sectors, but can also restrict the availability of water for aquatic and water-dependent habitats, thereby exerting greater pressures on the fauna and flora living in those habitats. In Germany, the water use index has been below 20% since 2004. Between 2010 and 2013, the value decreased significantly from 17.4% to 13.3%, and is therefore currently well below the critical water use index (Figure 18). Energy suppliers account for the bulk of water abstractions. The majority of this is cooling water (see chapter 3.4.1), which is returned to the surface waters with only minimal condensation losses, and is then once again available for use. If the cooling water portion is disregarded, the water use index the Germany is well below 10%. As such, Germany is under no real threat from water stress.

Figure 17

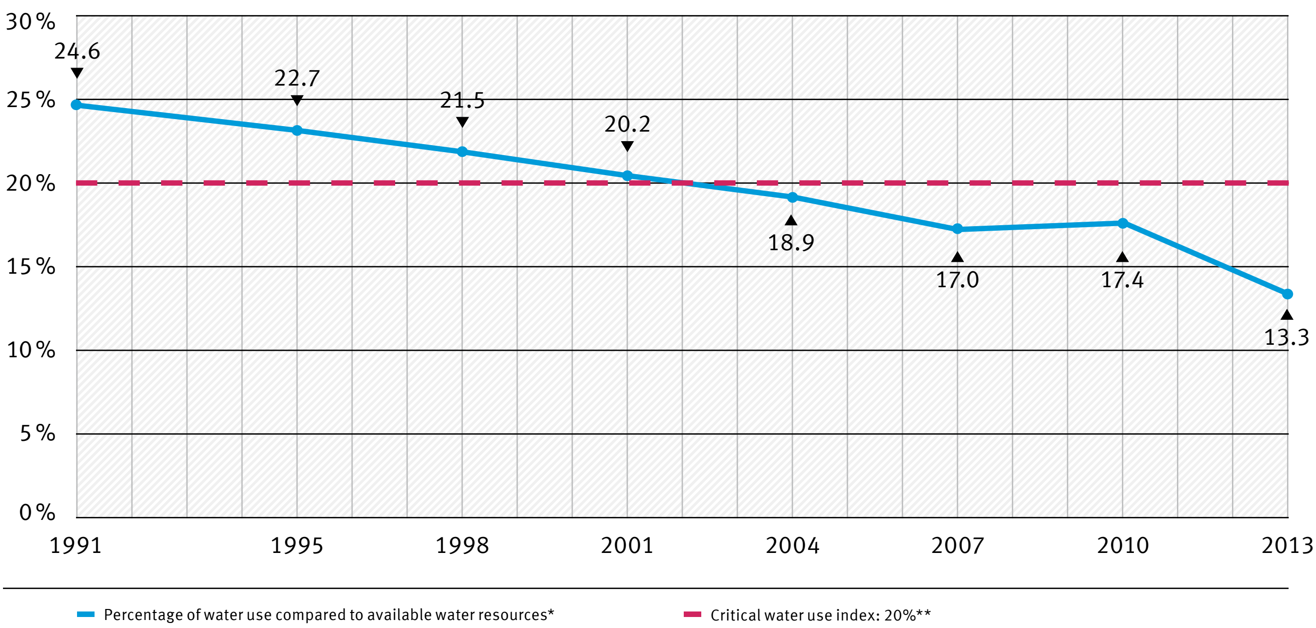
Available water resources and water use in Germany, 2013



Source: German Environment Agency[65]; data by the Federal Statistical Office (2015/2016) and Federal Institute of Hydrology (2015)

Figure 18

Water use index in Germany



*The water use index is formed from the ratio of total water abstractions in the year under review (since 2007 including agricultural irrigation) to long-term available water resources in Germany (188 bn m³).
**A water use index of 20% is considered the threshold for water stress.

Source: German Environment Agency ; based on data by the Federal Statistical Office (Fachserie 19, R. 2.1.1 and 2.2, Wiesbaden, various years) and the Federal Institute of Hydrology (2015) (communication dated 09/12/2016)

[5] See Umweltbundesamt (German Environment Agency): Waters in Germany: Status and assessment (2017) https://www.umweltbundesamt.de/publikationen/waters-in-germany

[6] https://www.destatis.de/DE/Publikationen/StatistischesJahrbuch/StatistischesJahrbuch2015.pdf?__blob=publicationFile

[7] For further details, please refer to UBA (2017): "Waters in Germany: Status and assessment" (2017) https://www.umweltbundesamt.de/publikationen/waters-in-germany

[8] http://www.umweltbundesamt.de/daten/wasser-als-ressource/wasserressourcen-ihre-nutzung

[9] Brandenburg Ministry for Agriculture, Environmental Protection and Land Use Planning (Brandenburgisches Ministerium für Landwirtschaft, Umweltschutz und Raumordnung), "Landschaftswasserhaushalt in Brandenburg – Kurzfassung", 2003

[10] The IPCC (Intergovernmental Panel on Climate Change) believes that human influence is "extremely likely" to be the reason for global warming. See IPCC 2014 "Climate Change 2014 Synthesis Report Summary for Policymakers https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

[11] http://www.dwd.de/DE/presse/pressemitteilungen/DE/2016/20161229_deutschlandwetter_jahr2016.pdf?__blob=publicationFile&v=3

[12] DWD (2016): Nationaler Klimareport 2016. 2nd amended edition, Deutscher Wetterdienst, Offenbach am Main, Germany. Reference period: 1971-2000

[13] The change in summer precipitation is no longer as pronounced under the new global emissions scenarios (RCP scenarios) as it is under the A1B-SRES scenario. RCP scenarios: "Representative Concentration Pathways". SRES scenarios according to the "Special Report on Emissions Scenarios". The RCP scenarios replaced the IPCC's SRES scenarios in 2013/14.

[14] To put this in context: For rain volumes ≥ 10 mm / 1 hour or ≥ 20 mm / 6 hours, the German Meteorological Service (Deutscher Wetterdienst, DWD) warns of "exceptional weather", and rain volumes ≥ 25 mm / 1 hour or ≥ 35 mm / 6 hours will prompt a storm warning

[15] adelphi / PRC / EURAC (2015): Vulnerabilität Deutschlands gegenüber dem Klimawandel. German Environment Agency (UBA). Climate Change 24/2015, Dessau-Roßlau. http://www.umweltbundesamt.de/publikationen/vulnerabilitaet-deutschlands-gegenueber-dem KLIWAS – Impacts of climate change on waterways and navigation. Concluding report of the BMVI: Technical conclusions from the results of the

[16] KLIWAS research programme, 2015 https://www.bmvi.de/SharedDocs/DE/Anlage/VerkehrUndMobilitaet/Wasser/kliwas_abschlussbericht_englisch.pdf?__blob=publicationFile

[17] See § 1 of the Federal Water Act (WHG)

[18] For more detailed information on the interesting work of the international River Basin Commissions in which Germany is active, refer to the links to these Commissions at http://www.bmub.bund.de/themen/wasser-abfall-boden/binnengewaesser/fluesse-und-seen/flussgebietskommissionen/

[19] UNECE = United Nations Economic Commission for Europe

[20] Act amending the Convention of 17 March 1992 on the protection and use of transboundary watercourses and international lakes of 2 September 1994 (Federal Law Gazette (BGBl.) II, p. 2333.

[21] Act on the Protocol of 17 June 1999 on Water and Health to the Convention of 1992 on the Protection and Use of Transboundary Watercourses and International Lakes of 16 August 2006 (Federal Law Gazette (BGBl.) II, p. 666).

[22] Further information can be found at: https://www.unric.org/en/

[23] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ No. L 327, p. 1, most recently amended on 12 August 2013, OJ L 226, page 1

[24] Federal Water Act (WHG) of 31 July 2009 (Federal Law Gazette (BGBl.) I, p. 2585, last amended on 4 August 2016, Federal Legal Gazette I, page 1972)

[25] Surface inland waters, coastal waters and groundwater

[26] Concern principle (see § 62, paragraph (1), sentence 1 of the WHG, inter alia)

[27] Surface Waters Ordinance of 20 June 2016, Federal Law Gazette (BGBl.) I page 1373

[28] Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, OJ L 348, page 84, amended on 12 August 2013, OJ L 226, page 1

[29] EU Commission Directive 2009/90/EC of 31 July 2009 laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status, OJ L 201 of 1 August 2009, page 36

[30] Commission Decision 2013/480/EU of 20 September 2013 establishing, pursuant to Directive 2000/60/EC, the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Decision 2008/915/EC

[31] Ordinance on the Protection of Groundwater (Groundwater Ordinance) of 9 November 2010, Federal Law Gazette (BGBl.) I, p. 1513, last amended by article 1 of the ordinance of 4 May 2017, (Federal Legal Gazette I, pg. 1044)

[32] Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration, OJ L 372, page 19, amended on 20 June 2014, OJ L 182, page 52.

[33] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy, OJ L 164, p. 19.

[34] Act Pertaining to Charges Levied for Discharging Wastewater into Waters (AbwAG) in the version promulgated on 18 January 2005 (Federal Legal Gazette (BGBl.) I, page 114), most recently amended by Article 2 of the Ordinance of 1 June 2016 (Federal Law Gazette (BGBl.) I, page 1290)

[35] Appendix to § 3 of the AbwAG

[36] Federal Waterways Act of 23 May 2007 (Federal Law Gazette (BGBl.) I, page 962; 2008 I, page 1980), amended by Article 4, para. (118) of the Act of 18 July 2016, Federal Law Gazette (BGBl.) I page 1666)), Last amended by Article 2 para (8) of the Act of 20 July 2017 (Federal Law Gazette (BGBl. I pg. 2808)

[37] Act on the Environmental Compatibility of Washing and Cleansing Agents (Washing and Cleansing Agents Act) of 17 July 2013 (Federal Law Gazette (BGBl.) I, page 2538), amended by Article 4, para. (71) of the Act of 18 July 2016, Federal Law Gazette (BGBl.) I page 1666))

[38] Act on Water and Soil Associations of 12 February 1991 (Federal Law Gazette (BGBl.) I, page 405), amended by Article 1 of the Act of 15 May 2002 (Federal Law Gazette (BGBl.) I page 1578)), last amended by Article 3 of the Act of 18 July 2017 (BGBl. I pg. 2774)

[39] Act on the Assessment of Environmental Impacts of 24 February 2010 (Federal Law Gazette (BGBl.) I, p. 94), last amended on 21 December 2015, Federal Legal Gazette I, p. 2490, 2491.

[40] Act on the Prevention and Remedying of Environmental Damage of 10 May 2007, Federal Law Gazette (BGBl.) I, p. 666, last amended on 4 August 2016, Federal Legal Gazette I, p. 1972, 1975.

[41] Penal Code (StGB) of 13 November 1998 (Federal Law Gazette (BGBl.) I, page 3322), amended by Article 8 of the Act of 26 July 2016 (Federal Law Gazette (BGBl.) I page 1818), last amended by Article 1 of the Act of 17 July 2017 (BGBl. I S. 2442)

[42] Act on Nature Conservation and Landscape Management of 29 July 2009, Federal Law Gazette (BGBl.) I, p. 2542, amended on 4 August 2016, Federal Legal Gazette I, p. 1972, 1974, last amended by Article 3 of the Act of 30 June 2017 (BGBl. I pg. 2193)

[43] Act on Protection against Harmful Soil Changes of 17 March 1998, Federal Law Gazette (BGBl.) I, p. 502, amended on 31 August 2015, Federal Legal Gazette I, p. 1474, 1491, last amended by Article 2 para (5) of the Act of 20 July 2017 (BGBl. I pg. 2808)

[44] Act to Promote the Circular Economy and Safeguard the Environmentally Compatible Management of Waste of 24 February 2012, Federal Law Gazette (BGBl.) I, p. 212, amended on 4 April 2016, Federal Law Gazette (BGBl.) I, p. 569, 584, last amended by Article 2 para (9) of the Act of 20 July 2017 (BGBl. I pg 2808)

[45] Article 28, para. (2) of the Basic Law (GG)

[46] Article 74, para. (1), no. 32 of the Basic Law (GG)

[47] Article 72, para. (3), no. 5 of the Basic Law (GG)

[48] Examples include the Federal Water Act, the Wastewater Charges Act, the Detergents and Cleansing Agents Act, the Federal Soil Act, and the Federal Nature Conservation Act

[49] See Article 50 of the Basic Law (GG)

[50] For further information on LAWA's tasks, please refer to: www.lawa.de/index.php?a=2

[51] Further information and application documents may be found at http://www.umweltbundesamt.de/das-uba/was-wir-tun/foerdern-beraten/verbaendefoerderung

[52] More information on twinning can be found at: https://www.umweltbundesamt.de/themen/nachhaltigkeit-strategien-internationales/kooperation-in-mittel-osteuropa-dem-kaukasus/twinning-instrument-der-eu

[53] Taiex= Program for Technical Assistance and Information Exchange

[54] More information on the Advisory Assistance Programme can be found at: https://www.umweltbundesamt.de/themen/nachhaltigkeit-strategien-internationales/kooperation-in-mittel-osteuropa-dem-kaukasus/beratungshilfeprogramm-des-bmub

[55] http://www.bmub.bund.de/themen/wirtschaft-produkte-ressourcen-tourismus/wirtschaft-und-umwelt/umwelttechnologie/exportinitiative/

[56] Eastern Europe, the Caucasus and Central Asia (the successor states to the Soviet Union excluding the three Baltic states)

[57] http://www.oecd.org/env/outreach/partnership-eu-water-initiative-euwi.htm as at September 2016

[58] http://www.germanwaterpartnership.de/de/gewp-allgemein/laenderforen/indien/projekte/sicheres-trinkwasser-fuer-hope-project-in-neu-delhi/index.htm

[59] http://www.germanwaterpartnership.de/de/gewp-allgemein/laenderforen/index.htm

[60] Statistisches Bundesamt (2016), Fachserie 19, Reihe 2.1.1, 2013; Z_2

[61] BDEW-Wasserstatistik 2015

[62] Branchenbild der deutschen Wasserwirtschaft 2015 https://www.bdew.de/internet.nsf/id/branchenbild-der-deutschen-wasserwirtschaft-2015-de

[63] With almost complete coverage, the public-law corporation is over-represented in the ATV/BGW survey, and this proportion cannot therefore be applied to the Federal Republic of Germany in general with regard to responsibility for and performance of wastewater disposal functions

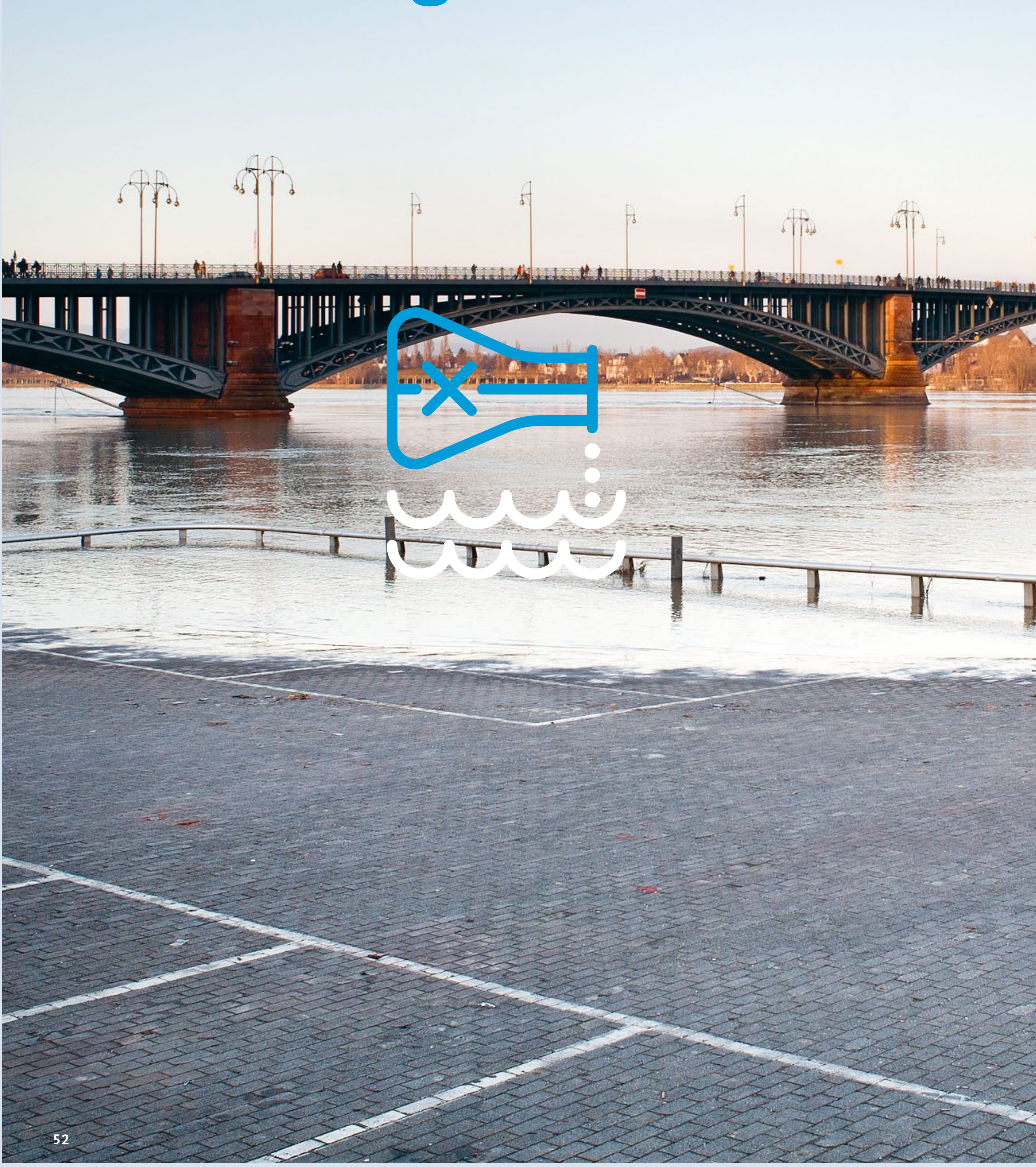
[64] http://www.umweltbundesamt.de/daten/wasser-als-ressource/wasserressourcen-ihre-nutzung

[65] http://www.worldwatercouncil.org/index.php?id=25

[66] Other sources define scarcity as 1,700 m3 (around 4,600 litres) or less available water per person, per year, and water stress as 1,000 m3 (around 2,700 litres) or less – cf. http://www.un.org/waterforlifedecade/scarcity.shtml

[67] http://www.umweltbundesamt.de/daten/wasser-als-ressource/wasserressourcen-ihre-nutzung#textpart-4

3 Water pressures and challenges



We as humans change waters in many different ways: We discharge chemicals and nutrients, modify waterbody structures, and abstract water. These interventions directly affect the waterbodies, and also create conflicts of use for the scarce resource water.

Wastewater treatment in municipal plants makes a significant contribution to water protection and reduces discharges of chemicals and nutrients into our waters. However, even when treated with the best available technology, residues of poorly degradable substances and micropollutants still enter the waters. For example, removing pharmaceuticals, biocides and personal care products and their transformation products is a current challenge for wastewater treatment (see chapters 3.1.4, 3.1.5).

The public water supply is usually the starting point of water use for private households and businesses (see chapter 3.1.1). Other water abstractions (see chapter 2.7) occur for industry (see chapter 3.3), energy extraction (see chapter 3.4), and agriculture (see chapter 3.2.1). The processing of water resources into drinking water as a flawless, clean foodstuff requires a number of complex processes, depending on the levels of pollution and contamination (see chapter 3.1.2).

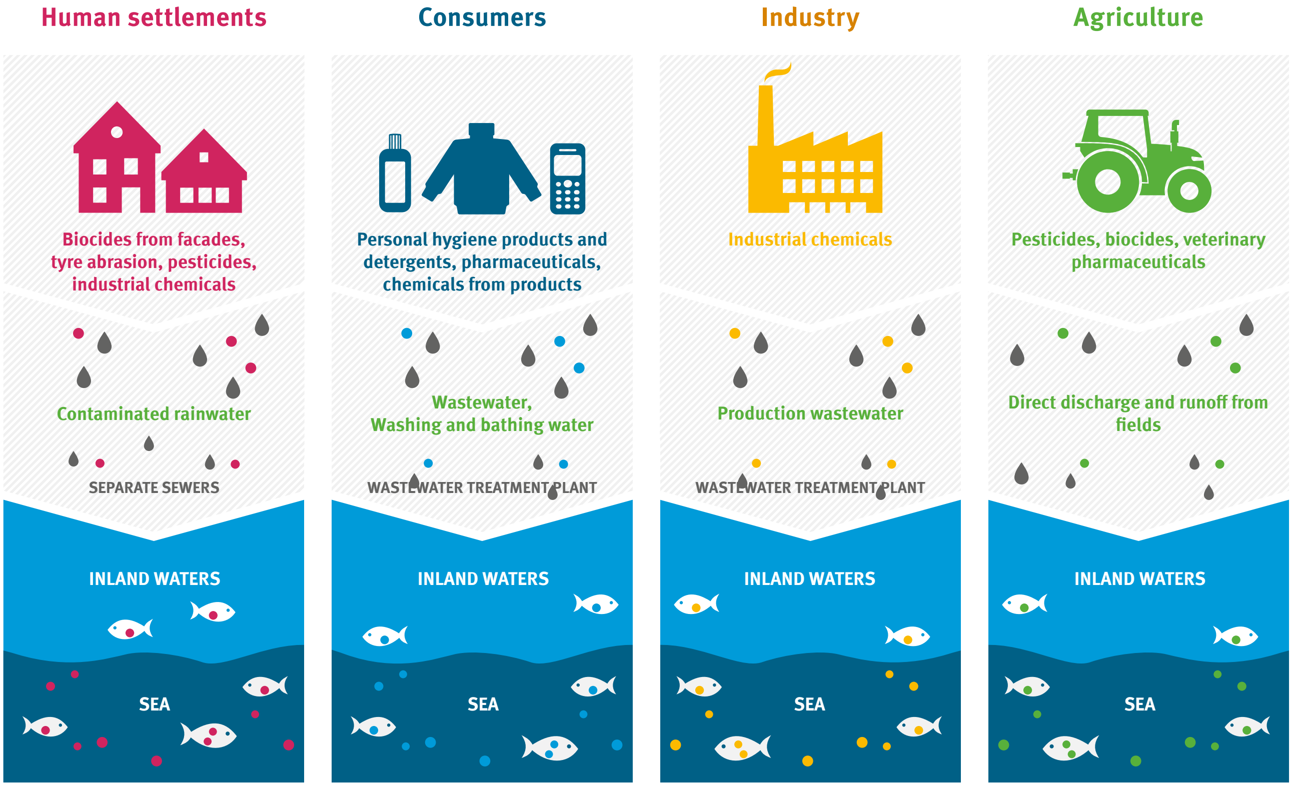
Apart from public wastewater treatment plants, pollutants may also be discharged by agriculture (see chapter 3.2.2), industry (3.3.1), energy extraction (3.4), transport (3.5), and fishing and aquaculture (3.6). Leisure activities in and on the water (3.7) and the use of poorly degradable substances in the home (3.1.4) can also adversely affect waterbody status. If persistent, chemicals and plastics from household products or waste pollute waterbodies and the organisms that live in them.

Morphological changes are caused primarily by shipping (3.5.1) and hydropower use (3.4.7). Other pressures arise as a result of noise (e.g. from shipping) or a rise in water temperature (e.g. from cooling water emissions, 3.4.1).

Social challenges arise as a result of impairments and changes to waterbodies. Flooding is a natural event which can place humans and society at risk due to interventions in the waterbody structure (3.8). Climate change is directly

Figure 19

Possible emission pathways for pollutants



[68] Source: German Environment Agency "Brassen – die Trendmacher, Schadstoffmonitoring mit Fischen in der Umweltprobenbank"[68], 2016

harmful to waterbodies and has consequences for society, such as the more frequent occurrence of extreme events (3.10).

By importing water-intensive products from abroad, Germany is also contributing to an increased water demand and pressures on water resources in other countries, as illustrated by the concept of the water footprint (3.11).

3.1 Public water management and households

Clean drinking water is essential for human health and everyday life; human beings reliant on perfect drinking water, not only for drinking and for food preparation, but also for personal hygiene and laundry.

3.1.1 Water supply

Nearly all households in Germany are connected to the distribution system of a public water utility (see also chapter 2.6.1): 99.2% of the population is supplied with drinking water in this way. Private supply e.g. from a domestic well is rare in the private sector.

In Germany, more than 70% of drinking water supply is covered by groundwater and spring water. Around 30% of drinking water is abstracted from surface waters, i.e. from reservoirs, or via groundwater recharge and bank filtration. In total in 2013, the public water utilities abstracted around 5 billion m³ of water.

Around 3.5 billion m³ was delivered to private households and small businesses by the water utilities. The remaining 1.5 billion m³ was shared between commercial enterprises, public institutions such as schools and hospitals, and consumption by the waterworks themselves.

In 1991, the water utilities needed more than 6.5 billion m³ to cover drinking water demand. There are two reasons for this decrease: The water utilities have reduced water loss, for example by repairing pipe breaks and leaks. However, the biggest single factor is the reduction in individual water consumption. The water consumption of 144 litres per person, per day in 1991 has dropped to 121 litres today, thanks to modified consumer behaviour and the use of water-saving household appliances and fittings (Figure 21).

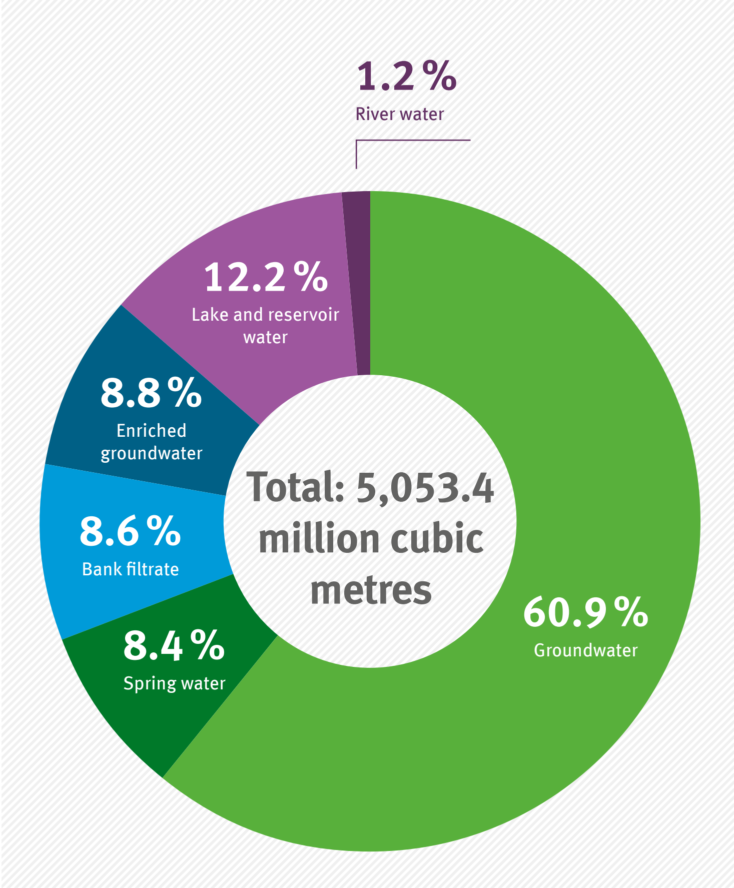
There are, however, sizeable differences in average household consumption between individual Länder. In North Rhine-Westphalia, Hamburg, Bavaria and Schleswig-Holstein, the average consumption per person was 130 l per day or more, compared with just 81 l in Saxony (Figure 22).

In households, on average, the highest proportion of water use is attributable to personal hygiene (showering, bathing) (36%). Toilet flushing accounts for 27%, and laundry 12% (Figure 23).

The suppliers' technical infrastructure ensures a high level of supply reliability with an adequate water quality and quantity. This enables them to supply areas with water shortages and limited groundwater supplies, which do exist in Germany despite adequate water resources overall. In urban agglomerations in particular, water demand exceeds the local supply. A long-distance supply system creates a balance between areas of water shortage and those with a surplus of water. Long-distance water supply systems exist primarily in Bavaria, Baden-Wuerttemberg, Lower Saxony, Saxony, Saxony-Anhalt, Thuringia, the Ruhr region and the Frankfurt/Main region. In Baden-Wuerttemberg, for example, drinking water is transported from Lake Constance as far as the Stuttgart region. Drinking water can also be abstracted from 311 reservoirs in Germany. They also perform important functions with regard to flood mitigation, raising low water levels, and supplying energy.

Figure 20

Water abstraction by water type*, 2013



*Including the volume of water abstracted by companies that only redistribute it

Source: German Environment Agency[69]; data by the Federal Statistical Office (2016), Fachserie 19, Reihe 2.1.1, 2015; Z_2

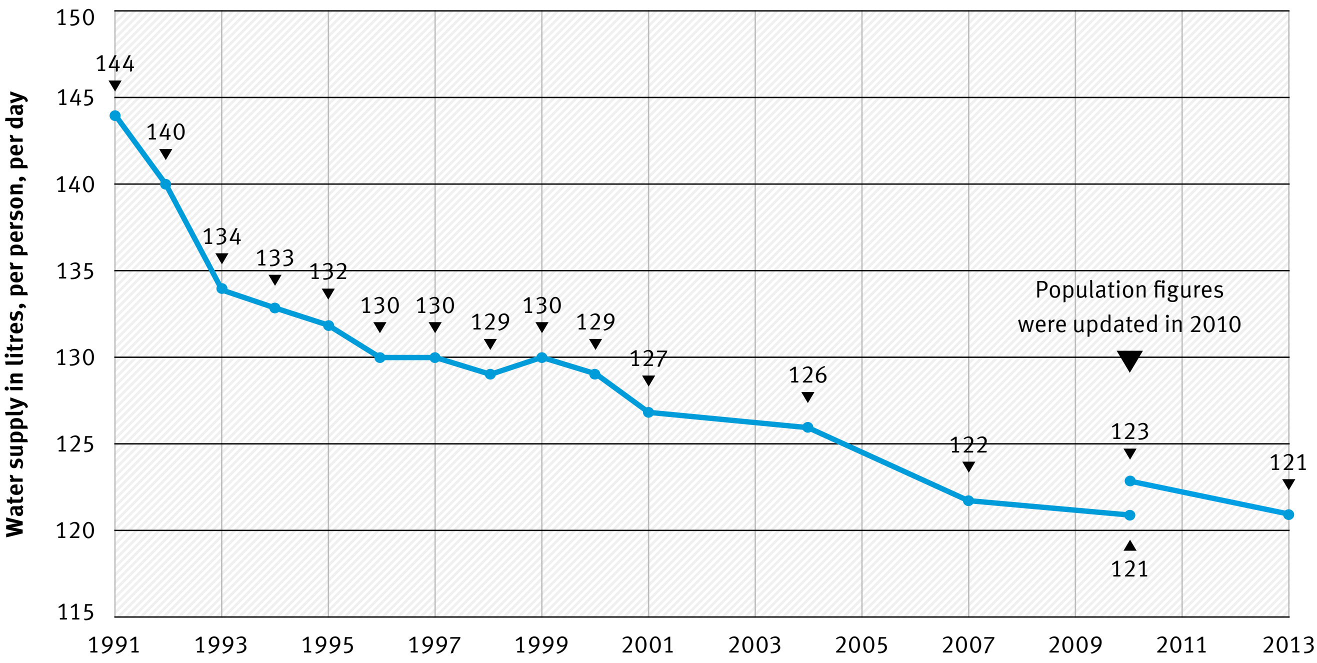
3.1.2 Drinking water treatment

The requirements governing drinking water quality are regulated by the German Drinking Water Ordinance (Trinkwasserverordnung, TrinkwV 2001)[70] and the EU Drinking Water Directive[71] (see chapter 6.1.1). They are based on the guiding principles of DIN 2000 and DIN 2001. Groundwater is particularly suitable as a source of raw water. The groundwater must be obtained from a sufficient depth in the natural hydrological cycle after passage through adequate filtering strata and must not be impaired in any way. Drinking water should be appetising and inviting to drink. It must be colourless, clear, cool, perfect in taste and smell, and low in bacteria.

Raw water that does not meet the requirements for drinking water must be purified in such a way that

Figure 21

Public water supply – Water delivery to households



Source: Federal Statistical Office (2013): Fachserie 19 Reihe 2.1.1 „Öffentliche Wasserversorgung und öffentliche Abwasserbeseitigung – Öffentliche Wasserversorgung“, 2015

its life-long consumption will not have any harmful effects on human health. It may also be necessary to treat the drinking water so that it does not suffer any adverse changes during transport from the water works to the consumer. Such changes relate not only to the quality of the drinking water itself, but also to possible changes as a result of the materials with which it comes into contact in the water supplier's distribution network and the consumer's home installation. As a general principle, the pipeline materials must be modified to suit the water, not the other way around. For this reason, the materials that come into contact with drinking water must be inspected and assessed for suitability. Only materials that are suitable for the present drinking water composition may be used. The Drinking Water Ordinance tasked the German Environment Agency (UBA) with assessing the suitability of materials that come into contact with drinking water.

Present knowledge indicates that a central public drinking water supply system offers the greatest safety and reliability for the supply of perfect drinking water in adequate quantities and with the pressure required for technical purposes. Over time, the requirements placed on water treatment technology have adapted in line with changing conditions. Higher standards are necessary, *inter alia*, due to the increasing size of distribution systems and hence the longer times taken by the treated drinking water for the journey from the water works to the consumer.

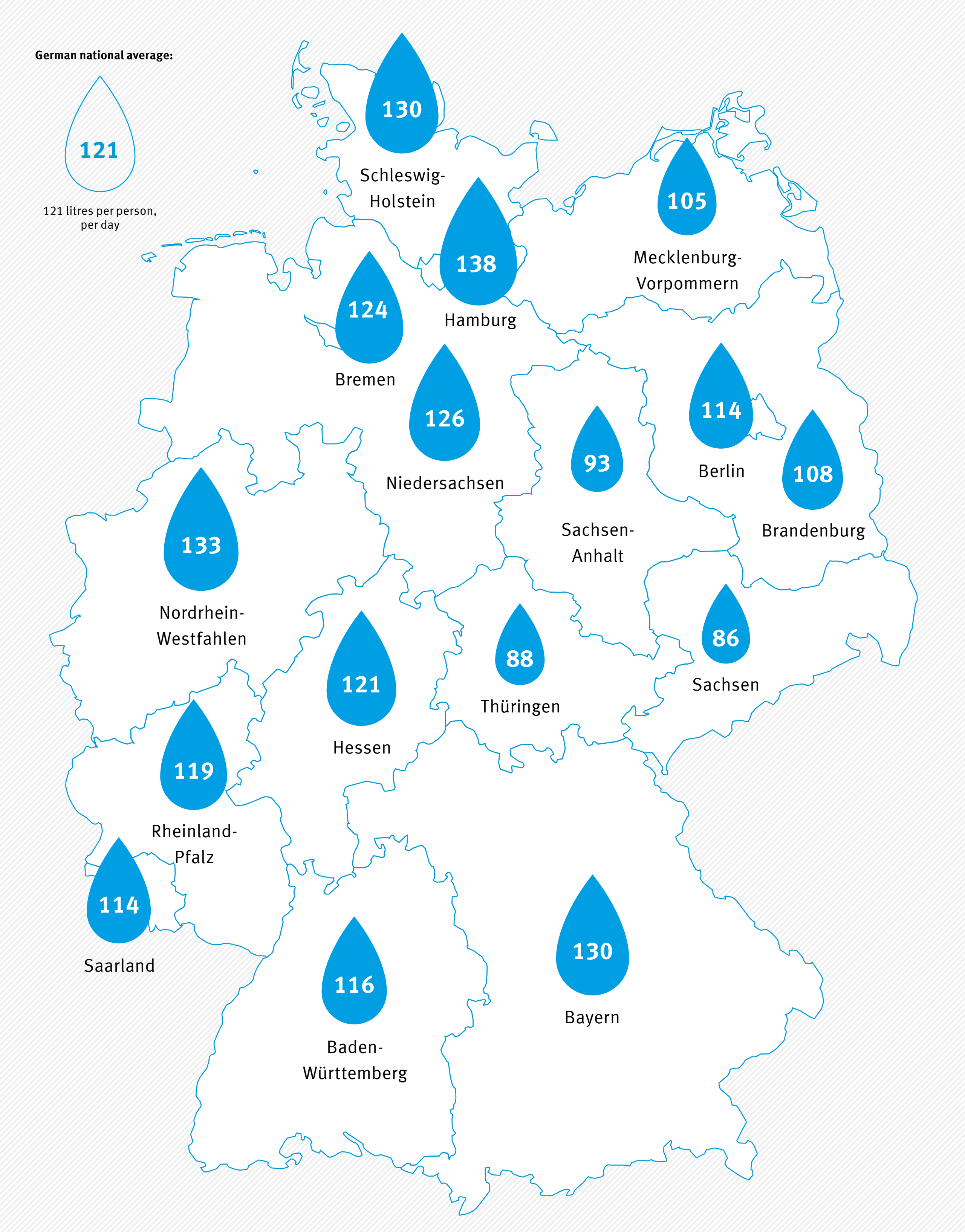
From a health perspective, a distinction must be made between microbiological pathogens and toxic chemical substances in drinking water. Microbiological impurities in the untreated water are prevented, firstly, by means of appropriate selection and protection of the raw water, and secondly (if necessary) by appropriate treatment, and finally by disinfection, which may if required be carried out in the distribution network.

From an aesthetic point of view, the issues here are improving acceptance of drinking water and its suitability for consumption. Impairments to the smell, taste and appearance of drinking water, although they may be immaterial from a health point of view, are always a deficit that must be remedied by means of appropriate treatment technology in conjunction with resource protection or, ultimately, by switching to a different source of raw water.

The composition of drinking water changes to a

Figure 22

Water supply for final consumption to households and small businesses by Länder, 2013

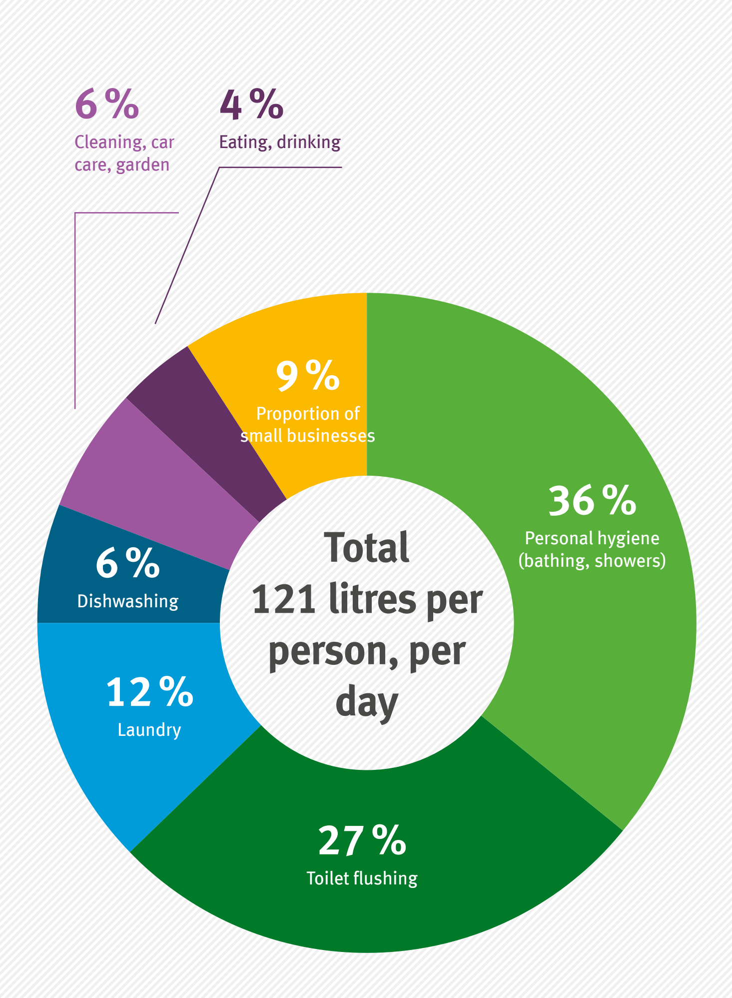


Water supply in litres, per person, per day

Source: Federal Statistical Office (2013): Fachserie 19 Reihe 2.1.1 „Öffentliche Wasserversorgung und öffentliche Abwasserbeseitigung – Öffentliche Wasserversorgung“, 2015

Figure 23

Average water consumption and water use in households and small businesses



Sources: Federal Statistical Office (2013): Fachserie 19 Reihe 2.1.1 „Öffentliche Wasserversorgung und öffentliche Abwasserbeseitigung – Öffentliche Wasserversorgung", 2015; BDEW Bundesverband der Energie- und Wasserwirtschaft e.V. 2013

greater or lesser extent as a result of distribution (see chapter 3.1.3) in fixed pipelines to the consumer. Such changes in water composition after treatment are caused by interaction with surfaces that come into contact with water, such as pipeline materials, both in public distribution networks (problems: iron, asbestos cement, biofilms) and in domestic installations (problems: lead, copper, nickel, plastics, biofilms). The interior surfaces of drinking water tanks in the water supply system or of water heaters in the household may also cause adverse changes in water composition. The following lists (Table 3, Table 4) indicate the main objectives of treatment and the techniques used.

The generally accepted best available technology offers a wealth of technical options for achieving these treatment objectives. The methods are distinguished primarily by their mode of action:

- Filtration or separation methods
- Precipitation and flocculation methods
- Biological methods
- Substance exchange at interfaces
- Metered admixture of additives
- Irradiation methods.

When processing raw water into drinking water,

Table 3

Treatment objectives and focal areas for specific action

Treatment objective	Focal areas for specific action
Removal of geogenic substances	Iron, manganese, turbidity, smell, taste, arsenic, nickel, fluoride, uranium
Removal of anthropogenic substances	Nitrate, dissolved organic carbon (DOC), microbiology, pesticides, micropollutants
Protection of distribution network	Inhibiting corrosion; preventing deposits; preventing bacterial growth
Technical usability	Softening; miscibility of water from different sources; hardening after application of membrane technologies
Maintaining correct technical functioning of water distribution	Identifying leaks

Source: German Environment Agency (UBA)

Table 4

Summary of techniques used and treatment objectives

Principle	Technique	Suitable objectives/parameters
A	Ion exchange	Calcium, magnesium, nitrate, heavy metals, uranium
A	Adsorption	DOC, organic substances
A, D	Corrosion inhibition	pH
B	Bioreactors	Iron, manganese, nitrate
BS	UV irradiation	Microbiology
D	Aeration	Oxygen concentration, pH
D	Oxidation	DOC, microbiology
D	Reduction	Excess of chlorine
D	Inhibition/stabilisation	Scale deposits (limescale), corrosion
F	Precipitation	Phosphate, arsenic
F	Flocculation	Turbidity, microbiology
S	Flotation	Turbidity
S	Evaporation	Desalination
S	Reverse osmosis	All objectives
S	Degasification/stripping	Methane, hydrogen sulphide, volatile halogenated hydrocarbons
S, B	Slow sand filtration	DOC, microbiology
S, D	Softening / hardening	Calcium, magnesium

A = exchange at interfaces; F = precipitation/flocculation; S = separation; B = biological methods;
D = metered admixtures; BS = irradiation

Source: German Environment Agency (UBA)

the addition of treatment chemicals (which are never entirely free of contaminants) may lead to an increase in the concentration of pollutants in drinking water, in addition to the desired treatment objective. The Drinking Water Ordinance (TrinkwV 2001[72]) states that only those treatment substances and disinfection techniques cited in a positive list held by the German Environment Agency may be used. This positive list helps to ensure that during drinking water treatment, any additional increase in pollutants that may occur is less than 10 % of the drinking water limit of a health-relevant parameter, which in turn means that the quality standards achieved are exemplary by European comparison.

As well as treating the raw water with chemicals, it is also possible to purify water using semi-natural techniques (such as bank filtration, slow sand filtration and artificial groundwater recharge). Pollutants or pathogens present in the water (such as viruses or bacteria) are removed by sand-based filter systems. The purification capacity of these filter systems is very variable, and as well as on the type of pollutant/pathogen, also depends heavily on the sand properties, the flow speed of the water, and chemical quality of the water.

Lead pipe in a drinking water installation

Figure 24

3.1.3 Drinking water distribution

The drinking water treated at the waterworks passes through a complex distribution system before reaching the consumer's tap. During transportation, the drinking water comes into contact with a wide range of different materials and components. These may emit substances into the drinking water which change the odour or taste of the water, have health implications, or lead to an increase in microorganisms and possibly pathogens. The potential substance emission depends on the intensity of contact. Long periods of contact or stagnation cause increased substance emissions into drinking water. In water pipes with a larger diameter, a large volume of water is in contact with comparatively little surface. By contrast, for smaller pipe diameters, found primarily in drinking water installations in buildings, the contact with materials is more intensive. Of course, whether and to what extent the water quality is altered during distribution also depends on the material itself, and in the case of some materials on the water quality (e.g. corrosion in metals), as well as on the temperature.

Generally speaking, in water distribution we distinguish between distribution by water utilities with large-scale pipes beneath the road, and the drinking water installation in buildings. The handover point is the water meter. After the water meter, the property owner is responsible for the quality of drinking water. The drinking water supplied by the water utility in Germany is of perfect quality almost everywhere. However, while passing through the drinking water installations in buildings, the water quality may be significantly altered by the time it reaches the tap. Due to the more intensive contact with materials in smaller pipes, frequent and lengthy stagnation periods of drinking water, and higher ambient temperatures, substances may enter drinking water in higher concentrations. As a result, samples taken from the tap more frequently exceed the parameters in the Drinking Water Ordinance than is the case for samples taken from the waterworks or central water supply installations.

At present, the most pressing problems are the growth of Legionella and (regrettably) the persistence of elevated lead concentrations in drinking water in old buildings with lead pipes (Figure 24).

Legionella are environmental pathogens that occur in low concentrations throughout the environment. In warm water at temperatures from around 25°C up to 60°C, they can multiply rapidly. *Legionella pneumophila*, the cause of severe lung inflammation, is particularly dangerous for older people, those with a weakened immune system, and smokers. The only reliable way to avoid the growth of Legionella is to ensure that hot water always has a temperature of at least 55°C throughout the entire pipe system.

Until the late 19th century/early 20th century, lead was a very popular material for drinking water installations, thanks to its outstanding technical properties. In some areas in the north of Germany, lead pipes were still being installed up until the 1970s. However, lead is a contaminant in drinking water with significant toxicological relevance. As a neurotoxin and hemotoxin, lead is particularly harmful to pregnant women, unborn babies, newborn babies and young children. It is therefore essential that all lead pipes are replaced. The lowering of the lead limit in the Drinking Water Ordinance to 10 µg/l in 2013 was intented to facilitate the complete replacement of lead pipes, as drinking water that flows through lead pipes cannot generally adhere to this limit. Further information on this topic can be found in the German Environment Agency's flyer "*Trinkwasser wird bleifrei*"[73] (German only).

The Drinking Water Ordinance regulates the quality of drinking water. It also contains requirements governing the materials that come into contact with drinking water. In order to further define these requirements, the German Environment Agency has set out assessment guidelines. Compliance with these requirements can be confirmed by a certification agency accredited for the drinking water sector, having conducted suitable tests and analyses. Only appropriately labelled products may be used for contact with drinking water.

Further information on this topic can be found in the German Environment Agency's brochures "*Trink was–Trinkwasser aus den Hahn*" and "*Rund um das Trinkwasser*"[74] (German only).

3.1.4 Emissions from households

A variety of chemicals are emitted into the public wastewater system by the use of everyday household products. If used outdoors, these may be transported into or seep into the sewer system via precipitation water.

Relevant product groups include pharmaceuticals, household chemicals such as detergents, cleaning agents and cosmetics, and biocides used for pest control (such as insects, mice, rats as well as algae, fungi or bacteria), as well as pesticides used in the garden and outdoor spaces.

Pharmaceuticals

The annual consumption of human pharmaceuticals in Germany is estimated at 30,000 t per annum, around 8,100 t of which are potentially relevant to the environment[75]. They enter the public wastewater system via excretion from hospitals and health facilities, as well as private households. In the household sector, improper disposal down the toilet or sink and showering or bathing following external application of medication (such as ointments) also contribute to emissions. The improper disposal of veterinary medicines used in private households can also contribute to environmental emissions.

Biocides

In Germany, there are more than 30,000 biocide products on the market, which are used in many sectors of private and professional life–in antibacterial detergents and disinfectants, material preservatives, facade and ship's coatings (see chapter 3.5.1), mosquito sprays and ant killers. The active ingredients enter the environment via various pathways when used by private individuals, commercially or by industry.

Surface waters, sediment, marine waters, soil, groundwater, the atmosphere and organisms can all be exposed to biocides through direct and indirect emissions.

Pesticides

Pesticides are not only used in agriculture (see chapter 3.2.2), but also on public green spaces and in private gardens, and can enter waterbodies via run-off and seepage. In Germany, there are currently 776 authorised pesticides with a total of around 277 active ingredients. In 2015, some 109,344 tonnes of pesticides (excluding inert gases) were emitted[76].

Detergents and cleaning agents, cosmetics

Around 1.3 million tonnes of detergents and cleaning agents are consumed by private households in Germany each year. On average, some 630,000 t of washing detergents, 220,000 t of fabric softener and 500,000 t of cleaning and care products, including some 260,000 t of dishwashing detergents, enter our wastewater each year. Washing and cleaning agents contain a wide range of chemical substances. The level of environmental impairment depends on the status of wastewater treatment and the nature of the constituents. Depending on the application area, laundry detergents and cleaning agents will usually contain surfactants, complexing agents, alkalis or acids, enzymes, optical brighteners, fragrances, preservatives, disinfectants and/or organic solvents. Fragrances are added to detergents, fabric softeners and cleaning agents to give users a sense of cleanliness and freshness with a pleasant fragrance. Even when used as directed, the constituents enter our waterbodies in considerable quantities. Some of them are not readily degradable, and can accumulate in the water and in organisms.

Micro-plastics are also used in cosmetics, hygiene products, and cleaning agents, e.g. in facial and body scrubs. The primary micro-plastic, which is manufactured directly in microscopic size, ca nnot always be removed by wastewater treatment plants and therefore enters the waters. Plastics cannot be completely decomposed by microorganisms and can take centuries to degrade (see chapter 3.8).

Table 5

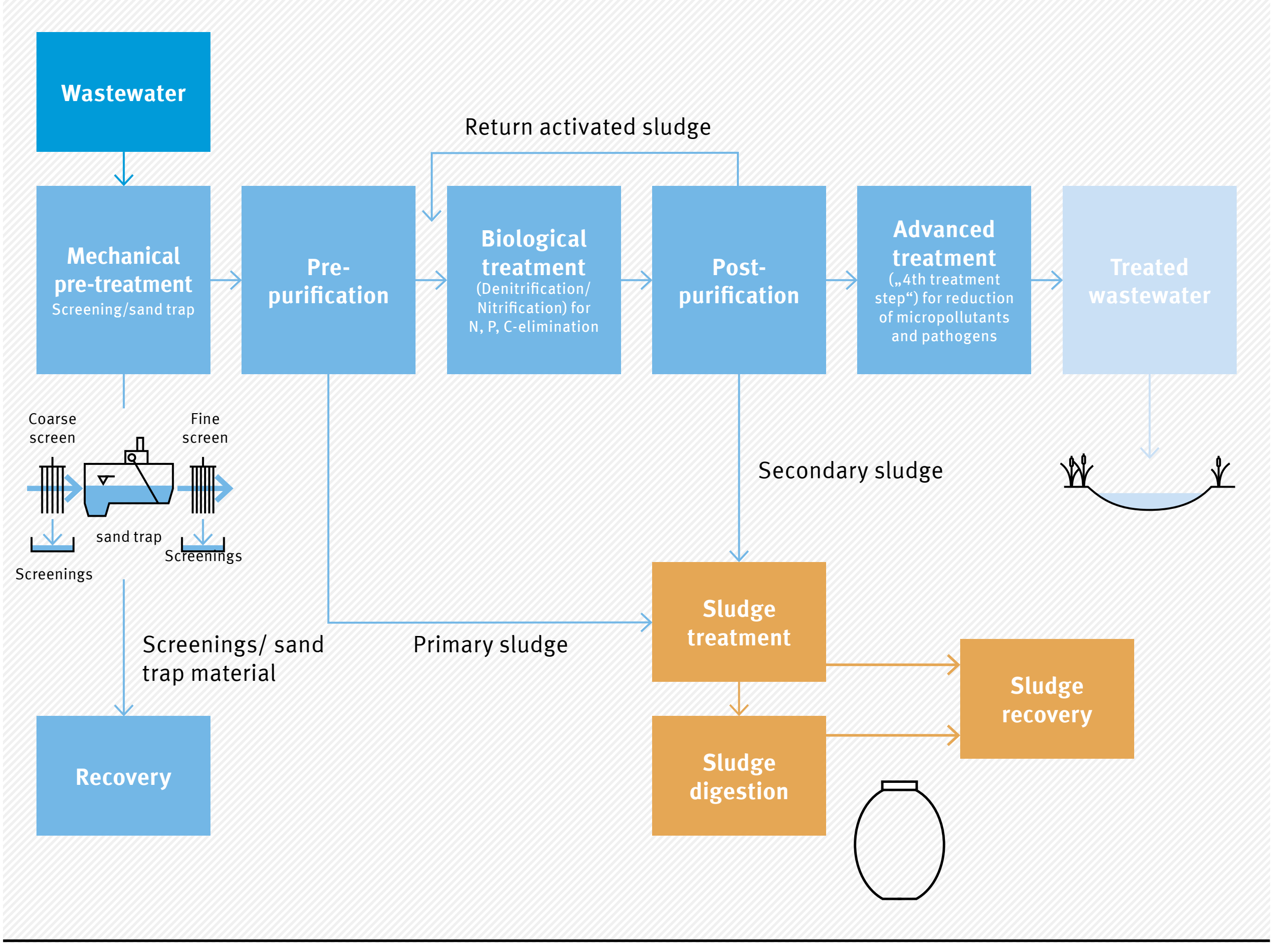
Volume of wastewater treated in public wastewater treatment plants, in million cubic metres

	1991	1995	1998	2001	2004	2007	2010	2013
Total annual volume of wastewater to be treated	8 512	9 847	9 640	10 473	9 410	10 071	9 988	9 825
Of which Sewage	5 158	4 854	4 905	5 254	5 204	5 213	5 013	5 021
Of which Sewage infiltration and precipitation water	3 354	4 993	4 734	5 219	4 206	4 857	4 976	4 804
Volume of biologically treated water	7 911	9 518	9 566	10 458	9 404	10 064	9 985	9 824
Volume of biologically treated water with additional process steps*	4 617	8 062	8 900	9 916	9 083	9 834	9 791	9 653
Of which Nitrification	–	–	7 660	9 477	8 887	9 767	9 756	9 631
Of which Denitrification	–	–	6 555	8 840	8 472	9 534	9 524	9 443
Of which Phosphorus elimination	–	–	8 134	9 242	8 465	9 152	9 168	9 009
Of which Filtration	–	–	1 234	1 572	1 504	1 537	1 516	1 674
Of which Denitrification and phosphorus elimination	–	–	6 110	8 336	8 025	9 014	9 040	8 939
Of which in mechanical wastewater treatment plants	582	319	75	16	–	7	3	1

- Not included in the statistic
Sewage: water altered by its use;
Sewage infiltration: unwanted discharge in a drainage system
* Multiple responses possible

Source: German Environment Agency[77], data: Statistisches Bundesamt (2016), Fachserie 19, Reihe 2.1.2, 2015; Z_2

Figure 25
Schematic representation of wastewater treatment



Source: German Environment Agency

Other chemicals and nutrients
Other chemicals are also used in private households, for example solvents, surfactants, fire retardants, adhesives and colourants during building and renovation work. During application or over the course of the product life they may be released (e.g. fire retardants) and indirectly emitted into waterbodies either via wastewater or rainwater.

Nutrients are also discharged together with public wastewater, particularly phosphorus and nitrogen compounds, causing the mass development of algae (algal bloom). Cyanobacteria (formerly known as blue-green algae), in particular, form toxins and allergens which may cause skin rashes in bathers and, in rare cases, poisoning.

Impacts on waterbodies
Substances with humano-toxic or eco-toxic effects, chemicals with persistent, bio-accumulative and toxic (PBT) or very persistent and very bio-accumulative properties (vPvB), or substances that act on the hormone system of humans and animals (endocrine disruptors), are a particular concern for the hydrological cycle. Persistent substances which are mobile and toxic in the hydrological cycle are also considered critical. These substances often cannot be removed completely in wastewater treatment plants (see chapter 3.1.5), and enter waterbodies via this pathway or via precipitation (see chapter 3.1.6). Options for reducing these emissions are addressed in chapter 6.2.2.

3.1.5 Municipal wastewater disposal

Public wastewater disposal is an important element of water protection in Germany, and makes a significant contribution to the achievement of good water status. Over the last 40 years, Germany has invested heavily in boosting the efficiency of wastewater treatment. In this way, key problems such as the emission of oxygen depleting substances and nutrients into waterbodies have been significantly reduced, leading to a substantial improvement in water status.

At the end of the 19th century, there was an urgent need to improve basic hygiene standards in human settlements through infrastructure measures, primarily in order to avoid epidemics in densely populated areas. The first technical measures included targeted wastewater discharge and mechanical treatment. To protect human health, it was necessary to prevent recognised emissions (especially of pathogens) into surface waters and, ultimately, into drinking water. Since then, technical wastewater treatment has undergone continuous improvements. To this day, the core task of public of the public wastewater management industry is to protect human health, waterbodies and their habitats. Climate change, demographic change and an ever-growing spectrum of pollutants of anthropogenic origin (such as cosmetics, pharmaceuticals, hormones and nanomaterials) pose new challenges for wastewater treatment.

The first step in public wastewater disposal is the collection and discharge of wastewater via public sewers into central treatment facilities. Conventional wastewater treatment facilities use a three-phase wastewater treatment system: mechanical, biological and chemical treatment. Biological wastewater treatment is used for nitrification and denitrification, and in Germany represents the best available technology for more than 95% of treated wastewater (Table 4). In advanced chemical treatment, chemicals are used for precipitation, flocculation or neutralisation (see Figure 25). After treatment, the wastewater is discharged into a waterbody.

In Germany, around 2 million tonnes of sewage sludge (dry solid matter) are generated during the treatment of wastewater. This sewage sludge contains nutrients (such as phosphorus and nitrate) as well as pollutants such as heavy metals and medicine residues, which are separated via sewage sludge during wastewater treatment.

Nearly all households in Germany (96.9%) are connected to the public sewers and to wastewater treatment plants. According to the water resource management survey by the Federal Statistical Office, in 2013 some 10 billion m³ of wastewater was treated in more than 9,300 public wastewater treatment plants (with 50 or more population units[78])[79]. Of these, around 2,100 were size class 4 and 5 for more than 10,000 population units (Table 6).

Table 6

Proportion of wastewater treated by size category of public wastewater treatment plants in Germany

Size category	Population units	No. of plants	Plant capacity / population units	Proportion (%) of treated sewage
5	› 100 000	232	80 823 334	52
4	10 001 to 100 000	1 908	61 970 739	38
Of which: 4a	50 001 to 100 000	305	23 007 180	14
Of which: 4b	10 001 to 50 000	1 603	38 963 559	24
3	5 001 to 10 000	870	6 686 511	4
2.1	50 to 5 000	6 468	7 283 708	6

Source: Data supplied by the Federal Republic of Germany to the EU Commission in implementation of the Water Framework Directive (2014)

In 2013, around 99.5% of the wastewater volume discharged via the public sewer system was treated in public central or local wastewater treatment plants. 2.5 million inhabitants dispose of their wastewater either by small treatment plants (approximately 2 million inhabitants) or via closed cesspits (0.5 million inhabitants)[80].

In Germany, wastewater is discharged via separate or combined sewage systems. In the separate system, wastewater and precipitation are separated, while in the combined system they are discharged together. Out of a total of 575,580 km of sewer network, 242,866 km are combined, 206,234 km wastewater and 126,480 km precipitation sewers[81]. Of the wastewater generated in 2013, approximately 51% was wastewater from households and small businesses, 26% precipitation, and 23% sewer infiltration water. Sewer infiltration water refers to water that penetrates the sewer system e.g. due to leaks (see below)[82].

The public wastewater system collects many different substances. These may originate from households (see chapter 3.1.4), commercial and industrial operations (indirect discharges) or are emitted by rainwater (e.g. discharge from sealed land via surface runoff) (see below).

The three-tier wastewater treatment system has been optimised to reduce nutrients, and for this reason, poorly degradable substances (such as heavy metals, polycyclic aromatic hydrocarbons (PAH) and organic micropollutants) cannot be eliminated completely. Public wastewater treatment facilities are a key emission pathway for these substances into waterbodies. However, substance emissions via public wastewater treatment plants can only be assessed on a Germany-wide basis for a few substances that are monitored in routine programs. It is therefore useful to prepare an inventory of emissions into water based on average substance concentrations in the outflows from wastewater treatment plants, which are derived, *inter alia*, on the basis of measurements from special measurement programmes. In conjunction with model calculations[83], heavy-metal emissions via public wastewater treatment plants into waters ranging from just under 2% (mercury) to 14% (nickel) of total emissions have been ascertained. For PAH, approximately 6% of total emissions (around 950 kg) are discharged into waters via public wastewater treatment plants. The challenge is therefore

Challenges associated with micropollutants in waterbodies

Micropollutants are an umbrella term for substances of anthropogenic origin belonging to a range of substance groups and application areas which occur in the environment in trace concentrations (ng/l to µg/l) at most, often close to or below the detection limit. Scientific studies have found residues of various substances in this concentration range in German rivers, lakes and seas, and in some cases, even in groundwater and drinking water.

Around 80% of micropollutants enter waterbodies via public wastewater treatment plants. Depending on the usage pattern, they may be emitted by other point and diffuse pathways, such as surface run-off, rainwater overflow, groundwater run-off and deposition.

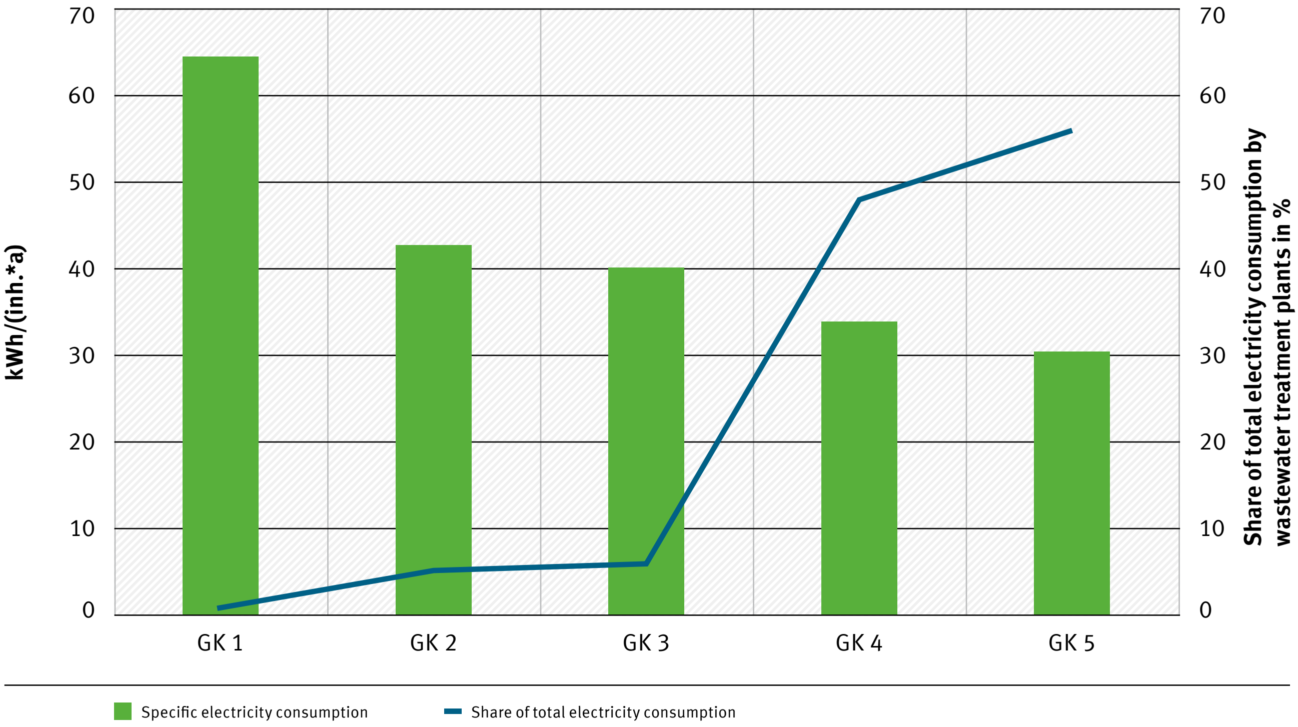
Substances with humano-toxic or eco-toxic effects, substances with persistent, bio-accumulative and toxic properties (PBT substances), very persistent and very bio-accumulative properties (vPvB substances) and endocrine disruptors, i.e. hormonally active substances, are particularly relevant to the hydrological cycle. Additionally, persistent substances which are mobile and toxic in the hydrological cycle should be considered critical if they enter the raw water used for drinking water production.

For example, adverse impacts have been detected on the sensitive reproduction systems of aquatic and soil fauna as a result of the active hormone used in the contraceptive pill and some menopause medications (17β ethinylestradiol). Laboratory fish exposed to this active ingredient in environmentally relevant concentrations of just 4 ng/l were found to have significantly lower reproductive rates. In laboratory studies, diclofenac, a constituent of analgesics and rheumatism drugs, which is often measured in elevated concentrations of › 0.1 µg/l in waterbodies, was found to seriously damage the kidneys of fish.

One key problem when considering micropollutants is that the properties and effects of these substances and their transformation products are not always known. Similarly, there is a lack of knowledge and uncertainty regarding the short-term and long-term effects and interactions of substance combinations.

Figure 26

Electricity consumption by public wastewater treatment plants 2015



GK: Größenklasse = size category

Source: DWA Leistungsvergleich 2015, German Environment Agency

to find effective, inexpensive, energy-efficient measures to improve the effective elimination e.g. of micropollutants and nanomaterials in wastewater treatment plants (see chapter 6.2.2).

Electricity consumption of public wastewater treatment plants

Wastewater treatment facilities consume high levels of electricity and are therefore classed as high consumers. At 20% of electricity consumption, wastewater treatment plants and pumping stations in the public sector consume considerably more than schools, hospitals, administrative buildings and other local government facilities[84]. Their annual electricity consumption is around 4,200 gigawatt hours[85], equivalent to the capacity of a modern lignite power plant. The volume of electricity currently used by public wastewater treatment plants generates emissions of around 2.1 million tonnes of CO_2 per annum[68].

Specific electricity consumption depends to a large extent on the size of the facility. Wastewater treatment plants in size categories 4 and 5 have a far lower specific electricity consumption than smaller facilities (Figure 26). The 1,900 or so wastewater treatment plants in size categories 4 and 5 which participated in the 28th DWA output comparison[87] treat around 92% of total wastewater in Germany, thereby consuming around 90% of the total electricity required for wastewater treatment. The figures in the illustration are based on data from the 28th output comparison of public wastewater treatment plants 2015.

Sewer system

Maintaining the 575,580 kilometre network of sewers is a major challenge, and for Germany's towns and municipalities, an ongoing task. As they age, sewers become damaged. If a sewer leaks or if its function is impaired, it becomes necessary to repair or completely replace it. According to a DWA survey[98], around 20 % of all public sewer reaches[89] are in need of remediation in the short to medium term.

Often, financial constraints preclude essential repairs. This may adversely affect the stability of the systems. Environmental impacts are possible from leaks, due to infiltration and exfiltration. With infiltration, precipitation water or groundwater[90] penetrates the sewer, overloads the sewer pipes, causes increased overflows of combined sewage, and leads to an increased hydraulic pressure on the wastewater treatment plants. The elimination performance decreases, and substance emissions into waters are increased. With exfiltration, wastewater escapes from a sewer, allowing substances to be discharged into the soil and groundwater.

The private sewer network, which includes domestic wastewater drainage pipes and pipes at industrial and commercial locations, is approximately twice as long as the public sewer network. Our knowledge about the status of private sewers is minimal, but it can be assumed that significant remediation work is required[91]. Leaking sewers pose a major potential threat at industrial and commercial locations that handle chemicals if these chemicals enter the subsoil due to leaks in the in-plant network or the public sewer system.

Possible solutions for wastewater treatment are explained in chapter 6.2.2. Information about new alternative sanitation systems (NASS) can be found in chapter 6.2.3, and approaches to the remediation of the sewer system in chapter 6.2.4.

3.1.6 Precipitation water

Precipitation water usually infiltrates into the ground as it falls. A large proportion is absorbed by the vegetation and re-enters the natural hydrological cycle by evaporation. Depending on land use, the remainder passes through various soil strata during the course of leaching and collects in the groundwater-saturated soil zone, the groundwater. This is known as groundwater recharge. By contrast, in heavily sealed areas, precipitation water is predominantly discharged via the sewer system, while at the same time, evaporation is significantly reduced. The comparatively unpolluted precipitation water absorbs various substances from polluted areas during outflow and becomes wastewater. Depending on the type and use of sealed land, it may contain for example dust, leaves, road and car tyre abrasion, petrol, oil and animal faeces. Recent studies also showed that rain water discharges in urban areas may also be a source of micropollutants, such as biocides from house facades and PAHs[92].

If drainage occurs via a separate sewer system, i.e. wastewater and precipitation water are discharged by separately, the precipitation water is discharged into a waterbody either directly, after interim storage, or following

Heavy rain–Flooding in an underpass

Figure 27

treatment in a rainwater purification basin. If discharged in a combined sewerage system, i.e. precipitation water and wastewater are discharged together, the wastewater treatment plant must handle a larger volume of wastewater whenever precipitation occurs. In heavy rainfall, the sewer system and pumping stations often reach their capacity limits, causing wastewater diluted with rainwater to be discharged directly into waterbodies. This creates high levels of waterbody pollution with nutrients and contaminants, and can even cause fish mortality as a result of oxygen depletion.

In recent decades, the construction of retention and treatment facilities in both types of sewer systems has reduced pollution with substance emissions from precipitation water. However, precipitation discharges from separate sewer systems and overflows from combined systems continue to significantly impair waterbody quality. Alongside material pollution of waterbodies, the growing incidence of heavy rainfall associated with climate change and the increase in surface sealing in many places is causing roads and underground structures such as garages, cellars and metro stations to flood. High masses of water falling in a short space of time can no longer be accommodated by the gullies, because the sewer system is not designed for such volumes of rain.

Model calculations[93] for Germany calculate the share of nutrient emissions from combined sewer overflows at 2.2% (10,500 t/a) for nitrogen and 8% (1,800 t/a) for phosphorus respectively. In relation to total emissions, the proportion of nitrogen and phosphorus emissions via the separate sewer system (rainwater) is just under 2% (9,200 t/a) for nitrogen and 7.5% (1,700 t/a) for phosphorus. Heavy metal emissions via combined sewer overflows range from 2% (chromium) to 14% (copper, mercury), and via separate sewers from 3% (chromium) to 22% (copper). For pollutants like PAH, 15% and 30% respectively of emissions into waterbodies occur via combined sewer overflows and separate sewers.

Biocides used, for example in facade coatings to protect against fungal and algal growth and in roof sealings as chemical protection against root penetration, may be emitted into the sewer with rainfall. For example, model calculations[94] indicate that in 2008, some 700 kg of diuron was discharged into surface waters via sewer systems in Germany as a whole. For public wastewater treatment facilities, emissions were estimated at 640 kg.

Options for semi-natural rainwater management are discussed in chapter 6.2.5. For details of measures to address heavy rain, see chapter 6.10.2.

3.2 Agriculture

Just under 52% of the area of Germany is agricultural land, which impacts both the environment and the landscape. Unlike other European countries, agricultural irrigation in Germany is a minor factor. However, agriculture puts pressure on waterbodies with substance emissions and morphological changes. Excessive nutrient emissions into waterbodies from the application of agricultural fertilisers play a decisive role in nitrate pollution of the water and the oversupply of nutrients (eutrophication) to rivers, lakes and seas.

3.2.1 Irrigation

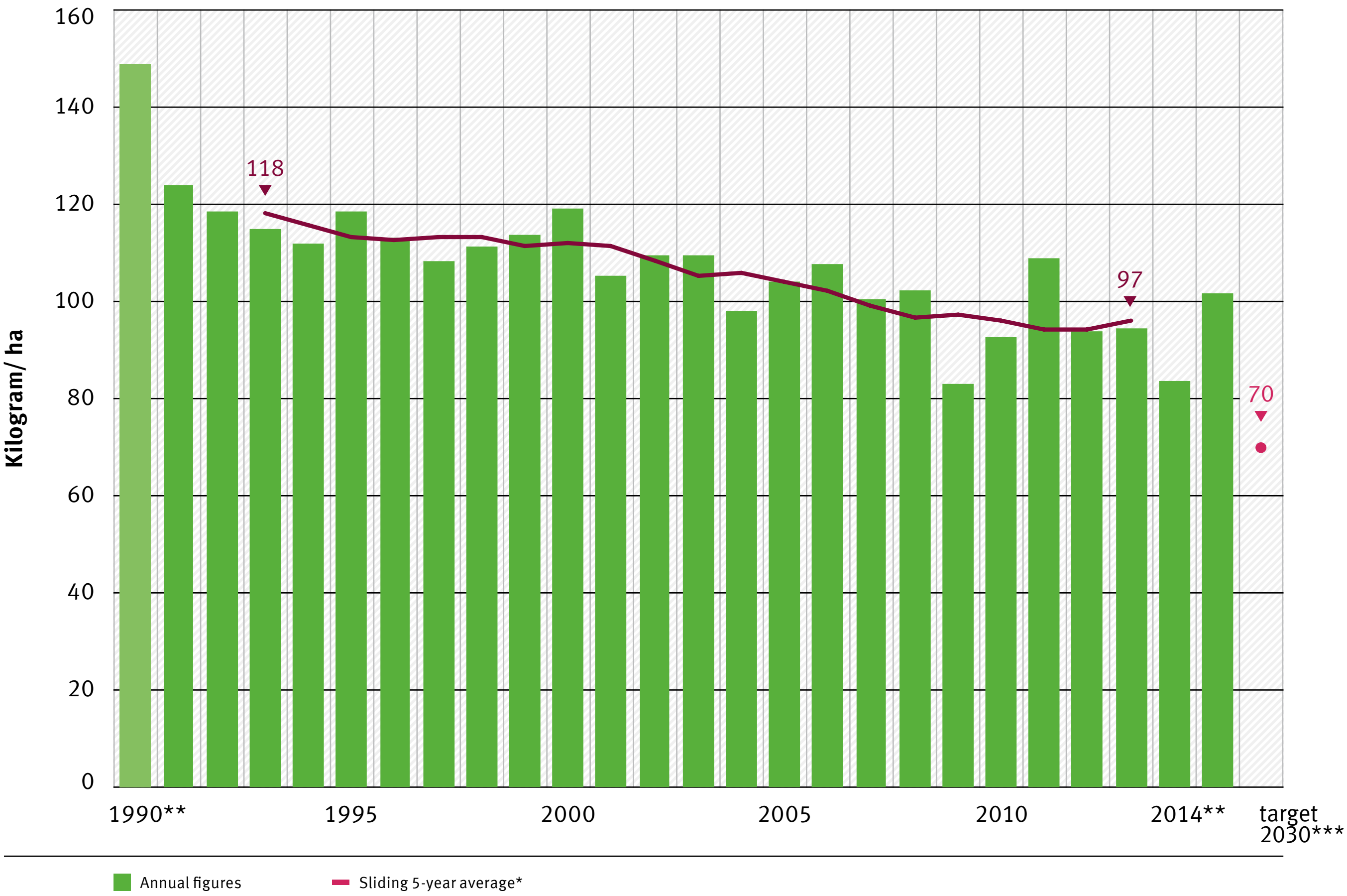
Compared with the European annual average of 36%[95] and up to 60% in the summer months, agricultural irrigation in Germany accounts for only a minimal share of 1.5% (0.3 billion m³) of total water abstractions (see chapter 2.7). Worldwide, 20% of all cultivated area is irrigated, and this land produces 40% of the world's food[96].

For Germany as a whole, in 2012 some 691 300 ha[97] of agricultural land was equipped with irrigation systems, slightly over half of which (365,600 ha) was actually irrigated, predominantly with sprinkler systems. This equates to 2.2% of agricultural land. The water used in Germany for irrigation was predominantly (just under 86.5%[98]) taken from groundwater (including spring water and bank filtrate).

Lower Saxony has the largest area of irrigated land (206,900 ha in 2012) of all the Länder. Alongside locations in the east of Lower Saxony (e.g. Lüneberger Heide), there are also irrigated areas in the west of North-Rhine Westphalia,

Figure 28

Overall nitrogen balance in agriculture in relation to agricultural land*



* Annual surplus relates to the middle year of the 5-year period
** 1990: Some figures uncertain, only partially comparable with subsequent years; provisional figures for 2015
*** Target of the Germany's National Sustainable Development Strategy related to the 5-year average, i.e. the time period 2028 to 2032

Data: Federal Ministry of Food and Agriculture (BMEL) 2017, nutrient balance 1990-2015 (MBT-0111260-0000)

Saxony, Saxony-Anhalt and Mecklenburg-West Pomerania. Most of the irrigated areas are intensively farmed with comparatively low levels of precipitation (<600 mm) and generally light soils. Irrigated crops include cereal, potatoes, sugar cane and special crops such as decorative plants, fruit and vegetables[99].

By importing agricultural produce to Germany, some of the water used abroad for irrigation is likewise imported (see chapter 3.1.1 on the water footprint). In 2010, 65.7 million tonnes of agricultural produce and foodstuffs were imported to Germany. Around 77% of the irrigation water used (also known as "blue water") is attributable to imports of crop plants, and 23% to imports of animal products[100]. The majority of products grown and irrigated for Germany are from Spain, France, the United States and Italy. For example, in 2013 Germany imported some 180,000 tonnes of tomatoes from Spain alone[101], equating to a virtual water volume of almost 15 million m³ per annum[102].

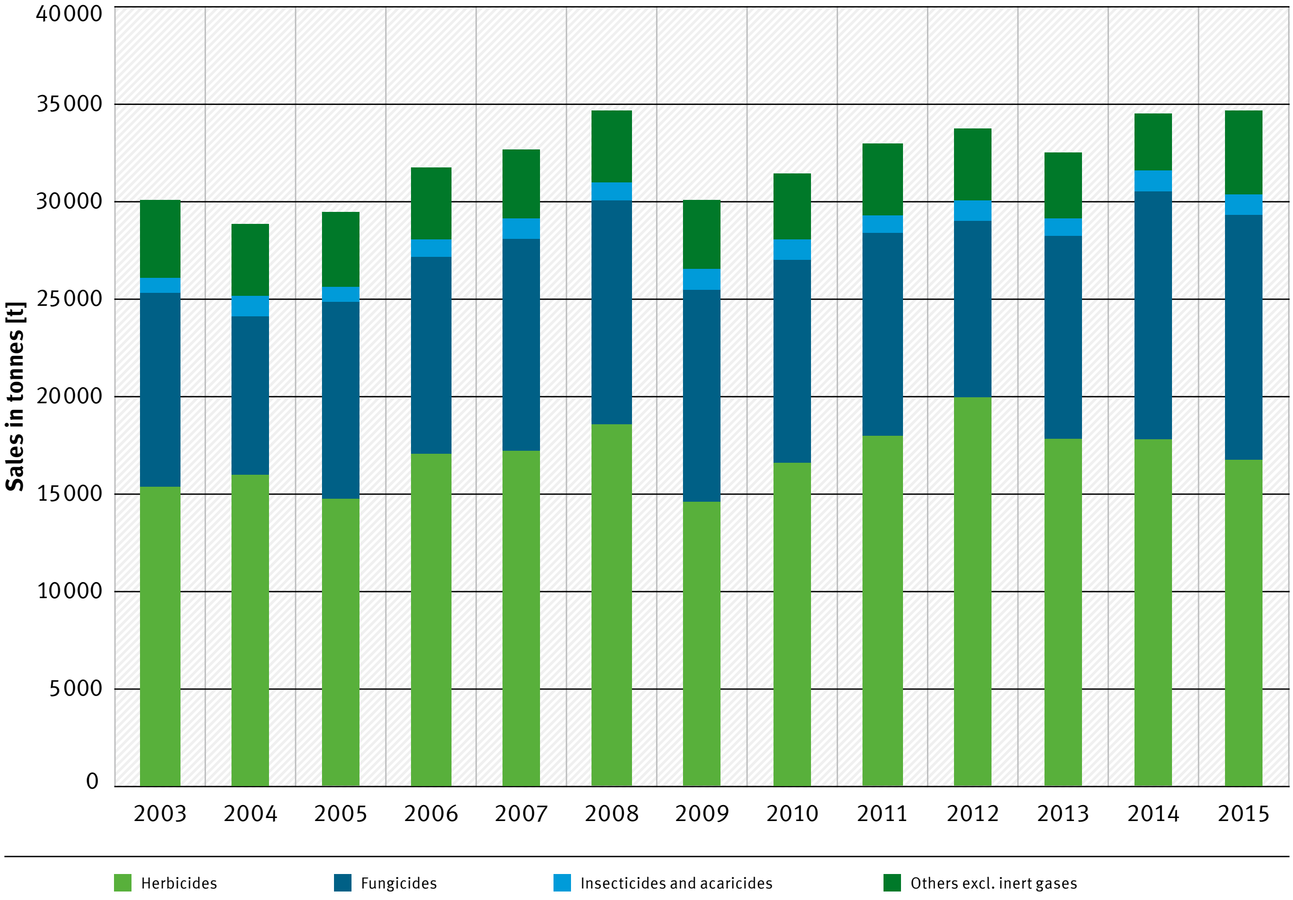
However, the majority of agricultural produce imported to Germany is grown on land irrigated mainly by natural precipitation.

3.2.2 Emissions from agriculture

For many decades, emissions of phosphorus-nitrogen compounds as well as pesticides have polluted the groundwater, streams, rivers and lakes, as well as the coastal waters and seas, in Germany and Europe. Reduction measures to date, such as the ban on atrazine (1991), the amendment to the Plant Protection Act (1996)

Figure 29

Domestic sales of active pesticide ingredients (excluding inert gases) in Germany during the period 2003 to 2015



Source: German Environment Agency based on data by Industrieverbrand Agrar e.V., BMELV, Statistisches Bundesamt et al.

and the Fertiliser Ordinance (1996, current version 2017), have only been partially effective.

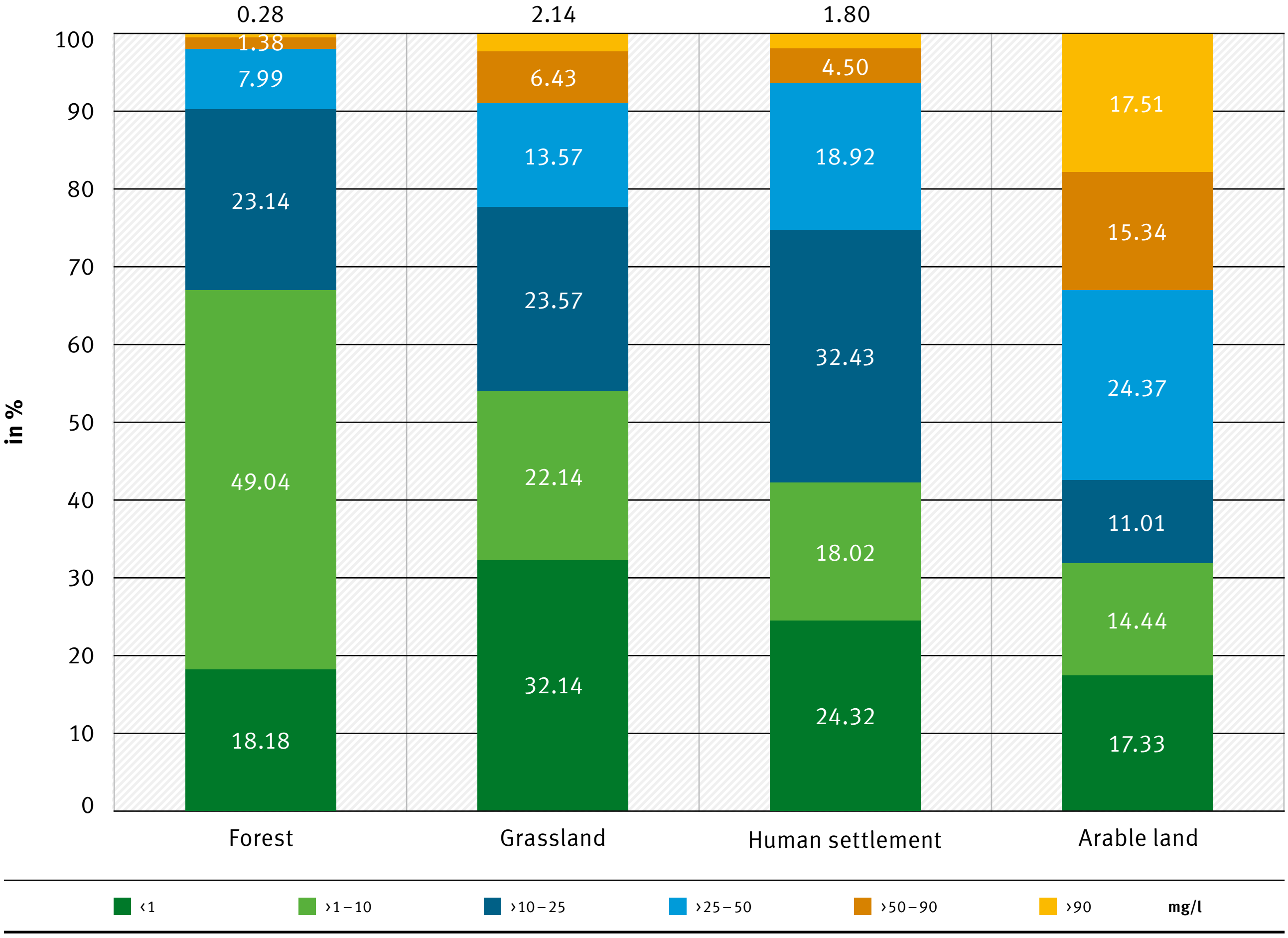
Nitrate pollution levels have been reduced compared with the early 1990s (see Nitrate Reports). However, in recent years this downward trend has flattened out, and some regions are seeing rising trends. The percentage of water pollution caused by agriculture has risen significantly, because in recent years the municipalities and industry have substantially reduced their emissions (in some cases with expensive measures).

Nitrogen is a valuable plant nutrient and is applied to the soil in the form of mineral nitrogen, slurry, liquid manure and fermentation residues[103]. Nitrogen that cannot be absorbed by plants or fixed in the soil may be displaced into groundwater or surface wasters.

The nitrogen surplus, calculated from the total nitrogen balance, is a useful way of gauging potential nitrogen emissions into groundwater, surface waters and the air. The total nitrogen balance is calculated from the difference between nitrogen flows in agriculture and nitrogen flows emanating from it. Nitrogen surplus is calculated as a mean average for Germany. There are major differences between individual regions and farms, primarily attributable to differing densities of livestock. In order to compensate for annual fluctuations caused by weather conditions and fertiliser prices, a sliding 5-year average is given for the middle year. The results indicate that, despite a tendential decline, nitrogen surpluses are still too high (see Figure 28). From 1993 to 2012, the nitrogen surplus on a sliding five-year average decreased from 117 kg/ha per annum (kg/ha*a) to 95 kg/ha*a, a decrease of around 20% since

Figure 30

Nitrate pollution of groundwater beneath forest, grassland, human settlements and arable land



Source: German Environment Agency

1992. The German Government is aiming to reduce the nitrogen surplus to 70 kg/ha, per annum by 2030[104]. The Commission for Agriculture at the German Environment Agency (KLU) promotes even lower surpluses of around 50 kg/ha*a to meet the water protection targets (such as compliance with the groundwater threshold of 50 mg/l) as well as the targets for the prevention of air pollution.

The phosphorus situation is slightly better: Phosphorus levels in soil had risen considerably in recent decades due to regular phosphorus surpluses. Many soils are now oversupplied, but farmers have responded and only apply minimal quantities, at least of mineral fertilisers. Phosphorus surpluses are now close to zero. Oversupplied soils, e.g. in cattle-intensive regions where phosphorus application in the form of slurry and manure is still admissible, remain a problem.

What is more, slurry and manure may also contain traces of veterinary medicines which then, depending on the quality of the soil, either seep into the groundwater or may enter surface waters via elutriation during heavy rain. However, the results of a research project[105] indicate that veterinary medicine emissions into groundwater are up to now only detected in exceptional cases.

Pesticides emissions also pollute waters. Pesticides are highly active chemical and biological substances that are applied in large quantities directly into the environment to protect crops from pests or protect against competition from weeds (approx. 110,000 t hand over in Germany in 2015). Thanks to the amendment to the Plant Protection Act and the changes in the licensing procedures for pesticides, many pesticides have been banned in recent decades or are subject to certain restrictions. As a result, the spectrum of active ingredients has changed and the pollution of waters overall has been significantly reduced; however, the quantities of active ingredients sold remained virtually unchanged during the period 2003 to 2015 (Figure 29).

Groundwater pollution

In terms of area, nitrogen emissions are the biggest source of groundwater pollution. If the nitrogen surplus causes an exceedance of the limit value of 50 mg/l nitrate as established by the Groundwater Ordinance of, this groundwater can no longer be used directly for drinking water abstraction.

An analysis of land use provides clear indications on the sources of nitrate. Measuring points in the catchment area of arable land indicate significantly higher nitrate concentrations in groundwater than measuring points whose catchment area is characterised predominantly by forests (Figure 30). Among forest, the nitrate concentration of 50 mg/l is exceeded at 1.7% of measuring points. At measuring points whose catchment area is dominated by grassland or human settlements, the proportions are around 8.6% and 6.3% respectively. In regions with predominantly arable land or special crops, the Groundwater Ordinance's threshold value with nitrate levels of more than 50 mg/l is exceeded by one-third (32.8%) of measuring points.

Detailed information on the status of groundwater, including findings of pesticides and their metabolites, can be found in chapter 4.1.3.

Pollution of rivers, lakes and seas

Whereas in the 1980s most nitrogen originated from point sources, primarily from wastewater treatment plants, since the mid-1990s inflows from agriculture via groundwater have been the principal source of nitrogen emissions into surface waters such as rivers and lakes.

From 2012-2014, around 50% of nitrogen was discharged into surface waters via groundwater[106]. Together with emissions from surface run-off, drainage and erosion, emissions from agriculture dominate nitrogen emissions into surface waters, at around 75%.

By way of comparison: Over the same period, the proportion of nitrogen emissions from point sources (public wastewater treatment facilities and direct industrial discharges) was 19% of total emissions.

However, waterbodies have a long memory. Although we have seen a substantial reduction in nitrogen surpluses in German rivers, they show a much delayed response to changes in pressures. In the case of the Rhine, experts expect a load reduction to become apparent within two to ten years, but in the case of the Elbe, this is likely to take 20 to 30 years[107].

Over the same period, around 50% of phosphorus entered our rivers and lakes from agriculture. In acidic, oxygen-free or extremely sandy soils, phosphorus is initially insoluble, and is discharged into the groundwater. Groundwater is therefore responsible for approximately 21% of phosphorus contamination in rivers and lakes. The proportion of soil erosion and surface runoff is similarly high at 16%. Phosphorus emissions from surface run-off drainage contribute around 10%.

In 2012-2014, emissions from point sources represented another significant emissions pathway, accounting for 34% of total emissions.

In the vicinity of the North and Baltic Sea coasts, nutrient emissions are one of the main factors in failing to achieve a good waterbody status (see chapter 4.3.2). Here too, emissions from agriculture account for the lion's share of diffuse sources.

In 2012-2014, 86% of waterborne nitrogen emissions and 64% of phosphorus emissions into surface waters in the German catchment area of the Baltic Sea (Warnow/Peene, Schlei/Trave and Oder river basins) originated from agriculture.

Over the same period, 80% of nitrogen emissions and 65% of phosphorus emissions from diffuse sources entered the North Sea, with agriculture accounting for 70% (nitrogen) and 48% (phosphorus) respectively.

The excessive nutrient emissions adversely impact microalgae and large algae, flowering plants (such as seagrass) and benthic invertebrates. It is not just nutrients that are harming our waters, but also heavy metals and pesticides.

High proportions of heavy metal discharges into surface waters originate from erosion or surface and drainage runoff from agricultural land. In particular, chromium (74 %) and lead (62 %) are emitted into surface waters as a result of erosion.

It is important to stress that other sources of pollutants, particularly from industry, have been substantially reduced, and the proportion of the overall load attributable to agriculture has therefore increased.

Most pesticide pollution originates from agriculture, both from application on the field, and from cleaning spraying machines and other equipment. Between 2006 and 2015, 3-year studies found that at 15 to 25% of representative surveillance monitoring points for watercourses in Germany, located primarily on major rivers, the annual averages of at least one pesticide exceed the environmental quality standard set out in the Surface Waters Ordinance. Over the same period, the drinking water limit of 0.1 µg/l was exceeded at 55 to 70% of measuring points in whose catchment areas drinking water is abstracted from surface waters. At 15 to 35% of these measuring points, the total sum of all pesticide residues even exceeded the combined limit of 0.5 µg/l at times. These exceedances were attributable to around 20 out of a total of more than 60 regularly tested agents. For a few substances that are banned or no longer licensed (e.g. atrazine) decreases in pollution levels since the 1990s can be seen.

In addition, morphological changes for the benefit of agriculture, such as drainage, are responsible for reducing watercourse diversity. Streams and ditches have been made narrower, straightened, shortened, and their beds constricted and deepened for development, maintenance and use. Often, agricultural use extends as far as the upper edge of the riverbank.

Measures to reduce agriculture-related pressures are outlined in chapter 3.6.

3.3 Industry and the extraction of raw materials

3.3.1 Water-relevant emissions from facilities

Since 2009, the general public has had free access to the Internet-based Web portal www.thru.de for information on water-relevant emissions. It publishes data on releases into the air, water and soil, on the emission of pollutants contained in wastewater and the disposal of hazardous and non-hazardous waste.

The Pollutant Release and Transfer Register (PRTR) is intended to provide the general public, industry, academia, NGOs and other decision-makers with transparent access to environmental information.

The structure and operation of the PRTR are based on an international convention by the UN Economic Commission for Europe (UN-ECE), the so-called PRTR Protocol, and the EU PRTR Regulation concerning the establishment of a European Pollutant Release and Transfer Register[108]. Germany has transposed this EU Regulation into national law[109].

Facilities are not required to report every emission or disposal operation; they must only do so if the pollutant emission exceeds a certain threshold value, or the waste exceeds a certain volume threshold[110].

Between 2007, the first year of reporting, and 2014, the number of facilities subject to reporting requirements has increased continuously, from 4,496 to 5,307. For the reporting year of 2015 a slight decline of facilities subject to reporting requirements has been noticed for the first time.

As can be expected, North Rhine-Westphalia (NW), the Land with the highest population, and Bavaria (BY) and Lower Saxony (NI), the Länder with the largest areas, reported the highest numbers of facilities subject to reporting requirements under the PRTR (see Summary Report of new PRTR data 2015[111]).

The majority of facilities subject to PRTR reporting are in the waste industry, and account for between 80% and 84% of the total share of PRTR facilities subject to reporting requirements.

Pollutant emissions into air are reported by 30% of PRTR facilities.

The number of facilities with pollutant discharges into external wastewater treatment facilities (such as public wastewater treatment plants) slightly exceeds the number of facilities with direct pollutant emissions into waters. The term "off-site transfer of pollutants contained in wastewater for wastewater treatment" is broader than the provision on indirect dischargers, and also covers reports of mobile transfer and transport routes, such as tankers or containers.

In each of these two sectors, the proportion of PRTR facilities subject to reporting requirements is just under 10%.

Many facilities report both pollutant emissions and the disposal of waste quantities, which explains why the percentages add up to more than 100%.

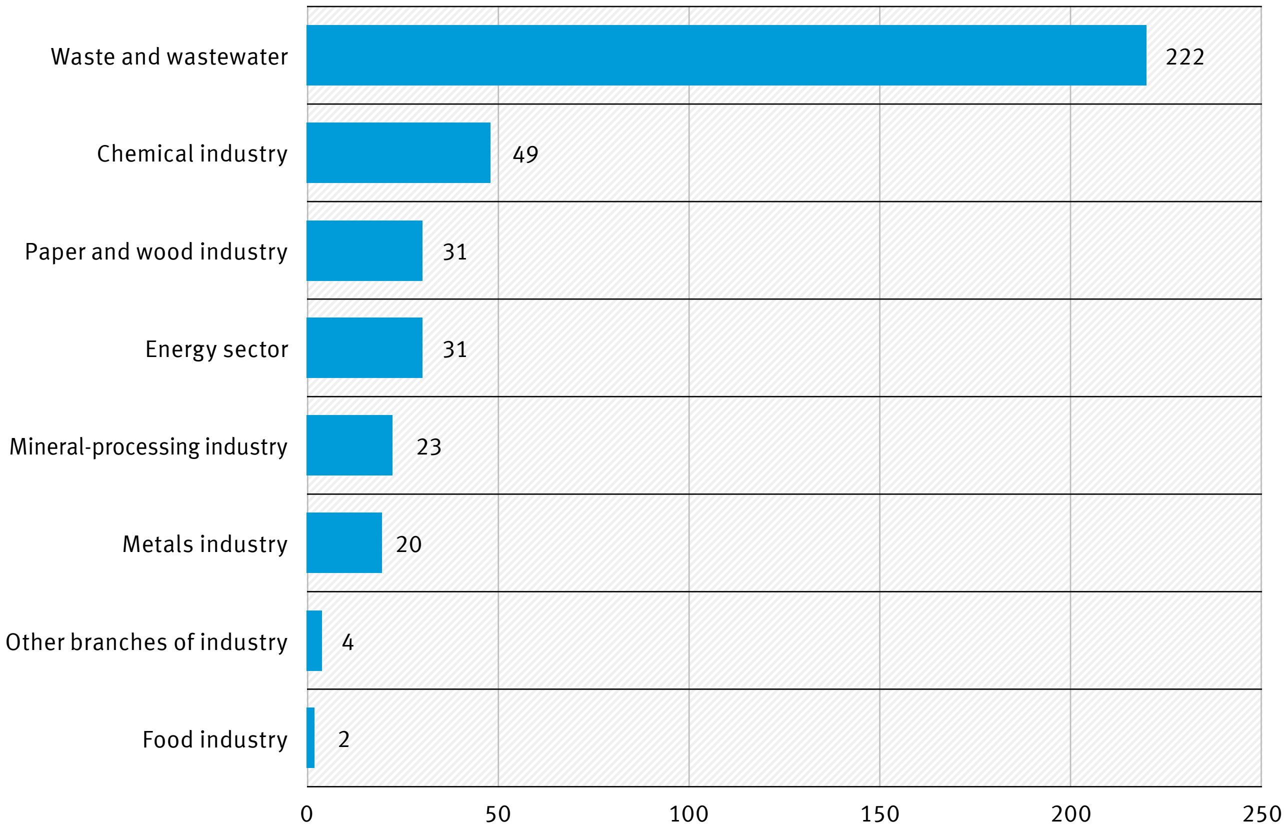
For the reporting year 2015, in total, 382 PRTR facilities reported emissions into water. This refers solely to emissions from direct dischargers.

Of these, 222 PRTR facilities (58%) are attributable to the "waste and wastewater" sector. Within this industry, "public wastewater treatment facilities with an output of 100,000 population equivalent (PE)" make up the bulk of PRTR facilities with reporting obligations, with 208 notified facilities (Figure 31). The remaining 14 PRTR facilities are assigned to other PRTR activities (primarily in the waste sector).

The "chemical industry", "paper and wood industry" and "energy sector" rank second and third, with a small number of 49 and 31 registered PRTR facilities respectively.

Figure 31

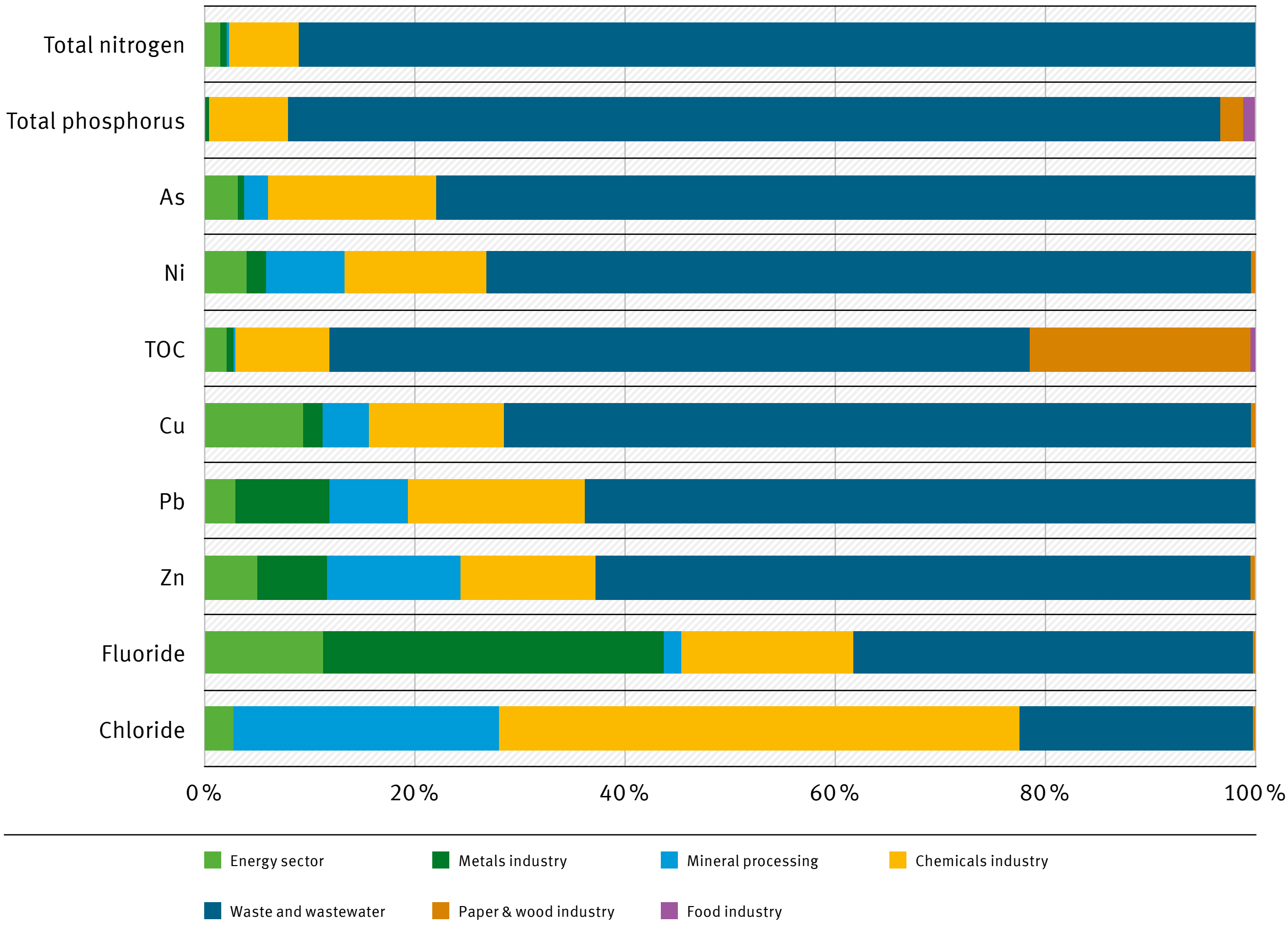
Number of PRTR facilities for release into water by industry, 2015



Source: www.thru.de German Environment Agency, reporting year 2015

Figure 32

Industry shares of the TOP 10 pollutants – Releases into water 2015



Source: www.thru.de German Environment Agency, reporting year 2015

Figure 32 shows the ten pollutants with the highest emission volumes into water and the main industries responsible in 2015.

The "Waste and wastewater" industry is the principal emitter into water by a wide margin of the pollutants total organic carbon (TOC), zinc (Zn), arsen (As), nickel (Ni), total nitrogen, copper (Cu), total phosphorus and lead (Pb), particularly "public wastewater treatment facilities with an output of above 100,000 population equivalents (PE)".

The bulk of chlorides originate from the "chemical industry" and the "mineral-processing industry". However, the "waste and wastewater" sector, particularly public wastewater treatment facilities, also reports a significant proportion of chlorides.

The "metal industry" and "waste and wastewater" sectors are responsible in almost equal shares for the emission of fluorides into water.

After eight years of PRTR reporting, the general public now has access to a well-documented, quality-verified reporting time series containing comprehensive information on current and existing environmental problems. The data is now utilised by numerous associations (including the Chemical Industry Association (VCI) and academic institutions for evaluations, theses, trend analyses etc.

Accidents with substances hazardous to water or with slurry, liquid manure and silage can cause fish mortality

Detailed information on PRTR facilities and the data reported can be found at www.thru.de. Using the Search option allows you to selectively search for individual facilities, sectors or pollutants. The map search function makes it easy to locate facilities in a given region. As such, the PRTR represents an important step towards a "transparent sewer pipe".

The database can be downloaded for an in-depth evaluation (https://www.thru.de/3/thrude/downloads/).

The requirements governing industrial wastewater within the context of the Industrial Emissions Directive and measures to prevent industrial wastewater and its recovery are outlined in chapter 6.4.1, 6.4.2 and 6.4.3.

3.3.2 Accidents in installations when handling substances hazardous to water

Despite the requirements placed on facilities and their safety features, accidents involving the handling of substances hazardous to water are a regular occurrence (see chapter 6.4.4). The relevant guidelines state that the release of substances dangerous to water into the environment (such as overground waterbodies, soil etc.) must be reported immediately to the competent authority or the nearest police station. The same applies if contamination of the immediate environment (waterbodies, soil) by substances dangerous to water cannot be excluded for other reasons. The notifications of reported events are evaluated annually by the Federal Statistical Office[112], based on the Environmental Statistics Act.

The figures shown here refer to the year 2015. They indicate that there were 786 accidents involving the handling of substances dangerous to water in commercial operations and private households, 92 of which involved slurry, liquid manure or silage. The quantity of pollutants released by these accidents totals 14.9 million m^3, 9.6 million m^3 (64 %) of which originated from slurry, liquid manure and silage installations, whose contents are not assigned to a water hazard class but are nevertheless considered generally hazardous to the aquatic environment and, in appropriate quantities, capable of causing environmental damage. In particular, this includes fish mortality in adjacent watercourses or lakes (due to oxygen depletion). Compared to 2014 the emissions from slurry, liquid manure and silage installations increased by 41 %.

Analysis of the principal causes of accidents in slurry, liquid manure and silage installations reveals that 60% of incidents are attributable to human error, and only 22% to material deficiencies.

Of the total volume of substances released by accidents in commercial operations and private households, 38% (5.8 million m³) were recovered by organisational and technical means. The figures relating specifically to slurry, liquid manure and silage facilities total 41% (3.9 million m³).

For further information about accidents during the transport of substances hazardous to water by road, rail and water and their transportation in long-distance pipelines, refer to chapter 3.5.3. Installation-related water protection is addressed in chapter 6.4.4.

3.3.3 Overground mining

Mining activities have major impacts on surface waters and groundwater both during the active phase, but also long after mining has been discontinued. In many cases, mining entails a dramatic intrusion into the natural hydrological cycle. Particularly in opencast mines, it is necessary to lower the groundwater level, which may have severe implications for adjacent aquatic and terrestrial ecosystems. As lignite has been mined in Germany's coalfields for well over 100 years in some areas, even after this work has discontinued, it will take decades for the natural groundwater level to be restored. The lowering of groundwater levels in conjunction with lignite mining are also responsible for the poor quantitative status of groundwater in parts of the Maas, Rhine, Elbe and Oder river basins.

In parts of the Ruhr district, hard coal mining has led to large-scale subsidence. If the groundwater level were to return to its natural level, large tracts would be underwater. For this reason, continuous groundwater lowering measures are needed to keep the groundwater at a sufficient depth below the site surface (poldering). It may also be necessary, for example, to relocate or dyke water courses, to regulate outflow with transverse structures, and to construct and operate pumping stations.

Potash salt is mined in the Weser river basin. Part of the salt water generated has until now been submerged in the subsoil, while another portion is discharged directly into the Werra. Studies have shown that naturally-occurring formation water with portions of submerged saltwater reaches higher aquifers or even the surface. Some of it then enters the Werra as a diffuse emission. There are also concerns that groundwater aquifers are being contaminated by salt intrusions.

Pollution with heavy metals poses another challenge. Although ore mining in the Weser river basin district was largely discontinued as early as 1930 and the last mine was closed in 1992, the remaining diffuse heavy metal emissions still represent significant water pollution, attributable to outputs from slag heaps, polluted alluvial soils and river sediment containing metals.

Once mine sites have been decommissioned, planners face the question of what to do with the large-scale, significantly reshaped landscapes. The post-mining landscapes of the Lausitz and Central German coalfields are being reformed into a series of 46 artificial lakes, containing some 25,000 ha of water, to be used as a recreational area. This entails filling the mine pits rapidly and constantly with river water. If they were to be filled with groundwater, this would generally produce acid lakes. This must be prevented, by ensuring that they are filled predominantly with surface water, which in turn draws large volumes of water from the surface waters. What is more, slag heaps often contain sulphurous minerals such as pyrite and marcasite, which react highly acidic in contact with water. The consequence is often extremely low pH values (2 to 4) in the lakes, precluding any form of use. Nevertheless, many recreational areas and invaluable refuges for rare animal and plant species have successfully been created in former open cast mining areas.

3.3.4 Deep sea mining

Countless mineral raw materials such as manganese nodules (polymetallic nodules), cobalt-rich iron and manganese crusts as well as polymineral massive sulphides are found on the deep sea bed. These are becoming increasingly sought-after: Manganese nodules for their comparatively high content of copper, nickel and cobalt; and massive sulphides for their non-ferrous metals such as copper, zinc and lead, and also precious metals gold and silver and trace metals such as indium, tellurium, germanium, bismuth, cobalt and selenium. Since 2001, 26 exploratory projects have been conducted on the high seas –16 for manganese nodules, 4 for iron and manganese crusts, and 6 for massive sulphides. The Federal Institute for Geosciences and Natural Resources is also involved in this exploration; it has held licences in the Pacific Ocean for manganese nodules since 2006, and in the Indian Ocean for massive sulphides since 2015 (Figure 23).

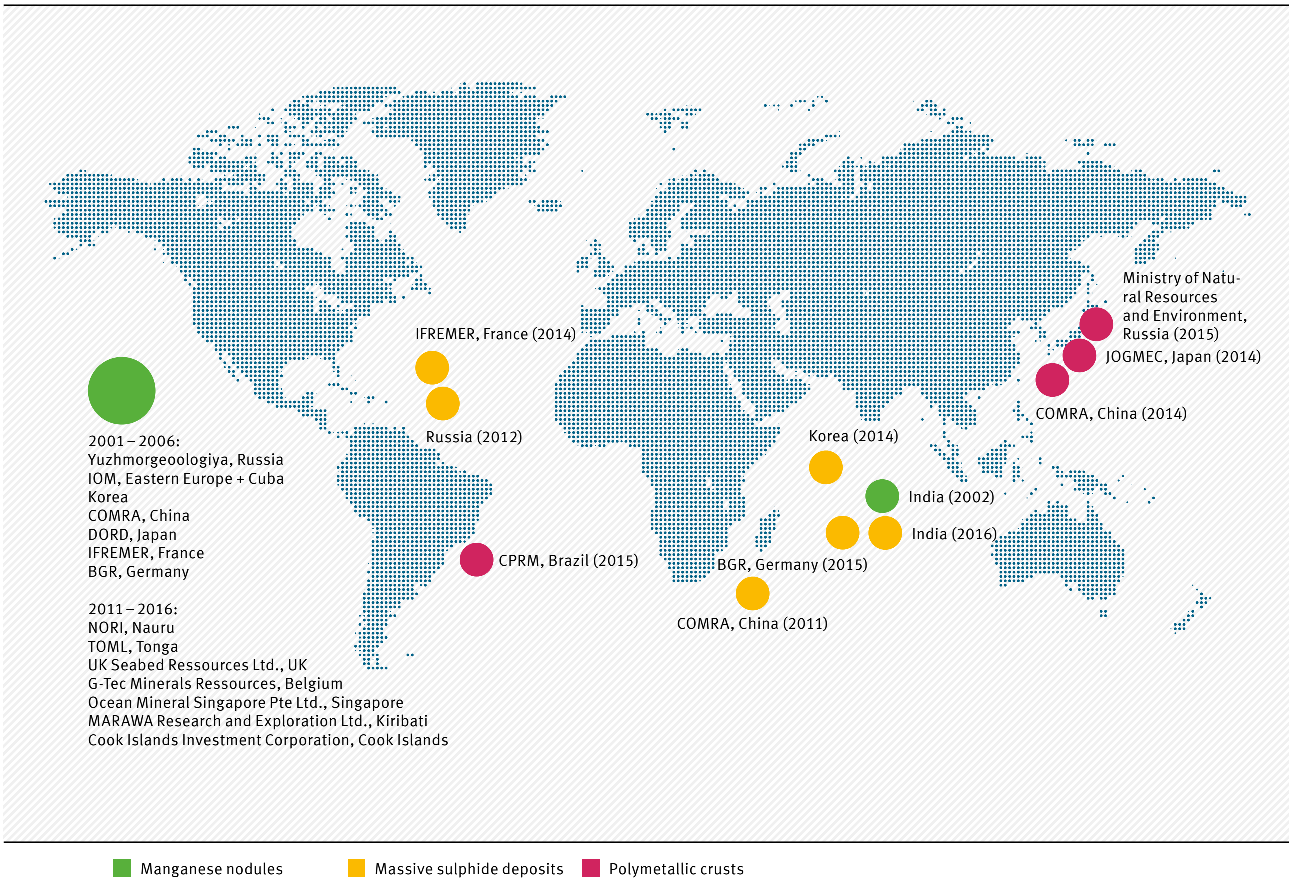
The United Nations Convention on the Law of the Sea describes the deep sea bottom as the "common heritage of mankind". The International Seabed Authority (ISA), founded in 1994 and based in Kingston, Jamaica, is responsible for issuing exploration mining licences, and monitors deep sea mining projects outside of national jurisdictions.

Mining projects on the deep sea bottom can have major impacts on oceanic habitats and biotic communities:

- Environmental damage on and in the sea bottom associated with the use of mining equipment: Complete pelagic communities are removed from their habitats together with the nodules. Recolonisation is not possible when the nodules are missing as substrate.
- Plume formation by sediment stirred up during the use of mining equipment, which drift and

Figure 33

Exploration licences, licence applications and initial explorations for marine metallic raw materials in international waters (as at 2017)



Source: German Environment Agency, data: International Seabed Authority, ISA

disperse close to the sea floor, and are then re-deposited as sediment in the direction of the current. This can bury bottom-dwelling organisms, such as sponges, due to sudden sedimentation.
- Creation of additional plumes on the surface or at medium water depths when the fine-grained transportation water (tailings) lifted together with the manganese nodules is returned. This sediment and the contaminants it contains are scattered in the sea and may accumulate in the food web, depending on their substance properties. Phytoplankton may be impaired as a result of turbidity.
- Individual species and species communities could become endangered or extinct

Our lack of knowledge about affected ecosystems is a major problem. It is almost impossible to predict specific environmental consequences–for example, whether entire species could be eradicated. The consequences for the individual ecosystem are also very hard to predict. For possible approaches to deep-sea mining, see chapter 6.4.6.

3.4 Energy

3.4.1 Cooling water

Cooling water is needed for many production processes and for energy extraction. In order to ensure the maximum possible efficiency during energy extraction, the heat generated must be removed from the process by means of cooling water. According to publications by the Federal Statistical Office, in 2013 around 17.6 billion m^3 of fresh water was used to cool production processes and to generate electricity[113]. In 2010, around 25.2 billion cubic metres was used for cooling purposes in non-public facilities. This equates to a decrease of 30.1%, or 7.6 billion cubic metres. Energy supply accounts for the lion's share (just under 75%) of the cooling water used, at 13.1 billion m^3.

Most of the water used is taken from rivers, lakes and reservoirs, as well as from bank filtrate and groundwater. After cooling, the water used is returned to the waterbody at an increased temperature. A certain proportion of the cooling water evaporates during use (in 2013, the figure for energy supply was around 4%).

The water temperature is of crucial significance for the living conditions of all aquatic organisms. Most aquatic organisms are unable to control their own body temperature–in other words, all physiological processes are dependent on the ambient temperature. The direct negative impacts of increased water temperatures range from disruption to feeding, the shifting of egg-laying periods to organ damage and heat-related death. As the water temperature increases, the solubility of oxygen decreases. At high levels of pre-contamination with organic matter, a temperature increase can lead to critical oxygen concentrations, and potentially to fish mortality. The introduction of waste heat from power plants can also trigger a range of indirect effects, such as changes in the species spectrum or the promotion of non-indigenous species. It can also lead to the migration of entire species.

As such, the abstraction of cooling water always represents an ecological pressure for the waterbody, the intensity of which varies according to the outflow conditions and water region. Approaches for reducing these pressures are described in chapter 6.5.1.

As a result of changes in air temperature associated with climate change, water temperatures are expected to rise (chapter 2.2), and the environmental problems associated with the use of cooling water therefore look set to increase in future. In low-water situations, energy supply may be impaired. On the one hand, the water supply is reduced, i.e. there is insufficient water available; on the other, water temperatures may already be so high that further warming associated with the use of cooling water is no longer admissible.

3.4.2 Geothermia

Geothermal energy refers to the energy stored in the form of heat beneath the earth's crust[114]. It is also known as ground heat or geothermia[115].

Geothermal energy potential is used to generate electricity and heat, and for cooling. Geothermal energy could play a key role in future, particularly in the supply of heating and cooling (which accounts for around half of final energy consumption in Germany), and as a renewable energy could help prevent greenhouse gas emissions by substituting fossil generation capacity. However, the proportion of heat obtained from geothermia is still low in Germany, at around 6 TWh/a or 0.5%[116].

The nature and scope of geothermal use depends on the depth. Below the area influenced by sunlight and precipitation–approximately 10 to 20 metres below the earth's surface–the temperature in our latitude is around 10°C; at greater depths, the temperature rises by an average of 3°C per 100 m. In favourable areas of Germany, the increase (temperature gradient) can be as high as 5°C or more. Underground rock layers and groundwater aquifers can also be used as thermal stores. When characterising geothermal uses and the associated risks, it is useful to distinguish between shallow and deep geothermia.

Shallow geothermia

Shallow geothermia refers to the use of geothermal energy up to a depth of 400 m, although in practice rarely less than 150 m[117]. Generally, heat is extracted indirectly in so-called closed systems, whereby a thermal transmission fluid circulates in plastic pipes. The most widely used systems in Germany are geothermal heat probes with vertical boreholes sealed against the surrounding subsoil and groundwater. Heat abstracted from groundwater by wells is used directly in only around 15% of cases. Heat pumps are used to raise the temperature to the required level, e.g. to supply room heating and hot water. There are already more than 330,000 geothermal heating (and cooling) plants in operation in Germany[118]. Shallow geothermal facilities currently account for the bulk of geothermal energy extraction (more than 80%), generally with a small, building-scale output (10 to 20 kW).

However, when the number of encroachments into the subsoil increases, so does the threat to the groundwater ecosystem and the use of groundwater as drinking water. The drilling itself poses the greatest threat. Damage often occurs due to a lack of knowledge about the subsoil conditions and the use of non-adapted technology, especially drilling technology. Until now, damage has tended mainly to affect the area close to the surface. Some typical types of damage include:

- Hydraulic short-circuits, i.e. the unwanted connection of separate groundwater aquifers and the potential entrainment of pollutants
- Settlement or lifting damage to adjacent infrastructure
- More highly mineralised groundwater may rise towards the surface.

Risks are also associated with changes in the temperature of the soil and groundwater, which has a decisive influence on metabolic processes in subsoil-dwelling organisms and on chemical and physical processes. Microorganisms and microbes are adapted to specific temperature ranges. Significant temperature changes can alter biotic communities, thereby potentially degrading the self-purification process. According to Grieber et al. (2015)[119] the direct threat to groundwater quality from probe leaks and the emission of substances hazardous to water is negligible. However, the number of actual leaks that go unreported is unknown.

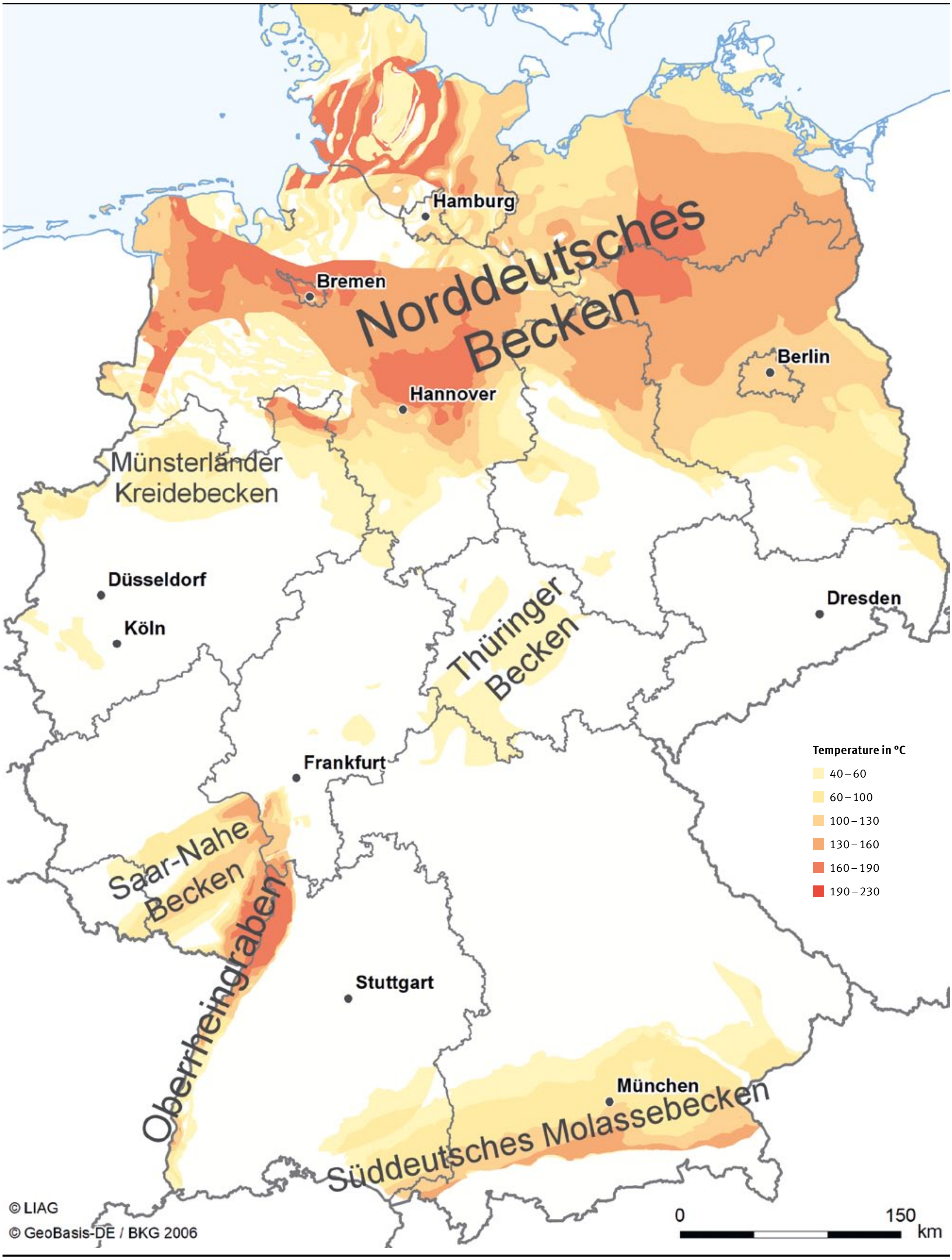
Deep geothermia

In deep geothermia, water acting as a thermal carrier is circulated between the surface and the subsoil via deep drillings to extract energy. In Germany, temperatures of more than 60°C are found at typical drilling depths of more than 1,500 m. The extracted energy is either used directly in the form of heat, or used to generate electricity. Corresponding CHP (combined heat and power) plants achieve a thermal output of tens of MW, which is sufficient to heat several thousand households. In deep geothermia, we distinguish between hydrothermal and petrothermal systems[120]. Hydrothermal systems convey groundwater available at depth; these systems rely on the occurrence of groundwater supplies at a suitable temperature (Figure 34). By contrast, petrothermal systems mainly use the energy stored in the bedrock. Apart from borehole thermal energy storage (BTES), petrothermal systems in Germany are still at the development stage. In order to utilise petrothermal deposits and achieve adequate water circulation, the cracks and chasms existing naturally in the reservoir rock, even at considerable depths, are expanded using stimulation measures (hydraulic stimulation/ fracking), or new water migration pathways are created by creating artificial cracks.

Alongside induced seismicity, the potential environmental impacts of developing deep geothermia include impairments to shallow

Figure 34

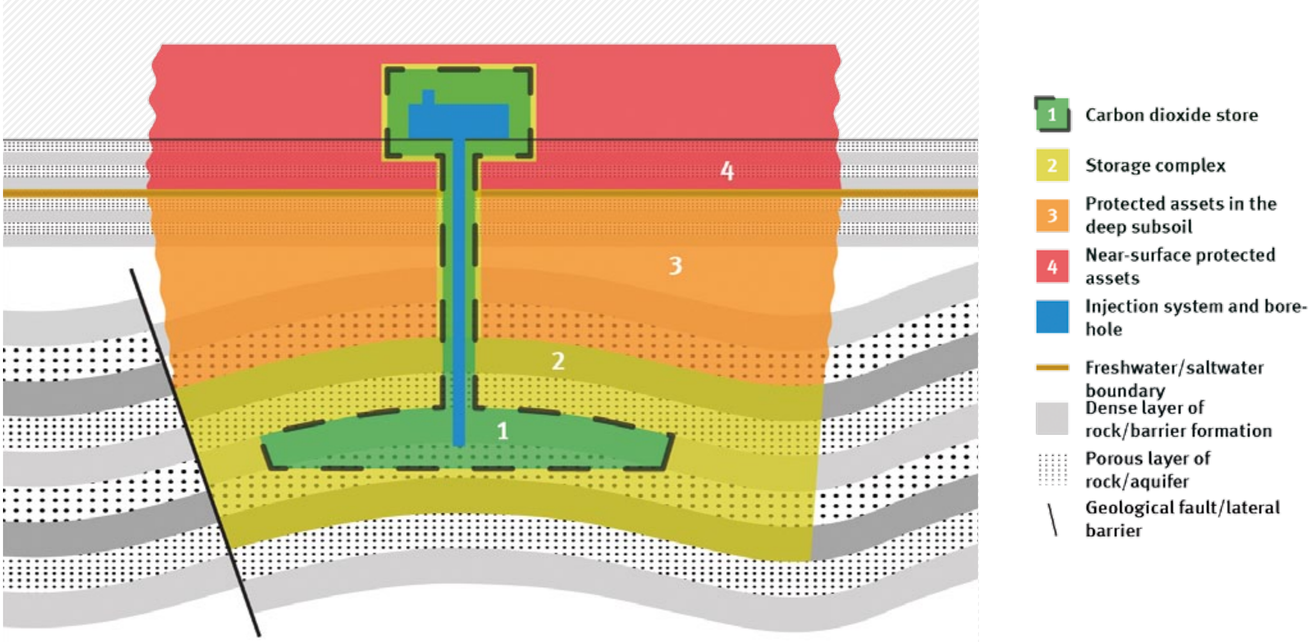
Regions suitable for hydro-geothermal use and related temperature ranges



Source: Suchi et al. 2014[121]

Figure 35

Schematic diagram of a facility for underground CO_2 storage



Source: German Environment Agency (UBA)

groundwater aquifers. This concerns all geothermal systems and drillings, but especially petrothermal exploration methods using hydraulic stimulation. Unlike the extraction of petroleum and natural gas, hydraulic stimulation in deep geothermia only uses water, with no other chemical additives. At most, the natural deep groundwater in the geothermal reservoir harbours a certain risk potential[122]. When exploiting geothermal energy, depending on the region, deep water with a high salt content and other trace substances relevant to drinking water hygiene may also be transported. However, the risk is comparatively low, since there are exacting standards governing deep drillings in Germany, and an incident in deep geothermia is expected to only produce reversible, local impacts on the groundwater[123]. During the construction phase, polluted drilling cuttings and small quantities of polluted deep water may also be incurred. The operation itself is an overground, closed hydrological cycle, and no deposit water requiring disposal is produced.

For measures in the area of geothermia, refer to 6.5.2.

3.4.3 Carbon capture and storage (CCS)

The permanent storage of carbon dioxide (CO_2) in the subsoil (carbon dioxide capture and storage, CCS) is intended to reduce emissions of greenhouse gases into the atmosphere. The CO_2 to be stored may originate either from the energy supply sector or from industrial facilities. Potentially suitable storage sites include depleted gas and oil fields, as well as saline aquifers in the terrestrial or marine subsoil (Figure 35). Storage in the water column in the seas is excluded by international agreements.

The storage of CO_2 poses various threats to the environment: The active pathways are similar to those found in fracking, as outlined below (see chapter 3.4.4). However, diffuse release via barriers and malfunctions are more significant here when stored CO_2 is venting upwards. Leaks could potentially have harmful impacts on the groundwater and soil. Experts are debating the extent to which escaped CO_2 could lead to the acidification of shallow groundwater, release pollutants in the subsoil, and displace saline groundwater from deep aquifers. Under unfavourable conditions, this saline groundwater could reach shallow fresh water aquiferous layers and be transported to the earth's surface, potentially causing damage (salinization) to the groundwater, soils and surface waters. Furthermore, CCS, which takes up a large amount of space underground, competes with other subsoil and/or groundwater uses. When CO_2 is sequestered into the sub-seabed, there is a risk of CO_2 and other toxic substances escaping from the storage formations, leading to acidification of the local marine environment and other contamination. Additionally, toxic substances such as heavy metals or radioactive substances may be mobilised in the CCS storage formation and impair the particularly sensitive biosphere of the ocean bed. It needs to be stated that storage in saline aquifers causes a displacement of saline groundwater from the storage formation, with associated risks for the groundwater, which is not confined solely to leaks and the escape of CO_2 from the storage formation.

CCS also harbours a certain level of risk for humans: By displacing atmospheric oxygen, CO_2 can (depending on the concentration) cause symptoms in humans ranging from headaches, fatigue, and poor concentration through to unconsciousness or even death. Despite the long-term safety standards required for the licensing of storage under the Carbon Dioxide Storage Act (KSpG, Kohlendioxidspeichergesetz)[124], a residual risk of diffuse CO_2 emissions nevertheless remains, for example, as a result of geological faults, legacy drillings, accidents, or blowouts. Close to the ground, the gas may flow out into deeper-lying areas, or collect in zones with little air exchange (such as sinks when there is no wind, cellars, or closed rooms). The German Environment Agency recommends minimising the residual risk to human health by not planning or licensing underground carbon dioxide stores beneath human settlements.

Further measures are described in chapter 6.5.3.

3.4.4 Fracking

Hydraulic fracturing (fracking) is a technique used to extract hydrocarbons and tap into deep geothermal energy (chapter 3.4.1). In fracking, fractures are created or existing fractures and openings are expanded by pumping liquid (frac fluid) into deep layers of rock. Mixtures of fluids consisting of a carrier medium (such as water), chemicals and a so-called proppant (such as sand) are used to extract natural gas by fracking. The technique is controversial due to the potential impacts on the environment.

Germany has unconventional natural gas deposits which could be extracted via hydraulic fracturing in dense shale formations (shale gas), coal seams (coal seam gas) and dense sandstone and limestone (tight gas). Figure 36 shows areas with potential shale oil or shale gas deposits. The Federal Institute for Geosciences and Natural Resources (BGR)[125] estimates the average technically exploitable shale gas volume in Germany at 940 billion m³. To put this in context: Germany's annual demand for natural gas is around 90 billion m³.

Risks to shallow groundwater are associated with the potential emission of methane, frac fluids, flowback and deposit water. There are numerous different overground and underground processes which can cause migration of gases and fluids, and hence potentially lead to groundwater contamination. In this respect, a distinction must be made between artificial technical pathways (such as drillings) and natural geological pathways (such as faults and fractures). The potential exposure pathways should be considered both separately and in terms of their combined effect vis-à-vis the contamination of shallow groundwater. As many flow operations in the deep subsoil occur very slowly, it is important to assess the long-term effects. Potential emission pathways for undesirable substances into shallow groundwater include the following (see Figure 37)[127]:

- Emission from the surface (pathway group 0): Unnoticed pipe leaks or accidents at the drilling site may lead to discharges of fracking additives, flowback and deposit water, which in turn may contaminate shallow groundwater. The risks from aboveground activities are comparable with those from many other surface industrial processes.
- Emission along boreholes (pathway group 1): Potential groundwater contamination may occur as a result of damage along exploration and extraction boreholes, e.g. due to defective cementation or leaking pipes.
- Emission via geological routes (pathway groups 2 and 3): Studies available on Germany assess the risk of groundwater contamination via fault zones and fractures as low. This is justified by the existence of numerous thick barrier rock

Figure 36

Overview of potential areas: Shale oil potential (shown in green) and shale gas potential (shown in red), indicating the respective rock formation

Source: BGR 2016[126]

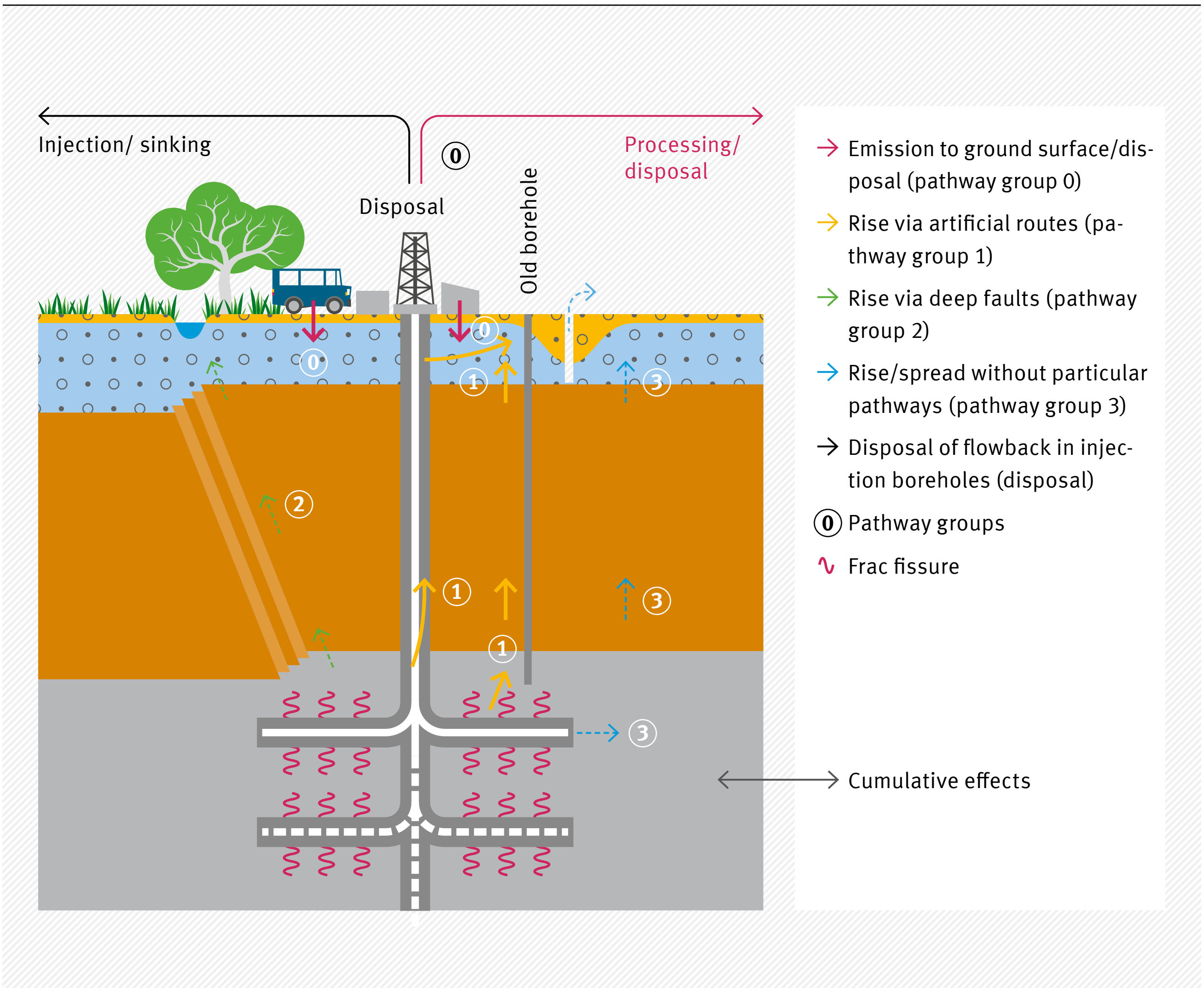
formations and–unlike the conditions in North America–by the large distances between the unconventional natural gas deposits and shallow groundwater aquifers.

- Emission of deposit water via compressed formations (pathway group disposal): The water that rises to the surface together with natural gas after the fracking process is essentially composed of reclaimed fracking fluid (flowback), deposit water and water vapour that condenses aboveground[128].

Experiences from the United States indicate that, alongside emissions from overground, leaks in the boreholes are the most common cause of groundwater contamination in conjunction with fracking[130]. For measures relating to fracking, refer to 6.5.4.

Figure 37

Schematic illustration of the potential emission pathways of undesirable substances into shallow groundwater aquifers due to fracking



Source: German Environment Agency based on ahu AG 2014[129]

3.4.5 Offshore wind power

Offshore wind power is an essential pillar of a sustainable national energy supply. The constant and reliably high offshore wind speeds mean that offshore wind power is a key element in the transformation of the energy system. One of the objectives anchored in the Renewable Energy Sources Act 2017 (EEG; Erneuerbare-Energien-Gesetz) is to increase the installed output of offshore wind power to 15 GW by 2030[131]. There are currently (as at 30 June 2016) some 800 wind turbines with an installed output of approximately 3.5 GW that feed into the grid. 90% of the total output is located in the German Exclusive Economic Zone (EEZ) of the North Sea. Figure 38 provides an overview of offshore wind farms in the North and Baltic Seas already feeding into the grid and those under construction.[132]

Key environmental impacts

Various broad-based studies, such as environmental monitoring in the Alpha Ventus test field in the North Sea, provide the basis for assessing the environmental impacts of offshore wind power. The following impacts are considered particularly relevant:

- Risk of collision with birds and barrier effect of turbines, together with loss of resting and feeding grounds for birds
- Damage to hearing, behavioural changes and extensive temporary repulsion of marine mammals such as porpoises due to the noise caused by pile-driving
- Changes in bottom-dwelling biotic communities near the turbine foundations

Measures to protect birds and marine mammals are outlined in chapter 6.5.5.

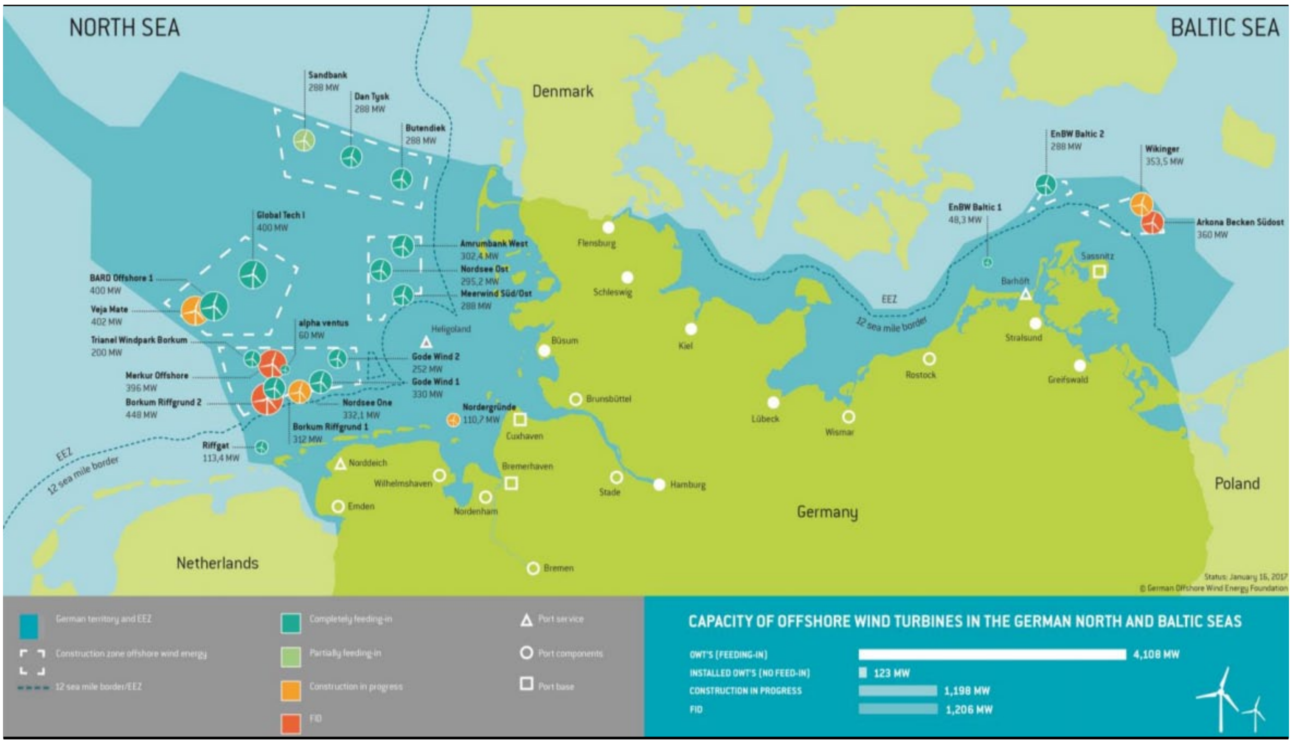
3.4.6 Offshore oil and gas extraction

The discovery of oil and natural gas in the North Sea in the 1960s and 1970s led to one of the largest investment projects in industrial history. Today, the North Sea is one of the world's largest production areas for the offshore industry.

Whereas the extraction of oil occurs primarily in British and Norwegian waters, natural gas is also extracted from the shallow waters off the Dutch and Danish coast. There are currently some 1750 oil and gas extraction installations in the OSPAR territory (North-East Atlantic and North Sea),

Figure 38

Offshore wind farms in the North and Baltic Seas



Source: Foundation Offshore Wind Energy (2016), https://www.offshore-stiftung.de/sites/offshorelink.de/files/documents/Factsheet_Status_Offshore_Wind_Energy_Development_Year_2016.pdf more than half of which are undersea. There are also currently some 70 drilling platforms in use in this region, although this figure may vary considerably depending on the oil price.

Compared with the situation in the North Sea, the number of oil platforms in the Baltic Sea is much smaller, with only three oil platforms installed there.

Oil and gas are likewise extracted in Germany's Exclusive Economic Zone (EEZ) and territorial sea, and exploration rights also exist over large areas. There are currently two offshore platforms in operation in the German North Sea: The Mittelplate oil platform (Schleswig-Holstein Wadden Sea National Park) and the gas platform A6-A in the EEZ. There are currently no offshore oil or gas platforms in the German Baltic Sea.

The exploration, extraction and transportation of oil from the North Sea invariably has consequences for the marine environment. Exploration and production, as well as the routing of pipelines, conflict with nature conservation and environmental protection interests, fishing, and future transmission networks for electricity from offshore wind farms, as well as with the wind farms themselves. Environmentally relevant factors include the increased threat to the environment from accidents, and the pressures associated with the installation and operation of platforms and related pipelines due to the discharge of pollutants into the sea.

In the production process, the extracted oil can enter the sea via four routes:

- As a result of accidents and leaks
- Via the operational discharge of production water[133]
- Via drilling cuttings[134] and
- As a result of flaring gas during test drillings (drilling to test the productivity of a potential deposit).

Seismic testing is used to explore raw material deposits in the subsoil of these areas. The use of airguns and other acoustic measurement techniques endangers communication between marine mammals, due to their acoustic, temporal and spatial characteristics, and impairs the animals' acoustic perception of their marine environment. Furthermore, the aforementioned methods may cause behavioural-biological or physical impairments, ranging to injury and even death. Marine mammals perceive the frequencies generated by airguns above 500 Hz even at a distance of more than 10 kilometres. For details of measures in the offshore oil and gas extraction sector, see chapter 6.5.6.

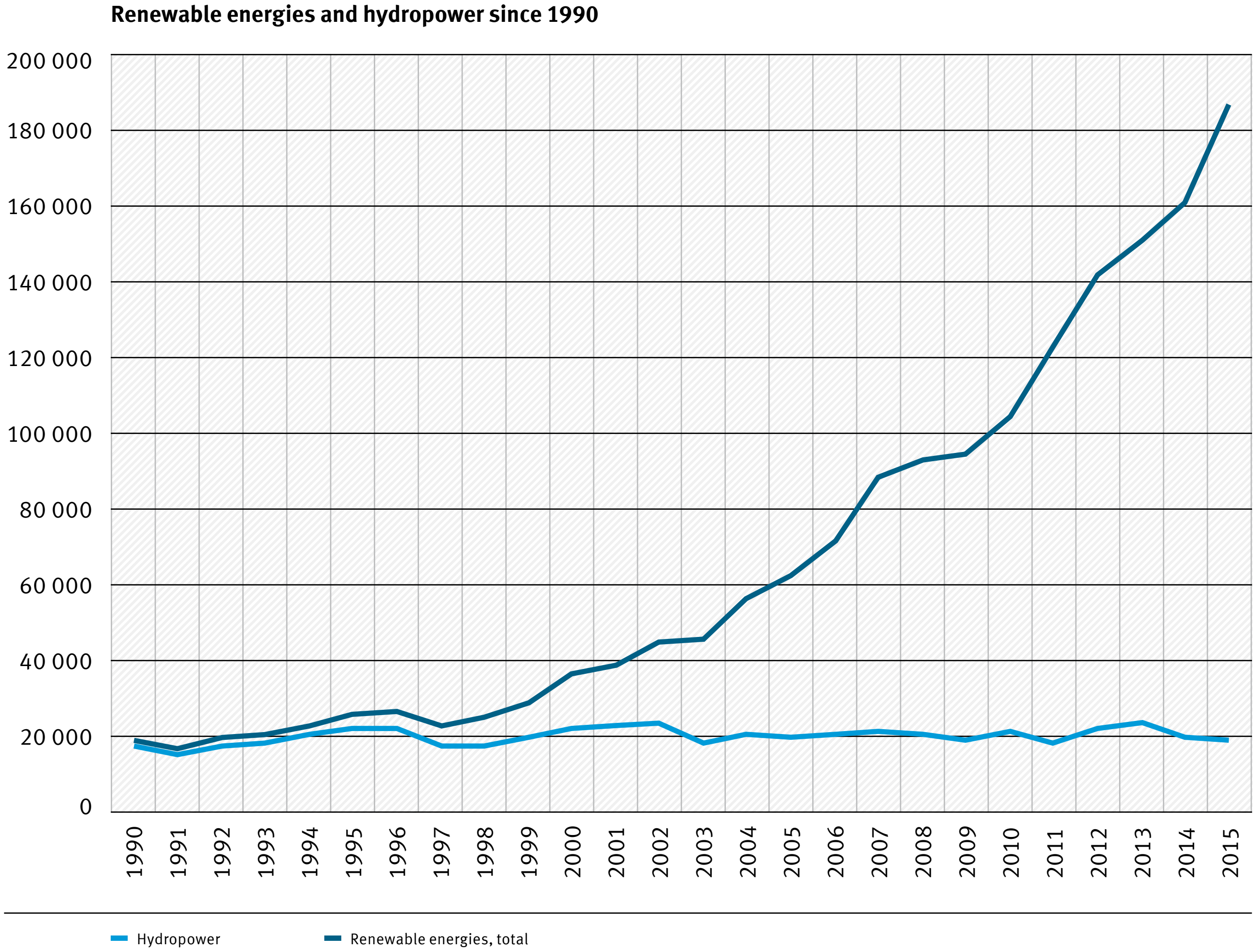
3.4.7 Hydropower

Renewable energy from hydropower is obtained from run-of-river, storage, and pumped-storage power plants[135]. The use of hydropower depends on both the natural gradient and the outflow level. In Germany, the natural conditions for the use of hydropower are less favourable compared with other European countries. Germany currently has around 7,700 hydropower plants with a total electrical output of around 5,590 megawatts (MW) (including pumped-storage power plants)[136], 406 of which, with a total electrical output of 3,400 MW, are classed as large hydropower plants with more than 1 MW capacity. These produce more than 84 % of Germany's electricity from hydropower, at a standard operating capacity of 20.9 terrawatt hours (TWh) in total, and are therefore pivotal to hydropower's contribution to the expansion target for renewable energies[137]. In 2015, according to the Federal Ministry for Economic Affairs and Energy (BMWi, Bundesministerium für Wirtschaft und Energie), some 19,000 GWh of electricity was provided from hydropower (Figure 39), corresponding to 3.2% of gross electricity generation in Germany. This figure is dependent on the hydrological conditions, and varies between 3% and 5%. Over 80% of energy volume is generated in the Central German Uplands in Bavaria and Baden-Wuerttemberg, areas with high levels of precipitation. In 2015, hydropower contributed around 10% to the gross electricity generated by all renewable energies. In Germany, the usable potential of water as an energy carrier, with due regard for technical, ecological, infrastructure and other requirements, is around 26 TWh, around 80% of which has already been developed. Output could be increased primarily by optimising and modernising or reactivating hydropower plants at existing impoundments in large waterbodies (4 TWh). In smaller and medium-sized waterbodies, there is far less potential for the construction of new capacity (1 TWh)[138].

Apart from the advantage of largely emission-free energy generation compared with fossil energy carriers, however, developing watercourses for

Figure 39

Gross electricity generation from renewable energy sources and hydropower, 1990 to 2015



Source: BMWi 2016[139]

hydropower use also has significant adverse consequences for the waterbody ecosystem. The principal impairments to the structure and function of water-dependent ecosystems associated with hydropower use is that it impounds waters, interrupts the passability of watercourses, and directly harms and kills organisms as a result of turbine operation and at power plant screens during downstream migration. Where several power plants exist in sequence, this damage has a cumulative effect, placing entire fish populations at risk. The weirs used for hydropower cause atypically low flow speeds, leading to sludge accumulation, oxygen deficiency, and the transformation of typical watercourse biocoenoses into degraded lake biocoenoses. Predation rates also increase. Dyke construction and uniformly high or unnaturally fluctuating water levels leads to a loss of contact with water meadows, and the water balance is disturbed. Sedimentation in the weir leads to the reabsorption of bed material below the weir, and deepening of the river bed, together with the lowering of groundwater in the water meadows. Given these multiple impacts, there are stringent legal requirements governing the construction and operation of such plants in the Federal Water Act and in the Fisheries Acts of the Länder (see chapter 6.5.7).

3.4.8 Use of bio-energy

Biomass is used in Germany to supply energy across all sectors. Whereas in 1995, bio-energy provided just over 1% of Germany’s energy, by 2015 this figure was just under 9% (8.5% of gross electricity consumption, 11.6% of final energy consumption for heat, 4.6% of final energy consumption in the transport sector)[140].

Biogas is mainly used to generate electricity, and is produced from the fermentation of renewable raw materials, slurry and other organic residual and waste materials, as well as solid fuels, primarily wood. Between 1995 and 2015, gross electricity generation from biogas rose from 18 GWh to 31,550 GWh. This rapid growth was prompted by the Renewable Energy Sources Act (EEG, Erneuerbare-Energien-Gesetz), which from 2004 to 2012 specifically supported the use of renewable feedstock in biogas plants. The most commonly used substrate in agricultural biogas plants is maize, thanks to its particularly high energy yields per hectare. Between 1995 and 2015, the maize cultivation area in Germany increased by just over 70% to 2.6 million ha, out of a total of 11.8 million ha of arable land.

At present, energy crops are cultivated on more than 17% of Germany's arable land. In particular, the amount of land dedicated to the two dominant crops, rapeseed (as a feedstock for biofuels) and maize (as a substrate for biogas generation), has been extended significantly. In smaller areas, perennial energy crops such as silphium perfoliatum are cultivated for biogas production, poplars and willows in short-rotation coppices or miscanthus for use as a solid fuel.

Although biofuels only account for a comparatively small portion of total fuel consumption, due to the low fuel yields per hectare, the cultivated area for rapeseed, the principal raw material for biodiesel production, has also increased in Germany. While in 1995, rapeseed was cultivated on 8% of Germany's arable land, by 2015 this figure had risen to 11% (but with large regional differences).

The escalating demand for biomass as a source of energy impacts soils and waters, both via land use and via the energy supply itself. The growing proportion of maize and rapeseed has adverse consequences for groundwater and surface water, because these intensively farmed cultivars also carry an increased threat of erosion (maize) and significant nitrogen losses (rapeseed). The growing demand for biomass also impacts waterbodies farther aside from maize and rapeseed fields, because the productivity of the land must be further increased, or humus-forming residual materials removed from the land. The displacement of agricultural production and the associated indirect changes in land use may also pose a threat to waters in other regions.

Apart from biomass production, also the biomass use may affect waterbodies. For example, in biogas production, with improper storage of silage, for example, ammonia, oxygen-depleting substances and phosphorus may be discharged into surface waters via silage leakage. Nitrogen can also enter the surrounding area and waterbodies from the storage of fermentation residues. Although nutrients are returned to the field during fertiliser application with fermentation residues, just like fertilisation with farm manures (see chapter 3.2.2), this can lead to nutrient emissions into groundwater and surface waters if fertiliser application is not adapted to the crop's requirements.

Measures for the sustainable handling of bioenergy are outlined in chapter 6.5.8.

3.5 Transport

3.5.1 Inland shipping

By comparison with the rest of Europe, Germany has the most extensive and best-developed network of inland waterways extending over 7,300 km, and the highest volume of traffic. The Federal waterways connect the major ports with economic centres in Germany and abroad, as well as interconnecting key industrial zones. Some 221 million tonnes of goods were transported by ship on these waterways in 2015[141]. However, this only equates to around 5.5 % (2014) of the total volume of all goods transported in Germany. The average distance transported per tonne of cargo is 259 km[142]. The core waterway network, which is divided into different categories (Figure 40), has the greatest significance for shipping.
Investments in developing and maintaining the infrastructure are concentrated on this area. The side waterways, by contrast, have only minimal freight traffic (less than 600,000 t/a) or none at all. The core area of German and also Central

European inland shipping is the Rhine corridor. Around 88% of the transport capacity of inland freight shipping occurs in this area. Other inland waterways such as the Oder, Ems, Danube, Elbe and Weser are not as developed and offer less favourable natural conditions than the Rhine. Furthermore, all waterways are also used for water tourism, water sports, fishing and angling, and recreational purposes.

The Federal waterways are Germany's major rivers, and perform important ecological functions for the water network. Together with their floodplains, they provide habitats for numerous species and form so-called *hotspots* of biodiversity. They are also migration routes for numerous species of fish, such as the eel, salmon and sea trout. Large parts of the Federal waterways are located in protected areas under national and European nature conservation law. Because the Federal waterways are used so intensively, e.g. for shipping, hydropower use, urbanisation and flood protection, they normally are no longer able to perform these functions. To facilitate the aforementioned uses, the original river and floodplain landscapes have been extensively transformed. Rivers have been straightened and forced into a predefined run with groins and longitudinal structures comprised of solid rock fill. The resultant depth erosion and flood protection measures have separated the floodplains from the rivers, and largely cut the link between them and river flooding. Today, this land is used for agriculture. Only 6 % of Federal waterways have a structure and habitat that can be classed as "unchanged to moderately changed" and therefore near-natural. The vast majority can be described as heavily altered, irrespective of the waterway category (Figure 39). The ecological status and ecological potential of the Federal waterways is therefore inferior to that of Germany's watercourses as a whole. Of the natural sections (approx. 1,400 km), only around 40 km are ecologically intact. The vast majority (71 %) of these sections are in "poor" to "bad" ecological status. Given the high usage intensity of the Federal waterways, they are generally (68 %) designated as "heavily modified". According to the Water Framework Directive, a good ecological potential must be achieved in these waterbodies. At present, the ecological potential of the Federal waterways is only "moderate" to "bad", the majority (51%) being classed as "poor". There is therefore an extensive need for renaturation measures throughout the entire Federal waterway network, necessitating a coordinated approach between the Länder and the Federal Ministry of Transport and Digital Infrastructure (BMVI, Bundesministerium für Verkehr und digitale Infrastruktur)[143].

Inland shipping measures are outlined in chapter 6.6.1.

3.5.2 Maritime shipping

Globally, maritime transport has seen continuous growth in recent decades. 90 % of EU external trade and more than 40 % of EU internal trade is sea-borne, with an annual increase of 2 to 3 % anticipated until 2020. On a global level, around one-third of all vessel movements are destined for or originate in the EU. Thus, the North and Baltic Seas are among the most frequently and densely travelled seas of the world. Each year, more than 30,000 vessels traverse the Kiel Canal; at any given time, there are around 2,000 vessels in the Baltic Sea.

At the German coast, shipping in the North Sea is concentrated in the southern German Bight, and in the Baltic Sea in the Kadettrinne. With its North Sea harbours of Hamburg, Wilhelmshaven and Bremen/Bremerhaven, Germany has got three of Europe's most significant harbours. In the Baltic Sea, Lübeck, Kiel and Rostock are key ferry ports, and increasingly important ports of call for cruise liners. Transit to Russian oil ports also accounts for a significant proportion of traffic in the Baltic Sea[143].

Maritime shipping is a major polluter of the marine environment. Environmentally hazardous chemicals in ships' paint, the introduction of non-indigenous organisms in ballast water, the discharge of wastewater and solid waste into the sea, underwater noise from ships' engines, and air pollutants from exhaust gases and oil contamination impair the state of the marine environment.

Coastal waters, the coasts themselves and port cities are particularly affected by environmental pollution, since the ships spend most of their time travelling close to the shore. Around 70 % of shipping movements occur within the 200 nautical-mile zone, 36 % within a 25-mile zone.

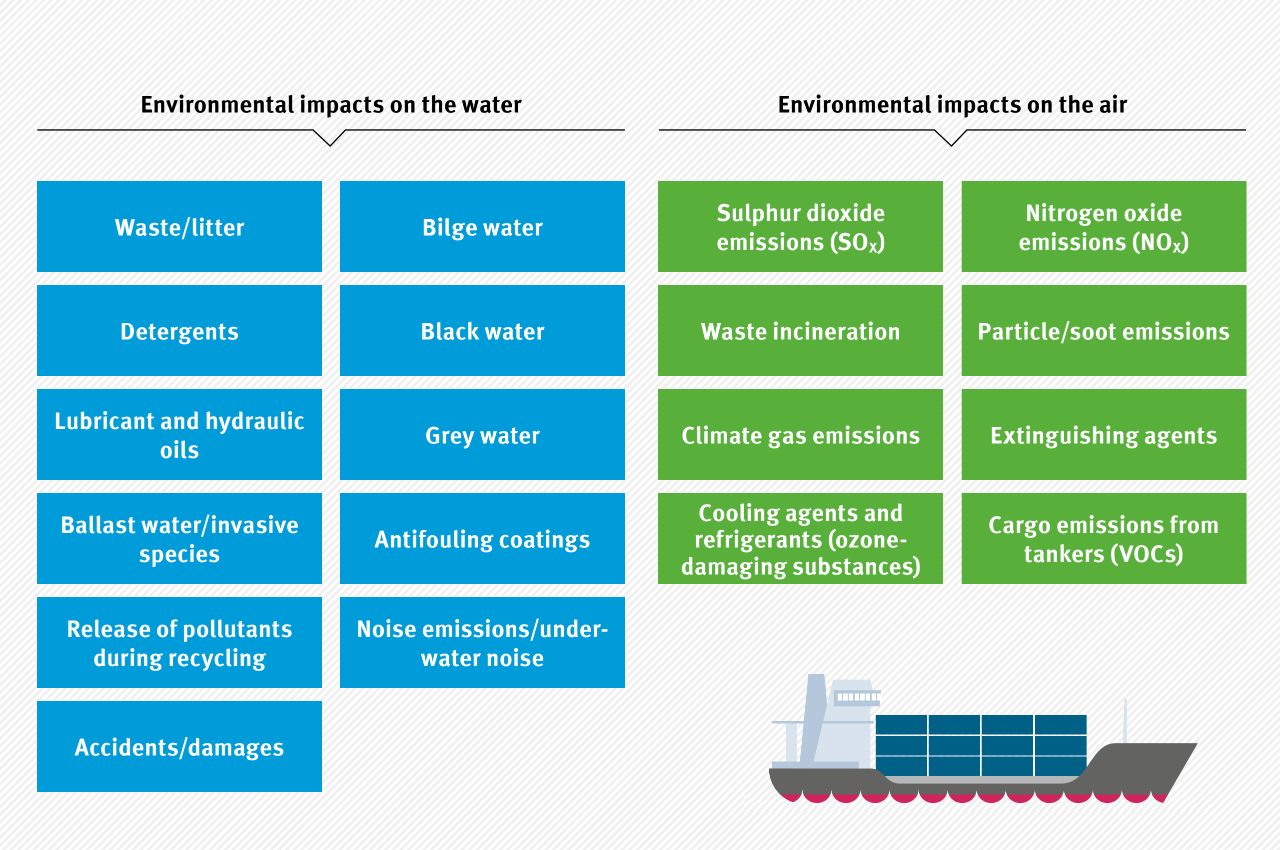
Figure 40

Network categorization taking the traffic forecast for 2030 into account

Source: Federal Ministry for Transport and Digital Infrastructure (BMVI) (2016):The 2030 Federal Transport Infrastructure Plan[144]

Figure 41

Environmental impacts of an ocean-going vessel



VOC: Volatile organic compounds, bilge water: Water that has penetrated the ship's hull collects in the bilge

Source: German Environment Agency

International maritime shipping on the world's seas is already responsible for more than two percent of global climate-damaging CO_2 emissions. In 2012, this totalled some 940 million tonnes of CO_2, more than Germany's total emissions for 2012 of 926 million tonnes of CO_2.

The impacts of shipping on the marine environment are reflected in the individual descriptors of the EU Marine Strategy Framework Directive (MSFD). Descriptor 10 in Annex I to the MSFD is concerned with marine litter (see also chapter 3.8.1), descriptor 11 addresses the introduction of energy, including underwater noise, descriptor 8 is concerned with contaminants, descriptor 5 with eutrophication (see also chapter 4.3.2.) and descriptor 2 with non-indigenous species.

Oil contamination

Most ocean-going ships are powered by heavy fuel oils (HFO), produced from refinery residues. Heavy fuel oil must be processed on board to make it suitable for use. This creates residues (sludge) that must be disposed of in port, but some ships still illegally dispose of sludge directly into the sea. In recent years, there has been a decrease in illegal oil contamination of the Baltic Sea, despite an increase in shipping movements but also in monitoring surveillance flights. The trend is therefore positive.

Oil spills are environmental disasters with long-lasting consequences. They also affect other uses such as fishing, tourism and coastal protection. In the North-East Atlantic, the most recent major oil disaster was in 2002, when the PRESTIGE tanker sank off the north-western coast of Spain. Fortunately, the Baltic Sea has been spared similar disasters to date.

Ship-generated waste

Marine litter is a serious environmental problem (see chapter 3.8.1). Shipping is responsible for a significant proportion of this, although it is generally difficult to clearly pinpoint the origins of litter.

Ship-generated wastewater

Ship-generated wastewater contains nutrients and pollutants which can lead to eutrophication and increased pollutant levels, particularly in sensitive areas and those with a low level of water exchange. The water on board is classified into black water, grey water and bilge water. Black water originates from toilets, sanitation areas, or rooms in which animals are transported. Grey water refers to effluents from kitchens, bathrooms and showers as well as from cleaning the ship. Large quantities of wastewater are created by passenger vessels (ferries and cruise ships) in particular. A passenger of a cruise ship produces approximately 32 litres of black water and 250 litres of grey water per day; for a vessel with 3,000 passengers (including crew), this translates into a weekly volume of 627 m^3 of black water and 5,250 m^3 of grey water, equivalent to 4,478 and 37,500 bathtubs respectively (assuming a bath capacity of 140 litres).

Although there are international and regional discharge bans in place (see chapter 6.6.1), large quantities of contaminated wastewater still find their way into the sea.

What is more, bilge water accumulates in the engine room as a result of operation. Ships are allowed to discharge this oily water, provided it adheres to certain limits (15 ppm).

Introduction of non-indigenous species by ships

With increasing shipping, organisms are transported unintendedly across the world, for example with the ballast water which ships need to stabilise their position in the water. Marine or harbour water is pumped into special tanks to balance out differing loads. In large vessels the tanks may hold up volumes up to 100,000 t. When loading new freight in the next harbour, the ballast water is partly or fully released. Thus, worldwide, some 10 billion tonnes of ballast water are transported each year–and with them, a variety of organisms.

In the North Sea alone, scientists have detected more than 200 non-indigenous species introduced on ships' hulls or in ballast water. If they find suitable living conditions, these species may cause adverse impacts, i.e. they may displace indigenous species, and in some cases, transform existing ecosystems. In the North and Baltic Seas, the hermatypic pacific oyster, the sea walnut (a ctenophore), and the Chinese mitten crab that advances into river systems, are among the best-known invasive species.

Apart from the risk of introducing non-indigenous species, the growth of organisms on the ship's hull ("fouling") also adversely impacts the ship's flow resistance. As the flow resistance increases, the ship's speed is reduced, or more fuel is consumed.

"Antifouling" paints or coatings are used to prevent the fouling with organisms such as barnacles and mussels. The most commonly used are coatings containing biocides, from which the active agents are permanently released into the water. These days, the effect of antifouling coatings is generally based on copper compounds and/or organic biocides (see also the UBA website on 'Biocides'), which can also be harmful to the organisms of the marine environment.

Emissions of air pollutants

Emissions of air pollutants from ocean-going vessels are significantly higher than from land traffic, because the fuels used on board have higher pollutant contents. The widely used heavy fuel oil contains high levels of sulphur (up to 3.5 % is permissible, which is 3,500 times higher than the admissible sulphur content in European road traffic). It also contains higher levels of polycyclic aromatic hydrocarbons (PAH) and heavy metals, which likewise enter the environment in exhaust fumes. Additionally, nitrogen oxides (NOx) and particulate matter (PM) are created in the combustion process; these are harmful to the environment and to human health. Studies indicate that unless further action is taken, by 2020, sulphur oxide and nitrogen oxide emissions from ships will exceed total land emissions.

Shipping noise

Underwater noise can be a stress factor for marine life. Shipping in particular has led to a significant increase in the ambient noise level in our seas. Today, the world's seas are criss-crossed by heavily frequented shipping lanes, with around twice as many ships as in the 1960s. As a result, on average, chronic ambient noise levels have doubled each decade.

Maritime shipping puts significant pressure on the marine environment

Scientific studies found increased mortality levels in the larvae of sea hares (a type of sea snail without shell) under the influence of shipping noise. Shipping noise can stress young damselfish to such an extent that they are twice as likely to become the victims of predatory fish as in a comparatively calm situation. Porpoises have been shown to wait underwater for ships to pass, which can prevent them from performing vital activities for long periods on a daily basis. What is more, acoustic noise interference can also mask ambient signals. If noise signals from the environment are masked, the "visual field" of marine mammals is reduced, as they perceive their environmental primarily using their acoustic senses. This can adversely affect biological fitness. For measures regarding the shipping sector, refer to chapter 6.6.2.

3.5.3 Transport of substances hazardous to water

Goods are transported across Germany in large quantities. In 2014, some 3 billion tonnes of goods were transported by road vehicles, while over the same period, some 365 million tonnes were transported by rail, and 229 million tonnes by inland shipping. Domestic traffic in Germany accounted for around 96 % of road traffic volume, around 65 % of rail traffic volume, and around 24% of inland shipping[147].

Some of these goods have properties that are hazardous to water, and can be assigned to one of the three water hazard categories anchored in German water legislation (see chapter 6.4.4). Hazardous goods may also be hazardous to water, but not every substance hazardous to water is also a hazardous good (such as operating materials from vehicle tanks, although these are generally included in the statistics on accidents with substances hazardous to water).

In 2014, some 140 million tonnes of hazardous goods were transported by road, 66 million tonnes by rail, and 47 million tonnes by inland shipping. Consequently, in 2014, both the largest volume of all goods and the largest volume of all hazardous goods were transported by road. At 18 % and approximately 21 % respectively, hazardous goods as a share of the total volume of rail transport and inland shipping was higher than in road traffic at around 5 %.

A survey by the Federal Statistical Office[148] (Statistisches Bundesamt) for 2014 indicated 1,709 accidents during the transport of substances hazardous to water by road, rail and water, during the course of which some 730,000 litres of such pollutants were released in total (including water hazard class "unknown"). Of this total volume, 113,000 l were likewise hazardous goods, including some 85,000 l "inflammable liquids" under hazard class 3. Around 300,000 l of the total volume (approximately 42 %) could not be recovered. Roughly 94 % of all accidents occurred with road vehicles (1,614 accidents). Here alone, some 600,000 l of pollutants were released, around 200,000 l of which (32 %) could not be recovered. The pollutants considered in this context also include operating materials from vehicle tanks. Some 27 % of the transport accidents with substances hazardous to water considered here occurred in areas meriting particular protection, such as water protection areas and floodplains. In around half of all accidents involving the transport of substances hazardous to water, human failure was the principal cause.

About 22 % were attributable to material defects in vehicles, safety devices and fittings or on tanks and packaging. For the remaining accidents, either no information about the cause was provided, or the accident was due neither to a material defect nor to human failure. Accidents during transportation with the aforementioned transport carriers accounted for around two-thirds of all recorded accidents with substances hazardous to water in 2014, but only caused one-sixteenth of the total volume released. However, the proportion of substances released in water hazard class 2, which also includes fuel oil for private households and diesel, was particularly high in the "Transport" accident category, at around 32 %, compared with the "Handling" category, at 9 %.

Transport of substances hazardous to water in long-distance pipelines

Germany currently has a network of long-distance pipelines with a total length of around 3,000 km for transporting substances hazardous to water, primarily crude oil and petroleum products. There is also a widespread network of long-distance military pipelines for petroleum products. Although in normal operation, these pipelines are relatively environmentally friendly compared to other transport carriers in terms of pollutant emissions, noise and energy input, they may, however, pose a substantial danger to soil and water in the event of an accident.

According to the Federal Statistical Office (2015), in 2014 there were nine accidents with substances hazardous to water in long-distance pipelines, during which 230.9 m³ were released. Of this, 150.6 m³ were recovered. For further information on the safe transport of substances hazardous to water, please refer to chapter 6.6.3.

3.6 Fishing and aquaculture

3.6.1 Marine fishing and its impacts

For decades, European fishing was driven by a short-term desire for profit. Under the Common Fisheries Policy (CFP)[149] with European catch quotas, this use of the seas developed into one of the most severe stress factors for our seas and oceans. The fishing methods used are a decisive factor. Fishing gear, in particular, causes structural damage to the sea floor, as outlined for example in the 2010 OSPAR status report for the North Sea[150].

In Europe and worldwide, these days, more than one-third of regulated fish stocks are considered overfished[151]. This means that so many fish of a particular species have been taken from the sea in a given region that those remaining will not be able to reproduce sufficiently to restore the original number. Individual fish species such as the European eel and the southern bluefin tuna are critically endangered, yet are still being fished. Eel and flounder are among the non-quota species and are therefore not subject to catch restrictions under the CFP. In particular, predatory fish are often lacking in the marine food web, because they were and remain particularly attractive to the marine fish sales market as a source of food. The EU is the world's largest importer of fish and fishing products. In 2014, according to the United Nations Food and Agriculture Organization (FAO), imports totalled some 28 billion US$, corresponding to 20 % of global imports[152].

Another cause for concern is the fact that for decades, around 40 % of the global catch has been tossed overboard as "discards", generally because the fish were too small, or the quota for a

Table 7

Accidents during the transport of substances hazardous to water, 2014

Mode of transportation	Number of accidents	Proportion of total accidents	Volume released [m³]	Volume recovered [m³]	Recovery rate
Road vehicle	1,614	94.4 %	606.4	412.1	68.0 %
Railway truck	32	1.9 %	72.1	4.0	5.6 %
Inland vessel	63	3.7 %	52.9	10.9	20.6 %

Source: Federal Statistical Office (Statistisches Bundesamt 2015), Technical series 19, File 2.3. (9B1) given species had already been used up. Although the size stipulations and fishing quotas are regulatory measures designed to prevent overfishing of certain species, in the past they have meant that million tonnes of fish were discarded each year. The fishing methods used are mainly responsible for the quantity of fish that are needlessly killed as by-catch.

Seabirds, turtles and mammals also end up in fishermen's nets or longlines as unwanted by-catch. According to data from the International Whaling Commission, some 650,000 seals and whales are so badly injured by fishing gear each year that they die. The use of driftnets is now largely prohibited. However, unrecovered lost, abandoned and otherwise discarded fishing nets often remain in the sea as floating "ghost nets" for many years and are death traps for marine animals.

France, Italy, Spain and the United Kingdom have the largest fishing fleets in the EU[153]. The German fishing fleet is among the ten smallest fleets in the European Union. According to the German Fishing Portal[154], as at 31 December 2014, it comprised some 1,500 vessels with a total gross tonnage of 59,970 and a total engine capacity of 138,770 kW, equivalent to around four and two percent of the EU fishing fleet respectively. Seven vessels in the German fleet are deep-sea fishing vessels, and there are a further 47 vessels catching mussels and being used for other special purposes. 300 vessels are designed for trawling and coastal fishing, and make up the core of the German fleet, the majority being beam trawlers. These beam trawls are special bag-like bottom trawls equipped with skids for catching North Sea prawns and flat fish, and in the Wadden Sea are used directly on the ocean floor. Small-scale coastal fishing with passive fishing gear such as bottom-set gillnets, pots and creels is practised almost exclusively on the Baltic Sea coast, and numbers around 1,100 fishing vessels.

The size and capacity of the fishing fleet also have an indirect impact on the marine environment. Today, shoals of fish are located by applying echo-sounders, which operate with ultrasonic waves. Most echo-sounders operate in the frequency from 50 kHz to 200 kHz. The sound waves disseminate through the water at speeds of 1,500 m/s. If an emitted sound wave hits the ocean floor or a shoal of fish, part of the wave is returned to the transmitter. There has been very little research into noise pollution of the seas as a result of fish echo-sounders and their direct impacts on the marine environment.

For more information on sustainable marine fishing, see chapter 6.7.1.

3.6.2 Marine aquaculture

Aquaculture, the controlled farming of fish, mussels, crabs and other marine creatures, is the fastest-growing sector of the worldwide food industry, with annual growth rates averaging 9 % since 1970. In 2014, almost 74 million tonnes of fish and seafood were produced in freshwater and sea farms[155]. In 2014, for the first time, the contribution of aquaculture to human nutrition exceeded that of fishing.

In many places, however, the intensive farming of fish and crustaceans poses major problems to the environment. Sustainable aquaculture cannot be guaranteed unless standards are observed.

In Germany, mariculture is confined almost exclusively to mussel farming. Problems arise in particular with the extensive removal of seed mussels from natural stocks and the introduction of foreign breeding organisms from other regions. For example, farming of the Pacific oyster *Crassostrea Gigas* in areas of the Netherlands and off the coast of Sylt has led to this species becoming established in the Wadden Sea and competing for habitats with the native common mussels.

Measures in the field of aquaculture are outlined in chapter 6.7.2.

3.7 Leisure use and tourism

The options for spending leisure time in and on the water are very diverse, and include swimming, sailing, sport fishing, rowing, canoeing and kite surfing. Leisure pursuits in and on the water rely on a healthy environment, but at the same time are also direct and indirect cause of water contamination.

- Antifouling protective coatings on boats (see also chapter 3.5.1) that are used to clean and

protect against algal growth endanger the natural flora and fauna in waters by emitting active biocide ingredients[156].
- Boat engines contribute to water contamination with exhaust fumes and lubrication mixtures.
- Intensive driving and walking across bank and shore areas, and the waves and noise caused by motor boats and other motorised sports equipment, impairs the bank vegetation and disturbs the animals that live and breed there.
- Infrastructure development of riparian areas for bathing sites including parking spaces and boat traffic, the creation of marinas, and entry and exit points for canoes disrupt the sensitive bank vegetation and the habitats it contains.
- Bathing may result in microbiological pressures and elevated nutrient emissions.

The special challenge posed by water use on holiday

Especially in arid and semi-arid holiday regions, water use on vacation can adversely impact the local water resources.

Depending on the destination and type of accommodation, there are significant variations in the water demands of travellers. For example, small guest houses and camp sites generally need less water per guest than large hotels. A 2015 study[157] showed a range of between 84 and 2,424 litres of water per traveller, per day, at their accommodation alone. Additionally, the irrigation of hotel gardens and golf courses uses large amounts of water.

Other countries face water shortages due to the climatic conditions and due to a lack of infrastructure, which may cause conflicts of use particularly with the local population and agriculture.

Often, in arid countries abroad drinking water must be shipped in by sea or road in tanks, in a costly and time-consuming process, or obtained from seawater. In some travel destinations, tourism is very seasonal (particularly coastal and mountain regions). For a short period during high season (around two to three months), there are more than ten guests to each local inhabitant. This poses a huge challenge for water supply and disposal. The wastewater pipes and treatment plants must be designed to cope with these strong variations in demand.

With regard to winter vacations, the creation of ski pistes, which is often associated with flattening, leads to water resource management problems. Destruction of the topsoil over large areas changes the runoff behaviour and encourages erosion.

Cruise tourism creates its own unique set of pressures (see chapter 3.5.1). Approaches to sustainability in leisure use and in tourism may be found in chapter 6.8.

3.8 Inputs of plastics into the environment

3.8.1 Plastics in the sea

These days, waste is found in all marine and coastal habitats. The detritus of our consumer society can even be found in the most remote and, in some cases, uninhabited regions of Pacific archipelagos.

The term “marine litter” refers to all persistent, manufactured or processed materials which enter the marine environment either as discarded or ownerless material[158]. This poses a potential threat to animals and habitats, and minimises the recreational value of our coasts.

The origins of the various types of litter in our seas are as diverse as the products themselves Marine litter arises, firstly, from sea-based sources such as shipping (see chapter 3.5.2) and fishing (see chapter 3.6.1), and secondly, from land-based sources such as inadequate waste management or the behaviour of individuals, such as littering (the careless discarding of waste in a public space). It is irrelevant whether emissions occur close to the sea, because waste incurred far inland can also enter the seas via rivers, discharges and wind. Although there is some basic data available on the origins of marine litter, a comprehensive inventory of sources and emission pathways has yet to be carried out. On a global level, 80% of marine litter originates from land-based sources, but the ratio varies depending on the marine region. In the North-East Atlantic, sea-based activities such as shipping, fishing and offshore activities account for 80% of litter inputs. Meanwhile, the Baltic Sea is dominated by land-based sources, such as leisure and tourism activities. The Baltic Sea is also polluted by inputs from fishing, such as ghost nets (nets that have been abandoned, accidentally lost or intentionally discarded). Both seas are subject to waste from industrial and wastewater treatment plants due to an inadequate treatment performance, as well as discharge from storm water drains.

The waste found in the sea is primarily comprised of plastic. It is estimated that 10% of the annual plastic production of 315 million tonnes ends up in the marine environment as marine litter.[159] An analysis of litter on the ocean floor of the southern North Sea found that it contains eleven kilograms of waste per square kilometre. Plastic dominates the litter found on Europe's beaches, accounting for an average of 75%. In addition to large-format waste such as plastic bottles and plastic bags, there is a growing incidence worldwide of microplastics found in ocean gyres, sediment and on beaches. Microplastics are defined as plastic particles less than 5 millimetres in size. These include secondary fragments arising from the breakdown of macro-plastic parts such as packaging materials, as well as primary microplastics which are manufactured directly in microscopic sizes and which are used, for example, as granulates in cosmetics, hygiene and cleaning products or basic pellets for subsequent production. Plastics take centuries to degrade, and microorganisms are incapable of decomposing plastics fully.

Some 800 species are known to be adversely affected by this litter. More than half of these species ingest plastic waste or become entangled in it. Microparticles can just as larger plastic parts, depending on the size of the organism, also damage the digestive tract, preventing digestion and blocking the absorption of nutrients. Plastic particles can also act as transport carriers and accumulate pollutants, invasive species and pathogens.

In particular, the extensively documented consequences of becoming entangled in or ingesting marine litter can adversely affect the health or even kill the animals concerned. One 2015 study found that all species of marine turtle as well as 67% of common seal, 31% of whale and 25% of all seabird species were affected by becoming entangled in marine litter.[160]

Marine litter also presents an aesthetic and socioeconomic problem. Beaches and diving areas are spoilt by waste. There is a risk for human health and safety, for example if divers or propellers become entangled in the remainders of fishing nets, lines or similar. The impacts on various branches of industry and the public sector incur direct costs to industry, local authorities and governments compared with the ecosystem services provided by an intact marine environment. One example is the cost of removing litter from popular beaches, which costs coastal communities between €3,083 and €65,000 per kilometre for beach cleaning and disposal.[161]

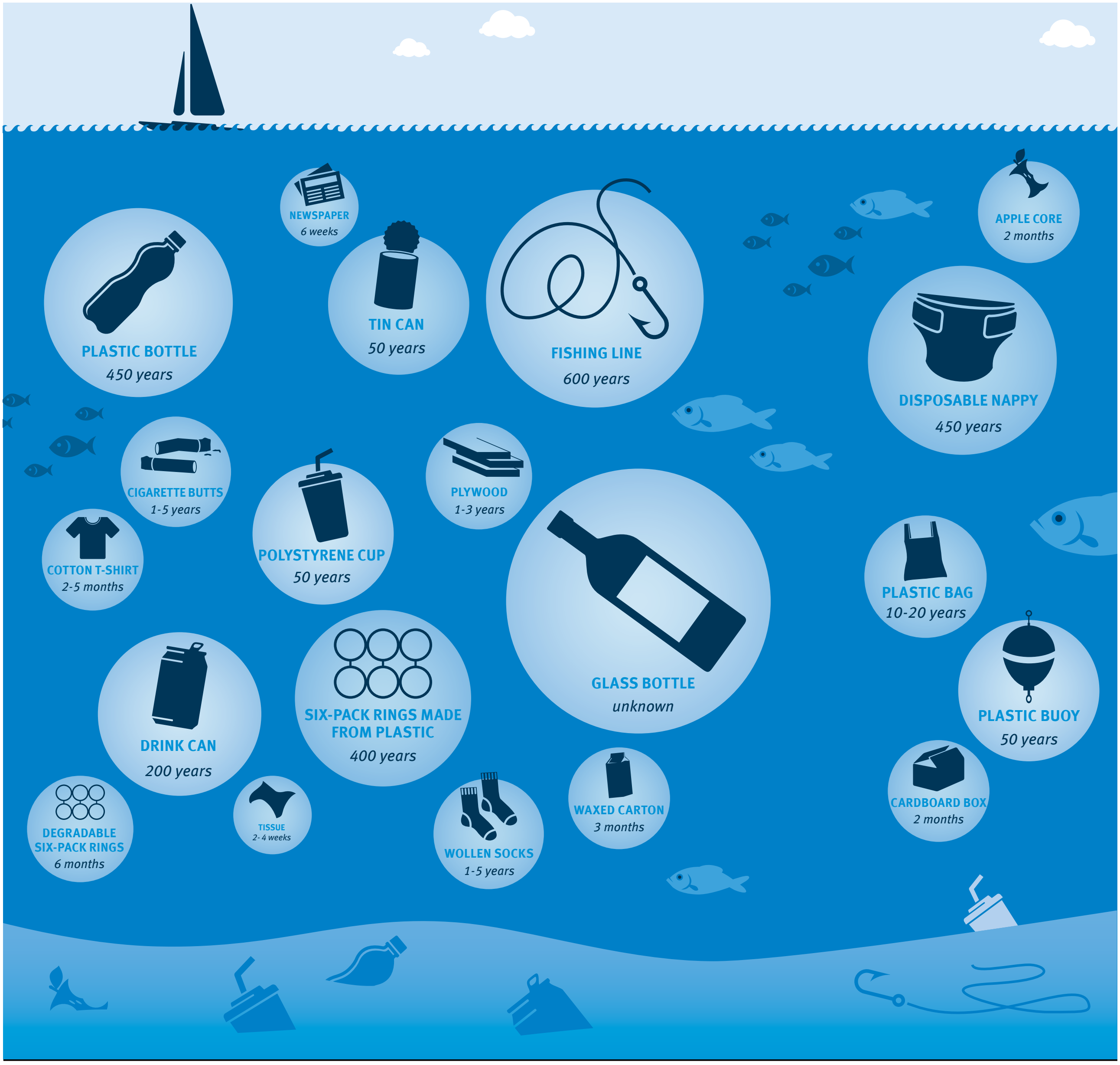
There is currently no adequate assessment system for the environmental impacts of marine litter. Descriptor 10 of the EU's Marine Strategy Framework Directive states that good environmental status has been achieved if the properties and quantities of marine litter do not cause harm to the coastal and marine environment (see chapter 5.4). Under the OSPAR Convention, small pieces of plastic waste on the surface of the sea are quantified by the OSPAR-Ecological Quality Objective "plastic particles in fulmar stomachs". This states that good environmental status for Germany's North Sea regions is achieved if less than 10 % of the northern fulmars (*Fulmarus glacialis*) used as indicators have less than 0.1 g plastic particles in their stomachs. However, studies indicate that plastic litter was found in almost all the stomachs examined.[162]

For details of measures to prevent the input of plastics into the sea, refer to chapter 6.9.

3.8.2 Plastics in inland waters

Five years ago, a team of Swiss and German scientists found evidence of microscopic plastic particles in rivers and lakes. Until then, similar findings were only known from the seas, where plastic litter has long been flagged up as a problem, while the investigation of plastic particles in inland waters is still largely in its infancy. Citizens are starting to ask questions about the potential environmental risks, and the topic has also been highlighted by the media. The Federal Government and Länder support research projects to find answers to these questions. The emphasis is on obtaining reliable measurements and gaining a better understanding of how much plastic there is in our waters, where it originates from, and how such inputs can be avoided.

Figure 42
Time marine litter takes to degrade



Source: German Environment Agency "What Matters 2013", https://www.umweltbundesamt.de/en/publikationen/what-matters-2013

In 2016, the Federal Government and Länder conducted an initial assessment of plastics in inland waters. The German Environment Agency (UBA) and Bavarian Environment Agency organized a workshop, which revealed that to date, only Bavaria, Baden-Württemberg, North Rhine-Westphalia and, to a limited extent, Hesse, currently analyse microparticles and larger plastic particles in inland waters. This means that most Länder currently have no data available on plastic loads in waterbodies. There is also a lack of data on the input of plastics from inland waters into the seas. As such, it is hardly surprising that experts have thus far been unable to adequately assess the potential risk. As well as environmental data, there is also a lack of techniques for assessing the potential impacts on environmental organisms and accumulation in food webs.

A European conference on plastics in inland waters, organised by the UBA and the Federal Institute of Hydrology (BfG) on behalf of the Federal Environment Ministry, reveals a similar picture. In 2016, international experts met for the first time specifically to discuss this topic in Berlin[163].

Exploration of plastic particles in inland waters is in many places still in its initial stages

The conference revealed that there are more questions than answers: Until now, only selected rivers and lakes have been investigated for plastic, and there is therefore no conclusive information available on the extent of waterbody pollution with plastics. Southern and eastern Europe have the largest information deficits. Together with Switzerland, Austria and the Netherlands, Germany is the driving force behind investigations into plastics in inland waters. Even in these countries, measurements are only carried out in certain years. Whether there are any trends, and whether the quantity of plastics in waterbodies is increasing or decreasing, is still completely unknown. To date, coordinated sampling and analytical detection methods for plastic particles have been lacking, and therefore, the small number of results are often not comparable with one another.

3.9 Flooding – Causes and origination

Flooding is a natural event. It occurs at regular intervals, and typifies the flow characteristics of rivers. The biotic communities in rivers and flood plains have adapted to the changing water levels. Flooding depends on the amount of precipitation, the characteristics of the catchment area, and the particular features of the river in question. The size of the river bed determines the volume of water that waterbodies are able to accumulate. Only when this volume is exceeded will the river burst its banks. In winter, flooding is usually caused by melting snow following a temperature rise. If rain then additionally falls on frozen ground, it is unable to seep away, exacerbating the risk of flooding. In summer, the cause is usually areas of exceptionally low pressure over the northern Mediterranean. At our latitudes, they cause violent downpours, which can transform rivers and streams into raging torrents as soon as the ground is saturated. In small river basins, localized heavy rain, often combined with storms, often causes small rivers and streams to burst their banks for a short period. Based on current climate change predictions, as well as temperature increases, we can also expect a significant intra-year shift in the precipitation regime in future, as well as increasing variability in the heavy rainfall. This will lead to an increase in extreme weather events, both flooding and drought. Simulated flooding trends vary according to region. Although these calculations entail substantial uncertainties, the vast majority point to a growing incidence of flooding on the west faces of the German Central Highlands, at the foot of the Alps and in East Germany.

Humans exacerbate the origination, development and impacts of flooding. Reclaiming land for human settlements, industry and changes of land use lead to the loss of key flood plains and water retention. In small river basins in particular, land sealing, soil compaction and drainage facilities such as drains and sewers can make minor flooding much worse. What is more, dyke construction and other river development measures can decrease the size of natural flood plains or even cause them to disappear altogether. For Germany as a whole, only around one-third of former flood plains can currently be used to retain the water in the event of major flooding. In large river basins such as the Rhine, Elbe, Danube and Oder, only 10-20% of the former flood plains remain in some river sections[164]. What is more, the river runs have been shortened due to straightening. For example, the watercourse section of the Rhine has been shortened by more than 100 kilometres, leading to an increase in flow speed. The discharges of many inflows are concentrated in a river bed at faster flow rates, which means that the flood wave is steeper and the runoff faster; this, in turn, increases the risk of flood damage.

In addition to the structural changes already described, the potential for damage in areas at risk of flooding has also risen substantially. For example, the Rhine Atlas indicates a damage potential of €165 billion for the entire Rhine region. This is because in the past, man has tended to accumulate tangible assets (buildings and their interior fittings, industrial plant, transport infrastructure, vehicles) increasingly in areas that were previously available to rivers as flood plains. For further elaboration on flood risk assessment and management refer to chapter 5.5.

3.10 Climate change impacts

chapter 2.1 and 2.2 outline the natural framework conditions in Germany, such as the generally adequate water supplies, as well as the significant regional variability in precipitation. It also describes the known impacts of climate change in Germany and its major river basins. To assess the consequences of climate change for waterbodies, the results of regional climate modelling, particularly of precipitation, are fed into water balance and discharge models which allow forecasting of future scenarios e.g. with regard to floodwater discharge, the potential extent of flooding, average discharge, low water discharge, and groundwater recharge.

Alongside the impacts of climate change, other pivotal factors in a region's water demand include population density, the demographic development of society (see chapter 2.3), and land use (also changing climatic conditions). Changes in both flooding and low water level situations caused by changes in rainfall will depend on the conditions in each individual river basin area, and must therefore be examined on a case-by-case basis.

The following fundamental impacts of climate change have been projected based on physical correlations, and have in some cases already been observed (see chapter 2.2):

- Changes in precipitation levels, e.g. less snow but more rain in the mountains, and changes in the seasonal distribution of precipitation influence discharge in river basins with a snow regime, such as the upper course of the Rhine, Danube or Iller. If less snow is retained in the mountains during winter months due to higher winter temperatures, the peak spring melts will be reduced. The spring melts will occur earlier in the year due to higher temperatures, leading to a shift in peak discharge levels. Low water levels in summer will be less effectively balanced out. However, if increased discharge occurs in winter because less precipitation is stored as snow, with winter precipitation falling as rain due to higher temperatures, these two factors may combine to increase the threat of flooding.
- Changes in precipitation (particularly a decrease in the amount of precipitation in summer) may lead to persistent low water situations, with adverse consequences for shipping and the transportation of goods.
- Localised flooding, caused by heavy rainfalls, is likely to increase. In particular, the resultant emissions of nutrients and pollutants from combined sewers will put additional pressure on waterbodies.
- Warming of the lower layers of the atmosphere will cause water and soil temperatures to rise. Particularly in low water situations, this will lead to changes in the chemical and biological status

of waters, with corresponding impacts on the fauna and flora that inhabit them. For example, the solubility of oxygen in waterbodies is reduced at higher temperatures, and may prove harmful to fauna. Longer-term increases in the water temperature may also lead to shifts in the species spectrum. Higher water temperatures, particularly in watercourses, impair their suitability for use as cooling water (chapter 3.4.1).

- Furthermore, evaporation will increase as a result of increased air temperatures. With reduced rainfall, particularly in the summer months, this could impair wetlands or cause them to dry out.
- Low water levels in rivers reduce the amount of retreat space available for species, causing stress to the aquatic biota and possible damage to the aquatic ecosystem as a whole.
- In lakes, alongside the direct effects of water temperature on organisms, changes in the ice coverage and the mixing regime are particularly important. These processes are responsible for the distribution of oxygen and nutrients, as well as for the light intensity in stagnant waters. In this way, they influence the water quality of lakes and their suitability as bathing waters. Higher temperatures can also encourage bacteria and the growth of blue-green algae in bathing waters.
- In areas with highly permeable soils, groundwater recharge may increase as a result of higher winter precipitation. This could lead to an increased supply of groundwater, despite lower summer rainfall and greater potential evaporation. On the other hand, in certain regions of Germany, groundwater recharge may decline.
- Alongside increased evaporation in summer, the extended vegetation period may cause an increased demand for irrigation water, which in regions with declining groundwater recharge would present an additional pressure for the groundwater.
- Both falling and rising groundwater levels may have further impacts, e.g. on the stability of buildings in affected areas.
- Rising sea levels on the North and Baltic Seas are also significant for the growing risk of storm surges. Furthermore, the brackish water limit may shift, with adverse impacts for groundwater supplies close to the coast.

Measures for adaptation to climate change are outlined in chapter 10.6.

3.11 Water footprint

Alongside water abstractions (i.e. direct water use) in Germany (see chapter 2.7), water is also used in other countries for the products and goods we import. In this way, we indirectly use water abroad; this is known as “virtual water”. The water footprint combines direct and indirect water use to calculate total water use.

The term water footprint refers to the total volume of water used by a country, company or consumer or in the manufacture of a certain product. The special feature of this concept is that it connects our consumption to water use in the manufacturing region by showing that we are constantly importing and exporting water in goods and services, and that our daily consumption in Germany therefore impacts water resources worldwide.

Table 8

Definition and examples of the three categories green, blue and grey water

Water type	Definition
Green	Volume of rainwater that is stored in the soil and absorbed and evaporated by plants during the course of the growth process.
Blue	Volume of groundwater or water from rivers and lakes used in the manufacture of a product. With agricultural crop production, this refers to the volume of additional irrigation used.
Grey	Volume of water that is contaminated during the manufacturing process or that would be needed to dilute contaminated water to such an extent that it complies with valid quality standards.

Source: German Environment Agency

There are a number of different approaches for calculating the water footprint[165].It can be helpful to break down water use into different categories to evaluate the water footprint. “Green water” is the naturally occurring groundwater and rainwater that is absorbed and evaporated by plants. It is therefore relevant for agricultural products. “Blue water” is the groundwater or surface water used in the manufacturing of a product which is not returned to a body of water. In agriculture, it refers to the water used for irrigation that is absorbed by and evaporated by plants. The demand for “grey water”–the volume of water that is contaminated during the manufacturing process–is less widely considered. As well as by industrial production grey water is also produced by agricultural production, whereby pollutants enter the soil and waterbodies via the use of fertilisers and pesticides. Alternatively, grey water can be represented as the volume of water needed to dilute the contaminated water to such an extent that it meets the relevant limits.

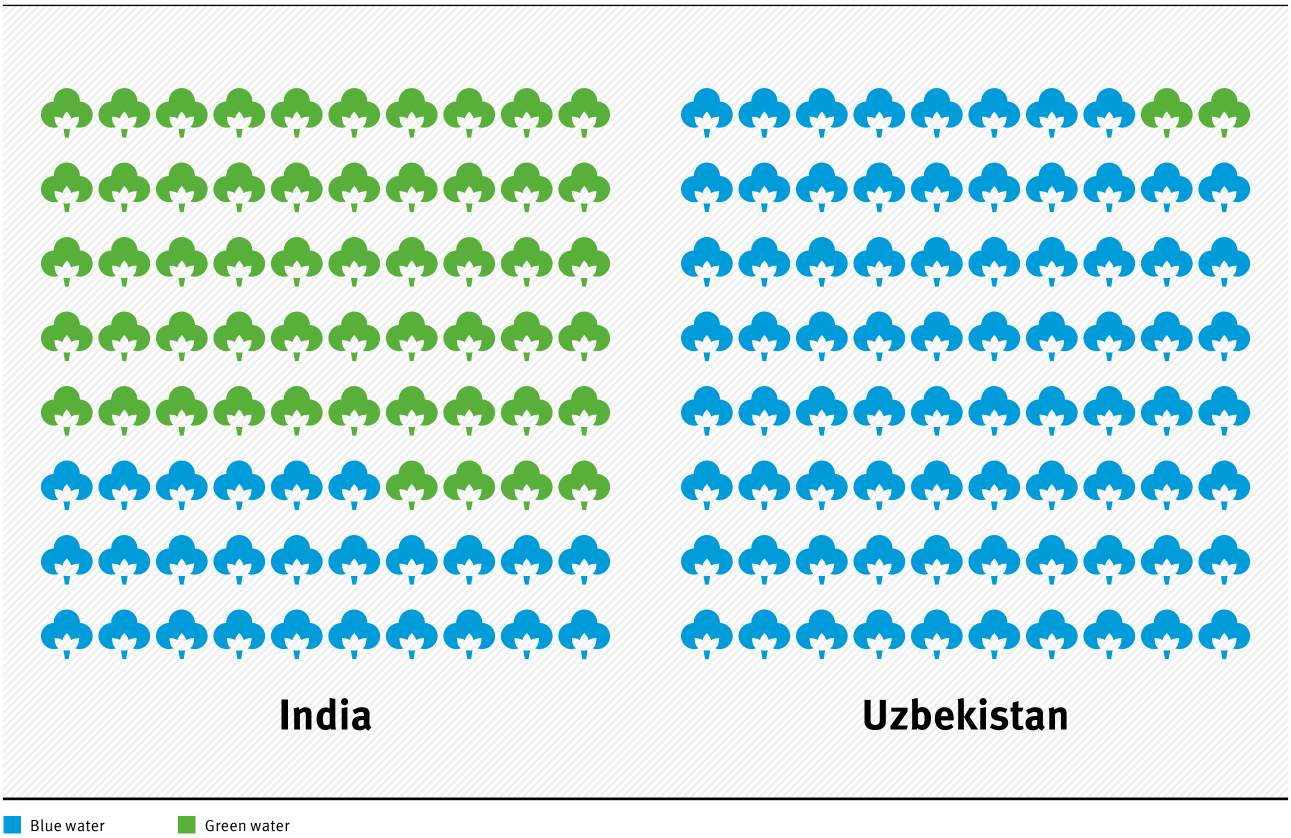
Water footprint of agricultural produce

Water footprint calculations are mainly available for agricultural products. According to Hoekstra et al.[166], for example, the global average water footprint for one cup of coffee is 130 litres. This is comprised of 96% green water, 1% blue water and 3% grey water. The average water footprint for one kilogram of beef is estimated at 15,400 litres, 94% of which is green water. The water footprint of a cotton shirt (approximately 250 grams) is calculated at 2,500 litres. Here, the proportion of blue water is significantly higher than for the previously cited products, at 33%. 54% is attributable to green water, and 13% to grey water.

However, the global average values cited are of limited use when assessing ecological impacts. A differentiated view based on cultivation regions shows that not only the water demand for manufacturing but also the shares of blue and green water can vary hugely for any given product. For example, in India, cotton is irrigated primarily

Figure 43

Origins of water in cotton cultivation



Source: German Environment Agency based on Federal Statistical Office 2013 with precipitation water (“green water”), whereas in Uzbekistan, it is almost entirely irrigated with irrigation water (“blue water”)[167].

The extensive use of irrigation can cause significant environmental pressures, particularly if water abstraction from surface water or groundwater exceeds natural regeneration or competes with water needed for drinking water supply or for ecosystems. One well-known example of an environmental disaster is the drying up of the Aral Sea. Once the fourth-largest inland sea covering 68,000 km², by 2007 it had lost 90% of its water volume due to large-scale water abstraction for cotton cultivation, accompanied by a rise in its salt content.

Germany’s water footprint

It is also possible to calculate a country’s water footprint. Germany’s total water footprint is approximately 117 billion m³ per annum[168], representing the amount of green, blue and grey water needed in Germany and abroad to manufacture the products consumed in Germany. This volume of water equates to approximately two-and-a-half times the volume of Lake Constance, and corresponds to 3,900 litres per day (1,426 m³ per person, per annum). Only around 5 billion m³ per annum is attributable to the public water supply. Germany’s water footprint is higher than the global average of 1,243 m³ per person, per annum. However, Germany also exports water: around 64 billion m³ of virtual water leave the country each year.

The concept of the water footprint – An instrument for evaluating water consumption?

The water footprint is an indicator of water resource usage. In this concept, the green and blue water footprint describe quantitative aspects, while the grey water footprint is an indicator of water quality. The water footprint does not allow any farther-reaching projections to be made regarding the environmental and social impacts of water use at the production location, such as conflicts of interest with drinking water supply. Furthermore, the concept is confined to the use of fresh water, and disregards the impacts on the oceans.

So far, communication of the water footprint to the general public has been aimed primarily at elucidating the dimension of water use associated with everyday products. However, local water availability is pivotal when assessing direct and indirect water use. A large water footprint in regions abounding in water may be less problematic than a smaller water footprint in arid or semi-arid regions. The awareness of a (too) large water footprint should be followed by action. On the one hand, measures may be taken at the point of production to reduce water demand, for example with a more efficient irrigation system. Among some multinational companies, there is a growing awareness of the importance of considering the water footprint in the production chain. In this regard, ISO standard 14046 contains recommendations for the consistent calculation and reporting of the water footprint of products, processes and organisations within the context of corporate environmental management.

Another option is to selectively modify consumption behaviour, but this relies on consumers having access to adequate product information if they are to avoid buying products with major human and environmental consequences at the point of production due to their high level of water consumption.

69 http://www.umweltbundesamt.de/publikationen/brassen-die-trendmacher

70 http://www.umweltbundesamt.de/daten/wasserwirtschaft/oeffentliche-wasserversorgung

71 Ordinance on the Quality of Water for Human Consumption, amended by a promulgation of 10 March 2016, BGBl. (Federal Law Gazette) p. 459, amended on 18 July 2016, BGBl. (Federal Law Gazette) p. 1666, 1668, last amended by Article 2 of the Act of 17 July 2017 (BGBl. I p. 2615)

72 Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, OJ L 330, p. 32, amended on 7 October 2015, OJ L 260, p. 6.

73 Ordinance on the Quality of Water for Human Consumption, amended by a promulgation of 10 March 2016, BGBl. (Federal Law Gazette) p. 459, amended on 18 July 2016, BGBl. (Federal Law Gazette) p. 1666, 1668, last amended by Article 2 of the Act of 17 July 2017 (BGBl. I S. 2615)

74 https://www.umweltbundesamt.de/publikationen/flyer-trinkwasser-wird-bleifrei

75 https://www.umweltbundesamt.de/publikationen/ratgeber-trink-was-trinkwasser-aus-hahn and http://www.umweltbundesamt.de/publikationen/rund-um-trinkwasser

76 IMS Health Verbrauchsdaten (Consumption Data), last updated 2012

[77] Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (Federal Office of Consumer Protection and Food Safety, BVL) 2015, sales of pesticides in the Federal Republic of Germany http://www.bvl.bund.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/meld_par_64_2015pdf?__blob=publicationFile&v=2

[78] https://www.umweltbundesamt.de/daten/wasserwirtschaft/oeffentliche-abwasserentsorgung

[79] Comparison figure for the pollutant loads contained in wastewater

[80] Statistisches Bundesamt (2015), Fachserie 19, Reihe 2.1.2, Strukturdaten zur Wasserwirtschaft 2013

[81] Statistisches Bundesamt (2015), Fachserie 19, Reihe 2.1.2, Strukturdaten zur Wasserwirtschaft 2013

[82] Statistisches Bundesamt (2015), Fachserie 19, Reihe 2.1.3, Strukturdaten zur Wasserwirtschaft 2013

[83] Statistisches Bundesamt (2015), Fachserie 19, Reihe 2.1.2, Strukturdaten zur Wasserwirtschaft 2013

[84] Results of nationwide substance emission modelling under the MoRE model (Modelling of Regionalized Emissions); mean for the period 2012 to 2014

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[86] DWA-Positionen 2011, "Positionen zur Energie- und Wasserwirtschaft" http://de.dwa.de/tl_files/_media/content/PDFs/Abteilung_WaBo/Energie-und-Wasserwirtschaft_Positionen.pdf

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[90] A sewer reach is the section between two shafts.

[91] When groundwater levels are high, drainage water is often deliberately routed into the sewers.

[92] Berger, C., Falk, C., Hetzel, F., Pinnekamp, J., Roder, S., Ruppelt, J. (2016): Zustand der Kanalisation in Deutschland – Ergebnisse der DWA-Umfrage 2015. KA Abwasser, Abfall, 63 (6)

[93] Wicke, D., Matzinger, A., Rouault, P.; OgRe - Relevanz organischer Spurenstoffe im Regenwasserabfluss Berlins, Berlin 2016 http://www.kompetenzwasser.de/fileadmin/user_upload/pdf/forschung/OgRe/Abschlussbericht_OgRe_final_rev2.pdf Results of nationwide substance emission modelling under the MoRE model (Modelling of Regionalized Emissions); mean for the period 2012 to 2014

[94] Results of nationwide substance emission modelling under the MoRE (Modelling of Regionalized Emissions) model; inventory of emissions, discharges and losses (priority substances) under EU Directive 2008/105/EG, diuron data as at 2008

[95] EEA 2016: http://www.eea.europa.eu/highlights/world-water-day-is-europe

[96] FAO 2014; http://www.fao.org/nr/water/aquastat/didyouknow/index3.stm

[97] Statistisches Bundesamt (Federal Statistical Office); Land- und Forstwirtschaft, Fischerei | Bewässerung in landwirtschaftlichen Betrieben/ Agrarstrukturerhebung 2013; published in 2014. Figures from 2012

[98] Statistisches Bundesamt (Federal Statistical Office), FS 19 Umwelt, R. 2.2 Nichtöffentliche Wasserversorgung, various years

[99] Seis et al. 2016, Rahmenbedingungen für die umweltgerechte Nutzung von behandeltem Abwasser zur

[100] landwirtschaftlichen Bewässerung, UBA Texte 34/2016 https://www.umweltbundesamt.de/publikationen/rahmenbedingungen-fuer-die-umweltgerechte-nutzung

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[105] German Sustainable Development Strategy, new edition 2016, https://www.bundesregierung.de/Content/DE/_Anlagen/2017/02/2017-02-27-nachhaltigkeit-neuauflage-engl.pdf?__blob=publicationFile&v=1

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[107] The figures for nutrient and heavy metal emissions are based on emission modelling under the MoRE (Modelling of Regionalised Emissions) model

[108] In the case of the river Elbe, this delay is greater than for the river Rhine, because the catchment area of the Elbe has a significantly lower average discharge per unit area (approximately 5 l/s/km², at Neu Dachau) than the Rhine (14 l/s/km², at Emmerich), and its proportion of loose stones is significantly higher

[109] Regulation (EC) 166/2006 of 18 January 2006

[110] Act implementing the Protocol on the Pollutant Release and Transfer Register of 21 May 2003 and executing Regulation (EC) No. 166/2006 (SchadRegProtAG) of 6 June 2007

[111] See Annex II to the European PRTR Regulation http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32006R0166&from=EN

[112] https://www.thru.de/fileadmin/SITE_MASTER/content/Dokumente/Downloads/01_Topthemen/Neue_PRTR-Daten_2015_in_thru.de/TOP-Topic_new_data_PRTR2015_170707_en_FINAL.pdf

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[135] Cuttings refer to the spoils left by drilling (fragments of rock), extracted via the drilling lubricant used.

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4 Water quality and impacts

4.1 Status of groundwater

Germany does not have a problem with groundwater quantity, apart from a few regional exceptions. However, the quality of groundwater is a different matter. In the past, groundwater was regarded as well-protected from anthropogenic pollution compared to surface waters. However, the purification and retention capacity of the overlying soil layers were overestimated. The systematic monitoring of groundwater quality reveals that in many locations the good quality of our groundwater is under threat. A substantial number of groundwater monitoring sites have recorded anthropogenic substance emissions and significant levels of pollution in some cases. In addition to point sources such as legacy sites (contaminated industrial, commercial or military sites), accidents involving substances hazardous to water or leaks in sewers, diffuse inputs from agriculture, industry, and transport are the principal threats and sources of groundwater pollution.

4.1.1 Groundwater monitoring

The monitoring of groundwater quality is the responsibility of the Länder. The aims of groundwater monitoring are:

- To promptly detect any adverse changes in quality,
- To identify the causes of contamination,
- To develop targeted remediation and minimisation strategies, and
- To assess the effectiveness of such protective measures.

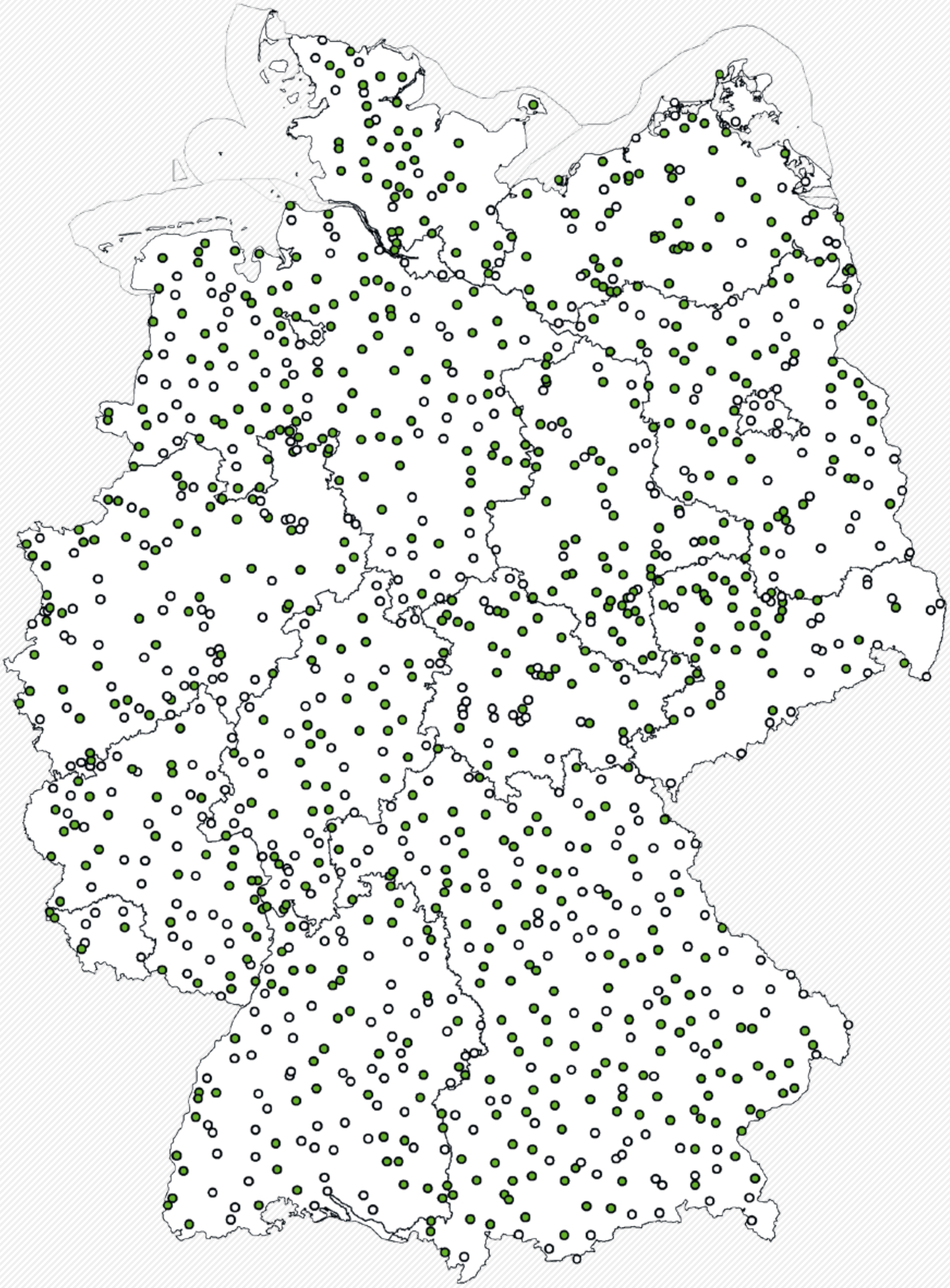
To this end, in recent decades, the Länder have systematically developed different groundwater monitoring networks.

Monitoring networks for reporting

Under the provisions of the Water Framework Directive (WFD), the Member States have established networks for monitoring the chemical and quantitative status of groundwater. The chemical status of groundwater is ascertained at operational monitoring sites and surveillance monitoring sites. Surveillance monitoring sites are established primarily in unpolluted bodies of groundwater, whereas operational monitoring sites are established in bodies of groundwater with poor status. The Länder are responsible for the creation and operation of monitoring networks. In total, they operate

Figure 44

Map of the new EEA monitoring network, which includes monitoring points of the new EU nitrate monitoring network (agricultural monitoring sub-network)



○ GW monitoring points ● Agricultural monitoring sub-network

Source: Geobasis data: DLM1000, 2015, BKG

4,892 surveillance monitoring points and 2,273 operational monitoring points. Just under 6,000 monitoring points monitor the quantitative status.

Some 20 years ago, the Länder and the German Environment Agency (UBA) set up a national monitoring network of around 800 monitoring points for reporting to the European Environment Agency (EEA groundwater monitoring network). In 2014/15, following a resolution by the Working Group of the Federal States on Water Issues (LAWA, Bund/Länder-Arbeitsgemeinschaft Wasser), the network underwent a fundamental overhaul, whereby the EU nitrate monitoring network and the EEA monitoring network were merged, and extended to around 1200 measuring points, distributed evenly across the whole of Germany, which are representative of groundwater quality nationwide. The data from this network provides the basis for some of the following evaluations. Figure 44 provides an overview of the distribution of monitoring points across Germany.

The WFD requires Member States to achieve good quantitative status and good chemical status in all bodies of groundwater.

As well as classifying the groundwater body's status, the Groundwater Directive also outlines provisions for the identification, assessment and treatment of rising pollution trends, and for limiting and preventing the input of pollutants into groundwater.

The first assessment of groundwater status in accordance with the provisions of the WFD occurred in 2004 as part of a baseline analysis. Over the years that followed, further selective studies and assessments of the quantitative and chemical status of groundwater were carried out.

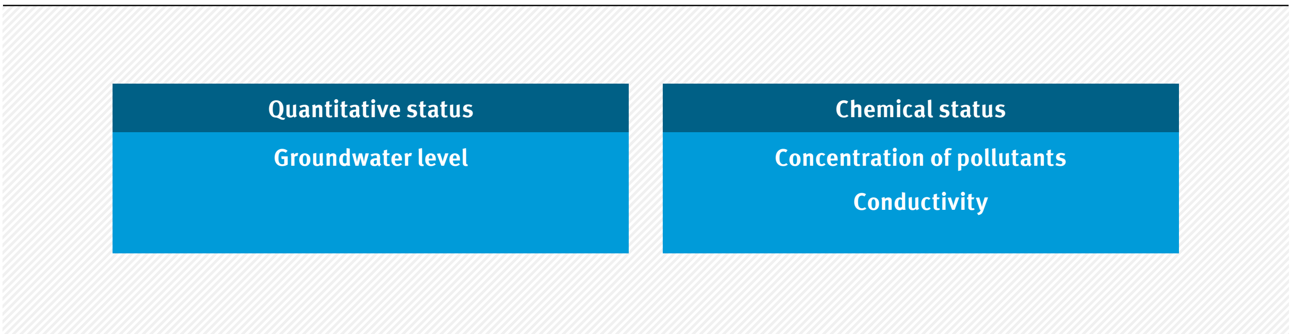
4.1.2 Quantitative status of groundwater

A good quantitative status means that there is a balance between groundwater abstraction and groundwater recharge. Furthermore, changes in the groundwater level due to water abstractions must not cause significant damage to surface waters or terrestrial ecosystems linked to the groundwater, and must not cause a significant deterioration in the quality of the surface waters themselves. Moreover, the water abstraction must not result in the inflow of salt water or other contaminants into the groundwater (intrusions).

shows the quantitative status of groundwater bodies. Overall in Germany in 2015, only 52 (4.2 %) of the 1,253 groundwater bodies failed to achieve good quantitative status.

Figure 45

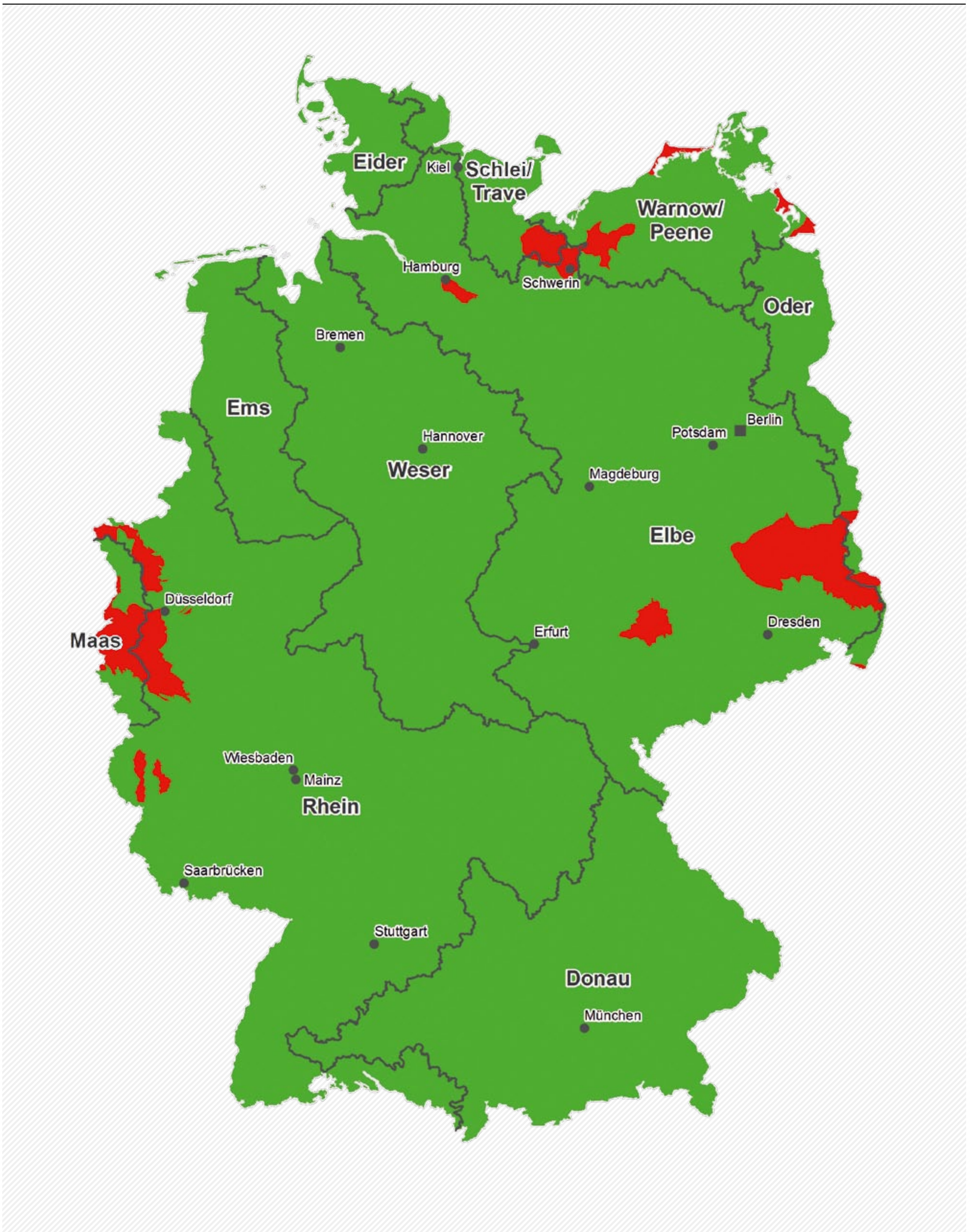
Overview of the status assessment of groundwater according to the WFD



Source: German Environment Agency brochure "Water Framework Directive", 2016

Figure 46

Quantitative status of groundwater bodies in Germany



Good
Poor

Data source: Berichtsportal WasserBLIcK/BfG, as at 23/03/2016

Quantitative problems can arise, for example, in conjunction with mining activities, particularly open-cast lignite mines (see chapter 3.3.3). In such regions, the groundwater level has often been lowered substantially over a period of several decades. Even after mining has been discontinued, it will take many decades for the groundwater to return to its natural levels.

In regions where salt is mined on a large scale, there are increased occurrences of man-made salt intrusions, leading to the groundwater's classification as "bad status". If saltwater pollution is attributable to high levels of water abstraction, the groundwater body is considered to have bad quantitative status. On the other hand, if the salt levels are caused e.g. by wastewater discharges from salt mining, the groundwater body is considered to have bad chemical status. The applicable assessment can only be determined by investigating the causes on site. In both cases, it is likely to take a long time for the groundwater body to return to natural "good status".

4.1.3 Chemical status of groundwater

The term "good chemical status" is defined in the Groundwater Directive in the form of quality standards and threshold values. The Directive specifies uniform European-wide quality standards for nitrate of 50 mg/l and for pesticides (plant protection products including their relevant metabolites and biocides) of 0.1 µg/l. Additionally, the Member States must specify threshold values for the parameters/substances which have led to the groundwater body's classification as "at risk" following analysis as per Article 4 of the WFD. Germany's threshold values as set out in the Groundwater Ordinance (GrwV) are summarised in Table 9. Following the amendment to the EU Groundwater Directive (2014/80/EU), the Groundwater Ordinance was revised in 2017, and new threshold values for nitrite (0.5 mg/l) and ortho-phosphate (0.5 mg/l) were adopted.

Table 9

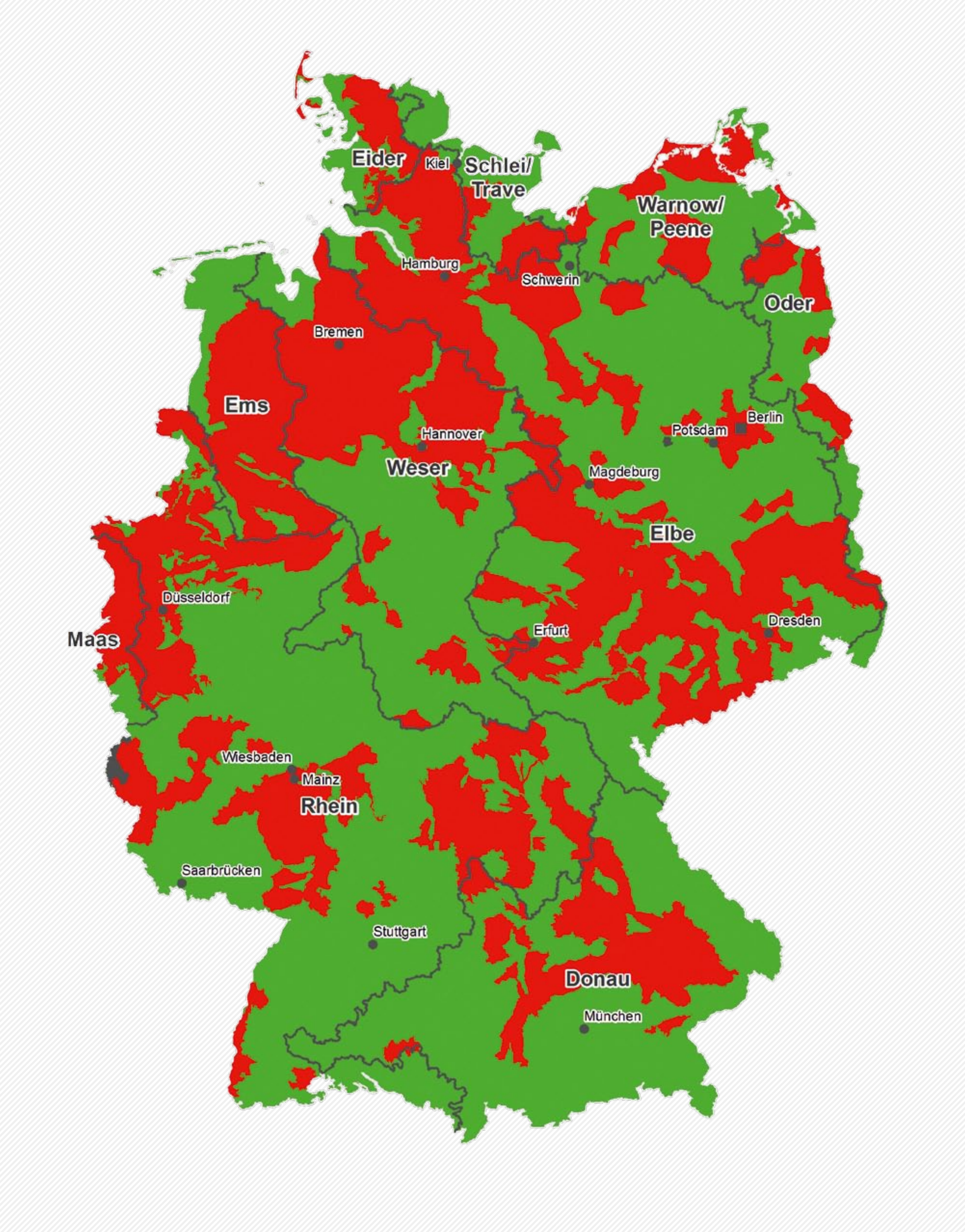
Threshold values in the Groundwater Ordinance (Annex 2)

Name of substance	Threshold value	Derivation criterion
Nitrate (NO_3)	50 mg/l	Groundwater quality standard as per Directive 2006/118/EC
Active ingredients in pesticides including relevant metabolites, active ingredients in biocide products including relevant metabolic or degradation and reaction products[1]) or critical substances in biocide products	0.1 µg/l each, in total 0.5 µg/l	Groundwater quality standard as per Directive 2006/118/EC
Arsenic (As)	10 µg/l	Drinking water limit for chemical parameters
Cadmium (Cd)	0.5 µg/l	Background value
Lead (Pb)	10 µg/l	Drinking water limit for chemical parameters
Mercury (Hg)	0.2 µg/l	Background value
Ammonium (NH_4^+)	0.5 mg/l	Drinking water limit for indicator parameters
Chloride (Cl)	250 mg/l	Drinking water limit for indicator parameters
Nitrite	0.5 mg/l	Drinking water limit for chemical parameters (annex 2 part II of the drinking water ordinance)
Ortho-phosphate (PO_4^{3-})	0.5 mg/l	Background value
Sulphate (SO_4^{2-})	2250 mg/l	Drinking water limit for indicator parameters
Sum total of tri- and tetrachloroethylene	10 µg/l	Drinking water limit for chemical parameters

Source: Groundwater ordinance of 2010 (Federal Law Gazette (BGBl.) I p. 1513), last amended 2017 (BGBl. I p. 1044)

Figure 47

Chemical status of groundwater bodies in Germany.

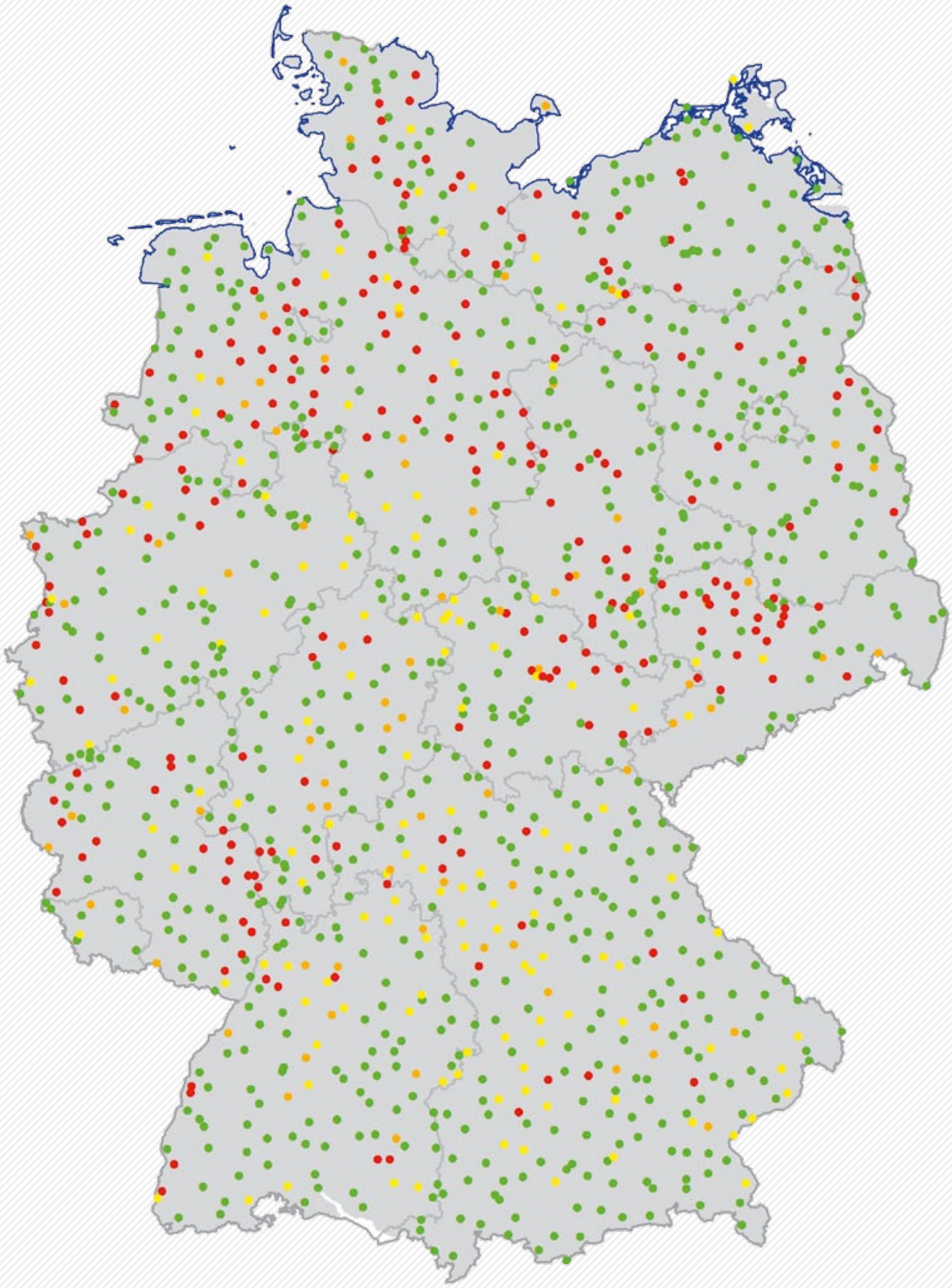


Good Poor Not assessed

Data source: Berichtsportal WasserBLIcK/BfG, as at 23/03/2016

Figure 48

Average nitrate levels at measuring points in the EEA monitoring network, 2012–2014



Nitrate levels in groundwater (mg/l nitrate)

- 0 to <= 25
- >25 to <= 40
- >40 to <= 50
- >50

Source: German Environment Agency (Umweltbundesamt, UBA) based on data supplied by the Working Group of the Federal States on Water Issues (LAWA).

The aforementioned European-wide quality standards (chapter 4.1.1) and the threshold values set by the Member States for relevant pollutants provide the yardstick for assessing the chemical status of groundwater. The 2015 assessment of the chemical status of groundwater found that 34.8% of all groundwater bodies have a poor chemical status (Figure 47).

The main causes are diffuse pollution from nitrate (27.1 % of groundwater bodies exceed the quality standard) and pesticides (2.8 % of groundwater bodies exceed the quality standard) from agriculture (see chapter 3.2.2).

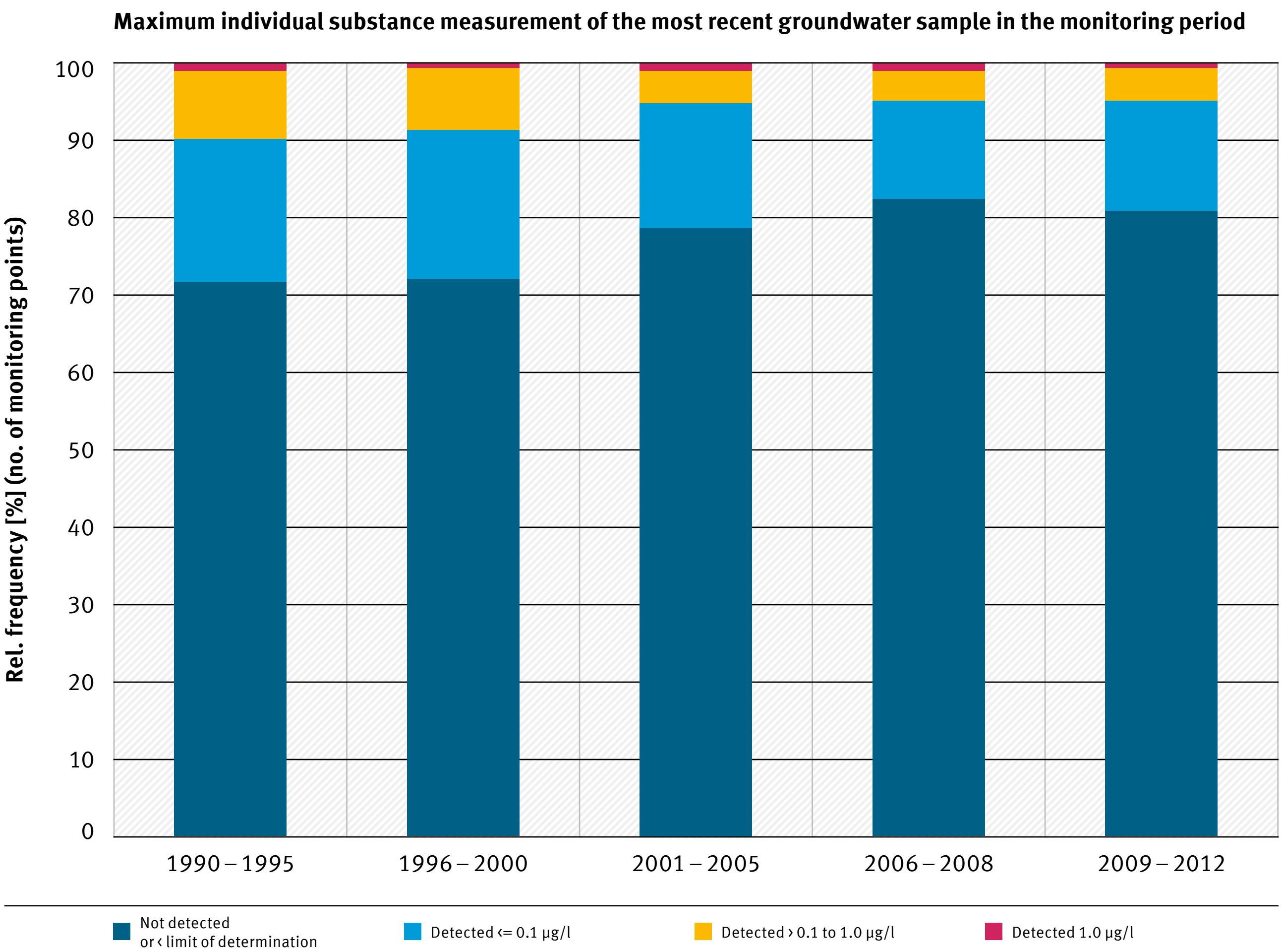
Nitrate in groundwater

Nitrogen compounds–generally nitrate–are the most common reason for a bad status of groundwater in Germany and most EU Member States. Based on measurement data from the EEA monitoring network, the following picture emerges for the period 2012 - 2014 (Figure 48):

Nitrate concentration figures in groundwater are available for 1215 monitoring points in the new EEA monitoring network for the period 2012 - 2014. Around 64.5 % of all monitoring points indicate nitrate concentrations of between 0 and 25 mg/l and are therefore not polluted at all, or

Figure 49

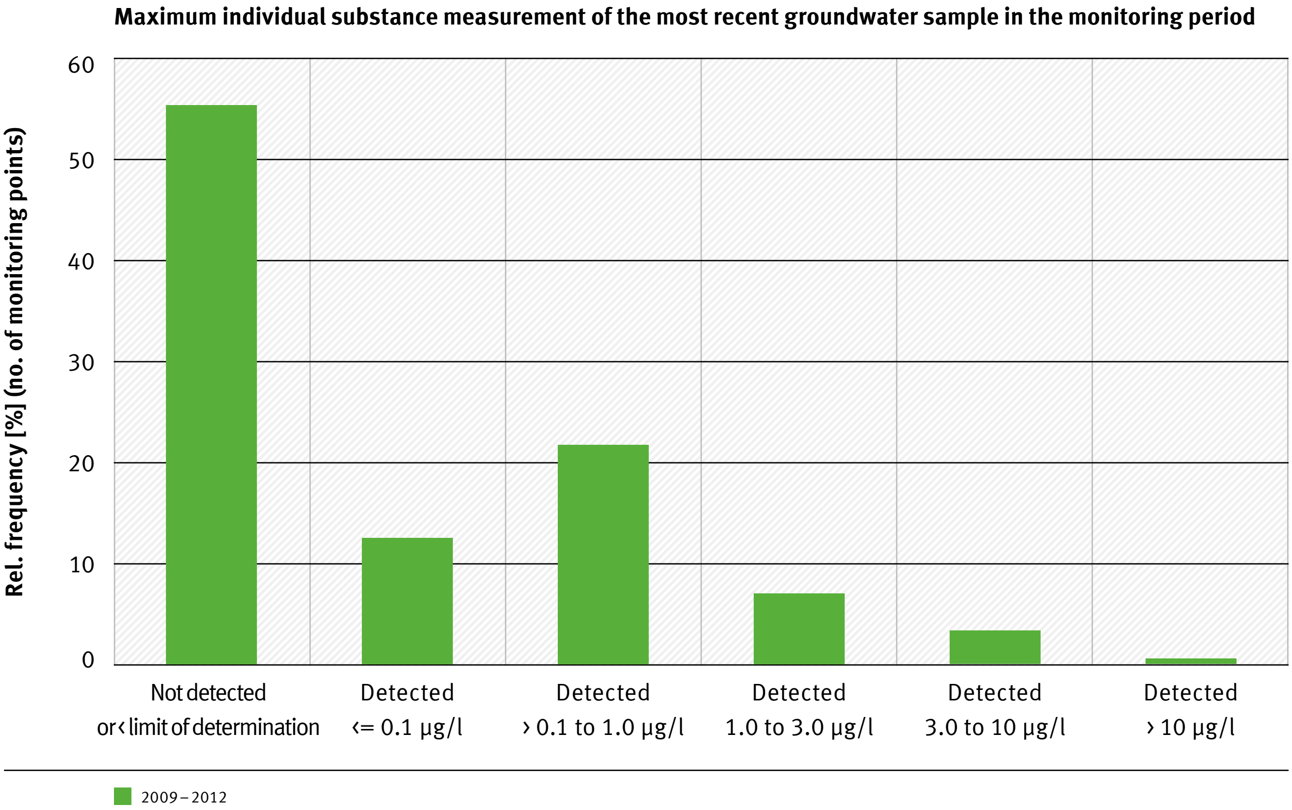
Frequency distribution of pesticide findings at filtered shallow groundwater monitoring points in Germany, 1990-1995, 1996-2000, 2001-2005, 2006-2008 and 2009-2012



Source: German Environment Agency based on LAWA

Figure 50

Frequency distribution of "non-relevant" metabolites at filtered shallow monitoring points in Germany's groundwater (2009-2012)



Source: German Environment Agency based on LAWA

only moderately. 17.4 % of monitoring points have a nitrate content of between 25 and 50 mg/l, which means that they are significantly to heavily polluted with nitrate. The remaining 18.1% of measuring sites are so heavily polluted with nitrate that the water cannot be used for drinking water abstraction without further treatment, because the limit set by the Drinking Water Ordinance of 50 mg/l (identical with the threshold value in the Groundwater Ordinance) is exceeded, in some cases significantly.

Pesticides

From time to time, LAWA and the German Environment Agency (UBA) compile a summarising report on the pollution of groundwater with pesticides. The 2015 report provides an overview of groundwater pollution during the period 1990 to 2012[169]. In all reporting periods to date (1990-1995, 1996-2000, 2001-2005, 2006-2008 and 2009-2012), the limit of 0.1 µg/l was exceeded by ever fewer monitoring points (Figure 49).

However, this reduction is primarily attributable to decreasing levels of atrazine, desethylatrazine and few other active ingredients and metabolites, the use of which has been banned for years or even decades

Between 2009 and 2012, 4.6% of the 13,400 monitoring points reviewed still exceeded the limit of 0.1 µg/l in shallow groundwater. Groundwater contamination with pesticides has therefore remained virtually unchanged compared to the period 2006-2008.

For the first time, the 4th report of 2015 systematically analysed findings of so-called non-relevant metabolites of active pesticide ingredients for the whole of Germany. Under the Plant Protection Act, non-relevant metabolites of active pesticide ingredients are defined as the degradation products of active pesticide ingredients which do not have a comparable pesticide effect as the original ingredients and are less humanotoxic or ecotoxic. They are not subject to the threshold values for active ingredients and relevant metabolites of 0.1 µg/l[170]. However, "non-relevant" does not mean that these substances are insignificant for groundwater. Some of them are converted into harmful substances during drinking water processing. Just like other non-natural substances in groundwater, non-relevant metabolites are not desirable.

Non-relevant metabolites were found at 45 % of monitoring points, 21.7 % in the concentration range from 0.1 to 1.0 µg/l, and a further 10.5 % above 1.0 µg/l. Concentrations above 10.0 µg/l occur at 30 measuring points (0.4 %) (Figure 50). Overall, non-relevant metabolites are found more frequently than active ingredients and relevant metabolites.

As a precautionary measure, we should aspire to further reduce the concentrations of all non-relevant metabolites in groundwater. In 2015, the 85th Conference of Environmental Ministers resolved that, given the large number of findings in groundwater, a nationwide threshold value should be set for all non-relevant metabolites.

4.2 Status of surface waters

4.2.1 Monitoring

The Länder monitor surface waters and assess their status at a large number of monitoring points. The location of monitoring points and spectrum of measured variables depend on the task in question, which range from monitoring the impacts of public and industrial discharges, measurements for warning of extreme events (such as incidents, flooding), and the assessment of waterbody status. To this end, chemical parameters are measured in the water, in materials in suspension, in fish and in mussels. The species occurring and hydromorphological parameters are identified. Three types of monitoring are assigned to the monitoring points for assessing the ecological and chemical status of surface waters:

- Surveillance monitoring
- Operational monitoring
- Investigative monitoring

Surveillance monitoring assesses the incidence of fauna (fish, mussels, crabs, insect larvae) and flora (algae, water plants), logs more than 100 pollutants, and examines the bed, banks, continuity for fish as well as the water volume.

Operational monitoring is carried out in those sections of waterbody whose status has been assessed as less than good. The choice of parameters depends on the pressure which has caused the section of waterbody to fall short of a good status. If the cause of the pressure is unknown, additional monitoring points will be set up to investigate it.

For the large rivers, extensive data is usually available over long periods. The data situation for smaller waterbodies has continuously improved since 2006 with monitoring for reporting under the WFD. Not all analyses are necessary or feasible in every section of water. In very small waterbodies, there may not be any fish of a sufficient size to ascertain the pollutant content, or the number of fish caught may be too small to reliably assess the ecological status of fish fauna. However, based on a knowledge of pressures in the catchment area, the results from one monitoring point may be transferred to multiple waterbody sections.

4.2.2 Ecological status

Since the WFD's entry into force, the "ecological status" has been assessed primarily based on the stock of fish fauna, invertebrates, macrophytes, phytobenthos and phytoplankton (biological quality elements). The status is assessed as "good" if their stock deviates only slightly from the natural status of that particular waterbody type. Additionally, the environmental quality standards for so-called river basin-specific pollutants must not be exceeded. If even one of these standards is exceeded, this will lead, at best, to classification as a "moderate" ecological status. Physico-chemical and hydromorphological quality elements support the assessment of the status. For example, these may include temperature, pH value, oxygen content and nutrients or hydrology and continuity (Figure 51). These elements must be present in a quality that permits a "good status" of biotic communities in waterbodies. Intact, natural biotic communities can only become established if the morphological structure and material conditions are favourable.

Figure 51

Overview of the status assessment of surface waters under the Water Framework Directive

Ecological status is assessed based on a system of five classes

Ecological status

Biological quality elements
(fish, invertebrates, aquatic flora)

Chemical quality elements
(river basin-specific pollutants)

in conjunktion with the following elements that support the biological elements:

Physicochemical quality elements
such as temperature, pH, oxygen content and nutrients

Hydromorphological quality elements
such as hydrological regime, continuity and tides

Chemical status

Priority substances

Other pollutants

Source: German Environment Agency brochure "Water Framework Directive", 2016

Ecological status is assessed based on a system of five classes:

- Class 1:High
- Class 2: Good
- Class 3: Moderate (from this class upwards, action is needed)
- Class 4: Poor
- Class 5: Bad

Class 1 describes the reference status, i.e. the waterbody status (virtually) devoid of disruptive influences and pressures from humans. For assessment purposes, the status of every relevant biological quality element in a waterbody type is examined, and categorised from "High" to "Bad". The worst individual result of a biological quality element determines its ecological status class ("worst case principle").

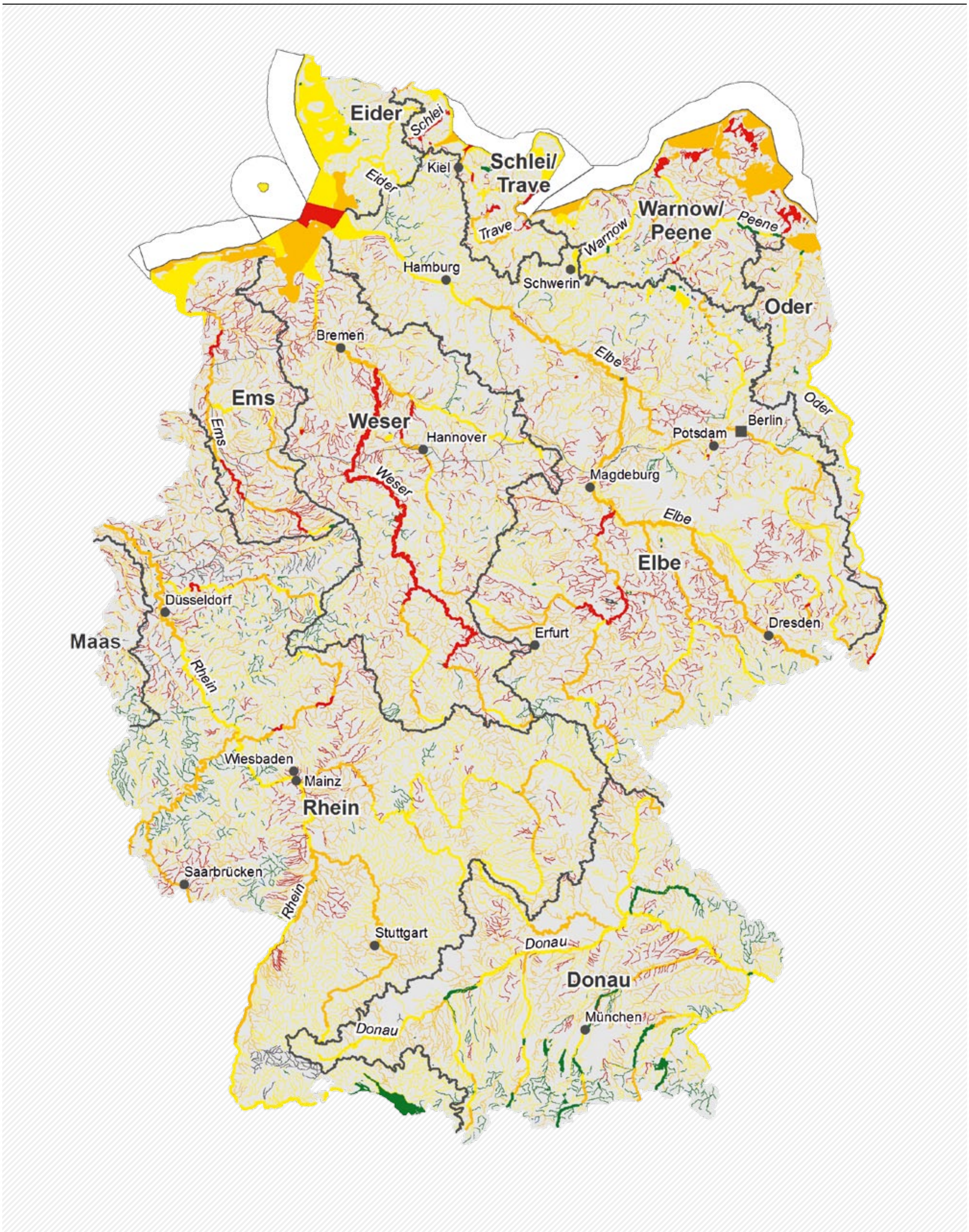
The current ecological status of Germany's waterbodies is shown in Figure 52 and Figure 53. The dominant colours yellow, orange and red in the maps and diagrams of ecological status indicate that many waterbodies still fall short of a good ecological status. The result reflects the high intensity of use of Germany's waterbodies by agriculture, industry, shipping, hydropower, the domestic water supply sector and leisure use.

A "High" or "good" ecological status is currently only found in 8.2 % of the 9,800 or so waterbodies.

The overall ecological status result essentially reflects the assessment of Germany's 9,000 or so watercourses, since these account for the bulk of surface waterbodies. The picture for Germany's 730 or so lakes is brighter. Here, 26 % achieve "high" or "good" ecological status (see Figure 53). At present, none of the coastal and transitional waters achieves "good" ecological status (see Figure 53 and chapter 4.3).

Figure 52

Ecological status of surface waters in Germany

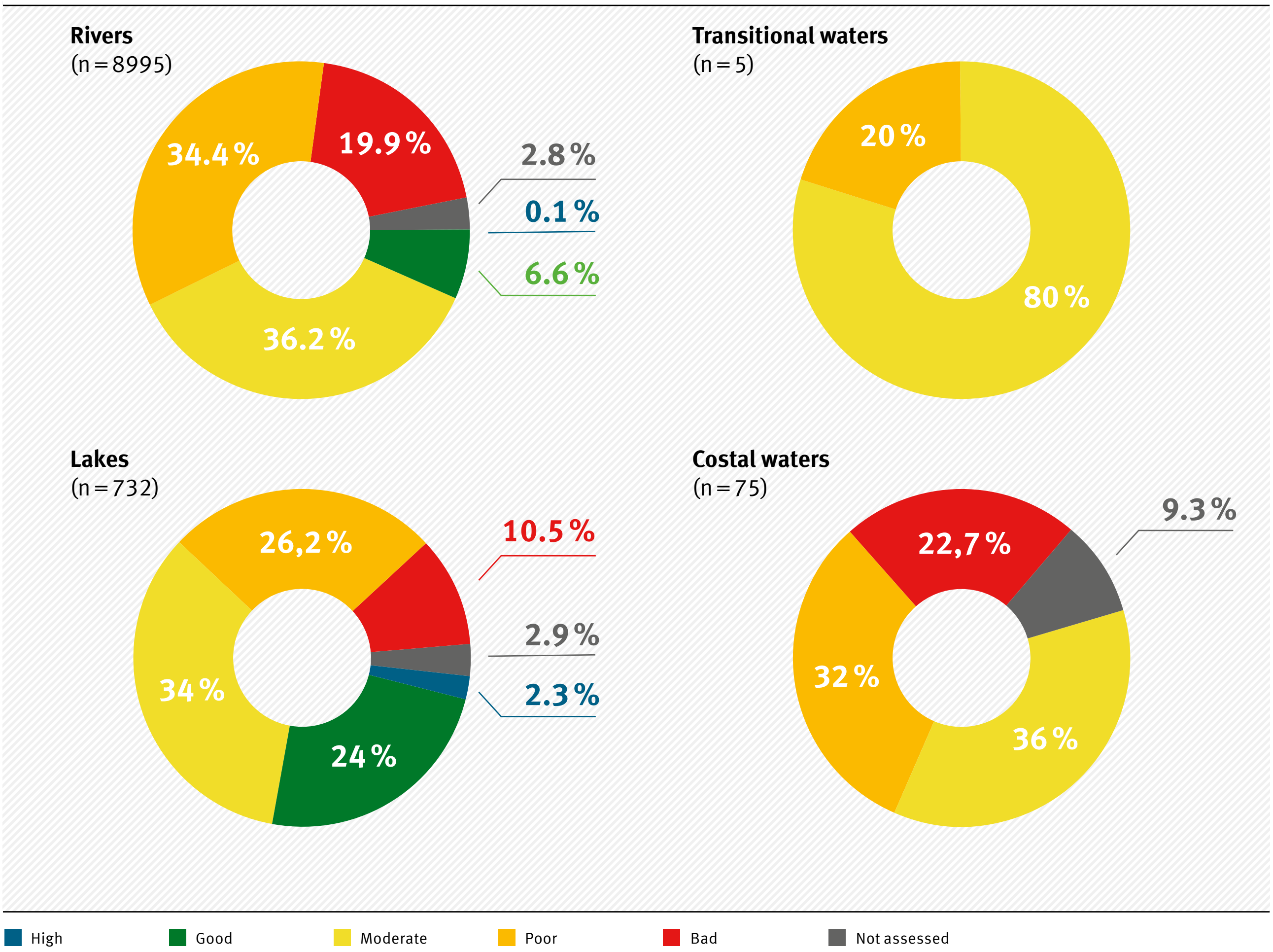


High | Good | Moderate | Poor | Bad | Unclear | No assessment of ecological status required

Data source: Berichtsportal WasserBLIcK/BfG, as at 23/03/2016

Figure 53

Ecological status of waterbody categories in Germany



Data source: Berichtsportal WasserBLIcK/BfG, as at 23/03/2016

4.2.3 Chemical status

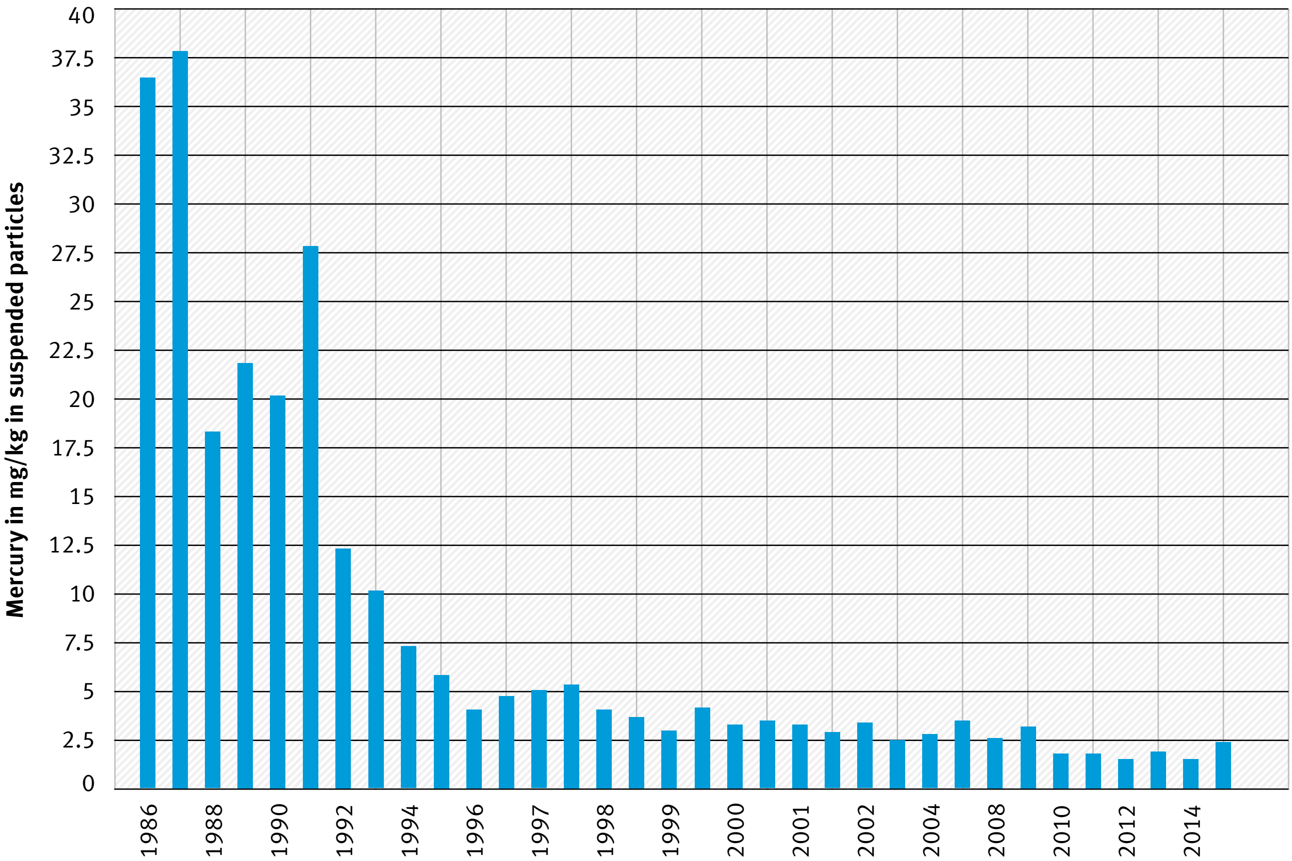
CA multitude of different substances can be measured in our surface waters. To assess these measurement results, at EU level environmental quality standards for selected substances are set out in EC Directive 2008/105. These are intended to ensure that the flora and fauna in our rivers, lakes and seas, as well as human health and animals that feed on these aquatic organisms, are not harmed by these substances. The selection is updated every 6 years. It currently comprises 45 substances/substance groups, including 12 substances that will only be included in the assessment of chemical status from 2018 onwards. They include metals, pesticides (plant protection agents, biocides) and other chemicals. 13 of the 45 substances are persistent organic pollutants (POPs), the manufacture and use of which is already prohibited or heavily restricted by Regulation (EC) No. 805/2004.

If the environmental quality standard for just one of these substances is exceeded, the chemical status of that section of waterbody is classed as “not good”, and action must be taken to reduce inputs.

For further information, please refer to:
German Environment Agency, UBA (2017): Waters in Germany: Status and assessment.
https://www.umweltbundesamt.de/publikationen/waters-in-germany

Figure 54

Mean mercury concentration at Schnackenburg (Elbe)



Source: German Environment Agency based on data supplied by the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLKWN)

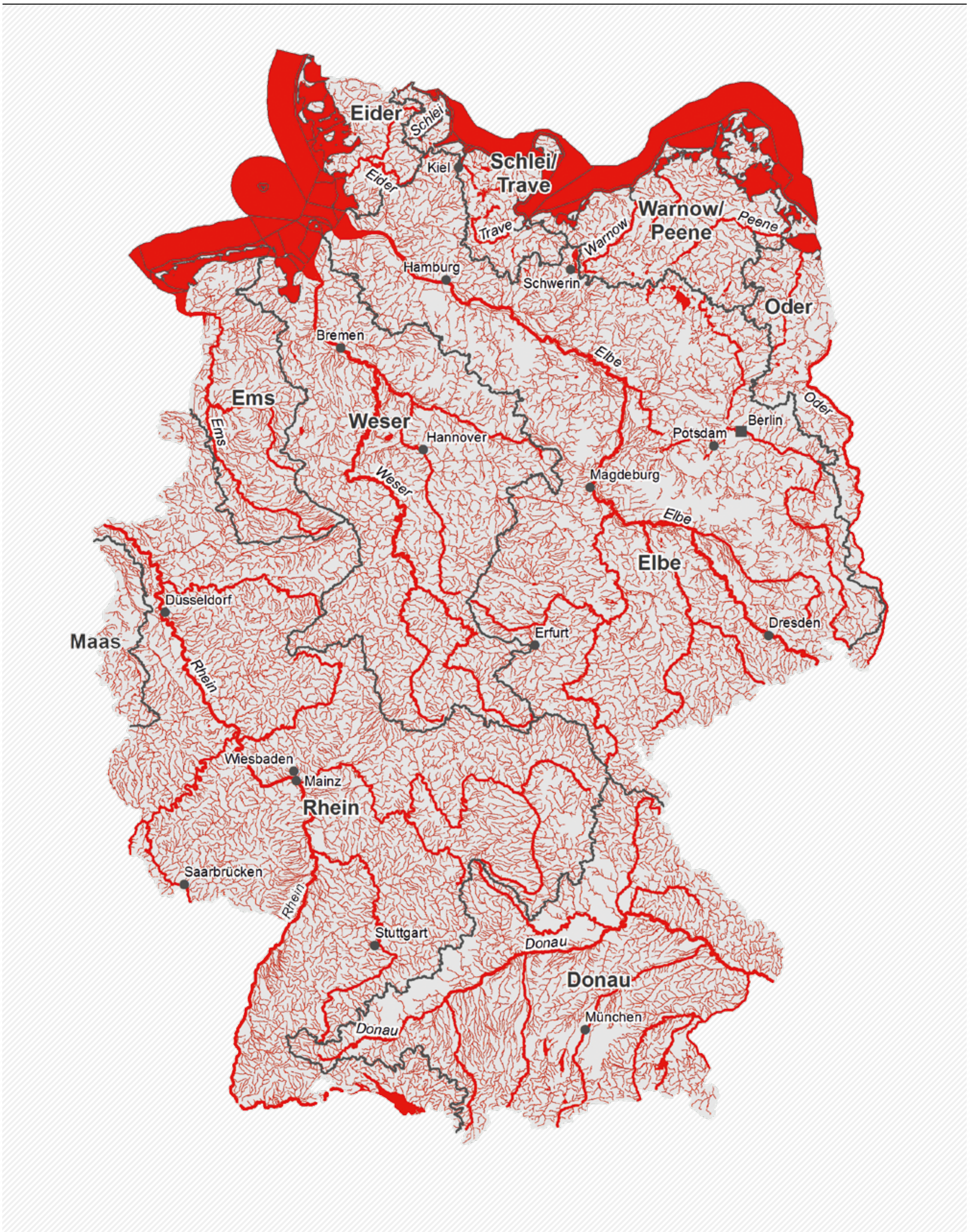
In the period 2009 to 2015, the environmental quality standards were met at all monitoring points for 12 of the 33 substances that had been regulated up until 2011. These include seven pesticides and five industrial pollutants. In the case of brominated diphenyl ethers (BDE), polycyclic aromatic hydrocarbons (PAH) and tributyl tin (TBT), the environmental quality standards[171] are frequently exceeded (Figure 55). Figure 56 and Figure 57 show a more differentiated picture, since the substances mercury, BDE, PAH and TBT have been disregarded in these assessments.

Although pollution with mercury has decreased substantially in the last 25 years, concentration levels of mercury in fish remain above the environmental quality standard, even in waters that otherwise have a low level of chemical pollution. These results have also been transferred to rivers, lakes and marine regions where it has not been possible to conduct measurements in fish. For this reason, the overall assessment of the chemical status of all German waters is "not good" (Figure 55). Mercury concentration trends can be exemplarily retraced by the concentration of suspended particles at the Schnackenburg monitoring point on the River Elbe (Figure 53).

The environmental quality standard for mercury was set at 20 µg/kg wet weight in fish, so as to protect birds and mammals (such as fish eagles and otters) that feed on fish. For mussels and fish intended for human consumption, the maximum quantities are 500 to 1000 µg/kg wet weight for food. Within the context of annual foodstuff monitoring, mercury level measurements revealed that only a minimum number of samples had exceeded the above maximum limits, with a few exceptions[172]. In such cases, the competent institutions for food safety issue warnings to anglers and prohibit the sale of fish.

Figure 55

Chemical status of surface waters, assessment of all substances regulated up until 2011

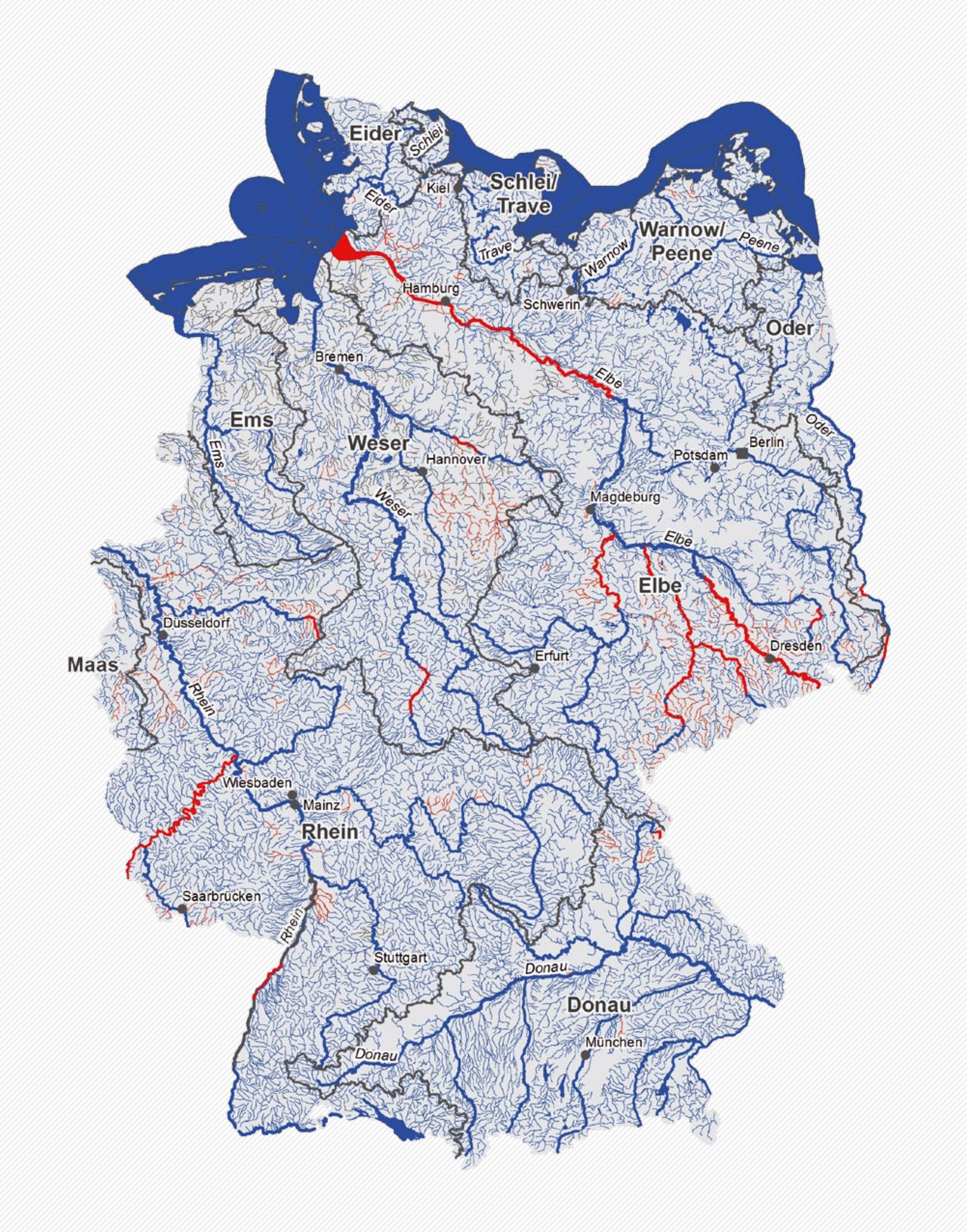


■ Not good

Data source: Berichtsportal WasserBLIcK/BfG, as at 23/03/2016

Figure 56

Map showing the chemical status of surface waters, with assessment of all substances regulated up until 2011, excluding mercury, BDE, PAH, TBT*



Good | Not good | Not assessed

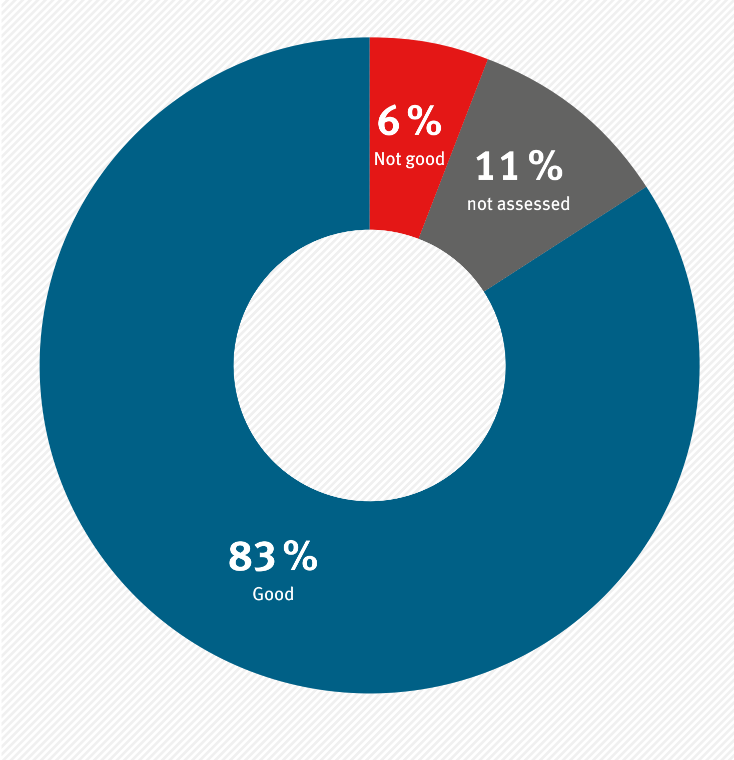
*substances with the numbers 2, 5, 15, 21, 22, 28, 30 as shown in Annex 8 to the Surface Water Ordinance are excluded

Data source: Berichtsportal WasserBLIcK/BfG, as at 23/03/2016

Elevated levels of pesticides tend to occur primarily in smaller waterbodies in rural regions, whereas relevant pollution with metals tends to occur primarily in waterbodies with inputs from abandoned mines (3.3.3). Exceedances of the environmental quality standard for industrial pollutants primarily occur in waterbodies in industrial conurbations.

Figure 57

Chemical status of surface waters, with assessment of all substances regulated up until 2011, excluding mercury, BDE, PAH, TBT*



*substances with the numbers 2, 5, 15, 21, 22, 28, 30 as shown in Annex 8 to the Surface Water Ordinance are excluded

Datasource: Berichtsportal WasserBLIcK/BfG, state 23.03.2016

4.3 State of coastal and marine waters

The current use and pollution situation in the North and Baltic Seas is far from being sustainable. In many cases, this "over-exploitation" of the seas and coasts places an excessive burden on the stability and resilience of our marine ecosystems. The regional conventions on the protection of the marine environment of the North-East Atlantic (OSPAR) and the Baltic Sea (HELCOM) (see chapter 5.4.2) have long been concerned with the assessment of environmental status, and more recently with an overarching assessment of the marine waters in their respective Convention territory. These holistic assessments indicate that both seas remain severely impaired by human pressures. In particular, intensive fishing has serious impacts on fish stocks and habitats. Eutrophication remains one of the principal pressures in both the North and Baltic Seas. In the North Sea, there are additional problems associated with large quantities of marine litter. In future, these problems look very likely to intensify as the pressures from human uses (from shipping, offshore wind power) increase. Furthermore, the adverse effects of climate change will increasingly be felt.

4.3.1 Basis for assessment

In 2012, Germany's coastal and marine waters were assessed under the EU Marine Strategy Framework Directive (MSFD) for the first time. This assessment includes a description of the principal characteristics and pressures, including an analysis of socio-economic aspects, and a description of the aspired "good environmental status", alongside the definition of environmental objectives in order to achieve or conserve this status (see also chapter 5.4 and 5.4.3). In 2012, qualitative and semi-quantitative assessments were conducted on the basis of work for the WFD, the Habitats Directive and the Birds Directive, as well as current assessments under the OSPAR Convention, the trilateral Wadden Sea collaboration and the Helsinki Convention. The area of application of the aforementioned directives and conventions partly overlap as shown in Figure 59. They indicate that Germany's North and Baltic Sea regions failed to achieve "good environmental status" in 2012[173]. Figure 58 provides a simplified, summarising overview of the initial assessment of Germany's marine waters. Many habitats and species in Germany's North and Baltic Seas are not in good status. Various biotope types, phytoplankton, fish stocks and seabirds are affected to a particular degree. Pivotal factors for this assessment especially include the high pressures associated with fishing (see chapter 6.3), eutrophication, pollutants, litter (see chapter 3.8.1) and noise. If Germany is to achieve "good environmental status" as

Figure 58

Summarising overview of the initial assessment of Germany‘s marine waters under the MSFD, conducted in 2012

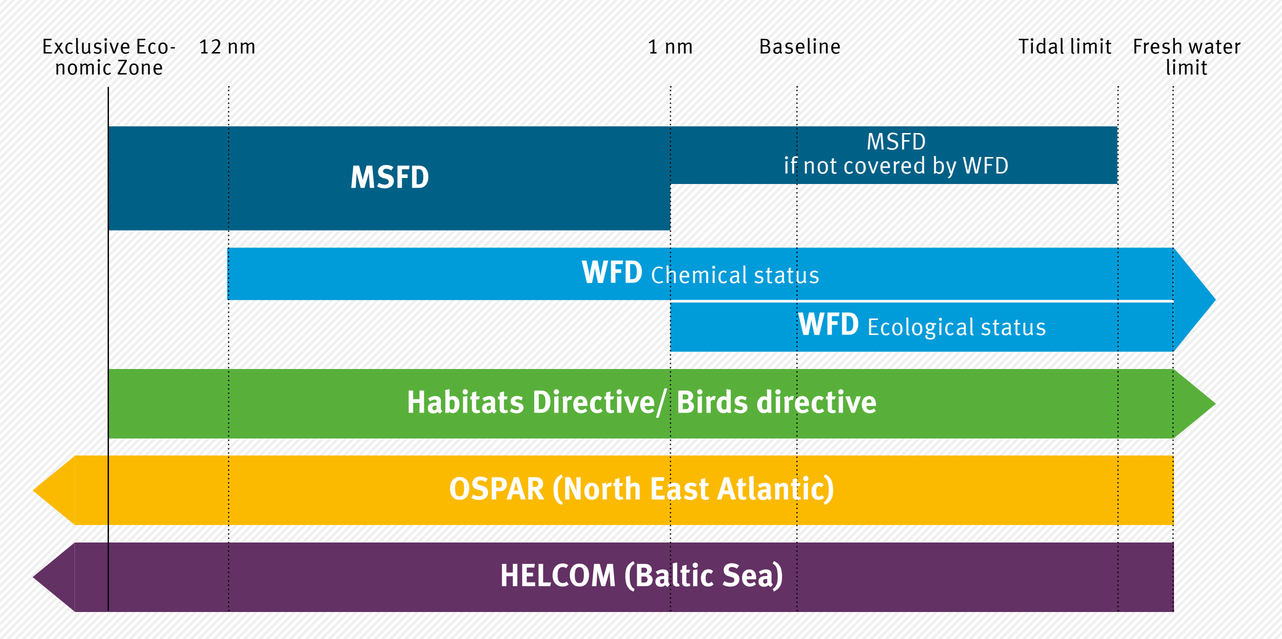
Characteristics, pressures and impacts	North Sea		Baltic Sea	
Biotope types	Not good		Not good	
Phytoplanktion	Not good		Not good	
Zooplankton	Not assessed		Not assessed	
Macrophytes	Not good		Not good	
Makrozoobenthos	Not good		Not good	
Fish	Not good		Not good	
Marine mammals	Not good		Not good	
Seebirds	Not good		Not good	
Smothering with sediment	Not assessed		Not assessed	
Sealing	Not assessed		Not assessed	
Changes in siltation	Not assessed		Not assessed	
Abrasion	Not assessed		Not assessed	
Selective extraction	Not good		Not assessed	
Underwater noise	Not assessed		Not assessed	
Marine litter	Not good		Not assessed	
Changes in thermal regime	Not assessed		Not assessed	
Changes in salinity regime	Not assessed		Not assessed	
Introduction of synthetic and non-synthetic substances	WFD	OSPAR	WFD	HELCOM
Introduction of radio-nuclides	Good		Good	
Contaminants in food	Not good		Good	
Systematic and/or intentional re-lease of substances	WFD	OSPAR	WFD	HELCOM
Nutrient and organic matter enrich-ment	Not good		Not good	
Introduction of microbial pathogens	Good		Good	
Introduction of non-indigenous species	Not assessed		Not assessed	
By-catch	Not good		Not assessed	
Cumulative and synergetic effects	Not assessed		Not assessed	
Overall enviromental status	**Not good**		**Not good**	

Good environmental status is achieved — Good environmental status is not achieved — Not assessed

Source: German Environment Agency (2014) based on the assessment under the MSFD

Figure 59

Area of application of EU directives (WFD, Habitats Directive and Birds Directive) and the marine protection conventions OSPAR and HELCOM relevant for the assessment under the MSFD



Source: German Environment Agency

defined in the MSFD by the set deadline of 2020, adequate measures are needed to reduce anthropogenic pressures. In line with the provisions of the MSFD, these measures are anchored in the programmes of measures published in 2016[174].

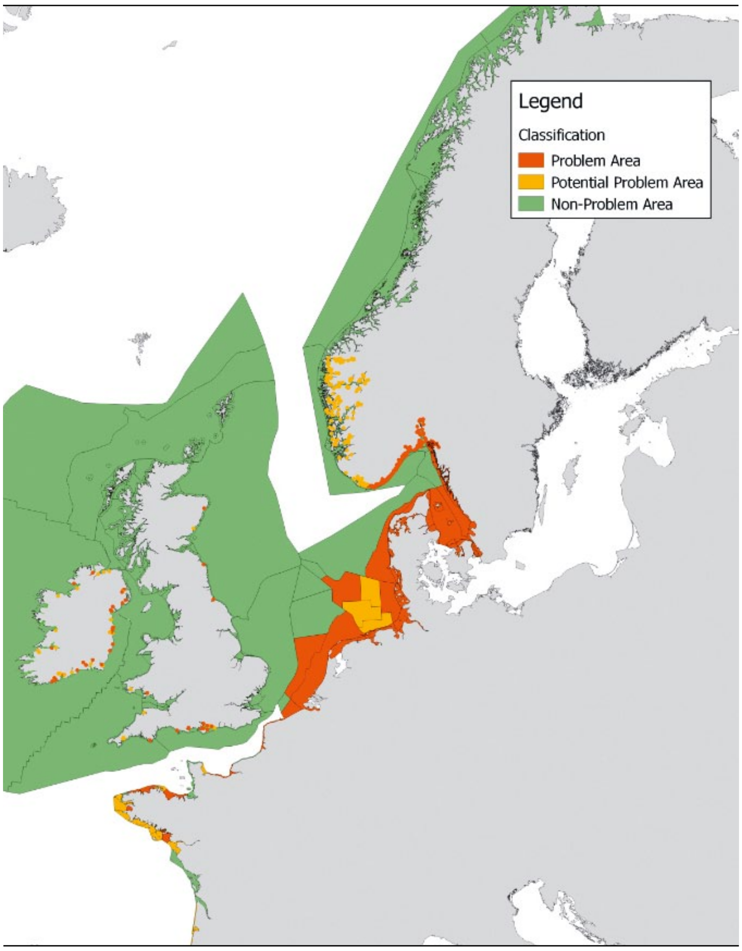
As the MSFD covers a six-year management cycle, a follow-up assessment of coastal and marine waters is due in 2018. As far as possible, this is based on a revised EU Commission Decision which defines primary and secondary criteria (indicators) together with more specific methodological standards for assessing environmental status. The foundations for this follow-up assessment were drawn up by OSPAR and HELCOM at regional level. In large part, the national follow-up assessment is based on the regional assessments–the OSPAR Intermediate Assessment[175] and the HELCOM "State of the Baltic Sea Report"[176], both published in summer 2017. As the principal pressures have not yet been sufficiently reduced, Germany's North and Baltic Sea regions still fail to achieve "good status". The follow-up assessment according to MSFD will be released on www.meeresschutz.info (in German).

4.3.2 Eutrophication of the North and Baltic Seas

Alongside overfishing, eutrophication is currently the biggest environmental problem in the North and Baltic Seas. Eutrophication is caused by excessive nutrient inputs, leading to a host of adverse impacts on marine ecosystems, such as excessive or toxic algal bloom, oxygen depletion, and impairments to benthic fauna and aquatic flora. Inputs of nutrients originating from inland areas, including those from non-littoral states, enter the seas via major river systems and via the atmosphere. Some river catchment areas are densely populated, highly industrialised and intensively farmed. In the majority of cases, elevated inputs of nitrogen originate from diffuse sources, primarily from the application of fertilisers to agricultural land and from livestock farming (see chapter 3.2.2) as well as from atmospheric inputs from ships' and factory fumes (see chapter 3.5.1). The majority of elevated phosphorus inputs likewise originate from agriculture, but are also caused by point sources, such as the discharge of public and industrial wastewater (chapter 3.3.1).

Figure 60

Provisional results from the Third Eutrophication Assessment of the North-East Atlantic by OSPAR (assessment period 2006-2014)



Non-Problem Area | Potential Problem Area | Problem Area | National boundaries of competence

Source: OSPAR Commission, 2017

Baltic Sea

Because of its character as a semi-enclosed sea and due to its minimal water exchange with the North Sea, the Baltic Sea is particularly sensitive to eutrophication. Over the past 115 years, the extent of "dead zones"–areas in which life is no longer supported due to a lack of oxygen at the bottom–has increased more than tenfold as a result of rising eutrophication[177, 178]. HELCOM regularly monitors and assesses the eutrophication status of the Baltic Sea. According to the recent assessment, based on data from 2011 - 2015, 97 % of the Baltic Sea is classified as eutrophic, including Germany's Baltic Sea waters[179]. Despite reduced nutrient inputs the eutrophication status has not seen any significant improvement since the last assessment, which was based on data from 2007 - 2011.

As early as 2007, HELCOM defined specific quantitative nutrient reduction targets for the Baltic Sea coastal states, adopted by the Environment Ministers of all Contracting Parties to HELCOM in Krakow, which are to be met by 2021. Based on the latest scientific findings available at that time, new nutrient reduction targets were agreed in 2013 at another Meeting of Ministers. Germany subsequently committed to reduce nitrogen inputs by 7,670 t by 2016, and phosphorus inputs by 170 t, compared with the reference period 1997 - 2003. Beneficial reductions have been achieved in recent years, particularly with regard to nitrogen inputs. Implementation of the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone has made a significant contribution in this regard. Phosphorus inputs nevertheless stagnate on a high level.

Between 1983 - 1987 and 2012 - 2014, nitrogen inputs into the surface waters of the German Baltic Sea catchment area (Warnow/Peene, Schlei/Trave and Oder river basin districts) were reduced by 65 % from 63,000 t/a to 22,200 t/a. Over the same period, phosphorus inputs decreased by 78 % from 3,600 t/a to 800 t/a. In particular, nutrient inputs from point sources were reduced by upgrading wastewater treatment plants and introducing phosphate-free detergents. In the period 2012 - 2014, 78 % of waterborne nitrogen inputs and 51 % of phosphorus inputs originated from agriculture, whereas only 9 % of nitrogen inputs and 20 % of phosphorus inputs originated from point sources.

North Sea

In the North Sea, the eutrophication problem primarily concerns the continental coastal region, a water belt along the coast approximately 50 to 100 km wide with excessive nutrient concentration levels caused by riverine inputs. OSPAR also assesses the eutrophication status at regular intervals. The current eutrophication assessment[180], based on data from the period 2006 - 2014, classifies 7 % of the assessed regions in the North-East Atlantic as problem areas in terms of eutrophication, including the German coastal waters and the German Bight with the exception of the outer northern region of the German Exclusive Economic Zone (EEZ) (the so-called "Duck's Bill") (see Figure 60). Compared with the last OSPAR assessment of the eutrophication status, the size of the problem areas and potential problem areas (areas for which only a small amount of data is available) in the North-East Atlantic has decreased further. The German North Sea has also seen an improvement in the open German Bight (Duck's Bill).

Concerned by high levels of nutrient inputs via rivers, at the International North Sea Conferences (INSC) in 1987 (London) and 1990 (The Hague), the Environment Ministers of all states bordering the North Sea adopted measures to reduce nutrient inputs by 50 % in the period 1985–1995. The deadline was extended to 2000 at the 4th INSC (in Esbjerg), but still has not yet been met by all littoral states of the North Sea. OSPAR has since abandoned its objective of an across-the-board reduction of nutrient inputs by 50 % in favour of scientifically derived individual nutrient reduction targets for the designated problem areas. These are to be met by 2020. Although, according to the OSPAR strategy, these targets should have been set back in 2012, the North Sea littoral states have thus far failed to agree on reduction targets, mainly because reductions of well over 50 % in nutrient inputs will have to be achieved in order to attain the status of a non-problem area for eutrophication. Added to this, the North Sea also faces the problem of transboundary nutrient transports. Strong currents distribute riverine nutrient inputs in an anti-clockwise direction along the coast, which means, for example, that the achievement of "good status" in Germany's marine waters depends to a large extent on nutrient reductions in the Netherlands. In turn, inputs from Germany's North Sea catchment area extend along the Danish coast as far as southern Norway.

Between 1983 - 1987 and 2012 - 2014, nutrient inputs into surface waters in the German North Sea catchment area (Elbe, Weser, Ems and Eider river basin districts) were reduced by more than 50 %, from 804,038 t/a to 353,400 t/a of nitrogen, and by more than 70 % from 67,164 t/a to 17,540 t/a of phosphorus. This means that the OSPAR 50 % reduction target was met. Similar to the Baltic Sea, nutrient inputs went down primarily as a result of the sharp decrease in inputs from point sources. In 2012 - 2014, 71 % of nitrogen inputs and 44 % of phosphorus inputs originated from agriculture. 21 % of nitrogen inputs and 35 % of phosphorus inputs came from point sources (e.g. wastewater treatment plants).

Eutrophication–Assessment and management objectives under the WFD

At present, in both the North and Baltic Seas, eutrophication is often the main or only reason for coastal waters failing to achieve "good ecological status" as defined in the Water Framework Directive. In 2015, no single waterbody achieved "good" or "high" status. Among the coastal waters of the German Baltic Sea, 34 % of waterbodies were in a moderate status, 32 % were classified as poor, and 34 % as bad. Among the coastal and transitional waters of the North Sea, only 7 % of waterbodies were classified as bad, 41 % were in poor and 52 % in moderate status[181]. The next two WFD management cycles must now be used to achieve "good ecological status" by no later than 2027.

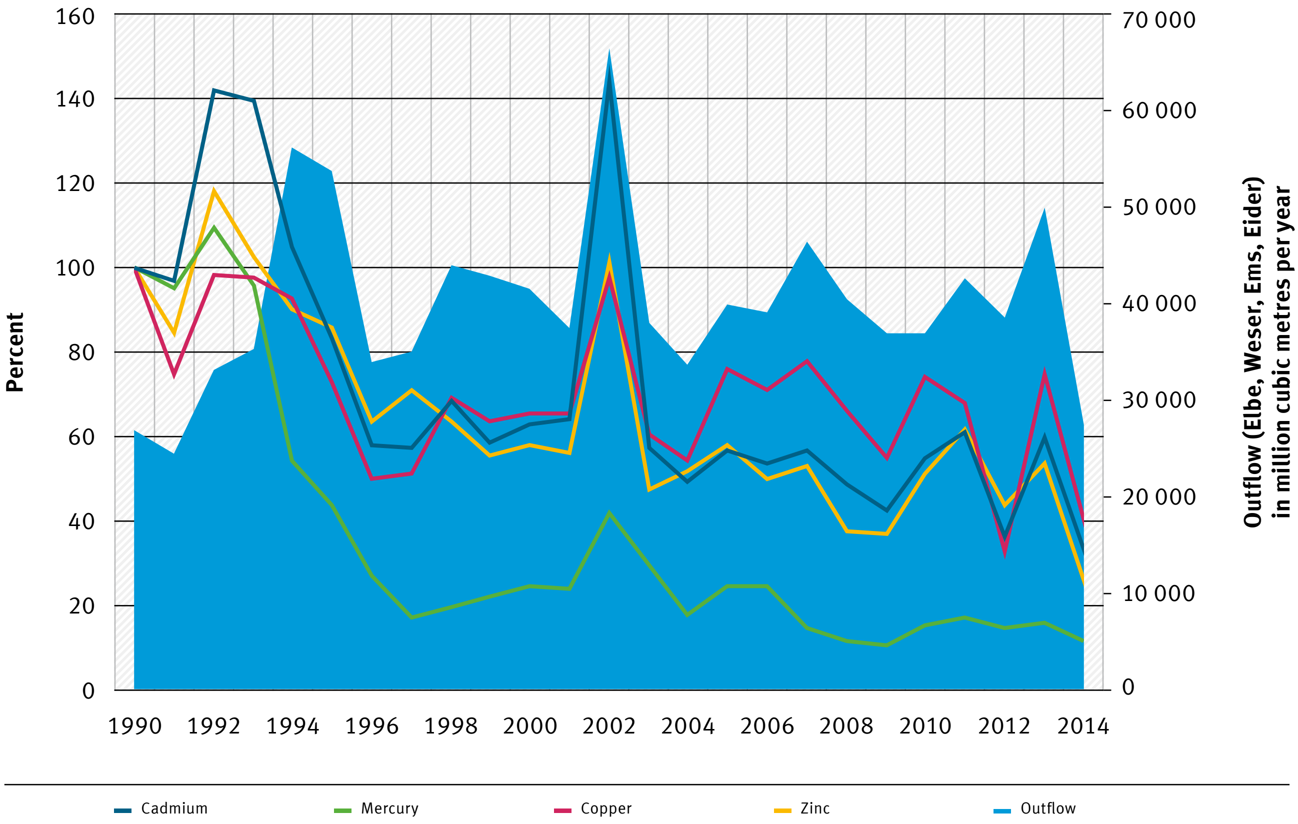
In 2016, Germany revised the Surface Waters Ordinance. Within the context of implementing the WFD, Germany included for the first time in the Ordinance management targets for the mean annual total nitrogen concentration of rivers discharging into the North and Baltic Sea. The management targets are derived in relation to marine quality objectives. The targets apply at the designated freshwater monitoring stations which mark the limnic-marine transition point. For the North Sea, the target management value is 2.8 mg/l total nitrogen, and for the Baltic Sea 2.6 mg/l. According to a provisional evaluation of the five-year average of river concentration levels for 2011 - 2015, only the rivers Rhine and Warnow met the targets. The highest nitrogen concentrations were detected in rivers (e.g. the river Ems) the water catchment area of which is located in regions with high livestock density.

4.3.3 Hazardous substances in the North and Baltic Seas

Hazardous substances enter the seas via a number of different pathways; indirectly via rivers discharging into the sea and via the atmosphere, and directly via discharges at the coast from

Figure 61

Heavy metal inputs via German rivers into the North Sea compared to the outflow



Source: German Environment Agency, Data on the Environment[183]

industry and wastewater treatment plants, as well as from shipping and offshore industries. Rivers and the atmosphere are the most important sources of indirect inputs into the Baltic and North Seas. Atmospheric emissions, which may be transported over long distances, originate primarily from transport, incineration facilities and maritime shipping. For example, it is calculated that 60 % of cadmium deposits, 84 % of lead deposits and 79 % of mercury deposits in the Baltic Sea originate outside the catchment area[182].

Hazardous substances originate from diffuse sources such as agriculture, combined sewage overflows and precipitation run off but also from wastewater treatment plants containing, among others, biocides and plant protection agents, as well as small quantities of consumer products, personal care products and pharmaceuticals. In the past, industrial facilities were responsible for significant inputs of heavy metals and POPs (persistent organic pollutants). They contributed significantly to the current pollution of river sediment, estuaries and marine sediment. The polluted sediment is still a source of input today, especially if it is displaced by flooding, currents or excavations. All hazardous substances that enter the sea can accumulate in water, sediment or biota, depending on their properties.

Heavy metals and lead inputs into the Baltic Sea via German rivers decreased by 45 % for cadmium, by 82 % for mercury, and by 79 % for lead between 2000 and 2014.

In 2010, HELCOM published a comprehensive assessment of hazardous substances in the Baltic Sea. This assessment was based on concentration measurements in organisms, sediment and selected samples of seawater between 1999 and 2007. Additionally, it considered the results of biological effect measurements. Concentrations of the pollutants PCB, lead, mercury, cesium-137, DDT/DDE, TBT, benzo[a]anthracene and cadmium were the most common reason for failing to achieve good status. The Kiel and Mecklenburg

Bights, achieving “bad” or “poor” status, are among the most heavily polluted areas. Pollution levels in marine regions off the coast, such as the Arkona Basin, were predominantly classified as “moderate”. In 2017, HELCOM published a new pollution assessment for the period 2011 - 2015, based on selected pollutant indicators (Figure 62). The HELCOM State of the Baltic Sea Report shows that pollution of all Baltic Sea areas with hazardous substances give cause for concern. Also in the Southern Baltic Sea the pollution levels continue to be high. Especially mercury and polybrominated diphenyl ether (BDE), ubiquitous in the environment, exceed the HELCOM threshold values in some regions. In Kiel Bight seven out of eight assessed contaminants exceed the agreed threshold, in the Mecklenburg Bight three out of six[184].

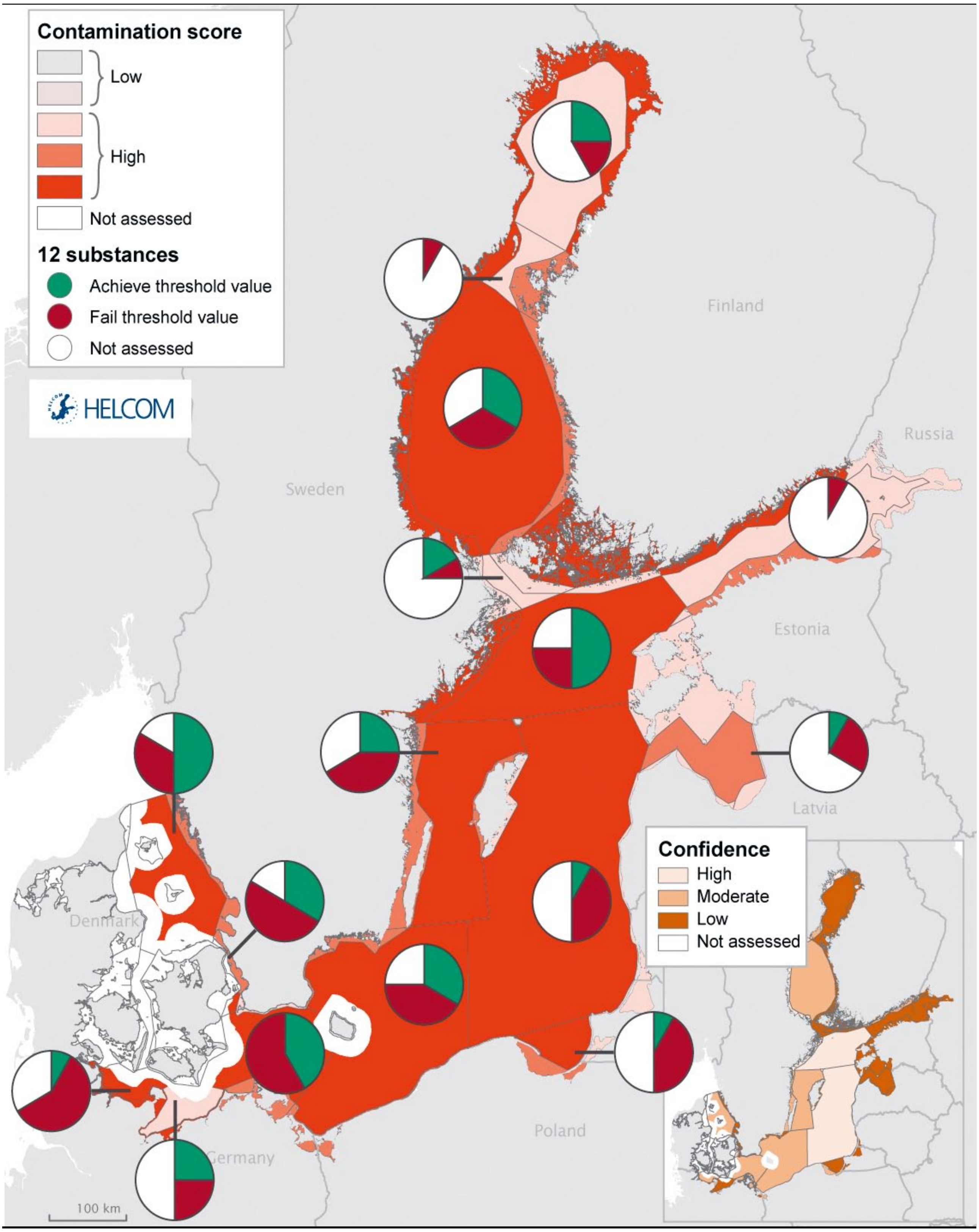
High inputs of hazardous substances via rivers were the reason for the Environmental Ministers to resolve, at the INSCs in 1987 (London) and 1990 (The Hague), measures for the period 1985–1995 aiming at reducing inputs of hazardous substances by 50 % and of priority hazardous substances (such as cadmium, mercury) by 70%. For those substances which failed to meet the emission reduction targets by 1995 (4th INSC in Esbjerg), the deadline was extended to 2000.

Inputs into the North Sea via the tributaries of the rivers Elbe, Ems, Weser and Eider are monitored. By 2014, cadmium inputs, e.g. from the river Weser, decreased by around 70 %, mercury inputs by about 76 % and lead inputs by approximately 46 %. Inputs depend to a large extent on the outflow (Figure 61). This means that, different from years with lower levels of precipitation, in years with intensive rainfall and high outflows, rivers carry more pollutants into the seas due to both, the mobilisation of pollutants accumulated in sediment and the runoff from riverbanks. At the 4th INSC in Esbjerg, the Ministers adopted in their Declaration an objective which is still valid to date: to prevent and eliminate pollution of the North Sea by ceasing or phasing out discharges, emissions and losses of hazardous substances. The aim is to put a halt to such inputs within a generation. The ultimate aim, however, is to achieve concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances by 2020.

In its detailed assessment of pollution in the North-East Atlantic, the OSPAR quality status report 2010[185] states that one third of the priority hazardous substances are expected to achieve this target by 2020 (such as TBT, as well as pesticides such as endosulphane and HCH)[186]. However, the vast majority of priority hazardous substances will probably not achieve this target (these include the heavy metals cadmium, mercury and lead, together with PCBs and PAHs)[187]. In 2017, the OSPAR Intermediate Assessment (IA) has reassessed pollution levels of the North Sea on the basis of selected pollutant indicators from 2011 - 2015. In the Southern North Sea, the region relevant for the German North Sea, lead, mercury and PCB 118 exceeded the stipulated threshold values[188].

Figure 62

Integral assessment of Baltic Sea pollution with hazardous substances using the HELCOM Hazardous Substances Status Assessment Tool (CHASE)



Source: HELCOM, 2017, http://stateofthebalticsea.helcom.fi/pressures-and-their-status/hazardous-substances/

Pollutants assessment under the WFD

The WFD requires an assessment of the chemical status of transitional and coastal waters up to 12 nautical miles. Assessment under the WFD for the second management cycle, based on data from 2009 - 2014, found that all waterbodies in the North and Baltic Seas have failed to achieve good chemical status. This is due to high mercury concentrations in fish which exceed the environmental quality standards. There are also incidences of the environmental quality standards for polybrominated diphenyl ether (PBDE) being exceeded.

[170] LAWA 2015, "Bericht zur Grundwasserbeschaffenheit. – Pflanzenschutzmittel – Berichtszeitraum 2009 bis 2012" http://www.lawa.de/Publikationen.html

[171] European Commission, 2003, Guidance Document on the Assessment of the Relevance of Metabolites in Groundwater of Substances Regulated under Council Directive 91/414/EEC https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_ppp_app-proc_guide_fate_metabolites-groundwtr.pdf

[172] Corresponding to the following substance numbers as set out in Annex 8 to the Surface Water Ordinance: 5 (BDE), 21 (mercury), 2, 5, 15, 22, 28 (PAH) and 30 (TBT)

[173] BMUB – Bundesminsterium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) (2016): Lead, Cadmium, Mercury - EU-wide Consumer Protection against Environmental Contaminants in Food http://www.bmub.bund.de/en/topics/health-chemical-safety-nanotechnology/food-safety/lebensmittelsicherheit/consumer-protection/schwermetalle/eu-wide-consumer-protection-against-environmental-contaminants-in-food-lead-cadmium-mercury/ (last updated: 23/08/2016)

[174] See - Implementation of the European Marine Strategy Framework Directive (MSFD) in Germany - Reports (German only): http://www.meeresschutz.info/berichte.html

[175] See http://www.meeresschutz.info/berichte-art13.html

[176] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/

[177] HELCOM (2017): First version of the `State of the Baltic Sea' report - June 2017, 202 Seiten http://stateofthebalticsea.helcom.fi To be updated in 2018

[178] Carstensen et al. 2013, Deoxygenation of the Baltic Sea during the last century http://www.pnas.org/content/111/15/5628.abstract

[179] http://stateofthebalticsea.helcom.fi

[180] HELCOM (2017): First version of the 'State of the Baltic Sea' report – June 2017, 202 pages http://stateofthebalticsea.helcom.fi To be updated in 2018

[181] OSPAR (2017): Third OSPAR Integrated Report on the Eutrophication Status of the OSPAR Maritime Area. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities-v2/eutrophication/third-comp-summary-eutrophication/

[182] LAWA (2016): Data of the Joint Water Commission of the German Länder reporting on Article 13 according to EC Directive2000/60/EC. Data source: Berichtsportal WasserBLIcK/BfG, as at 23/03/2016

[183] HELCOM, 2010: Hazardous substances in the Baltic Sea – An integrated thematic assessment of hazardous substances in the Baltic Sea. Balt. Sea Environ. Proc. No. 120B

[184] https://www.umweltbundesamt.de/daten/gewaesserbelastung/nordsee/flusseintraege-direkte-eintraege-in-die-nordsee

[185] http://stateofthebalticsea.helcom.fi/pressures-and-their-status/hazardous-substances/

[186] Quality Status Report (QSR) 2010, http://qsr2010.ospar.org/en/index.html

[187] http://www.ospar.org/work-areas/hasec/chemicals/priority-action

[188] http://qsr2010.ospar.org/en/ch05_03.html

[189] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities-v2/contaminants/

5 Trans-sectoral water protection measures under German, European and international law

5.1 Integrated water protection– The Water Framework Directive

In the mid-1990s, the Member States of the EU realized that formulating usage-oriented requirements was not sufficient to ensure comprehensive water protection. The directives existing at that point were not coordinated with one another, and only addressed sub-sections of water protection. Monitoring and reporting requirements were not harmonized with one another. The introduction of the Water Framework Directive (WFD) in 2000 created a framework which encompassed new management and planning elements, designed to enhance the effectiveness and acceptance of both new and old regulations.

The integrative approach of the WFD is expressed in the following aspects:

- The WFD applies to all waterbody categories within the European Union, i.e. rivers, lakes, estuaries, coastal waters and groundwater.
- The WFD also includes conservation of the marine environment, *inter alia* by requiring to meet good chemical status in the 12 sea mile zone.
- Waterbodies are to be managed on the basis of river basins, i.e. from the source to the mouth with all tributaries, whereby the WFD puts special emphasis on the transboundary dimension.
- The quality of surface waters is assessed on the basis of waterbody ecology, particularly water biology, chemical properties and hydromorphological aspects.
- Groundwater quality is assessed according to qualitative and quantitative criteria.
- The aim is to achieve good status everywhere: in surface waters, good ecological and chemical status, and in groundwater, good chemical and quantitative status.
- Economic aspects must be taken into account. For example, Member States must aim to set cost-recovering prices, including environmental and resource costs, for all water services (water supply and wastewater disposal), and must develop effective, cost-efficient measures to achieve the WFD objectives
- All uses affecting groundwater and surface waters are to be aligned with the management objectives. However, some of the structural changes made to waterbodies can no longer be reversed. Hence, for artificial and heavily modified waterbodies, the aim is to achieve a

good ecological potential, i.e. the status that is possible without significantly impairing the uses for which these waterbodies were created or modified.

- Member States are required to prepare programmes of measures and management plans which contain or build on all the aforementioned elements, and to update them at regular intervals (every six years). This occurred for the first time on 22 December 2009, with the aim of achieving good status by the end of 2015. If this proves impossible despite ambitious measures, deadline extensions or lower objectives must be justified.
- The general public is to be consulted on the plans.

Following a time-consuming planning process, in December 2015, the Länder, as the authorities responsible for waterbody management, updated the management plans and programmes of measures for the 10 river basins in Germany for the second management cycle until 2021. The plans were submitted to the European Union in March 2016 and are published on the Internet.

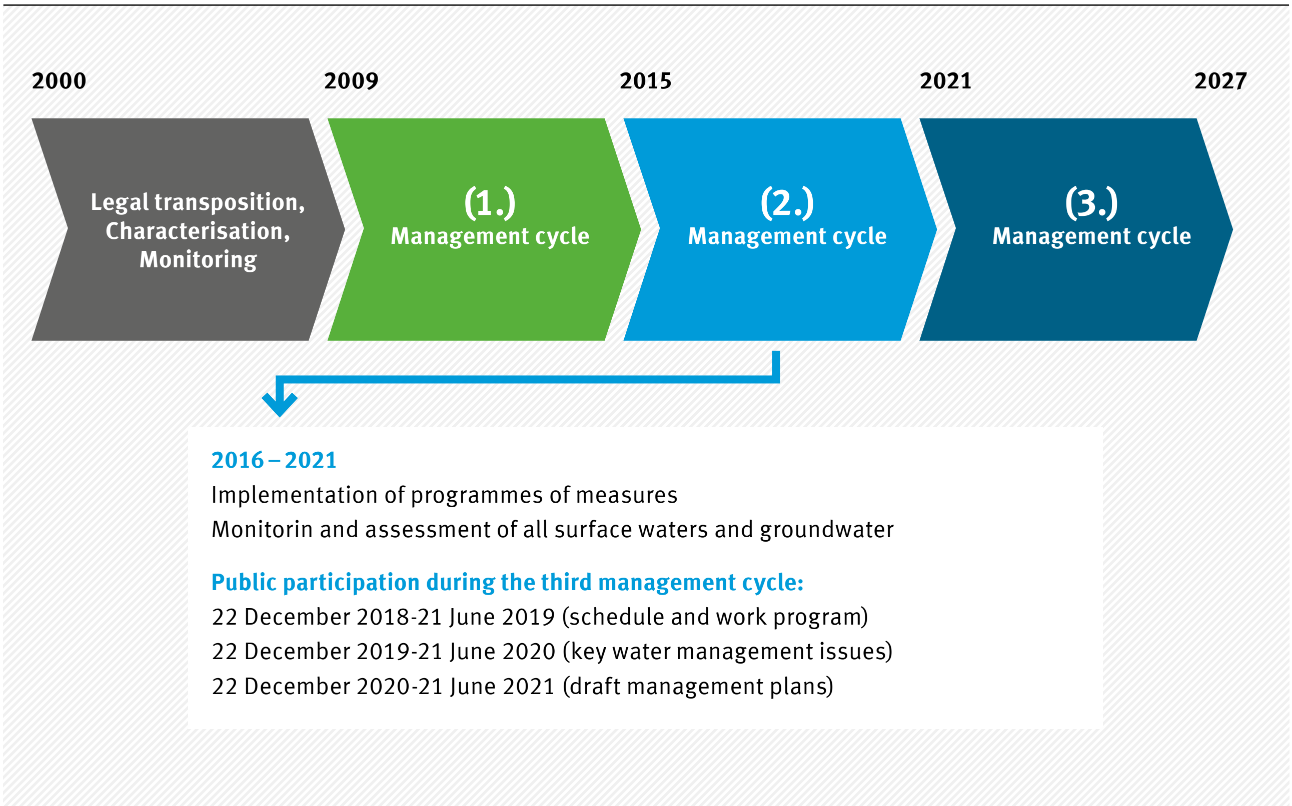
Further information on the management plans (including status, pressures on river basin districts, target achievement and links to the plans) and programmes of measures can be found in the brochure "Water Framework Directive–The status of German waters 2015[189].

5.2 Inland water protection in the WFD

The management plans bear witness to the fact that the WFD's ecological objective for surface waters is ambitious. It states that the species composition and frequency of organisms should only deviate minimally from the type-specific aquatic communities. At present, this target is only met by around 8% of surface waterbodies (chapter 4.2). Existing structural changes, coupled with nutrient and pesticide pollution, are the main reasons for falling short of the targets. As far as pollutants are concerned, waterbodies

Figure 63

Timeline for implementing the WFD



Source: BMUB/ UBA (2016) Brochure "Water Framework Directive – The status of German waters 2015" today indicate a good chemical quality for most substances. However, due to selected pollutants that occur everywhere (so-called ubiquitous substances, e.g. mercury) no waterbody can achieve good chemical status. Nowadays, degradable substances from wastewater treatment plant discharges only rarely pose a problem. Rather, the main problems arise from diffuse sources, substances with low degradability in wastewater treatment plants, and pressures originating from past emissions. However, nutrient pollution from agriculture still remains one of the principal problems in water resource management.

5.2.1 Co-operation in international river basins

Integrated management of transboundary surface waters and groundwater takes place within the framework of international or bilateral commissions for river basins, lakes or (for example) boundary waters.

Germany is a member of the

- International Commission for the Protection of the Rhine against Pollution (ICPR),
- International Commissions for the Protection of the Moselle and the Saar against Pollution (ICPMS),
- International Commission for the Protection of the Elbe (ICPER),
- International Commission for the Protection of the Danube River (ICPDR),
- International Commission for the Protection of the Oder against Pollution (ICPO)
- International Commission for the Protection of the Maas (IMC)
- International Commission for the Protection of Lake Constance

Germany maintains close relations with the Netherlands, Poland, the Czech Republic and Austria in bilateral commissions, primarily in respect of boundary waters.

In the Ems river basin, Germany cooperates with the Netherlands on multiple levels on the basis of a ministerial correspondence.

Cooperation with Denmark to implement the EU Directives on water protection is likewise regulated on the basis of a correspondence. The international river basin commissions address issues of waterbody management, flood protection and flood forecasting, as well as warnings and alarms in the event of incidents impacting waterbodies. They coordinate implementation of the WFD and the Floods Directive at international level. All of them have prepared international parts of the WFD management plans.

The river basin commissions have achieved major success in terms of improving water quality and water ecology. Thanks to a number of action programmes, for example, contamination levels in the Rhine and the Elbe have been reduced to such an extent that numerous fish species are now once again indigenous to both river basins. In the Rhine and the Elbe, the return of the salmon has been a particular milestone, and in the case of the Rhine this should be consolidated through implementation of the Master Plan Migratory Fish Rhine.

Even before the inception of the Floods Directive, the Commissions often had ambitious flood action programmes or plans, which will be incorporated into future flood risk management plans.

They now also address new challenges, such as the impacts of climate change, as indicated by the adaptation strategy of the International Commission for the Protection of the Danube, which manages the world’s most international river basin district.

The work of these Commissions serves as an excellent example to other regions of the world. In 2013, the IKSR, now more than 60 years old, won the newly created European Riverprize and later the international Thiess Riverprize, the latter having been awarded to the IKSD already back in 2007.

Germany continues to play an active part in

- the Central Commission for Navigation on the Rhine (CCNR)
- the Moselle Commission (shipping)
- the Danube Commission (shipping),
- the Commission for the Hydrology of the Rhine Basin,
- the UNECE Convention for the Protection and Use of Transboundary Watercourses and International Lakes
- the UNECE Convention on the Transboundary Effects of Industrial Accidents.

5.2.2 Programmes of measures

The principal pressures behind the continuing failure of surface waters to meet the targets set for ecological and chemical status are diffuse sources, point sources, flow control and morphological changes, together with water abstractions.

Looking at the planned measures for 2015, the largest group, accounting for 41.5 %, concerns measures for "flow control and morphological changes" (Figure 64). Of these, 19 % are attributable to morphology, such as the renaturation of sections of waterbody, 16.9 % to restoring continuity, and 5.6 % to the hydrological regime, such as ensuring a minimum outflow from waterbodies.

38 % of the planned measures are designed to reduce "diffuse sources", primarily affecting agriculture, e.g. to reduce soil erosion and runoff (alternative soil cultivation), as well as advising farmers on ways of managing their land in a more water-friendly way. Measures to avoid accident-related emissions (6.5 %) are designed to reduce water pollution caused by contaminants from populated areas, industry or agriculture. Measures to reduce other diffuse emissions (3.7 %) include mining, contaminated sites and derelict industrial sites or developed areas.

19 % of all planned measures are designed to reduce "point sources", including measures in municipalities and households (9.5 %). This primarily concerns the development and optimisation of public wastewater treatment plants. In order to reduce nutrient and pollutant emissions from combined sewage and precipitation water, old pipelines are often renewed, or larger storage basins are built to retain more precipitation water. Measures in the mining and industry sectors are negligible, accounting for just 1.0 % in total, and are therefore only relevant in areas affected by mining. Measures focusing on "water abstractions" are likewise of subordinate importance, accounting for just 1.5 % in total. They primarily comprise technical measures to increase the efficiency of water use during abstraction and irrigation.

In addition, there are a wide range of so-called conceptual measures which often cannot be ascribed to any individual priority area, but concern multiple priority areas in equal measure. These include research projects, more in-depth studies and controls, as well as educational and information events. Often, they cannot be allocated directly to a specific waterbody, but encompass large areas. In Germany, such measures are planned for nearly half of all bodies of surface water.

Measures to minimise pollution cannot be implemented unless there are adequate financial resources available. In Germany, the costs are mostly met from taxes, fees (such as wastewater fees) and levies (such as wastewater levies, water abstraction levies). Other key sources of finance are the European Union, Federal Government, Länder and local authorities with various funds and subsidies, such as the EAFRD (European Agricultural Fund for Rural Development) and the GAK (Joint Task for the Improvement of Agricultural Structures and Coastal Protection).

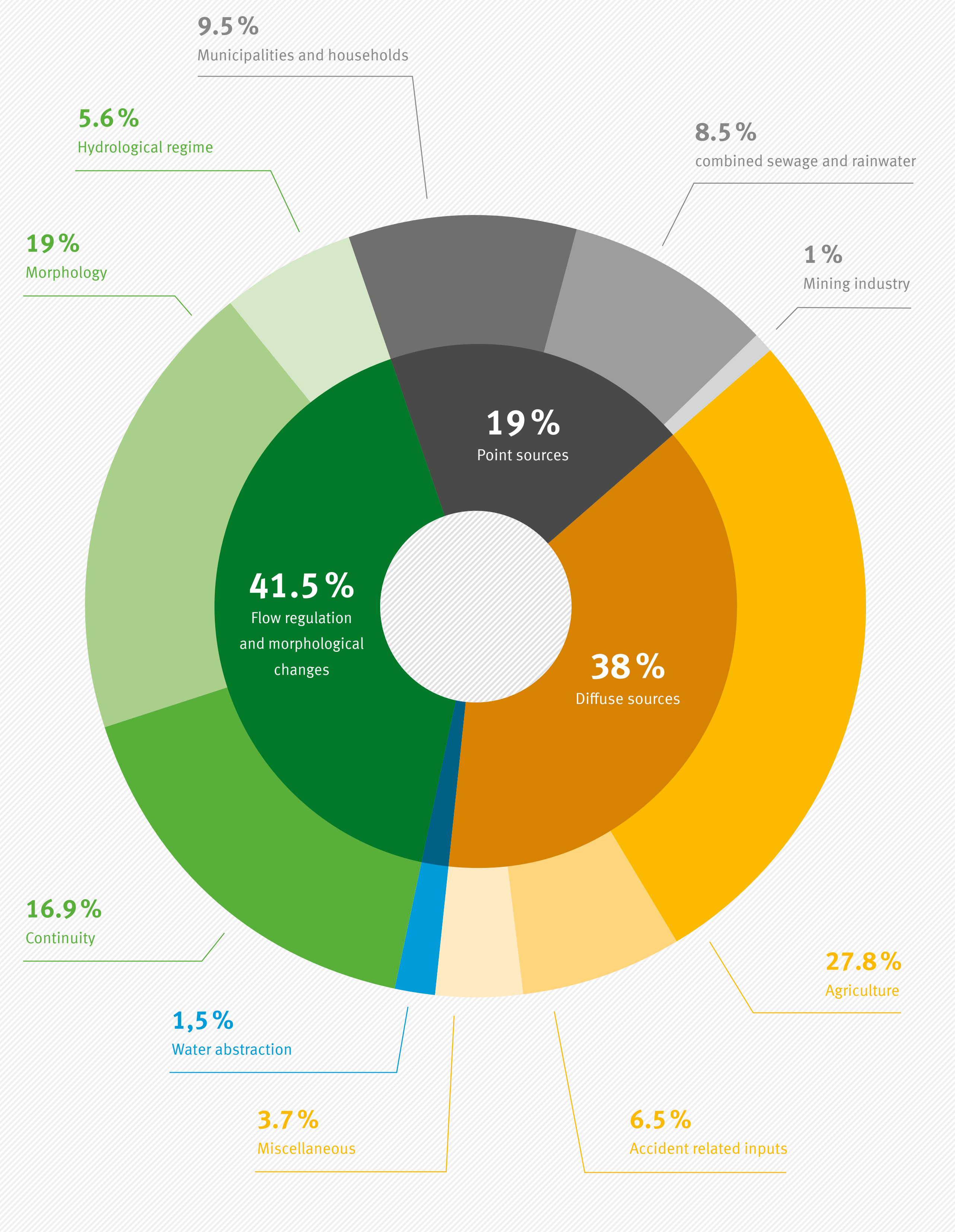
5.2.3 Deadline extensions and exemptions

In justified cases, Member States may deviate from the original environmental objectives (good ecological status/good ecological potential, good chemical status) or from the targeted achievement by 2015. As only 8 % of all bodies of surface water currently achieve good ecological status or good ecological potential, deadline extensions to 2021 or 2027 have been utilised for the remaining 92 %. Less stringent environmental objectives may be considered as exceptional circumstances if waterbodies are so heavily polluted or so extensively morphologically transformed that proportionate measures may not contribute to achieve good status in the foreseeable future. For example, such exceptions apply to surface waters in the Weser river basin, where the level of salts from slag heaps and saline water injection is so high that the indicative targets for salt ions can no longer be met. As the chemical status of surface waterbodies deviates from the targets nationwide, deadline extensions are being utilised for all surface waterbodies in this regard.

In almost two-thirds of cases, the technical unfeasibility of meeting the target on time has been cited as the justification for deadline extensions, while the remaining one-third cite natural conditions. This is because measures often take a long time to develop their full effect in waterbodies and biotic communities before achieving any measurable success. This applies for example to the recolonisation and colonisation of waterbodies that have undergone renaturation with typical organisms and flora. A third reason are disproportionately high costs, but this is only cited comparatively rarely.

Figure 64

Proportion of planned measures for surface water body, broken down by focuses of pressures, for the current Management cycle (2016-2021)



Source: BMUB/ UBA (2016) Brochure "Water Framework Directive – The status of German waters 2015". Data: WasserBLIcK/ BfG as at 23/03/2016

5.3 Groundwater protection

It was long thought that groundwater was well-protected from pollutant inputs by the soil and other covering layers. However, in many cases, this assessment has been proven incorrect. In recent years, numerous incidences of groundwater pollution from point, line and area-wide pollutant inputs have emerged. Area-wide emissions of nitrogen and, in some cases pesticides and their degradation products, play a particularly significant role in this regard, and are often attributable to agricultural use. There is also a range of pollutant inputs from point and line sources, for example from contaminated sites, incidents, leaking sewers and polluted surface waters.

Damage to the groundwater is not usually immediately apparent. Remediation, if at all possible, is very costly in terms of financial and technical resources, and is a lengthy process. Rigorous application of the precautionary principle is therefore of paramount importance. Given the important ecological functions and outstanding importance of drinking water abstraction, it is vital to ensure comprehensive groundwater protection. The European WFD and Groundwater Directive (see chapter 2.4.2 and 5.1) set out provisions in this connection. At national level, the relevant legal foundations are anchored in the Federal Water Act and the Groundwater Ordinance (see chapter 2.4.3).

The Fertiliser Ordinance (Düngeverordnung, DüV)[190], which implements the requirements of the EU Nitrate Directive[191], is intended to ensure that the groundwater is protected from excessive nutrient inputs. Key measures concern the application of fertilisers, soil additives, growing media and plant additives (see chapter 6.3). To protect waters, among others the application of fertilisers containing nitrogen is prohibited during certain periods. The Ordinance also defines minimum distances from waterbodies and maximum quantities of nitrogen applied with organic fertiliser which must not be exceeded.

Requirements governing the application of pesticides are derived from the European Regulation concerning the placing of plant protection products on the market[192] and the German Plant Protection Act (Pflanzenschutzgesetz, PflSchG)[193]. The "Good agricultural practice in plant protection" sets out a wide range of non-legally binding recommendations on the application of pesticides. Pesticides should never be used where harmful effects on groundwater are anticipated.

Additional regulations which supplement the nationwide protection of groundwater refer, for example, to water protection areas, which may be defined by the Länder and other bodies to protect drinking water. In such areas, certain uses may be prohibited or restricted, such as the application of farm manures or the handling of substances dangerous to water.

The EU Framework Directive on Pesticides[194] sets out the Community action framework for the sustainable use of pesticides. In Germany, this is transposed into national law by the National Action Plan on Plant Protection (NAP)[195], which aims to minimise the risks and impacts of pesticide application on human and animal health and on the ecosystem and defines targets in the areas of plant protection, user protection, consumer protection, and ecosystem protection.

5.4 Protection of the marine environment

Seas and oceans cover four-fifths of the earth's surface. They are independent from territorial boundaries, and encompass the entire globe. As their use is likewise predominantly transboundary in nature, the protection of the marine ecosystems can only succeed within the context of international agreements and cooperation. This has prompted numerous international, regional and European provisions on marine protection. The EU Marine Strategy Framework Directive (MSFD), which sets out the legal framework for coherent EU-wide and regionally coordinated marine protection and for national planning of measures, is based on these provisions

5.4.1 International marine protection law

At international level, the following conventions are particularly relevant for the marine sector:

- Convention on the Law of the Sea (UNCLOS)
- Convention on Biological Diversity (CBD)
- Convention on Climate Change and Paris Agreement
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and the Protocol on the Convention (London Protocol)
- International Convention for the Prevention of Pollution from Ships (MARPOL)

"The constitution of the seas" – the United Nations Convention on the Law of the Sea

The 1982 United Nations Convention on the Law of the Sea (UNCLOS)[196], which entered into force in 1994, is known as the "constitution of the seas". It transposed the previously valid, unwritten customary international law into the text of the Convention. UNCLOS regulates that the seas may be freely used by all countries, for example for shipping, fishing and marine research (freedom of the seas). However, it also obligates the Parties to protect the marine environment and therefore provides the basis for international action on the protection and sustainable development of the marine and coastal environment and its resources. UNCLOS requires the Contracting Parties to cooperate on a national, sub-regional, regional and global level to achieve effective protection of the marine environment. The cooperative concepts must be integrative in content and preventive and precautionary in effect.

UNCLOS applies both to the sovereign marine areas and the exclusive economic zones of the Contracting Parties and to the high seas.

UNCLOS defines the seabed and its subsoil as the "common heritage of all mankind". This has three core elements: Firstly, it prohibits the acquisition of the seabed (both as a whole and parts thereof) and the minerals it contains. Secondly, the seabed is subject to international administration, with the International Seabed Authority (ISA) in Kingston, Jamaica, being responsible for the development and execution of environmental standards. Thirdly, the financial and other economic benefits derived from the mining of minerals in the seabed must be equitably shared between all nations ("benefit of mankind"). To date, the ISA has only adopted environmental standards for prospecting and exploration projects, but is currently working on the regulation of manganese nodule mining, which will also include appropriate environmental standards (see chapter 3.3.4).

In the concluding document to the Rio+20 conference, "The Future We Want", the international community also expressed concern that the protection of biodiversity on the high seas is inadequate. The creation of protected areas outside of territories under national jurisdiction and a system of financial compensation for the economic use of genetic resources are currently under debate.

Protecting diversity in the oceans – the Convention on Biological Diversity (CBD)

The 1992 Convention on Biological Diversity aims at protecting the ecosystems and habitats within the national sovereign territories of each Party, including the exclusive economic zone and the continental shelf. Furthermore, the Parties undertake to ensure that the actions of their citizens do not impair the protection of biodiversity outside of their national jurisdiction, for example on the high seas. The Convention on Biological Diversity aspires to preserve local natural habitats by creating a system of protected areas. Conferences of the Parties have repeatedly addressed issues relating to the conservation of marine biodiversity. At the 9th Conference of the Parties in 2008 in Bonn, the Parties adopted scientific and ecological criteria for the creation of protected areas, leading to the subsequent definition of "Ecologically or Biologically Significant Marine

Areas" at a series of regional workshops. However, decisions regarding protection measures must be made by individual governments or within the context of UNCLOS.[197]

The ocean in a greenhouse – the Convention on Climate Change and the Paris Agreement

For several decades now, scientists have detected rising carbon dioxide concentrations in the upper marine strata, leading to acidification. This can have wide-ranging ecological impacts; calcifying organisms (such as coral reefs, gastropods and algae) are particularly affected. The water temperature is also rising as a result of climate change. As well as the physical effects of warming, this has also been found to affect the distribution of species, as they may migrate into warmer areas or retreat to colder regions.

Climate change mitigation policy is therefore vitally important for the protection of the seas. The United Nations Framework Convention of 9 May 1992 calls on the Parties to reduce emissions of climate-relevant greenhouse gases, and to prepare measures for adapting to the adverse impacts of climate change, such as the development of integrated management plans for coastal regions and the strengthening of coastal protection.

In the Paris Agreement of 12 December 2015 (which entered into force on 4 November 2016), the Parties undertook to limit the increase in the average global temperature to well below 2°C, and to make every effort to ensure that the temperature does not rise by more than 1.5°C. Furthermore, they will endeavour to achieve a balance between emissions and sinks (greenhouse gas neutrality) in the second half of the current century. The Parties are required to define and report on their nationally determined contributions, which must be revised at regular intervals (at least every five years) to ensure that the Agreement's targets are met. The Agreement is a major success, particularly given the binding adoption of the 2°C target and the comparatively clear operational provisions, and may therefore also contribute to marine conservation.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and London Protocol

The London Convention[198] of 29 December 1972 (87 Contracting Parties) was the first global agreement on the protection of the marine environment. Essentially, it aimed to reduce adverse impacts from the dumping of waste and other substances, and also formed the basis for the environmental law provisions of UNCLOS.

In 1996, the Parties to the London Convention adopted the London Protocol, an independent international treaty which entered into force in 2006 (49 Contracting Parties). The aim was to establish precautionary measures and improve monitoring. While the London Convention of 1972 only prohibited the disposal at sea of certain substances (black list), the Protocol of 1996 introduced a general ban on dumping. Under the 1996 Protocol, dumping of the following waste categories is only admissible in exceptional cases:

- Dredged material
- Sewage sludge
- Fishing waste
- Waste from vessels, platforms and other man-made structures at sea
- Inert, inorganic, geological materials
- Organic materials of natural origin
- Bulky items made of steel, iron, concrete or similar materials that primarily cause physical environmental impacts (only applies to locations with no other options for disposal, such as islands), and
- CO_2 streams, where these are sequestered in sub-seabed geological formations.

The exception for CO_2 streams (2007) is intended to facilitate their storage in the sub-seabed as a climate change mitigation measure. The storage of CO_2 streams (see chapter 6.5.3) in the water column is prohibited due to the environmental risks. The Contracting Parties have adopted specific guidelines that must be taken into account when approving CO_2 storage projects. Adverse impacts on the marine environment are to be avoided.

The London Protocol also includes a general worldwide ban on the incineration of waste at sea, a practice which was discontinued in the Federal Republic of Germany in 1989.

On 18 October 2013, the Contracting Parties to the London Protocol unanimously agreed a binding new regulation for marine geo-engineering measures. The new regulation prohibits commercial marine fertilisation activities, and introduces the mandatory licensing of research activities in this connection. The Contracting Parties must verify that the project is a genuine research activity, and that any adverse effects on the marine environment are excluded. The assessment criteria are derived from the legally binding "Generic Assessment Framework" and the non-binding "Ocean Fertilization Assessment Framework". The new regulation allows the Contracting Parties to place other marine geo-engineering measures under a control regime.

This is the first internationally binding regulation on geo-engineering measures. The regulatory concept for marine fertilisation, which includes a general ban with the reserved right to grant permits for research purposes and a forward-looking regulatory mechanism (listing principle), could serve as a role model for other areas. This is the first time that legally binding distinction criteria for research and application have been defined in international law. The amendment will not enter into force until it has been ratified by two-thirds of the Parties to the London Protocol.

International Convention for the Prevention of Pollution from Ships (MARPOL)

The MARPOL Convention for the Prevention of Pollution from Ships of 2 November 1973 is an international, globally valid convention designed to protect the marine environment. The Convention obligates the Contracting Parties to prevent the discharge of pollutants from shipping, and standardizes the requirements for the various types of contaminants associated with shipping in Annexes I-VI (pollution by oil, noxious liquid substances, harmful substances carried by sea in packaged form, sewage from ships, garbage from ships and air pollution). The revised version of Annex V specified that apart from a few exceptions, no garbage from ships is allowed to enter the sea (chapter 6.6.2)

5.4.2 Regional marine protection

At regional level, marine protection in Germany's North and Baltic Sea regions is regulated by the following conventions:

- Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)[199]
- Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM)[200]
- Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and other Harmful Substances (Bonn Agreement)

Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)

The 1992 OSPAR Convention entered into force at international level in 1998 and replaced the 1972 Oslo Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft and the 1974 Paris Convention for the Prevention of Pollution from Land-Based Sources. Sixteen Parties signed the OSPAR Convention: Belgium, Denmark, Germany, Finland, France, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Sweden, Switzerland, Spain, the United Kingdom and the European Union.

The Convention requires the Parties to take every action possible to prevent and eliminate pollution and to protect the marine environment from the adverse effects of human activities, to preserve marine ecosystems, and where possible, to restore impaired marine areas. To this end, within the context of the Convention, the Parties adopted a wide range of measures in the form of legally binding decisions and non-binding recommendations, plus other agreements, which they implement at a national level in the management of their marine waters. The purpose of these measures is to reduce land-based contamination (e.g. emissions of nutrients, pollutants and litter) and pollution caused by human activities at sea (such as input of pollutants, dumping of platforms, injection of CO_2 streams into geological formations of the sub-seabed, interference with marine nature), and to adopt regulations on marine nature conservation and the protection of biodiversity (such as the creation of marine nature conservation areas and measures to protect species and habitats). The measures follow the ecosystem approach for the integrated management of human activities, the precautionary principle and the polluter-pays principle, and apply the "best available technology" and "best environmental practice". The measures are based on the state of knowledge which the Parties generated jointly within the context of the Convention through research and development, and environmental monitoring and assessment.

Since 2008, the bodies of the OSPAR Convention have acted as a platform for the regional coordination of the implementation of the Marine Strategy Framework Directive and for supporting littoral states of the North-East Atlantic that are also EU Member States with their national reporting to the EU Commission.

Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention)

The 1992 Helsinki Convention (HELCOM) entered into force at international level in 2000 and replaced the preceding convention of 1974. Ten Parties signed the Convention: Denmark, Germany, Estonia, Finland, Latvia, Lithuania, Poland, the Russian Federation and Sweden plus the European Union.

The Convention obligates the Parties to individually or collectively take all appropriate measures to prevent and eliminate pollution in order to promote ecological recovery and the preservation of ecological balance. The Convention covers all possible sources of pollution from land and sea, including marine pollution caused by shipping accidents, and also includes marine nature conservation and biological diversity measures. The Contracting Parties also coordinate themselves on maritime spatial planning (see 5.4.4). They also cooperate on issues of fisheries and shipping in the intersection with marine conservation taking due regard for the competencies of the International Maritime Organization (IMO) for managing the environmental impacts from shipping and the EU's competencies for fisheries and agriculture. Within the context of the Convention, the Parties have adopted a wide range of measures in the form of non-binding recommendations and other agreements, which they implement at a national level when managing their marine waters. HELCOM follows the ecosystem approach for the integrated management of human activities, the precautionary principle and the polluter-pays principle, and applies the "best available technology" and "best environmental practice". The measures are based on the state of knowledge which the Parties will jointly generate within the context of the Convention through research and development, and environmental monitoring and assessment.

Since 2008, HELCOM has functioned as a regional platform to support the Contracting Parties that are also EU Member States in the implementation of the European MSFD in the Baltic Sea region. In this way, the Convention helps to coordinate Member States' reports to the European Commission. To this end, the HELCOM Baltic Sea Action Plan (HELCOM BSAP) adopted in 2007 and defined and updated by Ministerial Declarations in 2010 and 2013 serves as a dedicated, Baltic Sea-specific framework.

Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and other Harmful Substances (Bonn Agreement)

The Bonn Agreement[201] of 1969, which was extended and updated in 1983 and 1989, is dedicated to the avoidance, prevention and tackling of illegal and accident-related pollution of the North Sea with oil and other harmful substances from shipping and offshore installations. The nine Contracting Parties are Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden, the United Kingdom and the European Union.

The Contracting Parties undertake to mutually notify and assist one another in the event of (potential) pollution at sea or on their coastline, and to collaborate on surveillance measures to identify marine pollution. They adopt guidelines for the practical, operational and technical aspects of joint measures, emergency preparedness and for tackling pollution, and coordinate their approach in an emergency situation.

5.4.3 EU Marine Strategy Framework Directive

The 2008 EU Marine Strategy Framework Directive (MSFD) represents the environmental pillar of European integrated maritime policy, aimed at sustainably strengthening and expanding the marine sector. The Directive's objective is to achieve or maintain, by 2020, good status of the European marine waters based on the ecosystem approach. The EU Member States must take the necessary measures to achieve this.

Integrated management of marine waters

The Directive prescribes a structured sequence of implementation stages for developing national marine strategies, which must be reviewed and updated in six-year management cycles, thereby enabling corrective action and adjustment in the interests of adaptive management. The implementation stages are as follows:

- Assessment of the state of marine waters (for the first time by 2012)
- Definition and assessment of good environmental status (for the first time by 2012)
- Derivation of environmental objectives to reduce pressures (for the first time by 2012)
- Establishment of monitoring programmes to control success (for the first time by 2014), and
- Establishment and implementation of programmes of measures (for the first time by 2015 and 2016).

The site www.meeresschutz.info/berichte.html (German only) documents the aforementioned implementation stages and publishes the reports on the first management cycle for Germany's marine waters.

The Directive sets out the legal framework for the integrated management of all human activities that impact marine ecosystems in line with the ecosystem approach, and for the integration of environmental protection and sustainable use. For example, this means that

- All principal elements of marine ecosystems are to be assessed and protected holistically and in view of their reciprocal interactions. For the first time, the cumulative effects of human pressures on the marine ecosystems are to be considered. The Directive therefore moves away from the previous sectoral approach to the management of marine waters, in favour of a more holistic approach.
- Economic aspects are to be taken into account for management purposes. Within the context of assessment, this includes an economic and social analysis of the uses of the waters concerned and of the costs of deterioration of the marine environment. Economic considerations are also taken into account when assessing the impact of planned measures and when making a case for exceptions to target achievement.
- Management has many overlaps and synergies with other EU Directives and policies, such as the Water Framework Directive (see chapter 5.1),

- Nitrates Directive, Habitats Directive, Air Pollution Control Directive, the EU's Common Fisheries Policy, the EU's Common Agricultural Policy, as well as international and regional conventions. National spatial planning for the Exclusive Economic Zone and the coastal waters, together with the 2014 EU Directive on maritime regional planning (see chapter 5.4.4), provide additional instruments for the integrative management of marine waters, with a view to balancing use and protection interests.
- The general public is involved in all implementation phases.

The management units to which the MSFD applies are the North-East Atlantic (including the North Sea and Wadden Sea), the Baltic Sea, the Mediterranean and the Black Sea. The Directive obligates the littoral states to coordinate their marine strategies at a regional level, and to utilise existing cooperation structures wherever possible, i.e. existing regional conventions. For Germany, therefore, work is underway within the context of the cooperation structures under the OSPAR and HELCOM agreements (see chapter 5.4.2) with regard to monitoring, assessment, the derivation of environmental quality and management objectives, as well as measures.

Good environmental status and environmental objectives

The key reference point for the management of marine waters is "good" environmental status. The Directive defines good environmental status as the "status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations". The Directive describes good environmental status in general terms using eleven thematic descriptors, whereby good environmental status refers comprehensively to

- All elements of the marine ecosystem: Species, habitats, ecosystem functions, food webs
- All principal anthropogenic pressures and their impacts on marine ecosystems: Eutrophication, contaminants, non-indigenous species, pressures from fishing, interference with the seabed, hydromorphological changes, marine litter and underwater noise.

In 2012, with due regard for existing objectives, Germany defined good environmental status for the various ecosystem elements and pressures, and set qualitative environmental objectives. Since then, Germany, as part of the relevant bodies of the EU and the regional seas conventions for marine protection OSPAR and HELCOM, has been working on the development of indicators and assessment systems to enable the measurement of good environmental status in areas where this is not yet possible, and to gauge how far the current state of marine waters is from good environmental status, so as to quantify the required reduction in pressures and plan targeted measures.

In 2010, the EU Commission prepared a series of criteria and methodological standards which are intended to support the Member States in the concretization, definition and assessment of good environmental status. The EU Commission's 2016 proposal to revise the criteria and methodological standards aims to simplify and streamline the requirements, achieve better conformity of objectives and consistency with other EU Directives and the requirements of regional sea conventions for marine protection, and define mandatory minimum standards for comparable EU-wide implementation of the Directive. In this way, the EU Commission is responding to past experiences with implementation of the MSFD: The EU Member States have defined good environmental status very differently, leading to wide variations in the level of ambition for marine conservation in Europe, and a lack of regionally coherent management. The criteria and methodological standards revised in 2016 still leave the EU Member States scope for their own interpretation and application of good environmental status.

Programme of measures

The 2012 assessment revealed that overall, Germany's marine waters in the North and Baltic Seas are not in good status, particularly with regard to the assessed biotope types, phytoplankton, macrophytes and sea grasses, benthic fauna, marine mammals, fish fauna and seabirds. Furthermore, the assessment revealed that the pollution with contaminants, the accumulation of nutrients and organic material, as well as the biological disturbance are all too high, and are adversely impacting the ecosystem. Overall, the principal pressures on marine ecosystems are:

- Emissions of nutrients and organic material, primarily from agriculture and the transport sector, including shipping, and the associated eutrophication of marine waters (see chapter 4.3.2), and
- The removal of biomass, damage to the seabed caused by bottom-contact fishing gear, and the by-catch of non-target species by the fishing industry.

Furthermore, data on marine and beach litter, and on litter particles found in the stomachs of Northern fulmars, indicate that litter is a major pressure for marine ecosystems (see chapter 3.8.1). The assessment also found adverse impacts from underwater noise, *inter alia* on marine mammals. It was not possible to assess all pressures individually and in their cumulative and synergetic effects as a whole. However, the available data and analyses suggest that other pressures are also partly responsible for failing to meet good environmental status.

The MSFD programme of measures (2016 - 2021) prepared by Germany in 2015 and submitted to the EU Commission at the end of March 2016 was operationalised by the end of 2016. This took into account the contribution made by existing national measures within the context of European environmental Directives and other EU policies, together with international agreements, in meeting the objectives of the MSFD.

The priority action areas of the supplementary MSFD measures therefore focus on pressure sources at sea, namely:

- Reducing pressures from pollutant inputs, including emissions and discharges from ships
- Protecting marine biodiversity, *inter alia* by means of spatial measures for the protection of marine species and habitats
- Reducing pressures from litter inputs through a combination of measures relating to product design, waste management, after-care and PR work (see chapter 6.6)
- Reducing underwater noise by developing and applying noise mitigation measures, supported, *inter alia*, by noise mapping, a noise registry and biological limit values to protect marine organisms (there is currently a limit in place for the protection of harbour porpoises during the construction of offshore wind farms).

The updated programmes of measures for the second management cycle (2015-2021) of the Water Framework Directive are expected to help to improve the state of marine waters with regard to the riverborne pressures of nutrients and contaminants (see chapter 5.1). Pressures from agriculture should be further reduced by revising the Fertiliser Ordinance to implement the EU Nitrates Directive (see chapter 6.3.1) and the Ordinance on Installations for the Handling of Substances Hazardous to Water

The supplementary MSFD measures on pollutant inputs therefore refer primarily to shipping (see chapter 6.6.2). Germany plans to support the application to the United Nations International Maritime Organisation to class North and Baltic Seas as nitrogen emission control areas, so that more stringent emission requirements are introduced for all ships in both marine regions. Germany plans furthermore to support measures to reduce nitrogen oxide emissions from ships, such as refit programmes to convert to low-emission fuels, expanding the infrastructure in ports to convert to LPG fuel, and expanding land-based electricity connections. The programme of measures also envisages criteria and incentive systems for environmentally-friendly ships aimed at reducing the various pressures from shipping, such as pollutant inputs, noise, and the introduction of non-indigenous species, and also intends to impose requirements on the discharge and disposal of wash water from ship's exhaust gas cleaning systems (scrubbers) (see chapter 6.6.1) and to improve maritime emergency preparedness and emergency management.

5.4.4 Maritime spatial planning

With rising density of usage and escalating conflicts of interest in marine areas (e.g. in the areas of raw materials extraction, energy production, shipping and nature conservation), maritime spatial planning focuses on preventive action to facilitate sustainable development and regulate the marine area in line with environmental and ecological concerns. The statutory foundations for spatial planning in Germany are the Federal Spatial Planning Act (Raumordnungsgesetz, ROG) and the planning laws of Germany's coastal Länder[202].

The 2004 amendment to the Spatial Planning Act extended the scope of application of spatial planning to the German Exclusive Economic Zone (EEZ), and transferred competence for planning in the EEZ to Federal Government. The plan for the EEZ should contain provisions regulating commercial and scientific use, ensuring the safety and ease of shipping, and protecting the marine environment[203]. Specific areas may also be defined for these uses and functions. An environmental audit must be carried out. The general public and the public agencies whose interests are affected are to be notified and given the opportunity to voice their opinions on the draft plan.

Spatial planning also applies to the territorial sea (12 nautical mile zone). Following a 2001 resolution by the Ministerial Conference on Spatial Planning, the German coastal Länder extended the scope of validity of their regional plans to include the territorial sea. One recent example is the 2016 Mecklenburg Western Pomerania Spatial Development Programme, which entered into force in the summer of 2016.

The first regional planning ordinances for the German EEZ of the North and Baltic Seas entered into force in late 2009, and include provisions for the following action areas[204]:

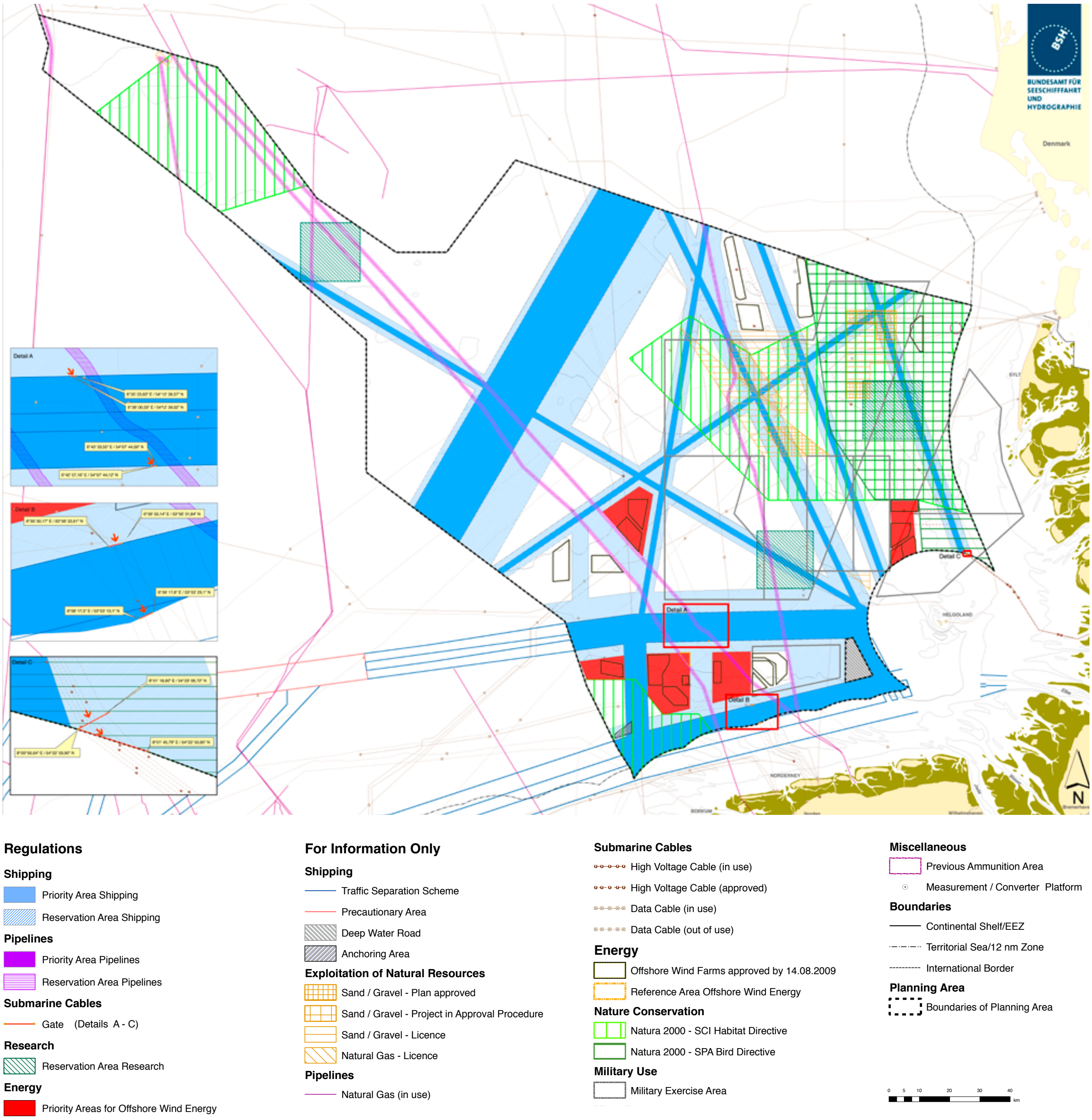
- Shipping
- Extraction of raw materials
- Pipelines and submarine cables
- Scientific marine research
- Energy production, particularly wind power
- Fishing and marine aquaculture
- Marine environment.

The plans define priority areas for wind power, and at the same time, prohibit the construction of wind farms in NATURA 2000 areas. In the transitional area to the territorial sea and for crossing the sea transport corridors, the plans designate target corridors to facilitate combined management of submarine cables that supply energy. They also stipulate the aim of dismantling offshore wind farms once use has been discontinued (Figure 65). A 2017 survey of affected authorities to ascertain their requirements will initiate the updating process.

On 23 July 2014, the European Parliament and the Council adopted a Directive establishing a framework for maritime spatial planning (2014/89/EU)[206]. The aim is to promote sustainable growth of the marine industry, the sustainable development of marine regions, and the sustainable use of marine resources. Each Member State is required to prepare and implement its own maritime spatial plans. In

Figure 65

Marine spatial plan for the German EEZ in the North Sea (map section)

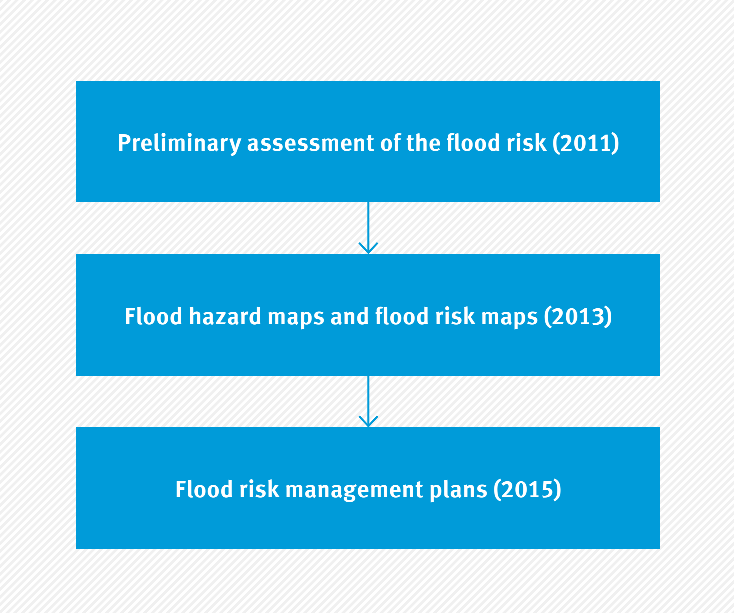


Source: German Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH)[205]

particular, these should promote sustainable development in marine areas using the ecosystem approach, and thereby contribute to the protection and improvement of the environment, including resistance to the impacts of climate change. Article 6 sets out minimum requirements for maritime spatial planning, such as the consideration of environmental, economic and social aspects as well as of land-sea interactions, stakeholder involvement and transboundary cooperation. With the 2017 amendment to the Spatial Planning Act the EU provisions were transposed to national law. For the Baltic Sea region, the cross-Länder HELCOM/VASAB (Vision and Strategies around the Baltic Sea) working group on the 2015 maritime spatial plan has developed a guide to application of the ecosystem approach.[207]

Figure 66

Implementation phases of the Floods Directive



Source: German Environment Agency

5.5 Flood risk management

In order to limit flood damage in future, viable long-term strategies at river catchment area level are being drafted both nationally and internationally. The flood risk is increasingly the focus of considerations. Water management administrations no longer merely assess the hazard of flooding, but also relate the likelihood of this event to the anticipated damage. The introduction of the EU Floods Directive 2007/60/EC created a European-wide framework for the assessment and management of flood risks to reduce the adverse flood-related consequences for human health, environment, cultural heritage and economic activities, known as risk receptors. The Floods Directive was transposed into German law with the revised Federal Water Act of 2009.

Implementation of the Floods Directive

Practical implementation of the Floods Directive occurs in three stages:

- Preliminary assessment of the flood risk
- Preparation of flood hazard maps and flood risk maps
- Preparation of flood risk management plans.

Analogous to the Water Framework Directive, these fundamental principles are reviewed and updated on a 6-year cycle (see chapter 5.1).

In accordance with the requirements set out in the Directive, by 2011 a provisional assessment of the flood risk across Germany was carried out using readily accessible information on previous flood events and the impacts of climate change on the probability of flood events. Analogous to the Water Framework Directive, this assessment was based on river basins. For areas with a potentially significant risk of flooding (known as risk areas), flood hazard maps and flood risk maps were subsequently prepared for the whole of Germany by 2013. The flood hazard maps provide information about the size of the affected areas (flood plains), the potential water depths and, where applicable, the flow speeds for the three flood scenarios, *frequent*, *medium* and *rare flood event*. The flood risk maps show the potentially affected resources, such as the number of affected inhabitants, protected areas, cultural assets or industrial plant, for frequent, average and rare flood events–in other words, the risk level. Figure 67 gives an impression on potential flood plains in case of a moderate/ rare and an extreme flood events in Germany.

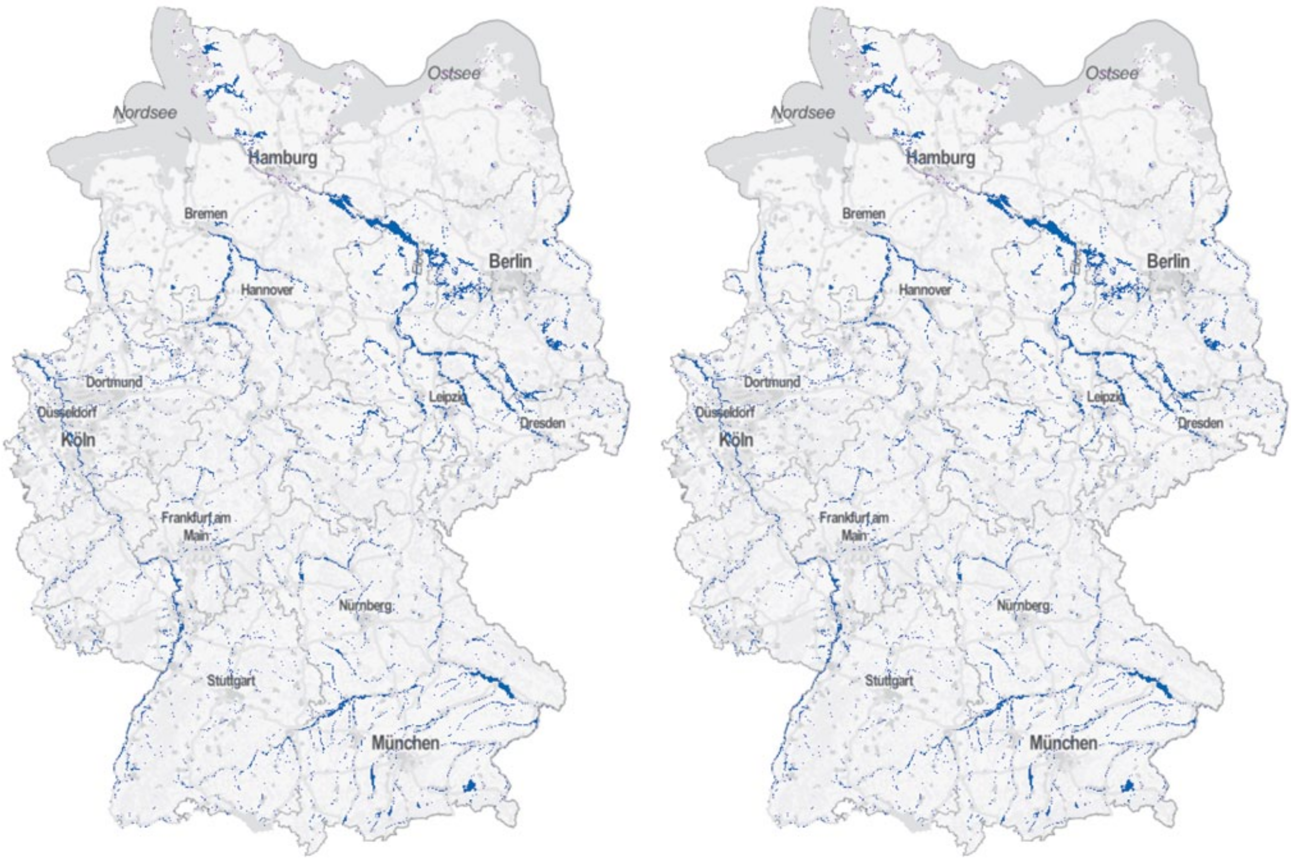
Based on the flood hazard and flood risk maps, by the end of 2015, the Länder had prepared flood risk management plans at river basin unit level. The flood risk management plans contain suitable targets for flood risk management, with an emphasis on reducing the flood-related adverse consequences for protected assets, and measures to achieve this, and also describe the implementation of measures. Analogous to the management plans under the Water Framework Directive (see chapter 5.1), the general public was notified and consulted. The measures comprise all aspects of flood risk management (see Figure 68), the main emphasis being on avoidance, protection and precaution.

Examples of prevention include the designation of flood plains, as well as development planning and structural precautions, such as flood-adapted construction. Flood plains are areas which have statistically been affected by flooding at least once in 100 years (flood level HQ100) or for which flood relief and retention are required. Farther-reaching provisions apply to designated flood plains which support an improvement in the ecological structures of waters, prevent measures that encourage erosion, ensure the conservation and recovery of flood retention areas, and regulate flood discharge as well as helping to minimise damage. Examples include:

Figure 67

Flood hazard maps

Flood plains for HQ 100 **Flood plains for HQ extreme**



Source: WasserBLIcK/BfG, 2015[208]

- Prohibiting the zoning of areas for new development; exceptions are only possible subject to compliance with strict prerequisites.
- Regulations governing the handling of substances hazardous to water such as the banning of oil heaters and flood-proof upgrading of existing oil heating installations.
- Measures to retain or improve the ecological structures of waterbodies and their flood plains.
- Requirements governing a site's proper agricultural and forestry use in order to reduce erosion and minimise pollutant discharge into waterbodies.

Flood protection – The national flood protection programme

Reclaiming flood plains, technical flood protection such as dykes, polders, flood control basins and dams, together with the national flood protection programme, all fall under the aspect of *protection*. Under the distribution of competencies in Germany's Basic Law, flood protection is a matter for the Länder. However, the devastating flooding of the rivers Elbe and Danube in June 2013 showed that preventive flood protection can only be achieved if the upstream/downstream problem is addressed by individual Länder acting in solidarity, and the Federation also has a role to play. With this in mind, at a special meeting of the Conference of Environmental Ministers on 2 September 2013, the Federation and Länder resolved to draw up a national flood protection programme, under the coordination of the Federation. Together with the river basin communities, the national flood protection programme was drawn up by experts from the Federation and Länder in the Working Group of the Federal States on Water Issues (LAWA), together with the National/Federal Consortium for Nature Protection, Landscape Conservation and Regeneration. It outlines supra-regional measures in the categories dyke relocation, managed flood retention (e.g. flood polders) and the elimination of weak points. It was adopted on 24 October 2014 at the Conference of Environmental

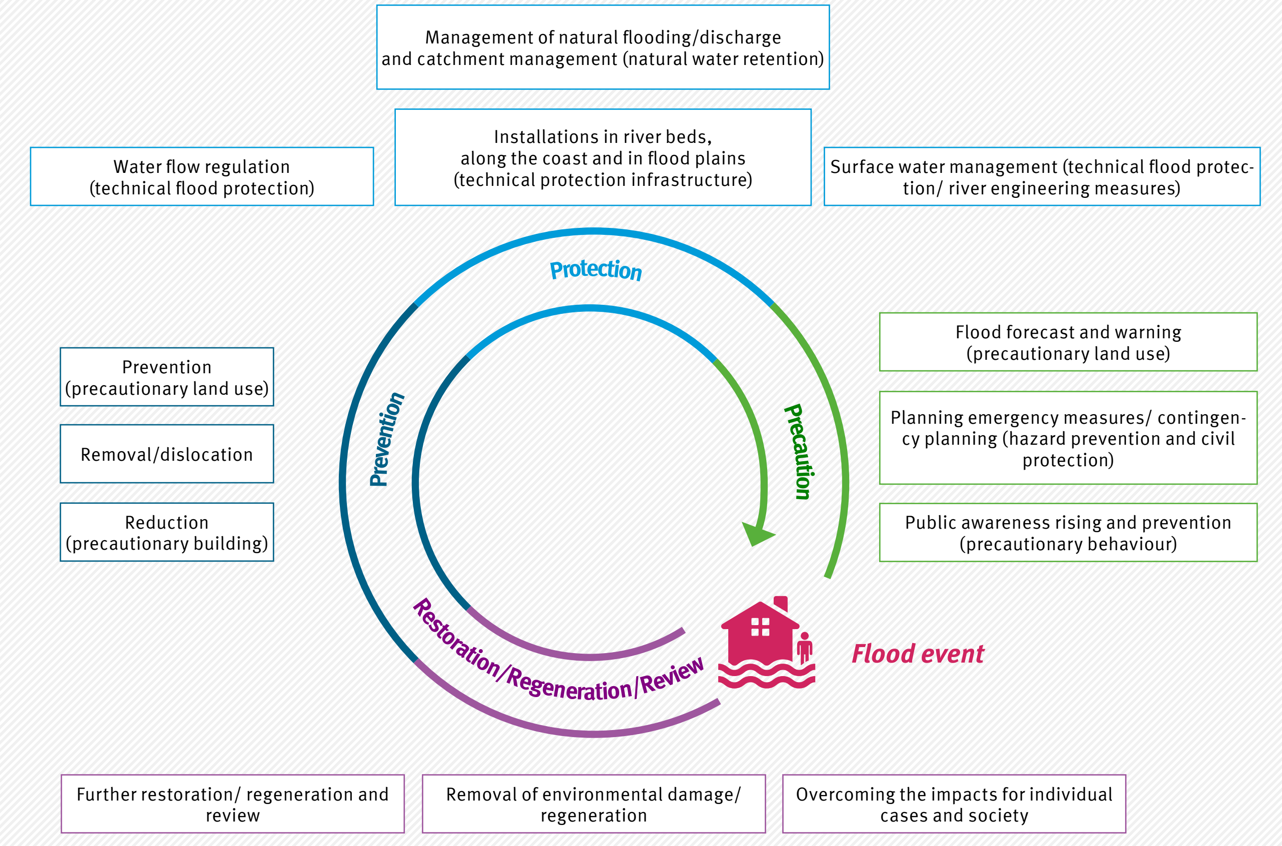
Ministers in Heidelberg. In total, to date, 32 supra-regional projects comprising more than 80 individual dyke relocation projects and 59 measures for managed flood retention have been defined. These projects aim to create more than 1,180 million m³ of retention volume, and through dyke relocation, create more than 20,000 hectares of new flood plains. Additionally, 16 projects to rectify weak points on existing flood protection facilities have been identified. The provisionally calculated total budget required for all measures under the flood protection plan is in the region of €5.5 billion. As the Federation and Länder will be contributing jointly to the funding, the Joint Task for the Improvement of Agricultural Structures and Coastal Protection (GAK) led by the Federal Ministry of Food and Agriculture (BMEL) was selected as a constitutionally compliant financing mechanism, and a special framework plan (Sonderrahmenplan, SRP) under the GAK was created, entitled "Preventive flood protection measures". This permits Federal funds to be used for up to 60% of the total eligible for support under the GAK. The 2015 Federal budget set aside €20 million for the SRP, and to date an amount of €100 million per annum has been earmarked for the years 2016 to 2018. The Federation plans to maintain expenditure at this level in subsequent years. Under the SRP, Federal funds should only be allocated to measures that create more space for rivers, i.e. dyke relocation and managed flood retention. As such, the cost of acquiring any urgently needed land is also eligible for financial support. Implementation of the first measures began in 2015. The flood protection programme is updated annually to incorporate new findings.

Flood precaution

Precautionary measures refer to flood projections and early warning systems such as the Länder flood portal, the alarm and action plans, as well as individual precautions. The aspect of restoration, regeneration and review includes reconstruction assistance, restoration, aftercare planning, and remedying environmental damages. Conceptual measures include the general coastal protection plans, for example.

Figure 68

Flood risk management cycle



Source: Based on LAWA 2013 Recommendations for the establishment of flood risk management plans (Empfehlungen zur Aufstellung von Hochwasserrisikomanagementplänen) http://www.lawa.de/documents/Empfehlungen_zur_Aufstellung_von_HWRMPL_mit_Anlagen_563.pdf (only in German)

[190] German Environment Agency (2016): https://www.umweltbundesamt.de/publikationen/water-framework-directive

[191] Fertiliser Ordinance of 26 May 2017 (BGBl. (Federal Law Gazette) I page 1305))

[192] Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources

[193] Regulation (EC) No. 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC, OJ L 309, p. 1 ff

[194] Plant Protection Act of 6 February 2012 (BGBl. (Federal Law Gazette) I, page 1281), amended by Article 4, para. (84) of the Act of 18 July 2016, Federal Law Gazette (BGBl.) I, page 1666)

[195] Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides, OJ L 309, p. 71 ff

[196] https://www.nap-pflanzenschutz.de

[197] http://www.un.org/depts/los/convention_agreements/texts/unclos/closindx.htm

[198] https://www.cbd.int/ebsa/about

[199] Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter http://www.imo.org/en/OurWork/Environment/LCLP/Pages/default.aspx

[200] www.ospar.org

[201] www.helcom.fi

[202] Bonn Agreement www.bonnagreement.org

[203] The Federal Spatial Planning Act (Raumordnungsgesetz, ROG) defines the basic principles of spatial planning (e.g. water- and environment-related principles in Article 2, paragraph (2), no. 6), which must then be concretised in the form of spatial development plans. The regulations governing development, organisation and protection of the areas include binding objectives and principles which must be taken into account in subsequent discretionary decisions.

[204] See Article 17, paragraph (3) of the ROG

[205] http://www.bsh.de/de/Meeresnutzung/Raumordnung_in_der_AWZ/index.jsp

[206] http://www.bsh.de/en/Marine_uses/Spatial_Planning_in_the_German_EEZ/documents2/MSP_DE_NorthSea.pdf

[207] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0089

[208] http://www.helcom.fi/helcom-at-work/groups/helcom-vasab-maritime-spatial-planning-working-group/

[209] http://geoportal.bafg.de/mapapps/resources/apps/HWRMRL-DE/index.html?lang=de

6 Sector-specific measures

6.1 Drinking water supply

6.1.1 Statutory framework and organisation of drinking water supply

Drinking water supply in Germany has essentially been organised in its current form for more than 100 years, but is continually updated in line with technical and hygiene requirements. The aim of public water supply is to ensure that the population has access to an adequate volume of drinking water at all times which satisfies the high quality requirements stipulated by law.

Water protection areas are designated in Germany in order to protect the drinking water supply. In 2017, there were 18,341 water protection areas covering a total area of around 55,000 km², equivalent to 15.4% of the total territory of the Federal Republic of Germany (Figure 70).

In order to ensure a reliable supply and adequate drinking water hygiene, a system of compulsory connection and use is regulated by local statutes. This means that each individual citizen and commercial company is obliged to connect to and utilise the public drinking water supply and sewers of the local government or the responsible special-purpose association. The requirement for mandatory connection and use is that this must be in the general public interest. Water supply and wastewater disposal are usually in the public interest. A regulated water supply is needed in order to protect public health (quality of drinking water), while wastewater disposal by the local authority serves both to protect public health (risk of epidemics) and to protect the groundwater. In selected cases of exceptional hardship, local by-laws provide for exceptions.

Building regulations ensure that no residential buildings may be constructed without a proper drinking water supply.

The qualitative requirements for drinking water are laid down in the Drinking Water Ordinance (Trinkwasserverordnung, TrinkwV)[209]. This was adopted on the basis of the German Protection Against Infection Act[210] and the Foods and Other Commodities Act[211] , and also transposes the EU Drinking Water Directive[212] into national law. The Drinking Water Ordinance outlines specific requirements governing the properties of drinking water and of water for food factories and drinking water treatment. It also regulates the

Figure 69

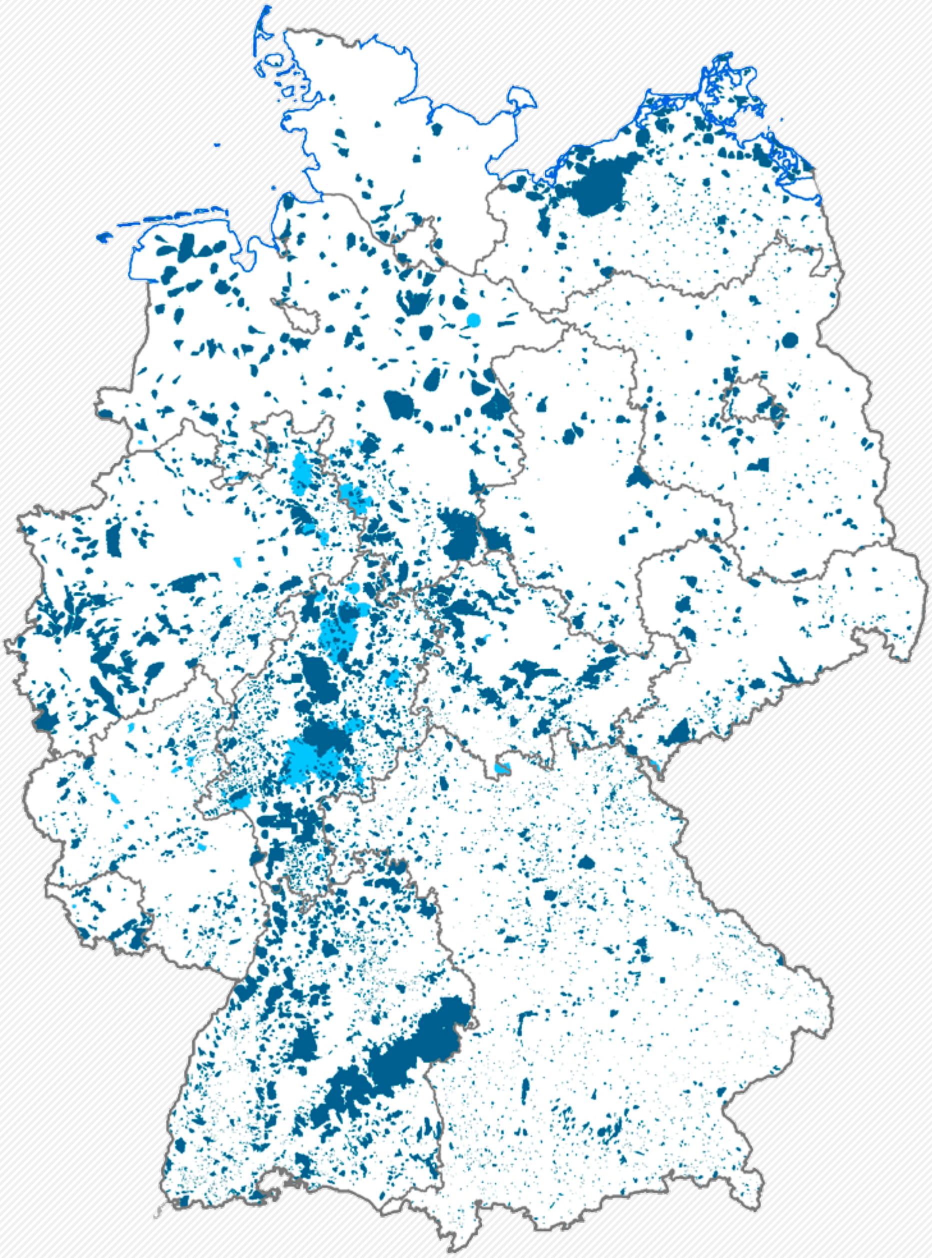
Drinking water protection area, zone I

obligations incumbent upon the operator of a water supply plant, and hygiene-related monitoring of the operator by the health authorities. It also specifies limits for substances harmful to human health (such as heavy metals, nitrate and organic compounds) and pathogens, as well as the scope and frequency of analysis. The limit values for these substances correspond to those in the EU Drinking Water Directive and are set at a level where no harmful effects are expected to result from lifelong intake. For organo-chemical pesticides and insecticides, for example, the maximum concentration is 0.1 µg/l. The sum total of such active ingredients is limited to 0.5 µg/l. The limit for nitrate in drinking water is 50 mg/l.

As in-house installations are also considered water supply facilities under the Drinking Water Ordinance, home owners are subject to the same regulations as all other companies and other owners of a water supply installation. With regard to quality assurance in the construction, operation and maintenance of water supply systems, parallel with and supplementary to the administrative regulations under construction and drinking water legislation, an important role is also ascribed to the technical regulations of private-law associations or federations such as the “German Association of Gas and Water Experts” (Deutsche Vereinigung des Gas und Wasserfaches e.V., DVGW) or the “German Institute for Standardisation” (Deutsches Institut für Normung

Figure 70

Map of water protection areas (WPA) in Germany



Drinking (Drinking water protection areas)

Spa (Medicinal spring protection areas)

No. of WPAs – 18 341
WPA area (absolute) – 54 967 km²

WPA as a percentage of total German territory – 15.38 %

Federal State	Area of WPA [km²]	% of territory
BB	1 333	4.49
BE	211	23.61
BW	9 378	26.22
BY	3 766	5.34
HB	31	7.73
HE	11 781	55.82
HH	90	11.90
MV	4 585	19.84

Federal State	Area of WPA [km²]	% of territory
NI	8 007	16.76
NW	6 075	17.82
RP	1 861	9.38
SH	558	3.51
SL	452	17.57
SN	1 466	7.93
ST	1 278	6.22
TH	3 735	23.06

Source: Geobasis data DLM1000, 2012, BKG, data by WasserBLIcK/ BfG and Länder authorities 1/5/2017, Thuringia: communication with Thüringer Landesverwaltungsamt 19/2/2018, Hessen: communication with Hessisches Landesamt für Naturschutz, Umwelt und Geologie 14/2/2018; Map prepared by German Environment Agency, 2018 e.V., DIN). These set out the technical specifications and document the best available technology. *Inter alia*, these regulations also stipulate the minimum required qualifications for employees in water works, the requirements for pipelines including the constituent materials, the conditions for pipe-laying, and the required qualifications for pipework installation companies.

The monitoring of drinking water quality by government bodies is the responsibility of the Länder, and at local authority level, the responsibility of public health departments. The public health departments supervise the internal control and quality assurance measures taken by the water utilities, including the prescribed documentation. They also carry out their own checks. The public health authorities also monitor trends in water quality, as the water utilities are required to notify the competent public health department immediately of any cases of non-compliance with the prescribed parameter values (limits). As a precaution, the water utilities are required to prepare plans of measures in the event of temporary non-compliance with the requirements and limits. Furthermore, water utilities have a duty to guarantee adequate water supplies and to make drinking water available in adequate quantity and quality by other means in the rare event of a failure in the drinking water supply system (for technical or hygienic reasons), for example by importing water from a different water works or by means of mobile water supply facilities (e.g. water trucks).

The required levels of supply reliability and drinking water quality also apply to small facilities. The definition of small facilities in the Drinking Water Ordinance does not distinguish between installations for personal use and installations for supplying third parties, e.g. guests in an isolated woodland restaurant or holiday home tenants. Small facilities and–under certain circumstances–in-house installations and installations for the use of rainwater are subject to monitoring by the public health authorities as provided for in the Drinking Water Ordinance.

6.1.2 Drinking water prices

The calculation of water prices in Germany is based on the actual costs incurred to companies in connection with every aspect of water supply. This concerns all costs associated with water abstraction, treatment, storage and distribution, as well as investments in maintenance and waterbody conservation. This reflects the cost recovery principle anchored in the Water Framework Directive. The cost recovery principle states that, in addition to on-going operating costs, the water rates must also cover all the capital costs incurred.

However, the existing structural and natural framework conditions for water abstraction and supply, such as population density, geographical location and hydrology, vary widely from one location to the next. This leads to different cost levels for the water utilities, which must be covered by locally valid water rates.

Depending on whether the supply companies are publicly or privately organized (see also chapter 2.6.1), their fees are subject to price supervision by local government law or cartel law. In the case of public water utilities, water prices are based on the principles of local government fee legislation (cost coverage, equality of treatment, equivalence).

The Federal Court of Justice has ruled that in the case of private water utilities, the cartel authorities may compare the water prices of one utility with those of a similar utility, since water supply constitutes a natural monopoly. To this end, the cartel authority must determine and compare the supply density (metered volume), the client density (network length per house connection), the number of residents supplied, the fee structure (household and small commercial clients), differences in procurement and treatment costs, and the overall yields of the water division.

The utility must provide evidence of any other significant cost factors such as topography (land structure), increased maintenance costs for the pipeline network or other special precautionary expenses for environmental protection and hygiene, to in order to justify potentially higher prices than other suppliers. In future, it will be important to formulate this obligation to provide evidence in such a way that the water utilities are still able to provide the full range of vital water protection and hygiene services.

In order to ensure these important services by the water utilities, in 2014 the Federal Ministry for the Environment and the Federal Ministry of Health published a “Catalogue of precautionary services by water suppliers for the protection of water and public health"[213], containing a list of water-protecting and hygienic precautionary services by water suppliers.

Prices are generally calculated from two fee components: The consumption-related price per cubic metre, and a basic monthly charge designed to cover the fixed costs for maintaining the supply infrastructure. These price components vary between municipalities, with the result that actual water prices differ considerably from the calculated average of €1.69/m³ for the year 2013, plus a basic annual fee of €70.98. The following chart summarises the fee categories:

A simplified calculation for a model household is used here to illustrate the costs. For this standardised two-person household in Germany with a water consumption of 80 cubic metres, the annual expenditure would be €206.18/annum. In other words, the cost of drinking water is €103.09 per person, per year i.e. the daily consumption of drinking water of 121 litres is covered by a charge of €0.28 per day. This figure does not include the cost of wastewater disposal (see chapter 6.2.6).

6.1.3 "Saving water"

Compared with other industrialised nations, Germany already has a low level of per capita drinking water use, and has achieved a very high level of awareness vis-à-vis the handling of drinking water. Industry and households have already reduced their use of water substantially. Almost all bodies of groundwater are in good quantitative status (see chapter 4.1.2). Daily drinking water use has been declining since 1991 (144 litres per person), and now totals 121 litres per person. However, further savings may become necessary. Such requirements apply primarily at a regional level and are seasonal in nature. This is therefore a topic to be discussed and implemented locally.

Overall, there is potential to reduce drinking water use in Germany without fearing a loss of convenience or reduced standards of hygiene. For example, large numbers of households could reduce their water use with simple measures, such as purchasing new, more water-efficient appliances (e.g. washing machines and dishwashers), or using rainwater to water the garden. Particular attention should focus on the use of hot water. Using hot water sparingly also means reducing the amount of energy needed to heat the water. Alongside the careful use of drinking water, it is also important to raise awareness of the fact that by purchasing products manufactured with the use of water abroad, we are importing virtual water, and thereby leaving behind a water footprint, which is often a major problem in arid regions (see chapter 3.1.1).

Difficulties with water supply or wastewater disposal pipelines associated with reduced water use should not be blamed on consumers. The water suppliers are responsible for ensuring a high quality of drinking water supplies in Germany, and are charged with developing the infrastructure. They can gauge the need for more frequent rinsing of drinking water pipelines due to declining demand, either due to smaller usage volumes per household or because of a declining population density (see chapter 2.3) far more precisely and effectively than their customers.

Table 10

2013 drinking water prices in Germany

	Minimum	Average	Maximum
Drinking water charge per m³	€1.23	€1.69	€2.17
Basic annual fee	€17.58	€70.98	€126.07
Costs per annum To purchase 80m³ including basic fee	€160.14	€206.18	€286.07

Source: Federal Statistical Office, 2013[214]

Municipalities themselves can respond to (potential) local shortages by providing local citizens with up-to-date information and by insisting on water-saving installations in public institutions. The municipalities also inform about potential impacts of climate change and, where applicable, the required local adaptation measures. They prepare recommendations for water use during dry summers, e.g. for watering the garden with rainwater and only at selected times, and where necessary, may impose a temporary complete ban in on the use of drinking water in the garden.

Table 11

Annex to Article 3 of the Wastewater Charges Act–Pollutants and units of noxiousness under the Wastewater Charges Act

No.	Evaluated pollutants and groups of pollutants	The following full units of measurement correspond to one unit of noxiousness	Threshold values according to concentration and annual quantity
1	Oxidizable substances in Chemical Oxygen Demand (COD)	50 kilograms of oxygen	20 milligrams per litre and 250 kilograms annual quantity
2	Phosphorus	3 kilograms	0.1 milligrams per litre and 15 kilograms annual quantity
3	Nitrogen as the sum total of individual amounts of nitrate nitrogen, nitrite nitrogen and ammonia nitrogen	25 kilograms	5 milligrams per litre and 125 kilograms annual quantity
4	Organohalogen compounds as adsorbable organic halogens (AOX)	2 kilograms of halogen calculated as organically bonded chlorine	100 micrograms per litre and 10 kilograms annual quantity
5	Metals and their compounds		and
5.1	Mercury	20 grams	1 microgram 100 grams
5.2	Cadmium	100 grams	5 micrograms 500 grams
5.3	Chromium	500 grams	50 micrograms 2.5 kilograms
5.4	Nickel	500 grams	50 micrograms 2.5 kilograms
5.5	Lead	500 grams	50 micrograms 2.5 kilograms
5.6	Copper	1,000 grams Metal	100 micrograms 5 kilograms per litre annual quantity
6	Fish toxicity	6,000 cubic metres of wastewater divided by G_{EI}	$G_{EI} = 2$

GEI is the dilution factor at which wastewater is no longer toxic in the fish egg test. The data in this table is based on the procedures for determining the toxicity of wastewater according to the relevant numbers in the Annex “Analysis and measurement techniques” to the Wastewater Ordinance in the version promulgated on 17 June 2004 (Federal Law Gazette (BGBl.) I, page 1108, 2625).

Source: German Environment Agency based on Wastewater Charges Act

6.2 Wastewater

6.2.1 Legal framework and organisation of wastewater disposal

Wastewater Ordinance

Under the Federal Water Act[215], the emission of substances into a waterbody is a form of use. This also applies to the direct discharge of treated wastewater, as this contributes to material pollution of the waterbody (see chapter 3.1.4) and requires a permit. Since 1976, minimum nationwide requirements have applied to the discharge of wastewater into waters and hence to the incidence, avoidance and treatment of wastewater. The minimum requirements are defined in § 57 (input of wastewater into waters, so-called direct discharge) of the Federal Water Act (Wasserhaushaltsgesetz, WHG). Since 1996, these minimum requirements have been based on the best available technology[216]. The permissible pollutant load depends on each industry's ability to minimise emissions into water by observing technically and economically viable, progressive processes.

The requirements to be met are set out in the Wastewater Ordinance[217] (Abwasserverordnung, AbwV), which contains provisions and emission limits and also defines the best available technology. The minimum requirements for wastewater quality are defined in sector-specific Annexes to the Wastewater Ordinance. To date, 57 such Annexes (in real terms 53 Annexes due to deletions) have been adopted. Annex 1 to the Wastewater Ordinance applies to domestic and public wastewater, while the other Annexes concern individual sectors of commerce and industry (see chapter 6.4.1).

The licensing requirements and conditions for the discharge of wastewater into public and private wastewater installations (known as indirect discharges) are outlined in Articles 58 and 59 of the Federal Water Act in conjunction with the Wastewater Ordinance. Above and beyond this, the Länder may also adopt their own statutory provisions, e.g. containing more stringent licensing conditions, for the indirect discharge of wastewater.

The Wastewater Ordinance also serves to transpose into national law the wastewater-related technical provisions of EU law, such as the Urban Wastewater Treatment[218], which obligates Member States to collect and purify wastewater from households and small businesses, and is designed to reduce organic pollution as well as nitrate and phosphorus emissions from these sources.

Implementing the Directive on Industrial Emissions (IE Directive[219]) has particular implications. This Directive underlines the importance of best available technology (BAT) by developing and adopting BAT conclusions taken from industry-specific codes of practice (see chapter 6.4.1).

Wastewater Charges Act

The Wastewater Charges Act (Abwasserabgabengesetz, AbwAG)[220] obligates direct dischargers to pay a fee for the direct emission of wastewater into a waterbody. The fee is determined from the quantity and harmfulness of specific constituents discharged into the water (see Table 11)[221]. In this way, direct dischargers must compensate, at least in part, for the costs associated with teir use of the environmental medium water (application of the polluter-pays principle). The charge is the first eco-tax to be levied at Federal level as a steering instrument.

The Wastewater Charges Act implements the requirements of the Water Framework Directive, which states that environmental and resource costs must be internalised with a view to cost recovery. The charge per unit of noxiousness increased several times to DM 70 in 1997 (now €35.79), but has not been adjusted since then.

The charge is designed to offer an economic incentive to avoid wastewater discharges as far as possible. The Wastewater Charges Act provides for rate reductions if certain minimum requirements are met. In addition, certain types of investment designed to improve wastewater treatment may be offset against the charge.

The wastewater charge is payable to the Länder. The revenue generated must be used for water pollution control measures.

6.2.2 Approaches to wastewater treatment

It is no longer sufficient to simply increase the function and elimination capacity of wastewater treatment plants that are built with the best available technology (see chapter 3.1.5). Instead, the challenge lies in integrating additional effective, inexpensive and energy-efficient measures for the effective elimination e.g. of micropollutants and nano-materials into the wastewater treatment plant as a fourth treatment stage. Moreover, in future, the wastewater treatment plant should not be seen purely as a pollutant sink, but also as an energy supplier and source of vital basic materials.

Some possible approaches are outlined below.

Fourth treatment stage

Biological wastewater treatment does not sufficiently reduce anthropogenic substances, such as micropollutants. Readily biodegradable substances such as ibuprofen are up to 90% removed, whereas other substances that are not readily degradable (such as radiographic contrast media) are hardly removed at all. The elimination capacity for micropollutants cannot be satisfactorily increased by optimising the wastewater treatment plant as conventional plants are not designed for the elimination of these substances.

The introduction of an additional processing stage (4th treatment stage) can help to significantly reduce emissions of micropollutants into surface waters.

The applied procedures should remove as many substances as possible, generate minimal by-products (transformation products), and be suitable for integration into existing plant. The cost/benefit ratio (energy, material and personnel costs) must be justifiable. At present, the two procedures that largely meet these requirements are adsorption using activated carbon (powder and granulated), and oxidation with ozone. These procedures have already been tested on wastewater treatment plants, and in some cases applied on a commercial scale with favourable results.

The development of additional techniques and combinations to eliminate micropollutants is still ongoing. For example, the application of membrane techniques (nano-filtration and reverse osmosis) and the use of other oxidation agents and techniques are being investigated.

The introduction of a 4th treatment stage would have additional positive effects on wastewater treatment, such as disinfection and further separation of unwanted substances in the water (such as residual phosphorus and natural organic material). The German Environment Agency favours the introduction of a 4th treatment stage in large public wastewater treatment plants, plants located on sensitive waterbodies, and plants that generate a high proportion of wastewater in the waterbody[222]. A financial incentive to reduce micropollutants in wastewater treatment plants could be achieved with a suitable revision of the Wastewater Charges Act) (see chapter 2.4.3).

In Switzerland, statutory provisions on the introduction of a fourth treatment stage in wastewater treatment plants was incorporated into the Swiss Water Protection Ordinance[223] following a referendum.

New approaches to sewage sludge recycling

Sewage sludge from public wastewater treatment plants is still being usepd as fertiliser in agriculture to add essential nutrients to the soil. The annual volume of sewage sludge incurred in Germany from public wastewater treatment plants (approximately 2 million tonnes of dry solid matter) contains some 50,000 tonnes of phosphorus. At present, around 24% of sewage sludge is recycled for agricultural purposes. Given the numerous contaminants that are present in sewage sludge, however, agricultural recycling of sewage sludge is problematic from an environmental perspective and should therefore be discontinued[221].

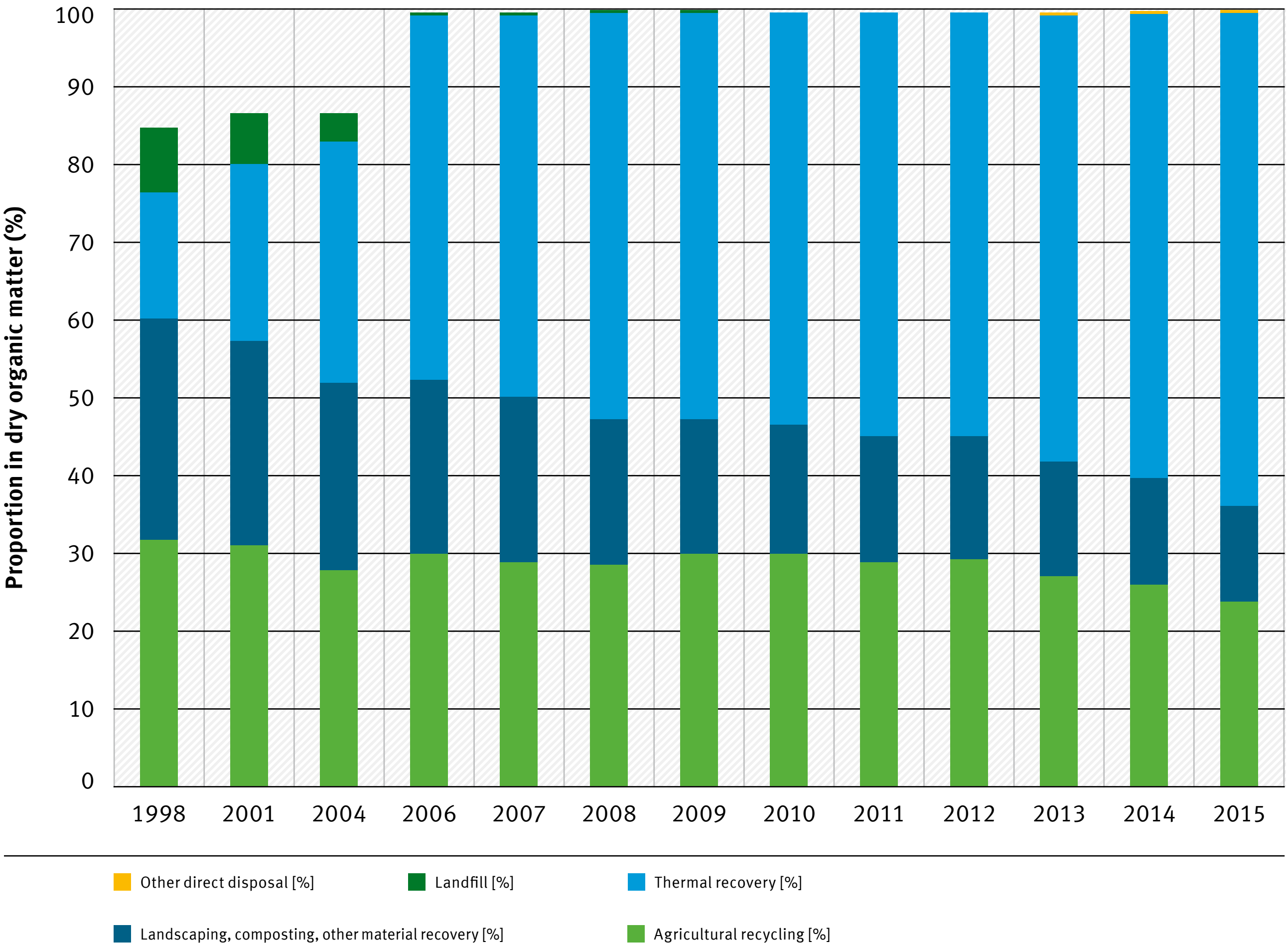
The agricultural application of sewage sludge is regulated by the Sewage Sludge Ordinance[225] and additionally, since 1 January 2015, by the Fertilisers Act. Limits set out in the Sewage Sludge and Fertilisers Ordinance[226] are designed to restrict the application of heavily contaminated sewage sludge to minimise this emission pathway for hazardous substances into soils, waters and foodstuffs.

Particularly because the prescribed limits are not adhered to, in 2015 around 64% of sewage sludge was thermally disposed of[227], approximately 39% of it by co-incineration and approximately 38% by mono-incineration. 24% of sewage sludge was used for agricultural purposes, and 12% was used for landscaping and other forms of material recovery[228] (Figure 71).

The revised Sewage Sludge Ordinance[229] envisages the partial phasing out of agricultural use

Figure 71

Sewage sludge recycling in Germany, 1998 to 2015



* Prior to 2006, the figures were collated using a different method. For this reason, the sum total of individual uses prior to 2006 does not add up to 100%. The shares of other forms of direct disposal, such as construction materials, humification, fermentation, is ‹ 1%

Source: Federal Statistical Office (Destatis): "Wasserwirtschaft: Klärschlammentsorgung aus der öffentlichen Abwasserbehandlung", various years[232]

of sewage sludge. For a transitional period up until 2027, sewage sludge from wastewater treatment plants with < 100,000 p.e. may be used agriculturally, and thereafter, only from wastewater treatment plants with < 50,000 p.e.

The co-incineration of sewage sludge leaves the resource phosphorus unused. It is removed from the material cycle, i.e. fixed in the cement, or heavily diluted in slag or in other incineration residues[230]. Under the revised Sewage Sludge Ordinance, the co-incineration of phosphorus-rich sewage sludge will be prohibited in future, and phosphorus recovery prescribed by law[231]. However, this regulation will initially only affect the largest wastewater treatment plants (> 50,000 p.e.).

The raw material phosphorus is mined as phosphate rock, of which only limited quantities of sufficient quality are available on earth. The European Commission has classed phosphate rock as a critical raw material.[233] Worldwide, in 2015 some 223 million tonnes of phosphate rock were mined (and the trend is growing), around 90% of which was processed into fertilisers. The global phosphorus reserves are estimated at around 69 billion tonnes.[234] Because of the finite nature of this resource, it is worth utilising existing material flows such as wastewater and recovering the raw material phosphorus.

In recent years, technical processes have been developed to enable at least part of the phosphorus to be recovered from sewage sludge, and made available for use as a fertiliser. Wet-chemical processes allow up to around 40% recovery of phosphorus, for example as magnesium ammonium phosphate (MAP). The recovery of phosphorus after mono-incineration of sewage sludge offers even greater potential. Up to around 90% of phosphorus can be recovered from the ash using so-called thermal processes. If the phosphorus were to be recovered from all Germany's sewage sludge, around half of the annual phosphorus mineral imports could be saved.

The development and implementation of suitable phosphorus recovery techniques from wastewater and sewage sludge or sewage sludge ash helps to conserve resources and manage wastewater sustainably. The techniques ultimately used must be decided on a site-specific basis.

Recycling of nitrogen in wastewater treatment plants

In 2015, some 1,250 wastewater treatment plants[235] were equipped with digestion towers for the extraction of digester gas. Ammonium/ammonia used in the production of fertilisers (such as ammonium sulphate) can be stripped from the wastewater. In this process, around 90% of the available ammonium/ammonia can be converted e.g. into fertilisers from the wastewater and made available to farmers. The remaining 10% is returned to the activated sludge tank, where it is mineralised into nitrogen.

Enhancing energy efficiency in wastewater treatment plants

Wastewater treatment plants offer huge potential to save energy and cut CO_2 emissions in power supply. Converting to energy-saving ventilation of the aeration tanks and the use of energy-efficient pumps and agitators are particularly promising options, and currently the principal approaches for energy optimisation.

Generating electricity from the extraction and recovery of digester gas is another important aspect for reducing CO_2 emissions from wastewater treatment plants. In 2015, some 1,395 Gigawatt hours of electricity were generated from sewage gas in Germany[236]. In other words, around one-third of the total electricity consumed by wastewater treatment plants can already be covered by digester gas generation. By optimising wastewater treatment, electricity consumption can be reduced and off-grid power supply boosted. The ultimate aim is an energy-autarkic wastewater treatment plant.

As part of its environmental innovation programme, the Federal Environment Ministry supports innovative projects to achieve energy efficiency in wastewater treatment plants[237].

Use of wastewater heat

Heat is lost when wastewater from buildings is discharged into the sewage system. With the aid of heat exchangers and heat pumps, this could contribute to an efficient heat supply (water and heating) to apartment blocks, office buildings or public institutions. The heat can be extracted from the wastewater either directly in the building being heated, in the sewer, or from treated wastewater at the wastewater treatment plant. The process can also be "reversed" and used to cool buildings.

Under suitable requirements, facilities for the use of wastewater are already financially competitive[238]. The option of using wastewater heat should be incorporated into the planning of heating systems with regenerative energy. It is currently estimated that around 60 such systems are under construction in Germany. Projects for the use of wastewater heat are also supported under the environmental innovation programme.

6.2.3 New Alternative Sanitation Systems (NASS)

New alternative sanitation systems allow wastewater subflows to be collected separately. Used locally, they facilitate the selective recovery of wastewater constituents (such as phosphorus, nitrogen, potassium) and the reuse of water. Wastewater flows may be separated into different material flows, such as grey water (material flow from the domestic environment excluding faecal matter), brown water (faeces with flushing water), yellow water (urine with flushing water) and rainwater (such as precipitation falling on land)[239]. Special engineering measures, such as suitable toilets and separate pipework, are required in order to install new alternative sanitation systems.

New alternative sanitation systems are a useful alternative when there is no connection to the sewage system available, it is already at full capacity, or it is necessary to separate urine and faeces in specific cases. It lends itself particularly to the development of new urban areas and the complete renovation of buildings in Germany[240]. For rural regions where population numbers are decreasing, where upgrades to the sewer system are needed and maintaining existing infrastructures is difficult, NASS systems are also an option.

Because of the well-developed wastewater disposal system in Germany, until now little consideration has been given to these new types of sanitation systems. For this reason, every new project is important for gathering experience of planning, construction and operation. Similarly, there has thus far been little research and development work into the processing and use of products from these new alternative sanitation systems, for example as fertilisers.

Against the backdrop of demographic change and its impacts on infrastructure, these new alternative sanitation systems are expected to gain significance in future.

6.2.4 Remediation of the sewerage system

The status of sewers must be ascertained (e.g. with a mobile camera) to take decisions on appropriate remediation. Private sewers must also be incorporated into the planning of remediation measures. Measures should also be prioritised from an environmental perspective, since a comprehensive approach is essential for avoiding adverse environmental effects. Repairing any leaks that are a potential threat to groundwater should be the top priority. Furthermore, remediation measures should take place on sewerage canals which can significantly reduce the volume of sewage infiltration water (groundwater entering the sewerage system) to ensure effective, energy-efficient treatment of wastewater in the affected treatment plants.

6.2.5 Near-natural rainwater management

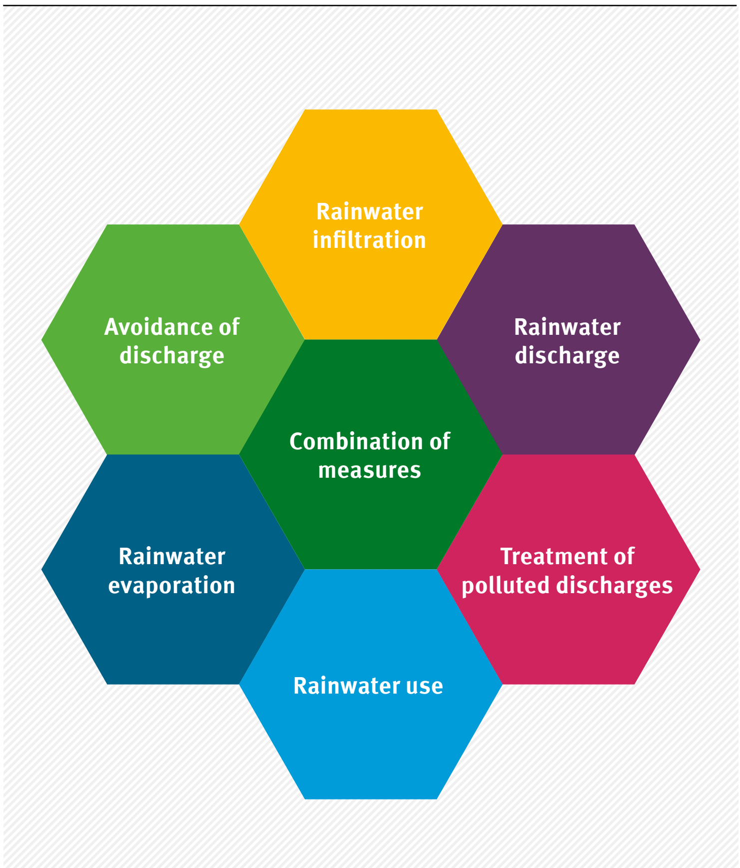
Near-natural rainwater management aims to approximate the hydrological cycle in its undeveloped state, even in urban regions, to reduce emissions of substances into waters, and at the same time, to ensure reliable drainage in towns and cities (protection from flooding) and benefit the urban climate. There is a broad spectrum of measures available to achieve these objectives via appropriate rainwater management. Local management measures are becoming increasingly important, and can be effectively combined both with one another and with central precipitation drainage measures, such as avoiding rainwater discharge through desealing, infiltration and evaporation as well as rainwater use (Figure 72).

Reducing land sealing to a bare minimum is the first step. Wherever possible, grassland should be created, or water-permeable coatings used as an alternative to complete sealing (e.g. for paths and access roads).

If land sealing is unavoidable, depending on the type of surface and degree of pollution, precipitation water may infiltrate, evaporate, or be used or treated. Land such as cycle paths and walkways in residential areas and low-traffic transport routes are considered to have low pollution levels. For example, this precipitation water may be stored directly where it arises in troughs or infiltration ditches[241] and allowed to leach via the soil zone.

Figure 72

Measures for achieving near-natural rainwater management



Source: German Environment Agency

Another option for the retention and rapid return of precipitation water to the natural hydrological cycle is temporary storage and evaporation via green roofs.

Rainwater is now used in the commercial and industrial sector e.g. for cooling buildings, for irrigating densely planted living roofs and building facades, and as process water in industry.

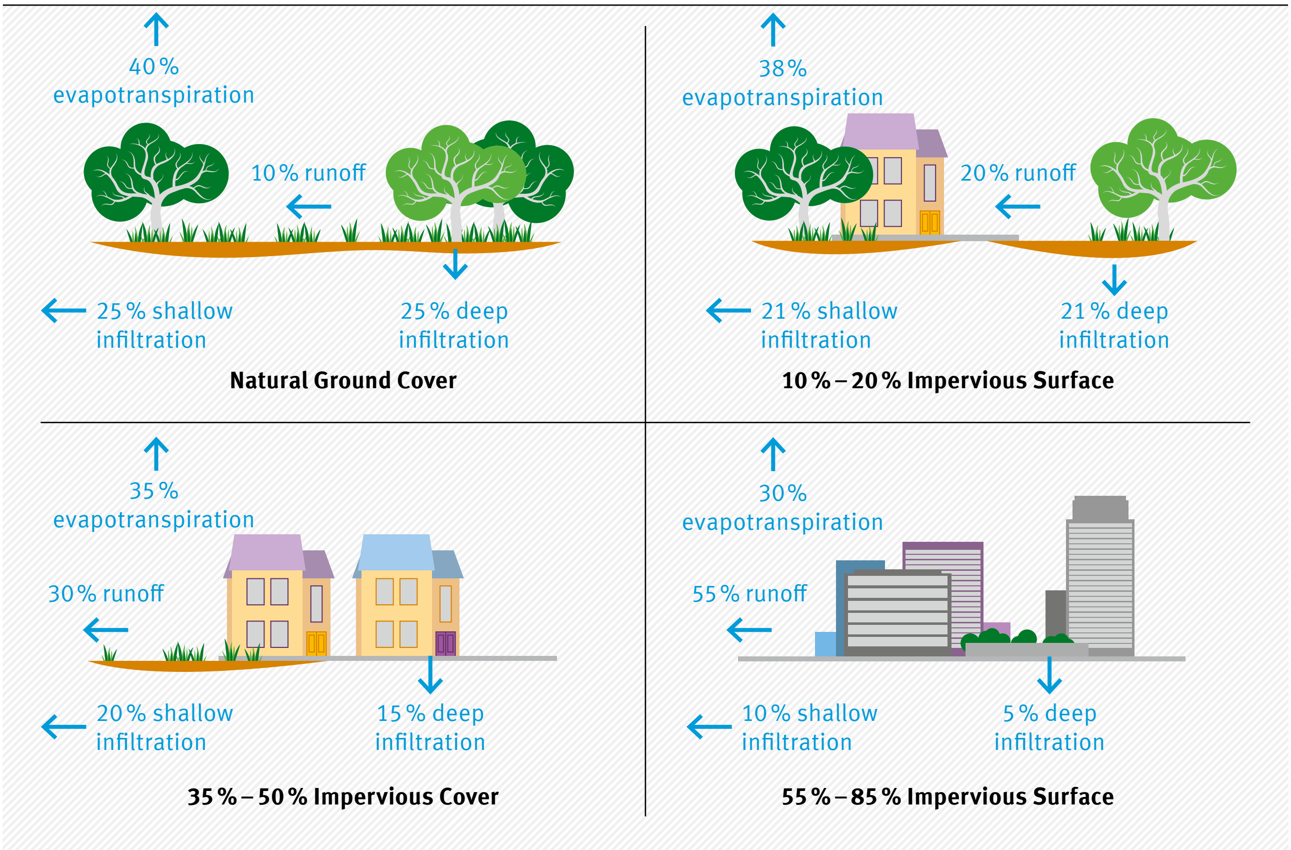
Precipitation water that falls, for example on roads, car parks in commercial and industrial areas, and airport runways need not be treated in wastewater treatment plants. It can be treated locally in filter systems located e.g. in shafts. These filters eliminate heavy metals, dust, oil and other constituents; their effectiveness is on a par with rain purification ponds. The treated water then infiltrates or is discharged into a waterbody. This can help to avoid combined sewage overflows into waterbodies.

Precipitation water e.g. from special land in industrial and commercial areas tends to be heavily polluted and is discharged into a wastewater treatment plant for treatment.

In essence, the Federal Water Act specifies that precipitation water should be allowed to infiltrate locally[242]. The formulation of this provision is quite broad and open (target requirement), to allow for varying local conditions (e.g. existing combined sewers in residential developments) and regional legislation. For example, the Brandenburg Water Act states that precipitation water should be allowed to infiltrate, provided there is no reason to fear pollution of the groundwater and there are no other causes for concern.

Figure 73

Changes in the natural water balance



Source: German Environment Agency based on US-EPA (Environmental Protection Agency) 2004

Figure 74

Facade greening in the courtyard of the Institute of Physics at Humboldt University in Berlin-Adlershof; climbers provide shade and cooling

6.2.6 Wastewater treatment prices

Like water supply, wastewater disposal is a public service task[243] which is carried out by the local authorities within the context of their constitutionally guaranteed self-administration. This means that wastewater charges are set by the local authorities and communities as per the local authority fee legislation of the individual Länder and their local statutes. Under such legislation, charges are set on a polluter-pays basis, and are payable by all property owners and companies connected to the public sewers. In keeping with the cost recovery principle, therefore, the revenues of the local authorities must not exceed the actual operating and investment costs incurred in conjunction with the discharging and treatment of wastewater in the disposal area.

The cost of wastewater disposal at local level varies considerably due to wide variations in regional and local conditions. The diverse natural and infrastructure-related framework conditions (such as topography, geology and population density) within Germany, together with the size of the wastewater treatment plant and its treatment capacity depending on the nature of contamination, as well as specific investments in the sewer network and treatment technologies, are all cost factors.

To protect waterbodies from pressures and advance the use of optimised treatment technologies, all companies in Germany that discharge wastewater into a waterbody (so-called direct dischargers), thus including the operators of municipal wastewater treatment plants, pay a wastewater fee, applicable nationwide. The level of the fee is based on the residual contamination remaining in the wastewater after treatment. The wastewater fee is incorporated into the price paid

Table 12

Wastewater prices 2010

Local authorities with	Proportion of local municipalities	Price in €		
	%	Wastewater fee per m³	Precipitation fee per m²	Basic charge per annum
Wastewater fee only	29.80	2.44	–	–
Wastewater fee and basic charge	28.70	2.57	–	73.45
Wastewater and precipitation fee	20.30	2.23	0.75	–
Wastewater and precipitation fee plus basic charge	12.70	2.45	1.03	53.54
Precipitation fee and basic charge	0.10	–	0.50	129.66
Basic charge only	0.60	–	–	178.03
Other fees	7.90	2.40	0.70	11.78

Source: Federal Statistical Office, 2013[244]

by consumers for wastewater disposal. In other words, the wastewater disposal providers may pass the wastewater fees onto their consumers.

Additionally, the local authorities may draw on various tariff models with different fee components when setting prices. The following factors are taken into account:

- A volume fee for wastewater in relation to the volume of freshwater consumed
- A volume fee for precipitation water per square metre of sealed land, and
- An annual basic charge to cover fixed costs

The basic charge covers around 75–85% of the costs for wastewater disposal, depreciation, interest, staffing and plant maintenance, irrespective of the quantity of water discharged and treated in the wastewater treatment plants.

A nationwide survey by the Federal Statistical Office in 2013 provides an insight into the tariff systems used and the broad variation in fee levels. Calculating an average nationwide price for the individual fee components produces the following costs:

- Average wastewater fee: €2.36 per m³ (according to freshwater consumption)
- Average precipitation fee: €0.49 per m², per annum
- Average basic charge: €15.39 per annum.

Taking as an example a standardised two-person household with a wastewater volume of 80 m³ plus a precipitation fee for 80 m² of sealed land and a basic charge, we can calculate the cost of wastewater disposal based on these average figures. In 2010, this translates into an average wastewater disposal cost of €243 for a two-person household.

The level of wastewater prices and the basic principles by which fees are calculated are a much debated topic among the general public. Recent court rulings on the admissibility of selected tariff models could lead to changes in the fee structure, but have thus far no impact on the level of fees.

6.2.7 Water reuse – Urban wastewater and grey water

Water scarcity and drought in arid and semi-arid countries means that in many places, the reuse of wastewater is already an established alternative to the use of limited natural water resources.

Wastewater may be reused for a variety of purposes, although it is most commonly used for agricultural irrigation and groundwater recharge.

Within the EU, Mediterranean Member States affected by water scarcity problems, such as Cyprus, Spain, Italy and Malta are the main user of treated urban wastewater. It has been estimated that in 2006, some 1,000 billion cubic metres per annum of wastewater were reused in the EU, equating to approximately 2.4 % of all treated urban wastewater in the EU[245].

Thanks to favourable climatic conditions, Germany is not lacking in natural water resources. Its irrigation requirements are also correspondingly low (see chapter 3.2.1), accounting for less than 1 % of the available water resources in Germany. Groundwater bodies are in good quantitative status almost everywhere (see chapter 4.1). It is true that longer and more frequent regional drought phases are more likely to occur as a result of climate change. However, as only around 13 % (including energy extraction and cooling) of the available water resources in Germany are currently being used, we do not anticipate water scarcity and a need for alternative water resources, even under dryer conditions.

Nevertheless, there are two locations in Germany–Wolfsburg and Braunschweig–which practise water reuse as a result of historical developments. As well as irrigating agricultural land, also aquifers are recharged with reclaimed water (Wolfsburg) for future use. Both wastewater treatment plants are state-of-the-art; however, investigations at these sites have revealed contamination of the groundwater, in some cases with pharmaceutical residues and radiographic contrast media that are not readily biodegradable, which can be traced back to the use of treated wastewater[246].

As conventional wastewater treatment does not remove all pollutants, using treated wastewater for groundwater recharge or irrigation may potentially introduce micropollutants, pathogens, heavy metals and surplus nutrients into the soil. In the long term, they may accumulate or enter the groundwater. In the short term, contaminants can be absorbed by plants and thus enter the food chain[247].

This poses a hazard to human health and the environment, which cannot always be conclusively predicted or evaluated. Ambitious water quality standards mare needed to ensure that drinking water and cultivated crops remain hygienically safe, the objective of good status of groundwater and surface water is not impaired, and the buffering and filtering function of soil is not damaged. This presupposes advanced wastewater treatment, which is currently being discussed in Germany for a variety of reasons (see chapter 6.2.2).

At European level, common minimum requirements governing the use of treated wastewater for agricultural irrigation are currently being drawn up. In Germany, we do not anticipate that this will lead to the more widespread use of treated wastewater for such purpose.

In industry, industrial wastewater is already recovered on a large scale (see chapter 6.4.3).

Households and small businesses do not necessarily need drinking water-quality water for every use. Particularly in countries that are water-deficient, the use of so-called grey water offers substantial potential savings. Grey water is the portion of domestic sewage excluding faecal matter; however, there is currently no standard international definition of grey water. European Standard 12056-1 “Gravity drainage systems inside buildings” defines grey water as wastewater with a low pollution level and no faecal matter such as produced by showers, baths, hand washbasins and washing machines and that can be used to prepare service water. By contrast, wastewater from the kitchen is not included, due to the high levels of fats and food waste it contains. The quantity of grey water produced is therefore measured primarily by the use of drinking water in the bathroom and for laundry. In Germany, this totals some 56 litres of grey water per person, per day[248].

The microbiological load in grey water usually necessitates some form of treatment. Grey water treatment aims to produce high-grade service water that is hygienically safe and can be used where drinking water quality water is not necessarily required, e.g. for flushing the toilet and for watering the garden. Various treatment technologies are available with proven effectiveness in wastewater treatment (such as separation of solids, biological purification, UV disinfection, ultra-filtration). Grey water treatment facilities must be notified to the competent local health authority in Germany.

6.3 Agriculture

For decades, emissions of nitrogen and phosphorus compounds, as well as pesticide residues from agriculture, have posed a problem for groundwater and surface waters, as well as for coastal waters and seas. A range of environmental policy measures is available to limit these emissions, designed to encourage water protection measures at individual farm level.

6.3.1 Environmental policy mechanisms for water protection

The existing environmental policy mechanisms to reduce waterbody impairments from agriculture may be divided into two categories. As part of regulatory law, acts and ordinances prescribe standards and measures to be complied with by farmers. Failure to comply with these measures is usually subject to sanctions. Farmers must comply with the provisions of regulatory law without compensation, as they represent minimum standards. In addition, financial incentives are available to compensate for the cost of implementing climate- and environment-friendly measures. One of the most important instruments in this regard is the support available under the EU's Common Agricultural Policy (CAP), which supports farmers directly, as well as rural regions. Support is divided into two pillars, the first pillar offering direct payments per hectare of land, and the second comprising support programmes for sustainable, environmentally-friendly management. The CAP was most recently reformed in 2013 for the funding period 2015 to 2020.

Statutory provisions on fertilisers

The Fertiliser Ordinance (Düngeverordnung, DüV)[249] is the central component of fertiliser legislation and an essential component of the national action programme to implement the EU Nitrate Directive[250]. It defines the requirements of the Fertiliser Act (Düngegesetz, DüngG)[251] vis-à-vis the application of fertilisers, soil additives, culture substrates and plant additives. The Fertiliser Ordinance defines good agricultural practice in manuring, with a view to minimising material risks from the application of fertilisers. For fertilisers containing nitrogen, the application periods are restricted, distances from waterbodies are regulated, and upper limits for the application of organic fertilisers are prescribed. To check whether the requirements of the Fertiliser Ordinance are met, annual nutrient comparisons for nitrogen and phosphorus must be prepared. As the provisions of the Ordinance failed to adequately reduce waterbody pollution, and became the subject of infringement proceedings by the EU Commission, it was extensively revised in a very lengthy process and finally adopted in spring 2017. The revised version states that plant-based farm manures (fermentation residues from biogas facilities) must be included in the maximum nitrogen limit for farm manures, and fertiliser planning based on uniform requirements must be made mandatory. Additionally, in future, in heavily fertilised soils, phosphorus may only be used up to the removal limit. The Länder get empowered to arrange additional measures in selected, polluted areas.

Statutory provisions on plant protection

Due to their high potential impacts, only licensed pesticides may be used. The terms and conditions of use stipulated in the licence must be upheld. The licensing and use of pesticides are regulated by European Regulation (EC) No. 1107/2009[252] and the German Plant Protection Act[253]. Additionally, users must observe "Good Plant Protection Practices", a published document[254] containing a wealth of recommendations which are not legally binding for the user. As a general rule, the Plant Protection Act prohibits the use of pesticides where they are likely to have harmful effects on the health of humans and animals or the groundwater, or unjustifiable impacts on the ecosystem. When licensing pesticides, the German Environment Agency assesses the extent to which an active ingredient or its metabolites are able to enter surface waters e.g. as a result of spray drift or runoff, or infiltrate the groundwater and damage the ecosystem. Pesticide licences therefore set out application conditions designed to limit the risk of damage to an ecologically justifiable scale. This could include, for example, minimum distances from waterbodies or other biotopes, the creation of vegetation-covered peripheral strips, or the obligation to use specific spraying techniques.

Statutory provisions on water and soil protection

Farming activities are affected by various water-related provisions in the Federal Water Act[255]. For example, the emission and storage/dumping of substances is prohibited if there is a risk of contaminating the groundwater. Buffer zones at riverbanks are to be preserved, and various activities are listed which are either banned or which may be prohibited under Land law. As well as prohibiting the ploughing up of grassland, this also includes the option of banning the use of fertilisers and pesticides on riverbank buffer zones. The management objectives set up for water (e.g. the threshold value of 50 mg nitrate per litre) have to be equally complied with by agriculture. Further requirements apply to farmers within the context of the Flood Prevention Act, for example when designating water protection areas. Among others, the ploughing up of grassland in flood plains is prohibited, as is the conversion of alluvial forest into other uses. Additionally, other measures may be defined to avoid and minimise erosion of farmland.

Water protection is closely related to soil protection. To protect the soil, the Federal Soil Conservation Act[256] defines the precautionary requirements of “good agricultural practice”. The “Principles for the enforcement of good expert practice in plant protection” published in 1999 were subsequently further elaborated by the Federal/Länder Working Group of the Federal Ministry for Food, Agriculture and Consumer Protection[257]. However, official orders can only be initiated to avert a direct threat (e.g. to avert the threat of harmful soil changes due to soil erosion from water) but not for precaution[258].

Support instruments under the Common Agricultural Policy

The first pillar of the CAP is the core element of EU agricultural support, accounting for around 75% of the total grant volume. It is comprised of land-related direct payments, divided into a basic premium accounting for around 70% of the budget, and a so-called “greening” component for the remaining 30%. Payments under the basic premium are linked to compliance with conditions (“cross-compliance”)[259], such as preserving agricultural land in a “good agricultural and ecological status”. This also includes water protection-related requirements such as the creation of buffer zones along watercourses, protecting groundwater from contamination, and a minimum soil coverage requirement. Compared with the cross-compliance guidelines, which are in between regulatory and support instruments, the greening guidelines introduced in the current period can be seen purely as an incentive instrument. Upon application, farmers undertake to maintain a minimum crop diversity, preserve permanent grassland, and farm 5% of the land eligible for subsidies as a so-called ecological priority area. Additional conditions relating to environmental and nature conservation are also admissible, which frequently also protect soils and waterbodies, but which are of very limited value to the main purpose of ecological priority areas–namely, to promote biodiversity. Organic farms and farms with predominantly grassland or forest remain exempt from the greening requirements. Grants under the first pillar more than compensate for the farmer’s additional expenditure on environmental and nature conservation, and therefore are not an efficient use of public monies, even after the most recent CAP reform.

The principal support instrument under the second pillar of the CAP is the European Agricultural Fund for Rural Development (EAFRD Regulation)[260]. In Germany, this is used for agro-environmental and climate protection measures, by offering farmers incentives to practice eco-friendly, water-friendly production and farming methods (includes numerous water protection measures, such as the creation of buffer zones at river banks, intercropping, use of alternative plant protection measures). The farmers voluntarily commit to uphold the agro-environmental and climate protection conditions defined by the Länder. Around €1.35 billion per annum in EAFRD funds is available for the funding period 2014-2020 in Germany, although this is co-financed by national funds. Additionally, as part of the CAP reform, the funds under the second pillar were cut to just under 25% of the total grant volume. The European Commission (COM) allows the Member States to reallocate up to 15% of funds from the direct payment volume from the first pillar to the second pillar. However, Germany has only opted to reallocate 4.5%. Given the comparatively weak second pillar and the low level of funding in some agro-environmental and climate protection programmes, the willingness for voluntary environmental and climate protection measures is clearly lacking.

6.3.2 Technical water protection measures

The policy measures outlined are all designed, in various ways, to implement the numerous existing technical measures to reduce emissions of nutrients and pesticides into groundwater and surface waters. Below, we consider a few selected measures which, at individual farm level, are suitable for reducing emissions.

Fertiliser management and soil cultivation

Demand-based fertiliser planning which is tailored to the specific nutrient requirements of the crops provides the basis for using fertilisers in a water-friendly way. The aim should be to limit the accumulation, elutriation and leaching of nutrients into groundwater and surface waters to a bare minimum, and to minimise nutrient surpluses. One of the most effective and inexpensive measures is to measure the nutrient levels in the soil and limit the quantity of fertiliser to the required amount. Other water-friendly fertiliser management measures include dispensing with the late fertiliser application for wheat (to reduce high levels of residual N), eliminating fertiliser application after harvesting the main crop (specifically in the case of rapeseed and winter grain, as well as rotting straw), increasing the storage capacity for liquid manure and fermentation residues, and extending the blackout periods for the application of liquid farm manures.

Site-adapted soil cultivation can help to minimise the loss of soil fertility associated with erosion of the nutrient- and humus-rich topsoil. Repeated erosion can reduce water storage capacity, as a result of which seepage decreases and surface runoff increases. Preferred techniques include the mulching and direct sowing methods, the strip-till method, ploughing in spring instead of autumn, and ploughing at right-angles to the slope. Conservation tillage also extends the fallow period and avoids soil and damage compaction. Site-adapted tillage is supported under agro-environmental and climate protection schemes. However, conservation tillage often entails the increased use of total herbicides, which can be particularly disadvantageous for species diversity. Instead of this, weed management in the sense of balanced crop rotation and soil-friendly, mechanical weed control (e.g. with shallow stubble cultivators) would be preferable.

Crop rotation, land use and landscape elements

Crop rotation should be organized in such a way that the humus levels are at least balanced and elutriation losses, surface runoff and soil erosion are avoided as far as possible. Cultivating crops with a high nutrient elutriation potential, such as maize and rapeseed, should be integrated into the crop sequence in a way that coordinates the nutrient demands of the pre-crop with those of the main crop. Similarly, nutrient elutriation and soil erosion after harvesting the main crop can be efficiently avoided by cultivating intermediate crops. Cultivating intermediate crops binds nutrients into the plant mass, which is then available to subsequent crops. The risk of wind and water erosion is reduced, while humus levels and soil humidity are benefited.

Land use changes such as ploughing up permanent grassland leads to extreme nitrate elutriation, by causing very rapid degradation of several decades' worth of humus. Prohibiting the ploughing up of grassland, particularly in areas at risk of erosion and flood-prone zones, and in water meadows and water protection areas, is therefore addressed by regulatory requirements (including the Federal Water Act) and grant eligibility conditions. As well as modified land use, landscape elements such as flower strips, protection strips and buffer zones along waterbodies can effectively reduce nutrient emissions into surface waters. Riverbank buffer zones should not be fertilised, and protection strips must be preserved for at least 5 years and apart from maintenance mowing, must not be subjected to any other use. Regulatory requirements on fertiliser application along waterbodies are outlined in the Fertiliser Ordinance. The creation of riverbank buffer zones at riverbanks is often supported under agro-environmental and climate protection schemes and within the context of greening.

Measures when using pesticides

For improved water protection, all pesticide use should observe integrated plant protection principles. These include the minimisation principle of using "chemicals as a last resort". Variety selection, crop rotation, crop management and biological pest control methods should primarily be used for prevention, and it is important to investigate whether the cost of using a chemical pesticide outweighs its benefits (harmful threshold principle). If pesticide use is

nevertheless necessary, the distance regulations and application guidelines should be stringently observed to avoid leaching and spray drift, and adequately controlled by the competent authorities. Farmers should consistently use spray drift-minimising nozzles, with a technique that ensures the most accurate, loss-free and clean application of pesticides possible. As well as using the right nozzles, it is also important to observe the prescribed application conditions such as pressure, water use and travel speed. Furthermore, spraying equipment should be cleaned on the field, and any residual quantities and cleaning fluids used applied to the field. Discharge into farmyard effluent and the sewage system is prohibited. When using pesticides in land cultivation and on special crops (fruit, wine, hops), the use of mobile spraying equipment with drift-reducing nozzle techniques is generally prescribed by administrative law. To prevent emissions of pesticides into waterbodies, furthermore, the area treated and the adjacent environment should be separated from one another. The creation of permanently overgrown marginal and buffer zones (such as hedges, buffer zones at riverbanks with bushes and trees) are an effective option which is also eligible for grants as an agro-environmental and climate protection or greening measure. The creation of compensation land at individual farm level may also contribute specifically to water protection.

Emission reduction measures should not be limited to authorization and operation but shall also address fertilizer application

6.3.3 Ecologically oriented waterbody maintenance

Article 39 of the Federal Water Act defines waterbody maintenance as the care and development of waterbodies including the banks. Improving the ecological conditions based on the natural type and meeting the requirements of users, e.g. with regard to outflow, are considered equally important. Impairments to the hydrological balance of land ecosystems and wetlands are to be avoided wherever possible.

If land is available along the watercourse, it should ideally be left to develop its own natural dynamics.

Semi-natural elements such as gravel banks may be left as they are. Side shifts may be prompted by deadwood or bank erosion. If streams must remain significantly below the upper edge of the land for drainage purposes, a secondary meadow may be facilitated.

Even if there is no space available, and stream beds are to remain in their current locations, waterbody maintenance can still be carried out carefully to ensure the diversity of waterbody structures, habitats and organisms. Hard bank and bottom structures can often be removed. Mowing, weeding, profile and wood maintenance can be carried out less frequently and more carefully. Shading from the tree line prevents the growth of weeds, and semi-natural structural elements can be left without hindering outflow, even within the current stream profiles. Finally, not all flood damage needs to be repaired, because this is a precursor to structural diversity[261, 262].

6.4 Industry and the extraction of raw materials

6.4.1 The Industrial Emissions Directive

Increasingly, dischargers in the industrial/commercial sector are governed by EU regulations. For example, the 2010 Industrial Emissions Directive 2010/75/EU–often abbreviated to IED–imposes new material requirements that also apply to Germany facilities. The Directive stipulates that the industrial facilities listed in Annex I of the IED must be licensed and operated in an integrated, cross-media approach using the best available technology. In other words, the separate consideration of air pollution control, water protection and waste avoidance/recovery has been replaced by the concept of integrated environmental pollution prevention and control. The relocation of environmental impacts into other environmental media such as air or soil, in contradiction of the best available technology (BAT), must be avoided. The IED demands the EU-wide application of BAT to ensure a high level of protection for "the environment as a whole", with a view to harmonizing the environmental requirements within the EU and avoiding distortions of competition from failing to observe environmental standards.

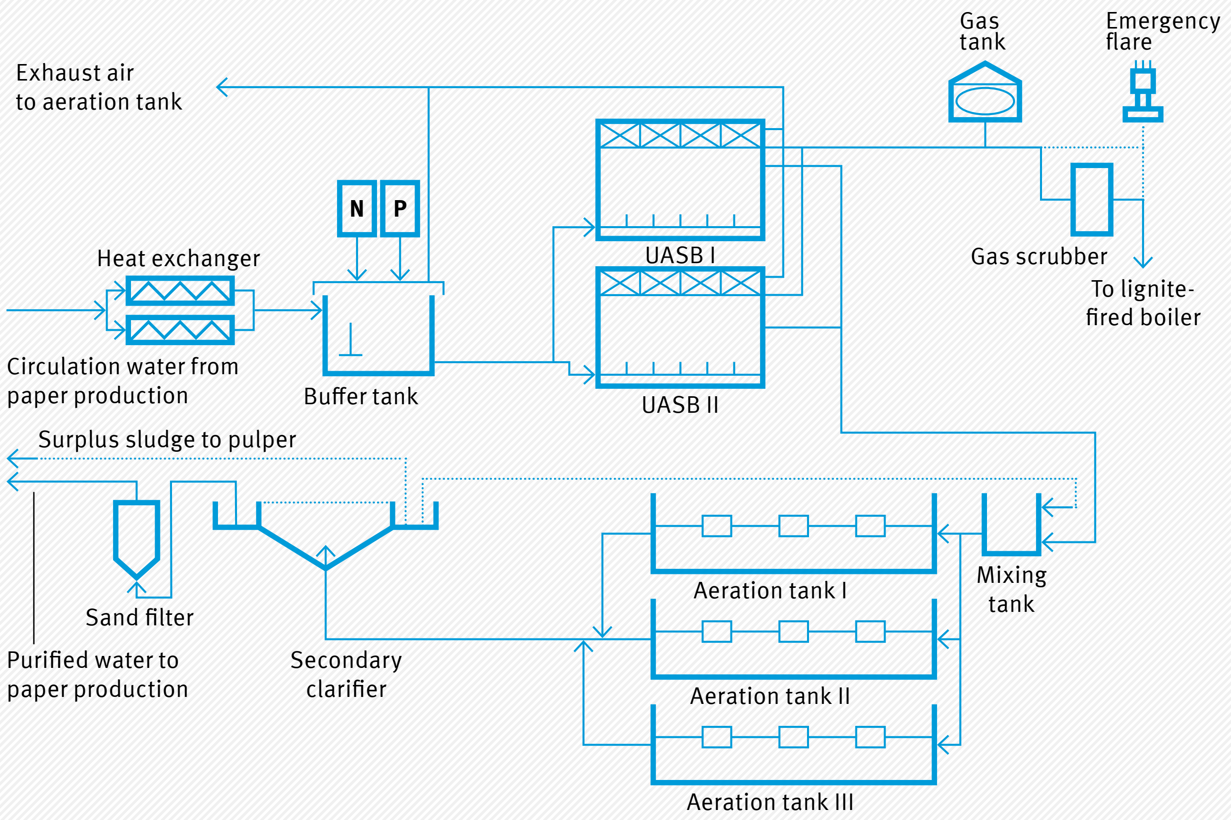
The EU Commission continuously publishes so-called BAT conclusions for all key industrial sectors, which are legally binding within the EU. These include the emission bandwidths associated with the BAT, i.e. binding European emissions standards that in Germany also trigger continuous updates to the industry-specific annexes to the Wastewater Ordinance (see chapter 6.2.1). The Annexes to the Wastewater Ordinance, which are centred on wastewater types and sectors, contain specific avoidance and treatment measures as minimum requirements for the discharge of wastewater into waterbodies. Since the amendment to the Wastewater Ordinance of 2 September 2014 (and most recently its 7th revision of 8 June 2016), the updated Annexes to the Wastewater Ordinance also contain all provisions on the EU's water-related BAT. Discharge permits will only be issued if the discharger carries out the minimum measures to avoid and minimise wastewater emissions according to the best available technology, as outlined in the relevant Annex to the Wastewater Ordinance. In this way, the discharging facility can then be analysed and evaluated in its entirety on a sector-by-sector basis, as outlined in the EU's BAT conclusions; avoidance and minimisation measures are more easily optimised. Particularly for hazardous substances (such as cadmium, mercury), requirements can also be defined before mixing with other wastewater in the substream or at the transfer point into the public sewer network (indirect dischargers). By focusing on specific sectors (such as metals, textiles industry, food and paper production) and selecting the parameters to be limited, especially guideline and

Example: "Zero Liquid Discharge" at the Smurfit Kappa Zülpich paper factory

Paper manufacturing usually entails a high level of water consumption. Smurfit Kappa Zülpich demonstrates that there are alternatives. The company has been manufacturing paper in a closed, wastewater-free water cycle ("zero liquid discharge") since 1970. With an integrated cyclical water treatment plant, in 1996 it introduced a new technical concept to safeguard the closed hydrological cycle. Zülpich Papier produces up to 450,000 t/a of raw corrugated papers from 100% waste paper on two paper machines. The cyclical water treatment plant is designed as an anaerobic/aerobic plant. However, unlike the usual practice in this industry, the treated process water is not discharged into waterbodies, but instead is returned in full to the process after passing through a number of stages (see illustration). The operating costs of the cyclical water plant are compensated by the use of the biogas produced. What is more, there are no wastewater fees, and fresh water is only needed to compensate for evaporation. However, the plant does require greater organisational and monitoring effort in terms of both personnel and technology.

Figure 75

Schematic illustration of the integrated cyclical water treatment plant at the Smurfit Kappa Zülpich paper factory



Source: Diedrich et al. (1996), Institut für Papierfabrikation an der Technischen Hochschule Darmstadt
Abwasservermeidung durch geschlossene Produktionskreisläufe mit integrierter Kreislaufwasserbehandlungsanlage in einer Papierfabrik, Abschlussbericht Nr. 7041, December 1996

collective parameters (such as TOC, TN_b, BOD_5, filterable substances and AOX) and effect parameters (i.e. biotests e.g. using fish eggs, water fleas, duckweed, luminescent bacteria), the measurement and monitoring effort can be kept to a reasonable scale. In accordance with the sector or wastewater type concept, therefore, rather than specifying requirements for specific individual substances, wastewater origin areas or sectors are defined where the best available technology (materially equivalent to the European BAT) must be applied. At European level, the requirements are defined in the BAT conclusions and–after updating–in the corresponding Annexes to the Wastewater Ordinance.

6.4.2 Industrial wastewater avoidance

In the industrial and commercial sector, wastewater avoidance refers to the use of processes that produce little or no wastewater. For example, this includes the use of production processes with zero sewage disposal, converting to water-conserving in-house circulatory systems, or using dry cooling towers instead of wet cooling towers. The Wastewater Ordinance supports the concept of avoidance via the general requirement that wastewater may only be discharged into a waterbody if the pollutant load is kept as low as possible via the use of water-saving procedures such as washing and cleaning operations, indirect cooling and the use of low-pollutant feedstocks and auxiliary materials (§ 3 of the Wastewater Ordinance). The industry-specific annexes to the Wastewater Ordinance outline measures for wastewater avoidance in greater detail. Avoiding wastewater by using wastewater-free techniques as far as possible is a demanding and often complex technical alternative for effectively reducing emissions into waterbodies. It generally requires a comprehensive in-house water management concept to measure and analyse the relevant material and water flows, and ensure optimum separation, combination and (where applicable) treatment.

There are numerous manufacturing processes and examples which largely (and in some cases completely) avoid the discharge of wastewater through a combination of measures, thereby preventing harmful effects in the waterbodies. For example, the following sectors and activities may lend themselves to wastewater-free production:

- Wastewater-free paper manufacturing (e.g. brown packaging paper)
- Wastewater-free flue gas scrubbing (e.g. with the combustion of lignite or municipal solid waste)
- Wastewater-free vehicle cleaning
- Wastewater-free powder-coating

Technologies which are not completely wastewater-free but which can significantly reduce wastewater volumes and pollutant loads should also be considered in this context. Examples include membrane technology, which has made significant progress in recent years, so that plant operators now have access to a broader range of application options with the various wastewater treatment techniques. Membrane techniques often have multiple advantages over conventional techniques such as precipitation/flocculation and biological techniques. For example, they facilitate

- Extensive wastewater treatment for virtually all wastewater parameters,
- Multiple reuse options for water as a production resource, and in many cases, additionally
- The production or derivation of hygienically faultless wastewater.

As always, the challenges associated with the more widespread use of such technology in plants include cost aspects, the need for wastewater pre-treatment adapted to each individual case, the required knowledge of operator personnel, and in some cases, more extensive inspections and measurements if membrane techniques are to be integrated into a factory's process water circuits.

6.4.3 Recovery of industrial wastewater as a raw material

The recovery of water as a resource for sustainable materials management in Germany, with a potential water supply of 188 billion m^3/a but which only uses approximately 25.1 billion m^3/a, is not an environmental imperative. However, alongside a slew of other criteria, the IED cites the careful stewardship of water as an important criterion for determining the best available technology[263]. This aspect has been adopted into the definition of the best available technology (BAT) in the Federal Water Act[264]. Reduced water consumption has thus acquired independent status, and wastewater itself is no longer seen merely as a source of pollution for the "environment resource water", but also as a production resource with its own intrinsic value. The recirculation of treated warmed-up industrial wastewater can additionally contribute to significant energy savings as the recirculated process water (e.g. in a paper factory) has a higher energy level as compared to the well water.

6.4.4 Installation-related water protection

For installations that handle substances constituting a hazard to water, the concern principle as outlined in the Federal Water Act applies to the protection of waterbodies. "Installations" are defined as stationary, structural properties for the storage, manufacturing and handling of substances and mixtures that are hazardous to water. The Act states that no adverse impacts on waterbodies must occur as a result of the properties, operation or decommissioning of such installations. Essentially, this means that they must be designed and operated in such a way that no substances are emitted (see chapter 3.3.2 with regard to accidents). To this end, the substances and mixtures used in the installations must be analysed and classified according to their water hazard potential.

Classification of substances hazardous to water

Since 1 August 2017, classification has been based on the Ordinance on Installations for Handling of Substances Hazardous to Water (AwSV)[264], which replaces the previous classification under the General Administrative Provision on the Classification of Substances Hazardous to Water (VwVwS) of 17 May 1999 and the General Administrative Provision Amending the VwVwS[266] of 27 July 2005.

As before, classification under the AwSV distinguishes three water hazard classes:
1. slightly hazardous to water
2. obviously hazardous to water
3. highly hazardous to water

Substances with zero water hazard potential are classed as "non-hazardous to water". The new category "generally hazardous to water" has been introduced for selected substances and mixtures. This also includes floating, liquid substances which are not otherwise considered hazardous to the aquatic environment that have been published in a separate list by the German Environment Agency. Annex 1 to the AwSV sets out the decisive classification criteria, harmonizing the water hazard classes with the CLP Regulation (Regulation on classification, labelling and packaging of substances and mixtures, EC No. 1272/2008). This therefore enables classification in accordance with the GHS (Globally Harmonised System) for the classification and labelling of chemicals.

Classification of a substance in a water hazard class or as non-hazardous to water may either be taken from the publication in the Federal Gazette, or else the plant operator must submit an application to the German Environment Agency documenting self-classification in accordance with Annex 1 to the AwSV.

To date, the water hazard classes of around 10,000 substances and substance groups have been documented, reviewed and published on the Internet by the German Environment Agency[267]. Substances, substance groups and mixtures that have already been classified by or on the basis of the VwVwS are considered to have legally binding effect upon entry into force of the new AwSV.

Based on self-classification by the plant operator, the German Environment Agency decides on the final classification of substances. The decision is initially notified to the documenting plant operator and the classification is then published with legally binding effect for everyone in the Federal Gazette and on the Internet. In this connection, the German Environment Agency may seek the advice of the Commission for the Evaluation of Substances Hazardous to Waters. Plant operators are obliged to notify the German Environment Agency without delay of any information at their disposal which could prompt the amendment of a published water hazard classification.

The water hazard class of mixtures can be derived from the published water hazard classifications of the constituent materials via application of a mixtures rule (AwSV, Annex 1). § 3, paragraph (4) of the AwSV states that substances whose water hazard class has not yet been published and for which there are insufficient studies available on toxicity and environmental hazardousness should be classified in the highest water hazard class as a precaution, in keeping with the concern principle anchored in the Federal Water Act.

The water hazard classification system designed for process safety is therefore an expedient addition to hazardous substances law for preventing damage to waters, particularly when handling untested substances. At the same time, classification creates a permanent incentive to substitute particularly hazardous or poorly documented substances with others that are less hazardous to water and have been well-tested.

Requirements for installations

The requirements applicable to an installation are based on the potential hazard level, derived from

- The water hazard potential of the substances being handled (using the water hazard class)
- The quantity of substances hazardous to water contained in the installation
- The local conditions (proximity to water protection areas etc.)

The higher the potential hazard, the more stringent the requirements governing the installation's operation and safety.

The plant operator is required to ensure documented compliance with the technical (material properties, collection devices, plant surveillance using suitable technology) and organizational requirements (operating instructions, training, contingency plans) placed on the operation of installations for handling substances constituting a hazard to water.

Until now, installation-related water protection was regulated in the respective ordinances on the handling of substances hazardous to water (VAwS) of the Länder. In order to ensure uniform, nationwide safety standards, the national Ordinance on Installations for the Handling of Substances Hazardous to Water (AwSV) replaced the previous Länder ordinances.

In addition to the AwSV, which refers specifically to water legislation, installations for handling substances constituting a hazard to water may also be subject to the Major Accidents Ordinance (12th Ordinance for the Implementation of the Federal Immission Control Act, 12th BImSchV)[268], which defines additional requirements on plant safety. In EU law, the 12th BImSchV is based on the Seveso III Directive 2012/18/EU[269]. Whether or not an installation is additionally required to meet the requirements of the 12th BImSchV is determined, firstly, by the actual or potential volume of hazardous substances. In this regard, the volume limits outlined in Annex I to the 12th BImSchV must be observed. Secondly, unlike conventional water legislation, rather than using the water hazard class to assess the substances present in the installations, the hazard statements under the CLP Regulation itself are used; these are the underlying basis for determining the water hazard class. Both of these criteria combined provide an indication of whether the safety requirements regulated in the 12th BImSchV must be met in addition to the requirements under water legislation.

6.4.5 Mining

Measures in the mining sector are aimed at reducing emissions from point and diffuse sources, minimising water abstractions, and reducing acidification caused by mining.

Measures to minimise point material emissions from mining include separate treatment of the minewater, controlling emissions of pit or tailings water into the outfall, and the preparation of feasibility studies.

Separate programmes are usually put in place to monitor diffuse material emissions from mining in order to obtain precise statements on the nature and amount of the discharge and, based on this, to define effective counter-measures. It is difficult to minimise material emissions from diffuse sources, some of which continue to enter waterbodies even decades after the mine has closed.

To reduce water abstractions from mining and prevent a decrease in groundwater volume, for example, official licences are adapted to the level of water abstractions.

Measures to reduce acidification caused by mining include the interim greening of refuse dumps and the liming of heavily acidified soils or waterbodies.

Often, the hydrological regime has been so severely disrupted by mining that it is seemingly impossible to improve the quantitative and chemical status of affected waterbodies by the set deadline. Safety risks associated with the flooding of mining lakes or the renaturation of slag heaps may impede remediation.

6.4.6 Deep sea mining

To limit the ecological risks described under

3.3.4, the German Environment Agency recommends the development and application of ambitious environmental standards for the mining of marine metal feedstock. There is an opportunity to develop these international requirements before mining begins.

As well as drafting and applying such standards, there is also talk of developing an environmental strategy for the International Seabed Authority (ISA). The core elements of such a strategy might include instruments for advanced spatial planning, overcoming planning conflicts with other competing uses (fishing, cable-laying) and between individual mining projects, adaptive management tools based on dynamic operator obligations, and an effective, strategic environmental audit and environmental impact assessment. However, normative criteria are also particularly important for reviewing the admissibility of individual projects, since these will ultimately determine the protection standards for the deep seabed. All these observations are based on the precautionary principle.

6.5 Energy

6.5.1 Heat load planning

As outlined in chapter 3.4.1, the abstraction of cooling water represents an ecological pressure for the waterbody concerned.

So as not to endanger the biotic community in the waterbody, maximum waterbody temperatures are defined, depending on the watercourse type and resident fish community, and limits on the admissible maximum temperature increase are imposed. These values are prescribed in the Surface Waters Protection Ordinance (Annex 7 to the OGewV) for the specific watercourse types and the fish communities that occur in them. The abstraction of cooling water must not endanger achieving good ecological status. For a comprehensive evaluation of a cooling water discharge, it is necessary to consider the discharge of heat into the entire river basin. Thermal load plans may offer a suitable mechanism in this regard. A LAWA guidance document summarises the requisite background information and represents an important basis for the assessment of cooling water discharges into waterbodies from a water resource management and hydro-ecological viewpoint[270].

6.5.2 Geothermal energy

In chapter 3.4.1, we considered the difference between near-surface geothermal and deep geothermal energy. This distinction is retained here when outlining measures for tackling the risks to groundwater.

Near-surface geothermal energy

Underground intrusions for utilising near-surface geothermal energy often occur in areas with groundwater that is suitable for drinking water abstraction. Not least due to the large number of intrusions, permanent quality assurance measures must be in place during the construction (specifically, the borehole itself and expansion of the borehole) and the operation and dismantling of geothermal installations. Many Länder have adopted requirements to ensure the safe handling of near-surface geothermal energy, generally in the form of guidance documents. These outline the statutory guidelines on water and mining legislation and their enforcement. Many of these guidance documents are very detailed and often stipulate compliance with recommendations in administrative regulations (DIN, VDI and DVGW)–for example, only specially certified drilling companies may be used. In areas with difficult underground geological and hydrogeological conditions, particular precautions must be taken when planning and executing the borehole[271]. The duty of care in the interests of groundwater protection includes adequate dimensioning of the facilities, with a view to avoiding excessive temperature changes compared with the initial status.

Deep geothermal energy

Two expert reports commissioned by the German Environment Agency focused on assessing the risks associated with deep geothermia[272]. Their recommendations are designed to minimize or eliminate the risks to groundwater. Above all, not least in view of the small number of existing facilities, they recommend extensive monitoring measures and intensive scientific accompaniment of the project. Seismological monitoring is now a standard requirement, as stated in the expert report by the Federal Institute for Geosciences and Natural Resources (BGR). This is a tool for influencing induced seismicity (as opposed to

Ground heat collectors take up the thermic energy saved in the underground and transport it to the heat pump

natural earthquakes) by regulating the water pressure. To protect the groundwater, it is important to observe existing standards when drilling. Additionally, hydrogeological monitoring stations should be set up, and sampling should begin before the construction phase starts, to create an effective early warning system. Cuttings and polluted deep water arising during drilling must be properly disposed of.

6.5.3 Carbon capture and storage (CCS)

To prevent damage from CO_2 injected into saline aquifers, into oil and gas reservoirs or into the marine subsoil, it must be placed in long-term storage (ideally for several millennia). In particular, old and inadequately sealed boreholes pose a potential threat to safety. Being a comparatively new technology, our experience of CO_2 persistence in such borehole seals is confined to a few decades. As well as the borehole seals, the pressure rise in the reservoir rock caused by the imported CO_2 is also an important consideration. It is essential that this is kept within narrow limits to avoid mechanical impairment to the covering layers. As well as monitoring shallow and/or managed groundwater aquifers, it is also extremely important to monitor all groundwater aquifers from the carbon dioxide store to the highest groundwater aquifer. Exceptional diligence is required when monitoring marine ecosystems. The obligation set out in the Carbon Dioxide Storage Act (KSpG)[273] to avert risks means that monitoring should begin at the site of origination, i.e. the carbon dioxide store itself. It is important to remember that the different release mechanisms require dedicated forecasting and monitoring instruments. Regarding the requirements to protect groundwater, we should differentiate between managed groundwater aquifers and non-managed groundwater aquifers. The managed groundwater aquifers tend to be shallow groundwater aquifers carrying fresh water. However, the uses of deep groundwater, e.g. for the abstraction of brine, mineral water and curative waters, must also be considered.

6.5.4 Fracking

In Germany, there are a number of legal and technical regulations designed to minimise the risk of groundwater contamination from deep drillings. On 24 June 2016, the Bundestag adopted a package of legislation on fracking technology, comprised of three skeleton regulations concerning water and environmental law[274] and mining regulations[275]. The principal content of these regulations is as follows:

- Fracking in shale, marl, clay, and coal seam rocks (unconventional fracking[276]) is generally prohibited. The ban will be reviewed by the Bundestag on 31 December 2021.
- As an exception, unconventional fracking may be authorised for a total of four experimental fracking measures, which must be accompanied by an independent expert commission. The aim is to investigate the impacts of this technology on the environment, particularly the subsoil and the hydrological regime. The affected Land government must approve the experimental measure.
- Furthermore, fracking measures are generally prohibited in or below protected areas, such as water protection and mineral spa protection areas, as well as the catchment areas of lakes and reservoirs used for public water supply.
- There are stringent rules governing licensable fracking measures in dense sandstone (conventional fracking) and deep geothermia, such as a mandatory environmental impact assessment, comprehensive monitoring, and compliance with the best available technology for fracking measures and for disposal of the deposit water.

The measures recommended by the German Environment Agency to minimise the risks of fracking have to a large extent been transposed into the revisions to the Federal Water Act and mining legislation[277].

6.5.5 Offshore wind power – Licensing procedure and minimising environmental impacts

Revision of offshore planning

During the course of refocusing the Renewable Energy Sources Act (EEG) in 2017[278], particularly the introduction of a tendering process, the framework conditions for offshore wind power have been revised. The Wind Energy at Sea Act was adopted and integrated into the 2017 Renewable Energy Sources Act with the aim of continuously developing and cost-efficiently promoting the expansion of offshore wind power. As well as formulating the invitations to tender, the Act also regulates prior land development and installation approval by integrating parts of the Offshore Installations Ordinance and coordinating offshore expansion with connection to the grid. In this way, key aspects of offshore wind power, such as land use planning, licensing, remuneration and grid expansion are coordinated with one another, and integrated into one Act.

Tendering for offshore wind farms will be introduced for all installations that begin operation from 2021 onwards.

The core element of the central tendering system is a preliminary examination of the land and the specification of a land development plan, incorporating parts of the former offshore network development plan and the German offshore plan. This therefore constitutes the central planning instrument. The preliminary land inspection carried out by the Federal Maritime & Hydrographic Agency (BSH), which determines suitability as a wind farm site in the land development plan, focuses on a number of aspects, including an analysis of the impacts on protected environmental assets, preliminary analyses of the subsoil, shipping collision analyses, and wind appraisals. This ensures that land is investigated and assessed using uniform yardsticks, including standard environmental and nature conservation aspects. In this way, all bidders receive the same initial information, and the approval phase is shortened, because wind farm operators are no longer required to procure the aforementioned information themselves. As before, wind farm operators must undergo a plan approval procedure. Applications for plan approval can only be submitted by wind farm operators with winning bids.

Minimising environmental impacts

chapter 3.4.5 addresses the environmental impacts of offshore wind power. Below, we outline a number of measures designed to minimise the adverse impacts:

To protect migrating birds, the German Environment Agency recommends the need-based lighting of offshore wind farms. To minimise bird losses from collisions, following an assessment, the licensing authorities reserve the right to require wind farms to fit deterrents or be temporarily switched off during nights with extensive bird migrations that coincide with poor weather and visibility conditions.

To prevent damage to porpoises–a key species–from the noise associated with pile-driving during the construction of offshore wind farms, the UBA recommends dual noise protection limits of 160 decibels sound exposure level and 190 decibels peak sound level at a distance of 750 metres from the source of the sound. The Federal Maritime & Hydrographic Agency (BSH) has adopted this recommendation and incorporated it into its licensing permits. The dual criterion was subsequently integrated into the noise protection concept applicable to the construction of offshore wind farms in the EEZ of the German North Sea, published by the BMUB on 1 December 2013[279].

Additionally, when connecting offshore wind farms to onshore power grids, it is important to protect the environment as far as possible. This includes bundling cables, routing them parallel to existing transmission routes, selecting the shortest possible path, and laying outside of protected NATURA 2000 areas wherever possible.

6.5.6 Offshore petroleum and gas extraction

The United Nations Convention on the Law of the Sea, the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) together with the Convention on the Protection of the Marine Environment of the Baltic Sea (HELCOM), provide the legal framework for the offshore oil and gas industry.

Following the explosion on the oil drilling platform "Deepwater Horizon" in the Gulf of Mexico in April 2010, the EU Commission undertook a comprehensive review of all safety concerns in the offshore oil and gas industry for all European seas, including the OSPAR Convention area. Following on from this review, on 12 June 2013 the EU Commission published Directive 2013/30/EU[280] of the European Parliament and of the Council on safety of offshore oil and gas operations.

The Federal Mining Act (Bundesberggesetz, BBergG) regulates the detection, extraction and processing of mineral resources with the aim of protecting raw material supplies. Pipelines laid to transport the raw materials likewise fall within the regulatory scope of the BBergG.

The aforementioned Directives and regulations are intended to reduce or prevent potential oil emissions from offshore installations.

6.5.7 Hydropower

Given that less than 20 % of watercourse sections in Germany have a waterbody structure that has been classified as unaltered to moderately altered, partly due to hydropower use, and there is negligible potential for building new capacity to meet the expansion targets for renewable energies, particularly in the case of smaller plants, it would be inappropriate to build any new hydropower plants in the few remaining undeveloped, passable sections of waterbody. Existing hydropower potential should only be maximised through modernisation or replacement construction. Modernising or reactivating hydropower plants should aim to optimise the plant's design and operating mode to improve the ecological balance in the water, as well as in connected terrestrial ecosystems and wetlands. In this regard, the legislator sets demanding requirements in the Federal Water Act[281] and in the fishing legislation of the Länder. These state that hydropower plants must take measures to maintain the passability of the waterbody and ensure minimum flow rates. The aspects of fish ladders (Figure 76), fish conservation and fish passes should be considered on a site-by-site basis to ensure ecological passability at the dam and the hydropower plant. When considering upstream continuity, passability for smaller, bottom-dwelling biotic communities must also be ensured. These days, the size and design of fish ladders can be dimensioned and built precisely according to the spectrum of fish species needed to pass upstream, with the aid of technical regulations. Because of their size, large species such as pike and catfish need suitable solutions.

There are various options available for minimising damage to fish at hydropower plants, the use of which should be decided on a site-specific basis. The spectrum of measures ranges from fish protection grids combined with fish bypass systems that prevent the fish of a certain size from entering the turbine zone, to operational or catch-and-transport measures, through to the installation of less harmful turbines. Particularly on larger hydropower plants capable of processing more than 50 m³/s of water in one turbine, so-called fish-modified operation of the plant can help to improve the fish bypass situation[282]. Early warning systems that record shoals of descending fish, particularly eel, emit an alarm which opens the weir for the descending eel or ensures maximum opening of the turbines. On the Rivers Moselle and Main, eel are caught before the hydropower turbines and released again below the last hydropower plant in the Rhine (catch and transport), allowing them to continue on their way to the Saragossa Sea undamaged. However, measures to improve habitat diversity or to reactivate the transportation of bed material can also be used to improve ecological status. At run-of-river power plants, it is vital that sufficient water remains in the original riverbed at all times, and only the part of the outflow that is not needed by the biotic communities is used for electricity generation. The range of measures relating to hydropower plants is also eligible for financial support on a case-by-case basis, depending on the Länder competencies. If the hydropower plant operator achieves higher revenues from the EEG by increasing the plant's capacity, it must also meet the legal requirements of the Federal Water Act in full.

6.5.8 Handling of bioenergy

Bioenergy crops are currently cultivated on more than 17% of arable land in Germany. Together with biomass from grassland and forests, as well as imported biomass, they produce less than 9% of total energy, indicating the poor land efficiency of bioenergy. Significantly more energy could be "harvested" on the same land with other renewable energies such as wind power and solar energy. To avoid the adverse environmental impacts of bioenergy, the German Environment Agency therefore advocates that only biogenic residues and wastes which cannot be more valuably recovered should be used to supply bioenergy[283]. The necessary rethink of subsidy provisions began with the abolition of the so-called NaWaRo bonus and the introduction of the maize cap under the 2017 Renewable Energy Sources Act (EEG)[284] and the sustainability ordinances for liquid biomass in the electricity and biofuels sector[285]. However, the expansion path for bioenergy set out in the 2017 EEG (150 MW gross/a from 2017 to 2019, and 200 MW

Fish ladder on the Moselle

Figure 76

gross/a from 2020 to 2022) is still excessive, while the use of residues and waste materials, such as waste wood, is not being adequately promoted. The environmental and management standards for the cultivation of energy crops defined with the 2009 sustainability ordinances for liquid biomass in the electricity and biofuels sector are likewise inadequate from a water protection perspective. The requirements are limited to good agricultural practice and cross-compliance regulations, and do not extend beyond this.

As long as renewable raw materials are produced for bioenergy use, it is far more important to observe the same principles of site-adapted, water-friendly management for energy crop cultivation as for other crops. Furthermore, the options of using plants for energy should always be exploited to reduce the use of fertilisers, pesticides and diffuse nutrient emissions. Such options include mixed cropping and dual crop systems, extending the range of species to include new cultivars such as millet, silphium perfoliatum and topinambur, and the cultivation of quick-growing timbers in plantations with a short rotation period. Grassland must be used in a water-friendly manner.

Fermentation residues play a central role in the operation of biogas plants. The inclusion of plant-based fermentation residues in the application limit set to 170 kg N/ha of organic fertilizer[286] represents an important step forwards for the more eco-friendly recycling of fermentation residues.

The targeted, precisely timed application of fermentation residues pre-supposes adequate storage capacities. Separating fermentation residues into a liquid and a solid phase and reducing the volume can reduce the required storage capacities and facilitate the transport of nutrient-rich fermentation residues to regions with a low cattle density. However, the treatment procedures for fermentation residues are not yet widely established. Furthermore, the problems of very high nutrient surpluses at regional level should be solved by changing the agricultural structure, and not purely by technical means.

When storing fermentation residues and silage, care should be taken to prevent material emissions into waterbodies. Minimum requirements such as only storing solid fermentation residues on stabilised land must be regulated by means of fertiliser, water and waste regulations. The prevention of other emissions is envisioned under the amendment of the Technical Instructions on Air Quality Control.

6.6 Transport

6.6.1 Inland shipping

The federal waterways reflect centuries of development and cultivation of our riverine landscapes for human settlements, agriculture, electricity generation and goods transportation, together with the consequences of restrictive flood protection and material pressures. Real success in water protection can only be achieved here through the combined efforts of the Federation, Länder, associations, riparian owners and water body users. One example is the reduction in wastewater load since the late 1970s, thanks to the construction of wastewater treatment plants. Implementation of the Water Framework Directive and the national flood protection programme have recently prompted a wide range of activities on federal waterways, whereby the focus is no longer solely on reducing material emissions. It is possible to minimise the impacts of river engineering measures on the water body ecology of federal waterways without significantly impairing their use for shipping purposes (Figure 77). To this end, integrated water body development concepts for Federal shipping lanes are being developed at a supra-regional level, combining aspects of shipping, flood protection, nature conservation, hydropower (where applicable) and water resource management. The ongoing development of an overall concept for the River Elbe[287] is a good example of this intensive collaboration between the Federation, Länder and relevant associations.

The division of competencies between the Federation and Länder, which for decades has hindered a comprehensive approach to Federal waterways in the community interest, is being reorganised under the Federal “Blue Band”[288] programme. In future, it should also be possible for the Federation to take action to improve ecological status, as is currently the case with measures to create river continuity at dams on Federal waterways and for waterbody maintenance. Another key environmental aspect lies in maximising the use of existing transport potential on Federal waterways to prevent further technical modification of the waterways and a further loss of valuable riverine and floodplain landscapes. This necessitates improvements at a nautical level, such as modern transport management, fleet modernisation and the logistical linking of transport carriers via the creation of intermodal interfaces at port locations. This would also help to ease the pressure on the environment from the pollutants still being emitted in large quantities by ships with outmoded engines. Other direct impacts of shipping on waterbody status, e.g. as a result of cargo residues or wastewater, are regulated by specific conventions (such as the Convention on the Collection, Deposit and Reception of Waste Produced During Navigation on the Rhine and Inland Waterways (CDNI))[289].

6.6.2 Maritime shipping

The International Maritime Organization (IMO) is a global authority and sets the rules for international shipping. Within the IMO, environmental protection issues are addressed by the Marine Environmental Protection Committee (MEPC[290]) and predominantly outlined in the “International Convention for the Prevention of Pollution from Ships” (MARPOL).

The MARPOL Convention comprises the original Convention, two additional Protocols and six Annexes[291]. Annexes I to VI of the Convention regulate the different types of pollution in conjunction with shipping:

- Annex I: Regulations for the Prevention of Pollution by Oil
- Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
- Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
- Annex IV: Prevention of Pollution by Sewage from Ships

Federal waterways have considerable renaturation potential. The River Elbe at low water

Figure 77

- Annex V: Prevention of Pollution by Garbage from Ships
- Annex VI: Prevention of Air Pollution from Ships

Other key IMO conventions that are relevant to environmental protection in shipping are:

- The 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and its 1996 Protocol updating the Convention (London Convention)
- The International Convention on the Control of Harmful Anti-Fouling Systems on Ships (AFS Convention, 2001)
- The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM convention; adopted in 2004; entered into force on 8 September 2017)
- The International Convention for the Safe and Environmentally Sound Recycling of Ships (Hong Kong Convention; adopted in 2009; not yet in force)

Other regional measures above and beyond this, whether at EU level or from HELCOM for the Baltic Sea region, may improve the protection of sensitive marine regions, but their effects are concentrated on a limited marine region or shipping segment, and can therefore be particularly difficult to implement politically.

In 2016, HELCOM published the "Baltic Sea Clean Shipping Guide"[292], summarising the environmental regulations and maritime shipping peculiarities applicable to the Baltic Sea, such as navigation requirements (transport separation schemes, icing) and special environmental conditions.

Prevention of Pollution by Oil

In Germany, the Central Command for Maritime Emergencies 293, an institution operated by the Federation and the coastal Länder, is responsible for joint accident management on the North and Baltic Seas in the event of emergencies such as oil pollution from ships and shipping accidents. It combines responsibility for the planning, preparation, practising and execution of fire control measures. In particular, the Marine Pollution Response Inshore unit organises oil and pollution management along coasts, estuaries, ports, shore zones and beaches on behalf of the five coastal Länder in northern Germany.

Waste/marine litter

In 2011, Annex V to the MARPOL Convention was revised, and now prohibits the discharge of all garbage into the sea from ships; exceptions are only admissible for certain types of litter. The new, more stringent regulations entered into force in 2013. The general ban on the discharge of plastics, plastic ropes, fishing nets, plastic bags and packaging materials has been extended (*inter alia*) to include incinerated waste (ash), glass, oil, paper, rags and bottles.

The North and Baltic Seas have been designated as special areas under MARPOL Annex V since 1991 and 1988 respectively. The EU Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues was adopted in 2000, with the aim of improving the disposal options for shipping waste and cargo residues in European ports. HELCOM has also adopted a number of recommendations for the Baltic Sea region, most recently in 2007, with HELCOM Recommendation 28E/10 "Application of the no-special fee system to ship-generated wastes and marine litter caught in fishing nets in the Baltic Sea area"[294], which introduced the "no-special-fee" system. This means that no additional costs incur for the onshore disposal of ship-generated waste at Baltic Sea ports, since this is already covered by the port fees. The fact that wastes from shipping only account for a minor proportion of Baltic Sea litter could indicate that the measures are having a positive effect. Analogous to the procedure for the Baltic Sea, the on-going revision of the EU Directive 2000/59/EC on port reception facilities should be used to ensure the uniform and uncomplicated acceptance of wastes are easily accepted in all European ports, with disposal fees already being included in the port fees. This should create an incentive to dispose of ship-generated waste onshore. The regional action plans for marine litter in the Baltic Sea and the North-East Atlantic likewise envisage measures to prevent pollution of the seas by ship-generated wastes. Proposals include the expansion of the "no-special-fee" system and measures regarding the handling of waste from the fishing sector (see chapter 6.7).

Wastewater

The provisions in MARPOL Annex IV primarily regulate the discharge of wastewater from ships into the sea; other agreements and national legislation are based on these regulations. The MARPOL provisions on the discharge of wastewater have been adopted for the North Sea and the North-East Atlantic. In 2011, the IMO designated the Baltic Sea the first, and so far only, special area under MARPOL Annex IV[295]. The more stringent provisions apply to the discharge of wastewater into the sea and its collection in the port, but only for passenger ships, i.e. ferries and cruise ships. With their large numbers of passengers and crew, these types of ships also produce substantial quantities of wastewater, which may significantly contribute to the eutrophication and pollution of the sensitive Baltic Sea marine region. These provisions will enter into force in 2019 for new ships, and in 2021 for existing vessels.

Under the HELCOM Convention (Annex IV[296], Regulation 5: Discharge of sewage by other ships), the MARPOL provisions are, in the Baltic Sea region, additionally applicable to smaller vessels and sports boats with a toilet on board. In these cases, the fitting of wastewater retention facilities on board is obligatory to have wastewater disposed of in collecting facilities in the port.

Introduction of non-indigenous species

To reduce the introduction of non-native species by international shipping, the Ballast Water Management Convention was adopted in 2004 under the IMO, and entered into force on 8 September 2017.

The Convention provides for the treatment of ballast water on board every ship, aiming at substantially reducing the number of organisms released with the ballast water. Systems that treat the ballast water, e.g. with chemicals (biocides) or UV light may be used[297]. The systems must be certified to document both, their effectiveness at reducing organisms and the harmlessness of the chemicals for the marine environment.

New coating concepts are being developed, including the use of nanoparticles and silicone, to reduce the transport of organisms on the ships' hull and, at the same time, to minimise the use of harmful biocides in ships' coatings. However, a comprehensive investigation into the potential eco-toxicological effects of such materials is still needed.

The environmental risks of all active biocide ingredients are currently being assessed under the Biocides Regulation (EU) No. 528/2012. In a second step, all (anti-fouling) products that contain biocides will also be investigated. This process is expected to be completed by 2027. As a consequence, only tested products will be placed on the market. Since all biocides harbour a certain risk to the environment, operators should convert to biocide-free anti-fouling systems wherever possible.

Since 2015 the EU Regulation on the Prevention and Management of the Introduction and Spread of Invasive Alien Species (EU No. 1143/2014) provides a legislative framework. The far spread mitten crab is one example of a species requiring management approaches[298].

Air pollutants

MARPOL Annex VI regulates the minimisation of air pollutant emissions from sea-going vessels. The Annex contains guidelines on the sulphur content in fuel (Figure 78), limits for nitrogen oxide emissions in exhaust gas (NOx), guidelines on the use of substances harmful to the ozone layer, and on emissions of volatile organic carbons (VOC) in tankers. It also sets out minimum requirements for the energy efficiency of new vessels (Energy Efficiency Design Index, EEDI).

No limits have yet been set for particle emissions or other fuel quality-related requirements from an environmental perspective.

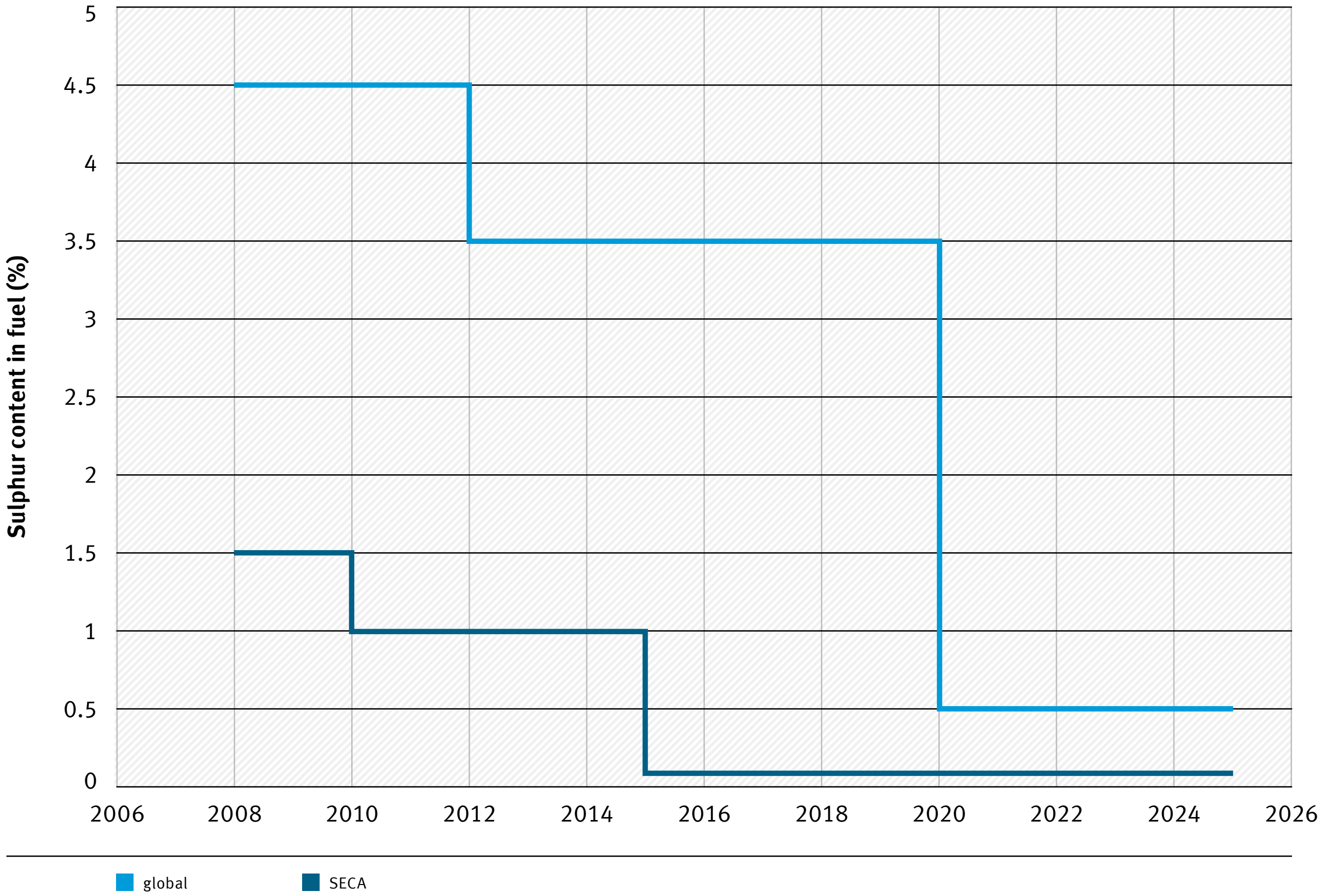
The Baltic Sea has been declared a SECA (Sulphur Emission Control Area) since 2006, and the North Sea since 2007. In these areas, fuel is subject to a maximum sulphur content of 0.1%. However, even this significantly reduced sulphur content is still 100 times higher than the permitted level in road traffic in Europe (0.001% sulphur).

In all European ports, a sulphur limit of 0.1% has been in force since early 2010, a measure designed primarily to improve air quality in port towns, where ships' emissions account for a significant proportion of SO_2 emissions (such as Lübeck-Travemünde, where they account for more than 90 % of SO_2 emissions). This is set out in the EU Sulphur Directive[299].

To comply with the sulphur limits, the use of secondary exhaust gas treatment systems

Figure 78

Sulphur limits in fuel in accordance with MARPOL Annex VI



SECA = Sulphur Emission Control Area

Source: German Environment Agency according to MARPOL Annex VI

(scrubbers) is admissible under MARPOL Annex VI. There are a number of different systems on the market. Wet scrubbers are the most popular choice, whereby the exhaust gas on board the ship passes through a fine water mist in the chimney. A distinction is made between “open scrubbers”, which operate with seawater, and “closed scrubbers”, which use fresh water and a buffer substance. There are also dry scrubbers which remove the sulphur emissions from the exhaust gas using limestone granules. The granules must be disposed of in the port.

Open systems need large quantities of seawater (approximately 40–50 t/MWh), which is then returned to the sea without being purified. (The required quantity of water depends on the output of the ship’s engine (capacity multiplied by time unit in MWh)). This wash water contains, among others, PAHs (polycyclic aromatic hydrocarbons) and heavy metals, and has low a pH value. In closed systems, fresh water and generally caustic soda solution are circulated through the system as a buffer substance. This system produces a smaller quantity of wastewater (approx. 0.1 t/MWh), which is then purified and discharged into the sea. Depending on the type of vessel and the amount of space on board, this water may also be stored on board for a period of time and then discharged in the port.

The *Guideline for Exhaust Gas Cleaning Systems* (MEPC 259(68)), adopted by the IMO in 2009, sets limits for the discharge of water into the marine environment. The guidelines are limited to pH value, PAHs, turbidity and nitrate. In 2014 the UBA published a study[300] assessing the environmental impacts of scrubber systems. Another UBA research project carried out by the Federal Maritime & Hydrographic Agency (BSH) is currently investigating the environmental impacts of wash water discharges from scrubbers.

From an environmental perspective, merely relocating pollutant emissions into the water, as is the case with scrubbers, is unacceptable.

As a general principle, the problem of high sulphur emissions should not be addressed by exhaust gas treatment systems on board ship, but should instead begin on land, by providing clean, low-sulphur fuels for sea-going vessels. These enable the use of additional exhaust gas treatment systems, such as particle filters to reduce soot emissions.

Nitrogen oxide emissions

Regulation 13 (MARPOL Annex VI) contains global limits for NOx emissions, but they are not very ambitious[301]. The more stringent limits set in "Tier III", valid in special NOx Emission Control Areas (NECAs), only apply to new vessels.

In autumn 2016, applications for the designation of the North and Baltic Seas as NECAs were approved by the Marine Environment Protection Committee (MEPC) of the IMO. The more stringent limits will then apply to all new vessels from 2021 onwards.

Emissions in the port

Because ships use their auxiliary engines and boilers to maintain on-board operation in ports, a few port towns have begun offering land-based electricity connections, enabling ships to switch off their auxiliary engines. Passenger ships in particular (ferries and cruise ships) have a particularly high electricity consumption while in port, due to the hotel operations provided on board.

Under the Environmental Innovation Programme (EIP), the BMUB supported the construction of a land-based electricity facility at a cruise terminal in Hamburg's port. Additionally, since 2015 Hamburg has been trialling the use of a "PowerBarge". This generates electricity using natural gas (LNG) on-board, which is likewise made available to cruise ships while in port. Energy from LNG is much cleaner than continuing to operate the on-board auxiliary engines, which run on marine gasoil (MGO).

Shipping noise

Shipping volumes look set to continue to rise, and noise emissions from ships are therefore unlikely to decrease. Consequently, the aim should be for ships to become quieter. This involves developing vessels with considerably quieter powertrains than at present. The IMO guidelines for reducing underwater noise from commercial ships, published in 2014, already contain a number of specific recommendations in this regard. The conditions for the award of the "Blue Angel" eco-label for eco-friendly ship design (RAL-UZ 141) (see below) include criteria governing underwater noise based on the IMO criteria.

The EU's Marine Strategy Framework Directive, which states that the introduction of energy, including underwater noise, must not adversely affect the marine environment, is a key policy mechanism. Continuous low-frequency noise must be monitored within the context of implementing this Directive.

Given the transboundary impacts and proliferation of anthropogenic noise sources, an internationally binding regime should be created to regulate the risk from noise sources in our oceans. The MARPOL Convention for the Protection of the Marine Environment would lend itself well to this purpose, since the Parties could develop and implement an Annex to regulate shipping noise. Alternatively, a convention on noise in the seas could be negotiated to regulate all non-military sources of underwater noise.

Environmental award for ocean-going vessels

The "Blue Angel" is one of the best-known eco-labels in the world. 2002 saw the introduction of the "Blue Angel for Environment-Conscious Ship Operations" (RAL-UZ 110[302]) followed in 2009 by the "Blue Angel for Eco-Friendly Ship Design" (RAL-UZ 141[303]), designed to highlight and publicise innovative environmental protection measures in shipping.

As part of the programme of measures to implement the MSFD (see chapter 5.4.3), the German Government undertook to incorporate environmental criteria (either from the Blue Angel or another ambitious eco-label) wherever possible into the purchase and operation of official vehicles and government-funded ocean-going vessels, such as research ships. These ships act as role models, and are applicable to the entire sector.

To date (as at September 2017), two German research vessels, the "Sonne" and the "Maria S Merian" as well some ferries operating along the

North Sea, have been awarded the "Blue Angel" for Eco-Friendly Ship Design.

6.6.3 Safe transportation of substances hazardous to water

By road, rail and water

In this context, environmental protection is expected to prevent or minimise the release of substances during accidents. Essentially, there are three ways to reduce the number and impacts of accidents with substances hazardous to water:

- Traffic prevention
- Traffic relocation
- Improving legislation, particularly governing the transport of dangerous goods, and the technical and organisational requirements to be met.

Traffic prevention is an interdisciplinary, long-term structural policy task. Implementing the concept of sustainable chemicals could additionally help to ensure that in future, substances hazardous to water are replaced by less hazardous alternatives, or production processes are redesigned in such a way that transport is avoided altogether. However, if the transportation of substances hazardous to water is unavoidable, it must be carried out safely. For example, this can be achieved by continuously updating the law on dangerous substances.

Regarding the potential relocation of traffic, it is important to remember that, as well as the quantity transported and the environmentally hazardous properties of the goods, the potential hazards are also determined by the nature of dispersion following release. Another decisive factor is how quickly and effectively an accident-related release can be prevented or rectified by technical safety measures. The extent of damage also depends on the regional sensitivity of the area affected. Transportation by road, rail and water also differs significantly in terms of the quantities transported per vehicle and the environmental segments potentially impacted by an accident. The pros and cons must be weighed up carefully.

Transport of substances hazardous to water in long-distance pipelines

The transport of substances hazardous to water in long-distance pipelines requires plan approval or authorisation under Part 2 of the Environmental Impact Assessment Act[304].

Under the revised Act on the Assessment of Environmental Impacts of 2001, the licensing obligation was transferred from the Federal Water Act to the Environmental Impact Assessment Act, in recognition of the fact that long-distance pipelines do not only impact and endanger waterbodies. Plan approval or planning permission should give equal consideration to encroachments into nature and soil e.g. as a result of construction measures or maintaining overground access to the route.

Licences and approvals may only be issued provided there are no risks to humans, fauna and flora, soil, water, air, climate and landscape, cultural assets and other assets, and precautions are taken to prevent impairments to these protected commodities, particularly as a result of structural, operational or organisational measures, in line with the best available technology. The project must not conflict with environmental provisions and other regulations under public law, must comply with regional planning objectives, and must observe work safety requirements. For long-distance pipelines used to transport certain substances hazardous to water, these requirements are set out in the Long-Distance Pipeline Ordinance[305] and the "Technical Rules on Long-Distance Pipeline Installations".

In line with Article 9 of the Long-Distance Pipeline Ordinance, the Committee for Long-Distance Pipelines[306] was set up to address technical issues arising from the transport of hazardous substances in pipelines. It is tasked with advising the BMUB and proposing suitable technical rules in line with the best available technology (BAT).

Long-distance pipelines are often transboundary installations, and the safety of sections of the pipeline in one country may be dependent on sections of the installation in another country. There are currently no applicable European directives in this respect. International recommendations governing the safety of the pipelines are, however, contained in the UNECE "Industrial Accidents" and "Water" Conventions. These "Safety Guidelines/Best Practices for Pipelines" define the minimum safety protection standards for transboundary pipelines[207].

6.7 Fishing and aquaculture

6.7.1 Is sustainable marine fishery possible?

There is no doubt that fishing places excessive pressures on certain fish stocks. In 2006[308], a comprehensive data analysis led to the pessimistic forecast that commercial fishing stocks might collapse by 2048 unless there was a drastic change in local and supra-regional management. Since the reform of the Common Fisheries Policy (CFP) entered into force in 2014, attention has focused on the following approaches for more sustainable, eco-friendly management:

- The development of environmentally compatible catch methods in fishery research
- A ban on discards, which must be gradually introduced by the Member States by 2019, with exceptions only permitted under stringent conditions
- Professional management of fish stocks by 2015 and 2020 respectively at a level which permits the maximum sustainable yield (MSY) in the long term
- Annual analysis of Member States' capacities to ensure an equilibrium between fleet capacity and fishing opportunities
- Transparent distribution of fishing quotas based on ecological, social and economic criteria
- EU fishing vessels will only be granted access to surpluses from third-party countries; EU regulations will also apply to external fisheries.

It remains to be seen whether the refocused CFP will exert a lasting positive influence on fish stocks. Some assessed fish stocks appear to have shown a gradual improvement in recent years. The EU Commission believes that MSY (maximum sustainable yield) fishing is a realistic and achievable target, and therefore included it in the CFP reform of 2013. In the North-East Atlantic, the EU Commission claims that the fishing of many pelagic stocks (living in the open water) is now at MSY level. In the Baltic Sea, negotiations by the Baltic Sea Fisheries Forum (BALTFISH) in 2013 sent out a positive message. Sprat, cod in the eastern Baltic Sea and herring in the western Baltic Sea and Bothnian Sea are now fished at a level consistent with MSY. By contrast, in the Mediterranean, studies during 2010 - 2012 found that 85 out of 113 stocks (i.e. 75 %) that are of interest to the EU were still being overfished[309].

Fishing activities must continue to be adequately regulated, particularly in the NATURA 2000 areas of Germany's EEZ, so as to preserve endangered populations and habitats along the German coastline. The German Advisory Council on the Environment (Sachverständigenrat für Umweltfragen, SRU)[310] believes that fisheries must be temporally and regionally restricted or even prohibited altogether if we are to meet the prescribed protection targets. These essential restrictions primarily concern gillnet fishing to protect whales and seabirds in coastal regions, as well as the use of mobile, ground-contact fishing gear in areas with reefs, sandbanks and other special habitats on the ocean floor.

Under the MSFD, since 2008 various programmes to improve the environmental status of the seas have been drawn up in Germany, as in other countries. The report on the programme of measures[311] published in 2016 refers to the "Design and implementation of a programme for public awareness work on the issue of 'sustainable, ecosystem-compatible fisheries', aimed at raising public awareness on this issue and providing relevant information", with a view to highlighting approaches to conscious, sustainable consumption.

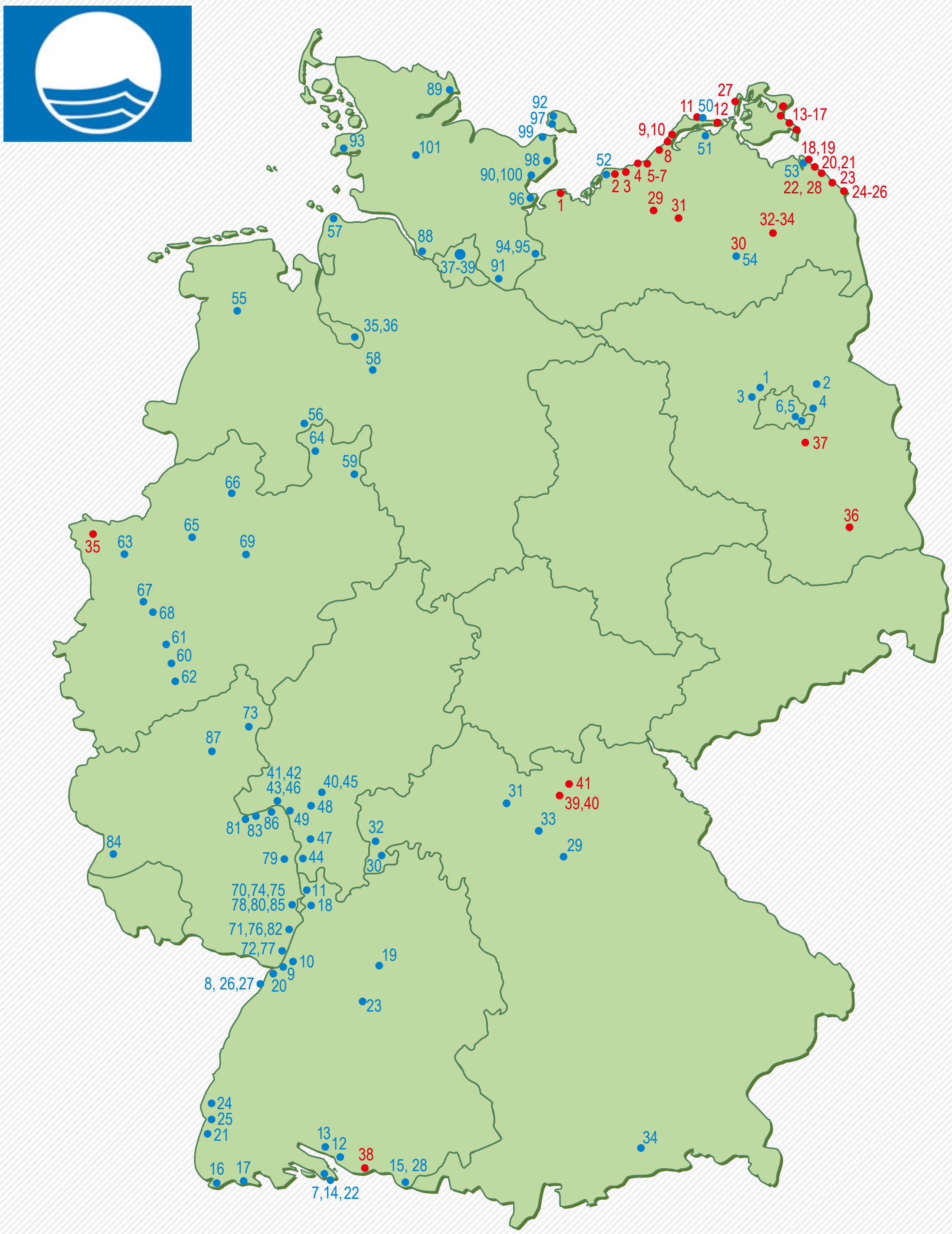
To support sustainable fishing, the independent "MSC" certification is a well-known label which tells consumers that their chosen fish originates from an exemplary, responsibly managed fishery. Certification by the "Marine Stewardship Council" (MSC[312]) is based on three basic principles: sustainability of the target stocks, maintaining affected ecosystems, and effective fishery management. To incentivise sustainable fishery, for the first time, certified facilities (e.g. mussel fisheries in Lower Saxony) have been given a deadline by which to meet the set conditions. The certifying agency is obliged to perform continuous annual checks in the MSC certificate's five-year validity period. It investigates whether there have been any significant changes to the fishery itself, the management of the fishery and any relevant environmental factors, and verifies that any conditions linked to certification are still being met.

6.7.2 Aquaculture

There is no doubt that organic aquaculture is growing in prominence. Environmental

Figure 79

Map of bathing areas (on inland waters) and sports marinas awarded the Blue Flag (2016)



Sports marinas   Bathing areas

Source: http://www.blaue-flagge.de/Ausgezeichnete.html organisations such as “Naturland” have been selling fish from organic aquaculture for some time now.

Although Germany is a world leader in this regard, the total volumes are still minimal compared with conventional fish farming.

The following aspects of organic aquaculture should be taken into account:
- The choice of location must be suitable for farming fish
- Evidence of a low level of mortality during farming must be provided.
- The water quality must be guaranteed so that the fish have good living conditions.
- Antibiotics must only be used under medical supervision, and only for sick animals.
- One of the most important concerns with organic aquaculture is the sustainability of the feed used: As far as possible, the use of conventional fish meal is to be avoided.
- The essential animal protein component should originate from the processing of fish for human consumption, which produces plenty of waste.

Activities by the EU and charitable organisations aspire to support sustainable aquaculture. For example, in 2009 the EU Commission adopted the new EU Regulation on Organic Production[313], the first ever European-wide regulation on organic fish and seafood. The “Aquaculture Stewardship Council” certificate (ASC) has existed in Europe for a number of years, and was initiated by the World Wide Fund for Nature (WWF) in collaboration with various food retailers and fishing companies.

In 2013, the Commission published strategic guidelines for the sustainable development of aquaculture in the EU[314]. The guidelines in the EU strategy are designed to support and advance aquaculture activities in the Member States and include, *inter alia*, shorter licensing procedures. The extent to which this is consistent with the principles of organic aquaculture will become apparent in due course.

Organic aquaculture could help to make fish farming more sustainable from an ecological, social and economic perspective. However, ambitious European regulations are needed if we are to meet our target of greater consumer confidence in organic aquaculture.

6.8 Tourism and leisure use

6.8.1 Leisure use and tourism

A range of measures are available to prevent or minimise the adverse impacts of leisure use and tourism on waterbodies:
- Limiting the use of motor boats in environmentally sensitive waters
- Protecting sensitive riparian areas from leisure use
- Efficient irrigation of golf courses and gardens via water recycling and water-saving irrigation systems
- In gardens and parks, the use of plants requiring little water, adapted to the local climate
- Sensitisation measures, e.g. for eco-friendly scuba diving, water sports and water use on holiday
- Seasonally adapted behaviour, for example to allow the undisturbed breeding of water birds
- Snowmaking on ski slopes without the use of additives

In holiday accommodation, examples of water-conserving measures include the following:
- Reusing towels and bed linen
- Water-saving taps
- Processing and reuse of rainwater and grey water e.g. for watering the gardens and flushing the toilets
- Use of certification systems such as the EU Eco-Management Certificate EMAS[315] for accommodation, or the Blue Flag for bathing waters and marinas
- Sensitising holidaymakers to water issues

In Germany, a total of 42 bathing areas and 109 marinas were awarded the Blue Flag in 2016[316]. Certification is currently awarded in 49 countries worldwide to more than 4,200 bathing areas and marinas.

6.8.2 Bathing

Bathing in natural waters may expose bathers to a number of potential health risks, ranging from cuts and abrasions to drowning.

If certain pathogens enter the water–for example, as a result of wastewater dischargers (see chapter 3.1.4), rainwater emissions (3.1.6) or runoff from agriculture (3.2.2)–sickness such as fever, vomiting and diarrhoea can be induced directly from the water.

To minimise and control the health risks associated with waterbodies, bathing waters in lakes, rivers and the North and Baltic Sea coasts are monitored prior to and during the bathing season. In Germany, this is organised at Land level.

Since the 2008 bathing season, bathing waters have been monitored in accordance with the new EC Bathing Waters Directive[317]. To protect bathers from infectious diseases, this Directive requires the regular analysis of two microbiological parameters as indicators of pathogens: the bacteria *Escherichia coli (E. coli)*, and intestinal enterococci. These usually harmless bacteria occur in the intestines of humans and animals. They enter waters in wastewater containing faecal matter, and are an indicator of such contamination. Depending on the level of contamination, the water quality of bathing waters is rated as "excellent", "good", "sufficient" or "poor".

The new Bathing Water Directive also requires the active management of bathing waters by compiling so-called bathing water profiles, including all sources of contamination that could influence the quality of the water, as well as any potential problems with cyanobacteria, and measures to improve water quality.

Further information on the quality of bathing waters can be found in chapter 8.1.3 and in the publication by the German Environment Agency "Rund um das Badewasser" (German only)[318].

6.9 Plastics in the sea

Inputs of litter into the sea, particularly plastic, are increasing around the globe. The litter in the world's oceans impacts marine ecosystems, including the associated marine organisms and seabirds (see chapter 3.8.1). Resolutions, action plans and programmes of measures to tackle marine litter have been adopted at various policy-making levels.

The final resolution of the UN Rio+20 summit in 2012, "The future we want" states in Article 136 "We further commit to take action to, by 2025, based on collected scientific data, achieve significant reductions in marine debris to prevent harm to the coastal and marine environment". The first and second UN Environment Assemblies (UNEA) in 2014 and 2016 also adopted two resolutions on marine litter, calling for a greater understanding of the emission pathways and impacts of marine litter, and the formulation of regional measures.

Under Germany's presidency a G7 Action Plan and a G20 Action Plan to tackle marine litter were adopted in 2015 and 2017 respectively. Both cover a broad spectrum of actions and provide for measures to tackle emission sources on land and at sea. They also address the issue of removing litter from the sea, and outline activities in the areas of research and public education. The Action Plans underscore the need for close regional cooperation to prevent marine litter, and envisage increased awareness-raising so that waste is no longer viewed as litter but as a resource. The G20 Action Plan focuses specifically on measures to prevent and manage waste as well as on resource efficiency, at the same time integrating socio-economic aspects, awareness raising and research.

An international conference on marine litter in Berlin in April 2013, organised by the UBA on behalf of the BMUB in collaboration with the European Commission, aspired to initiate or develop regional action plans to avoid further inputs and reduce existing marine litter in the European marine regions of the North-East Atlantic, the Baltic Sea, the Mediterranean and the Black Sea.

The Action Plans on marine litter for the North-East Atlantic and the Baltic Sea were developed under Germany's leadership within the framework of the OSPAR and HELCOM Conventions. They foresee numerous measures addressing the major land-based and sea-based sources of marine litter. Different priority areas are set according to each region, based on the principal sources and frequently occurring types of marine litter. The visionary aim of both plans is the prevention of marine litter and the removal of part of the already existing marine litter in the sea.

The action areas for land-based and sea-based sources include improving waste prevention and management, and developing measures for changes to the materials or design of products that are potentially hazardous to the marine environment. Other action areas include the reduction of single used items, the development of sustainable packaging materials, and avoiding the use of and reducing emissions of micro-plastic particles in products such as cosmetics, detergents and abrasives.

To reduce sea-based sources of marine litter, the improvement of the regulation on port collection facilities for the disposal of ship's waste is envisaged. In many Baltic Sea ports, a "no special fee" system has been introduced (see also chapter 6.6.1). This system does not charge additional waste disposal costs for vessels and are therefore an integral part of the general port fees. This means that all vessels pay a general fee for using the port reception facilities, regardless of whether they discharge waste land onshore. Thereby an incentive is provided to discharge on-board generated waste on land. Additionally, the collection of best practice examples on how to reduce marine litter from the fishing sector should be encouraged.

Further measures envisage the comprehensive establishment of the "fishing for litter" initiative, together with clean-up campaigns in the marine environment (and rivers) to remove marine litter, including fishing equipment.

The various source-specific measures are supplemented by awareness-raising and public outreach activities. For example, there are plans to draft a communications strategy and provide information and educational materials in conjunction with academic organisations, professional associations and educational institutions.

In October 2016, the Interest Group Plastics a working group was established as part of the network of European environmental agencies (EPA network), which is working on the land-based sources of litter into the environment. It is currently focussing on the EU Plastics Strategy expected by the end of 2017. The group is led by the German Environment Agency. In addition to the publication of a discussion paper in April 2017, the IG Plastics organised an expert conference "Recommendations towards the EU Plastics Strategy" together with the German and Austrian Environment Agencies, taking place in Brussels.

The national programme of measures under the Marine Strategy Framework Directive (reported to the EU Commission on 31 March 2016) envisages the following action areas for the national environmental objective "Seas without pressures from litter":

- Including the topic "marine litter" in learning goals, teaching plans and materials
- Modification/substitution of products in a comprehensive life-cycle approach
- Avoiding the use of primary micro-plastic particles
- Reducing inputs of plastic litter, e.g. plastic packaging, into the marine environment
- Measures relating to lost and abandoned fishing-nets and gear
- Establishing the "Fishing for litter" approach
- Removing existing marine litter
- Reducing amounts of plastic through local provisions
- Reducing emissions and inputs of microplastic

Some of the options envisaged in the regional action plans and in the programme of measures under the Marine Strategy Framework Directive have already been implemented, at least in part. For example, some 14 ports have signed up to the "Fishing for litter" initiative in Germany's North and Baltic Sea ports. The marine litter they collect is sorted and analysed to obtain important information about the origins and composition of the waste. The "Fishing for litter" project was initiated by a Naturschutzbund e.V. (NABU) project financed by BMUB/UBA; and was in a follow-up established by the coastal Länder under the coordination of NABU.

Since 2013, a voluntary agreement of the cosmetic industry is in place that aims to phase out the use of micro-plastic particles in cosmetic products. Since then, micro-plastics is no longer used in toothpastes. By 2020, at the latest, no micro-plastics should be used in cosmetics.

The Round Table on Marine Litter aims to support the implementation of the national Programmes of Measures and additionally identify and specify further needs for action. It was initiated by the German Environment Minister, the Lower Saxony Environment Minister and the President of the German Environment Agency on 18 March 2016. Some 150 experts from the fisheries and shipping sectors, the plastics industry, wastewater management, the cosmetics and tyres industry, retail, academia, public authorities and politics, tourism, environmental organisations and the art world participate in the Round Table on Marine Litter.

6.10 Adaptation to Climate Change

6.10.1 Options for adaptation in the water resource management segment

The debate about suitable measures for adapting to climate change is still raging, both nationally and internationally. In Germany, the overarching framework for all fields of action is the German Strategy for Adaptation to Climate Change (DAS). The DAS strategy highlights 15 fields of action, which alongside the energy sector, industry and commerce and human health also cover areas such as water, flood protection and coastal protection. Focusing on the impacts of climate change on water resource management and potential adaptation options, a group of experts from the Working Group of the Federal States on Water Issues (LAWA) is updating a related strategy document which will include an audit and specific action recommendations[319].

The prevailing scientific uncertainties concerning the extent and timing of climate change and its specific local impacts make it difficult to assess the effectiveness of such adaptation measures. Nevertheless, scientists agree that key steps must be taken now if we are to adapt to climate change. Suitable adaptation measures are not necessarily new. Particularly in water resource management, there are a wide range of existing measures which could help mitigate the consequences of climate change if differently combined or dimensioned. It is generally beneficial to operate with a raft of scenarios and regionalisation models. First, statements can be made concerning the direction and range of climate change, such as the extent to which precipitation in a given region is increasing or decreasing; and based on this, essential measures can then be derived.

Nevertheless, uncertainties remain. Water resource management measures should meet the following requirements under the framework conditions of climate change.

Table 13

Elements of the screening tool for water resource management measures

Check area	Topic	Note
Climate robustness	Topic 1: Relevance of measures	This topic investigates whether the measure is still relevant under changed climate conditions (query individual climate consequences).
	Topic 2: Effectiveness of measures	This topic gauges the measure's changing effectiveness under altered climate conditions (no cost/benefit analysis envisaged)
	Topic 3: Flexibility and reversibility of the measures	This topic analyses the extent to which the measure is flexible and adaptable to altered climate conditions
	Topic 4: Interactions	This topic investigates whether the measure will have a positive or negative impact on other ecosystems or activities in sectors relevant to water resource management in the future
Impact on climate change	Topic 5: Exacerbation of climate change	This topic investigates whether the measure exacerbates climate change, i.e. leads to the release of additional greenhouse gases.

Source: German Environment Agency

- They should be flexible. It must be possible to supplement or readjust a measure.
- They should be robust. Even if climate change does not have the anticipated impacts, the measure should take effect nevertheless.
- They should be effective. The chosen measure must be designed to stem the adverse impacts of climate change as directly and effectively as possible.
- In a best-case scenario, they should be designed to address several objectives, such as water resource management and nature conservation.

When planning measures, all these points should be checked in a coordinated approach. To this end, the UBA is developing a climate check tool for screening water resource management measures. First, the screening tool gauges the extent to which the pressure underlying a measure will change as a result of climate change, then it analyses which of the aforementioned criteria, such as climate robustness, the measure fulfils. The screening tool covers the following check areas:

The result transparently depicts the responses to the individual questions. As well as other planning-related criteria, the measure's interactions with climate change can therefore be incorporated into a decision for or against a measure.

6.10.2 Examples of adaptation measures in water resource management

Drinking water supply

Some areas are already unable to guarantee drinking water supplies entirely from their own resources due to quality problems. They supplement their supplies with water from reservoirs (e.g. Saxony, Thuringia) and long-distance pipelines. Even under altered climate conditions, Germany is unlikely to experience any fundamental problems with regard to drinking water supplies. Nevertheless, the possibility of regional shortfalls cannot be excluded, particularly during longer periods of drought.

Measures which help to improve the landscape water balance are the most suitable means of supporting groundwater recharge, since groundwater is the most important drinking water resource in Germany. Reducing the amount of land sealing and the decentralised infiltration of rainwater are two areas particularly worth highlighting (see chapter 6.2.5).

Flood risk management

Early adaptation measures are essential to limit the damage caused by flooding, also with a view to climate change. The measures already adopted, such as the National Flood Protection Programme, and the numerous measures under the flood risk management plans for river basins (see chapter 5.5) must be implemented promptly. In assessing the flood risk, allowance must be made for the potential impacts of climate change, as required by the Flood Risk Management Directive, based on regular reviews of the planning foundations. In future, special technical flood control measures, such as dykes, should consider the impacts of climate change, e.g. by incorporating a climate factor. Initial examples of applying climate factors and climate surcharges exist in Bavaria and Baden-Wuerttemberg for river dykes, and in Schleswig-Holstein for storm flood dykes. However, as well as technical adaptation, more widespread social debate is needed to ascertain which flood risks may be tolerated. This debate should be based on a map depicting the flood dangers and risks for various flood scenarios. In conjunction with cost/benefit considerations, it may be possible to agree on differentiated levels of protection and explore further options for a flood risk management policy that has been adapted to climate change (see chapter 5.5).

Dealing with heavy rain

The characterising feature of heavy rain is that extreme precipitation falls within a short space of time, which may cause flooding and major damage regardless of whether it is a river or stream. Advance forecasting heavy rainfall remains difficult. In principle, extremely heavy precipitation could occur anywhere in Germany. Projections illustrate that as a result of climate change, heavy rainfall is likely to become more frequent in Germany (see chapter 3.1.6). Damage caused by heavy rainfall can be reduced at various different levels with a range of measures, including the following:

- Extending the forecasting periods gives more scope for preparations.
- Heavy rainfall maps can be used to highlight the key risk areas.
- Using retention space in the sewers can help to step flooding from the sewer system, and in particular, overflows from combined sewers into waterbodies.
- Structural measures to secure cellar windows

and increase light wells to lower storeys prevents the ingress of rainwater.

- Careful urban planning can create additional retention space through multiple land use.
- Comprehensive population information reinforces precautions and prevents people from entering dangerous situations, for example in flooded cellars or underpasses.

The Federation and the Länder are currently in the process of drawing up a combined national strategy for effective management of heavy rainfall.

Dealing with low water discharge

In future, conflicts of use during low water situations associated with climate change may become more frequent. Watercourses are used for a wide range of purposes, such as shipping, hydropower and the supply of cooling water. To limit the adverse impacts on waterbodies and the aquatic biota, e.g. as a result of rising water temperatures, it may become necessary to impose usage restrictions. The modified control of weirs can relieve the pressures associated with both flooding and low water. Overall, improving the morphological structures of watercourses to strengthen their self-purification capacity, coupled with an improvement in wastewater treatment (see chapter 6.2.2), will help to minimise their vulnerability to low water levels (see chapter 6.5.1 on cooling water use).

[209] Ordinance on the Quality of Water for Human Consumption, amended by a promulgation of 10 March 2016, BGBl. (Federal Law Gazette) p. 459, amended on 18 July 2016, BGBl. (Federal Law Gazette) p. 1666, 1668, most recently amended by Article 2 of the Act of 17 July 2017 (BGBl. I p. 2615)

[210] Act on the Prevention and Tackling of Infectious Diseases in Humans of 20 July 2000 (Federal Law Gazette (BGBl.) I, page 1045), most recently amended by Article 4, para. (20) of the Act of 18 July 2016, Federal Law Gazette (BGBl.) I page 1666))

[211] Food, Commodities and Feed Code in the version promulgated on 3 June 2013, Federal Law Gazette (BGBl.) I, page 1426), amended by Article 4, para. (19) of the Act of 18 July 2016, Federal Law Gazette (BGBl.) I page 1666)), most recently amended by Article 1 of the Act of 30 June 2017 (BGBl. I p. 2147)

[212] Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, OJ L 330, p. 32, amended on 7 October 2015, OJ L 260, p. 6

[213] BAnz AT 28.08.2014 B2

[214] Federal Statistical Office, Press release no. 110 dated 21.03.2014 https://www.destatis.de/DE/PresseService/Presse/Pressemitteilungen/2014/03/PD14_110_322.html

[215] Act on the Regulation of Matters Pertaining to Water (Federal Water Act, WHG) in the version promulgated on 31 July 2009, Federal Law Gazette (BGBl.) I p. 2585, amended by Article 1 of the Act of 4 August 2016, Federal Law Gazette ((BGBl.) I page 1972)), most recently amended by Article 1 of the Act of 18 July 2017 (BGBl. I p. 2771)

[216] Defined in § 3 no. 11 of the WHG

[217] Ordinance concerning requirements for the discharging of wastewater into waters (Wastewater Ordinance – AbwV) in the version promulgated on 17 June 2004, Federal Law Gazette (BGBl.) I, page 1108), amended by Article 1 of the Act of 1 June 2016, page 1290, most recently amended by Article 121 of the Act of 29 March 2017 (BGBl. I p. 626)

[218] Council Directive 91/271/EEC of 21 May 1991, OJ L 135, p. 40 ff., amended by Regulation (EC) No. 1137/2008 of the European Parliament and of the Council of 22 October 2008, OJ L 311, p. 1, 14

[219] Directive 2010/75/EC of the European Parliament and of the Council of 24 November 2010 on industrial emissions (Integrated Pollution Prevention and Control)

[220] Act Pertaining to Charges Levied for Discharging Wastewater into Waters (AbwAG) in the version promulgated on 18 January 2005 (Federal Legal Gazette (BGBl.) I, page 114), most recently amended by Article 2 of the Ordinance of 1 June 2016 (Federal Law Gazette (BGBl.) I page 1290))

[221] Annex to § 3 of the AbwAG

[222] German Environment Agency, UBA (2015): Organische Mikroverunreinigungen in Gewässern – vierte Reinigungsstufe für weniger Einträge. www.umweltbundesamt.de/publikationen/organische-mikroverunreinigungen-in-gewaessern (German only)

[223] Water Protection Ordinance (GSchV) of 28 October 1998 (last revised 1 May 2017)

[224] The intention to largely phase out the agricultural application of sewage sludge was set out in the coalition agreement of 27 November 2013. https://www.bundesregierung.de/Content/DE/_Anlagen/2013/2013-12-17-koalitionsvertrag.pdf?__blob=publicationFile, p. 120

[225] Sewage Sludge Ordinance of 15 April 1992 (Federal Law Gazette (BGBl.) I, page 912), most recently amended by Article 74 of the Ordinance of 31 August 2015 (Federal Law Gazette (BGBl). I page 1474), as of July 2017: Provision on the revision of the sewage sludge utilisation (18/12495 of 24 May 2017)

[226] Fertiliser Ordinance of 26 May 2017 (Federal Law Gazette (BGBl) I page 1305))

[227] The term “thermal disposal” of sewage sludge generally comprises disposal in mono-incineration facilities (including gasification facilities), co-incineration in coal-fired power plants, and co-incineration in cement works and multiple waste incineration facilities. The constituents contained in the sewage sludge are recovered as materials or energy wherever possible

[228] Federal Statistical Office (Destatis): GENESIS-Online database - Dry matter of sewage sludge disposed of directly from waste water treatment plants (32214-0001)

https://www-genesis.destatis.de/genesis/online/data;jsessionid=0F0CC22F10F0664B3C38DE3DB86EE01B.tomcat_GO_1_1?operation=abruftabelleAbrufen&selectionname=32214-0001&levelindex=0&levelid=1522143200307&index=1

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230 Wiechmann, B, Dienemann, C., Kabbe, C., Brandt, S., Vogel, I., Roskosch, A. (2013): Klärschlammentsorgung in der Bundesrepublik Deutschland, www.umweltbundesamt.de/publikationen/klaerschlammentsorgung-in-bundesrepublik

231 http://www.bmub.bund.de/pressemitteilung/deutschland-soll-phosphor-aus-klaerschlamm-gewinnen/ (German only) Last updated 18.1.2017

232 Federal Statistical Office (Destatis): https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/Umwelt/UmweltstatistischeErhebungen/Wasserwirtschaft/Tabellen/TabellenKlaerschlammverwertungsart.html

233 www.europa.eu/rapid/press-release_IP-14-599_de.htm

234 www.minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/mcs-2016-phosp.pdf, www.ec.europa.eu/environment/consultations/pdf/phosphorus/DE.pdf

235 Federal Statistical Office (2016): Personal communication on a survey into the extraction, use and delivery of sewage gas dated 1 August 2016

236 Federal Statistical Office, Press release no. 266 dated 29 July 2016 https://www.destatis.de/DE/PresseService/Presse/Pressemitteilungen/2014/03/PD14_110_322.html

237 https://www.umweltinnovationsprogramm.de/

238 Müller, E.A.; Butz, J.; (2010) Abwasserwärmenutzung in Deutschland. Aktueller Stand und Ausblick; KA Korrespondenz Abwasser, Abfall 57; (5)

239 Neuartige Sanitärsysteme - Begriffe, Stoffströme, Behandlung von Schwarz-, Braun-, Gelb-, Grau- und Regenwasser, Stoffliche Nutzung - Weiterbildendes Studium “Wasser und Umwelt”, Bauhaus-Universität Weimar; 2015

240 von Horn, J., Maurer, M., Londong, J. (2016): Welche neuartigen Sanitärsystemen (NASS) sind für Deutschland besonders Erfolg versprechend? Korrespondenz Abwasser, Abfall 60 (8):

241 An infiltration ditch is a layer of gravel which stores the incoming precipitation water and allows it to seep into the ground A geotextile protects it from damage caused by root growth.

242 Article 55, paragraph (2) of the Federal Water Act (WHG)

243 Article 50, paragraph (1) of the Federal Water Act (WHG)

244 https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/Umwelt/UmweltstatistischeErhebungen/Wasserwirtschaft/Wasserwirtschaft.html

245 AQUAREC Deliverable D19; Wintgens, Hochstrat 2006 (p. 25)

246 For example evidence of pharmaceutical residues in the groundwater in Wolfsburg/Braunschweig; NLWKN (2014, 2017) https://www.nlwkn.niedersachsen.de/download/119484/NLWKN_2017_Regionaler_Themenbericht_Rueckstaende_von_Arznei-_und_Roentgenkontrastmitteln_im_Grund-_und_Oberflaechenwasser_-_Wiederholende_und_ergaenzende_Untersuchung_in_Abwasser-_bzw._Klaerschlammverregnungsgebieten_im_Raum_Braunschweig-Wolfsburg_Band_30_.pdf

247 Seis, W., Lesjean, B., Maaßen, S., Balla, D., Hochstrat, R., Düppenbecker, B. (2016): Rahmenbedingungen für die umweltgerechte Nutzung von behandeltem Abwasser zur landwirtschaftlichen Bewässerung, UBA-Texte| 34/2016 https://www.umweltbundesamt.de/en/publikationen/rahmenbedingungen-fuer-die-umweltgerechte-nutzung

248 Londong, J. et al. (2009): Neuartige Sanitärsysteme - Begriffe, Stoffströme, Behandlung von Schwarz-, Braun-, Gelb-, Grau- und Regenwasser, Stoffliche Nutzung - Weiterbildendes Studium “Wasser und Umwelt”, VDG Bauhaus-Universitätsverlag, Weimar

249 Fertiliser Ordinance of 26 May 2017 (BGBl. (Federal Law Gazette) I page 1305))

250 Directive 91/676/EEC of the Council of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, OJ L 375, p. 1, most recently amended on 11 December 2008, OJ L 311, p. 1

251 Fertilizers Act of 9 January 2009 (Federal Law Gazette (BGBl.) I, page 54, 136), most recently amended by Article 1 of the Act of 5 May 2017 (BGBl. (Federal Law Gazette) I, page 1068).

252 Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directive 79/117/EEC and 91/414/EEC

253 Plant Protection Act of 6 February 2012 (BGBl. (Federal Law Gazette) I, page 1281), amended by Article 4, para. (84) of the Act of 18 July 2016, Federal Law Gazette (BGBl.) I, page 1666)

254 Principles of good plant protection practice (Federal Law Gazette No. 220a of 2 November 1998)

255 Federal Water Act of 31 July 2009 (Federal Law Gazette (BGBl.) I, page 2585), most recently amended by Article 1 of the Act of 4 August 2016 (Federal Law Gazette (BGBl.) I page 1972)

256 Federal Soil Protection Act of 17 March 1998 (Federal Law Gazette (BGBl.) I, page 502), most recently amended by Article 101 of the Ordinance of 31 August 2015 (Federal Law Gazette (BGBl) I page 1474)

257 BMELV (2001): Federal Ministry of Food, Agriculture and Consumer Protection (editors): Gute fachliche Praxis zur Vorsorge gegen Bodenschadverdichtungen und Erosion. Bonn.

258 See Section 3 and Section 17 of the BBodSchG

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260 Regulation (EU) No. 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development

261 German Environment Agency (UBA): Kleine Fließgewässer pflegen und entwickeln - Neue Wege der Gewässerunterhaltung. 2009, https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3747.pdf

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263 See Annex III, no. 9 of the IED

[264] See no. 9 of Annex 1 to the Federal Water Act (WHG)

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[266] https://www.umweltbundesamt.de/en/topics/chemicals/substances-hazardous-to-waters

[267] http://webrigoletto.uba.de/rigoletto/public/welcome.do

[268] Twelfth Ordinance for the Implementation of the Federal Immission Control Act (Major Accidents Ordinance – 12th BImSchV) in the version promulgated on 8 June 2005, Federal Law Gazette (BGBl. I, page 1598), most recently amended by Article 79 of the Ordinance of 31 August 2015 (BGBl. I p. 1474), http://www.gesetze-im-internet.de/bundesrecht/bimschv_12_2000/gesamt.pdf

[269] Directive 2012/18/EC of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC (OJ L197 of 24 July 2012, p. 1) http://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32012L0018&rid=1

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[273] Federal Law Gazette (BGBl.) I 2012, page 1726

[274] Act to Amend Water and Environmental Law Provisions to Prohibit and Minimize the Risks of Fracking Technology of 4 August 2016, Federal Law Gazette (BGBl.) I, page 1972

[275] Act Extending Mining Liability to Borehole Drilling and Caverns of 4 August 2016, Federal Law Gazette (BGBl.) I page 1962 Regulation to Introduce Environmental Impact Assessments and Mining Requirements for the Use of Fracking Technologies and for Deep Drilling of 4 August 2016, Federal Law Gazette (BGBl.) I page 1957

[276] In Germany, fracking in shale, marl, clay, and coal seam rocks is known as unconventional fracking, and is largely comparable with so-called “high volume hydrofracking”, which is subject to the minimum recommendations of the EU Commission 2014/70/EU as set out in: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014H0070

[277] UBA (2014): Fracking zur Schiefergasförderung – Eine energie- und umweltfachliche Einschätzung; Umweltbundesamt, opinion dated November 2014, https://www.umweltbundesamt.de/publikationen/fracking-zur-schiefergasfoerderung

[278] Renewable Energy Sources Act of 21 July 2014 (Federal Law Gazette (BGBl.) I, page 1066), most recently amended by Article 2 of the Act of 22 December 2016 (Federal Law Gazette (BGBl.) I page 3106)

[279] https://www.bfn.de/fileadmin/BfN/awz/Dokumente/schalschutzkonzept_BMU.pdf

[280] Directive 2013/30/EC of the European Parliament and of the Council of 12 June 2013 on safety of offshore oil and gas operations and amending Directive 2004/35/EC

[281] Federal Water Act §§ 33 – 35

[282] German Environment Agency, UBA (2015): Forum “Fischschutz und Fischabstieg” - Empfehlungen und Ergebnisse des Forums. In: UBA TEXTE 97/2015. https://www.umweltbundesamt.de/publikationen/forum-fischschutz-fischabstieg By: Ecologic Institute, Berlin. Eleftheria Kampa, Ulf Stein

[283] UBA (2013): Sustainable Use of Global Land and Biomass Resources
https://www.umweltbundesamt.de/publikationen/sustainable-use-of-global-land-biomass-resources

[284] The 2014 EEG abolished input material-based fee scales and, associated with this, the increased fee for the use of renewable raw materials (NaWaRo). The 2012 EEG restricted the use of maize and cereal grain to 60%. This “maize cap” was reduced to 50% under the 2017 EEG, falling to 47% in 2019 and 2020, and 44% in 2021 and 2022. (Renewable Energy Sources Act (EEG) of 21 July 2014 (Federal Law Gazette (BGBl) I, page 1066), most recently amended by Article 2 of the Act of 22 December 2016 (Federal Law Gazette (BGBl.) I page 3106)

[285] Biomass Electricity Sustainability Ordinance of 23 July 2009 (Federal Law Gazette (BGBl.) I, page 2174), most recently amended by Article 8 of the Act of 26 July 2016 (Federal Law Gazette (BGBl.) I, page 1786), and the Biofuel Sustainability Ordinance of 30 September 2009 (Federal Law Gazette (BGBl.) I, page 3182), most recently amended by Article 2 of the Ordinance of 4 April 2016 (Federal Law Gazette (BGBl). I, page 590).

[286] The amended Fertiliser Ordinance limits the application quantity of organic fertiliser to 170 kg N/ha (Fertiliser Ordinance of 26 May 2017 (Federal Law Gazette (BGBl.) I page 1305))

[287] http://www.gesamtkonzept-elbe.bund.de/

[288] http://www.blaues-band.bund.de/

[289] http://www.cdni-iwt.org/de/

[290] http://www.imo.org/About/Pages/Structure.aspx#4

[291] http://www.bsh.dede/Meeresdaten/Umweltschutz/MARPOL_Uebereinkommen/index.jsp

[292] http://www.helcom.fi/news/Pages/Baltic-Sea-Clean-Shipping-Guide-released.aspx

[293] http://www.havariekommando.de/

[294] http://helcom.fi/Recommendations/Rec%2028E-10.pdf

[295] http://www.imo.org/en/OurWork/Environment/PollutionPrevention/Sewage/Pages/Default.aspx

[296] http://www.helcom.fi/about-us/convention/annexes/annex-iv

[297] Further information: http://www.bsh.de/de/Meeresdaten/Umweltschutz/Ballastwasser/

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[299] Current version: EU/ 2016/802; http://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32016L0802&from=EN

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[301] www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-(NOx)-–-Regulation-13.aspx

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[303] https://www.blauer-engel.de/en/products/business/schiffsdesign

[304] https://www.gesetze-im-internet.de/uvpg/

[305] Ordinance on Pipeline Installations (Pipeline Ordinance) of 27 September 2002 (Federal Law Gazette (BGBl.) I, page 3777, 3809), amended by Article 280 of the Ordinance of 31 August 2015 (Federal Law Gazette (BGBl.) I, page 1474), most recently amended by Article 2 para. 21 of the Act of 20 July 2017 (BGBl. I S. 2808)

[306] The Committee for Long-Distance Pipelines has 13 members from Land and Federal Government authorities and ministries, long-distance pipeline companies, manufacturer and other groups, and expert organisations. The latest results from their work into pipeline safety issues may be found at http://www.tes.bam.de/de/mitteilungen/afr/afr-arbeitsergebnisse.htm

[307] See: http://www.unece.org/env/teia/pubs/pipelines.html

[308] Worm et al. (2006) Impacts of Biodiversity Loss on Ocean Ecosystem Services. Science (5800):787-790; DOI: 10.1126/science.1132294

[309] European Commission (2013): Communication from the Commission (COM). Consultation on fishing opportunities. COM(2013) 319 final. Brussels: European Commission, p. 5

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[311] Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) (2016): MSRL-Maßnahmenprogramm zum Meeresschutz der deutschen Nord- und Ostsee – Bericht gemäß § 45h Absatz 1 des WHG. For English summary, see: http://www.meeresschutz.info/berichte-art13.html?file=files/meeresschutz/berichte/art13-massnahmen/MSFD_Art13_Programme_of_Measures_English-Summary.pdf

[312] MSC website: https://msc.org/de

[313] Council Regulation (EC) No. 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No. 2092/91, OJ L 189, 1; last amended by regulation EU No. 967/2008 of 29 September 2008

[314] Strategic Guidelines for the sustainable development of EU aquaculture (COM(2013)229)

[315] http://ec.europa.eu/environment/emas/index_en.htm, http://ems.iema.net/emas

[316] http://www.blueflag.global/

[317] Directive 2006/7/EG of the European Parliament and of the Council of 15 2. 2006 concerning the management of bathing water quality, OJ L 64, p. 37 ff

[318] https://www.umweltbundesamt.de/publikationen/rund-um-das-badewasser

[319] http://www.lawa.de/Publikationen.html

7 Outlook

The many different tasks facing water resource management were examined in detail in chapter 6. Here, we will consider three highly significant, trans-sectoral topics as examples.

7.1 Reviewing the Water Framework Directive

Article 19, paragraph (2) of the WFD requires the European Commission to review the Water Framework Directive by 2019 at the latest, and propose any amendments that may be required. As the management targets must be met by no later than 2027, and the WFD does not contain any guidelines for the period thereafter, the results of this review will determine the future of water resource management in the EU. Many different interest groups have voiced criticisms of the WFD, particularly those facing additional burdens as a result of water resource management, and those calling for reduced bureaucracy (management plans, reporting). On the other hand, the environmental administrations of the Federation and Länder largely agree that the significant progress made in water protection thanks to the WFD with its integrated management approach must be upheld and not reversed. As such, the European Commission must initiate a transparent review process as quickly as possible, and propose an amendment to the WFD, so that ambitious objectives for improving waterbody status in the EU can continue beyond 2027. For this reason, Germany feels that the core objectives and instruments of the WFD, and its reference to river basins and the principle of public participation, must be upheld. The management mechanism must continue beyond 2027.

7.2 The Federation’s strategy on trace substances

A coordinated strategy is needed to significantly reduce emissions of micropollutants into waterbodies as outlined in chapter 3.1.4, combining measures at the source with measures in application and downstream measures in such a way as to create an economically efficient and promptly implementable concept. To this end, we must clearly define the individuals addressed by the measures, those instigating the measures, the effectiveness and efficiency of the measures, and who will bear the costs. The BMUB and relevant stakeholders (those who manufacture, market, use and dispose of substances and other affected parties) explore their potential individual contributions to reducing inputs. The Ministry will then decide on a (voluntary and/or mandatory) catalogue of measures. Parallel to this, the various different players will clarify those areas where research is still needed (e.g. with regard to pressure situation, environmental effects, prevention and treatment technologies, financing of measures), with the key involvement of the German Environment Agency.

7.3 The need for an integrated nitrogen strategy

Excessive nitrogen levels are not only a problem for waterbodies (see chapter 3.2.2 and chapter 4), but are also detrimental to soils and air quality, and can impact human health. As such, we must not only consider the ecological and health consequences but also the social and economic consequences. The extent of the damage can be on any scale, from local to global.

- Sensitive ecosystems are particularly at risk. Increased nitrogen emissions lead to the eutrophication and acidification of aquatic and terrestrial ecosystems. Nitrogen pollution is one of the main causes of diminishing biodiversity worldwide.
- Various nitrogen components can impair human health through pathway-specific effects. For example, airborne nitrogen compounds can lead to respiratory and cardiovascular disease, both directly and as precursor substances for fine dust.
- In many cases, pollution causes defined protection targets to be exceeded, thereby reducing the opportunities for use or increasing the effort and cost involved to make environmental assets usable, for example, with regard to drinking water supply[320] or in the area of recreation and tourism.
- Nitrogen compounds contribute to climate change as laughing gas or as precursor substances to ground-level ozone.
- Material damage to structures, soil quality deterioration, and the loss of landscape quality are additional concerns.

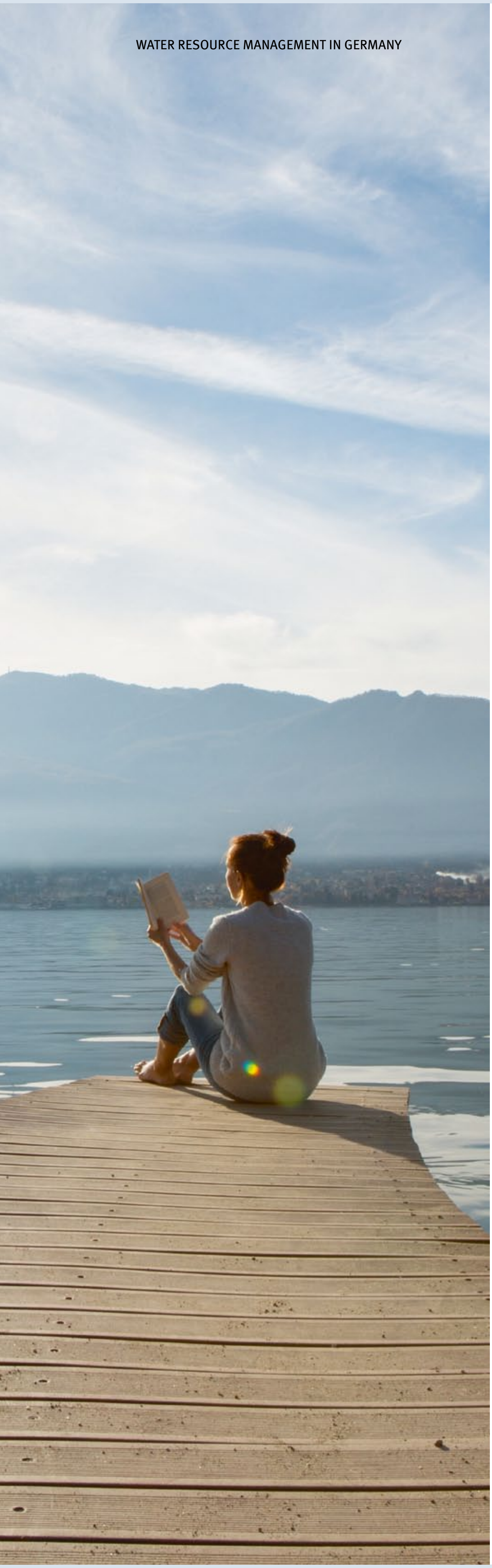
Although in Germany, and indeed in Europe as a whole, agriculture is the main culprit responsible for nitrogen pollution, the combustion of fossil fuels by the transport, industry and energy sectors, and to a lesser extent the waste and wastewater industry, also cause excessive emissions into environmental media. Last but not least, consumers, with their nutritional habits and mobility behaviour, also share responsibility for nitrogen pollution levels which exceed the natural capacity of environmental systems to cope with them.

In recent years, numerous reduction measures have been implemented, and individual sectoral policies introduced. However, their combined reduction success is not enough. The nitrogen problem has multi-causal origins, affects all environmental media and human health, occurs on a variety of spatial scales, and affects the interests of many different businesses and stakeholders. As such, a cross-sectoral, cross-media, coherent policy approach is needed if we are to solve this problem, and all responsible departments and active players must be united behind it. In other words, we need an integrated strategy for nitrogen reduction.

Also the combustion of fossil fuels by the transport, industry and energy sectors causes excessive emissions into environmental media.

[320] UBA-Texte 43/2017: Quantifizierung der landwirtschaftlich verursachten Kosten zur Sicherung der Trinkwasserbereitstellung, Mai 2017, https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2017-05-24_texte-43-2017_kosten-trinkwasserversorgung.pdf

8 Information, brochures, databases



The following information sources are available for further reading and research:

8.1 Databases, registers

8.1.1 Pollutant Release and Transfer Register (PRTR)–Online information about emissions and waste disposal by industry (www.thru.de)

Since July 2009, Germany's PRTR data (**P**ollutant **R**elease and **T**ransfer **R**egister) has been readily accessible to the general public on the Internet at www.thru.de (Thru.de) free of charge. Thru.de provides information on releases into the air, water and soil from facilities, the transfer of pollutants contained in wastewater, and disposal of hazardous and non-hazardous waste.

Further information on the PRTR can be found in chapter 3.3.1 of this brochure.

8.1.2 Environmental Specimen Bank

Since the 1980s, experts at the Federation's Environmental Specimen Bank have been collecting, analysing and archiving specimens from humans and the environment, including specimens of fish, mussels and suspended particles. Specimens from a few selected areas in Germany dating back to the 1990s are stored in the environmental specimen bank. The Federation can use these specimens at any time to conduct retrospective trend analyses. The fish are brass, which are caught annually at 18 locations on the Rivers Danube, Rhine, Saar, Elbe with Mulde and Saale and two lakes in North Germany. At the North and Baltic Sea coast, the Environmental Specimen Bank collects eel-pout, common mussels and the eggs of Silver Gulls. New time series for fish are available from the Environmental Specimen Bank for biota-relevant priority substances in inland and coastal waters. They can be viewed at *www.umweltprobenbank.de* and as a publication *https://umweltprobenbank.de/de/documents/publications/24323*.

The archive of the Environmental Specimen Bank stores more than 500,000 samples from the last 30 years

When comparing the values from the Environmental Specimen Bank with the results from the Länder, it is important to remember that the fish, at 8-12 years old, are significantly older than those referred to in the guidelines of the LAWA framework concept (RAKON) for biota monitoring under the Water Framework Directive.

8.1.3 Quality of bathing waters

The EC Bathing Waters Directive calls for comprehensive information of the general public. Interested individuals will find information about bathing waters in the form of summarised bathing water profiles and the results of water quality measurements on the websites of the Länder, and on information boards at bathing waters. Any potential problems with cyanobacteria are also indicated.

Each year in May/June, the European Commission publishes a report on the "Quality of Bathing Water" in Europe, based on data regarding the hygienic quality of bathing waters collated by the Member States from the previous year's bathing season.

Information on bathing water quality can be accessed at: *https://www.umweltbundesamt.de/themen/wasser/schwimmen-baden/badegewaesser* and *https://www.umweltbundesamt.de/en/indicator-bathing-water-quality*

8.2 Further information

8.2.1 Brochures and background documents published by the UBA

- Waters in Germany. Status and assessment (September 2017) *https://www.umweltbundesamt.de/publikationen/waters-in-germany*
- Umweltschutz in der Landwirtschaft (German only), January 2017 *https://www.umweltbundesamt.de/publikationen/umweltschutz-in-der-landwirtschaft*
- The water framework directive–The status of German waters 2015, September 2016 *https://www.umweltbundesamt.de/publikationen/water-framework-directive*
- Rund um das Trinkwasser (German only), July 2016 (4th edition) *http://www.umweltbundesamt.de/publikationen/rund-um-trinkwasser*
- "Brassen–die Trendmacher" (German only), March 2016 *http://www.umweltbundesamt.de/publikationen/brassen-die-trendmacher*
- Arzneimittel: NICHT in die Toilette und Spüle (German only), October 2015 *https://www.umweltbundesamt.de/publikationen/arzneimittel-nicht-in-die-toilette-spuele*
- Organische Mikroverunreinigungen in Gewässern-Vierte Reinigungsstufe für weniger Einträge, Positionspapier (German only), March 2015 *https://www.umweltbundesamt.de/publikationen/organische-mikroverunreinigungen-in-gewaessern*
- Wie viel Antifouling vertragen unsere Gewässer? Umwelt-Risiken durch Sportboote in Deutschland (German only), October 2014 *https://www.umweltbundesamt.de/publikationen/wie-viel-antifouling-vertragen-unsere-gewaesser*
- Wassersparen in Privathaushalten: sinnvoll, ausgereizt, übertrieben? - Fakten, Hintergründe, Empfehlungen (German only), September 2014 *http://www.umweltbundesamt.de/publikationen/wassersparen-in-privathaushalten-sinnvoll*
- Gesundes Trinkwasser aus eigenen Brunnen und Quellen - Empfehlungen für Betrieb und Nutzung (German only), January 2013 *http://www.umweltbundesamt.de/publikationen/gesundes-trinkwasser-aus-eigenen-brunnen-quellen*
- Trinkwasser wird bleifrei (German only), November 2013 *https://www.umweltbundesamt.de/publikationen/flyer-trinkwasser-wird-bleifrei*
- Hochwasser -Verstehen, erkennen, handeln!

(German only), January 2012
http://www.umweltbundesamt.de/publikationen/hochwasser

- Handlungsmöglichkeiten zur Minderung des Eintrags von Humanarzneimitteln und ihren Rückständen in das Roh- und Trinkwasser (German only), August 2010
http://www.umweltbundesamt.de/publikationen/handlungsmoeglichkeiten-zur-minderung-des-eintrags
- Gewässerschutz mit der Landwirtschaft (German only), January 2010
https://www.umweltbundesamt.de/publikationen/gewaesserschutz-landwirtschaft
- Kleine Fließgewässer pflegen und entwickeln - Neue Wege für die Gewässerunterhaltung (German only), January 2009
http://www.umweltbundesamt.de/publikationen/kleine-fliessgewaesser-pflegen-entwickeln
- Grundwasser in Deutschland (German only), August 2008
http://www.umweltbundesamt.de/publikationen/grundwasser-in-deutschland
- Die Wasserrahmenrichtlinie - Neues Fundament für den Gewässerschutz in Europa (German only), November 2004
http://www.umweltbundesamt.de/publikationen/wasserrahmenrichtlinie-neues-fundament-fuer-den
- Ratgeber: Trink was - Trinkwasser aus dem Hahn, Gesundheitliche Aspekte der Trinkwasser-Installation (German only)
https://www.umweltbundesamt.de/publikationen/ratgeber-trink-was-trinkwasser-aus-hahn

- Versickerung und Nutzung von Regenwasser - Vorteile, Risiken, Anforderungen, Ratgeber (German only), January 2005
http://www.umweltbundesamt.de/publikationen/versickerung-nutzung-von-regenwasser

8.2.2 Websites

- UBA websites on "Water"
https://www.umweltbundesamt.de/en/topics/water
- UBA - Water-related environmental indicators
https://www.umweltbundesamt.de/en/data
- H2O media database UBA database of instructional and educational materials relating to water (German only)
http://www.h2o-wissen.de
- KomPass–Climate impacts and adaptation in Germany
https://www.umweltbundesamt.de/en/topics/climate-energy/climate-change-adaptation/kompass

8.2.3 Videos

- Educational film about water hardness (German only)
https://www.umweltbundesamt.de/themen/hartes-wasser-weiches-wasser
- Educational film about nitrogen (German only)
https://www.umweltbundesamt.de/themen/stickstoff-ein-komplexes-umweltproblem
- Educational film about the disposal of medicines (German only)
https://www.youtube.com/watch?v=nLH6s5fPUDA
- Short film about the future of agriculture (German only)
https://www.youtube.com/watch?v=Z9s_X9hQekI

8.3 What can we as individuals do? – Water protection tips

Drinking water

Drink tap water!

Compared with bottled water, drinking tap water saves money and packaging, and helps to protect the environment. For 50 cents, you get 121 litres of drinking water a day (including wastewater disposal). The tap water in Germany is perfectly safe to drink; it is the best-monitored foodstuff in Germany.

Further information can be found at:
http://www.umweltbundesamt.de/publikationen/wasser-wertvolles-nass-ueberfluss

Food

Buy organic produce!

Nitrogen emissions and pesticides from agriculture impair the quality of our groundwater, rivers, lakes and seas. Organic farming aims to avoid substance emissions from agriculture into groundwater and surface waters by prohibiting the use of chemical-synthetic pesticides. Nitrogen mineral fertilisers are replaced by cultivating legumes (pulses that are capable of immobilising nitrogen with bacteria) combined with more varied crop rotation; problematic nitrate emissions into the groundwater are rare. An intact soil and soil hydrology are vital for organic farming, and also leads to improved groundwater recharge. By purchasing properly labelled organic produce, you are making a valuable contribution to groundwater protection.

Also ...

- Regional and seasonal foods do not usually cause water volume problems; foods from dry regions, on the other hand, can be critical.
- By throwing away less food, you are also helping to conserve water resources. Often, large quantities of water are needed to produce foods in water-deficient regions.

Eat less meat! When buying meat and fish, be conscious of sustainability!

Our consumption of meat has huge impacts on the environment. Nitrate in groundwater, ammonia in the air, and antibiotics in the soil are just a few examples. This environmental damage is largely attributable to intensive animal husbandry in Germany. 60% of our agricultural land is used to grow feed for cattle, pigs and other animals; only 20% is destined for direct human consumption. By eating more fruit and vegetables and less meat, we are directly helping to protect the environment and the climate, as well as benefiting our own health. The average annual meat consumption is 60 kilograms per person; the Deutsche Gesellschaft für Ernährung (German Nutrition Society, DGE) recommends halving this for health reasons. So, eat less meat, and ensure that the meat you buy is organically certified.

When buying fish products, be mindful of sustainability. More than one-third of regulated fish stocks today are classed as overfished. Fishing equipment causes structural damage to habitats on the ocean floor. Fish, as well as seabirds, turtles, seals and whales end up in fishermen's nets or lines as unwanted by-catch. The independent MSC seal certifies that the fish you have chosen is from a responsible fishery operated according to best practices. Certification by the "Marine Stewardship Council" (MSC[321]) is based on three basic principles: the sustainability of the target stocks, maintaining affected ecosystems, and effective fisheries management.

In 2016, a new portal, "Fischbestände online" (German only)[322], was launched by the Thünen-Institut, containing information about the status of fish stocks that are relevant to the German market.

Waste disposal

Dispose of your waste responsibly!

Please help to ensure that no substances that cannot be filtered out or which require costly treatment procedures are able to enter the sewers and wastewater treatment plants. This is the only way of effectively protecting our rivers, lakes and seas, because active water protection does not begin with sewage treatment, but with avoiding the creation of wastewater in the first place! The following substances, products and waste must not be disposed of in the toilet or sink.

a) Solid waste, such as
- Textiles
- Disposable nappies
- Hygiene products
- Cotton wool
- Cotton buds
- Razor blades
- Cigar and cigarette residues
- Pet litter etc.

b) Lacquers, paints, pharmaceuticals
Chemical residues, tables and unwanted medicines should never be flushed down the toilet or sink. If chemicals and active constituents in pharmaceuticals are flushed down the toilet, they will enter the wastewater treatment plant via the sewer.
Wastewater treatment plants are unable to completely remove such substances. For example, undecomposed pharmaceuticals and their degradation products will enter surface waters together with the treated wastewater, and subsequently enter the groundwater via soil passage or bank filtration.

There are various disposal options for unused medicines in Germany that vary according to region. The site *www.arzneimittelentsorgung.de* is your first point of call for discovering how to correctly dispose of medicines in your region.

Further information can be found at:
http://www.umweltbundesamt.de/publikationen/arzneimittel-nicht-in-die-toilette-spuele

c) Used household oils and fats
These substances combine with the ballast of wastewater and solidify into a glutinous mass. Used frying oil (e.g. chip fat) and other roasting fats should be disposed of in the biowaste bin together with kitchen waste and food residues.

Laundry and cleaning

Use the correct dosage of cleaning agents and laundry detergents!

Super-compact laundry detergents can be used sparingly as per the instructions at the lowest possible washing temperature. This saves detergent, energy, and money. Be aware of different water hardness levels. Water hardness varies from place to place; contact your water plant or local authority to find out more. What is more, using biodegradable cleaning agents and laundry detergents helps to protect waters.

Notes on laundry (German only)
https://www.umweltbundesamt.de/themen/wirtschaft-konsum/umweltbewusstleben/waesche-waschen-waschmittel

Excessive use causes residues and streaks! For this reason, you should also use cleaning and care products as sparingly as possible in accordance with the instructions. Avoid using disinfectants in private households as a precautionary measure, as this can encourage allergies. Use cosmetic products such as shower gels, shampoo and personal care products sparingly and only when necessary.

Always clean your car at the car wash!

Cars should always be washed at the car wash to prevent pollutants from entering the water.

From an environmental perspective, it is always advisable to wash cars at designated car washes, ideally those with the “Blue Angel” eco-label. The wastewater produced when washing a car contains various chemical substances and compounds that can damage groundwater, even if you only use clean water for washing. By washing

your car on unsealed ground, you are placing the groundwater at risk, and committing an administrative offence at the very least.

Dispose of batteries and accumulators properly!

Batteries and accumulators should never be mixed with domestic waste or simply thrown away! If this happens, the pollutants they contain can contaminate the groundwater from waste incineration or landfill. Batteries containing the heavy metals mercury, cadmium or lead are particularly harmful to the environment.

In Germany, 43,549 tonnes of batteries were sold for use with appliances in 2012– that equates to over 1.5 billion batteries. Put another way, on average, each consumer purchases around 20 batteries a year. Depending on the battery system, these contain significant amounts of valuable materials such as zinc, nickel, iron/steel, aluminium, lithium, cobalt and silver. Other potential constituents such as mercury, cadmium and lead are toxic, and pose a threat to the environment if incorrectly disposed of. Heavy metals can have health-damaging effects on humans, animals and plants, and can accumulate in the food chain and in the environment.

Batteries contain substances hazardous to the environment and should therefore be disposed of adequately

Wherever possible, use accumulators rather than batteries, as these can be recharged multiple times and are therefore more efficient. For everyday appliances, give preference to nickel metal hydride (NiMH) or lithium ion accumulators. Nickel cadmium accumulators are banned from most household appliances and should no longer be sold, because they contain toxic cadmium.

Collect all unusable batteries and accumulators and take them to a battery collection point at a retailer or your local authority, where they will be accepted free of charge. More and more consumers are complying with the statutory obligation to return used batteries–in 2016, 46% were collected.

Further information on the use and disposal of batteries and accumulators can be found here (German only)
https://www.umweltbundesamt.de/umwelttipps-fuer-den-alltag/elektrogeraete/batterien-akkus

Take your own shopping bags with you – Avoid plastic bags

Plastic bags are not just a symbol of the throw-away society; if they enter the environment, they can drift over long distances and become caught in trees and bushes, for example, or enter the water. Apart from the aesthetic problem of litter, there is also the fact that plastic decomposes into ever smaller pieces over a long degradation period, whereby additives such as plasticisers can be released. Animals confuse small plastic particles with food or accidentally swallow them. The plastic fragments can damage the digestive tract or block the animal's stomach, leading to death from starvation, or cause internal injuries.

By buying a new bag every time you shop, not only are you wasting money and resources unnecessarily, you are also generally creating unnecessary waste. It is far preferable to use a fabric shopping bag or a durable, stable shopping basket, in which fruit and vegetables can be safely transported without packaging. When buying bread and rolls, you can use a clean, washable fabric bag. If a plastic bag is unavoidable, be sure to reuse it as many times as possible.

https://www.umweltbundesamt.de/umwelttipps-fuer-den-alltag/haushalt-wohnen/plastiktueten/

Avoid land sealing or use permeable surfacing materials!

Rainwater normally seeps into the subsoil where it falls, but in developed or sealed areas this is usually prevented from happening. In such areas, only some precipitation water is able to enter the water cycle via the natural route, while a significant portion is discharged via the sewer system. To minimise impairments to the groundwater balance, the first step should therefore be to examine the need for sealed and developed land. In many cases, a particular usage no longer applies or a planned usage has failed to materialise, and these areas may be converted back into grassland. If it becomes necessary to stabilise land due to the way it is used, there are various opportunities for minimising the extent of sealing. For example, paths, roads, parking spaces and terraces may be stabilised with water-permeable coverings.

Ensure that rainwater seepage reflects the best available technology!

Decentralised rainwater management in human settlement and transport areas is considered the best available technology. There is no good reason for not applying this principle. For the seepage of minimally to moderately contaminated precipitation water, the best available technology is considered to have been met if it has an adequately dimensioned soil zone covered in vegetation, or infiltration facilities with proven substance retention effectiveness.

Further information on rainwater seepage and use may be found at (German only): *http://www.umweltbundesamt.de/publikationen/versickerung-nutzung-von-regenwasser*

In the garden, avoid the use of chemical pesticides and biocides, and be sparing with the use of fertiliser!

In your own garden, too, avoiding the use of chemical pesticides and biocides and using fertiliser sparingly can help to prevent groundwater pollution. Remember: More is not necessarily better!

Have your sewage tanks and private sewer connections checked for leaks, and upgraded where necessary!

Wastewater can seep into the soil and groundwater from leaking pipes and sewage tanks if they are located above groundwater level, and could potentially contaminate the soil and groundwater. Cracks in tanks or pipes, tree roots, faulty connections and leaky seals are potential sources of leaks. The land owner is responsible for ensuring the proper operation of wastewater pipes that traverse private land.

Soil coverings that are permeable to water allow rainwater to infiltrate

Avoid using salt in winter!

Salt damages the roadside flora and fauna. Saltwater that seeps into the soil can impair valuable groundwater. As well as contaminating our waterbodies, salt also contaminates wastewater treatment plants with melting ice and snow from the sewers. Salt is also damaging to the paintwork of cars. Eco-friendly alternatives include salt-free grits and sands.

Be an eco-friendly traveller and use limited water resources abroad responsibly!

Travellers wishing to protect the environment can check for an environmental certificate before booking (examples include EMAS, TourCert, Travelife, Green Key, Green Globe, Eco Camping, EU Ecolabel). As well as energy-saving requirements, these also apply criteria for reducing water consumption. Additionally, guests can choose not to have their towels and bed linen changed on a daily basis. Water should be used sparingly on holiday in exactly the same way as at home. This is particularly important in arid regions.

The design of the holiday, the choice of accommodation and your personal conduct can make an important contribution to preserving scarce water resources in arid regions.

Avoid health risks when bathing

The better the water quality, the lower the risk of infection. With this in mind, wherever possible, you should swim in waters with an excellent or good quality. In waters where there are problems with mass development of cyanobacteria:
TIP: If you are standing in knee-deep water and cannot see your own feet, there are too many cyanobacteria in the water, and you should not swim.

Get involved

EU Directives and initiatives offer a wide range of opportunities for you to get involved. For example, the general public must be consulted when designating new bathing waters.

The next cycle of management plans and programmes of measures under the WFD will be on display for public consultation and published on the Internet from December 2020 to June 2021.

The same applies to assessments and programmes of measures under the MSFD. Under the Federal Water Act, the following documents will be on display for consultation and/or published on the Internet:

- The draft follow-up assessment (and update of the description of good environmental status and the specification of environmental objectives): from 15 October 2017 to 14 April 2018
- The draft update to the programme of measures: from 31 March to 30 September 2021.

More everyday environmental tips can be found at *https://www.umweltbundesamt.de/umwelttipps-fuer-den-alltag*

[321] MSC website: https://msc.org/de

[322] "Fischbestände online": http://fischbestaende.portal-fischerei.de/

Information about the quality of bathing lakes are available online:

https://www.umweltbundesamt.de/wasserqualitaet-inbadegewaessern

9 Glossary

A

Anthropogenic: Caused by man.

Arid: Description of a climate zone in which the potential evaporation exceeds the annual precipitation, resulting in a low level of humidity.

Bank filtrate: Groundwater formed by the outflow or seepage of stream and river water (infiltration).

B

Bathing waters: Waterbodies or parts of a waterbody where the competent authority anticipates a large number of bathers and there is no permanent ban on bathing. Bathing waters that are part of a waterbody are often referred to as bathing sites.

Benthos: Totality of organisms living on and in the soil of a waterbody.

Bioaccumulation: Accumulation of substances in organisms, both from the ambient medium and via food.

Biocides: Substances and products designed to control pests and vermin such as insects, mice or rats, as well as algae, fungi or bacteria. Biocides may be used, for example, as antibacterial detergents and disinfectants, wood preservatives, insect sprays and ant poison.

Brackish water: Fresh water in estuaries that is mixed with seawater, containing high levels of bacteria.

By-catch: By-catch refers to marine fauna which is caught in the net but is not part of the desired target catch. Most of these animals die painful deaths in the nets. They include many endangered species such as sharks and sea turtles, as well as seabirds and dolphins.

C

Chemical status: As defined in Directive 2000/60/EC, the chemical quality of bodies of surface water and groundwater; defined by pollutant limits set by the EU; in the case of bodies of groundwater, other aspects of chemical quality must also be taken into account; the Directive distinguishes between good and bad chemical status.

Coastal waters: As per the Federal Water Act, coastal waters comprise:

- The territorial sea as defined in the United Nations Convention on the Law of the Sea (UNCLOS), i.e. the waters seaward of the base-

line up to a maximum of 12 nautical miles, and
- The waters landward of the baseline up to the coastline at mean flood level, or the seaward limit of surface waters. Coastal waters are part of the internal waters as defined by UNCLOS.

A littoral state has unlimited sovereignty within its coastal waters.

Coastal zone: The coastal zone is a dynamic and natural system which extends seawards and landwards from the coastal line. The boundaries are determined by the geographical expanse of the natural processes and anthropogenic influences occurring there. As a unique and limited component of the physical environment, coastal zones have a complex interrelationship between the land and the sea.

Colibacteria: Bacteria that live in human and animal intestines. Evidence of colibacteria in drinking water is an important indication of contamination with faecal matter and the possible presence of other pathogenic organisms.

Combined sewage: Collected wastewater containing household wastewater, commercial and industrial wastewater, sewer infiltration water (groundwater that has seeped into the sewer system) and precipitation water.

Convention on the Law of the Sea (UNCLOS): Global United Nations Convention with 168 Contracting Parties, regulating the rights and obligations of countries with regard to the use and protection of marine waters and their resources.

D

Denitrification: Decomposition of nitrate into nitrogen and oxygen caused by bacteria. The bacteria remove the oxygen, while the nitrogen is absorbed by the air.

Direct dischargers: Direct dischargers refer to all municipal and industrial/commercial operators of wastewater treatment plants (sewage treatment plants) that discharge treated wastewater directly into a waterbody.

Drainage: Discharge of soil water (dehydration) into a body of surface water via artificial hollows or ditches.

Drinking water: Water suitable for human consumption and use that meets certain quality criteria as defined in laws and other legal standards. The basic requirements for safe drinking water is that it should be free from pathogens, have no health-damaging properties, be low in germs, appetising, colourless, cool, odourless, pleasant-tasting, and have a low content of dissolved substances. Moreover, drinking water must not cause excessive corrosion damage to the pipe network and should be available in adequate quantities at sufficient pressure.

E

Ecological status: Here: The structural quality and functioning of aquatic ecosystems in relation to surface waters.

Ecology: Ecology is the science of the natural balance. As well as the interrelations between organisms and their environment, it also examines the reactions and developments of complex systems containing numerous different microorganisms, plants and animals.

Ecosystems: System of community and dependencies between various types of creatures and their environment.

Elutriation: Procedure whereby substances contained in the topsoil are dissolved in rainwater and diffusely enter surface waters together with the surface runoff

Emission: Release of solid, liquid or gaseous substances which are harmful to humans, animals, plants, air, water or other environmental media.

Environmental compatibility: Extent of a project's effects on the protected assets soil, water, air, climate, humans, fauna and flora, including the respective interrelations.

Environmental impact assessment: An environmental impact assessment (EIA) is a systematic analysis procedure to ascertain, describe and evaluate the direct and indirect effects of a project on the environment at the planning stage.

Environmental quality standard (EQS): Environmental quality standards specify limits for priority substances. Environmental quality standards are designed to minimise the occurrence of certain chemical substances in surface waters that pose a significant risk to the environment or human health.

Epidemiology: The study of epidemics or of the spread of diseases or pathogenic organisms.

Erosion: The wearing away of soil or rock, primarily due to the effects of water.

Estuaries: River mouths. Many of the rivers that flow into the North Sea have formed funnel-shaped mouths (estuaries) under the influence of the tides. On the German North Sea coast, this applies to the mouths of the Eider, Elbe, Weser and Ems. A natural area of brackish water and turbidity is formed, where considerable quantities of sand and dead suspended matter are deposited and form sand or silt sediment. Estuaries are transitional waters.

European Water Framework Directive 2000/60/EC (WFD): Directive in force since December 2000 on the protection of European waters. The WFD aims to manage the catchment areas of rivers and lakes and groundwater reserves in such a way that an existing very good or good status is maintained, or a good status is achieved. The WFD includes a detailed timetable for implementation of the water resource management requirements. For example, by 2015 all surface waters must have attained good ecological (biological and morphological) and chemical status, and a good chemical and quantitative status of groundwater.

Eutrophication: Increase in plant production (algal bloom and large populations of aquatic plants) in waterbodies due to a high supply of nutrients caused, for example, by discharges from agriculture or wastewater discharges.

Exclusive Economic Zone: Under the United Nations Convention on the Law of the Sea, the Exclusive Economic Zone (EEZ) is the territorial sea adjacent to the 12 nautical-mile limit. The littoral state has certain sovereign rights and authority over the economic use of the water column, ocean floor and subsoil (e.g. fishing rights). For Germany, the EEZ is identical to the continental shelf.

F

Federal Water Act: Act regulating the hydrological balance and outlining provisions for the management of water resources with a view to ensuring public well-being. Examples include requirements on water abstraction, water storage and wastewater disposal in order to avoid any impairments. It also defines the management guidelines of the WFD for waterbodies.

Fertiliser Ordinance: Regulations governing good agricultural practice with the application of fertilizers, including transposition of the Nitrate Directive into national law.

Flood level (HQ): A certain flood event used as a basis for planning flood alleviation measures such as dykes. For example, HQ100 is a flooding event that will occur with a probability of once in 100 years. The variables „“water level” and “runoff,“ allocated to this event will determine the height of a dyke dimensioned according to HQ100.

Flood plains: Areas that flood in high water. Legally designated flood plains must be taken into account by the local authorities in their zoning plans.

Flood protection plans / flood risk management plans: These plans aim to minimise, as far as possible, the risks of a flood expected to occur statistically once in 100 years. For example, the plans may contain measures such as: conservation and recovery of retention areas, relaying of dykes, conservation and recovery of water meadows.

Flooding: According to the Federal Water Act, flooding is the temporary coverage of land not normally covered with water by surface waters or by seawater penetrating in coastal regions.

Flood-prone zone/risk area: Flood-prone zones/risk areas are areas that extend beyond flood plains or which could be flooded if public flood defences were to fail.

Freshwater: Generally speaking, freshwater refers to water that can be drunk by humans, i.e. precipitation water, surface waters on the continent, and groundwater with less than 500 mg/l dissolved salts.

G

Geo-engineering: Concepts that attempt to curb climate change via industrial interventions into global ecological processes, such as fertilising the ocean with iron.

Geothermia: This term is derived from the Greek words geo = earth and therme = heat, meaning heat from the earth. Energy stored below the earth’s surface in the form of heat (synonym: ground heat).

Groundwater: Underground water in the saturation zone, in direct contact with the soil or subsoil that cohesively fills the hollows in the earth’s crust (pores, chasms etc.). It is at a pressure equal to or greater than the atmosphere, and its movement is determined by gravity and frictional forces.

Groundwater aquifer: Loose (e.g. gravel, sand) or solid stone (e.g. chalk, sandstone), with cohesive hollows (pores, chasms) of a sufficient size to allow water to flow through them easily. By contrast, rocks with very small or non-cohesive pores (e.g. clay) are groundwater inhibitors.

Groundwater body: A demarcated volume of groundwater within one or more groundwater aquifers.

Groundwater Directive: EC daughter directive on the protection of groundwater from contamination and deterioration.

Groundwater recharge: New groundwater created from the seepage of precipitation.

Groundwater storey: A sequence of communicating groundwater aquifers.

H

Habitat: The natural home of a plant or animal.

High sea: Under the United Nations Convention on the Law of the Sea, the High Seas comprise all parts of the ocean not belonging to the exclusive economic zone, territorial sea or internal waters of one specific country. The High Seas are open to all countries, which are free to use these waters in accordance with the provisions of UNCLOS.

Humid: Description of a climate zone in which the annual volume of precipitation exceeds the evaporation capacity. This results in a high level of humidity.

I

Immission: The effects of air contamination, pollutants, noise, radiation etc. on humans, animals, plants, air, water and other areas of the environment.

Indirect discharger: All industrial and commercial operations that discharge wastewater into a public sewer or public wastewater treatment plant. Pre-treatment may be necessary, depending on the composition of the wastewater.

Inland waters: All stagnant or flowing waters on the earth's surface and all groundwater on the landward side of the base line from which the width of sovereign waters is measured.

Inorganic: Relating to the inanimate part of nature; in the natural sciences in general, refers to bodies derived directly from mineral substances, as compared to substances originating from the plant or animal kingdom (organic).

L

LAWA: The Bund-Länder-Arbeitsgemeinschaft Wasser (LAWA) is a working body of the Conference of Environment Ministers (UMK) within the Federal Republic of Germany. Members of LAWA are the heads of department of the supreme Land authorities for water management and water legislation in the Länder, and since 2005 also include the Federal Government, represented by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). http://www.lawa.de

Legionella: Legionella are rod-shaped bacteria that live in the water. They can occur in both freshwater and salt water. Due to natural dispersion, they also occur in small quantities in drinking water. There are various different measures for preventing legionella, such as chemical and thermal disinfection.

Limnology: The study of inland waters, research and study of stagnant and flowing inland waters and groundwater, particularly substance balance.

Low water: Low water refers to a water level of waterbodies that is below the defined normal level. We distinguish between low water in a tidal area and in inland waters.

M

Macrophytes: Aquatic plants visible to the naked eye.

Macrozoobenthos: Invertebrates visible to the naked eye that live on the water bed.

Management plan: Central control element for implementing the WFD; contains an analysis which must be regularly updated, site-adapted monitoring programmes, and binding programmes of measures for achieving the management/environmental objectives; from 2009 onwards, a management plan must be produced every six years for every river basin.

Maritime spatial planning: The organisation, development and protection of marine areas with regional plans. The various demands placed on the area must be coordinated with one another, taking care to ensure the individual uses and functions of the space. The guiding principle is based on sustainable development which harmonises social and economic interests with ecological functions

Monitoring: Observation or monitoring of natural phenomena to obtain data and knowledge, to test hypotheses, and to aid understanding.

Morphology, morphological: In general, the study of constellations, forms, shapes and structures. Here: The course of a river; its width and depth, its bed and banks, and the properties of the adjoining land.

N

NATURA 2000: The NATURA 2000 network refers to a transnational system of protected areas within the European Union. It comprises the protected areas under the 1992 Habitats Directive and the 1979 Birds Directive. Accordingly, NATURA 2000 areas are areas of Community importance or Special Protected Areas within the European Union that have been designated by the European Union Member States.

O

Off-shore: Abbreviated term for the exploration of petroleum and natural gas reserves off the mainland coast, on the continental shelf, and in large inland waters. Around 37 % of the world's known oil reserves are located in offshore regions. In the North Sea, some 1,000 exploratory drillings were carried out between the late 1950s and 1978. It is thought that several thousand more drillings will be necessary to fully exploit petroleum reserves. Such activities pose a constant threat to our seas and rivers.

Organic: Belonging to animate nature, produced by living creatures.

P

Passability (also known as biological passability): Opportunity for fauna to migrate in a watercourse. Transverse structures such as weirs interrupt passability. Diversion streams and fish ladders restore the connection.

Phytobenthos: Benthic algae, i.e. algae that live on the water bed.

Phytoplankton: Algae suspended in the water.

Pre-treatment: In-house treatment measures for commercial and industrial wastewater prior to discharging into public sewers or sewage treatment plants.

Priority substances: List of currently 45 pollutants or pollutant groups that the WFD considers relevant for determining the good chemical status of surface waters. Some of these substances are classified as priority hazardous substances.

R

Rain basin: Rain basins are artificial basins used to retain and/or treat rainwater or mixed water, such as rain retention basins.

Rain overflow: A rain overflow is an overflow structure in a mixed water sewer used for rain relief. Wastewater treatment plants are generally designed for the inflow of dirty water plus the same volume of rainwater. As rainwater outflow can be up to 100 times the dirty water outflow during heavy rainfall, the inflow into the wastewater treatment plant must be limited.

Rain retention basin: A rain retention basin is a form of rain basin used to store precipitation water rather than allowing it to flow directly into the outfall.

Raw water/ pure water: Water taken by the water plant from a water resource (groundwater, spring, surface water) for use as drinking water. Where no processing is necessary, raw water and pure water are identical.

RCP - Representative Concentration Pathways: These scenarios assume certain greenhouse gas concentrations for the year 2100 and radiative forcing for the period 1850-2100. In turn, radiative forcing (RF) depends on greenhouse gases, surface reflection, zone content, aerosols etc. The RCP scenarios replaced the IPCC's SRES scenarios in 2013/14.

Renaturation: Generally, the restructuring of a developed waterbody into a semi-natural, ecologically effective form. Here: Restoring an unnatural river landscape caused by human intervention to a semi-natural state, particularly by recreating or significantly improving the waterbody structure.

River basin: An area of land from which all surface run-off from surface waters flows into the sea at a single river mouth, estuary or delta.

River basin district: A main unit for the management of river basins defined as an area of land or sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, as set out in Article 7, paragraph (5), sentence 2 of the Federal Water Act (WHG).

River regulation: Correction of the course of a river to benefit agriculture, shipping, human settlements and hydropower use by means of river straightening, bank reinforcement and riverbed obstruction Transverse structures, low weirs, drop structures, weirs or dams are used to prevent excessive depth erosion.

Runoff: The proportion of precipitation that runs off into rivers and streams. It is measured as the volume of water per unit of time, and is quoted in cubic metres per second (m3/s). Runoff is measured indirectly via the speed of the water. Such measurements are carried out at longer intervals with different water levels, and this data is used to create a runoff curve. Via this runoff curve, it is possible to allocate a runoff to every measured water level.

S

Salt water: Salt water is generally seawater containing on average 3 % dissolved salts, and is unsuitable for human consumption. Special forms include spring water and groundwater that has been in contact with salt deposits, from which it has absorbed considerable quantities of salt (brine, mineral springs).

Saprobes: Aerobic, i.e. oxygen-consuming organisms that live in waterbodies and mineralise dead organic substance, thereby achieving biological self-purification of the water. Saprobes include certain species of worms, bacteria, fungi and algae.

Sediment: Deposits in waterbodies created by the sedimentation of mineral and/or organic solid particles. Depending on the type of deposition, we distinguish between sea (marine), lake (limnic) and river (fluviatile) sediments. Some pollutants (e.g. heavy metals such as cadmium) can accumulate in high concentrations in sediment, but can also be released from the sediment, posing a threat to biotic communities in waterbodies.

Sewage sludge: Term for the sludge from sewage treatment plants that has rotted or been stabilised in some other manner. Sewage sludge from domestic wastewater contains a wealth of nutrients and humus, and under certain circumstances can be used as a fertiliser. Depending on the type of wastewater and treatment technique, sewage sludge may contain substances that are harmful to the environment and/or human health.

SRES scenarios: The 1992 IPCC scenarios were revised from 1996, leading to the creation of the SRES scenarios ("Special Report on Emissions Scenarios"). They highlight potential developments in the 21st century in the areas of population growth, economic and social development, technological changes, resource consumption and eco-management and provided the basis for the 2001 and 2007 IPCC reports; they were replaced in 2013/14 by the RCP scenarios.

Sub-basin: An area of land from which all surface run-off flows through a sequence of overground watercourses to a particular point in an overground watercourse.

Substances hazardous to water: Chemical substances and mixtures of substances or their reaction products that are capable of contaminating waterbodies or adversely altering their properties in some other way. These include solvents, residues containing petroleum, pesticides, heavy metals (e.g. cadmium, mercury), phosphates and halogenated hydrocarbons, acids, lyes and PCBs.

Surface waters: Inland waters (with the exception of groundwater) plus transitional waters and coastal waters; as an exception, sovereign waters are included for the purposes of chemical status.

Suspended matter: Undissolved, dispersed mineral and organic solids (particles) that are suspended in the water due to their density and/or flow speed in the water.

T

Transitional waters: Bodies of surface water close to estuaries which have a certain salt content due to their proximity to coastal waters but which are essentially influenced by fresh water flows.

W

Wastewater: The water modified by domestic, industrial, commercial, agricultural or other forms of use, as well as the water that is continuously discharged with this in the sewer system (dirty water), and the precipitation that runs off from developed or sealed land.

Wastewater treatment plant: Plant for the treatment of industrial and household wastewater. Depending on the properties of the wastewater and the design and capacity of the treatment plant, wastewater treatment is comprised of a mechanical stage (stage 1), a biological stage (stage 2) and a subsequent stage (stage 3).

Mechanical treatment also removes trace and suspended matter. It uses physical properties to retain the undissolved substances contained in the wastewater. In stage 2, the wastewater, having usually been pre-treated mechanically, is treated with the aid of microorganisms. In the subsequent stage, further substances such as phosphates and heavy metals are precipitated and flocculated via the use of chemicals, and thereby removed from the water.

Water abstraction fee: The water abstraction fee is levied in certain Federal Länder for water abstraction and use. The revenues are used to protect drinking water and water resources.

Water cycle: Water is in a constant cycle due to solar energy. It evaporates on the surface of seas and land masses. The rising water vapour cools down at altitude and condenses into clouds. When these clouds cool down further, they discharge their humidity as precipitation.

Water hazard class (Wassergefährdungsklasse WGK): The potential of substances and preparations to adversely alter the properties of water are categorised in a classification system based on biological test procedures and other properties. There are 3 water hazard classes:
- WGK 1 = slightly hazardous to water
- WGK 2 = obviously hazardous to water
- WGK 3 = highly hazardous to water

Water properties: The physical, chemical or biological properties of the water in a body of surface water or body of coastal water and groundwater.

Water protection area: Part of a catchment area or the entire catchment area of a drinking water abstraction plant in which usage restrictions are imposed in order to protect the abstraction of drinking water. Designation of a water protection area requires a formal procedure.

Water quality: Quality of a waterbody evaluated according to prescribed bio-chemical criteria.

Water use: Defined by Directive 200/60/EC as water services and any form of human activity having significant impacts on water properties. Water services refer to services such as wastewater disposal or water supply.

Waterbed: Comprises the waterbody bed and the bank as far as the top edge of the escarpment.

Waterbody: Significant, uniform sections of a surface or coastal water and demarcated volumes of groundwater within one or more groundwater aquifers (bodies of groundwater).

Waterbody maintenance: Waterbody maintenance refers to the shaping and development of a waterbody and its banks and flood plains according to biological and landscape management aspects.

Waterbody management: Management of surface and underground waters. The emphasis here is on preserving or restoring the ecological balance while simultaneously ensuring the optimum supply of drinking water and service water to the general public and/or to industry.

Waterbody monitoring: Waterbody monitoring is (usually) carried out by the water management authorities, either continuously or on a random sample basis. These controls are designed to monitor waterbody quality and promptly identify any irregularities.

Waterbody structure (hydromorphology): The form diversity created by the natural flow process (undercut-slope banks and slip-off slope banks, meanders, gullies and islands) in a waterbed. The waterbody structure is crucial to its ecological function: The more diverse the structure, the more habitats are available for fauna and flora.

Waterbody type: Waterbodies of a similar size, altitude, morphology and physico-chemistry in the same region are distinguished by similar aquatic communities, allowing individual waterbodies to be grouped together into waterbody types. The reference status which forms the reference point for biological evaluation is defined by the biological, chemical and hydromorphological properties of a waterbody type.

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