Water Framework Directive

The Status of German Waters in 2021
Progress and Challenges

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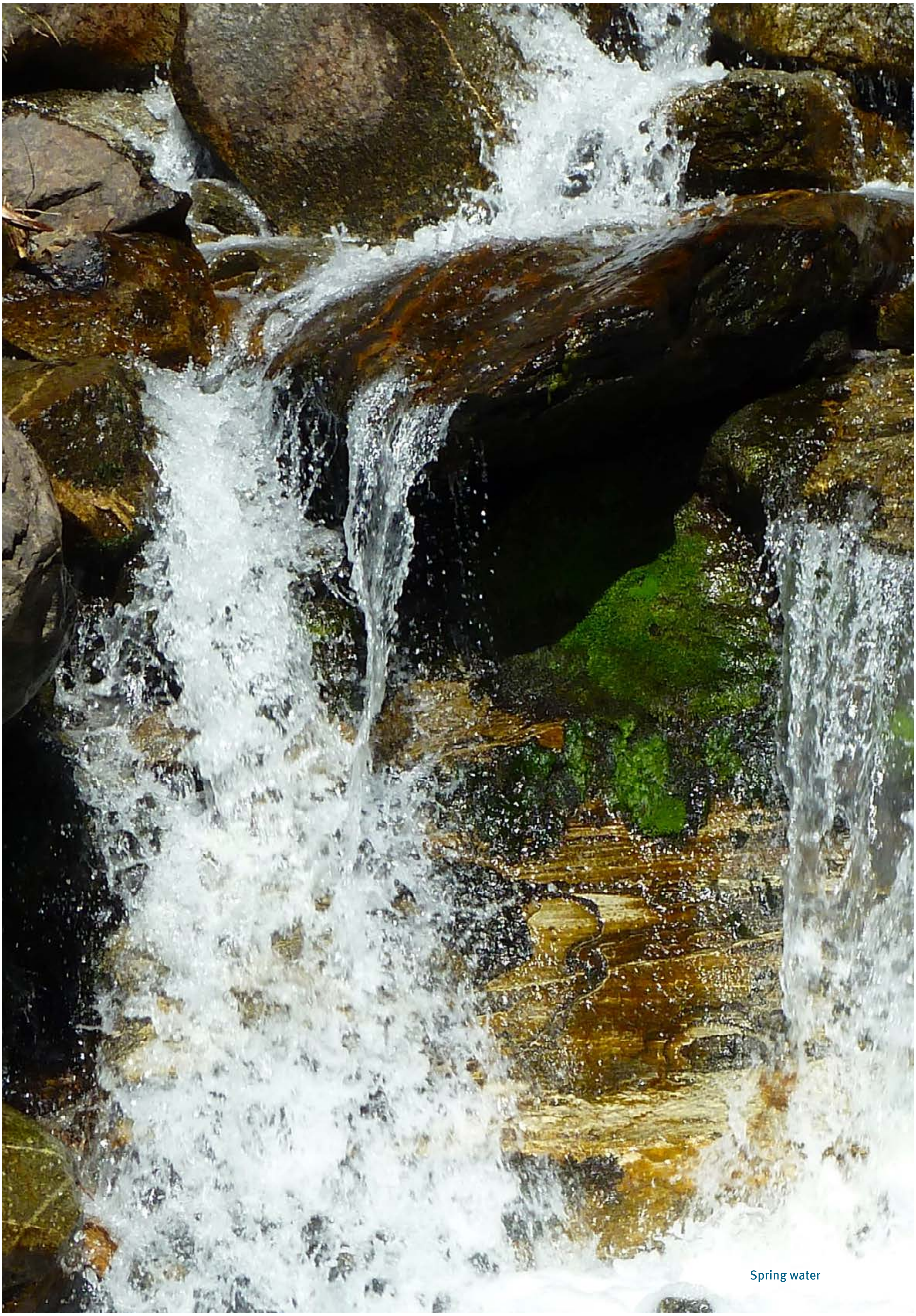

Spring water

Foreword

Dear Reader,

Water, our main livelihood and most important resource, must be protected and treated with care. We are used to water being available at all times in high quality and in any quantity, but this resource is increasingly coming under pressure, for several reasons. Many water bodies are contaminated, and, due to climate change, extreme conditions such as heat and drought, torrential rains and floods are becoming the ‘normal condition.’ We must find better ways to adapt to this. In doing so, providing for unspoiled waters plays a key role.

The EU Water Framework Directive stipulates that “good status” is to be achieved for all European water bodies. This means: water in sufficient quantity and of high quality as well as good living conditions for all terrestrial and aquatic plants and animals.

This booklet presents the state of Germany’s water bodies in 2021 in texts, maps and graphics and describes pressures as well as the improvements achieved in recent years. It also points out measures necessary to ensure that our waters provide habitats for diverse species and sufficient clean water for all of us in the long term.

The objectives of the Water Framework Directive have not yet been achieved for a major part of water bodies in Germany. However, the federal government, federal states and local authorities have already achieved improvements and initiated numerous measures with great commitment and financial expenditure in order to facilitate progress.

Wastewater treatment plants have been expanded, agri-environment schemes implemented, rivers restored, obstacles for fish removed and dikes relocated. Experts and scientists monitor and assess water bodies on an ongoing basis, elaborate new management plans and adapt measures. In order to make precautionary water protection a key element in all fields of action, the Federal Ministry for the Environment has elaborated Germany’s National Water Strategy in conjunction with a comprehensive action programme. Another measure to leverage progress is our Federal Action Plan on Nature-based Solutions for Climate and Biodiversity, aimed at strengthening, protecting and restoring ecosystems in order to maintain their natural functions as water and carbon stocks.

There is still a long way to go before all water bodies will have achieved “good status”. I am committed to moving closer to this goal step by step, in collaboration with the federal government, the federal states, local authorities and all stakeholders involved in water management. In this way, our waters can be used sustainably in the long term and make their important contribution to coping with the climate crisis and preserving biodiversity.

I trust that after having read this report, water body protection will become a matter of concern to you as well.

Steffi Lemke
Federal Minister for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

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Lake in Brandenburg

1 Water protection in Germany

1 Water protection in Germany

The EU Water Framework Directive aims at comprehensively protecting surface waters and groundwater. By 2027 at the latest, "good ecological" and "good chemical status" is to be achieved in surface waters and "good chemical" and "good quantitative status" in groundwater. Much is being done to meet these objectives of ambitious water protection. Extensive data is collected on the status of our water bodies and related to the diverse pressures to which groundwater and surface waters are subject. Based on this knowledge, measures to improve water body status are elaborated and described in management plans and programmes of measures that form the basis for action for water protection in Germany and the European Union.

Our water bodies fulfill numerous, sometimes vital, functions. At the same time, they are exposed to many different demands and pressures as well as increasing climate change and the resulting continued biodiversity loss. This is why water protection must be based on a holistic and integrative strategy. Thus, all rivers, lakes, estuaries, coastal waters and groundwater of an entire river basin fall within the scope of the Water Framework Directive. Water protection requirements must also be reflected in other policy areas and sectors, such as energy and agriculture – here, contradictory objectives or instruments contrary to water protection are out of the question, which means that water, nature, flood, climate and marine water protection are inseparable. In this regard, numerous measures have already been implemented in a wide variety of areas, resulting not only in an improvement in water body status. For example, restoring watercourses not only increases biodiversity in the river, but can also serve flood protection and the avoidance of maintenance costs. Such synergies also play a key role.

Kingfisher

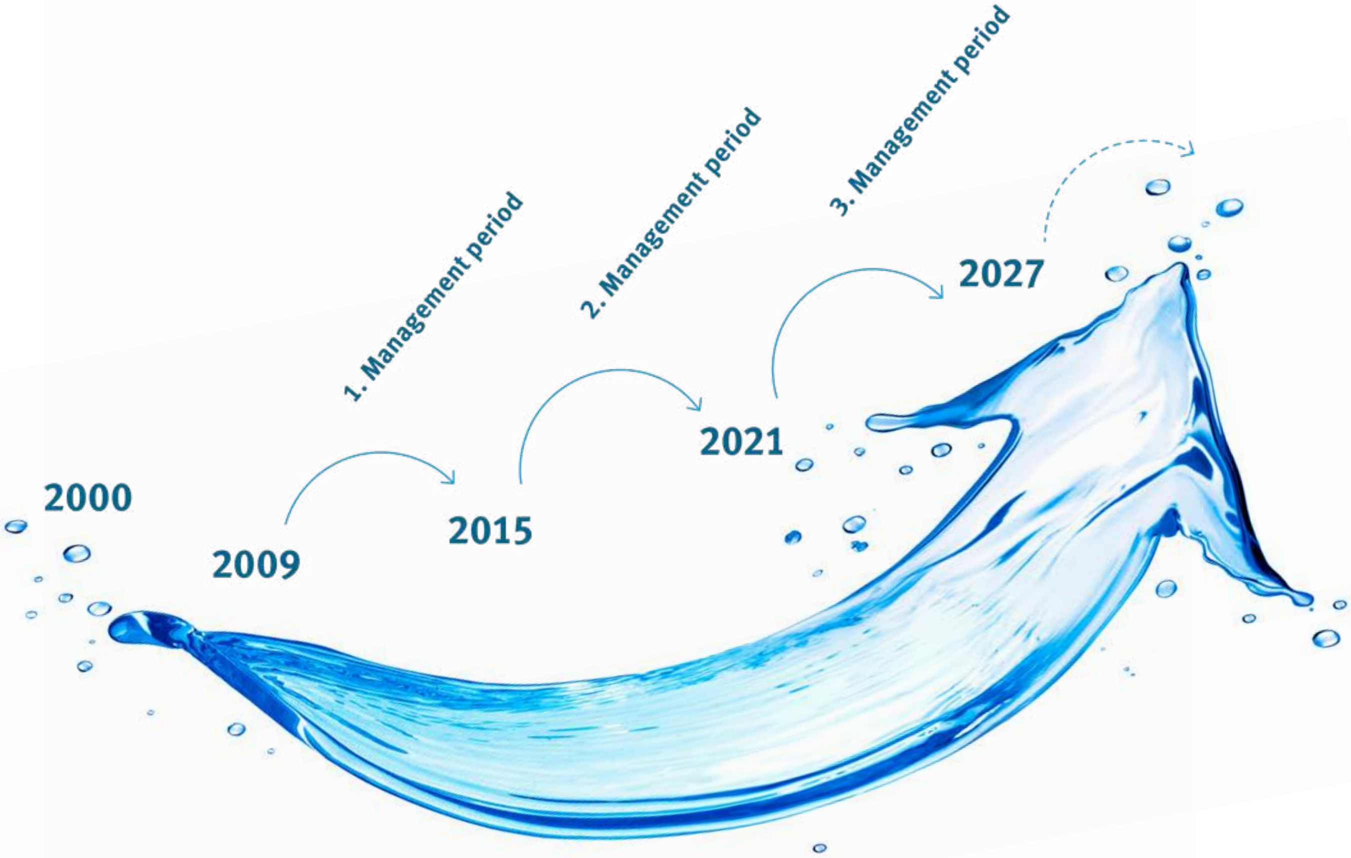
Droughts and heavy rainfalls are best mitigated by well-adapted and near-natural water bodies, which can only be achieved through overarching and sustainable water protection as provided by the Water Framework Directive's broad approach.

Water Framework Directive implementation is an ongoing process (Figure 1), and the management plans and programmes of measures required for this are regularly updated. Certain implementation steps are taken every 6 years, with each cycle corresponding to a separate management period. Responsibility for implementation primarily lies with the federal while the federal government is also responsible for achieving Water Framework Directive objectives on federal waterways.

We are currently at the beginning of the third management period, lasting until 2027. Management plans and programmes of measures elaborated for this period were published in December 2021. This booklet builds on these plans and programmes as well as the digital reports to the European Commission. It provides information on how we use water bodies, on the resulting pressures and on how these pressures impact water bodies. Both the current status of surface waters and groundwater and measures planned to improve this status are presented in detail, as well as progress achieved and the challenges we face.

Figure 1

Water Framework Directive – implementation timeline



Management period

Implementation of programmes of measures, monitoring and assessment of surface waters and ground-water	
	① Survey of pressures on water bodies and their impacts, risk analysis for achieving objectives, economic analysis of water uses and for implementing measures
	② Public Participation on preparing and drafting management plans and programmes of measures, taking into account timetable and work programme and major water management issues
	③ Preparation or updating of management plans and programmes of measures
	Publication of the management plans and programs of measures and reporting to the European Commission

Management in river basin districts

Management planning in the European Union is based on river basin districts (Map 1), of which there are ten in Germany: Danube, Eider, Elbe, Ems, Meuse, Oder, Rhine, Schlei-Trave, Warnow-Peene and Weser. A river basin district comprises all waters in the catchments of one or more large rivers, lakes, ponds and includes groundwater as well as associated coastal waters. Since river basins often extend beyond national borders, more than one Member State is usually responsible for their management. Thus, water protection concerns all states that are responsible for river basin management plans. Germany or certain federal states are members of the international commissions for the protection of the Danube, Elbe, Meuse, Moselle/Saar, Oder, Rhine and Lake Constance. Germany is also involved in bilateral commissions for water protection jointly with Denmark, the Netherlands, Austria, Poland and the Czech Republic.

At the European level, Member States in collaboration with the European Commission are continuously developing a common understanding of the work to be done in Water Framework Directive implementation, which is the only way to ensure that water management issues can be assessed and dealt with in a standardised and comparable manner.

At national level, cooperation in water protection is coordinated across federal state borders in several river basin associations. In this regard, the federal state governments coordinate their efforts. One of the instruments to achieve this is the Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA), which is tasked with facilitating nationwide exchange of information on water management, water legislation, on development and coordination of important technical foundations and solutions, and recommendations for their application.

Public participation

Public participation is very important for implementing Water Framework Directive objectives. Municipalities, water users, water conservationists and interested public are actively involved, which not only raises public awareness of environmental issues and the status of water bodies, but also improves the quality of implementing measures. Moreover, active participation is a solid foundation for achieving long-term management solutions that are accepted by all stakeholders. This also helps to identify potential conflicts at an early stage and avoid unnecessary expense.

The federal states undertake activities that successfully inform people about Water Framework Directive implementation. This is done by actively involving the public with hearings. Participants from associations, municipalities, industry, agriculture and forestry, fisheries as well as the environmental protection and nature conservation communities are involved through Water Framework Directive advisory boards that meet regularly in round tables. In this regard, each federal state has developed the approach appropriate to its needs and adapts it as required. Networks such as the Wassernetz (water network) in North Rhine-Westphalia, the Gewässernachbarschaften (water neighbourhoods) in Bavaria, Hesse, Rhineland-Palatinate and Saarland or the sponsorships for water bodies in Baden-Württemberg contribute to Water Framework Directive implementation, support it and involve the public as well as local operators. Moreover, the federal states and the federal governments offer a wide range of information on various digital platforms, for example on action planning, water assessment procedures and water body restoration, or provide access to interactive maps on the quality of water bodies. There is also a variety of other measures, such as regional and local information events on water protection, participatory projects and water protection competitions.

Map 1

The ten German river basin districts (figures without territorial waters)

Baldeneysee reservoir near Essen in the Ruhr area

2

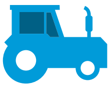
At a glance – results of the third cycle management plans

2 At a glance – results of the third management plans

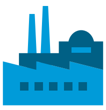
Long-term protection of water bodies as habitats for animals and plants and ensuring the availability of water resources for humans are the essential goals of water management. The Water Framework Directive represents/is the basic legal instrument in this regard. Updated results concerning the status of water bodies, the main pressures and impacts and the planned measures are now available.

Based on the Water Framework Directive, waters are differentiated into surface waters and groundwater and then further categorised into water bodies. In total, there are about 11,000 water bodies in Germany, of which almost 9,000 are rivers, more than 700 are lakes, almost 100 are coastal and transitional waters and 1,300 are groundwater bodies.

Water bodies in Germany are used in multiple ways. Water users that most severely impact on our waters are agriculture, industry as well as municipalities and households.



Agricultural production in Germany supplies us with almost 90 percent of our food, with many products also being exported. It is a source of diffuse inputs of nutrients and plant protection products (PPPs) that remain too high. In addition, many rivers and streams have been straightened and modified in order to gain agricultural land or to facilitate cultivation. In 77 percent of surface waters and 29 percent of groundwater, impacts on the status of water bodies are caused by agricultural production.



Our standard of living is largely based on industrial production, such as the chemical industry, mechanical engineering, motor industry and energy generation. Progress in wastewater treatment and air pollution control notwithstanding, pollutants are still discharged into water bodies, which, in 67 percent of all surface waters, results in effects on water status that are primarily due to industry and mining.

Municipal wastewater treatment plants significantly contribute significantly to reducing nutrient and pollutant inputs. Nevertheless, these inputs are still too high. Comprehensive flood protection is needed to protect settlements, necessitating that water bodies be developed accordingly. In 35 percent of surface waters, impacts on water status can be attributed to pollution from municipalities and households.

Other water uses such as flood protection, hydropower and navigation can also result in significant pressures and impacts on water body status. However, multiple pressures and multiple impacts are typical. Almost half of the groundwater bodies are polluted, and in more than 80 percent of surface waters, two to six pressures occur simultaneously – only one percent is considered to be without pressures. The main effects of these pressures are altered hydromorphology, interruption of continuity and pollution due to excessive nutrient and pollutant inputs.

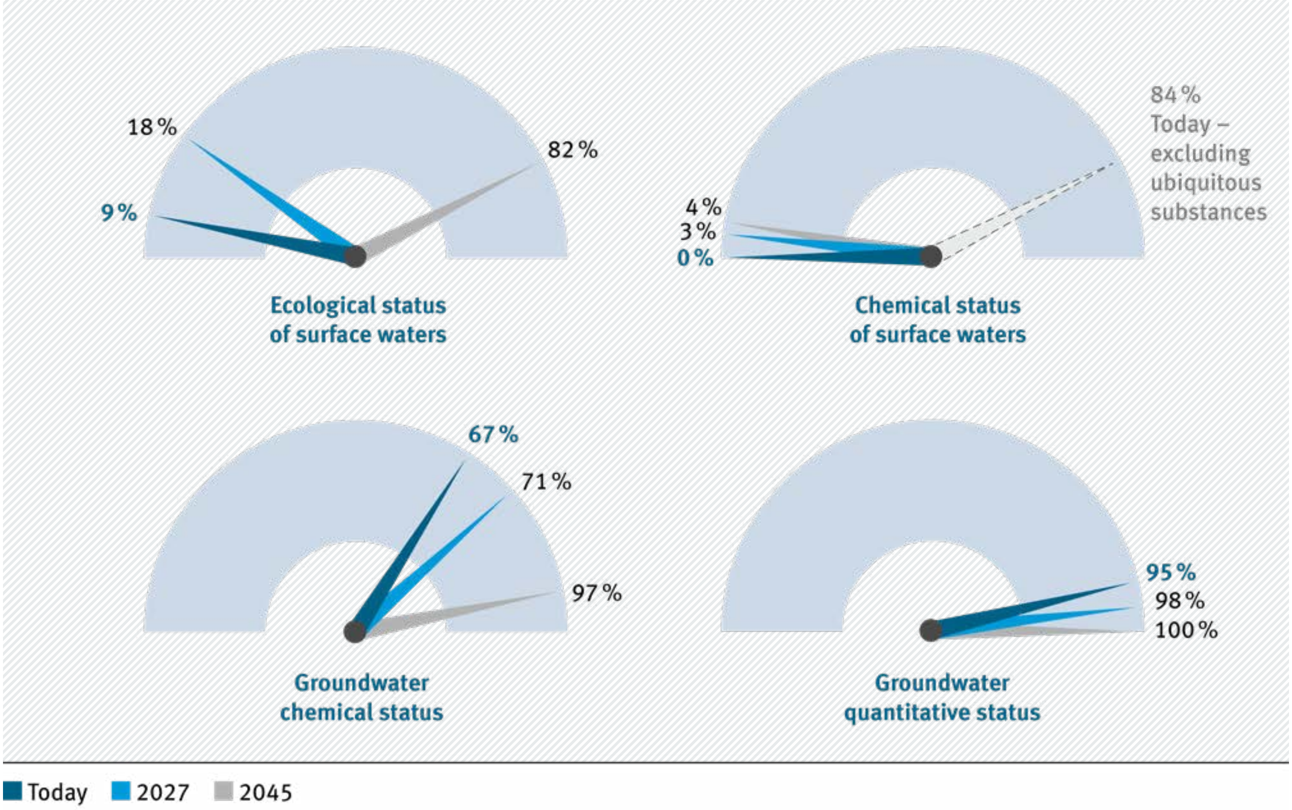
Climate change effects on water bodies are also increasingly apparent: Runoff and water temperatures are changing; heavy rainfalls and longer periods of low water levels are occurring more frequently.

In the last management period, water status was monitored at more than 20,000 monitoring sites in surface waters and almost 13,000 monitoring sites in groundwater. In surface waters, ecological status and ecological potential, respectively, as well as chemical status are assessed. For groundwater, chemical and quantitative status are relevant.

At present, 9 percent of all surface waters achieve good ecological status or potential potential or better, which is about one percent more than in 2015. Accordingly, the number of water bodies assessed as "poor" has decreased by the same amount. Assuming the planned measures are implemented by 2027, 18 percent of the water bodies should achieve Water Framework Directive objectives (Figure 2).

Figure 2

Status of target achievement and outlook for the years to come



Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022.
Editing: Umweltbundesamt, Bund / Länder-Arbeitsgemeinschaft Wasser (LAWA)

Today, not one of the surface waters achieves good chemical status. This is primarily due to the fact that mercury becomes airborne through "longterm burning" of fossil fuels and is deposited ubiquitously in soils and water. Other pollutants are also a cause for missing the target. By 2045, a slight improvement in chemical status to four percent is expected, due to the implementation of comprehensive and complex measures.

Today, 67 percent of groundwater bodies achieve good chemical status – an increase of three percent compared to the last management period. Measures, primarily in the agricultural sector, are expected to bring about a further 30 percent improvement in chemical groundwater status by 2045.

Already today, 95 percent of all German groundwater bodies achieve good quantitative status.

In more than 80 percent of surface waters, restoration measures are planned to improve animal and plant habitats; nutrient and pollutant inputs are to be reduced in over 60 percent from diffuse sources and in almost 30 percent from point sources. In the farming sector, measures to reduce groundwater pollution from diffuse sources predominate, accounting for more than 50 percent.

The implementation of the Water Framework Directive, which aims to protect our waters and ensure the availability of this most important resource, remains a long-term mission.

Lake Constance


3
Germany's waters

3 Germany's waters

Germany's temperate-humid climate engenders precipitation levels that the subsoil cannot completely absorb and that feed numerous and extensive surface waters such as rivers and lakes. In part, precipitation water seeps into the ground and forms, via percolation and depending on geological conditions, large groundwater reservoirs.

3.1 Surface waters

Germany's surface waters are categorised into rivers, lakes, transitional waters and coastal waters. This type of water body categorisation is also used in the Water Framework Directive.

The length of Germany's riverine network amounts to more than 500,000 kilometres. River catchments larger than ten square kilometres are subject to reporting to the European Commission, which is the case in about a quarter of all watercourses. However, legally binding water protection objectives apply to all water bodies regardless of reporting obligations. Among the longest watercourses with the highest runoff are the Rhine, Danube and Elbe, with the Rhine having the highest average runoff and a width of more than 700 metres at gauge Rees on the Dutch border. Almost 3,000 cubic metres of water per second flow past there, which corresponds to the quantity of water of 25,000 bathtubs dumped in one second. This amount of water would cover a football pitch to 5 metres high in only 10 seconds.

Scattered across the country, most of Germany's natural lakes were formed during the last ice age by the action of inland ice and meltwater, which is why they are mainly located in the North German Plain, the Alpine Foothills and the Alps. Here, they number more than 12,000. In addition, there are numerous artificial lakes (opencast mining lakes, quarry ponds or excavation lakes having their origin in clay, sand and gravel extraction, as well as barrages and lowland reservoirs). Of all the lakes, 738 measure more than 0.5 square kilometres of surface and are thus subject to Water Framework Directive reporting. Lake Constance, parts of which are located in Germany, is the largest natural lake (total area: 536 square kilometres) and also the deepest German lake (254 metres). In terms of surface area, it is followed by the Müritz and the Chiemsee (105 and 80 square kilometres, respectively), and in terms of depth by the Königsee and the Walchensee (both about 190 metres).

Transitional waters are estuary waters bordering the seas, thus still subject to freshwater influence but already having a certain salinity. This category of waters includes the lower reaches of the Eider, Elbe, Ems and Weser at their mouths in the North Sea.

Adjacent to transitional waters or directly to the coastline are coastal waters, which, in Germany, include the waters along the Baltic Sea coast, among others. Coastal waters cover up to one nautical mile seaward, beyond which territorial waters begin. One essential Water Framework Directive objective is protecting the marine environment: The requirements for chemical status must also be met in territorial waters (which in Germany cover more than 25,000 square kilometres).

Different types of water bodies

Germany's water bodies are different in type and they also differ in the living conditions they provide. This is exemplified by the simple fact that a small headstream in the Alps is home to completely different animal and plant species than in the large Elbe stream in the Northern Lowland, and the same applies to lakes, transitional and coastal waters. These differences are causally related to geological, climatic and hydrological characteristics of water bodies and their catchments and give rise to categorisation criteria for water bodies. Thus, we distinguish 25 types of rivers, 14 types of lakes, 2 types of transitional waters and 9 types of coastal waters. This categorisation is fundamental for defining reference conditions against which water bodies are assessed. Reference conditions describe the potentially natural state of a water body at present as it would be without artificial structures and without any pressures due to human interference.

The most widespread water body type in Germany is the rocky-soil, low-lime upland stream (total length: 20,000 kilometres), which was chosen Water Type of the year in 2011.

Water Type of the Year

An award of the Federal Environment Agency:
https://www.umweltbundesamt.de/themen/water/water-type-of-the-year

Assessment of surface water bodies

As per the Water Framework Directive, surface waters are assessed on the basis of so-called water bodies, which is why all of the assessments and illustrations in this booklet relate to water bodies. A water body can consist of one or more associated streams, a river or river reach, a lake or part of a coastal water. For analytical reasons, water bodies are delimited on the basis of technical criteria. For example, the selected reach is significant, corresponds to a certain type of water body and has a comparable status. Based on these criteria, more than 9,700 German waters are designated as surface water bodies. Streams and rivers account by far for the largest share, with about 92 percent (8,925 water bodies) and a total length of 137,000 kilometres. Water bodies in the Elbe, Saale or Moselle, for example, are very long stretches (more than 200 km).

In contrast, there are numerous small water bodies that barely reach one kilometre in length. In addition, there are 738 lake water bodies, 5 transitional water bodies, 72 coastal water bodies and 7 territorial waters (Table 1).

Natural, heavily modified and artificial water bodies

The Water Framework Directive distinguishes between natural, heavily modified and artificial surface waters, a classification made at water body level. A "**natural**" water body is hardly put to any use or is used only to a lesser extent; hence, it retains many of its natural features. In contrast, a water body is designated as "**heavily modified**" if, due to one or more specific water uses, it has been altered in its shape to such an extent that it cannot achieve "good ecological status" without significantly impairing these uses, and, in addition, these uses can also not be substituted.

One typical heavily modified water body is, for example, the Moselle, which is used intensively for shipping and power generation and is continuously dammed. "**Artificial**" waters are human-made waters in places where there were no waters before, such as canals or opencast mining lakes.

Table 1

Statistics on surface and groundwater bodies

Water category/water body type	Number of water bodies	Length or area	
		Total	Average
Rivers	8,925	137,030 km	15 km
Lakes	738	2,423 km²	3 km²
Transitional waters	5	834 km²	167 km²
Coastal waters (territorial waters included)	79	14,450 km²	200 km²
Groundwater	1,291	358,000 km²	284 km²

Technical data: WasserBLIcK/BfG & Competent authorities of the federal states, 29.03.2022
Editing: Umweltbundesamt, based on Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) data.

One management objective other than good ecological status applies to heavily modified and artificial water bodies: "good ecological potential". It calls for the best possible ecological design, allowing the existing intensive use by humans to be maintained. If uses cease, heavily modified water bodies can also be reclassified as natural. Whether natural, heavily modified or artificial – a good chemical status must always be achieved.

In Germany, 35 percent of all surface water bodies were classified as heavily modified and 17 percent as artificial (Map 2), meaning that for 52 percent of surface water bodies, the objective is "good ecological potential" instead of "good ecological status". The following water uses are most frequently cited as reasons for designating heavily modified water bodies: drainage for farming purposes (66 percent), urbanisation (28 percent) and flood protection (19 percent), although several uses can occur in parallel.

Above all, water bodies in the vast, heavily farmed regions of the Northern Lowlands as well as water bodies in the northern parts of the Upper Rhine Plain count among the heavily modified water bodies. Large rivers such as the Rhine and the Weser and the transitional waters of the Eider, Elbe, Ems and Weser, which are used as shipping lanes, are classified as heavily modified as well, as are certain reaches of the larger water bodies of the Alpine foothills such as the Iller, Lech, Isar and Inn, which are used for hydropower generation. The Lahn, Main, Moselle, Neckar and Saale rivers as well as certain stretches of the Danube are examples of distinct combinations of uses for transport, flood protection and energy production.

In the farmed regions of the lowlands, waters are also increasingly designated as artificial water bodies – often ditches and channels for farmland drainage. Other artificial water bodies are navigation canals such as the Dortmund-Ems Canal, the Mittelland Canal, the Kiel Canal or the Main-Danube Canal, but also opencast mining lakes such as the new Cottbuser Ostsee.

3.2 Groundwater

Groundwater is subterranean water and, like surface water, part of the water cycle. It is formed by rainwater percolating through the soil and subsoil. The climate in Germany usually leads to groundwater recharge in the winter months, whereas in the summer, groundwater levels drop because, for example, plants take up water from the soil, or it evaporates. In addition to precipitation, groundwater recharge is also facilitated by fractured rock or unconsolidated sediments that can absorb, store and transfer seepage water. Rocks that can do this particularly well are, for example, gravel, crushed rock or sandstone, hence those very well capable of absorbing groundwater; they are called aquifers. In contrast, there are rocks that primarily impound water, such as clay, gneiss or granite, and that can be almost impermeable to groundwater. Often, groundwater-conducting and -impounding rocks in the subsoil alternate, so that so-called groundwater horizons are formed.

Groundwater resources near the surface support valuable wetland biotopes and supply plants with water. In wetlands and springs, groundwater comes to the surface and feeds streams and rivers.

Groundwater and surface water are closely linked to one another in that during floodings and inundation of riverine floodplains surface water seeps into the groundwater, whereas in the low-rainfall periods of the year, a large part of the water in our rivers can, in turn, come from groundwater. Quality and quantity of groundwater thus also influence surface waters. Around 74 percent of drinking water comes from groundwater, making it our most important drinking water resource. A groundwater body is defined as a distinct volume of water within a single aquifer or several aquifers. A total of 1,291 groundwater bodies have been designated over the entirety of Germany, with an average area of about 284 square kilometres (Table 1).

Map 2

The water network in Germany. Natural, heavily modified and artificial water bodies

■ Natural water bodies ■ Heavily modified water bodies ■ Artificial water bodies

Spatial base data: Geobasis-DE/BKG 2015
Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
Editing: Umweltbundesamt, Bund / Länder-Arbeitsgemeinschaft Wasser (LAWA)

Container vessel on the Rhine

4

Uses, pressures and impacts

4 Uses, pressures and impacts

Water bodies are used in multiple ways, many of which directly affect water bodies: Water is abstracted for irrigating farmland and for producing drinking water; treated wastewater from wastewater treatment plants of municipalities, households or industry is discharged into water bodies; goods are transported by ship; and energy is generated by hydropower. In addition, water bodies are deliberately modified, straightened or relocated, for example to make room for industry or housing. Certain pressures also affect water bodies indirectly. Many substances released by combustion processes or washed away by rainwater, for example, find their intricate ways into watercourses.

Each of these direct or indirect activities can become a pressure for water bodies and result in more or less far-reaching consequences for them. For example, nutrients used on farmland for plant growth (fertilisers) can be washed into adjacent water bodies where they stimulate algae growth. When these algae die off, oxygen content in a water body can decrease to such an extent that fish life is threatened. In addition, blue-green algae blooms can occur and impair bathing water quality. These interrelationships between uses, pressures and their impacts (Figure 3) are considered and analysed when implementing the Water Framework Directive; they form the basis for determining measures to reduce pressures.

Figure 3
Overview of key water uses, pressures and impacts

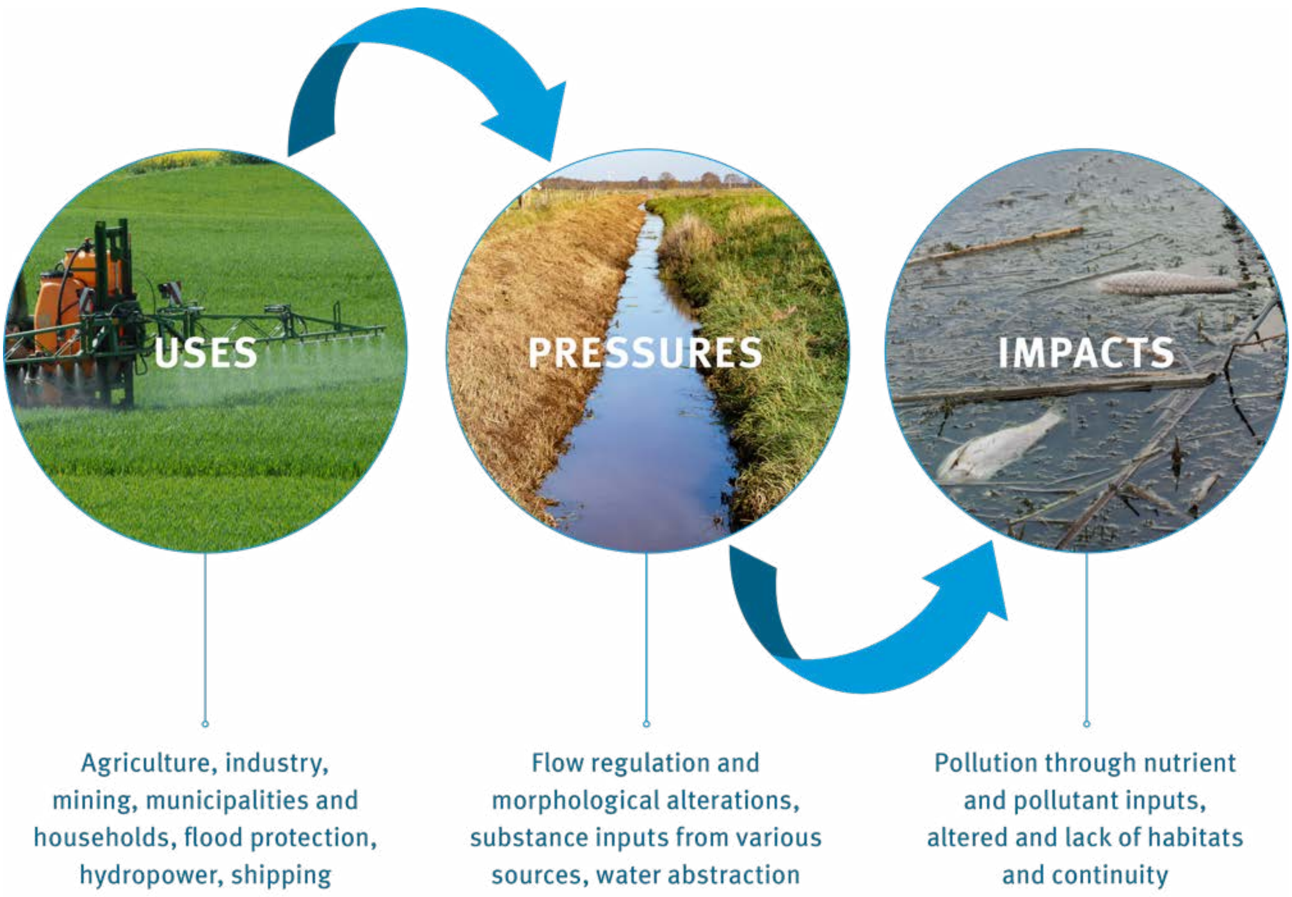
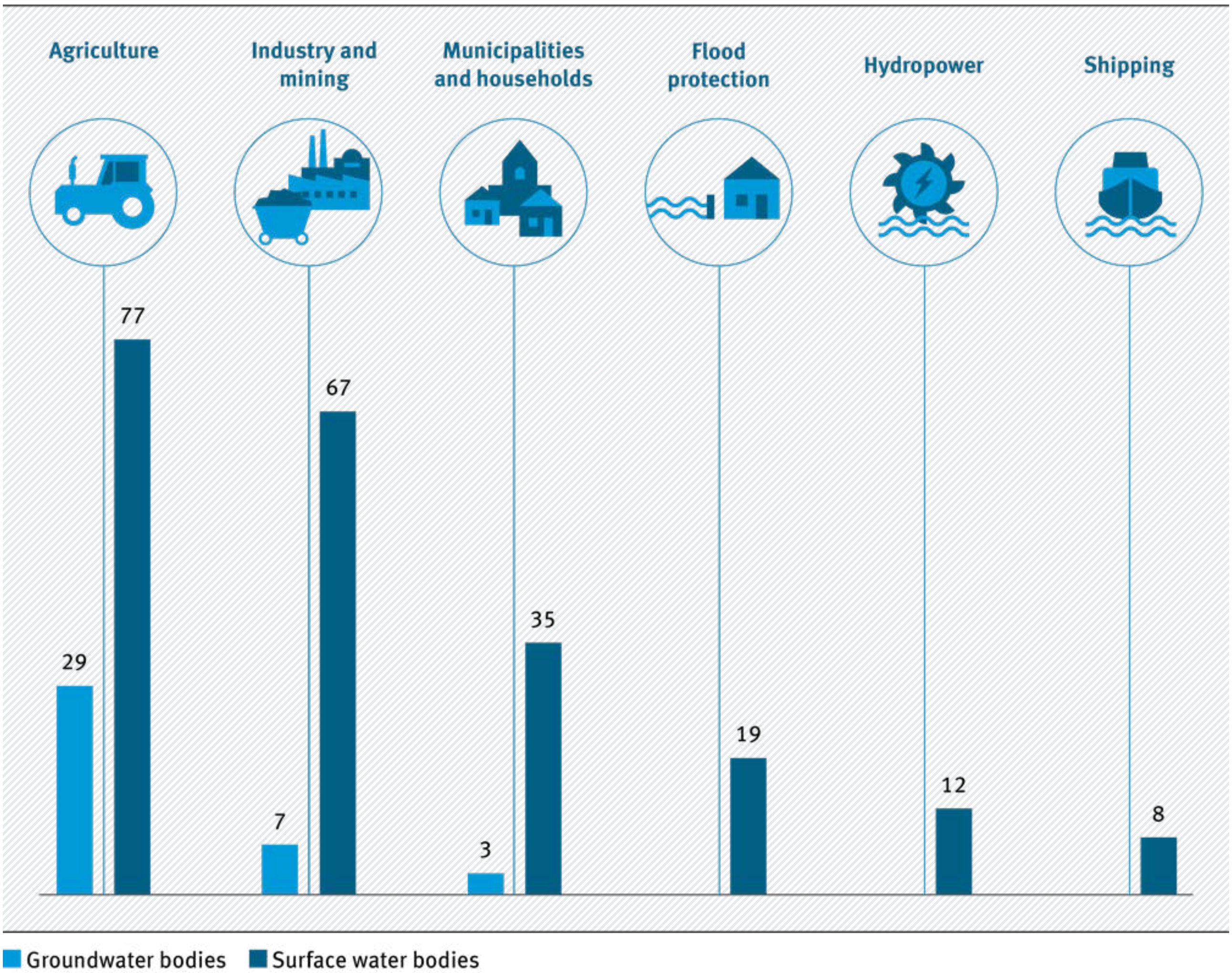


Figure 4

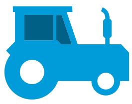
Percentage of surface and groundwater bodies in which the specified water uses have a significant impact on achieving management objectives



Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
Editing: Umweltbundesamt, Bund / Länder-Arbeitsgemeinschaft Wasser (LAWA)

4.1 Uses of the aquatic environment

The six major uses that affect the aquatic environment presented below, include farming, industry, mining, municipalities and households, hydropower, navigation, fisheries, and recreational and leisure activities. The need to protect these uses and investments entails flood protection measures, which in turn can also place a significant pressure on water bodies (Figure 4). Increasing attention in water body management is also being paid to the impact of climate change (Chapter 4.3).



4.1.1 Agriculture

Some 47 percent of Germany's land area (equivalent to 16.6 million hectares) is used for agriculture, a large part of which is arable and pasture land (11.7 million hectares). Just under 4.8 million hectares are used as permanent pasture and particularly as grazing land. Agriculture's share in the gross domestic product is currently 0.8 percent, with an overall degree of self-sufficiency of almost 90 percent. Domestic agricultural products form the basis of the German food sector.

In addition, manufacturing and supplier industries associated with farming contribute to value creation and job creation. In 2020, there were 262,776 farms in Germany employing 936,900 people (i.e., about 2 percent of the workforce), half of which were part-time. Since 2001, there has been a 41 percent decline in the number of farms. The share of organically producing farms is about 9.6 percent.

Pressures related to agricultural use are manifold and vary depending on location. Especially in conventional and intensive agricultural production, nitrogen and pesticides increasingly enter surface waters and groundwater. In more than 60 percent of surface water bodies and in 38 percent of groundwater bodies, diffuse substance inputs are related to agricultural use, inputs that are particularly high in regions with large livestock densities, where comparatively large amounts of manure and slurry are applied to the fields, a practice associated with higher nutrient losses as well as nutrient excess in the soil. Pressures from agricultural use mainly result in contamination of groundwater and eutrophication in lakes, rivers and coastal waters. Diffuse substance inputs also include fine sediment eroded from farmland and entering water bodies, thus covering water beds and resulting in oxygen deficiency and habitat loss, for example.

Levels of diffuse nitrogen inputs from agriculture are quantified by the "nitrogen surplus", an indicator provided in the German Sustainability Strategy. In 2018, the nitrogen surplus was 87 kilograms per hectare and year on a 5-year average, with a downward trend over the past four years.

Excess means that not all of the nitrogen supplied is incorporated into plant and animal products, but can potentially enter groundwater, water bodies or the atmosphere as diffuse nitrogen losses. As these loads cannot be completely avoided, they must be reduced to a minimum. The corresponding objective of the federal government's sustainability strategy is to reduce this surplus to 70 kilograms of nitrogen per hectare by 2030.

Agriculture is also responsible for a significant part of phosphorus inputs into water bodies, which can, depending on how farming is practised regionally, account for about one third to one half of the total phosphorus inputs. Similar to nitrogen, regional differences are mainly due to the uneven distribution of livestock, which in certain areas entails a particularly intensive use of organic fertilisers, resulting in phosphorus accumulating in soils. Crops such as maize being cultivated on sloping ground increase soil erosion risk. As a result, the risk of phosphorus and fine sediment inputs into water bodies increases significantly during heavy rainfall.

In addition to nitrogen and phosphorus, pesticides and their active substances associated with certain farm management practices can also enter water bodies and harm aquatic organisms.

The trend of groundwater being polluted by active pesticide substances is partly declining. One reason for this is degradation of active substances that have been banned for many years, such as atrazine with its degradant desethylatrazine, and gradual replacement of particularly hazardous and persistent substances by such substances that are less dangerous to the environment.

Thus, this downward trend is only evident in the case of active substances that are no longer authorised. On the other hand, groundwater contamination with active substances that are still authorised remains high; in addition, their degradation products have been detected much more frequently in groundwater in recent years.

Developed, straightened watercourse in a pasture landscape with lack of shade. Sparse as it is, the remaining plant covering is further damaged by cattle treading, and fine sediments can enter surface waters.

Surface waters are also polluted with pesticides. Pressures can be high, in particular in small water bodies directly adjacent to intensively farmed land.

In regions dominated by farming, many overly wet areas are drained by means of drainage systems, and watercourses are straightened, deepened and narrowed for faster runoff. Floodplains and inundation areas are often lacking, as are buffer strips, which provide for retention of nutrients and eroded soil. Thus, in more than 5,500 surface water bodies, intensive farming results in altered habitats or lack thereof or limited water body continuity. Lack of embankment vegetation giving shade causes water body temperatures to rise, an effect that is amplified by global warming. Overall, the habitats of many animal and plant species adapted to water are shrinking or are heavily modified, while, in addition, little land is available for natural water body development.

If all effects of farming are considered together, 77 percent of all surface water bodies and 29 percent of all groundwater bodies (Figure 4) have not yet achieved Water Framework Directive management objectives due to agriculture. All surface water bodies of rivers, lakes, transitional and coastal waters are equally affected. Thus, agriculture is by far the most significant source of pressures on waters in Germany. In summary, despite demonstrable improvements, nutrient and pesticide inputs into water bodies are currently still too high. In addition to nitrate- and pesticide-related groundwater pollution, nutrients are causing many lakes and all coastal waters fail to achieve a status. Hence, nutrient inputs (e.g. nitrogen and phosphorus from farming) must continue to be significantly reduced.

4.1.2 Industry

Larger industrial facilities must report on their pollutant emissions. In Germany more than 5,000 facilities are registered in the Pollutant Release and Transfer Register (PRTR). Besides PRTR, the register of contaminated sites, lists areas and sites with problematic substances resulting from former human activities.

Many of these substances are particularly critical when they are toxic, accumulate in the environment and are not or hardly degradable. Some of them are also bioaccumulating, which means they accumulate in organisms and can thus enter the food chain. This is why bans on the use and application of certain substances are increasingly being stipulated in updating the best available techniques.

Substances from industrial activities can enter groundwater and surface waters via waste water, emissions to air or contaminated sites.

As regards waste water treatment, there are more plants with so-called indirect effluent discharge – plants that discharge their waste water to an external waste water treatment plant for final treatment (e.g., a municipal plant or central company plant) – than those with direct effluent discharge and final treatment plants of their own.

Waste water from industrial sectors such as the chemical industry or mechanical and automotive engineering may contain substances that are difficult to remove biologically and are therefore usually treated in proprietary plants, sometimes using special processes. The German Waste Water Ordinance defines minimum requirements for the discharge of indirect discharges and treated wastewater relating to different industrial sectors. As most substances contained in industrial food-processing sewage such as from slaughterhouses, breweries, distilleries, dairies and the like, are readily biodegradable, these businesses are often connected to municipal waste water treatment plants. Despite the fact that best available techniques are implemented, pollutants can enter surface waters. Industrial effluents can therefore cause problems in water bodies locally and also regionally.

Industrial emissions to air also spread across national borders and contribute to soil and water pollution. Among such substances are priority water pollutants such as mercury or polycyclic aromatic hydrocarbons, whose main source is either coal combustion or which are direct products of combustion.

In 67 percent of all surface waters and in 7 percent of all groundwater bodies, impacts on water status can be identified that are attributable to industrial operations and mining (Chapter 4.1.3) (Figure 4), which means that Water Framework Directive objectives are not being achieved.

4.1.3 Mining

Mainly lignite, rock salt and potash are mined in Germany. The three largest lignite deposits are located in the Rhine, Lusatian and Central German regions. Economically important salt deposits comprise the large mining areas in the states of Hesse and Thuringia. From a water protection perspective, however, the impact of past hard coal mining in the Ruhr and Saar regions, the Saxon Uplands and the Dresden area, of former uranium mining in Saxony and Thuringia, and past ore mining activities in the Erzgebirge, the Harz and elsewhere in Germany is also a major factor. Mining activities can have serious effects during the active life of a mine and for many years thereafter.

Very often, mining activities rigorously interfere with the natural hydrological cycle, with the consequence, for example, that hard coal mining resulted in large-scale mining subsidence in parts of the Ruhr region.

If groundwater levels were returned to their natural state, this would in turn result in the inundation of large areas. Hence it is necessary to lower groundwater levels on an ongoing basis in order to keep them sufficiently below ground level. Other measures in this regard include diverting watercourses or building levees for them, and flow regulation by building transverse structures such as weirs and installing and operating pumping facilities.

In the Weser river-basin district, potash salt mining is an important industry. In addition to dry salt waste being stockpiled, part of the salt wastewater was sunk underground or discharged directly into the Werra until 2021.

Studies have shown that subsoil saline wastewater- reaches higher groundwater horizons or the surface, with part of it running off into the Werra as diffuse inputs. Aquifers have already been contaminated by salt inputs.

Landscaping in post-lignite mining areas in Lusatia, Brandenburg

As discharging salt wastewater finally ceased at the end of 2021, a gradual reduction in groundwater contamination and diffuse inputs into the Werra can be expected in the future.

Ore mining in the Weser river-basin district was for the most part discontinued in 1930, and the last mine closed in 1992. However, diffuse heavy metal input from the Harz region is still a significant source of pollution in the Leine and Aller rivers. This is caused by emissions from mine dumps, from contaminated floodplain soil and from river sediments containing metals. In the Elbe river-basin district, more than 800 years of ore mining in the Erzgebirge resulted in irreversible, large-scale pollution of groundwater from diffuse sources, for example with heavy metals.

Mining oftentimes entails major interventions in the natural water cycle, particularly in the case of open pit mining, which necessitates lowering groundwater levels, which can be deleterious for adjacent aquatic and terrestrial ecosystems. For lignite mining in the Lusatian coalfield, groundwater had to be lowered over extensive areas and to a depth of up to 80 metres. All in all, the total affected area in these regions is approximately the size of Saarland, with a resulting groundwater deficit being estimated at about 13 billion cubic metres. The abstracted groundwater was discharged into rivers, such as the Spree, resulting in a massive increase in the Spree runoff and to lasting changes in near-river ecosystems such as the Spreewald. Due to the extent of lowering groundwater levels, it will take several decades before a largely balanced groundwater level is re-established, even after cessation of mining activities.

Flooding needs in opencast mining can hardly be met, as only limited amounts of water from surface waters and groundwater recharge are available. These will continue to decrease due to climate change, which in turn will possibly result in competition among water users in river basins and among riparian dwellers. Therefore, restoring balanced water regimes is one of the most challenging tasks in the context of rehabilitation in surface mining areas.

In addition, lignite mining dumps often contain sulphurous and ferrous minerals, such as pyrite and marcasite, as do many soils of the Lusatian coalfield. Once exposed to air and rain, these minerals decompose, forming sulphurous acid, among other things, which enters into associated groundwater and surface water bodies. This results in lakes with extremely acidic pH (pH 2-4) and high dissolved iron and sulphate concentrations. Due to acidity, the diversity of organisms is relatively poor and human use is not possible without countermeasures. High concentrations of iron in water bodies are equally problematic as iron precipitates in the form of orange-brown ochre and can lead to suffocation of benthic organisms (life at the bottom of a water body). High sulphate concentrations, unlike iron, can spread far downstream and are then mainly a concern for drinking water production.

These difficulties notwithstanding, it has already been possible to create many new lake ecosystems and valuable refuges for rare animal and plant species in former opencast mining areas. Restored opencast mines can also be attractive local recreational areas.

4.1.4 Municipalities and households

Building residential and transport infrastructures includes important functions for human life (such as water supply, waste water disposal or protection of human settlements against floods). Landuse in this way is associated with various pressures on water bodies.

Clean drinking water is essential for human health and everyday life. Almost 74 percent of Germany's drinking water supply comes from groundwater and spring water, and about 26 percent is obtained from lakes and reservoirs or via groundwater recharge and bank filtration.

Around 10 billion cubic metres of waste water per year are collected in our public sewage systems. Its composition depends on the type of sewer system, whether it is a separate or a combined sewer system. The households and businesses account for the largest share of domestic waste water. In combined sewers additionally, rainwater from sealed surfaces such as roads and pavements enter treatment plants. The remaining runoff is so-called external water, for example, groundwater infiltration into sewage systems.

97 percent of the domestic waste water and a large share of rainwater is treated in more than 9,100 municipal waste water treatment plants before being discharged into surface waters. Waste water treatment in municipal waste water treatment plants thus significantly contributes to water protection and reduces inputs of nutrients and chemicals into surface waters.

Despite, considerable technological advance in waste water treatment was made, nutrient and pollutant inputs from municipal waste water treatment plants into surface waters are still too high in some cases and must therefore be further reduced.

For phosphorus (another nutrient), the objectives for good ecological status go well beyond the requirements for municipal waste water treatment plants. For very small plants, minimum requirements are not defined yet but hopefully in the near future. Another current challenge for waste water treatment is the removal of trace substances, as current implemented technologies are not designed for targeted trace substances removal. However, a double-digit number of the municipal waste water treatment plants in Germany already use ozonation and/or activated carbon for this purpose.

Sedimentation tanks of the Hetlingen wastewater treatment plant in Schleswig-Holstein

Rainwater contaminated with pollutants (e.g. metal from roofs, biocides from house fronts) can enter streams, rivers and lakes and affect them. If wastewater and rainwater (combined) are discharged into sewage plants and, in case of heavy rainfalls, can no longer be stored, the combined waters enter water bodies in a highly diluted form. Therefore, heavy rains result in pressures on water body status in 22 percent of rivers and 6 percent of lakes.

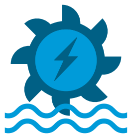
Due to climate change, heavy rainfalls may increase in the future and lead to even higher pressures.

In addition to pollution caused by discharges, water habitats are also affected by urbanisation. In the past, watercourses were relocated and floodplains were drained to develop land for human settlements. As a result of residential and commercial use, many watercourses have been straightened, piped or forced into a channel-shaped flow section, the direct effects of which can be seen in more than 1,600 surface water bodies.

In addition, flood alleviation measures such as embankments to protect households and businesses can cause major losses of floodplains and retention areas. In more than 19 percent of surface water bodies, the effects of flood protection measures are regarded as significant and impairing ecological status (Figure 4).

Land consumption for living, working and transport continues to be too high, currently amounting to 52 hectares per day in Germany. The aim is to reduce this to 30 hectares per day. Each additional case of compaction and sealing of soils places greater demands on managing heavier rainfalls and increases the burdens of climate change on us.

When these influences are considered together, the pressures are attributable to municipalities and households in 35 percent of surface water bodies and in 3 percent of all groundwater bodies, resulting in failure to achieve Water Framework Directive objectives (Figure 4).



4.1.5 Hydropower

The importance of hydropower varies from one river basin to another. Favourable conditions for hydropower, with higher runoff and many sloping areas, are found especially in the German uplands, the Alpine Foothills and the Alps as well as in all of the larger rivers. Thus, more than 80 percent of hydroelectric power is generated in southern Germany, and hydropower use is particularly important in the Bavarian and Baden-Württemberg parts of the Danube and Rhine river basins.

At present, about 8,300 hydropower plants are operated in Germany, most of which (95 percent) are small plants with an installed capacity of one megawatt or less. The remaining 5 percent is shared by large hydropower plants with an installed capacity of more than one megawatt (436 plants) and pumped storage plants (numbering 31), both of which account for more than 90 percent of hydropower electricity. Some 7,300 hydropower plants feed into the public grid; depending on annual flow rates, they contribute 2.9 to 3.8 percent of gross electricity consumption. Hydropower currently still has a share of 8 percent in renewable electricity generation, which will continue to decrease as the potential for hydropower use in Germany has largely been tapped, while other renewable energy sources continue to be expanded.

Eddersheim hydropower plant on the Main

The increase in periods of drought caused by climate change can also have a negative impact on the energy yield of hydropower plants.

Hydropower electricity in Germany is mainly generated by run-of-river plants, of which a quarter are located directly in the river and three quarters are operated with water channelled out from the riverbed. Only a few plants (about 2.5 percent) are storage power plants.

Construction and operation of hydropower plants are associated with considerable pressures on water bodies. This form of energy generation causes adverse effects on water body status in 12 percent of all water bodies (Figure 4). In terms of water body length, this corresponds to more than 50,000 kilometres of flow length and thus more than one third of the hydrological network whose status is reported to the European Commission. Only 3 percent of these water bodies achieves good ecological status or good ecological potential.

Pressures result predominantly from weirs construction and turbine operation. Weirs impede or interrupt river continuity and thus disturb fish migration for spawning, feeding and spreading. The habitats of invertebrates are also affected. In addition, hydropower plants disturb natural sediment transport. Backwater formation at weirs and diversion stretches with insufficient flow-through or that dry out result in considerable habitat losses, as watercourses lose much of their dynamics and their material and temperature balance is altered.

Turbine operation, as well as other plant components, can injure and kill fish of all ages as they migrate downstream.

Altogether, chains of dams with successive installations endanger entire populations. Fish species such as eel, barbel, salmon and common nose, which migrate over long distances and have to pass numerous hydropower plants, are particularly affected. Due to the heavily altered fish fauna, Water Framework Directive management objectives are largely not achieved in this regard.

4.1.6 Shipping

Germany has 23,000 square kilometres of maritime shipping routes and three of the most important European ports: the North Sea ports of Hamburg, Wilhelmshaven and Bremen/Bremerhaven. In the Baltic Sea, Lübeck, Kiel and Rostock are key ferry ports and ports of call for cruise ships.

More than 10,000 kilometres of the inland network of water courses are used for shipping, of which about 7,300 kilometres are federal waterways, linking the major seaports with industrial centres. Inland waterways include all of the major rivers such as the Danube, Elbe, Ems, Main, Moselle, Neckar, Oder, Rhine, Saale and Weser as well as many canals. Every year, up to 240 million tonnes of goods are transported on federal waterways, or 9 percent of all modes of transport. The focus of German inland navigation is on the Rhine corridor, which accounts for around 88 percent of inland waterway transport. In contrast, other inland waterways such as the Elbe, Ems, Oder and Weser are of lesser and in some cases further declining importance in this regard.

Waterways with lower density of use often serve recreational purposes. Water sports and water tourism are also important drivers for economic development in rural areas.

In order to be able to use natural rivers as efficient waterways, alterations to watercourses and their floodplains were and are necessary. In conjunction with other uses, such as human habitation and farming, this has led to rivers being narrowed, cut-off from their natural floodplains by flood protection structures and dammed in certain stretches.

Rivers as transport routes

In 8 percent of surface water bodies, significant impacts on water status can be attributed to navigation (Figure 4).

In German federal waterways there are more than 340 impoundments, most of which are not passable for fish. Impounding water courses slows down flow speed in these sections, causing nutrients and pollutants to accumulate there and limiting natural sediment transport. Low water flow rates cause river water temperature to rise more rapidly and algal blooms can develop more easily. Such changes due to transverse structures also disturb the dynamics of water flows.

More than 90 percent of federal waterways' hydromorphology has been altered either substantially or completely. According to the Federal Agency for Nature Conservation floodplain status report, not more than 20 percent of the former floodplains on the major rivers Elbe, Danube, Oder and Rhine still have the capacity for flood retention. Of the remaining floodplains on rivers with catchment areas of more than 1,000 square kilometres, only 9 percent can be deemed as natural or near-natural, which is why typical aquatic organisms no longer find the conditions necessary for their survival. Additional pressure on aquatic communities can also be caused by immigrated or introduced species (e.g., Chinese crab, round goby). These deficits and the intensive use of federal waterways usually lead to the heavily modified status of these water bodies.

4.2 Pressures on waters

Although the various uses of water bodies and other human activities serve different purposes, the interventions made on water bodies and their consequences are often similar. For example, in order to abstract water for energy generation, irrigation or drinking water production, or to enable navigation, availability of a sufficient supply of water is essential throughout the year. Often, this necessitates impounding water bodies by building transverse structures, the ecological consequences of which are comparable. Thus, certain typical pressures can be categorised regardless of the type of use.

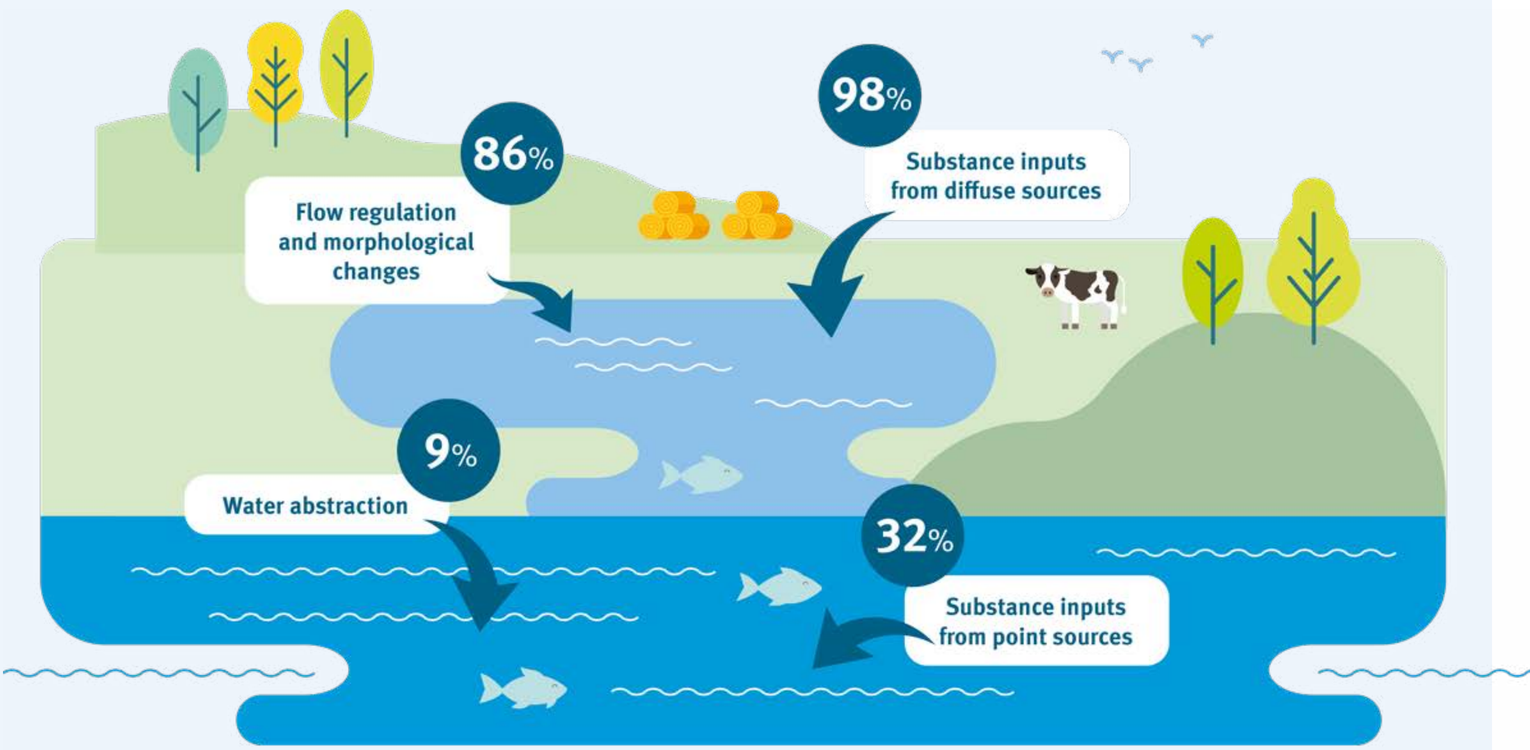
For example, transverse structures are assigned to the category “flow regulation and morphological changes”. In this booklet, five major groups of pressures are distinguished.

Flow regulation and morphological changes for agriculture, municipalities and households, energy production, flood protection, navigation and mining

86 percent of surface water bodies are subject to pressures that can be assigned to this group (Figure 5). Water uses often require massive development and bank protection measures and the straightening of water courses, which sometimes completely alters water body morphology.

Figure 5

Multiple pressures on surface waters. Percentage of surface water bodies subject to specific pressures



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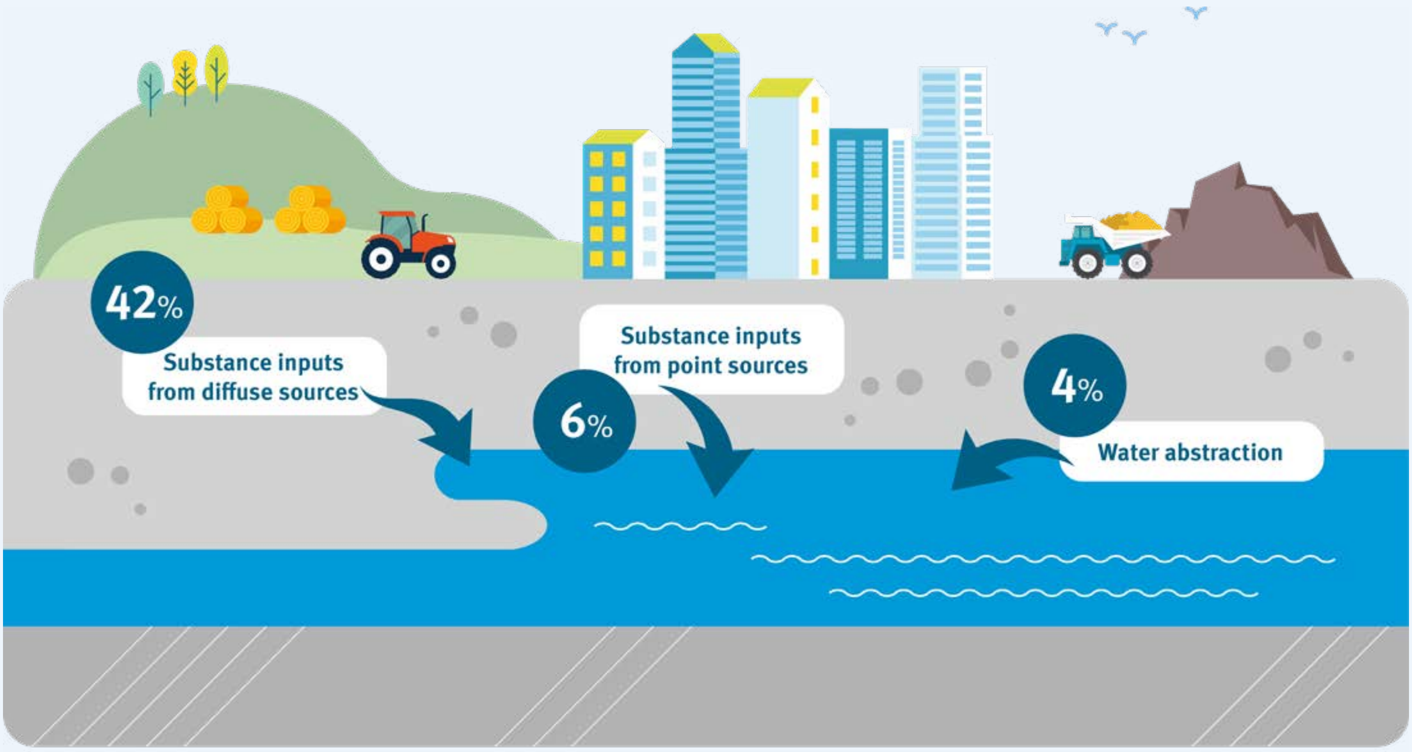
This affects 81 percent of water bodies. Dams or weirs interrupt continuity in 55 percent of all surface water bodies, resulting in backwater formation. The hydrological regime in 22 percent of water bodies is deemed to be significantly affected.

Diffuse sources of substance inputs from agriculture, mining, built-up areas, contaminated sites or old sites and accident-related inputs

Inputs of substances from diffuse sources occur almost everywhere, be it groundwater or surface water, causing pressures in 42 percent of groundwater bodies and 98 percent of surface water bodies (Figure 5 and Figure 6).

Diffuse inputs are inputs that cannot be attributed to a particular point source, for example nutrient and pesticide inputs into water bodies via runoff and soil erosion on farmland. In 60 percent of water bodies, such substance inputs are caused by farming. In urban areas, inputs from runoff from agglomerations play a role, for example, and in groundwater, diffuse substance inputs from mining areas are also relevant.

Figure 6
Multiple pressures on groundwater. Percentage of groundwater bodies subject to specific pressures



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Ludwigshafen industrial area

Atmospheric deposition of air pollutants from industry, agriculture, municipalities and households

Aerial deposits are also diffuse substance inputs. As atmospheric deposition is of particular concern, this group of pressures must be given special attention. Almost all surface waters are polluted by aerial deposits, such as mercury from combustion processes in power plants and from certain flame retardants. Aerial deposits also include nitrogen emissions from farming and unintentional inputs from drift in the application of plant protection products.

Point sources of substance inputs from municipalities and households, trade and industry, combined sewage and rainwater, mining, contaminated sites or abandoned industrial sites

Point source substance inputs are inputs that can be assigned to one particular source, such as discharges of treated wastewater from municipal wastewater treatment plants, from the chemical and pharmaceutical industries, or from the food, paper and pulp industries. Substance inputs from point sources affect 32 percent of surface water bodies, which can mainly be attributed to municipalities and households, point source inputs via combined sewage and rainwater, or industry and commerce, as well as mining.

In contrast, groundwater pollution resulting from point sources is less frequent. Pressures on groundwater can result from contaminated sites (4 percent) or mining (3 percent) (Figure 5 and Figure 6).

Water abstraction for industry and commerce, agriculture, mining, public water supply, power generation, shipping or fisheries industry

Water bodies are used for irrigation, for public water supply, as non-utility water, as cooling water for power plants or for hydropower plants on diversion stretches, for rehabilitation of former opencast mines, for navigation canals or for the management of fish ponds. Water abstraction from surface waters is deemed significant, when, for example, fish fauna and benthic invertebrates (animal organisms at the bottom of water bodies – Chapter 5.1.1) are prevented from achieving good status or is very extensive or not in compliance with minimum water regulations. This is the case in 9 percent of surface water bodies and in 4 percent of groundwater bodies (Figure 5 and Figure 6).

Developed watercourse in an intensively farmed landscape

The above-mentioned five groups of pressures can be considered in even more detail. They can be subdivided into more than 40 different individual pressures. An individual pressure for itself does not necessarily lead to failing to meet Water Framework Directive objectives.

In Germany, less than 1 percent of surface waters do not exhibit any pressures. In more than 80 percent of surface waters, 2 to 6 pressures occur simultaneously, and in more than 13 percent more than 6 pressures are identified (Figure 7), in some river stretches, even 16 different pressures. These multiple pressures call for a variety of improvement measures, making it considerably more difficult to achieve Water Framework Directive objectives (Chapter 5).

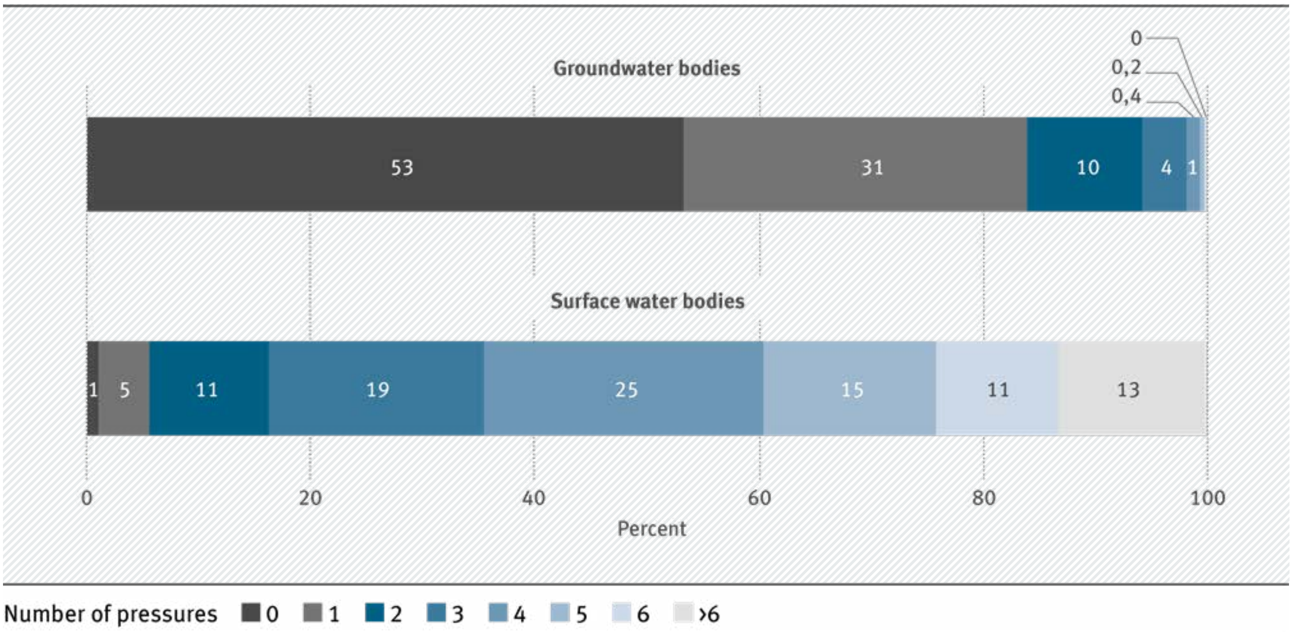
Concerning groundwater, the situation is slightly better: 53 percent of groundwater bodies are considered free of pressures. 31 percent show 1 pressure, and 16 percent multiple pressures, with a maximum of 6 pressures occurring simultaneously (Figure 7).

This situation gave rise to tackling major water management issues for German river basin districts. These issues form the starting point of Water Framework Directive management planning, help identify pressure hot spots in river basin districts as well as the need for action to improve water bodies.

In all ten river basin districts, reducing nutrient and pollutant inputs from diffuse and point sources is regarded as being of major importance.

Figure 7

Occurrence frequencies of several different and simultaneous pressures in surface waters and groundwater (in percent)



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In response to the extensive pressures on water bodies from flow regulation and morphological alterations, improving water body morphology and restoring continuity for fish passage were identified as essential water management issues. These issues had been given consideration in the two previous management periods, with another new focus in the current management plans on climate change impacts in all ten river basin districts. Other key water management issues in individual river basin districts concern hydrological regimes, reducing mining impacts, inputs via soil into water bodies, salt loads and water quantity management (Table 2).

4.3 Water Framework Directive in the age of climate change

Changes in climate that can already be observed as well as changes projected by means of climate modelling have a variety of consequences for surface waters and groundwater, such as changing medium discharge conditions and more frequent occurrence of high and low water. Increased air temperatures and more sunny days cause rising water temperatures and evaporation rates. Changes in precipitation result in declining groundwater recharge. On the coasts, there is a rise in sea level. Depending on season and region, climate change is already bringing about noticeable changes. Effects on the ecological and quantitative status of water bodies are also to be expected.

Table 2

Overview of key water management issues for the third management plan in the 10 German river basin districts

	Danube	Eider	Elbe	Ems	Meuse	Oder	Rhine	Schlei/ Trave	Warnow/ Peene	Weser
Nutrient inputs	x	x	x	x	x	x	x	x	x	x
Pollutant inputs	x	x	x	x	x	x	x	x	x	x
River structure	x	x	x	x	x	x	x	x	x	x
Continuity	x	x	x	x	x	x	x	x	x	x
Climate change	x	x	x	x	x	x	x	x	x	x
Hydrological regime	x						x			x*
Impact of mining			x		x		x			
Inputs via soil	x									
Salt intrusion										x
Water quantity management			x							

* in connection with climate change

In Germany, the mean air temperature has risen by about 1.6 degrees Celsius since 1881, a greater increase in temperature than the global average. Warming here was most obvious in recent decades and 2014, 2018, 2019 and 2020 were the warmest years on record.

Increasing air temperature not only results in elevated temperatures in surface waters, but also affects groundwater. Studies show an increase of up to half a degree Celsius per decade since 1990 in groundwater near the surface.

Precipitation and evaporation levels shape both surface runoff and groundwater recharge. On average, 789 millimetres of rain fall in Germany each year, with regional differences due to natural conditions. Precipitation of less than 600 millimetres are normal in the north-east and in the central parts of the country, while in the Alps or in the Black Forest, more than 1,500 millimetres per year are common. However, these levels have changed. Average annual precipitation increased by about eight percent from 1881 to 2018, primarily due to a 25 percent increase in mean winter precipitation. Summer precipitation, on the other hand, has remained constant or is slightly decreasing.

Mean precipitation levels are not the only relevant indicator for many aspects of water management; another is the tendency with which extreme events such as heavy rainfalls or sustained drought occur.

Dry summers, for example, cause surface runoff to decrease sharply, even to the point where water bodies dry up completely, with immense ecological consequences for flora and fauna. Also, lower water levels result in temporary deterioration in water quality. Thus, given constant wastewater volumes, the ratio of natural runoff to wastewater increases, and at the same time nutrient and pollutant concentrations; groundwater levels drop. These problems are exacerbated, for example, by regulation and waterway construction, drainage systems or increased pressures of use, for example for irrigating fields, gardens and parks.

In contrast, heavy rains can cause catastrophic floods, whose benefit for replenishing groundwater reservoirs is low, as the water falling in a short period of time cannot be absorbed by the soils. Heavy rains also increase the risk of increased inputs of moderately or heavily polluted rainwater from street drains and other paved surfaces or the input of rainwater mixed with sewage from combined sewer systems (see Chapter 4.1.4).

Mulde low water near Dessau. Due to the drought in 2018, the river bed has dried up to a large extent.

According to the projections of regional climate modelling, it can be assumed that trends towards more heavy rains will continue until the year 2100. The July 2021 flood disaster is a cautionary example here.

The detailed results on water bodies status called for in the Water Framework Directive and the corresponding need for action are of great importance for elaborating climate adaptation measures. There are numerous water protection measures that also serve climate adaptation: River and floodplain restoration to increase water retention in the river basin and store carbon; provision of areas for watercourse development to return more space to rivers; shoreline planting to provide shade and lower water temperature; upgrading of wastewater infrastructure to increase treatment capacity and create more space for wastewater retention.

These and numerous other measures planned to implement the Water Framework Directive foster water body resilience against climate change impacts, thus protecting water resources and biodiversity.

4.4 Impact on water bodies

The consequences of pressures on water bodies are described as “impacts”, which, in surface waters, are primarily changes in the biological, hydromorphological and chemical characteristics of a water body that are caused by pressures and affect its ecological or chemical status.

In groundwater, one or more pressures result in impaired quantitative and chemical status. The four most significant impacts are described below.

4.4.1 Pollution from nutrient inputs

All plants need nutrients such as nitrogen and phosphorus in order to grow. However, any oversupply of nutrients – so-called eutrophication – is harmful to aquatic ecosystems. In the past, much has been achieved in avoiding nutrient inputs into water bodies.

Nevertheless, too many nutrients from farming (more than 5,400 surface water bodies are affected) and from municipalities and households via wastewater treatment plants (about 2,300 surface water bodies, Figure 8) enter our waters, resulting in increased algae and plant growth. When these algae or plants die and sink to the bottom, they are decomposed by microorganisms, a process in which microorganisms consume oxygen in great quantity. If too much oxygen – vital for all aquatic organisms – is consumed, the result is an oxygen deficiency that can be fatal in the worst case.

Increased nutrient concentrations in lakes, rivers and seas can lead to a shift in species composition and to algae mass development. These so-called algal blooms can have considerable adverse effects on underwater plant growth, as they block sunlight from reaching greater depths. In case of blue-green algae, not only is transparency reduced due to water turbidity, but toxic contaminants are also formed that can cause skin rashes in humans on bathing and diarrhoea on swallowing water. Hence it is necessary to prohibit swimming in lakes with high levels of blue-green algae. Such toxins can also interfere with purification treatment of surface waters for potable water.

Farming, too, affects groundwater in that nitrogen from soils accumulates in groundwater as nitrate (in about 60 groundwater bodies, Figure 8). High nitrate levels impair drinking water quality and can affect health when nitrate is converted in the human body to carcinogenic nitrosamines. Nitrate loads often also enter lakes and streams fed by contaminated groundwater.

Oceans are also affected, where high nutrient inputs lead to mass proliferation of algae, the consequences of which can be seen on beaches in foam formation (when cell protein is released and transformed into foam by the natural motion of the water).

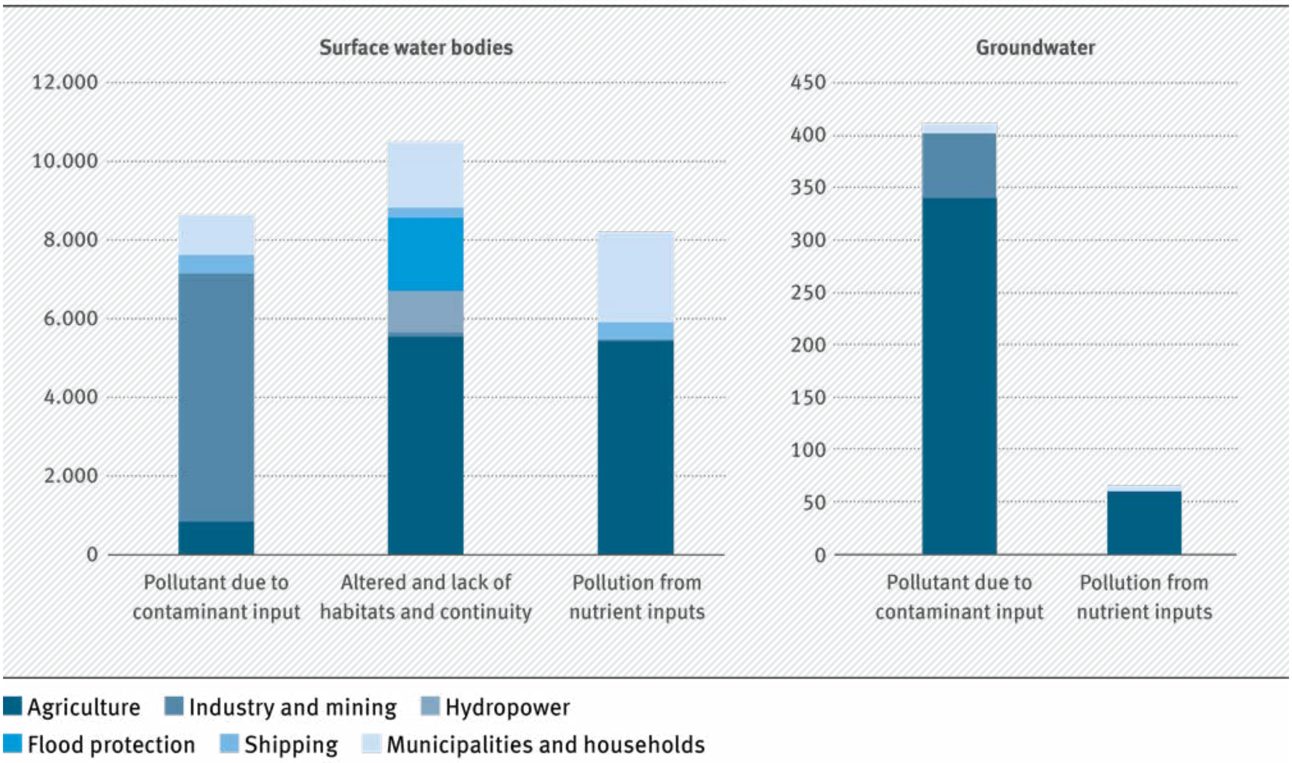
Further implications are lower levels of transparency; reduced distribution of large plants in greater depths (macrophytes); oxygen deficiency and impairment of bottom-dwelling animals (zoobenthos). High nutrient loads and the consequential algal blooms can also result in increased fish mortality.

4.4.2 Pollution due to contaminant inputs

Pollutants enter our waters via various pathways; they have different effects on humans, animals and plants depending on type of substance, level of input and duration of effects. They can affect single individuals, species composition in biotic communities or entire aquatic ecosystems. Pollutants can enter food webs and thus also affect our health.

Figure 8

Number of surface and groundwater bodies exhibiting impacts of specific uses



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Major sources of pollutants are the industry (threshold exceedances in more than 6,300 surface water and groundwater bodies), agriculture (in over 1,200) and municipalities and households (in over 1,000 surface water and groundwater bodies) (Figure 8). The effect of a substance or a mixture of substances is often complex and can sometimes only become apparent in the long term. Pollutants can also impair uses such as water supplies and fisheries.

Whether substance concentrations pose problems for water body status is determined on the basis of limit values, so-called environmental quality standards or threshold values, that must not be exceeded. Such EU-wide or national quality standards are applicable to more than 100 pollutants.

The effects of key pollutants, which to a large extent affect surface waters and groundwater status, are briefly described below.

- Cadmium, nickel and lead directly harm aquatic organisms. Active as well as abandoned/historic mining sites and contaminated sites are sources of input for these three heavy metals.

- Mercury is usually emitted by fossil fuel combustion and spreads through the atmosphere over large distances. Further pathways into water bodies are refining processes in the metalworking industry and the chlor-alkali industry, where mercury was used as a catalyst. Mercury is toxic, accumulates primarily in top-of-the-food-chain animals and can harm the nerve system or reduce reproductive rates, which is why predatory fish, birds of prey and waterfowl, otters and seals are particularly affected.

- Polycyclic aromatic hydrocarbons (PAHs) are formed during incomplete combustion of organic material such as wood, coal or oil; a large proportion enters the atmosphere through forest fires, volcanic eruptions or other combustion processes. Bound to soot or dust particles, they can also enter water bodies through the air. As a component of coal and petroleum, PAHs can also occur in all products made from these fossil resources. Many PAHs are persistent and accumulate in food webs; once in the environment, they are carcinogenic, mutagenic or reprotoxic for humans and animals.

- Active substances of plant protection products, such as bifenox or cypermethrin, are very toxic and sometimes difficult to degrade, a property necessary to achieve the desired effect of protecting crops from pests and weeds. They accumulate in the soil or are transported with the rain into surface waters and groundwater and harm animal and plant life. These substances and their metabolites such as desethylatrazine are often difficult to remove and continue to pollute soils and waters even long after application.

- Some compounds, being synthetic substances, do not occur naturally in the environment, but are introduced through human activities. Some of these compounds are persistent (difficult to degrade), toxic and bioaccumulative and affect the marine environment and it’s organisms. Compounds of major importance include:
  - Polychlorinated biphenyls (PCBs) are persistent organic pollutants and can enter water bodies if previously used, for example, in paints or sealants.

– Bromodiphenyl ethers (BDEs) were used as flame retardants and will continue to pollute the environment for a long time due to their former manifold utilisation. They accumulate in the environment and can cause neurotoxic effects.

– Perfluoroalkyl substances, or PFAs, are a group of industrial chemicals that have long been widely used in numerous sectors and also in households. They include about 4,700 persistent substances, many of which are toxic, and some accumulate in food webs. They are used, for example, in paints, leather and textile coatings, in impregnation agents and lubricants. Another substance class are perfluorinated alkyl sulfonates, to which, for example, perfluorooctanesulfonic acid (PFOS) belongs. PFOS have water- and oil-repellent properties and were used in fire extinguishing agents, electroplating operations or for fabrics (jackets, tents, etc.) and anti-stick cookware. The use of PFOS has been severely restricted since 2006 and is now almost completely banned.

4.4.3 Altered habitats, lack of habitats

Many aquatic organisms are adapted to a wide variety of habitats and need clean water for their survival. These habitats include, for example, shallow gravel riverbeds, varying water depth, shelters under roots, aquatic plants, trees lying or floating in the water, so-called deadwood such as branches or twigs and loose sands. One measure of aquatic habitat diversity is the quality of their hydromorphology, having a significant influence on the ecological functioning of water bodies. The more diverse hydromorphology, the more dynamically these structures can change, the more manifold are habitats and the more diverse biotic communities can become.

Thus, restoring near-natural structures, which can develop if sufficient space is available, is essential for achieving good ecological status under the Water Framework Directive.

Many of our streams and rivers, as well as lakes and small ponds, have been altered or destroyed in past centuries by straightening, bank fixation or damming. In 5,500 surface water bodies, the main impairments are farming, flood protection (1,800), municipalities and households (1,600) and hydropower (1,000) (Figure 8); uses, pressures and their impacts can occur simultaneously. The result is monotonous water bodies with degraded diversity of habitats and living organisms. This also alters the self-purifying capacity and resilience to the impacts of climate change. In addition, high costs are incurred annually to maintain the state of development of water bodies and to counteract associated negative consequences.

4.4.4 Altered and lack of continuity

In pristine nature, rivers and streams are readily passable upstream and downstream for aquatic organisms, and the accompanying floodplains are accessible. This continuity, as it is called, also encompasses unhindered transport of solid and dissolved substances in water bodies. Continuity can be reduced during low water periods or by beaver dams, but is interrupted in the strict sense only in extreme cases, for example by natural conditions such as waterfalls.

The situation is different in cultural landscapes. Due to uses such as hydropower, navigation, drinking water production, irrigation or the construction of artificial impoundments for flood protection or drinking water supply, interruptions of continuity and flow regulation are no longer the exception but the rule.

In Germany, data on more than 215,000 artificial transverse structures has been collected so far. At almost every second flow kilometre there is some type of technical transverse structure (regarding the entire German riverine network) – not all of which significantly impair continuity. Most problematic are structures that extend across the entire watercourse width, are operated permanently and, due to their height, bring migration of aquatic organisms or bedload transport to a standstill. This is the case, above all, with dams and weirs for navigation, hydropower and drinking water production. Longitudinal structures such as dikes interrupt connectivity of river and floodplain. If too large volumes of water are diverted from a river, for example at hydropower plants, rivers or stretches thereof may become very shallow or go completely dry, a fact that in turn can also severely impair river continuity.

Especially for spawning and feeding, it is crucial that the fish can migrate over long stretches of water, in order to find the conditions they need in their various life cycle phases. For example, a suitable spawning habitat may be located many kilometres upstream in a shallow and gravelly stretch of a river, whereas feeding grounds may be located far downstream in deeper and warmer waters and winter retreats may be sited far downstream in deep oxbows or potholes. To ensure these conditions for fish, it may be necessary either to dismantle weirs or to attach ramps or fish ladders. During their downstream migration, fish need to be protected from impending injuries at the turbines of hydropower plants or at water abstraction plants and be directed past them.

Bedload retention at transverse structures can cause a lack of sediment and poor habitat conditions downstream. This can cause lack of transport material, in which case flowing water erodes the riverbed and deepens it more and more. Often, floodplain groundwater enters these deepened areas, which impairs retention of water in the landscape.

Weir in the Mulde near Raguhn

River landscape on the Isar

5

2021 Water body status

5 2021 Water body status

Water body status assessment is a prerequisite for management planning under the Water Framework Directive. The management objective to be achieved for all surface waters and groundwater is good status, with good status only slightly deviating from reference status, which would exist without human interference. If this objective is not yet achieved, measures must be taken to improve water body status.

Water body status assessment is based on regular water monitoring as per uniform specifications and evaluation of scientific data. This procedure provides conclusive and well-founded results on the status and pollution of surface water bodies and groundwater. Regular monitoring reveals changes – such as whether restoration measures or reducing pollutant inputs have led to an improvement – as well as trends in pollutant loads.

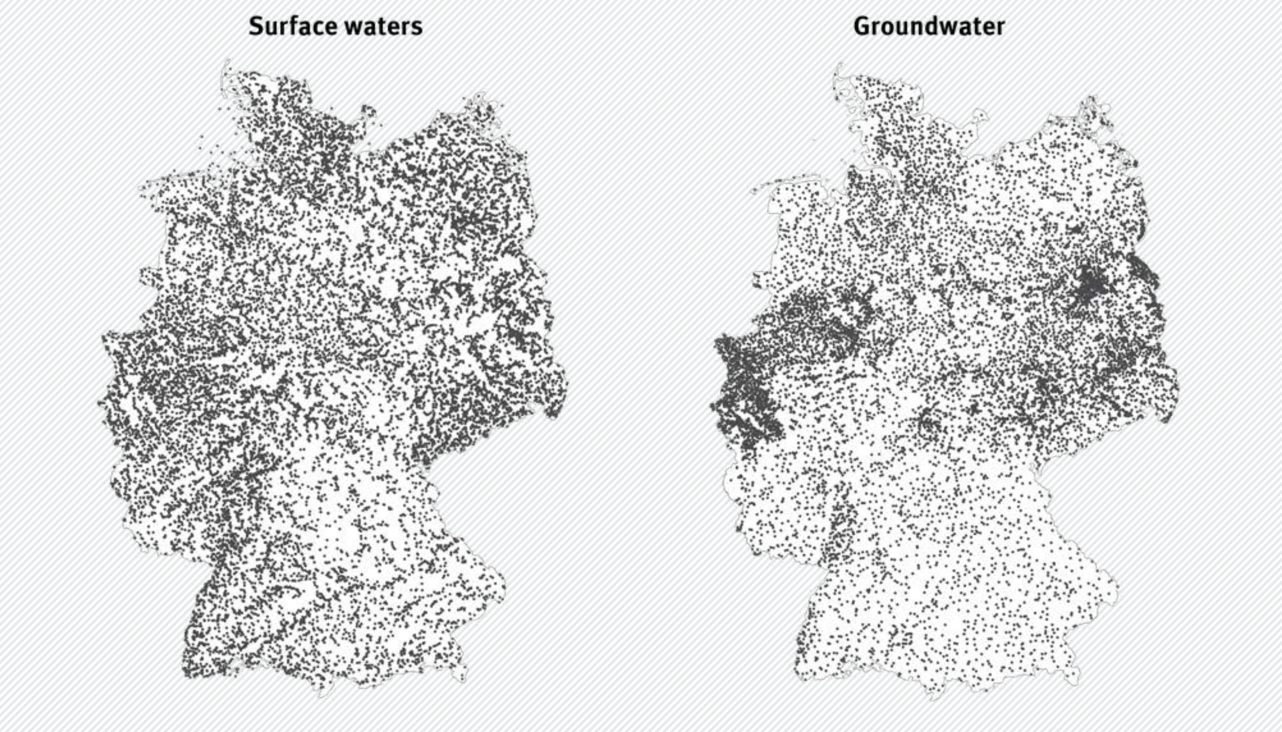
In surface waters, water is sampled regularly, animals and plants are collected, counted and identified; this data are analysed, and water course hydromorphology is mapped, covering thousands of kilometres. In recent years, the number of monitoring sites has increased from 8,500 (until 2009) to 16,000 (2009 to 2016) and now to more than 20,000.

Around 13,000 monitoring sites are used to monitor groundwater status. Groundwater is sampled for nutrients and pollutants at 7,900 of these sites, and quantitative status is assessed at 7,700 sites (some of the monitoring sites are used for both purposes).

The number of monitoring sites in groundwater has also increased significantly in recent years: from 6,500 in the first management period to more than 7,200 in the second and to almost 13,000 in the third (Map 3).

Map 3

Overview of monitoring sites in surface waters and groundwater



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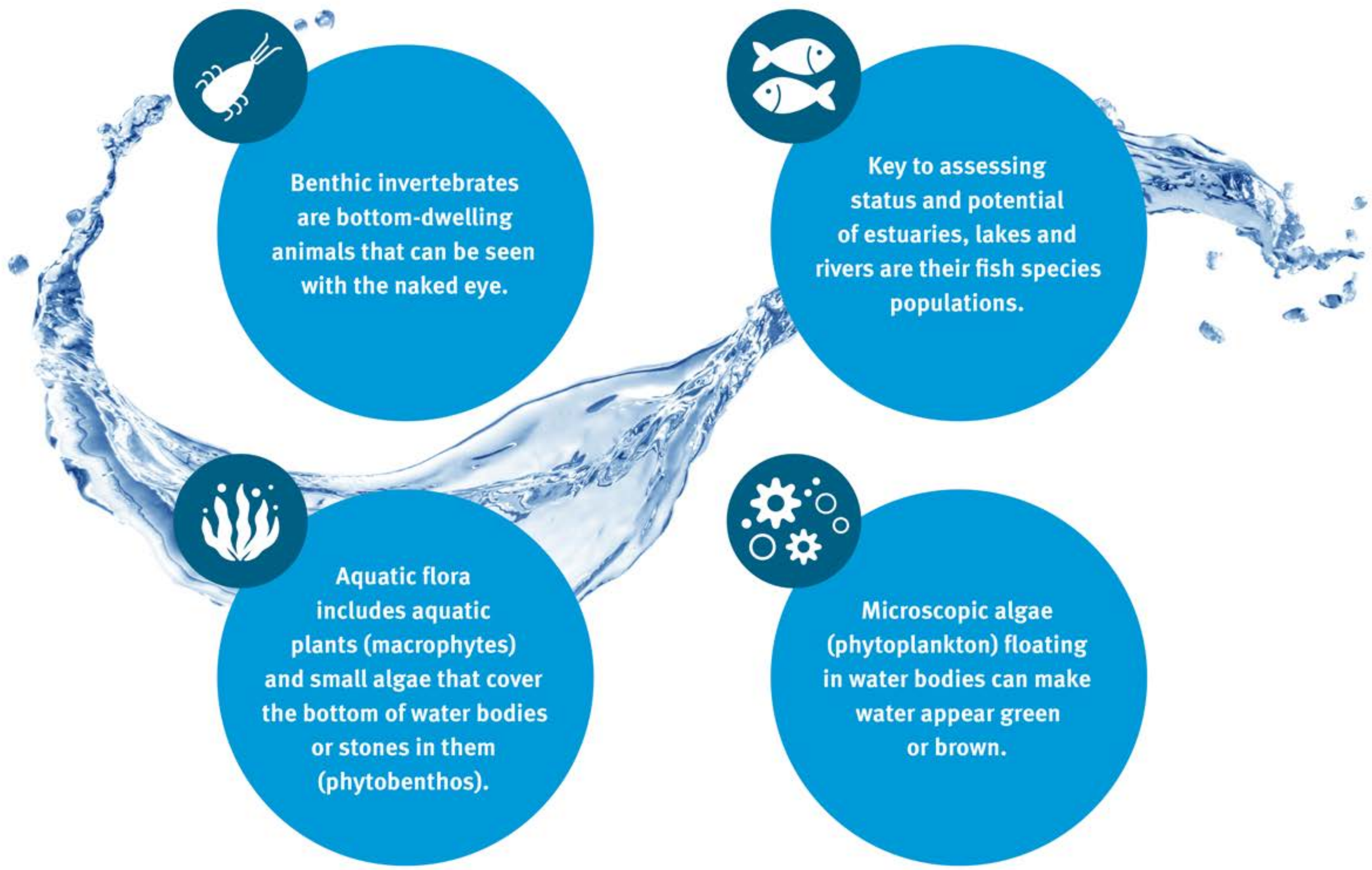
5.1 Surface water status

5.1.1 Ecological status and ecological potential of surface waters

Determining whether good ecological status or good ecological potential is achieved is based primarily on the assessment of aquatic biology, which is used as an indicator of whether the water bodies are sustainably managed and are functional in terms of providing general-interest public services. In assessing rivers, the following biological groups (Water Framework Directive calls them "biological quality elements") are analysed: fish fauna, benthic invertebrates, phytoplankton, macrophytes and phytobenthos (Figure 9).

The assessment is based on a comparison of the species found in a water body and their abundance with a condition that would be free of human impacts (reference state). The less biotic communities in a water body deviate from reference conditions, the better the assessment will be. For a water body to be rated as "good", a slight deviation from reference conditions is tolerable, meaning that the Water Framework Directive objective is achieved.

Figure 9
Biological elements used for water body status assessment



Oberhavel near Henningsdorf, Brandenburg

The results of assessing ecological status and potential are differentiated by specified classes (Table 3). Class 1 equals reference conditions, with the following classes deviating more and more from them. Of particular importance is change from good to moderate status or potential. If status or potential is moderate or less, measures must be taken to achieve the objectives.

Table 3

Classification of ecological status and potential

Class	Ecological status	Ecological potential
Class 1	high	maximum
Class 2	good	good
Class 3	moderate	moderate
Class 4	poor	poor
Class 5	bad	bad

Our water bodies are subject to a combination of many pressures (Chapter 4.2). Aquatic life reacts differently to these pressures. For example, all fish species rely on different habitats at certain times. For spawning, some species migrate to shallow and cool stretches of water in the upper reaches of rivers, while their hunting grounds are found in stretches that are primarily rich in food. In winter, they again migrate to deeper river stretches.

Fish therefore are very sensitive to river engineering measures that interrupt river courses and cut them off from their habitats. Phytobenthos (such as diatoms), on the other hand, are less sensitive to watercourse development, but their quantity and composition immediately change significantly if too many nutrients enter the water body (Chapter 4.4).

This means that biological elements react differently, depending on the type of stress, and that their classification can therefore be different in a single water body. In Germany, this holds true for 44 percent of river water bodies, for example. Most often, classifications of biological elements differ by one class. That said, in very rare cases, there are also differences of up to 4 classes, hence the status of fish fauna might be “poor”, for example, but phytoplankton “high”. If a water body is subject to significant pressures, the biological element that is most sensitive to this pollution is monitored, which is why not all but only one biological element is finally assessed (this is the case in 28 percent of river water bodies).

This water body then is assigned an ecological status class corresponding to its worst assessed biological elements (“worst case principle”). For example, if fish are assessed as class 4 and all other biological elements as class 3, the overall assessment of this water body is class 4 (poor).

Achievement of good ecological status being prevented by only one biological element is the case in 15 percent of water bodies.

In assessing ecological status and potential, further criteria are taken into account as supporting elements, for example physicochemical (such as water temperature, nutrient content) and hydromorphological elements (e.g. structure of the coastal / river bed or the intertidal zone). These supporting elements must be of a quality that allows for water body biotic communities to be assessed as having good status, for intact biotic communities can be established in a given water body only insofar as its hydromorphological and chemical conditions are conducive to such establishment.

For more information on assessing ecological status and ecological potential of water bodies, see *www.gewaesser-bewertung.de*.

In addition to biological elements as supporting parameters, specified pollutants are also included in the ecological assessment. These pollutants are not relevant for assessing chemical status, rather they are characteristic of a river basin (hence called river basin-specific pollutants), for example chemical substances emitted by a local industrial operation.

In Germany, limit values, so-called environmental quality standards, have been set for 67 river basin-specific pollutants and measured in more than 4,000 surface water bodies. If the environmental quality standard of just one pollutant is exceeded, ecological status or ecological potential can at best be assessed as moderate, even if the biological elements achieve the objectives.

For 49 of these 67 substances, exceedances were registered in at least one water body – for zinc most frequently, followed by copper and arsenic. As regards arsenic in water bodies located in river basins with old mining sites such as the Mulde, exceedances of copper and zinc are mainly found downstream of larger cities and conurbations.

Also, environmental quality standards for pesticides, biocides and persistent organic pollutants are exceeded in numerous water bodies.

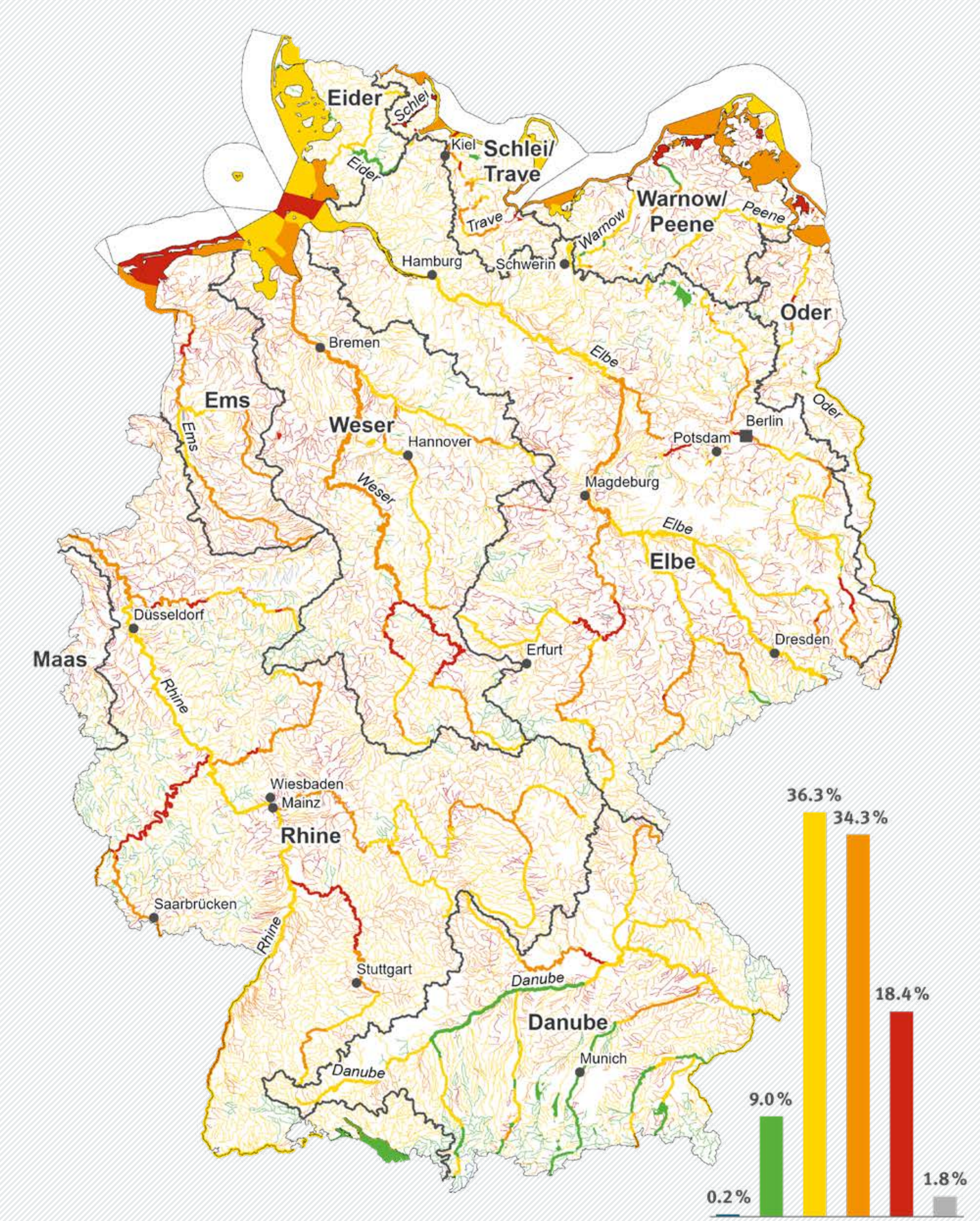
Assessment outcomes

Map 4 shows results for ecological status and potential of surface waters in Germany, with yellow (= moderate), orange (= poor) and red (= bad) predominating. Good ecological status or good ecological potential is currently achieved in 9 percent of water bodies. Water bodies in moderate status, in which biotic communities are only one class away from the target, account for the largest share with 36 percent. For 34 percent of water bodies, status is assessed “poor” and for 18 percent “bad”.

Mecklenburg Western Pomerania

Map 4

Ecological status/ecological potential of surface water bodies, 2021



■ High ■ Good ■ Moderate ■ Poor ■ Bad ■ Not assessed

□ Ecological status assessment not required

Spatial base data: Geobasis-DE/BKG 2015
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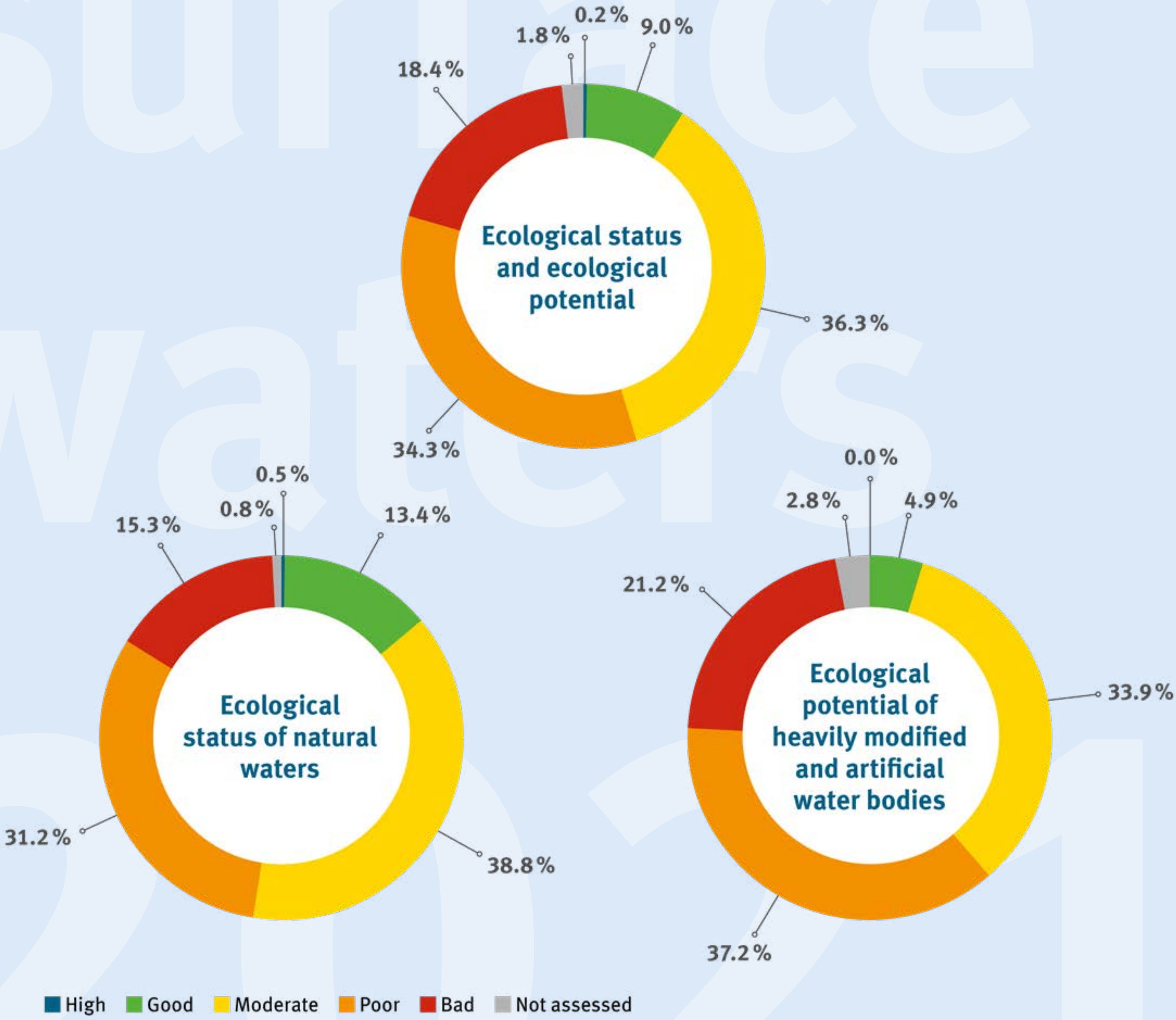
There are clear differences in target achievement if we depart from a combined assessment of ecological potential and ecological status (Figure 10). Considered separately, almost 14 percent of all water bodies currently achieve Water Framework Directive management objectives in natural waters, and only 5 percent in heavily modified and artificial waters, while almost 60 percent of these water bodies also have a potential that does not exceed class 4.

Figure 10
Ecological status and ecological potential of surface waters in 2021



Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
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Rivers

Overall assessment of ecological status and potential of Germany's waters depends primarily on the assessment of rivers, streams and creeks, as these make up the largest portion of water bodies. Looking only at the category of rivers, 13 percent have currently achieved good ecological status and 4 percent good ecological potential (Figure 11). This concerns many watercourses of the Alps and the adjacent Alpine foothills, the uplands of the Bavarian Forest, the Thuringian Forest and Slate Mountains, the Ore Mountains, the Harz Mountains, the Rhenish Slate Mountains as well as parts of the Baltic Uplands. Some larger rivers – Danube, Isar and Inn – also have stretches already with good status or have good potential. In rivers, it is often the assessment of fish fauna that is most relevant for the overall status and most clearly reflects the multiple pressures in watercourses.

Lakes

The assessment for lakes is more positive, as 20 percent achieve high or good ecological status and 36 percent at least good ecological potential (Figure 11). Map 4 reveals that even many of the largest lakes achieve the target, including Lake Constance, Müritz, Lake Ammer, Lake Starnberg and Chiemsee.

"Failure to achieve Water Framework Directive objectives" often follows from the assessment of macrophytes and phytobenthos revealing excessive nutrient concentrations.

Transitional and coastal waters

None of Germany's transitional or coastal waters currently achieve good ecological status or good ecological potential. Of particular concern are high percentages of poor ecological status and poor ecological potential classifications (21 and 60 percent respectively) (Figure 11).

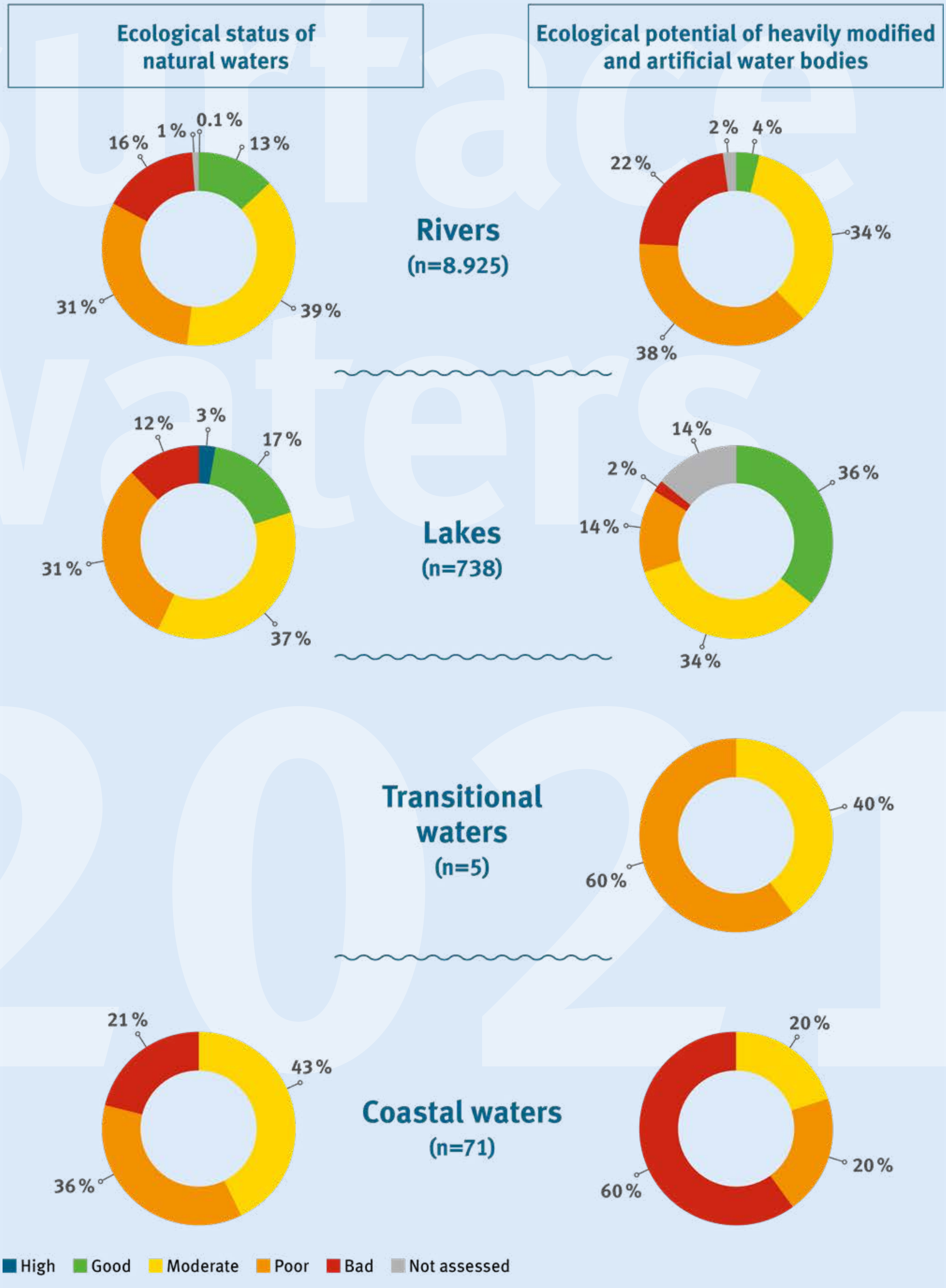
In the Ems and Weser transitional waters, it was primarily a decline in seagrass stocks that resulted in moderate assessment of fish fauna and benthic invertebrates (seagrass is sensitive to excessive nutrient concentrations). In contrast, ecological potential of fish, macrophytes and benthic invertebrates in the Elbe estuary can be assessed as good.

In coastal waters, high nutrient levels result in suboptimal phytoplankton assessments (less than good status in all coastal waters). As regards macrophytes, assessments refer to seagrass, large algae and reedbeds, brackish and salt marshes. Here, excessively high nutrient content also leads to less-than-good assessment of relevant elements, whereas benthic invertebrates have good status.

Müritz National Park in Mecklenburg-Western Pomerania

Figure 11

Ecological status and ecological potential of rivers, lakes, transitional and coastal waters



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5.1.2 Chemical status of surface waters

Inputs of chemical substances used in industry, households or farming can damage aquatic ecosystems and harm human health.

European waters carry a vast number of substances in concentrations of ecological concern, which is why the chemical status of water bodies is assessed on the basis of pollutant concentrations, as stipulated by the Water Framework Directive.

There are 45 substances that are designated as priority substances, for which European-wide limit values (environmental quality standards) have been defined. Priority substances pose a particularly high environmental risk in terms of their toxic effects on human and animal health. Of these substances, 21 were even classified as "priority hazardous", hence, they are particularly critical. Inputs of these substances are to be stopped or phased out.

Among the 45 priority substances are eight so-called ubiquitous substances, which include bromodiphenyl ether (BDEs), mercury and tributyltin. They fall under special monitoring rules, and they can be considered separately in reporting chemical status (Map 6).

To monitor chemical status, pollutant concentrations are measured either in water, suspended matter, sediments or aquatic organisms such as fish or mussels.

If the environmental quality standard of just one single substance is exceeded, a water body's chemical status is no longer "good", and measures must be taken. Surface water chemical status is classified as either "good" or "failing to achieve good" (Table 4).

Table 4

Classification of chemical status

Symbol	Chemical status
■ (blue)	good
■ (red)	failing to achieve good

16 of these priority substances do not exceed the environmental quality standards in surface waters, including benzene (found in petrol), dichloromethane (used as a solvent or paint stripper), alachlor, atrazine and simazine (all plant protection products, no longer authorised), and pentachlorophenol, which is difficult to degrade and was formerly used as a biocide against fungal contamination (e.g. in wood preservatives).

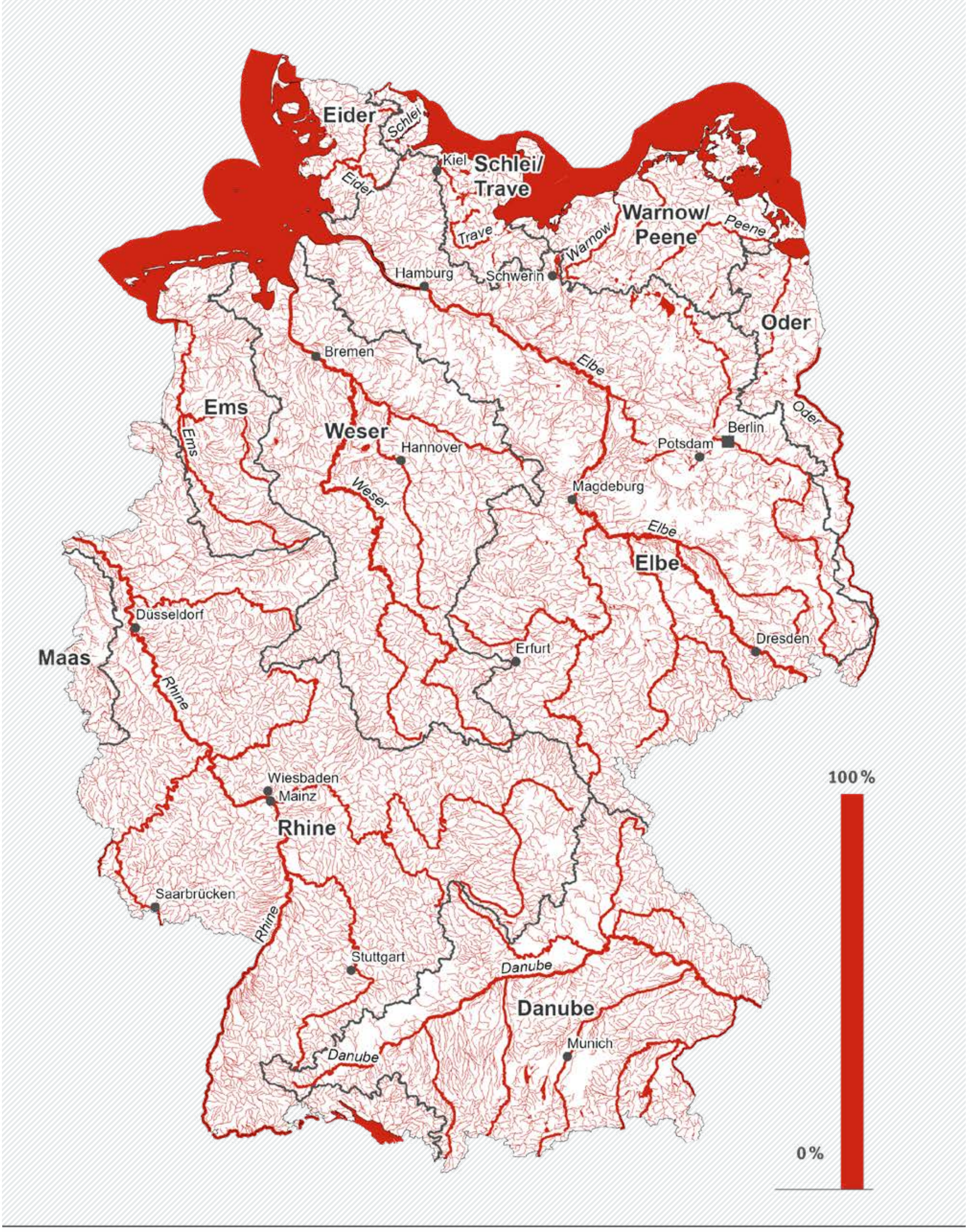
In view of these results, all water bodies in Germany were assessed as "failing to achieve good" chemical status (Map 5), due to the ubiquitous substances that are critical here. Environmental quality standards for mercury and certain flame retardants are exceeded everywhere in fish fauna, with both substances being a problem across the board.

Other priority substances also exceed environmental quality standards in surface waters.

- The environmental quality standard for perfluorooctanoic acid (PFOS), which is toxic to aquatic organisms and toxic for reproduction, is exceeded in 400 water bodies.
- Polycyclic aromatic hydrocarbons (PAHs) were found in excessive concentrations in 328 water bodies (including anthracene, fluoranthene and naphthalene).

Map 5

Chemical status of Germany's surface water bodies, 2021



■ good ■ failing to achieve good

Spatial base data: Geobasis-DE/BKG 2015
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- The environmental quality standard of fluoranthene, considered very toxic to aquatic organisms and carcinogenic, is exceeded in 227 water bodies.

- The environmental quality standard for heptachlor, an insecticide, was exceeded in 224 water bodies. The use of this insecticide, a persistent organic pollutant that degrades only slowly, has been banned in Germany since 1992. Exceedances were also found for other active substances in plant protection products that are no longer authorised, such as isoproturon (banned since 2016).

- Cadmium concentrations were assessed as “failing to achieve the good status” in 186 water bodies, that of nickel in 137 and that of lead in 118. The environmental quality standards for nickel and lead were lowered (higher protection level) in 2013. Mining, old mining or contaminated sites are sources of inputs for these metals.

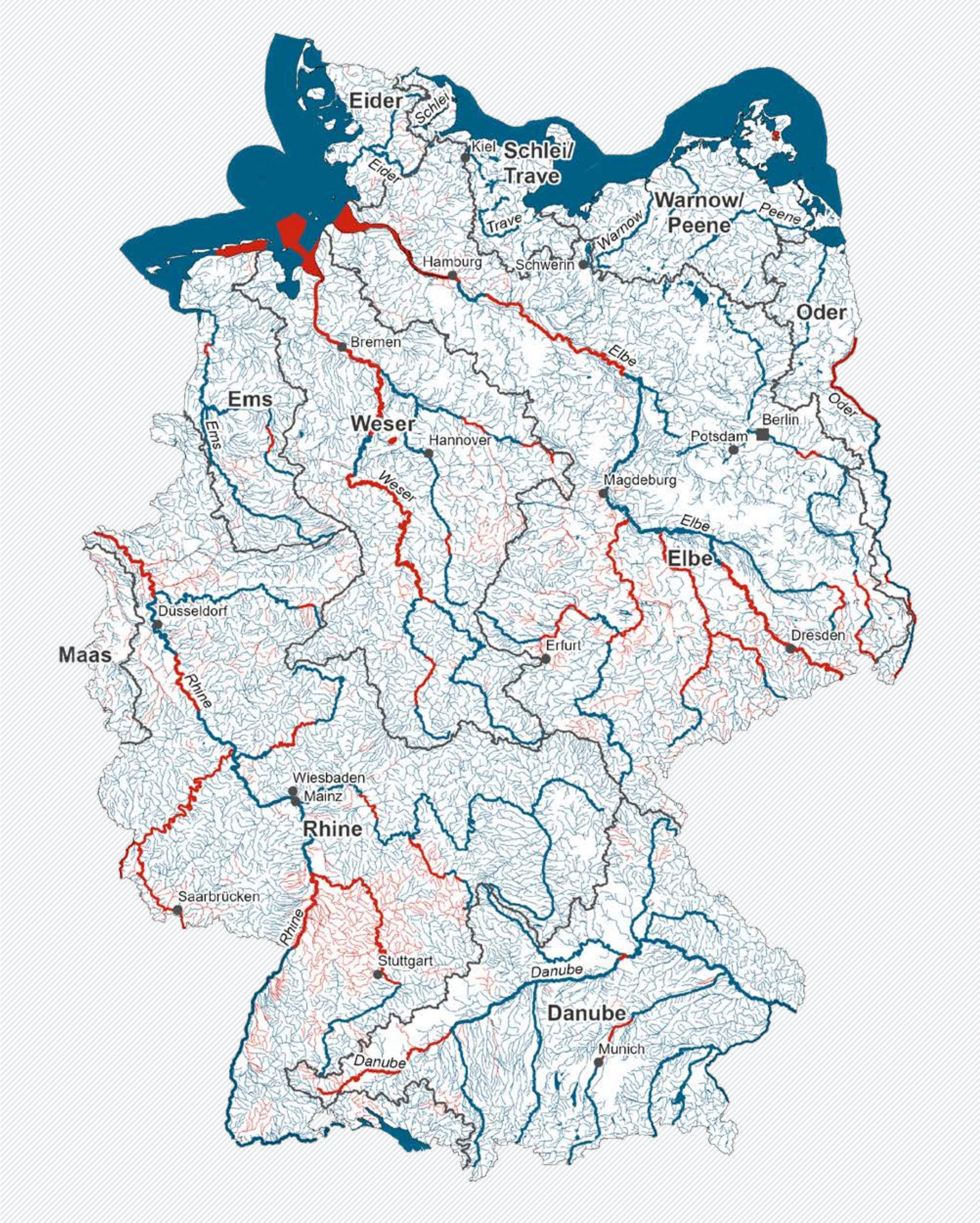
- The standard for tributyltin was exceeded in 119 water bodies. Tributyltin, a biocide, was used until 2008 as an antifouling paint, for example for boats, in wood preservatives or roof tarpaulins, but is no longer authorised as a biocide. High tributyltin concentrations are found in water body sediments downstream of harbours or industrial sites where this substance was manufactured.

- Diethylhexyl phthalate (DEHP) was detected in 25 water bodies in excessive concentrations. DEHP is one of the most commonly used softeners, the use of which has been restricted or banned for many products (e.g., food packaging, toys) since 2006. Contamination due to this and other substances of this compound group already banned are therefore expected to decrease further.

If the eight ubiquitous substances are not considered in chemical status assessments, the picture is completely different (Map 6), as exceedances of environmental quality standards would occur at only 16 percent of the approximately 5,000 chemical monitoring sites.

Map 6

Chemical status of Germany's surface water bodies – excluding ubiquitous substances, 2021



■ Environmental quality standard not exceeded ■ Environmental quality standard exceeded

This classification of surface water body chemical status is based on the environmental quality standards concerning substances with the numbers 1, 2, 3, 4, 5, 6, 6a, 7, 8, 9, 9a, 9b, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 29, 29a, 29b, 31, 32, 33, 34, 36, 38-42, 45 (Anlage 8, OGewV).

Spatial base data: Geobasis-DE/BKG 2015
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5.2 Groundwater status

Groundwater status is assessed in terms of groundwater bodies, whereby their quantitative and chemical status are to be determined; assessment classes are either "good" or "poor" (Table 5).

Table 5

Classification of quantitative and chemical status

Symbol	Classes of groundwater status
🟩	good
🟥	poor

5.2.1 Groundwater quantitative status

The main criterion for assessment of "good quantitative status" is groundwater level, which requires several conditions to be met.

1. Natural recharge of available groundwater resources must not be less than the long-term mean annual groundwater abstraction (i.e., the groundwater level must not be lowered in the long term).

2. Groundwater level shall not be subject to human-induced changes that result in
   a. Ecological objectives in surface waters connected to groundwater failing to be achieved,

   b. Water quality being significantly degraded

   c. Terrestrial ecosystems directly dependent on the groundwater body being significantly harmed, or

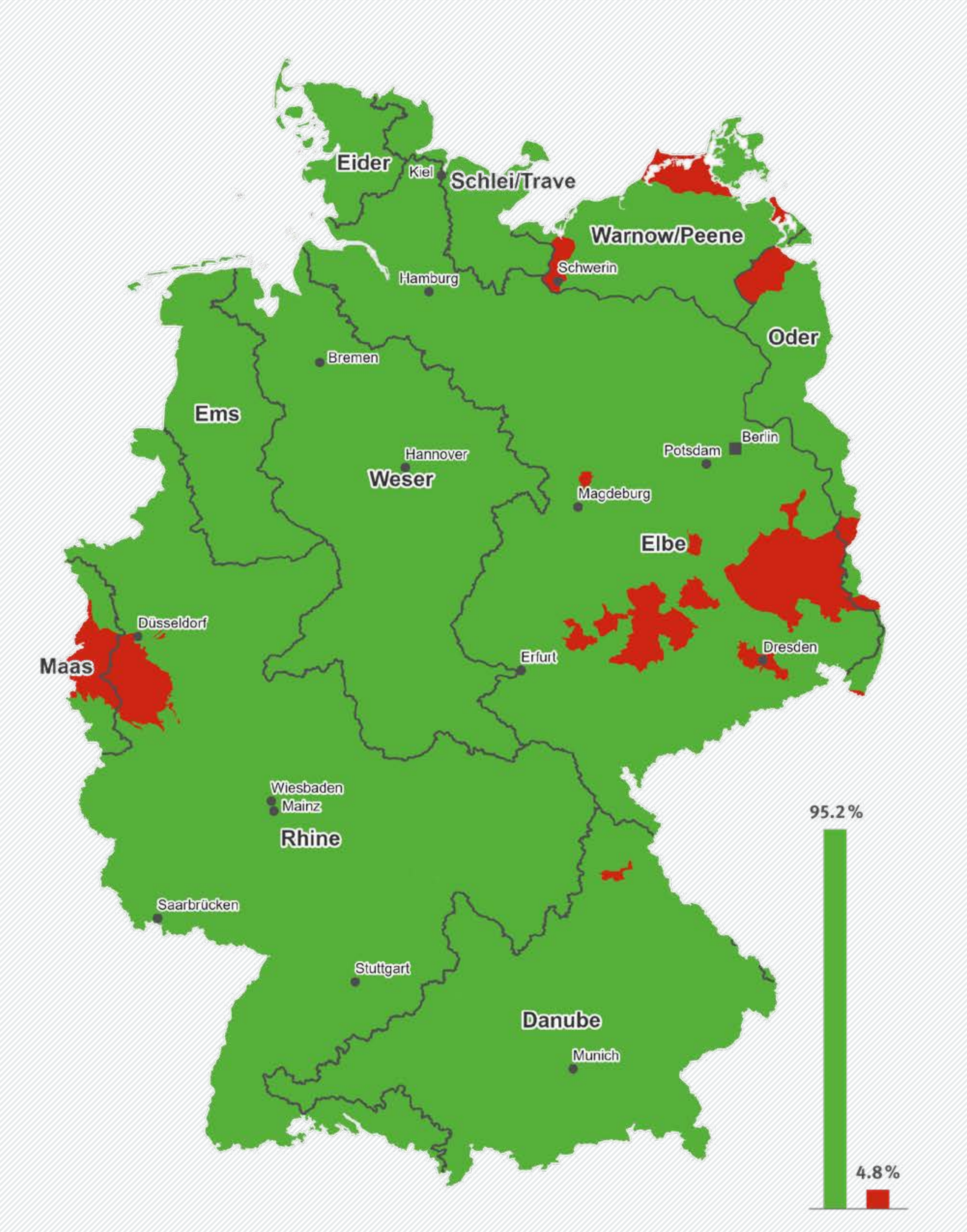
   d. Influx of saltwater or other influxes (intrusions) into groundwater.

To ensure good quantitative status of groundwater, allowable abstractions must be significantly below recharge rates. If abstraction and recharge rates are the same, the unavoidable natural outflow will reduce the groundwater level and thus the volume of groundwater that flows into surface waters and wetlands. Overall, there are only a few groundwater bodies in Germany that are over-exploited, with only 4.8 percent of all groundwater bodies failing to achieve good quantitative status (Map 7).

Groundwater bodies in poor quantitative status are found in the Danube, Elbe, Meuse, Oder, Rhine and Warnow-Peene river basins. Five groundwater bodies in the Warnow-Peene river basin are in poor quantitative status due to saltwater intrusion from the Baltic Sea and the waters along the Baltic Sea coast. Both being sensitive hydrogeological systems, they require special groundwater management to avoid saltwater inflows. In the Elbe, Meuse, Oder and Rhine river basins, poor quantitative status is often attributable to mining in general and lignite mining in particular, which has been (or was) actively pursued for decades in these regions, and whose groundwater levels have in many cases been extremely lowered for centuries. Even after mining comes to a halt, restoring groundwater to natural levels will take decades.

Map 7

Quantitative status of Germany's groundwater bodies, 2021



Good Poor

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Groundwater abstraction for public water supply in Bavaria, Germany

5.2.2 Groundwater chemical status

Groundwater must meet the following requirements in order to exhibit “good chemical status”:

- There is no evidence of salt or other intrusions.
- Environmental quality standards (limit values) and threshold values under EU legislation are not exceeded.
- Pollutant concentrations do not exceed a threshold that would
  - fail the management objectives for surface waters connected to groundwater,
  - cause the ecological or chemical status of surface waters associated with groundwater to deteriorate significantly, or
  - significantly damage groundwater-dependent terrestrial ecosystems

The EU Groundwater Directive specifies limit values (environmental quality standards) to be complied with by all Member States, and also stipulates that long-term trends of pollutant loads in groundwater must be monitored and increasing trends must be reversed through appropriate measures.

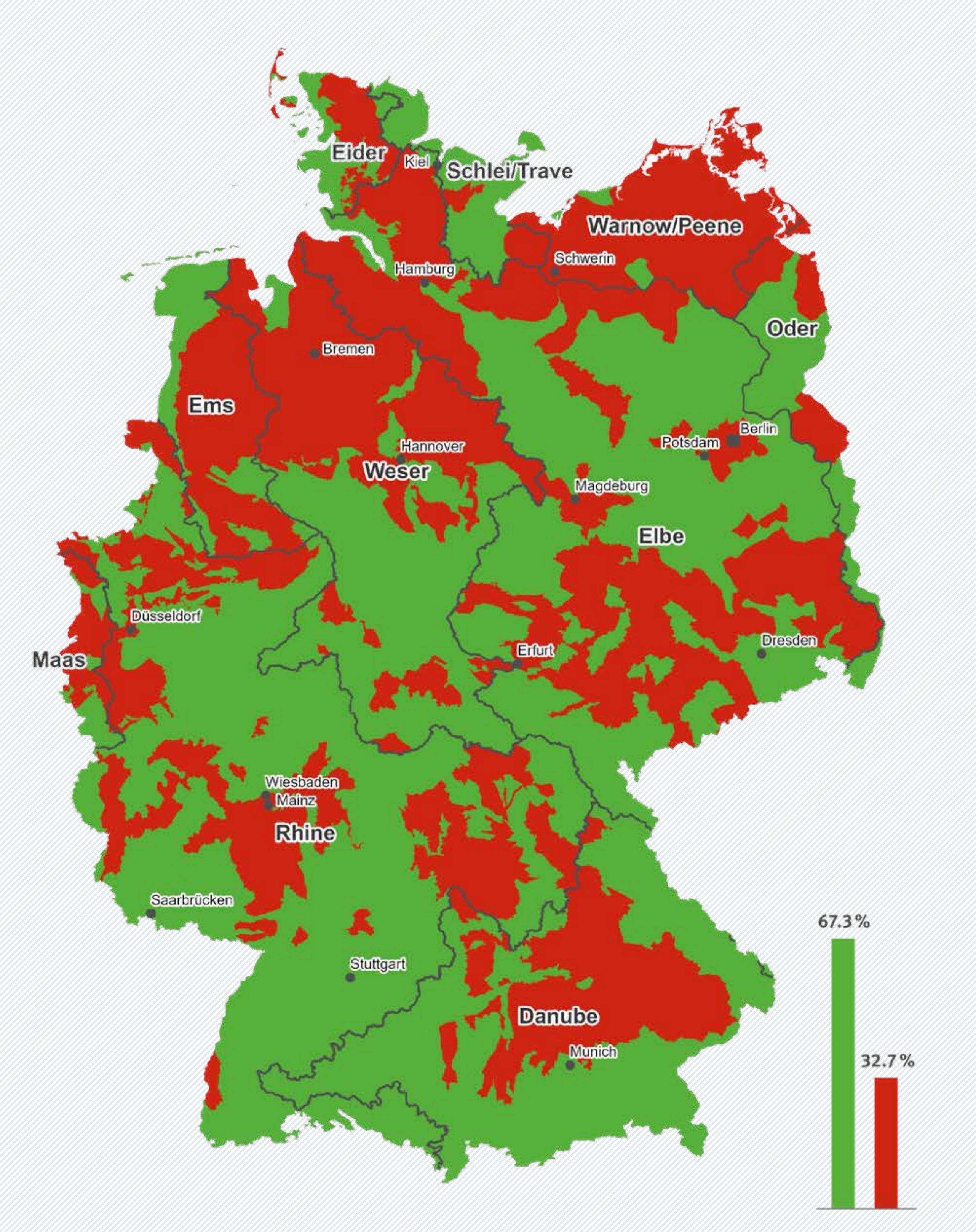
Apart from the Ground Water Directive’s environmental quality standards, which apply to all Member States, the latter are required to set threshold values for other substances referred to in this Directive. These environmental quality standards and threshold values are the key assessment criteria for chemical groundwater status. Other criteria also come into play such as a size criterion, which factors in the size of the area affected by any given contamination.

If environmental quality standards or threshold values are not exceeded at any monitoring site, the groundwater body is in good chemical status. But if, on the other hand, such a standard or threshold is exceeded at one or more monitoring sites, the size of the polluted area and the environmental impact of the anthropogenic pressures in question must be determined. If the impact is relevant or if the polluted area exceeds a certain size, the entire groundwater body’s chemical status is classified as “poor”, and measures must be implemented to reduce pressures.

According to the current chemical status assessments of groundwater bodies, 67.3 percent of all groundwater bodies are currently in “good chemical status”, while 32.7 percent are in “poor chemical status” (Map 8).

Map 8

Chemical status of Germany's groundwater bodies, 2021



Good Poor

Spatial base data: Geobasis-DE/BKG 2015
Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
Editing: Umweltbundesamt, Bund / Länder-Arbeitsgemeinschaft Wasser (LAWA)

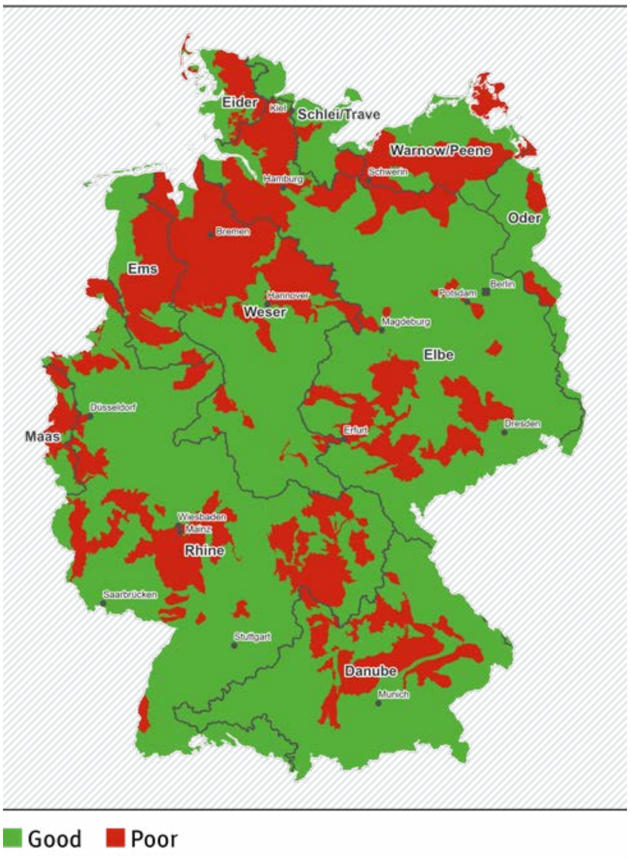
The fact that good chemical status is not achieved in groundwater bodies has various causes (Figure 12).

Groundwater pressures attributable to nitrogen compounds (usually nitrate) remain the main reason why German groundwater bodies exhibit "poor chemical status", which is the case in 22 percent of all groundwater bodies in Germany (Map 9).

In addition to nitrate, pollution by pesticides and their degradation products is another main cause for this state of affairs (Map 10). Most frequently, the use of six active substances as herbicides (weed killers) results in threshold values being exceeded (Table 6, page 67).

Map 9

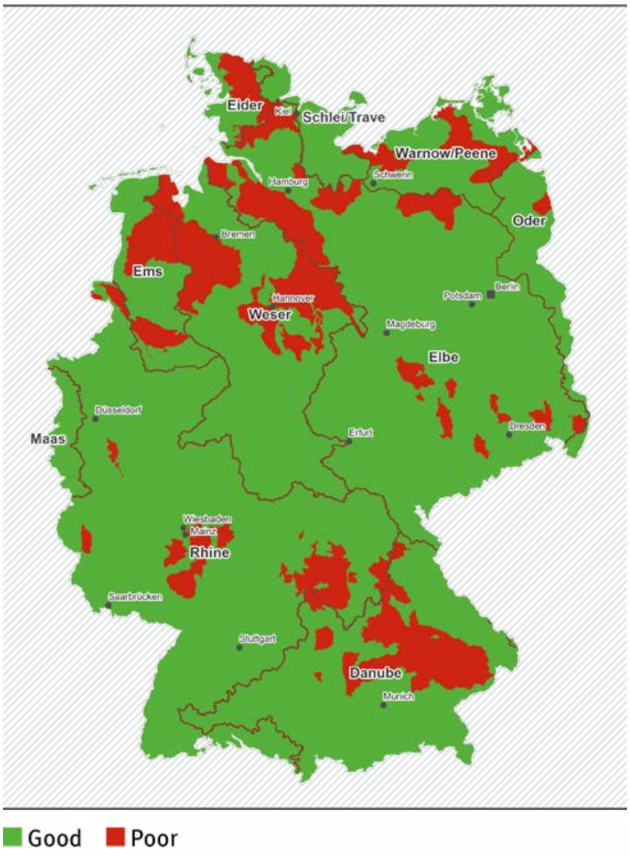
Groundwater bodies failing to achieve good chemical status due to nitrate pollution, 2021



Spatial base data: Geobasis-DE/BKG 2015
Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
Editing: Umweltbundesamt, Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA)

Map 10

Groundwater bodies failing to achieve good chemical status due to pollution with plant protection products, 2021



Spatial base data: Geobasis-DE/BKG 2015
Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
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Table 6

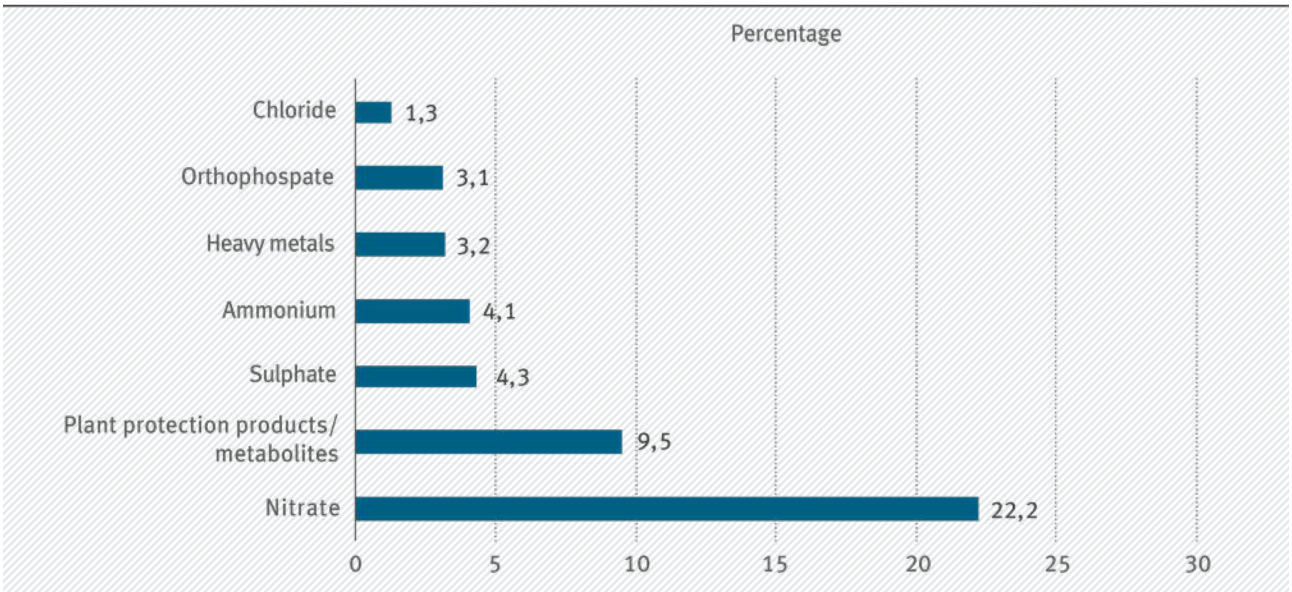
Pesticides and their degradants that often cause groundwater bodies' chemical status to be classed as "poor"

Active substance	Scope	Authorisation in Germany
Atrazine	Herbicide (cultivation of maize/market gardening)	No longer authorised (since 1991)
Bentazone	Herbicide (cereal cultivation)	No longer authorised (since 2018)
Metazachlor	Herbicide (rape cultivation/market gardening)	Currently authorised
Metolachlor	Herbicide (cultivation of maize)	Currently authorised
Chloridazon	Herbicide (beet cultivation)	No longer authorised (since 2018)
Dimethachlor	Herbicide (rape cultivation)	Currently authorised

Other substances or substance groups such as heavy metals, ammonium, sulphate, phosphate and arsenic have also resulted in threshold values being exceeded and thus to groundwater bodies' chemical status being classified as "poor" (Figure 12).

Figure 12

Proportion of substances/substance groups resulting in poor chemical status of groundwater bodies



Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
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5.2.3 Pollutant loads trend in groundwater

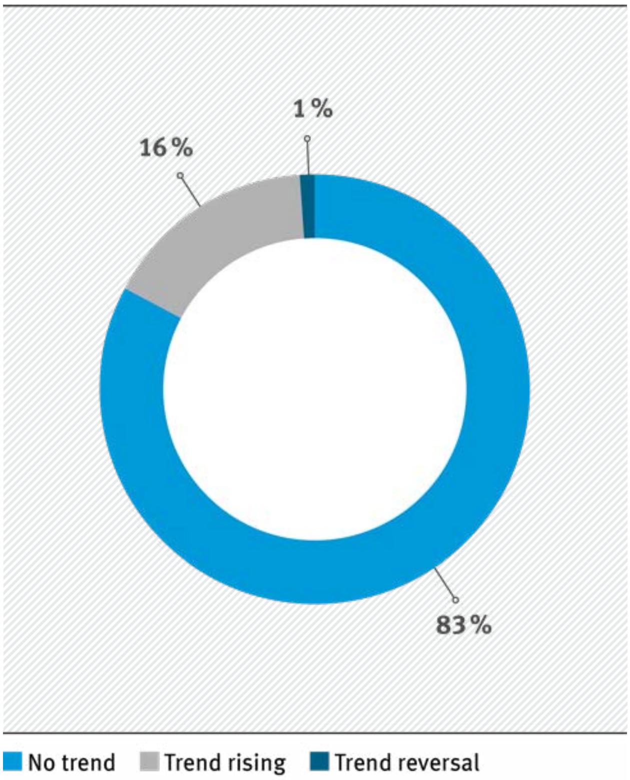
Groundwater has a good memory: Once an aquifer has been polluted, it often takes a long time and high technical and financial effort to restore it to “good chemical status”. For this reason, the Groundwater Directive also requires that any “significant and sustained upward trend in the concentrations of any pollutant” is to be reversed, a rule intended to prevent further accumulation of pollutants in groundwater, and to protect groundwater that has thus far been subject to little or no pollution.

As to groundwater bodies polluted with nitrate, 16 percent show an upward trend (Figure 13), and only one percent of groundwater bodies with poor chemical status due to nitrate exhibit a trend reversal. In 83 percent of nitrate-polluted water bodies, no trend can be identified or is unknown due to insufficient data.

For all groundwater bodies in “poor chemical status” due to pesticides pollution, no validated conclusions concerning trends can be reached because, for example, sufficiently long time series concerning nutrient and pollutant concentrations are not available. This will only improve with further implementation of the Water Framework Directive.

Figure 13

Trend development in groundwater bodies in poor chemical status due to nitrate (in percent)



Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
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Blauhöhle, Swabian Alps (Photo: Arge Blautopf)

Elbe near Magdeburg

6 Measures to achieve management objectives

6 Measures to achieve management objectives

Key to achieving the Water Framework Directive management objectives is taking appropriate measures. Many of these measures simultaneously increase biodiversity of rivers and lakes, serve to adapt to climate change, provide natural flood protection and protect the seas from inland pollution. Groundwater protection measures are particularly necessary as groundwater (among other sources) is also used as a drinking water resource; thus, supply of sufficient and high-quality potable water must be ensured.

In order to meet the aims of the Water Framework directive in the third management plan (now 2022 to 2027), as many measures as possible are to be implemented by 2027. These measures necessary for achieving good status of surface waters and groundwater are listed in the programme of measures, with clear information on whether measures can possibly only be implemented in subsequent management periods. All planning is based on previously identified pressures and the status of the water bodies concerned.

Measures to reduce the impacts of the numerous pressures on water bodies are manifold, necessitating guidance on uniform reporting on planned measures. For this reason, the Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) has drawn up a list of measures comprising 174 types of measures. In addition to Water Framework Directive measures, it also includes those to implement the EU Flood Risk Management Directive and the Marine Strategy Framework Directive, as these are closely linked to the Water Framework Directive implementation.

Moreover, it contains conceptual measures such as research projects, agricultural extension programmes or funding programmes, some of which not only refer to individual water bodies, but apply to regions or larger planning units.

The list of measures also provides information on whether a measure supports adaptation to climate change.

The following section describes how many measures are planned for the key focuses of pressures in management period 2022 to 2027 and beyond in order to reduce impacts on water bodies. A detailed description of measures is provided in the chapter 6.1 titled “Actors in the implementation of measures”, underpinned with practical examples.

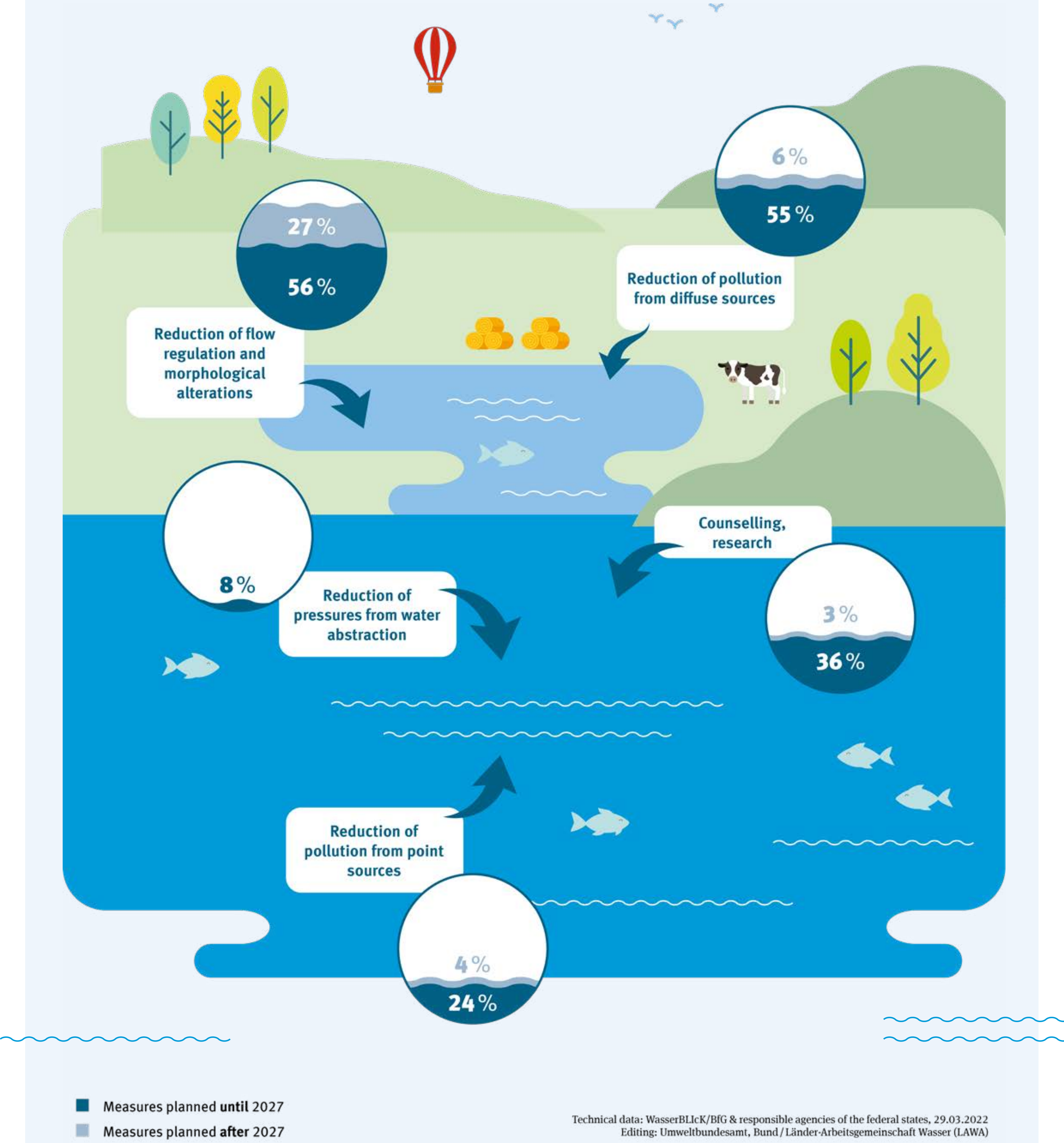
Figure 14 presents an overview of the measures planned in the key focuses of pressures flow regulation, morphological alterations, diffuse sources, as well as measures in the field of consulting and research activities, point sources and water withdrawal in surface waters. It is possible to plan several different measures for a single water body, with the number of measures planned for the focuses corresponding to the importance of the groups of pressures (Figures 5 and 6).

In 83 percent of all surface waters, measures are planned to reduce pressures from flow regulation and morphological alterations. In the run-up to 2027, a large proportion of these measures are already to be implemented in 56 percent of water bodies. Even beyond 2027, the focus of measures will be distinctly on restoration for the purpose of creating aquatic habitats (27 percent of water bodies) and on restoring continuity (26 percent of water bodies). Improvement measures to provide a near-natural water supply or for a dynamic water regime are planned in 19 percent of surface waters by 2027, followed by measures in other water bodies (2 percent).

Measures to reduce pollution from diffuse sources are primarily intended to prevent extensive eutrophication (nutrient over-supply) of water bodies and to reduce pressures from pollutant inputs. Measures are planned for 55 percent of surface waters by 2027, with another 6 percent to be implemented thereafter.

Figure 14

A variety of measures for surface waters. For each focus of pressures, the percentage of surface water bodies in which various measures are planned until 2027 or thereafter is indicated (n=9,747)



Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
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These are almost exclusively measures to reduce pollution from farming, including conceptual measures, such as agricultural extension programmes, but also research projects to further expand knowledge about pressures, impacts and efficient measures (36 percent by 2027 and 3 percent thereafter).

Reducing **pollution from point sources** is planned in 24 plus 4 percent of surface waters, intending to reduce nutrient and pollutant inputs significantly.

This is mainly achieved with measures at municipal wastewater treatment plants (14 plus 2 percent) and combined sewage and rainwater treatment (12 plus 3 percent). Measures in industry, commerce and mining are of minor importance in surface waters (with 1 percent).

Measures to reduce pressures from water abstraction are also planned (with eight percent for the 2022–2027 management period and only 0.1 percent more beyond that), which, are intended to ensure ecological minimum flows. They often also serve to adapt to climate change, as water resources are expected to become scarcer in the medium and long term.

Although atmospheric deposition (inputs via the air) as a diffuse source of pollution concerns a large part of surface waters, only a small number of measures have been taken in this regard. These are similar to conceptual measures and are often not directly related to a water body, but to higher planning levels. Since lowering atmospheric substance inputs is not in the hands of water management, measures must be taken in other policy and environmental areas (especially in the energy sector). One example is the international Minamata Convention (2014), aiming to protect human health and the environment from human-induced emissions and releases of mercury. Improvements in air and water quality are expected, for example, after shutting down coal-fired power plants and phasing out coal use by 2038 or earlier.

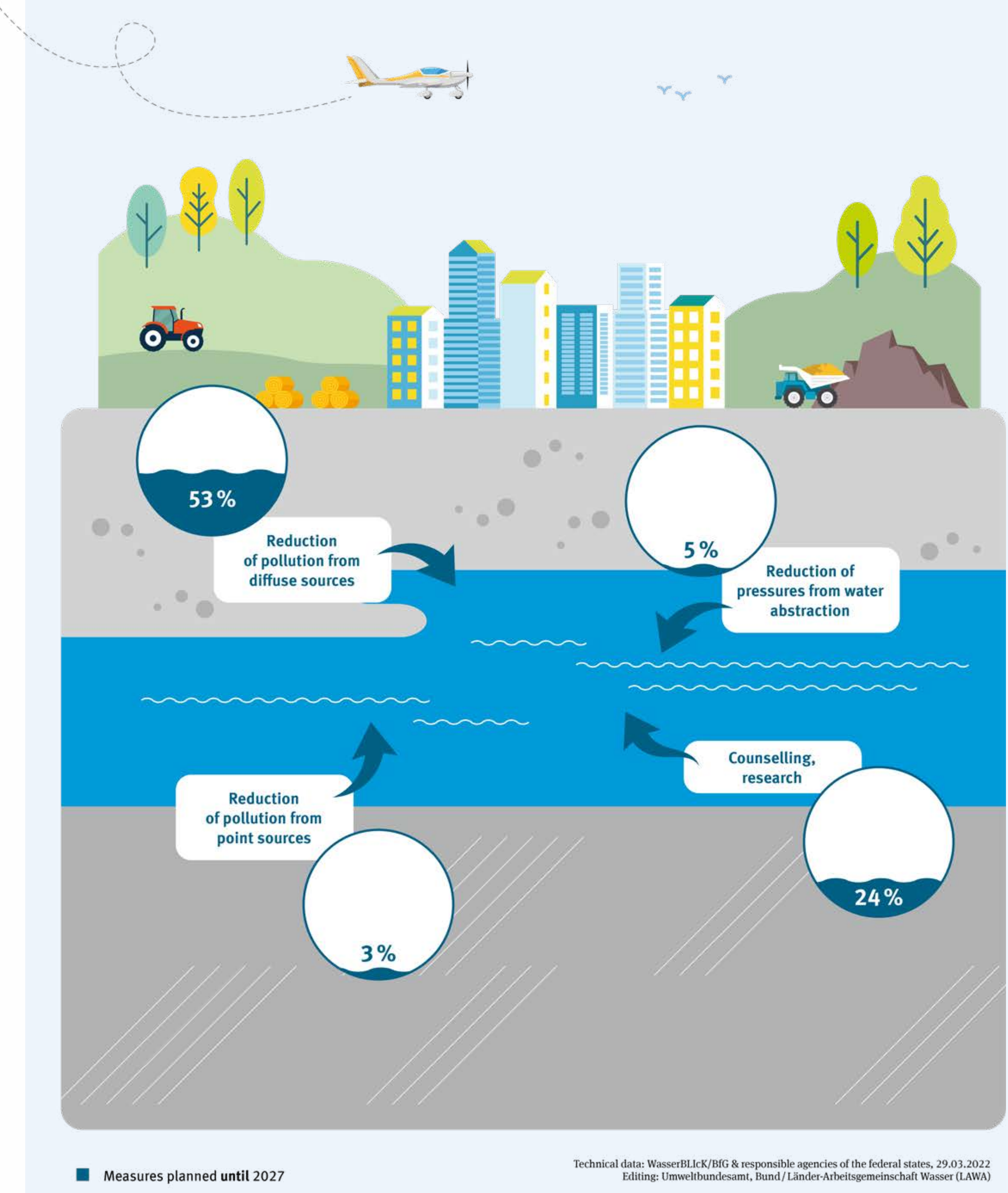
Figure 15 presents different measures planned for groundwater.

Almost all measures required for groundwater can probably be taken by 2027, and only 1.5 percent of them might be taken thereafter (thus we refrain from detailing this share of measures).

In 53 percent of all groundwater bodies, measures are planned primarily to reduce nutrients and pollutants from agriculture, and to a very small extent in the mining sector (51 percent and 2 percent respectively). As with surface waters, conceptual measures such as agricultural extension programmes and research projects are of certain relevance to this issue (24 percent). Measures to reduce pressures from water abstraction (5 percent) concern two groups of pressures: mining (3 percent) and public water supply (2 percent). For both, usually amendments to official approvals are required.

In groundwater, measures to reduce pollution from point sources (3 percent of groundwater bodies) are implemented primarily in the area of contaminated sites or abandoned sites (e.g., brownfields or waste disposal sites).

Figure 15
A variety of measures for groundwater. The share of groundwater bodies in which various measures are planned until 2027 is indicated in each case (n=1,291)



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6.1 Actors in the implementation of measures

There are numerous relevant stakeholders responsible for implementing measures. Federal states and municipalities are the competent authorities for measures to improve morphology, continuity and hydrological regime (Chapter 6.1.1) in the entire network of water courses, except for federal waterways, for which the federal government has competence regarding measures to establish continuity and improve morphology (Chapter 6.1.7). Municipalities are also responsible for implementing measures to ensure optimal capacity of wastewater treatment plants and combined sewage and rainwater treatment (Chapter 6.1.3). Implementers in the private sector are, for example, farmers (Chapter 6.1.2), hydropower plant owners (Chapter 6.1.6), industrial or mining companies (Chapters 6.1.4 and 6.1.5).

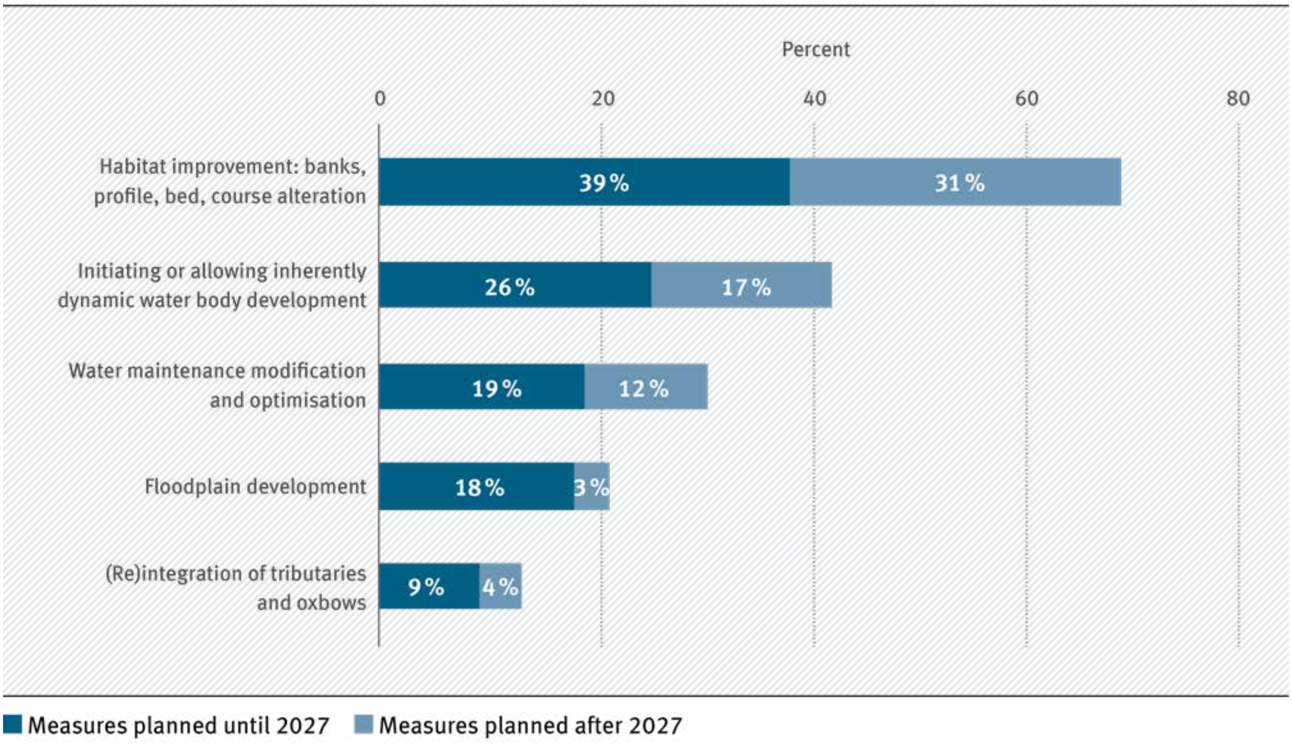
6.1.1 Federal states and municipalities

A major proportion of Water Framework Directive measures are financed and implemented by the federal states and municipalities. In addition, to optimising public wastewater management, these measures primarily aim at reducing pressures on water bodies from flow regulation and morphological alterations. Here, the federal states are responsible for larger water bodies, the municipalities – mostly organised in water and soil associations – for smaller water bodies and streams.

Due to the manifold pressures caused by morphological alterations, improving hydromorphology is an important water management issue in Germany, which is also reflected in the planned measures forming the focus of future action planning and implementation in

Figure 16

Measures in surface waters: Proportions of measures to reduce pressures from morphological alterations (n=9,747)



Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
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surface waters, not only until 2027, but also thereafter (39 plus 31 percent, respectively; Figure 16).

In 70 percent of all surface waters, a variety of measures are planned to improve morphology, including habitat improvement through more natural shaping of river banks, by raising the riverbed and widening the river profile or by reversing straightening measures. In addition to active conversion measures to create more natural watercourses, there are also plans to allow for inherently dynamic water body development (43 percent). For example, broken-down riverbanks will not be restored, so that floods can make a river more natural again. By 2027, such measures are planned in more than 4,000 water bodies, meaning that in the Danube river basin district alone, restoration measures will be carried out over a total length of more than 6,000 kilometres.

Worth seeing
Restoration of rivers and streams in Germany (video clip, German Environment Agency)
https://www.umweltbundesamt.de/themen/wasser/fluesse/gewaesserrenaturierung-start

Water body maintenance is within the responsibility of water owners, being, at the municipal level, mostly water and soil associations or local water authorities. The tasks of water body maintenance are defined in the Federal Water Act (WHG). Originally, they merely comprised ensuring proper water flow, but under the revised Federal Water Act, they now also include ecologically oriented maintenance and development measures, which should strictly adhere to Water Framework Directive objectives.

This means allowing natural riverbank vegetation to develop on its own, planting site-specific riparian vegetation or dismantling bank revetments. Measures such as these are also planned beyond 2027 in 31 percent of water bodies (19 and 12 percent, respectively; Figure 16).

Increasingly, floodplain development and oxbow reintegration play a major role in morphological measures (21 and 13 percent, respectively), since, for example, regularly flooded floodplains are spawn areas for many fish species and can contribute significantly to decentralised flood prevention.

Responsibility for restoring continuity is with the federal states and municipalities, owners of transverse structures or, on federal waterways, the German government. These measures include, among others, building bypasses that guide fish past obstacles. Other technical installations for fish migration and fish protection are also intended to serve the same purpose, thus enabling fish to migrate through water bodies as undisturbed as possible. In Bavaria, for example, more than 15,000 individual measures are planned at transverse structures to restore continuity.

Examples of current measures

“100 Untamed Streams for Hesse”
Since 2019, one hundred deliberately chosen streams in Hesse have been reshaped and restored to a near-natural state as part of a programme initiated by the Hessian Ministry for the Environment aimed at the implementation of measures under the Water Framework Directive until 2027. The programme also contributes significantly to the Hessian Biodiversity Strategy, the state-wide biotope network, ecological flood protection and establishing fresh air corridors, especially in urban areas.

Reshaping the straightened riverbed (having a deepened and narrow profile and almost completely lacking buffer strips) into a structurally rich multi-bed channel, with small islands forming, watercourse widening and banks flattening, with deadwood and rocks for inherently dynamic development

A special programme feature is support for municipalities for restoration measures. For example, Hesse takes responsibility for project management and planning, for planning of land use and organising implementation of measures, from funding application to acceptance of installations. This arrangement relieves municipalities from work that is demanding on staff resources. Further support includes pooling technical information to increase efficiency in project implementation or improving public awareness of water body restoration. In addition, Hesse takes on 95 percent of programme costs.

In the run-up to the programme, all municipalities and water associations had the opportunity to apply for participation, and finally, 100 streams were selected, with catchment areas between 10 and 100 square kilometres, or other water bodies of particular importance for endangered animal and plant species. 150 municipalities in Hesse are participating in the programme, which was initially designed for the period from 2020 to 2023 and has now been extended to 2027.

River development plan middle Isar

The Oberföhring weir, built in 1924/28, served to dam the river and to divert up to 150 cubic metres of Isar water per second into the Middle-Isar-Canal, with five barrages between Munich and Moosburg. As a result, the river bed was deepened, floodplain inundation decreased, river stretches were separated from their floodplains, and barriers and falls constructed to prevent further deepening.

The river development plan was based on an increase of the minimum hydropower plant water discharge from 8 to 15 cubic metres per second, which can only be ecologically effective to a limited extent without structural improvements in the riverbed, necessitating a large number of measures, such as:

- Dismantling of bank reinforcements, flow control and structural improvement including performance monitoring
- Modification of large transverse structures and construction of fish ladders
- Integration and linkage with dependent waters as well as establishment and near-natural conversion of alluvial forests, and dike relocation
- Construction of sporting boat wharfs at weirs, creation of bathing areas, creation of floodplain nature trails, “Isarwächter” (Isar guardian) information system.

This concept, covering 64 kilometres of Isar flow length in the middle stretches, was developed back in 2001 and planned to run for twenty years. Implementation of the extensive measures was within responsibility of the Landshut and Munich water authorities. Their costs amount to around 22.5 million euros, of which 75 percent is borne by the hydropower operator and 25 percent by the Free State of Bavaria.

Raising public awareness of water

The federal states and local governments are also responsible for raising awareness of water issues among the general public as well as in policy and practice. For this purpose, a variety of different initiatives have been started that specifically address the relevant target and interest groups.

For example, forums are held for associations, the private sector, science community, municipalities and state administrations in Baden-Württemberg, Hesse and North Rhine-Westphalia to provide information on processes underway and results concerning Water Framework Directive implementation. These forums also offer opportunities to discuss water management issues, present measures or form networks.

In each of the federal states, reports, management plans and programmes of measures for Water Framework Directive implementation are made publicly available via the internet (mostly websites of the relevant ministries or agencies), together with detailed results in map applications, and including federal state-specific brochures.

Videos on rivers that also address pressures and possible countermeasures are particularly illustrative, as are explanatory videos that elucidate complex ecological interdependencies. Blogs and children's books are further opportunities of raising public awareness of water issues.

Worth seeing

Animated film on Water Framework Directive objectives and measures (3 min.) European Water Framework Directive 2021
https://vimeo.com/597145538

6.1.2 Agriculture

Measures to reduce nutrient and pollutant input are to be implemented primarily by farms, whereas conceptual measures, such as agricultural extension programmes, are mostly carried out by the authorities or other institutions, such as chambers of agriculture.

Farming in Germany is subject to a number of regulatory – hence binding – requirements concerning protection of surface water bodies and groundwater, codified, for example, in the 1996 Fertiliser Regulation (based on the EU Nitrate Directive). However, pressed by the European Commission, the Federal Government has had to revise this regulation twice in the past four years because nitrate levels are still too high. Today, the Düngegesetz (German Fertiliser Act), the Fertiliser Regulation and the relevant administrative regulation ("on Designating Nitrate-Polluted and Eutrophic Areas") impose strict requirements on farms and significantly higher obligations concerning polluted areas. As regards pesticides, the European Plant Protection Products Regulation has been transposed into national law (German Plant Protection Act).

For the third management period, measures to reduce pressures from farming are planned in more than 50 percent of all surface waters and in half of the groundwater bodies (without considering conceptual measures such as extension programmes).

In surface waters, these measures mostly aim to reduce nutrient inputs due to runoff and erosion. (Figure 17). Such measures include the greening of areas on exposed slopes or catch cropping (e.g., with charlock) in order to avoid soils being exposed over longer periods of time and to prevent wash-out of nutrients into surface waters.

Other measures include optimising fertiliser use or switching from conventional to organic farming.

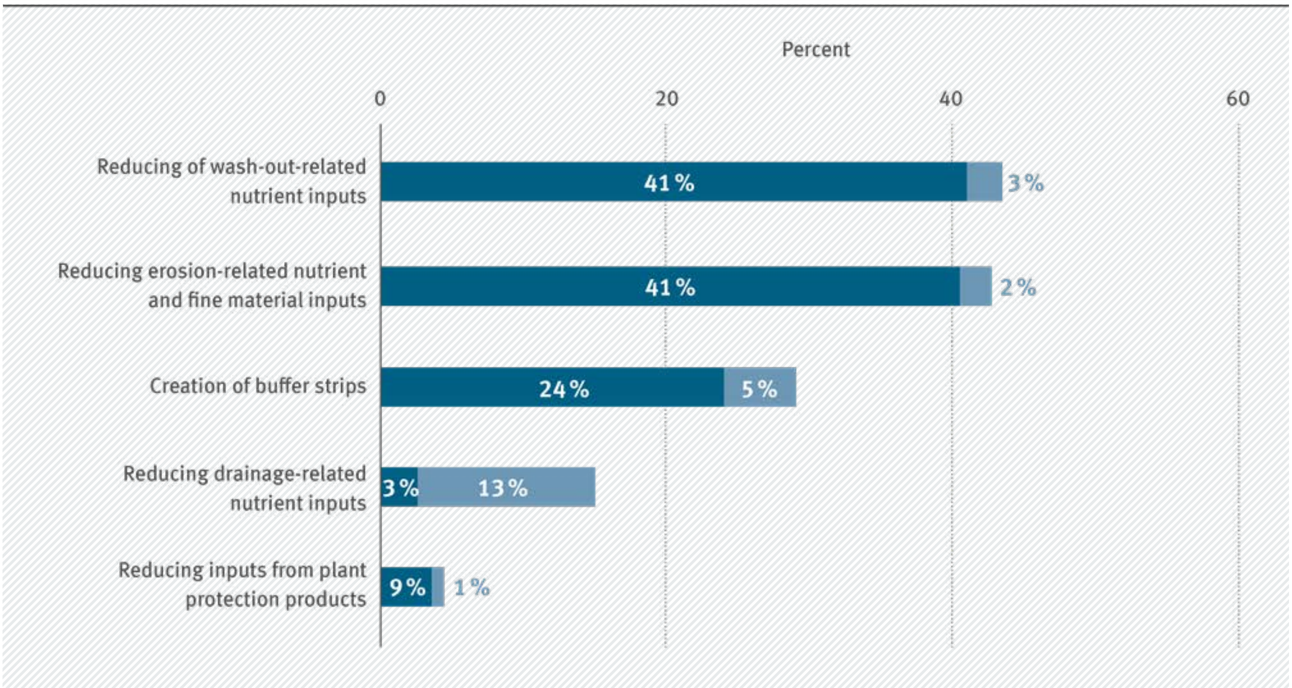
Wide buffer strips and retention zones with natural copses and shrubs also provide effective protection against nutrient and fine sediment inputs into surface waters and contribute to increasing structural diversity. To serve this purpose, measures are planned in 29 percent of water bodies. The Federal Water Act provides for buffer strips of five metres to the right and left of water bodies, with the federal states being authorised to enact deviating regulations.

Drainages on farmland, such as ditches or pipes to discharge water into adjacent water bodies, can pose problems, resulting in high diffuse nutrient and pollutant inputs into these water bodies. Most measures to reduce these substance inputs will only be implemented after 2027 (13 percent).

Measures aimed at pesticide reduction, such as promoting water-protective methods of use or bans on pesticide application, are less frequently planned in surface waters (10 percent).

Figure 17

Measures in surface waters: Proportions of planned measures to reduce pressures from agriculture (n=9,747)



Measures planned until 2027 | Measures planned after 2027

Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
Editing: Umweltbundesamt, Bund / Länder-Arbeitsgemeinschaft Wasser (LAWA)

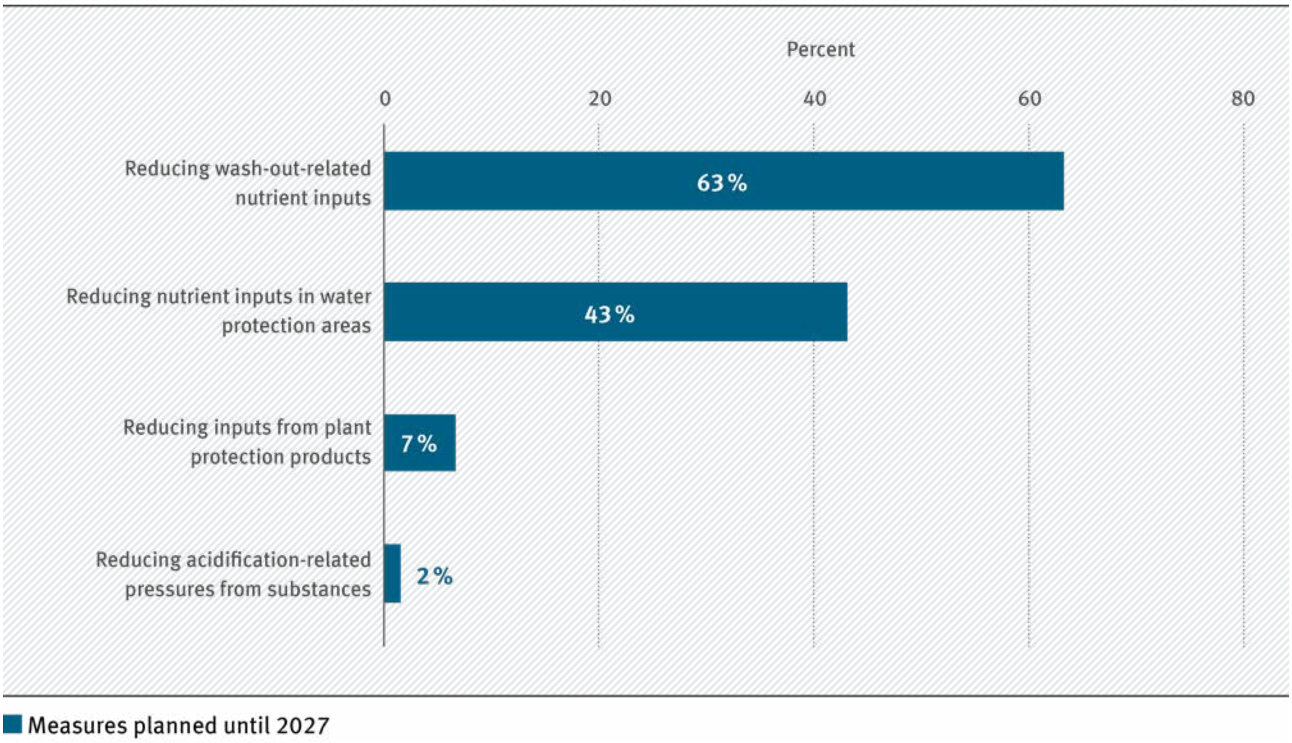
Not only nutrient and pollutant inputs, but also surface water hydromorphology is influenced by farming activities, a fact that necessitates hydromorphological measures in intensively farmed regions. This includes returning more surface area to water bodies so they can develop more naturally again. Implementing these hydromorphological measures mostly lies in the hands of municipalities and water and soil associations.

For groundwater, measures to reduce nutrient inputs through wash-out into groundwater predominate (63 percent, Figure 18). Catch cropping and reduced fertiliser use are useful:

Intermediate crops absorb part of excess fertiliser so that it can no longer enter groundwater via wash-out into the soil. Intermediate crops are worked into the soil and serve as natural fertilisers for the crops to follow. As groundwater is a drinking water resource, appropriate protection measures are particularly important (43 percent), especially in water protection areas. Accordingly, the relevant German regulations provide for restrictions on fertiliser and pesticide use tailored to the respective protected zone. In addition, for nitrate and pesticides in groundwater the same limit tresholds apply as to drinking water. Implementation of groundwater protection measures in water protection areas is ensured by contractual agreements between farmers and municipalities.

Figure 18

Measures in groundwater: Proportions of planned measures to reduce pressures from agriculture (n=1,291)



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Editing: Umweltbundesamt, Bund / Länder-Arbeitsgemeinschaft Wasser (LAWA)

Entering into dialogue on water protection measures with all users as early as possible is essential for public acceptance.

In all federal states, conceptual measures are also planned to reduce farming-related pressures based primarily on information and training, voluntary cooperation and certification systems for agricultural products and food. These measures are organised differently in each of the federal states and have different focuses depending on the strength of pressures. For example, the Lower Saxony Chamber of Agriculture and consulting engineers under contract to the Chamber have been offering farmers agricultural advice focusing primarily on pre-defined highly polluted areas and also including investigations of soils, plants and water bodies, as well as providing the public with information.

The EU Common Agricultural Policy (CAP) allows for financing the implementation of certain measures in the farming sector.

However, in order to be eligible for CAP direct payments, certain basic requirements ("cross compliance") must be met: Farmers must maintain their land in a "good agricultural and environmental condition" (GAEC) and meet the "statutory management requirements". In Germany, these requirements are the legal minimum standards for environmental protection, food safety, animal and plant health and animal welfare.

Examples of current measures

The Thuringian "Servicepaket" (Service Package)
This initiative was launched in 2021 to actively support farmers in meeting new requirements. Developed by the Thuringian Ministry for the Environment, Energy and Nature Conservation and the Thuringian Ministry for Infrastructure and Agriculture. It aims to reduce nitrate and phosphate pollution in Thuringia's waters, and comprises three components:

1. Carrying on cooperation in water protection (established 2009), focusing on nitrogen management and reduction of erosion-related phosphorus inputs. This includes, for example, information events, field days with inspections of affected areas, presentation of feasible and particularly efficient methods and joint evaluations for participating farms concerning the issue of fertilisation and erosion.

2. Regional cooperation in groundwater protection initiative for joint explication of nutrient-related problems (e.g., in specific nitrate-polluted areas) and joint elaboration and implementation of customised solutions, with farmers, advisors and water management experts.

   This cooperation project aims at reducing nutrient concentrations necessary to repeal the "nitrate-polluted" status of affected water bodies.

3. Newly designed individual counselling comprising several modules on the entire fertiliser issue with its wide variety of aspects of fertiliser use, nutrient and material flows accounting.

The costs are borne by the federal states and the European Agricultural Fund for Rural Development (EAFRD), based on EAFRD criteria.

FAKT, a support programme for agri-environmental measures, climate protection and animal welfare in Baden-Württemberg, is based on the support for agricultural measures begun in Baden-Württemberg in the 1990s. The current programme aims at giving grassland sites, organic farming promotion, water and erosion protection as well as additional animal welfare measures even greater weight, and at narrowing the requirements for receiving subsidies. As an example, payments are only granted if the relevant measures go beyond good professional practice as legally required. Participation in the funding programme is voluntary, but applicants have to commit to at least five years for numerous sub-measures.

One eligible measure is, for example, “precision farming”, which is currently subsidised with 80 €/ha. Key criterion for precision farming is that fertilisers are applied on the basis of nutrient maps (that chart soil sample measurements), based on soil testing using state-of-the-art sensors to analyse plant nutrient supply in real time, so that each plant can be optimally supplied with nutrients according to its needs, even if nutrient requirements vary within a field.

With the exception of areas subject to legally binding accounting obligations (as per § 7 (2) of the relevant protected areas and compensation regulation, SchAlVO), generally all farmed land is eligible for support, such as that managed with reduced tillage (“strip tillage”) (currently subsidised at 120 €/ha). This method is based on working the soil only in strips, leaving at least 50 percent of soil surface unworked. Unworked strips significantly reduce erosion risks because crop residues on these strips improve soil structure and thus both slow down rainwater runoff and facilitate infiltration of water into the ground.

FAKT measures are funded by the EAFRD (see above) and Germany’s Joint Task for the Improvement of Agricultural Structures and Coastal Protection (German abbreviation: GAK) as well as with financial resources from the State of Baden-Württemberg.

Upper Danube Nature Park, Baden-Württemberg

6.1.3 Municipalities and households

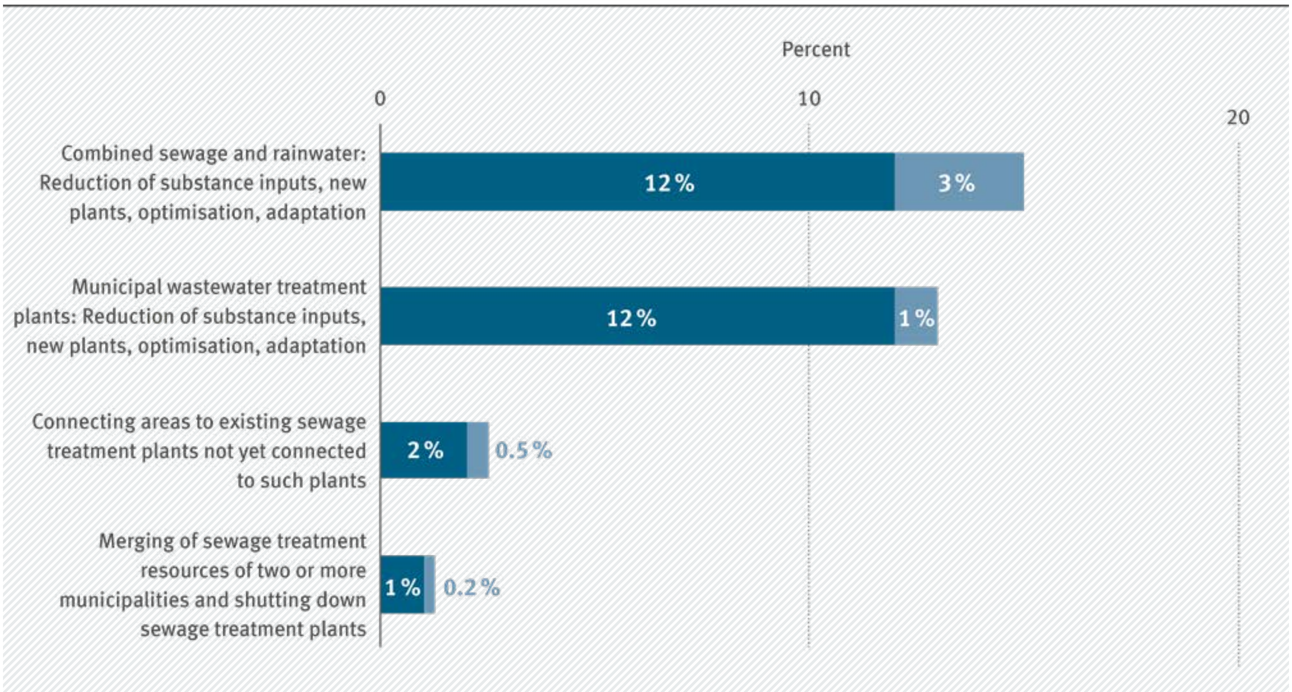
Responsibility for implementing measures to reduce nutrient and pollutant inputs from municipal wastewater treatment plants and combined sewage and rainwater treatment into surface waters is with the sewage disposal operations and water boards of municipalities and water associations. Costs of maintaining a functioning sewage disposal system are financed from contributions and charges paid by the public, including commercial enterprises connected to municipal sewage treatment plants. Further measures such as installing filters to reduce phosphorus can also be passed on to residents and businesses. Owners of private small wastewater treatment plants, too, can be charged for the implementation of measures and the costs incurred.

For the third management period and beyond, measures to reduce pollution from municipalities and households are planned in almost one third of all surface water bodies, comprising, in equal proportions, the reduction of nutrient and pollutant inputs from municipal wastewater treatment plants and combined sewage and rainwater treatment (Figure 19).

Measures at municipal wastewater treatment plants include additional phosphate precipitation, construction or optimisation of plant expansion to reduce input of pharmaceutical residues and other trace substances, for example.

Figure 19

Measures in surface waters: Proportions of planned measures to reduce pressures from municipalities and households (n=9,747)



Measures planned until 2027 | Measures planned after 2027

Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
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In combined sewers, wastewater from households and rainwater are jointly routed to a sewage plant. During heavy rainfalls, an overstressed sewage plant may not be able to completely take up the combined sewage, which is therefore stored in specially built retention systems and later fed to the treatment plant. Should these systems also run full, the diluted and possibly pre-purified combined sewage is discharged into water bodies, where it can cause pollution. Further expanding retention volumes allows for more combined sewage to be stored, reducing water pollution from sewage discharges.

Converting combined sewer systems to separated systems that discharge wastewater and rainwater independently of each other reduces discharges of combined sewage into water bodies. Rainwater is then usually discharged directly into watercourses, possibly leading to pollutant inputs, as in the case of tyre wear particles from road runoff, which is a major cause of microplastics entering water bodies. This necessitates building rainwater treatment plants to significantly reduce inputs.

To relieve pressure on sewer systems, rainwater is allowed to infiltrate into the ground in urban areas, for example, by leaving surfaces unsealed; parks and green roofs have a similar effect. At the same time, groundwater is recharged and the city's climate is improved. The term "sponge city" was coined for this model of water retention on an urban scale.

Given the large part of the population already connected to the public sewer network, there are comparatively few measures for centrally connecting previously unconnected areas (3 percent). In less populated regions, expanding sewer networks is sometimes too expensive, meaning that decentralised installation of small sewage plants or other technical treatment processes on site are more cost-effective.

Often, networking several small sewage plants into one large plant can also improve treatment capacity and significantly reduce nutrient and pollutant inputs into water bodies (1 percent).

By taking measures themselves, citizens, too, can do a lot for water protection and reduce pollutant inputs into the water cycle. Such measures include proper disposal of pollutant containing items and medicines, purchase of sustainable products (e.g., with the Blue Angel eco-label), and generally avoiding products containing pollutants.

Examples of current measures

Berlin: Water-sensitive urban design

Water-sensitive cities serve, for example, to reduce flooding risks from heavy rainfall and summer heat wave risks. In fact, evaporation of rainwater creates a better microclimate, especially in densely populated innercity neighbourhoods, and water stored in cities can minimise water body pollution through combined sewer overflows and rainwater discharges. In addition, targeted rainwater management promotes groundwater recharge.

To this end, Berlin has significantly intensified its activities in the field of decentralised rainwater management. Commitments and targets of the corresponding programme include integration of water management policies into urban planning, reviewing all possibilities of decentralised rainwater management matched with the local environment, annual one-percent reduction of property space from which rainwater is directly discharged into combined sewer systems. In addition, in outlining and structural planning, new residential quarters are already to be oriented towards decentralised rainwater management.

In order to support Berlin in achieving the above-mentioned targets, the Berlin Rainwater Agency was established in 2018 with the incurring personnel and material costs being financed from the state budget. The Agency focuses in particular on building and funding consultancy.

Worth seeing
Lake Eixendorf (Oberpfalz) – how can its water quality be improved sustainably and recurring blue-green algae blooms be brought under control in the long term? (Video clip by the Weiden Water Management Office)
https://www.youtube.com/watch?v=7cfF0S2N8pE

Saarland: New Erfweiler-Ehlingen sewage treatment plant
High phosphorus concentrations resulted in failure to achieve good ecological status in the Mandelbach, caused in part by discharges of treated wastewater from the Erfweiler-Ehlingen sewage treatment plant, which was commissioned in 1993 and is no longer state of the art. The authorities therefore decided to completely rebuild and expand the plant in order to also connect a neighbouring community to the sewage system.

As per the legal requirements for state-of-the-art wastewater treatment plants with a capacity of 2,500 population equivalents, the former pond treatment plant was superseded by a new one. At the former facility's site the new plant was build, using technical wastewater treatment and designed as a combined sewage treatment plant with a downstream retention ground filter for further treatment of the purified wastewater.

This measure aims at significantly reducing nutrient inputs into the Mandelbach by, among other things, tightened thresholds for wastewater, especially for nitrogen and phosphorus.

Rooftop garden in Berlin-Mitte, an effective way to implement decentralised rainwater management

New Erfweiler-Ehlingen sewage treatment plant

Construction began in 2019 and is expected to be completed by 2022, with the neighbouring municipality to be connected to the plant and the entire measure finalised by 2024. The costs amount to 6.3 million euros. Construction is managed by the Entsorgungsverband Saar.

6.1.4 Mining

Responsibility for implementing and financing measures in the mining sector is with the relevant companies. Once mining activities have ceased, they are also responsible for rehabilitating abandoned opencast mines.

Measures to reduce pressures from mining are planned for the third management period and beyond in 1 percent of surface waters and in 4 percent of groundwater bodies. In groundwater, measures to reduce water abstractions play a particularly important role in order to prevent further lowering of groundwater levels.

In most cases, these measures involve adjusting existing approvals concerning the volume of groundwater to be abstracted. In addition to mining, measures with regard to water abstraction are also planned in the areas of public water supply and farming (irrigation), but to a much lesser extent.

The Weser River Basin Community is currently implementing measures to reduce saline wastewater and pile water inputs from potash mining into the Werra. These are primarily on-site reduction measures (including evaporation, underground stacking, mine waste covering) as well as transporting saline wastewater to flood pits outside the Werra plant (see example of measures).

Changes in hydrological regimes due to mining activities as well as weather and climate-related influences can require adjustments in water management for surface waters and groundwater in order to keep demand and supply in balance. For example, some surface waters in the Lusatian region are largely fed by pit water (accumulated by pumping groundwater to lower groundwater levels in opencast mines), which is why discontinuing mining activities by 2038 at the latest will also have an impact on the existing water supply in surface water resources in this catchment area. In order to be able to make reliable water supply and water quality projections for the year 2038 and far beyond, the Federal Environment Agency commissioned a project to forecast water supply, water quality and water uses, also taking climate change into account.

Treatment of pit water is an example of measures for surface waters made necessary by mining. Special monitoring schemes are designed to detect mining impacts on water quality (such as salinisation or increased heavy metal concentrations) at an early stage; such schemes form the basis of reduction and prevention measures.

A decision was made to phase out coal use in Germany by 2038, which should ideally be brought forward to 2030. When mining is discontinued, the question arises as to what is to be done with landscapes that to a great extent have been significantly altered by mining. The abandoned mining areas in the Lausitz and Middle German regions will be turned into a recreational zone containing 46 lakes that comprise a water body surface area amounting to 25,000 hectares.

Mining companies are paid more than 4.3 billion euros by the federal government to compensate for loss from mining discontinuation. How and for what purpose these funds are used is regulated by the relevant phase-out legislation, stipulating that, in addition to remedying the ecological impacts of mining, structural changes in former mining regions be financed from these funds.

Examples of current measures

Saarland: Water treatment at the Camphausen mine
In the context of a special measuring programme of the Saarland Office for the Environment and Occupational Safety (LUA) in 2016 and 2017, high concentrations of polychlorinated biphenyls (PCBs) and zinc, bound to suspended matter, were detected in the Fischbach and the Klinkenbach. They are contained in mine wastewater from coal mining that has been discharged into these streams for many years (on average, 1.6 million cubic metres into the Fischbach alone).

Wastewater treatment aimed at reducing suspended matter in order to reduce inputs into these two water bodies.

For this purpose, RAG stock corporation elaborated pit water treatment measures, which include optimised pumping operation (for example by equalisation to reduce the mobilisation of suspended matter) and reducing discharge volumes by about 40 percent into the Fischbach, followed by further mine water thickening, mechanical dewatering and post-sedimentation before discharge.

Rehabilitated opencast mine: the “Ostsee” near Cottbus

Soil covering of a salt waste dump

Germinating plants on a dump covering

These technical solutions are expected to reduce suspended matter by up to 80 percent. Implementation measures are taken by RAG stock corporation, accompanied by extensive monitoring in cooperation with the contracting authority.

Werra and Weser: Package of measures to reduce salt loads

For more than 100 years, potash salts have been industrially mined by the mining company K+S (K+S Kali GmbH) for fertiliser production in the Weser river basin district, which generates large quantities of solid and liquid residues being either deposited on dumps, discharged into the Werra or sunk underground. Point source and diffuse inputs still result in high salt loads in the Werra and Weser as well as the groundwater bodies there, with a large proportion of diffuse inputs being due to many years of water injection (now discontinued).

River Basin Community Weser has set up a special programme with measures or combinations thereof to reduce pressures within the current management period (2021 to 2027), also taking into account previously implemented measures, primarily aimed at largely avoiding and reducing production wastewater and dump water on site. This programme includes operating a kainite crystallisation plant (in which saline wastewater is boiled down), underground stacking of 3.2 million cubic metres of saline wastewater, covering existing dumps with synthetic geomembranes or soil and construction waste and removal of production and/or dump wastewater by truck or rail for flooding into other pit spaces or above-ground and underground temporary storage.

The programme aims to achieve good ecological potential in the Weser and the highest possible ecological status in the Werra by the end of 2027.

Implementation is carried out by the K+S company, alongside with R&D projects, ecological and economic monitoring and implementation controlling by the Weser River Basin Community's working group on salt reduction.

6.1.5 Industry

Industrial sewage treatment plants are financed and measures are carried out by the company involved.

Measures to reduce inputs from industry are planned in just under two percent of surface waters and in 3 percent of groundwater bodies. In both surface and groundwater bodies, these measures most frequently aim to reduce substance inputs from contaminated sites and abandoned sites and include, in particular, rehabilitating these sites as well as extended soil testing to determine potential hazards more precisely.

Further measures in the industrial sector include building new industrial wastewater treatment plants or the adaptation or optimisation thereof to increase their treatment capacity so that fewer pollutants enter water bodies.

Another focus is reducing heat discharges from industrial facilities where mostly surface water is used as cooling water and water heated-up in this manner is discharged back into the water body. Measures to reduce such pressures are planned at 17 industrial sites, for example, to reduce cooling water discharges, optimise cooling facilities or build new ones and draw up thermal load plans in which temperature regimes of watercourses can be precisely calculated and forecast, considering thermal load. These measures are planned in particular in larger watercourses, such as the Danube and Main in Bavaria or the Rhine, Wupper and Ruhr in North Rhine-Westphalia, as well as for the Elbe in Hamburg and the Spree in Berlin.

Examples of current measures

Saar: Reducing heavy metal discharges

Saarstahl AG produces high-quality alloy steels at its Völklingen site using LD and electric arc furnace processes. In addition to steel, this process also generates various types of slag, which are subjected to initial pre-treatment (cooling with water) in an area separated from the sewage system. In the past, heavy rainfalls caused rainwater to flow unmanaged from this area into an area connected to the drain (direct discharge into the Saar), resulting in heavy metal inputs and pollution loads.

These loads were compounded by trucks leaving the plant. In order to avoid inputs into the Saar, different measures were taken:

Truck traffic

Introducing a one-way system ensured that all trucks must pass upgraded tyre washing facilities before leaving the site. In addition, the newly asphalted driveways and paved areas are cleaned by sweepers, depending on contamination levels.

Rainwater

For the purpose of reducing uncontrolled discharge of contaminated rainwater from the plant premises into the sewer, discharging such waters towards the collection basins was optimised based on a digital terrain model. Ditches and collecting basins were upgraded and rehabilitated and a hydraulic separation stage between plant premises and asphalted traffic areas was implemented by constructing a dam. In addition, the drain will be connected to the Völklingen sewage treatment plant in 2025. This package of measures is expected to significantly reduce inputs of heavy metals into the Saar.

Hydropower on the Rhine

6.1.6 Hydropower

Responsibility for implementing measures to reduce pressures on water bodies is with the operators of hydropower plants. Generally, permission for structural modifications to hydropower plants is only granted if these also include ecological improvement measures.

Measures at hydropower plants primarily concern restoration of the longitudinal continuity of water bodies and include fish ladders to ease migration upstream and downstream as well as fish protection facilities. If fish cannot overcome human-made obstacles, they can no longer reach much needed habitats such as refuges, spawning grounds and wintering grounds. Fish screens are designed to prevent fish from migrating downstream into hydropower turbines and possibly being injured or killed.

Mechanical fish protection systems such as these horizontal fish screens can now be installed and operated safely at hydropower plants with an average flow capacity of up to 50 cubic metres per second (corresponding to an installed output of up to one megawatt). This applies to 95 percent of all hydropower plants in Germany. At larger plants, more fish-friendly operating methods are available, at least for eels, where, for example, hydropower turbines are switched off or weirs are opened when eels set out on their long journey from the rivers into the Sargasso Sea.

Numerous measures are also planned to reduce peak flows that occur during hydropower plant operation, intended to avoid use-related flow variation and the associated hydraulic stress for water bodies and aquatic organisms as far as possible. This is achieved, for example, by widening the river profile in certain stretches.

In order to improve minimum flows in diversion stretches of hydropower plants, the Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) recommends a procedure that allows for technically deriving an ecologically sound minimum water flow (i.e., how much water must remain in the watercourse). The range of measures to be taken at hydropower plants also includes hydromorphological improvement measures to increase habitat diversity downstream.

Examples of current measures

Inn: Large-scale improvement of river and floodplain

Between 2017 and 2021, VERBUND Innwerk AG implemented various measures on the Inn (including at Ering) to improve water body and floodplain status.

Since construction of the Ering-Frauenstein power plant, the Lower Inn floodplains that had been diked previously were completely separated from the river (though not in case of extreme events). After re-connecting tributaries to the Inn, this separation was largely overcome, resulting in floodplain water levels fluctuating again dynamically by 0.8 metres. Due to a new bypass, migration of fish into the floodplain is also now possible on a permanent basis, offering fish fauna valuable water habitats such as gravel spawning grounds and habitats for juvenile fish.

Over a total length of about 2.6 km, the bypass enables fish to overcome a difference in levels of about 10 metres between power plant headwater and tailwater. Besides ensuring river continuity and passability for fish the entire bypass comprises elements typical of watercourses, such as fords, gravel banks, shallow water zones, deadwood and bays, which are valuable key habitats, in particular for current-loving fish species, so that some find all their habitat requirements fulfilled between the two barrages over their entire life cycle.

Furthermore, a system of tributaries and small islands was established on about 30 hectares, involving in part clearing a bank of the Inn of boulders over a length of 2.5 km and creating large areas of gravel banks and small bays, which various fish species use as spawning grounds and habitats for juvenile fish.

These measures, whose aim was to enable fish to migrate unhindered and to significantly contribute to preserving endangered fish population, cost more than 11 million euros. Planning for this complex of measures included integrating Natura 2000 objectives, which also comprise terrestrial aspects for gravel bank flora and fauna, dynamic floodplain development with crude-soil sites and potential dynamic processes. Hydropower operators and the Free State of Bavaria cooperate in this and support all measures through research projects in order to be able to document the impact of measures on water bodies and floodplains. Monitoring is key to this programme in order for future measures to be tailored optimally to restored and habitat-improved river stretches.

Worth seeing
Video clip on restoring the Inn
https://www.youtube.com/watch?v=-4JwMMIjm4TM

Larger gravel island and newly connected tributary in a restored Inn river stretch directly downstream of a hydropower barrag

Aerial view of the Öblitz hydropower plant when under construction (one can see three turbine channels and the fish ladder to the right)

Saale: Fish protection at the Öblitz hydropower plant
Demanding fish species such as salmon are to be reintroduced in many river basins such as the Saale and its tributaries.

Salmon not only need good water quality and structurally-rich habitats, but also unobstructed migration routes from the sea to their spawning grounds in the low mountain ranges where they lay their eggs, young salmon grow up and young fish – called smolts – start their return journey to the sea. To ensure they survive this long journey unharmed, they must be protected, especially from hydropower turbines.

A prime example of fish protection is the Öblitz hydropower plant on the Saale, fitted with three dive turbines, an average flow of 48 cubic metres per second and with a total capacity of 900 kW. Smolts and other fish species are protected from the turbine by a screen made up of metal bars with 10 mm bar spacing, making it impassable for fish, which drift along the screen to a bypass through which they can continue their journey unharmed.

This screen and bypass system (by EBEL, GLUCH & KEHL) is exemplary of effective fish protection and fish migration at hydropower plants and can be used in a wide range of hydropower plants, depending on flow capacity and screen arrangement, hence, in principle, in more than 80 percent of German plants.

6.1.7 Shipping

A large number of measures are carried out on federal waterways without affecting navigation such as hydromorphology improvement, continuity restoration and conceptual measures.

As regards Water Framework Directive objectives, responsibility for restoring continuity at transverse structures in federal waterways and for water resource maintenance is with the WSV (the owner of the waterways), and, since June 2021, also for upgrading measures on federal waterways needed to achieve Water Framework Directive objectives (following an amendment of the relevant legislation, i.e., the Bundeswasserstraßengesetz). In addition to ecologically reoriented maintenance planning, sovereign obligations include water resource development measures that also can significantly contribute to achieving Water Framework Directive goals on federal waterways.

Based on this framework, the WSV can also plan and implement restoration measures in the future – for example as part of the Blaues Band federal programme – and thus contribute to improving ecological status. This programme, adopted in 2017, is a joint initiative of the Ministry of the Environment and the Ministry of Transport, aimed at creating a biotope network of national scope and giving waterways a new development perspective through restoration measures. In order to ensure that restoration measures on federal waterways and their floodplains result in long-term ecological status improvement, the manifold water uses and interests are taken into account and restoration measures are coordinated, such as reintegrating oxbows, dismantling or replacing massive bank revetments by more natural bank protections (plants, wood) or ecologically oriented reshaping of stream and regulating structures. These processes provide various ways of aligning shipping and environmental requirements.

In addition, synergies between Blaues Band measures and Water Framework Directive implementation on federal waterways can be used for water protection.

At the regional level, a joint concept is being implemented for the Elbe that allows for harmonisation of ecologically oriented transport needs and water management challenges of conserving valuable natural areas. On the Lahn, the LIFE-IP project LiLa – Living Lahn combines measures aimed at environmental protection, nature conservation, flood protection and tourism, making it possible to bring together land and water users, associations and local citizens in jointly shaping the future of the Lahn federal waterway. Project measures are primarily intended for ecological upgrading of the Lahn environment.

Restoring water body continuity is of particular importance with a focus on building fishways for migration.

At the national level, the Federal Transport Ministry is implementing a nationwide prioritisation approach for restoring ecological continuity of federal waterways.

Other direct effects of shipping traffic on water body status resulting from pressures such as load residues or sewage are governed by international treaties such as the Convention on the Collection, Discharge and Reception of Waste arising from Navigation on the Rhine and Inland Navigation (CDNI).

Examples of current measures

Pilot project "Blaues Band Germany-pilot project Kühkopf-Knoblochsaue at the Rhine".
This is a floodplain project in the Darmstadt region and one of five pilot projects on the Rhine and Weser within the Blaues Band framework, with a focus on implementing local restoration measures on busy waterways. They are supposed not only to improve federal waterways' morphology, but are also intended as ecological stepping stones for the planned biotope network of national importance.

In the Kühkopf-Knoblochsaue region, near-natural river banks are being protected as typical habitats to integrate water bodies and floodplains. To serve this purpose, on a two-and-a-half-kilometre stretch of the Rhine, rock armour on banks were removed in 2019 and 2020 and, in certain places, replaced

A bank section from which all rocks that had formerly served protection purposes and were no longer needed were removed. An ecologically valuable terrace has formed.

Renaturalised shallow bank section at the Kühkopf-Knoblochsaue on the Rhine.

by nature-based solutions such as native willows as bank revetments. Allowing for natural bank-forming processes and structures significantly contributes to the Rhine's structural diversity. Deadwood close to the banks provides additional habitats for alluvial and riparian animal and plant species and thus supports biodiversity.

Worth seeing
How to implement near-natural bank revetments on the Rhine (9 min.)
https://www.youtube.com/watch?v=k-cF2QFKP0So

The project is implemented by the competent authority (Wasserstraßen- und Schifffahrtsamt Oberrhein) in collaboration with the Darmstadt regional administrative government (Regierungspräsidium Darmstadt) and monitored by the Federal Institute of Hydrology (BfG) and the Federal Waterways Engineering and Research Institute (BAW). In September 2020, this pilot project was honoured by the United Nations as a project of the UN Decade on Biodiversity.

Mühlberg pilot project
Mühlberger Hafen in the state of Brandenburg is a pilot project initiated by the WSV and the federal states waterways and shipping administrations to link preventive removal of polluted sediments in the Elbe with upcoming dredging measures serving navigation based on a comprehensive sediment management strategy in the Elbe river basin.

Since August 2021, around 21,000 cubic metres of sediment have been removed from Mühlberg harbour (equivalent to around 300 shipping containers). Effects of sediment removal on water quality and suspended sediment loads are being studied and monitored by the Federal Institute of Hydrology with support from the WSV and the state of Saxony.

Such projects foster synergies between the federal government (tasked with maintaining federal waterways) and the federal states (being responsible for water quality), and thus significantly contribute to jointly implement the Water Framework Directive.

6.2 Funding measures

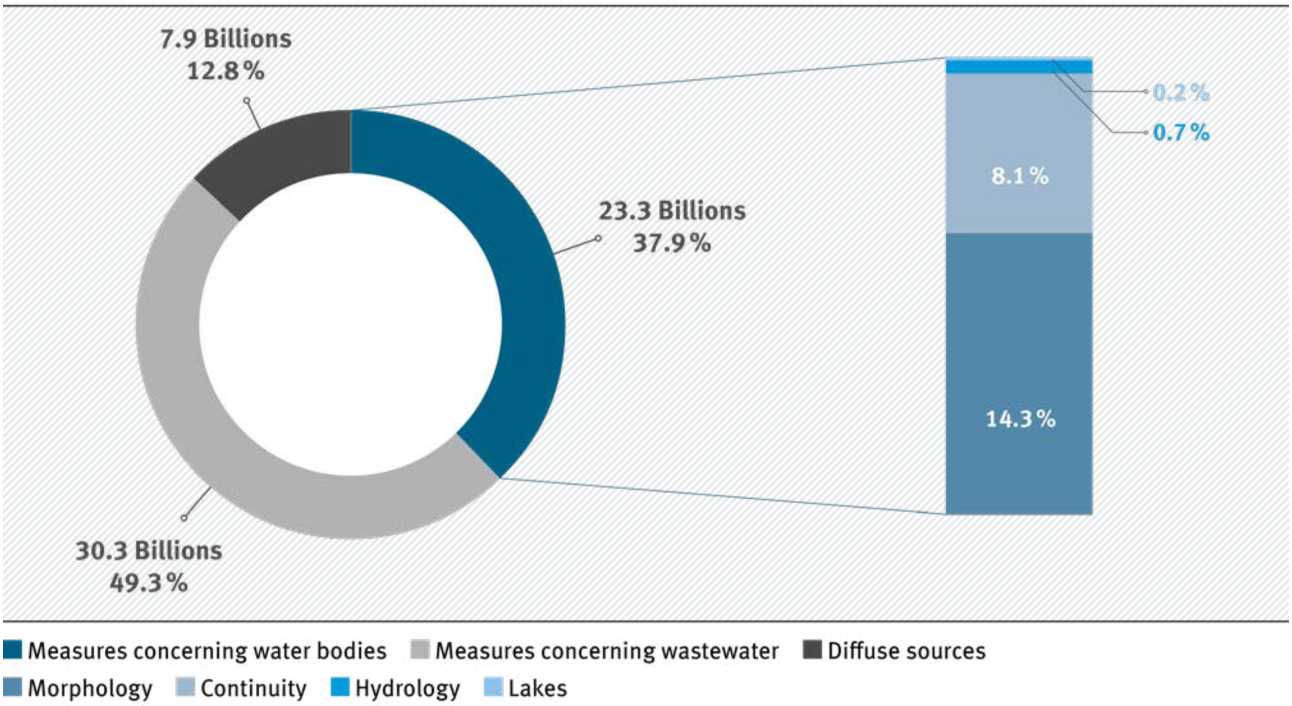
Costs of activities

Total investment costs for implementing all Water Framework Directive measures in Germany already carried out and those planned up to 2027 and beyond are currently estimated at around 61.5 billion euros, of which around 21 billion euros are budgeted for the third management period (2022 to 2027). The budget for the previous management period (2016 to 2021) was 15 billion euros. By way of comparison, in 2013 alone around 19.2 billion euros were spent on roads (about 230 euros per capita). In contrast, water protection costs are six times lower and amount to an average of about 37 euros in fees and taxes per year per capita.

Investments for Water Framework Directive implementation in three fields of action and according to management planning were estimated over the 2010 to 2027 period (Figure 20), with almost 50 percent of investments being made for measures in the field of sewage disposal (30.3 billion euros) and 38 percent for measures to establish continuity and to improve morphology and hydrological regime (23.3 billion euros); 13 percent will be devoted to reducing substance inputs from diffuse sources (7.9 billion euros). Within this framework, most of the funds are earmarked for improving hydromorphology, followed by measures for restoring continuity. In contrast, little is spent on measures to improve hydrological regimes and on standing waters.

Figure 20

Costs of implementing measures and percentages broken down by fields of action 2010 to 2027



Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 29.03.2022
Editing: Umweltbundesamt, Bund / Länder-Arbeitsgemeinschaft Wasser (LAWA)

Funding measures and instruments

More than 80 percent of implementation costs are borne by the federal states and municipalities, less than 5 percent by the federal government and about 10 percent by private sector actors.

Federal states and municipalities fund a large proportion of measures from taxes, fees and duties.

- Under Water Framework Directive principles, construction, maintenance and operating costs for water supply and sewage treatment facilities must be covered by prices and fees paid by citizens, amounting to about 200 euros per year and capita for drinking water supply and wastewater disposal, which is about five times more than the investments in water protection (i.e., 37 euros as mentioned above).

- All German company and municipal treatment plants that discharge sewage into water bodies are required to pay sewage fees. Municipalities that have wastewater treated and disposed of via municipal wastewater treatment plants pass on sewage fee costs to the citizens via fees for wastewater disposal.

- Most federal states levy a charge for abstracting groundwater or surface water (called a water abstraction charge) that the parties that abstract water are subject to, – and in the case of public water supply, this means water utilities. They, too, pass on the costs to their customers.

- When setting water prices, environmental and resource costs are also taken into account, including charges for excessive pollution or abstraction. Environmental and resource costs are charged via nationwide sewage fees and water abstraction charges (introduced in 13 federal states).

Besides cost recovery, water pricing policies should provide adequate incentives for efficient and sustainable water resource use.

In addition to the **federal states**, the government also takes measures to achieve Water Framework Directive management objectives through measures such as water resource development and expansion on federal waterways, through implementing the Blaues Band Germany federal programme, restoring ecological continuity on federal waterways or financing by funds from the Joint Task for Agricultural Structures and Coastal Protection (GAK).

- Additional expenditure for maintaining federal waterways – taking into account water management concerns – amounts to approx. 9 million euros per year.

- Costs of water resources development measures on federal waterways to achieve Water Framework Directive objectives were estimated at approx. 60 million euros per year up to 2027, assuming, however, that implementation will not be completed before 2050.

- The Federal Ministry of Transport had originally earmarked about 50 million euros per year for restoring rivers as part of the Blaues Band programme.

  However, as these measures overlap to a large extent in content and spatial scope with the planned water resources development measures on federal waterways, this amount will be reduced accordingly. Another 12–15 million euros per year are to be used by the Federal Ministry for the Environment for purchasing and restoring land in floodplains within the Blaues Band programme.

- Between 2016 to 2019, around 850,000 to 2.5 million euros were spent annually on restoring ecological continuity.

View of the Kühkopf-Knoblochsaue

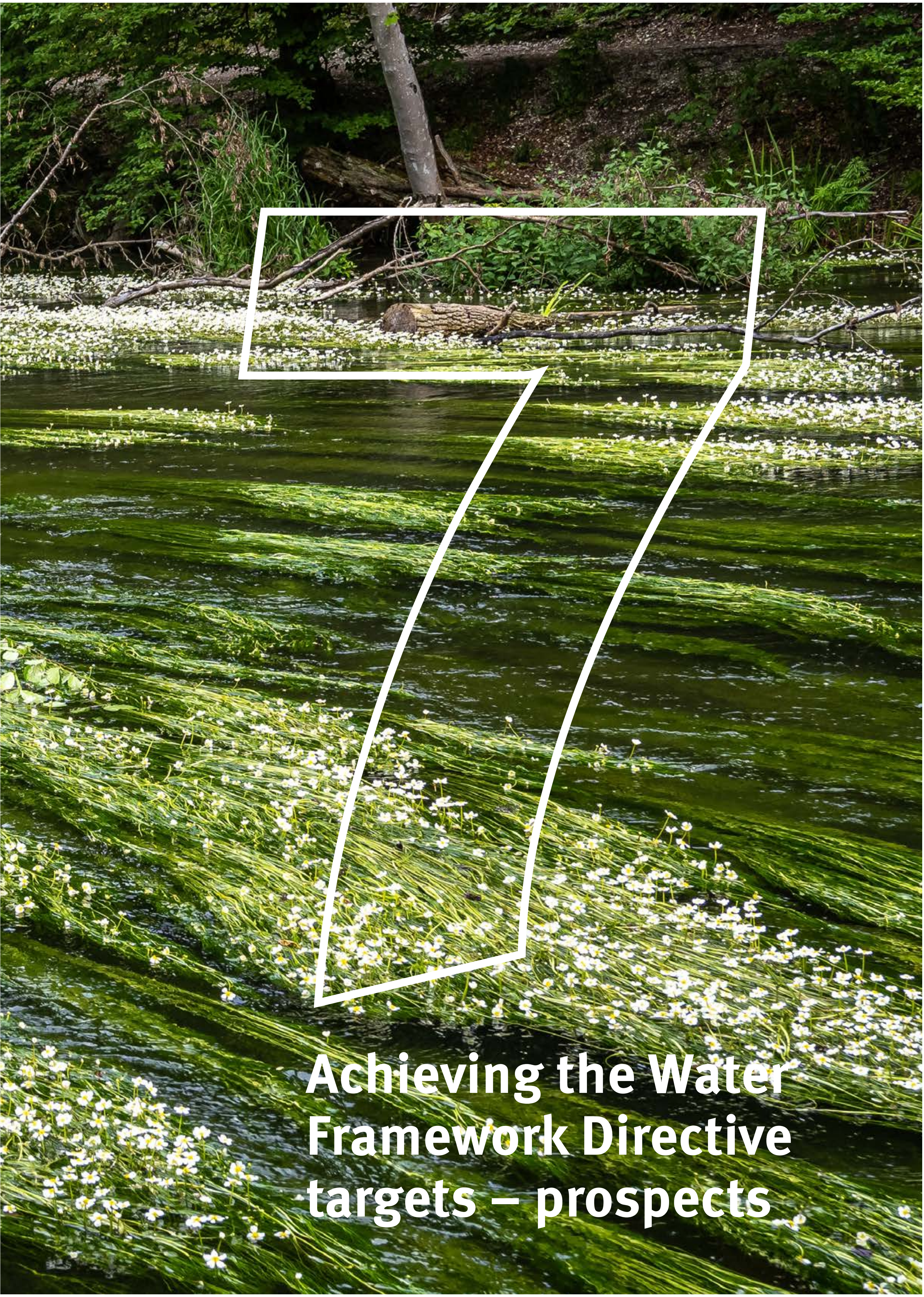
Private parties are obliged to reduce water pollution they have caused and must bear the costs in accordance with the polluter pays principle, which is a cornerstone of EU environmental policy: If you pollute the environment, you have to pay. The general public is only called upon to pay in such cases if the polluter is unavailable or unknown, or where passing on the costs to the polluters would involve disproportionate effort.

At **EU level**, European funds such as the European Agricultural Fund for Rural Development (EAFRD) or the European Regional Development Fund (ERDF) can be used by the federal states to implement and finance Water Framework Directive measures, which also implement the EAFRD Regulation through specific rural development programmes to support EAFRD measures. These EU funds must be co-financed from national funds by the federal government, federal states and municipalities.

The next funding period of the common agricultural policy is expected to begin in 2023 (including EAFRD) with the EU Commission’s guidelines giving member states considerable leeway in shaping their national agricultural policy. The ways in which this leeway is used must be set out in national strategy plans and approved by the EU Commission.


Swamp forest


River water-crowfoot



7

Achieving the Water Framework Directive targets – prospects

7 Achieving the Water Framework Directive targets – prospects

Although thousands of measures have been implemented in recent years, they have not yet resulted in a nationwide achievement of the Water Framework Directive objectives. However, rivers and lakes and especially fish fauna, benthic invertebrates and phytoplankton exhibit improvements of ecological status – a success that should not be disregarded but acknowledged. We are on track, but more time and further measures on a large scale are needed.

Speed and scope of implementing measures are crucial for achieving Water Framework Directive objectives. Lessons learned in the past show that good status cannot be reached for many surface waters and groundwater bodies in a short time. In addition, measures do not have as rapid impact on water ecology as expected. It can take many years in some cases before measures have a positive effect in this regard.

The Water Framework Directive allows Member States to extend the deadline for achieving its objectives, to set less stringent management objectives and to allow temporary or permanent deterioration. These deadline extensions and exemptions may only be invoked if stringent requirements are met and after all feasible measures have been planned. They must also be clearly documented in the relevant management plans.

If management objectives have not yet been achieved, priority is given to deadline extensions and only in exceptional cases are less stringent targets set or exceptions (as to temporary deterioration) made use of. Our ambition is still to achieve good status.

Reasons for extensions

Failure to achieve Water Framework Directive objectives is mainly attributable to hydromorphological alterations (and the accompanying lack of habitats) as well as excessive river nutrient and pollutant loads.

These and other pressures usually occur simultaneously in a water body, which is why individual measures to improve water body status are often not effective. Rather, different and sometimes complex combinations of measures are necessary to achieve measurable improvements in status or potential and measures often must also be carried out via a mandatory order.

Implementing Water Framework Directive measures requires sufficient financial and human resources. It may become necessary to extend financing over a longer period in order to not overburden the public or private party concerned. In general, budgets in the order of billions must be earmarked for the measures that are still required and the funds available should be used in a more targeted manner in the future. In addition, the lack of staff in public administration should be remedied.

A further problem is posed by the lack of land available for river development, for the following reasons. Often privately-owned land adjacent to rivers cannot be purchased. In addition, land consolidation (i.e., reallocating publicly owned land) can take a long time and is not easy to handle in practice. Or, financial support notwithstanding, many land owners and relevant parties are often not willing to implement Water Framework Directive measures. Remedying this state of affairs requires proactive advocacy on the ground.

Numerous measures are subject to complex administrative procedures. In addition, many organisations that plan and implement measures lack the experts required, resulting in delays in implementing measures. For example, more than half of the measures envisaged for the second management period to improve morphology, continuity and hydrological regimes have not yet been started. This is why a great number of measures are now again part of programmes in the third period.

Taking into account that pressures on groundwater and surface waters resulted from centuries-long uses, implementing all measures necessary to improve water body status will not be completed by 2027.

Holnis in Schleswig-Holstein

That said, major effort is being made to bring as many water bodies as possible to good status by the end of 2027, or at least to implement as many measures as possible by then and, if necessary, to continue implementation consistently beyond that date.

After completion of implementation, improvements in water bodies are not always immediately quantifiable, because it often takes time before measures take effect due to natural conditions in catchments and natural processes. For example, major floods are essential for a diverse hydromorphology to form, though they do not occur regularly. Rather, in lowland watercourses, high structural diversity and thus diverse habitats depend more on whether shrubs and trees grow on the banks, which is often not the case in regions with intensive farming, for example. It takes up to 20 years for trees and shrubs to grow up on banks, as with black alders, for example, that at the age of 20 years reach just half of their adult height. Sufficient vegetation to give shade to water bodies thus emerges slowly and can have a positive effect on water temperature regulation and thus on aquatic organisms only after several years.

Water management experts and scientists reckon that the desired ecological effect of fully implemented measures will only unfold in rivers and coastal waters after 10 to 20 years, and in lakes after 10 to 50 years, with this estimate being subject to uncertainties, however. The potential of recolonisation with aquatic organisms, the occurrence of alien species and climate change as well as many other factors play essential roles in determining how long it will take to restore a water body to a near-natural state.

In sum, natural conditions are most often the major reason why deadline extensions are employed before management objectives can be achieved. Such exemptions have been invoked for rivers (76 %), for lakes (69 %) and for transitional and coastal waters (100 percent). Insofar as even extensions do not result in achievement of management objectives by 2027, although all necessary measures have been taken, further extensions can be made use of beyond 2027.

There are, however, even more reasons why water bodies will not achieve good status in 2027, including technical infeasibility, disproportionate effort or lack of human and/or financial resources to implement all necessary measures by 2027. The large number of measures required and the multiple pressures on water bodies can also result in failure to meet the ambitious Water Framework Directive objectives within the 2027 deadline.

For these water bodies, the Water Framework Directive does not provide a feasible solution after 2027 because upon Water Framework Directive adoption 20 years ago, practical implementation problems were neither apparent as such nor to their entire extent. However, the ambition to achieve the aims set by the Water Framework Directive undiminished in these water bodies should be preserved, requiring, however, more time beyond 2027.

7.1 Trends in ecological status and potential of surface waters

For several reasons, current status assessment results can only be compared with reporting year 2015. In reporting year 2009, not all assessment procedures had been developed and agreed upon between the EU Member States, there were also amendments in water body designation in the following years.

In a synthesis of all assessments for all natural, heavily modified and artificial surface water bodies of rivers, lakes, transitional and coastal waters, a slightly positive trend emerges as compared to 2015 (Figure 21). The proportion of water bodies in good ecological status or with good ecological potential has increased by 1.1 percent. In roughly the same proportion, water bodies previously assessed as bad have decreased and are now assessed as moderate and poor.

Status or potential comprises assessments of several elements (see Chapter 5.1.1), which, when we look more closely, provide a more conclusive picture of the trends in water body status and potential (Figure 22).

Examining the ecological status and ecological potential of all surface waters separately, it becomes apparent that the ecological status has improved more significantly, with an increase of 2.8 percent in good assessments. On the other hand, trends in ecological potential of heavily modified and artificial water bodies have been rather negative. This is true for almost all water body categories and biological elements assessed (Chapter 5.1.1).

In natural rivers, 13 percent of water bodies now achieve good ecological status, corresponding to an increase of almost three percent over the last six years. Encouragingly, "bad" and "poor" ratings have decreased by more than 2 percent during this period. These positive trends mainly reflect benthic

Figure 21

Ecological status and potential assessments of surface waters and changes between 2015 and 2021

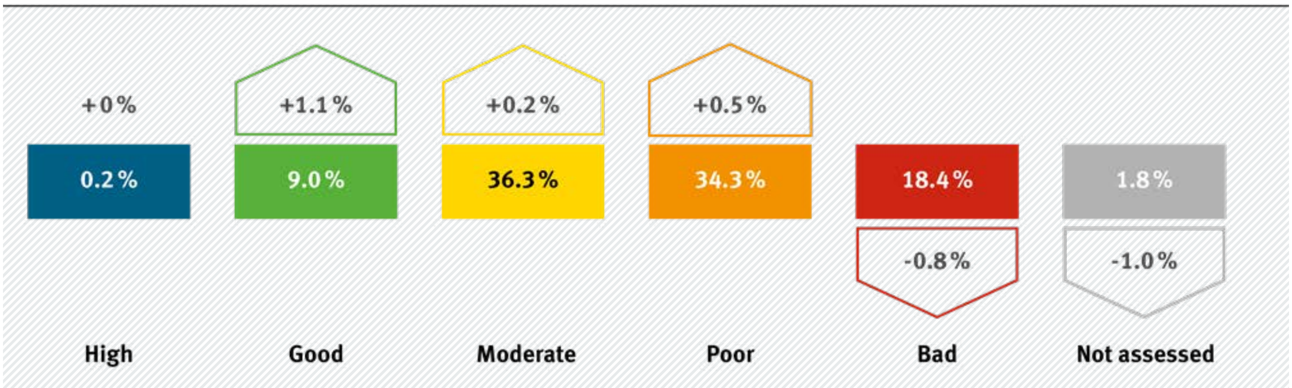


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Figure 22

Changes in ecological status and potential assessments related to water body categories and biological elements between 2015 and 2021

Technical data: WasserBLIcK/BfG & responsible agencies of the federal states, 23.03.2016 and 29.03.2022.
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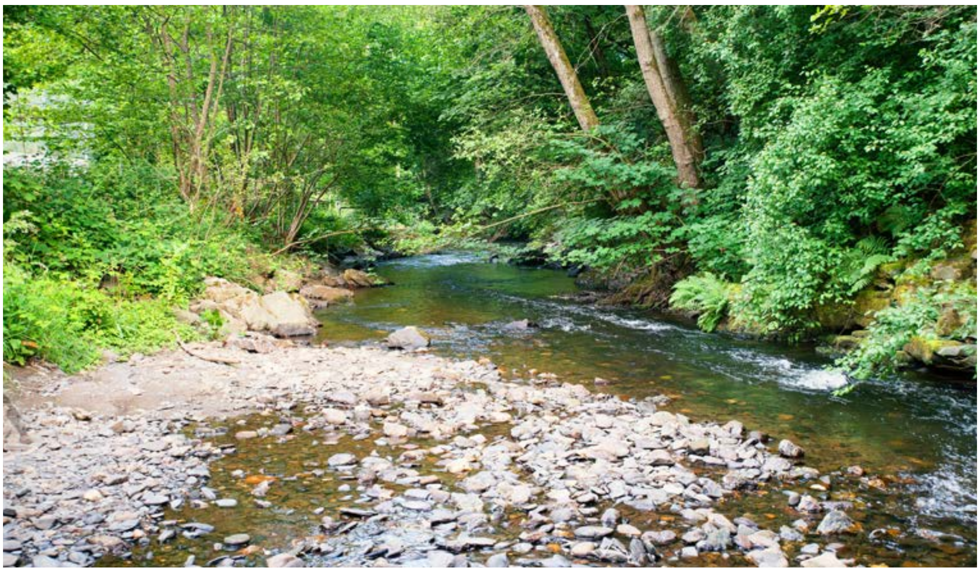
invertebrate development, which today is assessed as "high" to "good" in more than 40 percent of water bodies, a proportion that has increased by more than six percent compared to 2015. Assessments of fish fauna show the same trend that more than 20 percent of the river or stream stretches currently achieve good or even high ecological status (about 1 percent more than in 2016).

The ecological status of lakes has also improved, with a plus of almost three percent that now achieve good and high status as compared to 2015. This is mainly due to the improved status of phytoplankton, 45 percent of which now achieve high or good status (a plus of almost 10 percent as compared to 2015). Benthic invertebrate assessment has also improved by three percent.

In heavily modified and artificial water bodies (lakes), however, good and high potential of phytoplankton (for example, green algae) in heavily modified and artificial lakes has declined considerably in the same period, possibly also due to new assessment procedures for ecological potential.

In Germany, there are only five transitional waters (Chapter 3.1), all of which are designated as heavily modified. None of them currently achieve good ecological potential, as was the case in 2015. In addition, there is a negative trend from moderate to poor, with only benthic invertebrates showing a positive trend.

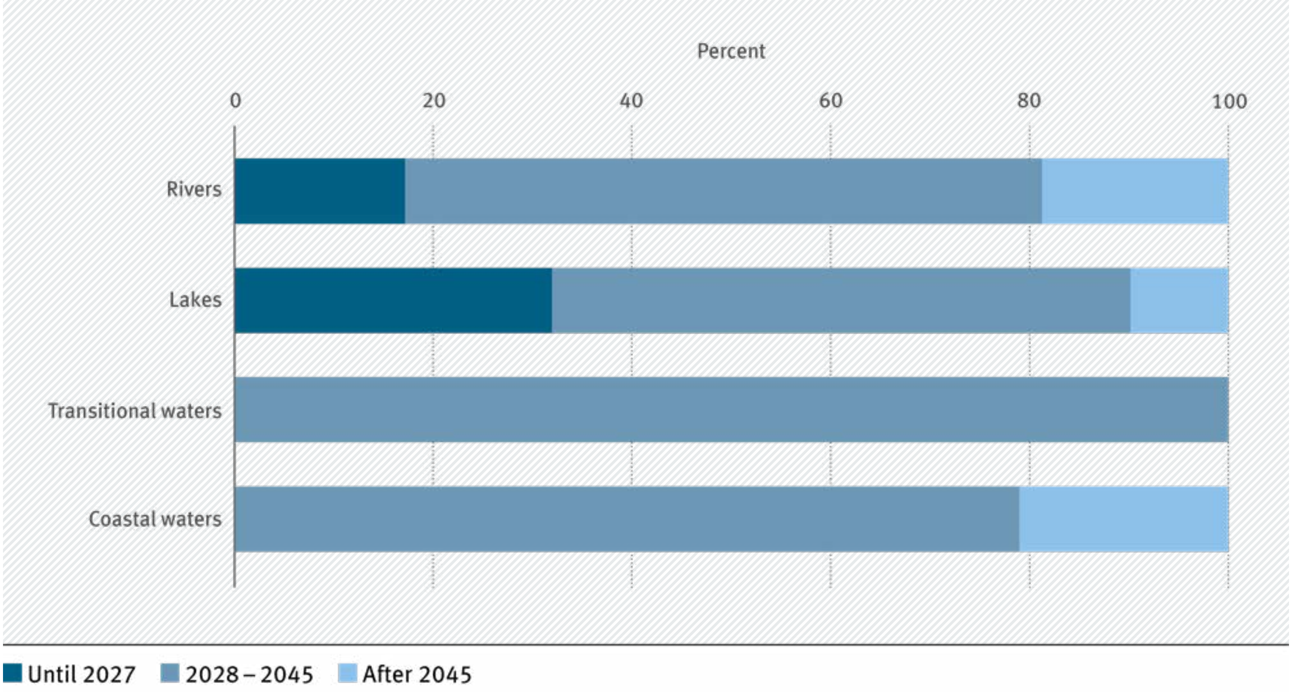
None of the coastal waters has yet achieved good ecological status or potential, with a slight decrease, however, in "bad" ratings, towards moderate status and potential, resulting from improved benthic invertebrates and phytoplankton. In 23 percent of the coastal waters, benthic invertebrates currently achieve good to high status (phytoplankton in 20 percent), equivalent to improvements in one to about seven percent of water bodies (Figure 22).



The Ruwer in the Moselle Valley

Figure 23

Target achievement in ecological status and potential in four categories of waters



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Exemptions and achievement of objectives

Insofar as Water Framework Directive management objectives should have been achieved in 2015, 90 percent of the deadline extensions are currently being invoked in surface waters to achieve good ecological status and potential. By 2027, 17 percent of the management objectives in rivers and 32 percent in lakes are expected to be achieved, with further delays in achievement of targets chiefly due to natural conditions. It is anticipated that in 2045 this rate will be between 79 and 100 percent, depending on water body category (Figure 23).

The objective "less stringent management objectives" was set for only 76 river water bodies, because the applicable environmental quality standards cannot be achieved, not even through remedial action. This mainly concerns water bodies in old mining areas, such as in the Harz or the Eifel, with exceedances for cadmium but also other elevated heavy metal concentrations. Salt inputs from the potash industry (river Werra) or discharging pit water from opencast lignite mining (river Erft) also result in invoking less stringent management objectives. Less stringent targets have not been set for lakes, transitional and coastal waters.

"Temporary deterioration" of ecological status or potential is currently only justified in nine river stretches. Exceptions from the prohibition of deterioration were permitted for one lake and four river water bodies. It is possible that the flood disaster of July 2021 will result in further exceptions.

7.2 Trends in surface water chemical status

For the period 2015 to 2021, environmental quality standards for some substances were amended, in addition 12 new substances were regulated, which is the reason why trends in chemical status can only be determined based on those substances whose environmental quality standard has remained unchanged since the last management period (in total 31 substances). Figure 24: results for 2015 and 2021 Once again, ubiquitous substances were not included.

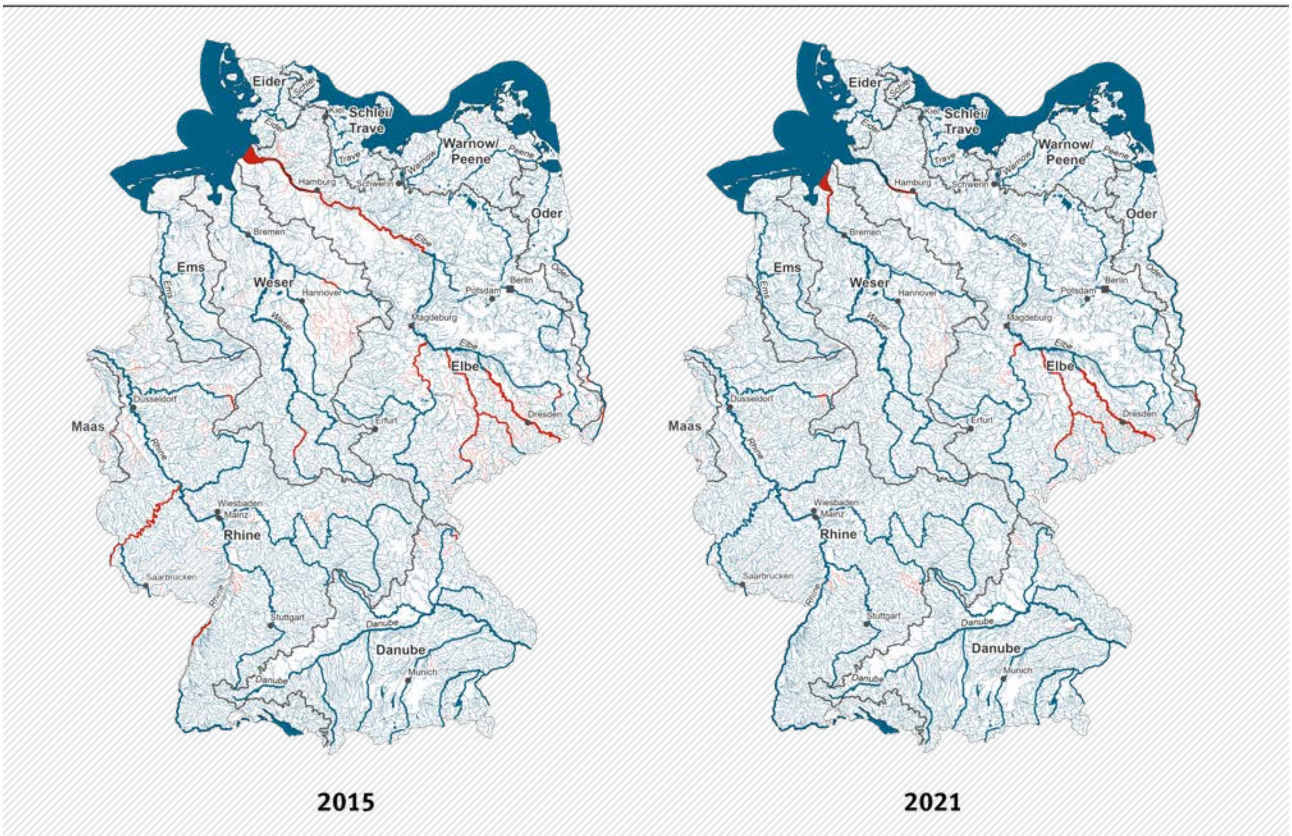
Comparing 2015 and 2021, there are clear improvements in the classification of these 31 substances, for example in the Elbe, Moselle and Rhine. In 2015, 11 percent of approximately 5,000 chemical water monitoring sites recorded exceedances, and in 2021 only five percent.

Exemptions and achievement of objectives

Insofar as Water Framework Directive management objectives were already to be achieved in 2015, 100 percent of the extensions for good chemical status are currently being used, because environmental quality standards for mercury and certain flame retardants have been exceeded across the board.

Figure 24

Comparison of surface water chemical status for 31 priority substances between 2015 and 2021



■ Environmental quality standard not exceeded ■ Environmental quality standard exceeded

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By 2027, 4 percent target achievement in rivers is expected. Due to natural conditions, achievement of good chemical status will be quite delayed (Figure 25).

7.3 Trends in groundwater status

In contrast to surface waters, there have been no significant amendments to assessment methods used to survey groundwater quantitative and chemical status as compared to the first management period (2009–2015), which allows for directly comparing the results of all three management cycles. This assessment shows that although neither the quantitative nor the chemical status of groundwater has improved significantly, though it has also not significantly deteriorated.

Groundwater chemical status in 2009, 2015 and 2021 does not differ significantly (Figure 26). Compared to 2015, groundwater chemical status has improved. In 2015 only 64 percent of groundwater bodies had good chemical status, and 67 percent in 2021, chiefly due to diffuse nutrient inputs from intensive farming. These are the main cause of high nitrate levels in groundwater, especially in regions with many livestock and consequently large amounts of manure and slurry.

That being said, there are also improvements because, overall, nitrate pollution has decreased. In 2015, around 27 percent of groundwater bodies showed poor chemical status due to nitrate, whereas this proportion could be reduced to 22 percent in 2021.

Figure 25

Achievement of chemical status targets in four categories of waters

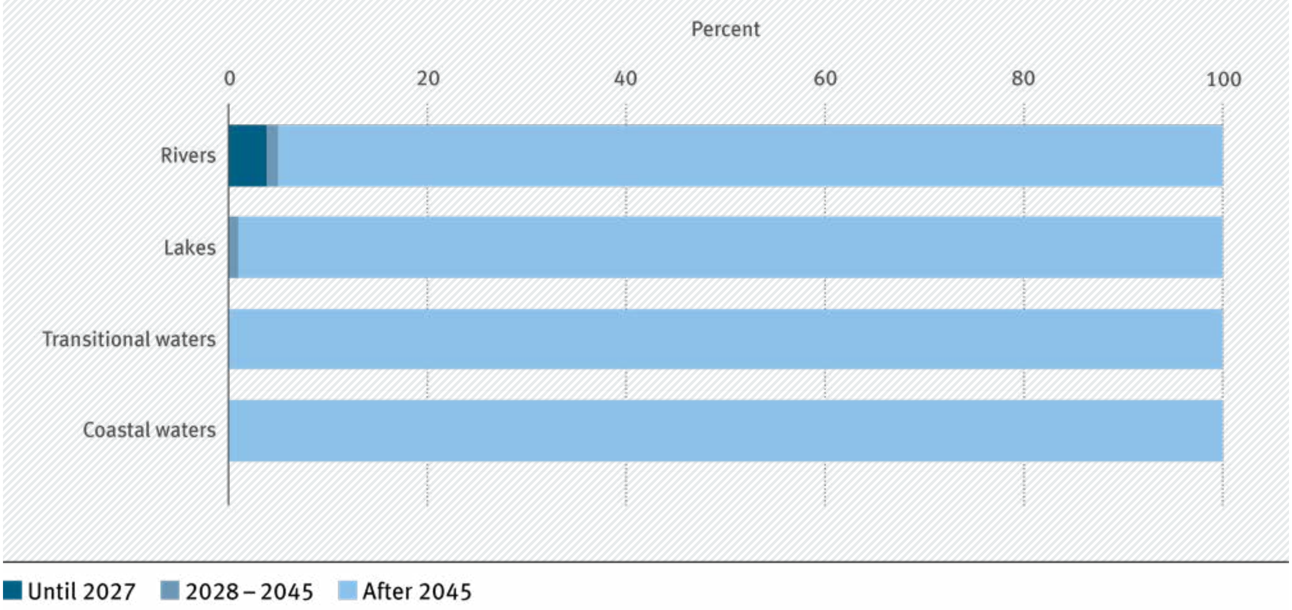

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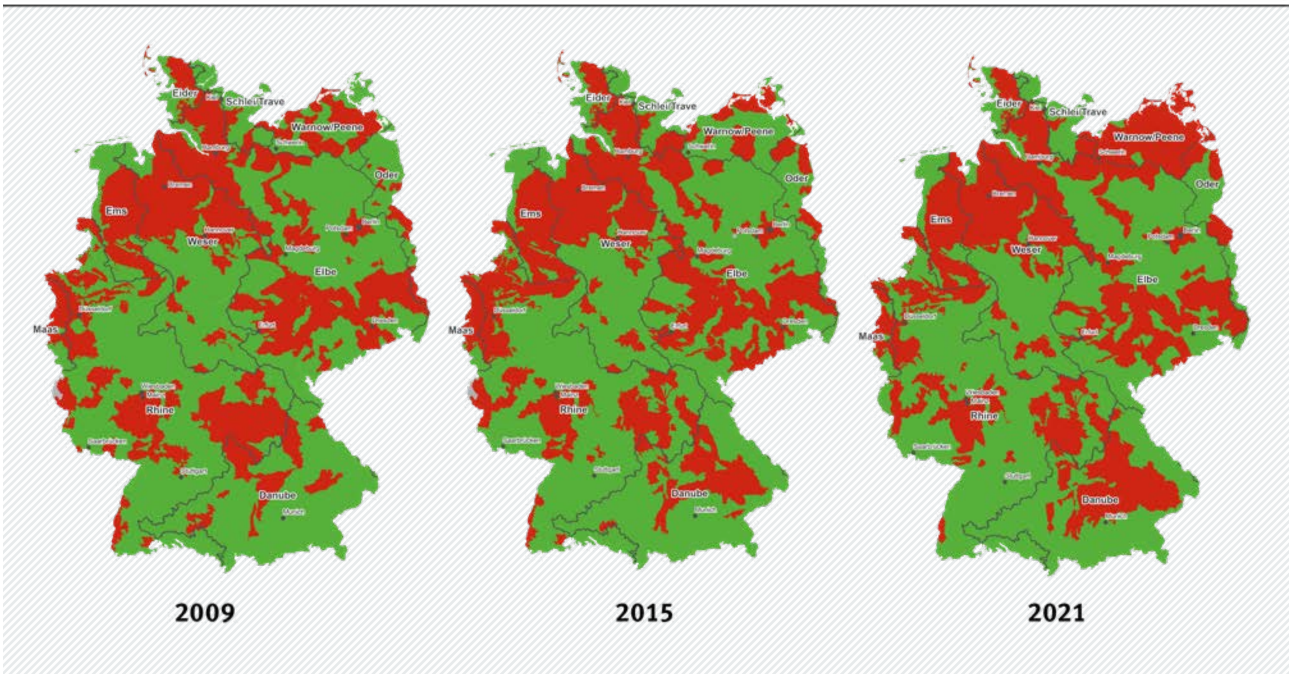
Figure 26

Comparison of groundwater chemical status 2009, 2015 and 2021



Good Poor Not assessed

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The fact that groundwater body pressures did not change significantly between 2015 and 2021 is also attributable to (a) the lengthy retention time of water in the soil and its slow percolation rate into groundwater and (b) slow or lacking underground breakdown processes. As a result of these factors, the effects of groundwater quality improvement measures do not materialise for quite some time and the pressures are not immediately visible because, under certain circumstances, the causes of groundwater pollution date back decades.

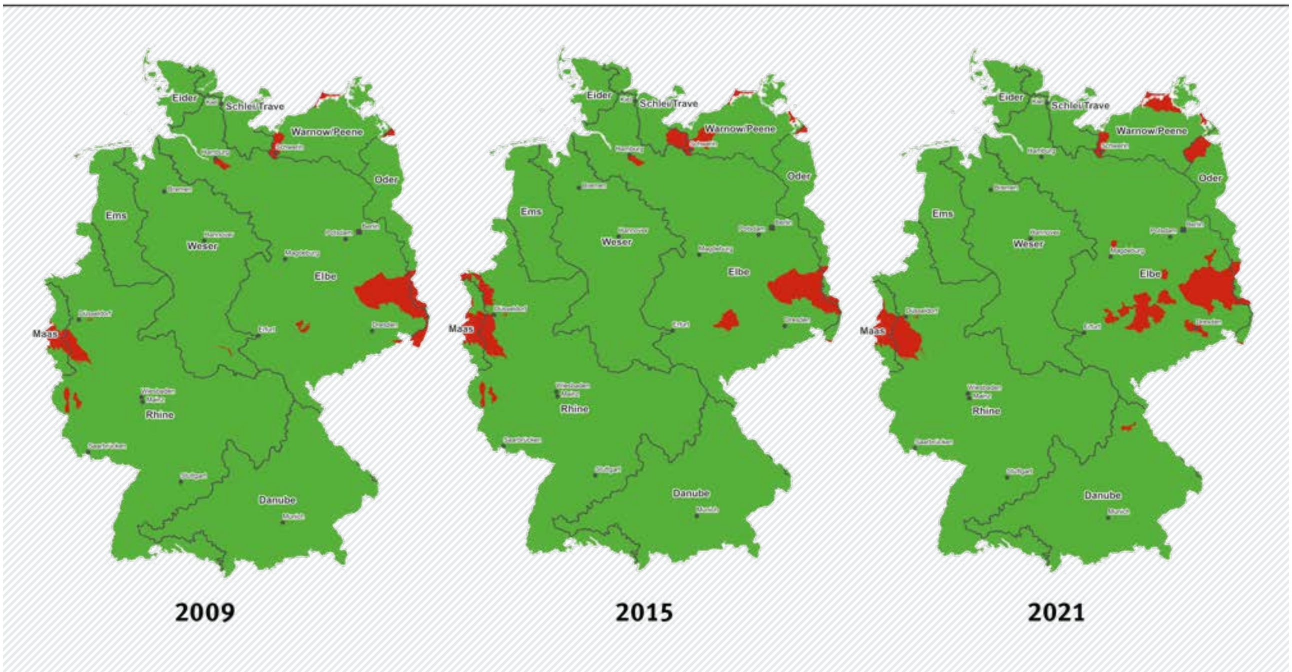
As regards quantitative status, 95 percent of all groundwater bodies currently have good status, meaning that their overall status has not changed fundamentally since the beginning of the first management period. Nevertheless, deterioration in groundwater levels is also evident at regional level (Figure 27). Groundwater bodies in poor quantitative status are mainly located in mining regions where groundwater levels have been or are still being lowered over larger areas, for example in Central Germany, Lusatia and the Rhineland. Another reason for poor quantitative groundwater status is that groundwater levels have dropped significantly in some regions due to lack of precipitation in recent years. As was already foreseeable early in the planning and implementation stages, it will take decades before these groundwater bodies can achieve good quantitative status again. For this reason, the federal states have initially set justifiable less stringent management objectives for these water bodies.

Exemptions and achievement of objectives

By 2027, 71 percent of groundwater bodies are expected to achieve "good chemical status" and 98 percent "good quantitative status", most likely with further delays in achievement of targets due to natural conditions. It is anticipated that in 2045 almost all groundwater bodies will no longer show any quantitative problems and 97 percent will no longer show any substance-related problems (Figure 28).

Figure 27

Comparison of groundwater quantitative status in 2009, 2015 and 2021



Good Poor Not assessed

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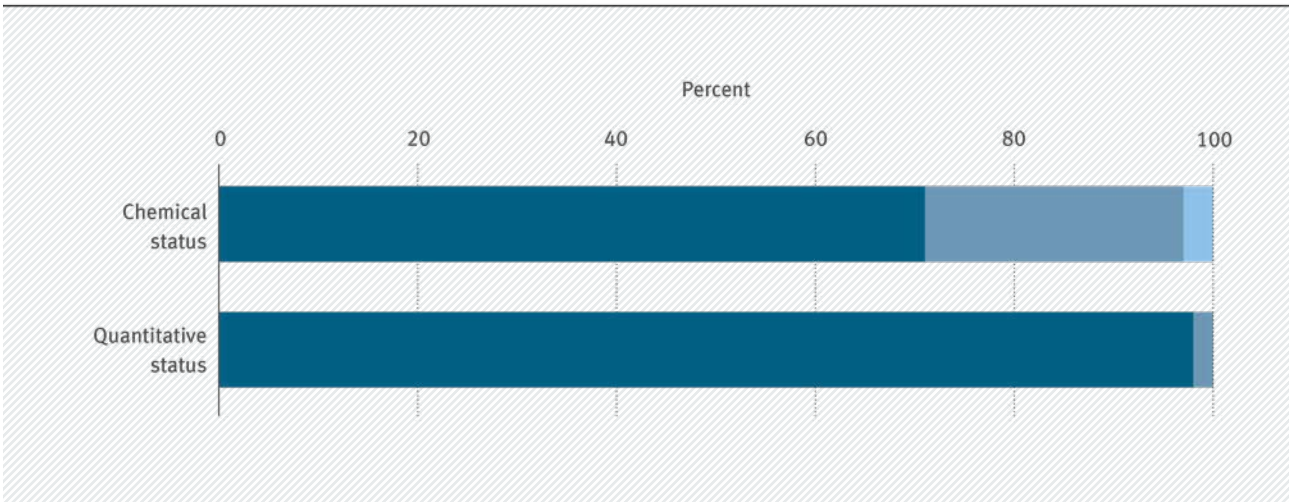
Less stringent management objectives were only allowed in 38 groundwater bodies and temporary deterioration of quantitative status due to mining activities (such as groundwater lowering for lignite and lime mining) was only permitted in 27 groundwater bodies. Permanent exemption from the ban on deterioration was not allowed.

Figure 28

Target achievement for groundwater chemical and quantitative status



Until 2027 2028 – 2045 After 2045

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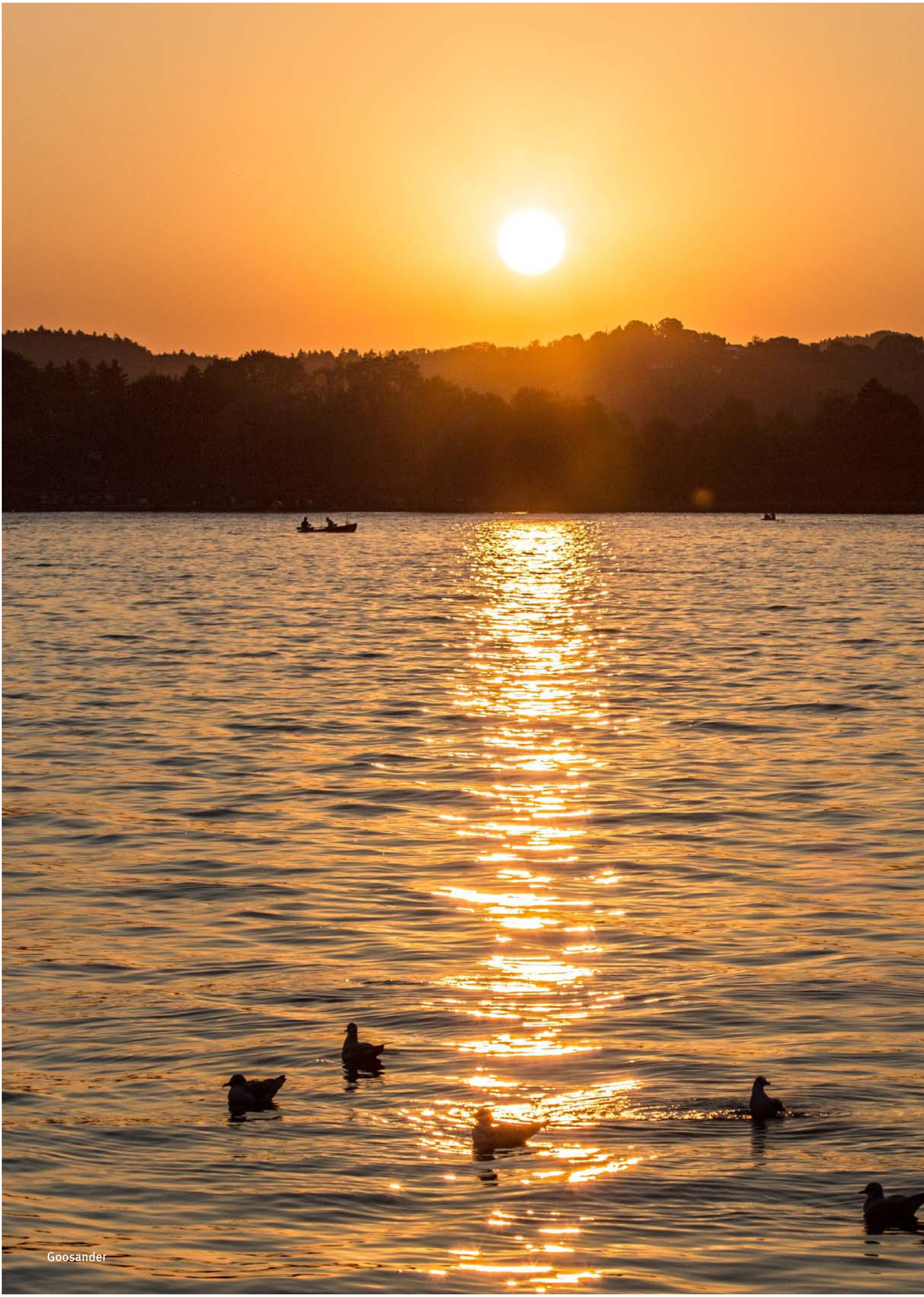

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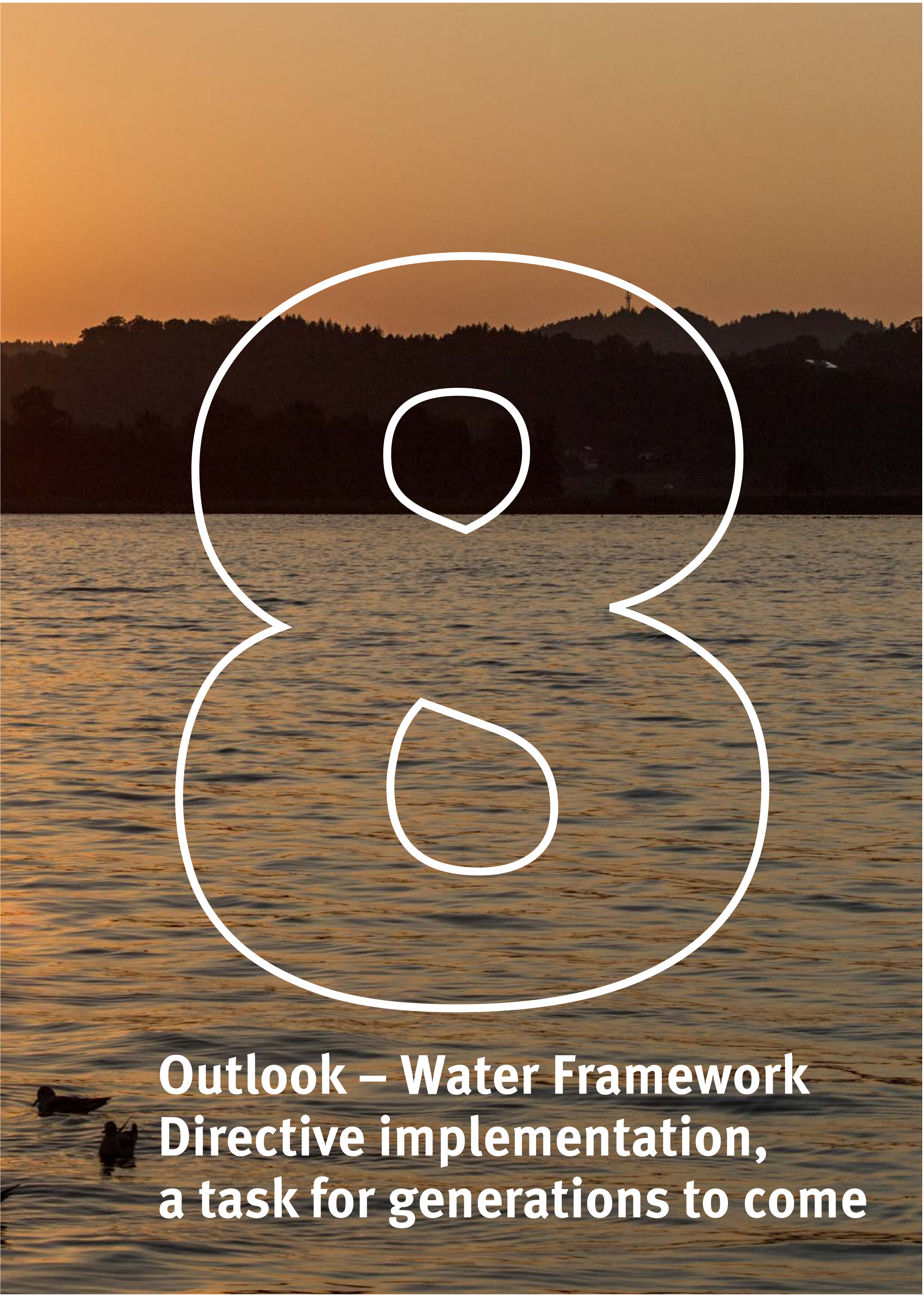

8 Outlook – Water Framework Directive implementation, a task for generations to come

8 Outlook – Water framework directive implementation, a task for generations to come

Water bodies – valuable ecosystems worth protecting

Surface waters and groundwater are resources of major importance for water supply, industry, commerce, cooling water for power plants and for irrigation in farming. Water is indispensable for human life. Water bodies are used for recreation and for transportation, they take up our wastewater and have always attracted centres of human settlement.

At the same time, water bodies are habitat to countless animals and plants, they are hotspots of biodiversity. Ecologically intact water bodies and floodplains retain water in soils and landscape, are carbon sinks and have a cooling effect, thus serving natural climate protection and adaptation to climate change. All of these benefits make water bodies valuable ecosystems that particularly merit protection.

Water protection under the Water Framework Directive focuses on comprehensive management of river basins. In this regard, Water Framework Directive environmental objectives and the relevant instruments have proven their worth, the major target being the achievement of “good status” for all water bodies.

This booklet describes the uses that constitute pressures on our waters and their impacts, both of which are so diverse that despite numerous measures already implemented, only just under 10 percent of surface waters are in good ecological status even though good progress has been achieved in some elements. Groundwater is less exposed to pressures: Almost two-thirds of groundwater bodies are in good chemical status; nevertheless improvement for the remaining third will take a long time.

All in all, Water Framework Directive objectives have not yet been achieved for many water bodies, not even after twenty years, necessitating further measures that must be implemented as soon as possible. This poses great challenges for those responsible.

Adapting policy areas and provisions to water protection objectives

In view of the measures still required, the demands placed on water bodies by multiple uses and the effects of climate change, water protection must be given higher priority in other policy areas.

Safeguarding space for more natural river development must be explicitly embedded in spatial planning regulations.

European agricultural subsidies should be consistently aligned with the principle of “public money for public environmental services” and thus provide strong incentives for agri-environmental measures in order to significantly increase financial scope for water protection. Opportunities associated with this approach were not sufficiently exploited in the current agricultural policy reform. For example, prohibition of fertiliser use on five-metre shore-line buffer strips could not be enforced. The minimum width as per relevant legislation is only three metres; too little for consistent water protection, which is also criticised by the EU Commission in its Observation Letter on the German national strategy plan.

In addition, legislative coherence across EU areas of law concerning water, substances, products and plants must be improved. What is needed are overarching provisions for substances with properties of very high concern as well as their monitoring in water bodies. For example, current legislation for plant protection products will arguably not suffice to reduce substance inputs from plant protection products, which is why additional measures will be necessary.

One of the fields in which water management in Germany has long-proven expertise is planning and construction of sewage systems and wastewater treatment plants, one example being tertiary treatment facilities for nutrient removal which is established nationwide at larger plants. New processes for pollutant removal to reduce micro pollutants (quaternary treatment) are increasingly in use.

One major challenge is posed by combined sewage and rainwater treatment. In this regard, increasing occurrence of heavy rainfalls associated with climate change require further adaptation measures, such as systems with larger reception capacity.

Combined sewage and rainwater treatment – a major challenge

Another necessity for preserving and improving biodiversity as well as water body resilience to climate change is providing more space for water bodies and making use of synergies between river and floodplain development; this is also important for creating retention zones, for flood protection and low water management as well as for near-natural water body development.

To this end, room for development must be identified and area-based targets defined, be translated into law and implemented.

In order to better link water-related information available at many levels, there are plans to optimise data management and to openly handle data collected. This will also enable Member States to fulfill their reporting obligations at EU level more efficiently.

Greater transparency also serves to better inform the public and facilitate acceptability of measures.

Taking broader European perspectives on water

The Water Framework Directive is embedded in various EU strategies that strengthen existing links between the various sectors concerned. The EU's Green Deal is of particular importance in this regard, being a new growth strategy that aims to transform the EU into a fair and prosperous society with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use.

The Green Deal is underpinned by strategies such as on biodiversity, aimed at ridding the environment of pollution and reducing nutrient and contaminant inputs within the framework of a "Farm to Fork-Strategy". This is expanded and complemented at the German level by the National Water Strategy, the National Peatland Conservation Strategy, the Natural Climate Protection-Action Programme and the BMUV's dialogue on trace substances.

Enormous challenges, different approaches

National level strategies have their merits; however, measures are implemented at the local and the federal state level by municipalities and the relevant waterways and shipping authorities. This should be continued, especially in projects where interested parties have entered into cooperation, for example with farmers, where land is available along the shorelines or where funds are available for expanding wastewater treatment plants and sewage systems.

That said, good status will only be achieved through significantly more measures in certain areas, through more comprehensive use of synergies and through legally binding measures.

Third management plan coverage until 2027 – and what next?

Per their third management plans and programmes of measures, the federal states and the river basin district associations lay the foundations for further improving water body status. These instruments compile for the first time for the whole of Germany all measures needed to achieve good status, considering current levels of experience. By 2027, as many measures as possible need to be implemented and obstacles to implementation as well as uncertainties must be reduced or eliminated. Much remains to be done.

Thus, management plans will continue to be elaborated every 6 years, and implementing the Water Framework Directive will remain an ongoing challenge – even beyond 2027.

River basin management plans and programmes of measures

Links and QR codes providing additional information

Danube
https://www.fgg-donau.bayern.de/wrrl/bewirtschaftungsplaene/index.htm

Eider
https://www.schleswig-holstein.de/DE/fachinhalte/W/wasserrahmenrichtlinie/fgeEider.html

Elbe
https://www.fgg-elbe.de/berichte.html

Ems
https://www.ems-eems.de/wasserrahmenrichtlinie/berichte

Meuse
http://www.meuse-maas.be/Directives/Directives-cadre-sur-l-Eau.aspx?lang=de-DE

Oder
https://www.wasser.sachsen.de/wrrl-bewirtschaftungsplaene-10865.html

Rhine
https://fgg-rhein.de/servlet/is/4367/

Schlei/ Trave
https://www.schleswig-holstein.de/DE/fachinhalte/W/wasserrahmenrichtlinie/fgeSchleiTrave.html

Warnow/Peene
https://www.wrrl-mv.de/wrrl-dokumente/bmu/bwz1/#warnowpeene

Weser
https://www.fgg-weser.de/oeffentlichkeitsbeteiligung/anhoerung-eg-wrrl/bewirtschaftungsplan-und-massnahmenprogramm-2021-bis-2027

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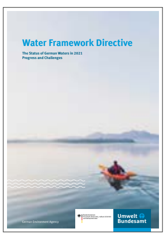
Waterfall in the alps



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