Visions for the Rhine

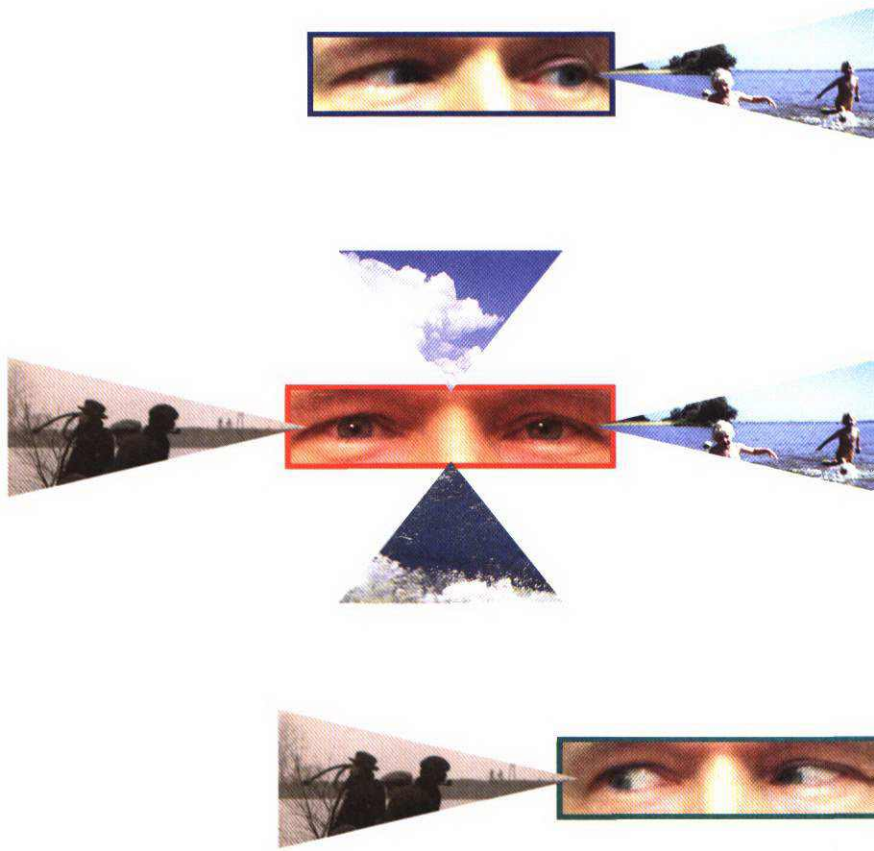
March 2000

world water vision

world water forum

With thanks to Heinrich Heine's Deutschland. Ein Wintermarchen (1844)

Contents



← Model of a Roman wine vessel found in Neumagen/Moselle

All earth's powers are due to the gift of water. [...] Nature employs her tireless force nowhere with greater power than in the waves, the ocean swell, the tides that ebb and flow, and - if we admit the truth - in the rapid river currents, since this element commands all others.

Natural History, Pliny the Elder (23-79) (Translation: J.F. Healy)

Preface

State Secretary's Foreword to Rhine Vision

The Netherlands is for the most part a delta area. Three large European rivers cross it, the largest and most important of which are the Rhine and its tributaries.

On the edge of land and sea, Dutch people are used to living with the water. Since early times, we have been building dikes to protect ourselves against flooding, either from the rivers or from the sea. The result is an ingenious water management system, which allows millions of Dutch people to live and work in low-lying areas. Without the dikes, 65% of the land would regularly be flooded.

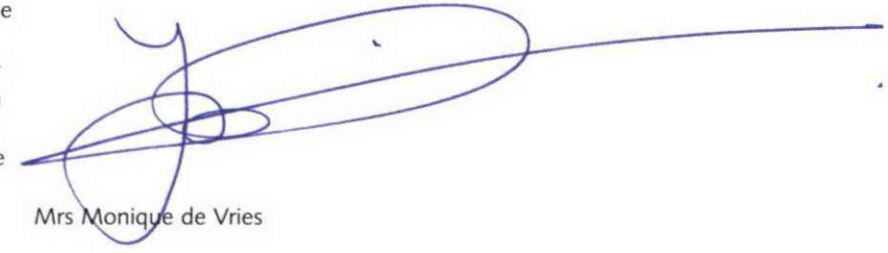
Over the last decades, our perspective on water management has shifted to some extent. The key word nowadays is integrated water management. Problems in different water related areas, such as abundance or shortage, quality, flood prevention and nature conservation- are to be seen and solved in relation to one another. We now try not to fight against, but to work with the water, giving it space where it needs it.

Some near-disasters have accelerated this shift. In 1993 and 1995, the Rhine confronted us with extremely high waters. On the latter occasion, a number of Dutch polders were almost flooded, and 200.000 people were evacuated as a precaution. The disaster caused by the fire in the Swiss Sandoz chemical plant (1986) boosted international cooperation between the five Rhine states and the EU. The famous Rhine Action Programme was set up within a year of the fire. Although pollution of the Rhine had already been decreasing since the 1970s, a much greater reduction in pollution has been achieved since then. As a natural consequence of all this, the ecological restoration of this important river has been placed high on the agenda.

From 17 - 22 March 2000, the Netherlands has the honour of hosting the second World Water Forum (WWF) and the Ministers Conference in The Hague. At the forum, the World Commission for Water in the 21th century (WWC) will present a World Water Vision. This Vision will be based, in part, on regional and thematic visions. The Netherlands has offered to initiate and support the development of a regional vision for the Rhine basin.

Based on the guidelines of WWC's Vision Unit, within a relatively short period a whole array of activities have been undertaken, ranging from workshops and interviews to consultations. The result of all these efforts has been condensed in this booklet. It contains the facts, lessons learned, visions and wishes provided by the many motivated people who have contributed to this regional vision. I hope that the outcome of this process may help us to make further progress in achieving a sustainable integrated water management system, be it in the Rhine basin or anywhere else in the world.

The State Secretary of Transport, Public Works and Water Management



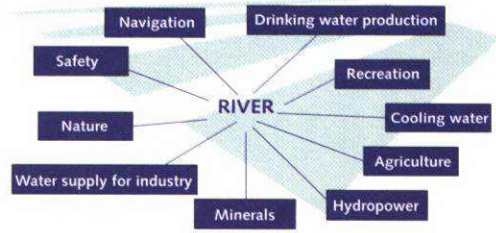
Mrs Monique de Vries

← Schaffhausen falls

1 Introduction

The Rhine: Muse and Provider

Old Father Rhine is a majestic river. Down the centuries it has been a rich source of inspiration for artists, scientists and politicians around the world. But the Rhine is also an important source of drinking water and one of the main inland commercial shipping routes in Europe. Flowing for 1320 kilometres through the economic heartland of Western Europe, it carries more traffic than any other river in Europe. It has made Rotterdam the biggest seaport anywhere in the world and Duisburg the biggest inland port in Europe. For thousands of years, the river has provided the means of increasing trade and transport. Great industrial regions like the Ruhr have grown up along its banks. The Rhine links cultures and nations. Some 55 million people live and work in its catchment area and 20 million people depend on it directly or indirectly for their water supplies. The relationship between the river and the surrounding population has always been a matter of give and take. The river has brought prosperity, but has also swept away goods and property in its many more or less catastrophic floods. At times it has posed a threat, but man has also threatened the river, notably through the disastrous pollution of the 1960s, 70s and 80s. This has since been greatly reduced, allowing the river to resume its role as a main arterial link between ecosystems far and wide. In short, the various functions of the river have been brought into a better balance. But a perfect balance has not been reached yet, either for the river or for the entire basin drained by it...



Towards sustainable management

In the lead-up to the World Water Forum (held on 17-22 March 2000 in the Dutch city of The Hague), a vision has been formulated for water in the Rhine basin in the 21st century. The main aim of this vision exercise is to increase public awareness and make people think. For this reason, this document looks mainly to the future and concentrates on the aim of cooperation to achieve some form of sustainable water management as early as possible in the 21st century. The words 'cooperation' and 'sustainable' imply that due account must be taken of all the relevant human interests and all the properties of water, while the long-term nature of the vision makes it possible to avoid ad hoc solutions.

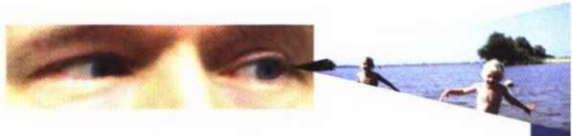
The Long-Term Vision for Water, Life and the Environment - better known as the World Water Vision - is a worldwide, participatory exercise in vision development, prompted by the urgent desire to develop new and innovative ways of dealing with global water problems. The vision itself is based on various sectoral and regional visions for water management. The World Water Vision has been prepared by the Vision Management Unit of the World Commission for the 21st Century. This document, entitled "Visions for the Rhine", is one of its regional components. Work on its development started in April 1999 with the intention of presenting it at the World Water Forum in March 2000.

Choices and decisions, how and by whom?

This book is the product of consultations (workshops, interviews, brainstorming sessions and written exchanges of views) between many different parties and players with an interest in the future of the Rhine. But this does not mean that it is an agreement, a policy document or a statement of belief by these different parties, or indeed a statistical summary. It is none of these things. Rather, it is a basis for discussion. It is designed to show where we have succeeded and failed in the past, and to encourage reflection not only about the immediate future but also about the long-term consequences of current decisionmaking on the Rhine and other rivers. After all, the presence of a clear and inspiring long-term goal is likely to give us a better chance of making the right decisions for the future. Though, even then, the decisionmaking process will involve difficult choices between different aims and interests, and between likely costs and benefits. The Institute for Inland Water Management and Waste Water Treatment (RIZA) was asked by three Dutch government departments - the Ministry of Transport, Public Works and Water Management, the Ministry of the Environment and the Ministry of Agriculture, Nature Management and Fisheries - to coordinate the drafting of this regional vision. Contributions were received from innumerable people and institutions.

Overview of the Regional Visions

Southern Africa Vision
South America Vision
Central American and Caribbian Vision
North America Vision
Americas Vision
South Asia Vision
Southeast Asia Vision
Australian Vision
Aral Sea Vision
Rhine Basin Vision
Central and Eastern Europe Vision
Mediterranean Vision
Nile Vision
West African Vision
Chinese Vision
Russian Vision
African Vision
Arab Countries Vision
Lake Biwa Vision
Morocco Vision



2 Shared visions and dreams

The vision - What is a vision?

There are two main ways of picturing the future of any river basin. The first is to envisage a desirable future state (a dream) based on established knowledge, experience and above all, expectations. The second is to construct a vision of the use and development of the river and its catchment area on the basis of the present desires and preferences of all the interested parties. For the sake of clarity, we refer to the first of these in this booklet as a dream and to the second as a shared vision. In this section, we begin with the shared vision. This is the result of a process of negotiation and consultation.
It is vital to have both a dream and a shared vision. Where there is no shared vision, there is no progress. Where there is no dream, the people perish.

Shared vision for the Rhine and its basin

The need for a vision arises in relation to conflicts or problems that need to be solved. These have changed over time. The first issues tackled in this way related to safe, easy and free navigation on the Rhine. Action on these started as long ago as the early 19th century. A second group of issues, which emerged as early as the 1930s but peaked in the 1970s, related to the wish to stop water pollution in the Rhine. In the 1980s and 1990s it became clear that the ecological restoration of the Rhine requires not only pollution abatement but also habitat reconstruction. The floods of 1993 and 1994/95 reminded us that the river had lost large parts of its floodplains in the course of the 20th century, with a resultant major increase in the risk of flooding. A likely concern in the near future will be the expected change in discharge patterns in the Rhine as a result of climate change. More extreme floods in winter will require additional flood protection measures, while extremely low discharges in summer may require careful negotiations on the management and distribution of the scarce river water available for vital uses like navigation, irrigation and drinking water supplies.

A shared vision for the Rhine basin may be derived from international organisations dealing with all these aspects. There are many international bodies responsible for water management in specific parts of the Rhine basin. These include the International Commission for the Protection of the Moselle and Saar, the International Commission for the Protection of Lake Constance and the Permanent Dutch-German Transboundary Waters Commission. Two administrative bodies cover most of the Rhine basin: the Central Commission for the Navigation of the Rhine (CCR) and the International Commission for the Protection of the Rhine (ICPR). The latter, founded in 1950, is responsible for water management in the entire Rhine downstream of Lake Constance.

Finally, there is a plethora of universities, institutes and organisations providing reliable and universally accepted data to serve as a basis for discussion between the different national representatives. One important scientific institution worth mentioning is the international Commission for the Hydrology of the Rhine basin (CHR), which provides accepted transboundary data and concepts to serve as a basis for understanding and discussion of hydrological processes and water resources management. Another institution worth mentioning is the International Association of Waterworks in the Rhine river basin (IAWR), founded in 1970. This organisation strives to reduce the pollution of (surface) water in the basin through discussion with governments and industry, based on facts derived from the IAWR monitoring network.

In addition, the major part of the Rhine basin lies within the territory of countries which are members of the European Union. Through issuing directives, the Union has been involved in transboundary water politics since 1972 and it is an increasingly uniting factor in the area.

← Grazing horses create diversity in floodplain vegetation

The core policy documents of the CCR and ICPR are the official reflection of what may be called the shared vision for a large part of the Rhine basin: that is, the view shared by the goverments most of the riparian states. These documents represent the cumulative result of discussions and negotiations which have taken place in these forums over more than a century. In the course of this long process, the ideas and needs of the people involved have changed.

The shared aims of all the participants in the ICPR are:

- sustainable development of the Rhine ecosystem, in particular through the maintenance and improvement of water quality, natural functions, natural interactions and natural habitats, the protection of populations of organisms and species diversity, and the environmentally sound and rational management of water resources taking ecological requirements into account when implementing technical measures, e.g. for flood protection, shipping or the use of hydroelectric power;
- the production of drinking water from the waters of the Rhine;
- improvement of sediment quality in order that dredged material may be deposited or spread without adversely affecting the environment;
- general flood prevention and protection, taking account of ecological requirements;
- the restoration of the North Sea through measures in the Rhine basin in conjunction with other actions taken to protect it.

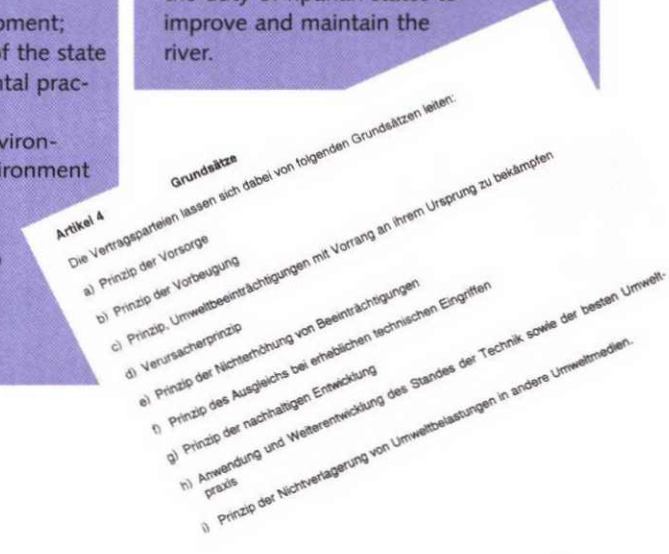
They are guided by the following principles:

- precautionary principle;
- principle of preventive action;
- principle of rectification, as a priority at source;
- polluter pays principle;
- principle of not increasing damage; principle of compensation in the event of major technical measures;
- principle of sustainable development;
- application and development of the state of the art and best environmental practice;
- principle of not transferring environmental pollution from one environment to another.

Source: Rhine Treaty, signed 12 April 1999 by Switzerland, France, Germany, Luxembourg, the Netherlands and the European Union.

Basic principles of the 1868 Mannheim Convention for the Navigation of the Rhine:

- free navigation for convention states and associated countries;
- equal treatment of all vessels and their masters;
- simplification of customs procedures;
- exemption from navigation taxes;
- the duty of riparian states to improve and maintain the river.



↑ Upper Rhine scenary in 1810: upstream view from Isteiner Klotz

↑ fragments of a few of these principles written in German

But quite apart from these core policy documents, there are many similarities between local and national water management policies in the river basin and in the ways these are evolving. These have provided the basis for the following shared vision.

We share a vision of a basin.....

- **..... in which uses and management are invariably tailored to the possibilities and constraints presented by the water system,**
- **..... in which all concerned strive for the sustainable development of water-dependent eco-systems,**
- **..... in which every stakeholder is aware of the opportunities, constraints and threats presented by the water system,**
- **..... in which every stakeholder has the opportunity to participate in decisionmaking concerning the uses and management of the water, and**
- **..... in which such decisions are taken on an integrated basis, taking account of all present and future interests in all parts of the basin and in all compartments through which the water passes, on a basis of solidarity and mutual understanding and by way of consultation and negotiation,**
- **..... so that a fair balance is approached which allows the water and the waters of the Rhine and its basin to satisfy the needs of all functions and uses.**

Using scenarios - developing dreams

The "shared vision" before is formulated in abstract terms. This was necessary in order to reach agreement on it, but it is less inviting to think and dream about the future in such abstract terms than in a more concrete and specific way. Developing a more concrete vision for the long term will be a difficult task. Projections of existing trends beyond the near future are generally considered unreliable. Technological developments will impact on what mankind is able to do, while natural and human disasters will influence the public will to take action.

Scenarios can be used to assist the development of a vision. They are used in all the sectoral and regional vision exercises which form part of the World Water Vision process. Scenarios are not projections or forecasts, **but stories about a possible future** which help focus attention on causal processes and decision points. Scenarios challenge conventional thinking, encourage debate and provide a common framework enabling stakeholders to address concerns and identify alternatives.

The narratives provide no numerical or exact descriptions of possible future situations, but they do indicate the direction of change and the mechanisms likely to cause it by giving an impression of the general nature of such situations. Occasionally, the situations may be slightly caricatured in order to stress the differences between them. For this reason, they should certainly not be taken as blueprints of strategies for the achievement of water sustainability. Their purpose is to make people think about the future.

During the process of vision development, a number of different scenarios have been evolved. This document - which is intended to serve as a basis for further discussion - gives three different scenarios for the Rhine basin in the year 2025:

The Business as Usual (BAU) scenario:
assuming the continuation of current policies with a realistic rate of success;
The "BAU scenario" will not produce any real water crisis in the Rhine basin, but may lead to a deterioration in the quality of life and the environment as compared to the present and will make the water system more vulnerable to degradation.

The Economics, Technology and the Private Sector (TEC) scenario:
relying on the market, the involvement of the private sector and mainly technological solutions and national/local or basin-level action to move towards water sustainability;
The "TEC private sector scenario" will lead to greater water sustainability but may result in less solidarity and an increase in friction between upstream and downstream countries and between rich and poor.

The Values and Lifestyles (VAL) scenario:
focusing on a revival of human values, strengthened international cooperation, emphasis on education, international mechanisms, international rules, increased solidarity and changes in lifestyles and behaviour as a way of moving towards water sustainability;
The "VAL human values scenario" will produce greater water sustainability in a world which may seem rather utopian at present, but could eventually become reality (although possibly only after a change in attitudes and values caused by a disastrous event, such as a catastrophic flood).

↑ Abandoned brickyard and clay extraction holes

↑ Rhine near Ludwigshafen

Scenarios

The "Business as Usual" (BAU) scenario

If we go on living the way we do now, water sustainability will not be achieved. In 2025, the situation in the Rhine basin might be something like this:

Some moves have been made in the direction of sustainability, but most people regard short-term economic interests as more important than long-term environmental values. Present economic trends persist, so expansion continues at the same rate as in 2000. Energy consumption has grown rather less fast and in the middle and lower parts of the Rhine basin renewable energy still represents only a small percentage of the total. Water-borne transport has more than doubled and there are more containers and transport chains. Shipping now operates around the clock and there are regular delays due to congestion.

As Eastern European countries, where food can be produced much more cheaply, have joined the EU, agriculture in the Rhine basin has decreased. It is still protected by EU regulations, but subsidies are lower than in 2000. The price of agricultural products has risen.

As a result of climate changes, peak river discharges are higher. The risk of floods and other disasters has been slightly reduced by measures but increased by climate changes. The rate of capital investment in flood-sensitive and other endangered areas has declined, but there has still been an increase in the overall amount of capital invested. The measures taken since 2000 to reduce the risk of flooding were initially directed at river bed widening and floodplain restoration, with consequent major ecological benefits. More recently, however, retention polders have been preferred, as being a cheaper way to protect against flooding. These have produced fewer benefits for the natural environment.

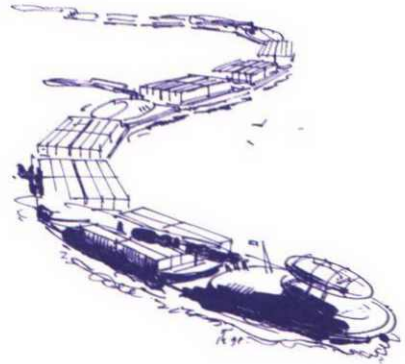
There has been a slight decrease in water consumption. Ground water quality has deteriorated. More surface water is being used to prepare drinking water. There are great disparities in the quality and price of the raw material but drinking water is of good quality throughout the Rhine basin. Micropollutants and in general the presence of more unnatural substances in the environment are a persistent problem. Although there have been many reductions in emissions from industry, households and agriculture, most problems have not been resolved. Most houses have been connected to sewage treatment plants. Industry is still producing new substances every year and agriculture still uses large amounts of pesticides and fertilisers, although less than in 2000.

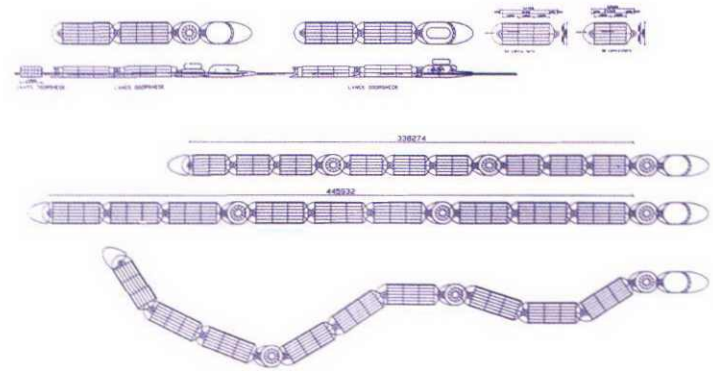
There is a single commission for the entire river basin and it is now also responsible for shipping. Switzerland has joined the EU. Many efforts have been made to achieve integrated decisionmaking for the whole Rhine basin but the results have been poor.

The policymaking process, in which public participation is an important feature, is extremely slow since few people are willing to make even minor sacrifices to achieve sustainability and serve the interests of society as a whole. Information systems have been greatly improved. Access to the Internet is now widespread and information is easier to find than in 2000. Implementation of the few fully integrated decisions that are taken is slow and incomplete. Costs of policymaking processes continue to rise and the public sees little benefit. It demands better leadership and sees the state more as an opponent than as a partner.

Lines of action derived from this scenario:
A single integrated river basin authority should be established by the European Union. Eastern European countries should be allowed entry to the European Union. Protection of European agriculture should continue. On most other subjects, the main approach is to continue present policies.

↑ Flood March 1999



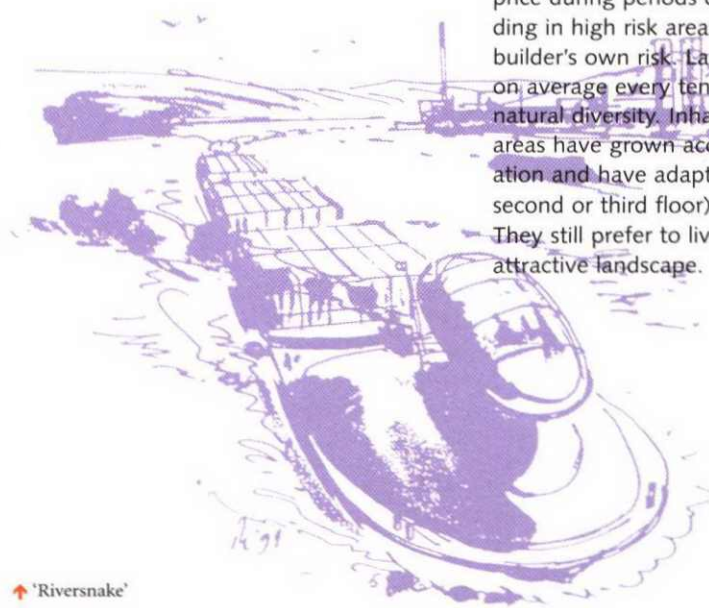


Towards sustainability through Economics, Technology and the Private sector (TEC scenario)

If we try to achieve water sustainability through the private sector, market forces and confidence in technology, the situation in the Rhine basin in 2025 might be something like this:

There has been a major withdrawal of government and most issues are now dealt with by the private sector in a free market context. Technology has led to high energy consumption. Energy is now mainly renewable but the path to this situation has required mainly fossil fuel. The economy is growing faster than in the BAU scenario. Large snake-like flexible boats power their way around kilometres of river bends. Mass transportation on water has largely taken over from road transport. Zeppelins are the second most important means of mass transportation. The overall demand for transport has decreased in Western Europe due to a fairly rapid change from a production economy to a service economy. Manufacturing industry has moved to regions with more space, closer to the mining areas.

Agriculture requires a far smaller input of minerals. In Western Europe, specialities are produced with high efficiency. Bulk application of fertilisers has almost totally disappeared from the Rhine area. Instead, specially cultivated fruits and vegetables are being grown using high-precision fertilisation systems. Genetic manipulation has been used to modify these species to suit the climate.



↑ 'Riversnake'

Climate change is now apparent: sea levels are some tens of centimetres higher than at the turn of the century. River discharges are more pronounced: sometimes extremely high and sometimes very low. All along the river, major investment has created industrial clusters dependent on transport over water. These clusters are specially protected against flooding. On-line flood warnings are provided by insurance companies at a fair price during periods of high discharges. Building in high risk areas is allowed but at the builder's own risk. Large areas are flooded on average every ten years, enhancing natural diversity. Inhabitants of flood-prone areas have grown accustomed to the situation and have adapted to it (living on the second or third floor) or pay high insurance. They still prefer to live there because of the attractive landscape.

Water supply is a major concern for agriculture. The highly industrialised manner of production requires a sufficient supply of water at all times. Especially in the southern part of the Rhine basin, climate change has produced a more uncertain supply situation. At the cost of considerable amounts of energy, water is pumped upstream in times of water shortage. Since renewable energy is now abundantly available and water quality has improved significantly, this "recirculation" system works well for weeks at a time.

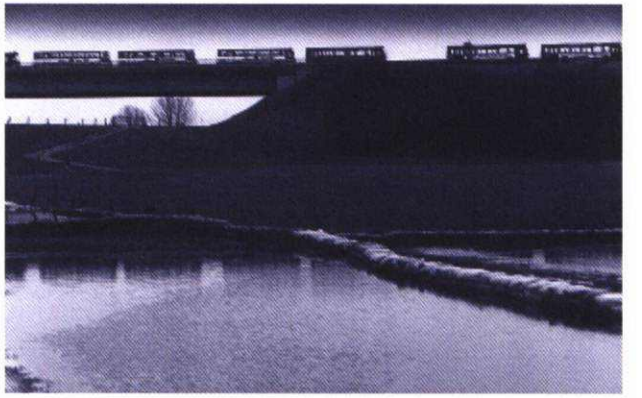
Water quality has improved greatly. Diffuse sources are no longer a threat to the environment. Pesticides are applied very sparingly by robots able to identify possible threats to the crop. Fertiliser requirements are assessed on the basis of evidence of crop stress provided by remote sensing and fertiliser is applied using global positioning systems (GPS) accurate to within a few metres. As a result, high concentrations of pesticides in the water are no longer a frequent occurrence. This situation has been achieved by the imposition of heavy fines in

the past (polluter pays principle). European government is mainly a matter of coordination and setting ecological and public health standards. Within these limits, and with the widespread acceptance of open negotiations between owners of labour and capital, some sort of dynamic but sustainable situation has been created in Europe. National governments implement European directives and regulations and complement them in areas where there is no common interest (subsidiarity). Sub-national government no longer exists. Large companies negotiate directly with governments.

Government encourages technological change by creating excellent opportunities for research and education at all levels. Research is stimulated by a system of cheap loans and grants. Government also provides information on public affairs (mainly health, environment and nature) to all parties in negotiations on an equal basis and at marginal cost. Since these are all matters with an international dimension, this is organised by the European Union (now comprising the whole continent, with the UK in a special associated position). Responsibility for providing such information on water issues is delegated to the Rhine Basin Authority (RBA).

Lines of action derived from this scenario: Market places should be created where current intangibles can be negotiated: ground water abstraction permits should be awarded for a period of 15 years. Strong support should be given for scientific and technological development, especially in the energy, agriculture and transportation fields. Government should ensure a strong education system and provide public information. We should expect a European government to evolve, but at the same time build a strong network of large industrial companies.

↑ Artist's impression of floating and rotating houses



Towards sustainability through a change in Values and Lifestyles (VAL scenario)

If we try to achieve water sustainability through a change in our values and lifestyles, the situation in the Rhine basin in 2025 might be something like this:

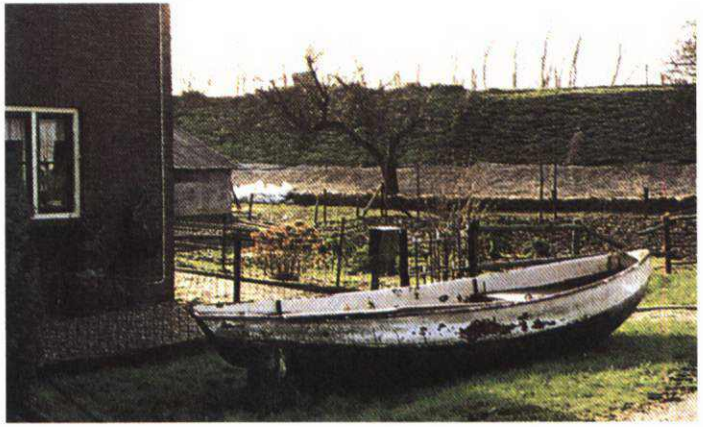
The main social mechanisms are sustainable behaviour by people both as individuals and in groups and social interaction based on respect and solidarity. Personal health and a healthy environment for present and future generations are more important motives than money and profits. Therefore people reject goods produced in non-sustainable ways and are willing to pay higher prices for those produced sustainably. Because of this change in consumer behaviour, sustainable production techniques and technologies can be implemented while profits are maintained at the same level.

The economy in the Rhine basin is still growing but is becoming smaller in scale. The emphasis is on local production for local consumption. For this reason, total transport volumes have decreased. Shipping has become the most important element in transport, which now mainly consists of transport chains. There is extensive sustainable food production on small multifunctional farms. Farmers are both food producers and guardians of the landscape.

Water quantity problems still occur. As a result of climate change, peak water discharges are more intense and flood abatement measures like river bed widening or rainwater storage are only sufficient to prevent more frequent flooding. No new settlement is taking place in areas vulnerable to river flooding, but people are not leaving high-risk areas either. Riverside urban areas are protected by high dikes and dams to avoid flooding. Forecasting techniques have been greatly improved.

Many floodplains that help protect against flooding have been given back to nature. These wildlife areas are linked to others upstream to produce a continuous network of high-quality nature conservation areas which are freely accessible to all for recreational purposes and small scale fishing. Many species of migratory fish and other species so far unable to find a suitable habitat in the Rhine basin will be attracted back by the newly created habitats. The increased area of wetlands in the Rhine basin gives rise to occasional local epidemics of water-borne diseases but well-developed medical knowledge means that these pose no threat to society as a whole.

↑ Coaches waiting to evacuate a region threatened by flooding

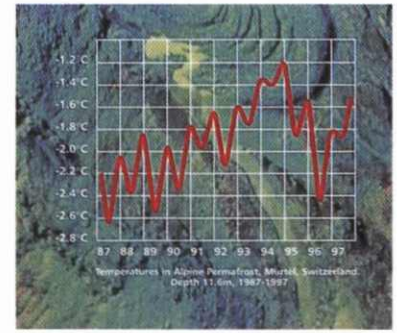


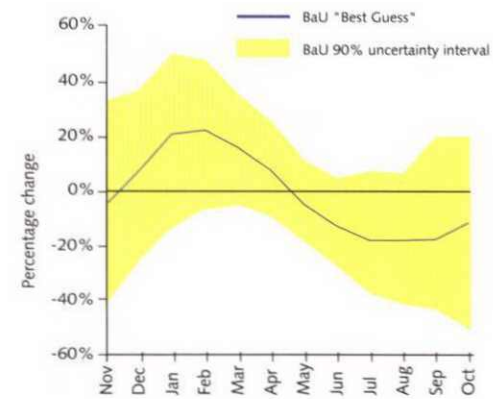
Use of the natural ability of the soil to retain water prevents water shortages occurring more frequently during dry periods than at the end of the 20th century.
Pollution by households, agriculture and industry has decreased. Water quality is therefore much better than in the business as usual scenario. Good quality drinking water is available to all inhabitants of the Rhine basin without the need for high-tech purifying measures. Water consumption has decreased and surface water is used increasingly instead of ground water.

Knowledge of many aspects of water in the Rhine basin is stored in one enormous shared database. Knowledge plays a key role in achieving sustainability and information on sustainable technological solutions and other matters is freely accessible to all. Knowledge is communicated via high-tech information networks.
The Rhine river basin is governed by a large international authority such as the European Union, which facilitates and supports sustainable action on the ground. Since this authority is responsible for all the functions of the Rhine basin, integrated decisions can be made. Via public participation in policymaking, government strives to achieve majority stakeholder agreement on policies. There are government subsidies for landscape conservation by the agricultural industry and government meets the costs of flood protection and damage, nature development, etc. These are used by government to facilitate agreements between stakeholders. The consequent high tax rates are accepted by the public. The costs of information exchange and policy implementation are high compared to those under the "Business as Usual" scenario. On the other hand, decisionmaking is easier and therefore cheaper because there is universal support for the aim of sustainability.

Lines of action derived from this scenario: Action is needed to increase public awareness of environmental issues and invest in education for all. A single integrated commission must be created for the Rhine basin as a whole. A change is required in governmental procedures to increase opportunities for public participation. Finally, since the public needs to be well-informed if it is to make a useful contribution to policymaking, knowledge and information networks should be developed to provide relevant information free of charge and the generation of new knowledge should be stimulated.

↑ Flood forecasting techniques have been greatly improved ...





Current situation and stakeholder visions

The following descriptions and visions are not integrated and not necessarily shared. They describe the future from the point of view of the present and focus on single aspects or functions of water.

Climate change

Emissions of so-called greenhouse gases, such as carbon dioxide, are expected to cause a change in the climate. Climate models predict that global warming will result in higher temperatures and wetter conditions in Western Europe, especially during the winter. These processes will tend to increase the discharge of the Rhine in the winter and reduce it during the summer. It is likely that changes will manifest themselves over the coming decades.

♦

Climate scientist:

"When my grandfather was born there were six glaciers in the vicinity of our village, now there are only two. The climate is changing."

♦

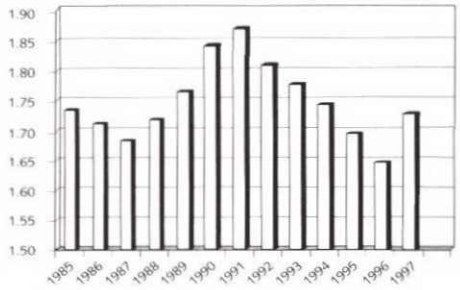
More frequent low discharges will affect the cost and reliability of shipping, energy supplies, the cooling of thermal power plants and the supply of drinking water and irrigation water. At the same time, demand for the latter will rise as a result of climate change. Winter peak floods in alpine rivers will increase, as will the risk of winter floods in the main stem of the Rhine. A flood that occurs on average every 1250 years, to which level water defence systems may be tailored, will increase by 5-8% by the year 2050 in the lower stretches of the Rhine. The warming in the Alps will not only reduce the size of the glaciers, but also increase mud flows, slope failures and flash floods. It will also dramatically reduce the winter sports potential of the Alps. In addition to all this, a significant sea level rise is expected.

↑ Rhine valley Liechtenstein

↑ Temperature in Alpine Permafrost, Murtèl Switzerland, Depth 11.6 m., 1987-1997

↑ Best guess monthly discharge at the Dutch German border under the IPCC BAU scenario

Water extraction from Lake Constance (million m^3) 1985 - 1997



Bulk water use

The main water uses in the Rhine basin are public water supply, agriculture, industry (process water), cooling of power plants and navigation. Use of Rhine water for human consumption by country and sector varies between 5% and 15% of mean annual discharge. This may not seem much, but consumption is not spread evenly over the year: demand is greatest in summer, when mean discharge is lowest. This means that the available water must be carefully apportioned during dry summers.

By far the greatest volume is used for cooling. In the whole Rhine basin, this accounts for about 65% of all water use. Increases in water temperature affect the environment by disturbing the natural conditions for ecosystems. Little water is lost from the system due to evaporation.
Environmental regulations restrain industrial water use. Industry is willing to cooperate with environmental measures, but profits always come first. Internal recycling of water and the purification of process water are expected to increase steadily.

♦

Navigation requires minimum water levels and is limited by maximum water velocities. For the first purpose, the Rhine and its tributaries have been partially canalised and split up into sectors, separated by locks. The amount of water used to supply this canal system is relatively small in comparison with other uses. On a regional scale, however, the canals can have a significant influence on the hydrology of the basin. For example, in France the canals cut through some important aquifers, thereby draining ground water.

♦

At only 10% of total consumption, agricultural water use is relatively low compared to that in arid climates. However, this consumption represents a permanent loss to the system since almost all the water consumed by plants is lost through evaporation. Dutch agriculture is the largest consumer, using Rhine water to maintain a constant water level in the polders and low-lying areas of the delta in the summer. The discharge of relatively clean Rhine water is also used to refresh surface water polluted by salt, fertilisers and pesticides.
On the French-German border, there are important agricultural areas. After Tulla's canalisation of parts of the Upper Rhine in the 19th century, the water table dropped 15 metres in some parts of this area. To compensate, irrigation water is supplied free of charge to the affected areas.

Policy scientist:

"The influence of agriculture in EU policymaking is still too strong to allow for a drastic change in water supply or water quality measures in the rural areas."

♦

♦

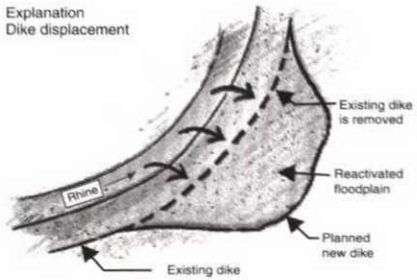
Industry official:

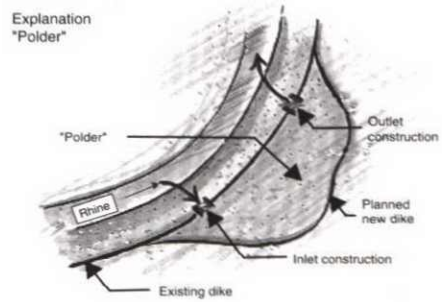
"The chemical industry is ready to play a constructive part in all dialogue about economic aspects of the environment and health, including the internalisation of external costs, economic instruments and the application of the precautionary principle. I want to make it clear, however, that the main objectives of the industry are to respond to the demands of society and to make profits. Without profits, no other objectives can be considered, because the industry will simply disappear."

♦

↑ Water extraction from Lake Constance

↑ River water used for cooling



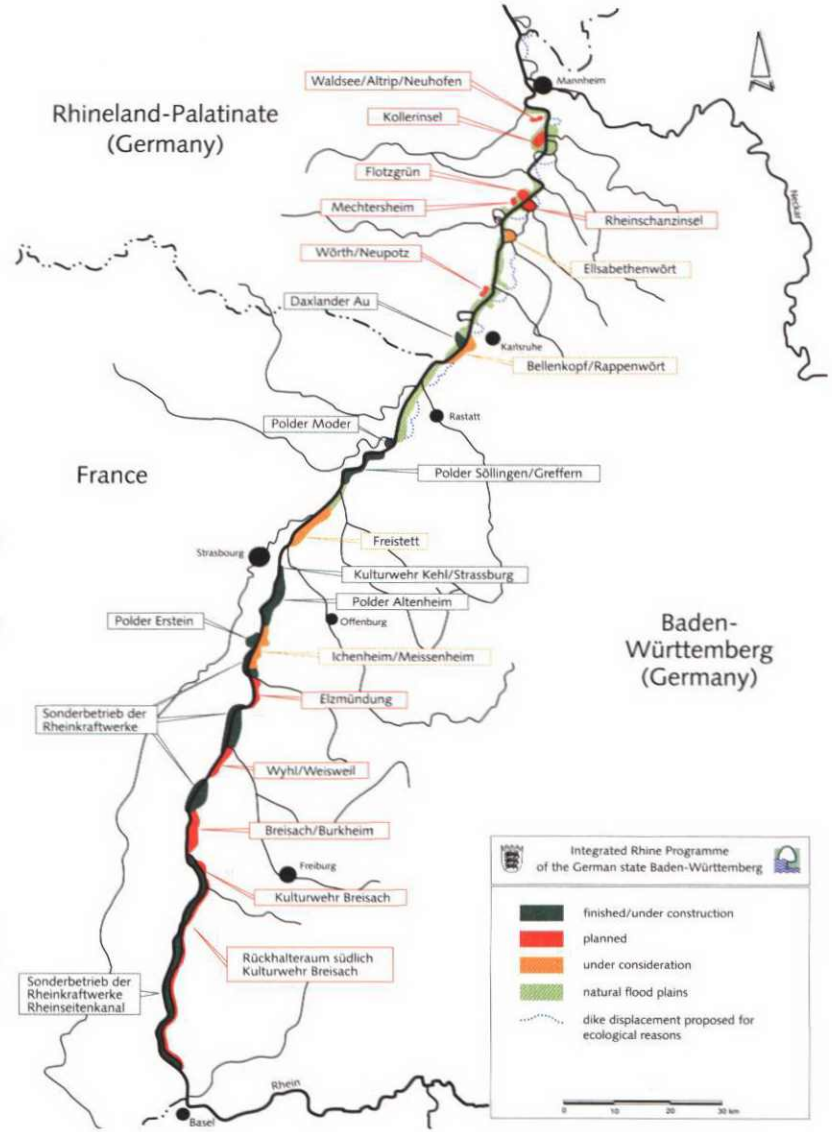


Flooding

In the past, we have looked mainly to short-term solutions. These days, however, policy-makers - faced by a scientifically based expectation of climate change - are increasingly aware of the need to think in terms of decades. A century may be a long time in terms of petty human lives, but it is a mere instant in the life of a river. Since rivers are by nature ever-changing and unpredictable, we must learn to cope with uncertainty. The debate about sustainable flood prevention must centre on attitudes and not simply on juggling the dry profit and loss of figures and functions. Because we are dealing with the forces of nature, it is important to concede to the river rather more than may seem strictly necessary. Sustainable risk reduction will benefit us all.

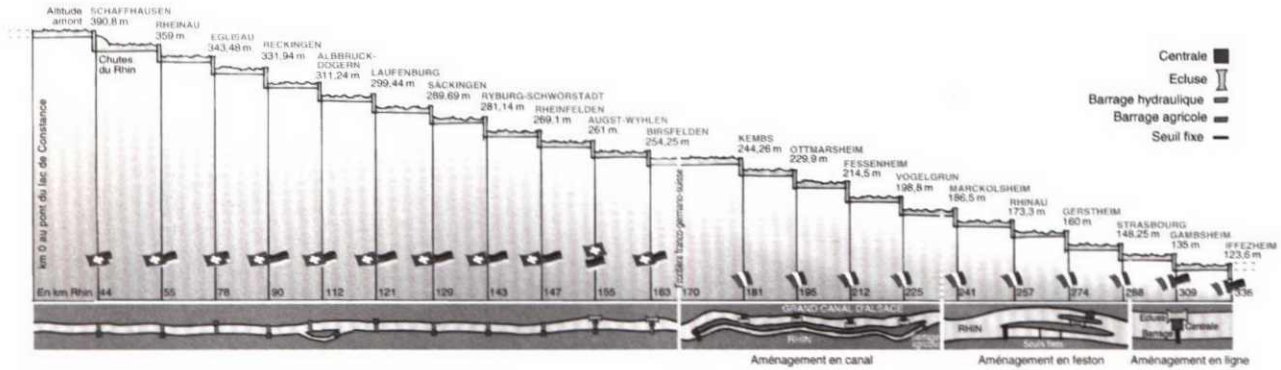
ICPR is a body involving cooperation by five riparian states and the EU. Following the river floods of 1993 and 1994/1995, the Commission became aware of the flood problems and, at the invitation of the EU ministers of spatial planning, produced an Action Plan on Flood Defence. This was endorsed by the riparian states in January 1998. The Action Plan calls on them to help attenuate flooding by setting aside more room along the river for the retention of water at times of peak discharge. The main objectives are: to reduce the risk of flood damage by 10% in 2005 and 25% in 2020; and to reduce the peak discharge level downstream of the section of the Upper Rhine regulated by weirs by 30 cm in 2005 and 70 cm in 2020. The flood forecast models will be improved to extend the forecast period by 50% at the end of 2000 and 100% in 2005.

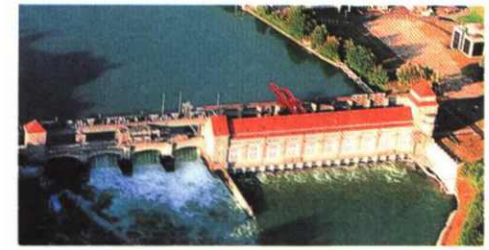
A number of countries in the Rhine and Meuse Basins have submitted a joint flood control programme to the European Commission. This was approved in 1997 and was given the name IRMA: Interreg-Rhine-Meuse-Activities. Participants in the programme include not only a number of EU member states, but also Switzerland (on a project basis). The aims of the programme are: to maximise the retention of river water within the catchment area, to give rivers enough space to achieve their discharge without flooding, to encourage joint action in the field of sustainable flood control and to heighten public awareness.
All over the Rhine basin, sustainable measures are being planned and taken to provide more room for the rivers within its borders.



↑ Polder and dike reallocation are possible flood prevention measures in the Upper Rhine

↑ Planned retention locations in Baden-Württemberg





Energy

The source of energy that is mostly associated with the river is hydropower. Large-scale use of hydropower occurs in the upper part of the Rhine basin. In Switzerland, 60% of the energy generated is hydropower and in the French part of the basin there are many hydroelectric schemes in the main stream of the Rhine. In lower parts of the river, there is less potential for hydropower because of the shallower gradients.

Hydropower has undoubted advantages: a high energy yield (90%) and a great potential for energy storage (the biggest practical problem with electricity being the fact that it cannot be stored). The associated reservoirs also serve other functions, including irrigation, fisheries, recreation and water storage. None of these advantages are shared by other sources of renewable energy. The more than 2 billion m^3 of water available upstream of Basle, combined with the lakes bordering on the Alps, also make some contribution to flood leveling downstream.

♦

Hydropower company official:

"Hydropower is an inexhaustible and unpolluting source of energy, in balance with nature. It makes a major contribution to reducing the use of other, environmentally damaging, energy sources".

♦

Despite all these advantages, the rate of expansion of hydropower generation is less than might be expected. This is largely because hydropower generation relies on dams and reservoirs, which inevitably disrupt natural water systems and ecosystems and create visual intrusion in the landscape. For this reason, new hydropower stations should normally be sited in areas where similar facilities already exist, rather than in semi-pristine areas, and measures must be taken to compensate for damage to the landscape and biotopes.

It should not be forgotten, however, that such compensation is bound to be incomplete.
With the forthcoming liberalisation of the EU energy market, the future of hydropower in the Rhine basin is uncertain. Swiss hydroelectric companies fear that in a free energy market hydropower will lose out to cheaper nuclear energy from other countries.

♦

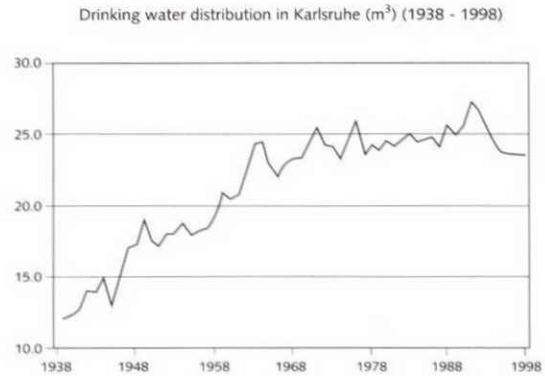
Ecologist:

"Hydropower is not as ecologically sound as most electricity producers claim. The advantage of renewability is greatly outweighed by all the damage to the natural environment caused by hydroelectric stations."

♦

↑ Hydroelectric equipments on the river Rhine from the Lake Constance to Iffezheim

↑ Laufenburg hydroelectric power station



Sanitation and drinking water

Up to the 20th century, epidemics of cholera and other water-borne diseases claimed many victims in the Rhine basin, but these diseases have now been virtually banished from the region. Nowadays, people know that good hygiene and a healthy environment can prevent disease and society provides the means and resources to act accordingly. In the past, sewer systems were designed to flush waste water into the rivers and other relatively clean sources were used for drinking water. As a result, the Rhine became an open sewer. These days, waste water in most places in the Rhine basin passes through treatment plants and industry has to meet waste water quality standards.

The Rhine provides drinking water for 20 million people, though most drinking water in the Rhine basin is now prepared from ground water.

The amount of Rhine water available for public water supplies has never been an important issue. In the future, this sector is expected to be given top priority, so drinking water shortages are not likely to become an issue even if summertime river discharges are reduced by climate change.

♦

Drinking water company employee:

"Not every substance that can be made should be made."

♦

The population of the Rhine basin is not expected to grow to any great extent and economic prosperity is likely to decrease if present trends continue. These factors are likely to produce a decline in overall consumption.

Drinking water companies are more concerned with the quality of the Rhine water. Every year, large numbers of new substances are produced and consumed. Many of these will eventually end up in the river basin environment. They will often be difficult to detect and there is no doubt that many of these substances will pose a health threat if they escape the purification process and end up in our drinking water.
At the same time, water treatment plants are becoming ever more effective at removing the pollution caused by domestic and industrial consumers. In the past, combined action by drinking water companies has been effective in persuading point polluters to cease their emissions. However, this is now becoming more difficult as more and more pollution comes from diffuse sources.

↑ Drinking water distribution in Karlsruhe (m³) (1938-1998)

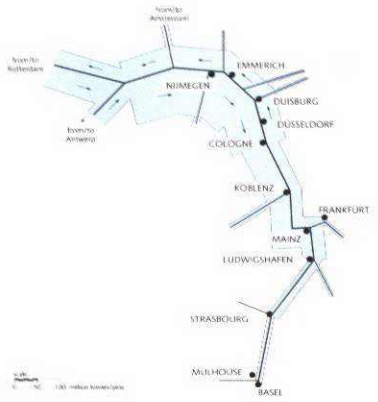
♦

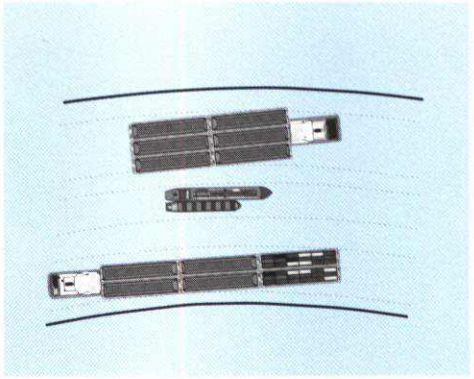
Drinking water company employee:

"The dream of the water companies in the Rhine basin area is that the Rhine can once again become a source of drinking water demanding only 'natural' purification techniques like river bank filtration and sand filtration."

♦

↑ Sewage plant near Ludwigshafen





Transport

Demand for transportation in the Rhine basin - whether by water, air, road, rail or pipeline - is expected to show a continued increase. Because highway capacity is now limiting the increase in road transport and the public rejects further expansion of the highway system, the growth in demand will have to be met mainly through an increase in the other modes of transport (modal shift).

♦

Shipping organisation employee:

"An increase in water-borne transport capacity requires hardly any extra land, whereas other means of transport do. And land is an increasingly rare commodity throughout the Rhine basin".

♦

Especially in the lower part of the basin, freight transport by ship will be selectively encouraged, perhaps to levels doubling or even tripling present capacity. A large part of the increase will be containerised. This will help alleviate the problem of limited access over water, since containers can switch easily between rail, road and water. Road transport is the second most important mode, although at present it is limited by the capacity of the highway system. Rail transport is now the least important of the five, but there is a political intention to increase its share. The same is true of pipelines, though use of this mode is limited to bulk transport of basic chemicals. It cannot be used for special chemical products.

In the upper part of the Rhine, upstream of Basle, transport by ship is not the strongest option. The other three modes predominate, with comparable political efforts being made (especially in the Alpine region) to encourage shifts from road to rail.

♦

♦

Inland harbour employee:

"We want to create more transport chains. Without more ambitious modal-shift targets, it may be more difficult than expected for the inland waterways to compete with road transport."

♦

Ecologist:

"The ever-increasing modification of river morphology to accommodate larger and larger ships is depriving the river of the last remnants of its natural landscape and leading to an irreversible and progressive lowering of average water levels in and around the river. This is having serious effects both on the human population and on ecosystems."

♦

↑ Transport of goods over the Rhine to the hinterland

↑ Three-lane shipping traffic

↑ Ship carrying containers

♦

Tourist organisation employee:

"A large part of the Rhine valley in Germany should become a UNESCO World Heritage site."

♦

Recreation

The Rhine is now a central axis of economic development in Europe. Throughout the basin, rapid urbanisation is taking place. By 2025, people in the Rhine basin are expected to have even more spare time on their hands than at present. Population will be increasingly concentrated in urban areas and these will expand over the period to form conglomerations.

♦

Naturalist:

"In the future, cities will be the main engine of change in the country areas of the Rhine basin. Urban populations will demand space for nature development and recreation rather than agriculture. There will be a smooth transition."

♦

There will be inevitable consequences for recreational needs: areas designed to meet these will fan out around the urban agglomerations. To satisfy the demand for land-based recreation, considerable areas of countryside will have to be developed. Safe boating corridors will need to be created between the areas devoted to water-based recreation, and it will be important to ensure that these corridors are isolated from commercial shipping routes. Despite increased demand, recreational uses are not likely to become the main function of the areas of the river basin designated for them.

Moreover, water-based recreation in the Rhine basin is not limited to surface water areas. Winter sports are also an important form of recreation dependent on water in the shape of snow. Climate changes are expected to reduce the area suitable for them. Expanding skiing facilities by developing new slopes will make areas more vulnerable to erosion and mud-flows and is undesirable for other environmental reasons.

↑ Riverside beach beside the Rhine

♦

Ecologist:

"Our aim must be to restore the natural biodiversity of the river; the salmon is a good symbol but it is only a small part of the whole."

♦

Nature activist:

"I am dead against the way little bits of wetland are being developed here and there and the often beautiful and still unspoilt floodplains are being excavated. Many municipal authorities and water boards still cling to an unshakeable belief in civil engineering measures which cut across solutions exploiting natural systems. For example, we should be looking more to the old spillways. Even in areas with a high population density, there is room for places which can be flooded to relieve pressure downstream."

♦

Ecology

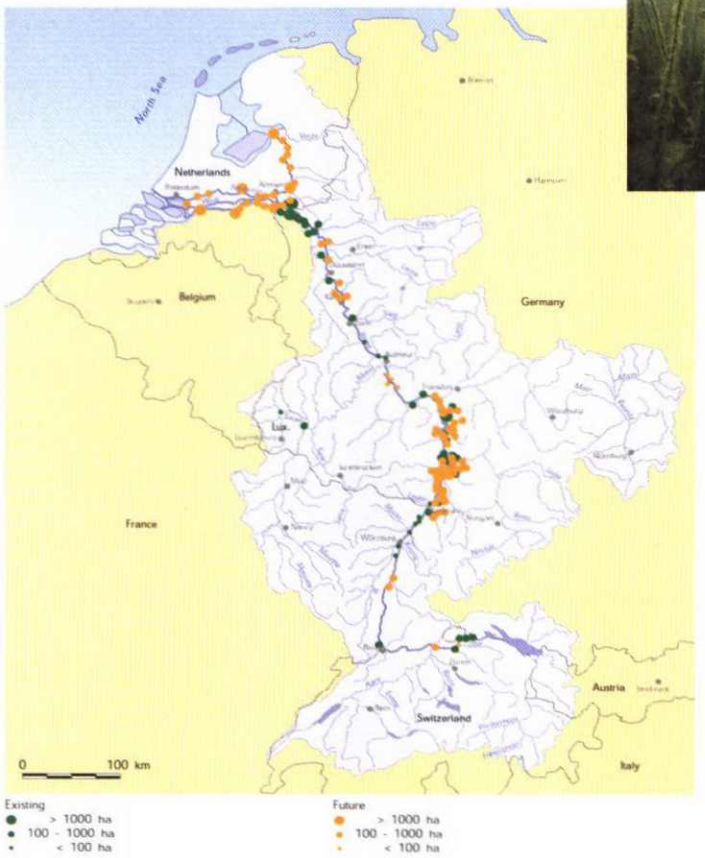
Ecological restoration of the Rhine and its tributaries is an important aim of the riparian states. For many years, improvements in water quality were seen as the main means to achieve this. Now, however, the greatest barrier to the return of many typical river organisms seems to be the lack of sufficient suitable habitat and free migration routes. Attempts are being made to remedy the situation by protecting existing habitats, developing new habitats to replace those lost and developing a coherent network of wildlife areas throughout the entire river basin. In addition, of course, efforts to further improve water quality must still be maintained. Following a survey of the basin's ecologically valuable areas, conducted under the auspices of the ICPR, work is now going on at national level to protect and develop wildlife areas and link them up to form an ecological network.

♦

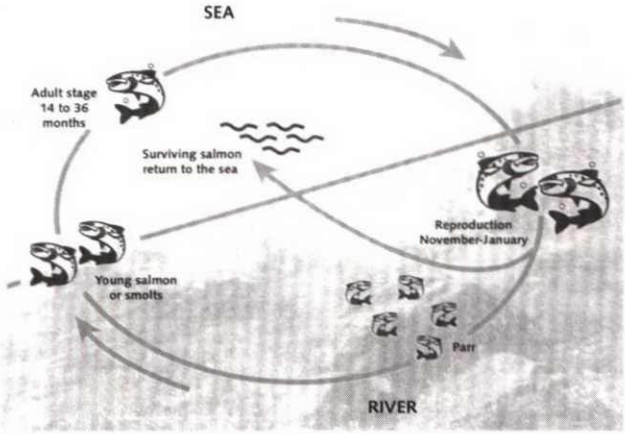
Nature conservationist:

"Some of the natural features which currently survive are extremely sensitive to changes in water or land management. Decreasing the intensity of management to develop new wildlife areas may actually endanger these old features of the ecology."

♦



↑ Stepping stones in the masterplan to rehabilitate the Rhine ecosystem



↑ The life cycle of the salmon

Angling organisation:

"Our dream is that the Rhine and its floodplains will one day offer a welcoming environment for recreational anglers. The area is open and easily accessible for all forms of recreational fishing all year round. The permits are unambiguous. Holders of fishing rights are the contact point and consultation partner for government bodies and management authorities in the area. Access is determined in consultation with angling organisations. After all, we are all concerned to protect nature. A diverse landscape is the best setting for sustainable angling. Access and development tailored to the location, not the same everywhere. Fish stocks vary from place to place and proper management is necessary to preserve that diversity and maintain the conditions for sustainable use."

Scientist:

"Fish stocks and the fishing industry in the Rhine and its branches have evolved over time: in the nineteenth century they provided a source of food and economic activity; in the 1970s, they acted as a water quality indicator; now and for the future they supply evidence of high environmental quality and serve as a popular form of recreation."

Fisheries

Over the first eighty years of the 20th century, deteriorating water quality, river training and over-fishing caused major declines both in fish stocks and in the fishing industry in inland waters. Since then, however, water quality has improved greatly and most of the original fish species have now returned to the Rhine. The inland fishing industry now relies mainly on catches of eels and is still shrinking due to the serious decline in the numbers of young eel entering the Rhine from the sea since the early 1980s.

By contrast, recreational fishing has increased considerably over recent decades. Recreational anglers have always varied widely in terms of the type of satisfaction they derived from their sport. Nevertheless, a clear shift is now perceptible from the simple desire to catch as many and as large fish as possible to an appreciation of a wide range of species in a more natural environment.

In fisherie policy there is also an observable change taking place from sector-by-sector policies to an integrated approach. The industry is currently working on the principle of the sustainable maintenance of fish stocks (an ecological aim) to serve the interests of the fishing industry (a utilitarian aim). In the Netherlands, it is now compulsory to establish fish stock management committees within which commercial and recreational fishing interests can cooperate, with advice from local water managers and nature conservationists.

To ensure that migratory fish can once again reach their spawning grounds, fish passes need to be constructed in certain places, not just in the Rhine but also in its dozens of tributaries and branches. And wherever possible river banks must be designed in a wildlife-friendly way. Salmon need new gravel bottoms where they can lay their eggs. Different zones need to be created: places with rapid water flow alternating with sheltered areas where the fish can lie up. It is vital that the Rhine and its tributaries should provide a good habitat not only for larger wildlife like waterfowl and predatory fish but also for smaller life-forms like insects and plankton.

Agriculture

Agricultural land use is an important element in the chain of rainfall — runoff relations in the Rhine basin. Investments in land drainage, external water supply and large-scale use of biocides and fertilisers have increased agricultural production. Land drainage has created a faster response of runoff to rainfall, increasing flood risks. Increased use of biocides and fertilisers has led to the pollution of water systems.

Since society now demands sustainability, high water quality standards have been set and these are driving environmental improvement in agricultural production systems. Farmers want to meet the demands of society by combining their role in food production with other functions in areas like nature restoration and conservation. The sector sees this multifunctional role as the preferred future for agriculture in the Rhine basin. Agriculture will be to some extent small in scale, low on external inputs and labour-intensive. The availability of land is expected to be a limiting factor.
Where water is concerned, agriculture will help to reduce land erosion, conserve water by reducing artificial drainage (restoring the sponge function of the soil) in higher places and enhance flood protection through (temporary) controlled inundation. Agriculture will adapt itself to the environment, rather than adapting the environment to the farming system.

♦

Farmers' organisation:

European farmers and their cooperatives want to respond to the expectations of society and exploit our main natural resource to provide vital food supplies in a sustainable way, offering added value to both rural and urban dwellers.

♦

Products will be identified in the retail chain as high quality goods produced in a healthy and environmentally responsible manner and the consumer will be prepared to pay for this increased quality.

However, this multifunctional role can - according to the sector - only be fulfilled if agriculture is protected by the government. If the European Union were to continue the expansion of international free trade in the agricultural sector, farmers would find it extremely difficult to obtain a return from the market and to be multifunctional. Another threat to the competitiveness and multifunctionality of agriculture in the Rhine basin is the expansion of the EU towards the east, where conditions for agriculture are much better than in the Rhine basin.

Alongside the market for high quality agricultural products, there will remain one for cheap bulk food production. Technological innovations and genetic engineering will lead to further increases in food production per hectare. It is claimed that genetic engineering will reduce the use of pesticides and herbicides (though it is uncertain whether the consumer will embrace this new step in agriculture).

This high technology agriculture will be confined to a few designated production areas. Production factors will be optimised. Emphasis will be on closed systems and (where necessary) purification of drainage water. This type of agriculture will produce cheap food.

♦

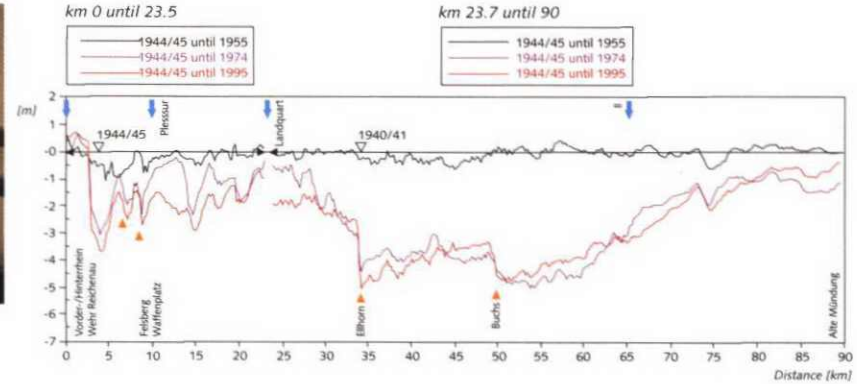
Scientist:

"Diffuse pollution by agricultural nutrients and pesticides will remain one of the greatest threats to water quality throughout the Rhine basin. None of the Rhine basin countries has adequate government policies to deal with this problem."

♦

↑ Diffuse pollution by agricultural nutrients

↑ Irregation



Extraction of minerals

Gravel extraction company employee:

"Balanced extraction of sand and clay from deposits in the lower reaches of the river may help to solve flood problems as well as provide a renewable source of minerals".

Activist:

"Opencast coal mining in the western part of Germany may in the long run have devastating effects on ground water levels in the southern Netherlands. Hardly any attention is being paid to the problems which may arise from this phenomenon".

The extraction of minerals such as gravel, sand, basalt and brown coal (lignite) is absorbing increasing amounts of scarce land throughout the Rhine basin. Gravel, sand and clay are mainly being taken along the river, where they have been deposited in the past. Their extraction produces gaping holes which affect the value of the landscape around the river. Although extraction is by definition unrenewable. The resources available are insufficient to meet the present demand for construction materials and there is also increasing extraction of sand and gravel from the North Sea.The extraction of other resources like brown coal, basalt and marl does not affect the river directly, but does cause major local declines in water tables.

The gravel dredger:

"As a member of the public, I can see why the extraction of gravel should be limited to protect the natural landscape of the river basin and even to encourage the development of wildlife. On the other hand, over the last few years we have developed plans for the areas where we want to remove gravel. We are increasingly focusing on types of secondary gravel removal which take account of other needs. Even so, I wonder how far public authorities can and should go in subordinating the legitimate commercial interests of an industry like ours to those of other players."

↑ Opencast coal mining

↑ Sand extraction holes

↑ Change in elevation of the river bed in the Alpine Rhine over the period 1941-1995

3 System Description

Countries in the Rhine basin

Just over 95% of the Rhine basin lies in Switzerland, Germany, France and the Netherlands. Some features of these countries are discussed below. The remaining 5% of the basin lies in Belgium, Luxembourg, Austria, Liechtenstein and Italy.

Switzerland

The Rhine rises in Switzerland. The capital city of Switzerland is Berne and the largest city is Zurich. The population of the country is approximately 7.2 million. Official languages are German, French, Italian and Romansch. Switzerland is one of the most mountainous countries in Europe. Long valleys and gorges contain numerous lakes and rivers. The Rhine and its tributaries form the principal river system. Water power is the chief natural resource. Switzerland has a well-developed industrialised economy and one of the highest standards of living in the world. Switzerland is also a major international financial centre. Politically, the country is a republic in which the people vote for their representatives and decide important issues by means of referendums. It is composed of a confederation of 23 states, called cantons. Switzerland is not yet a member of the European Union.

Germany

The capital of Germany is its largest city, Berlin. The country has a population of approximately 82 million and is highly urbanised. The official language is German. There are three major geographical regions: a lowland plain in the north, an area of uplands in the centre, and a mountainous region in the south. Germany's most important river is the Rhine, which forms part of its border with France. The country has one of the strongest economies in the world, dominated by the manufacturing sector. The head of state is a president elected for a five-year term by a Federal Convention. The parliament consists of two houses: the Federal Council, which is chosen directly by the people, and the Federal Assembly, which is chosen by the state governments. After World War II the country was divided, but in 1990 East and West Germany were reunited. Germany is one of the largest countries in the European Union.

France

The capital and largest city of France is Paris. The population of the country is approximately 59 million. Most of the people live in urban areas. The official language is French. The main geographic features of the country are mountain ranges on the southern and eastern side, a south central plateau and an extensive plains region, consisting of gentle lowlands and fertile river valleys. The west side of the Rhine basin is largely bordered by the mountainous area of eastern France. In recent decades France has become increasingly industrialised, although its commercial sector is still characterised by a preponderance of small, privately owned shops. Most of France's electricity is generated by nuclear power. The country has one of the most highly developed transport systems in Europe. Politically, France is a presidential republic. The French parliament consists of the National Assembly and the Senate. France is one of the largest countries in the European Union.

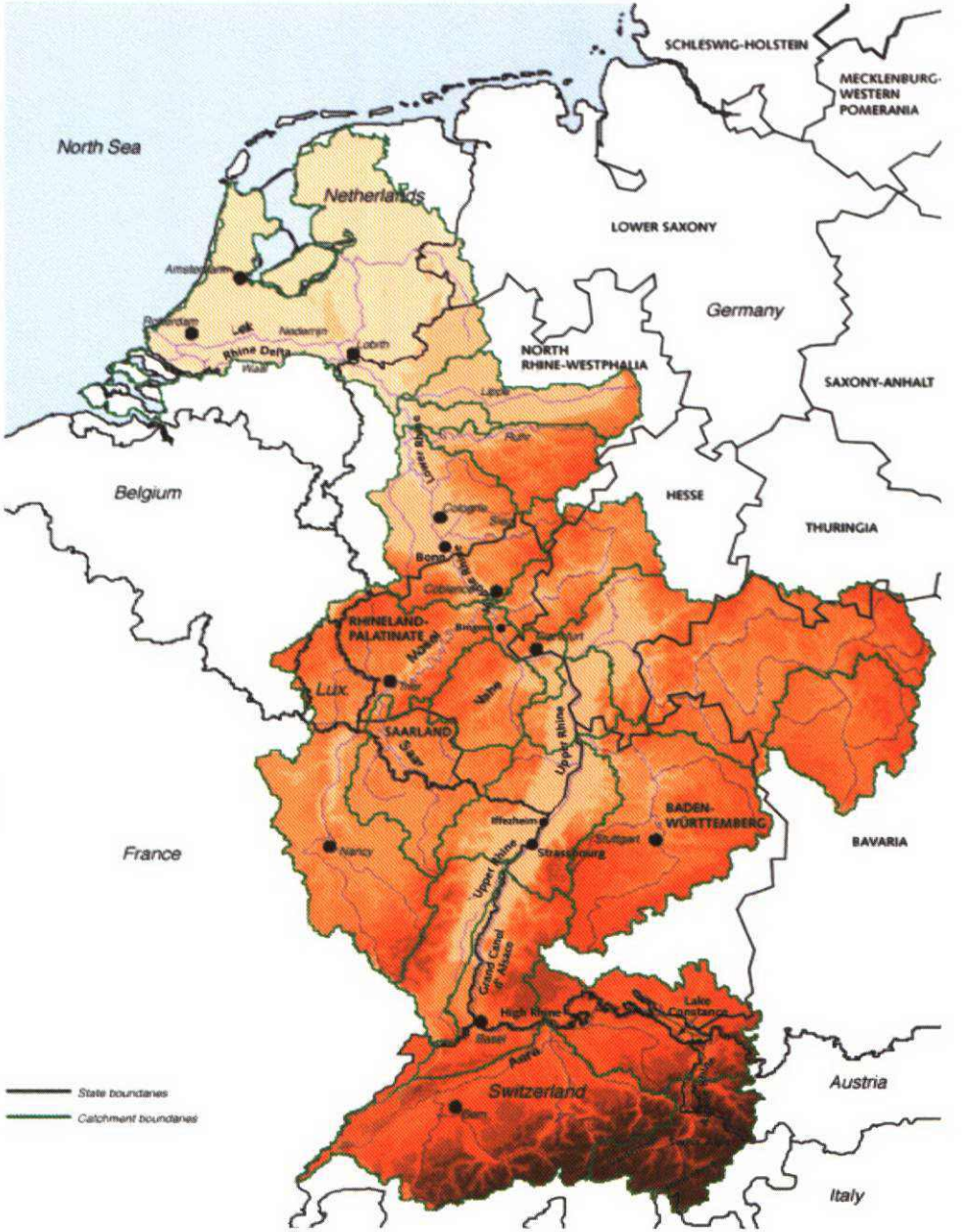
The Netherlands

The Netherlands are also known unofficially as Holland. Its capital and largest city is Amsterdam. The population of the Netherlands is approximately 16 million. Some 89% of the people live in urban areas. The official language is Dutch. The Netherlands is a low-lying country, about half of which is below sea level. The land is protected from the sea and rivers by dunes and systems of dikes, dams and locks. It is kept dry by continuous mechanical pumping. Major rivers are the Rhine, Meuse and Scheldt, which form a delta covering much of the country. Trade is an essential part of the economy. Goods flow into the ports of Rotterdam and Amsterdam, where canals and rivers provide easy access to the interior of Europe. After World War II, industrial production became more important. The port of Rotterdam became a leading centre for refining petroleum and expanded to become the largest sea port in the world. The Netherlands is a constitutional monarchy with a bicameral parliamentary system of government. It is one of the largest in the group of small countries in the European Union.

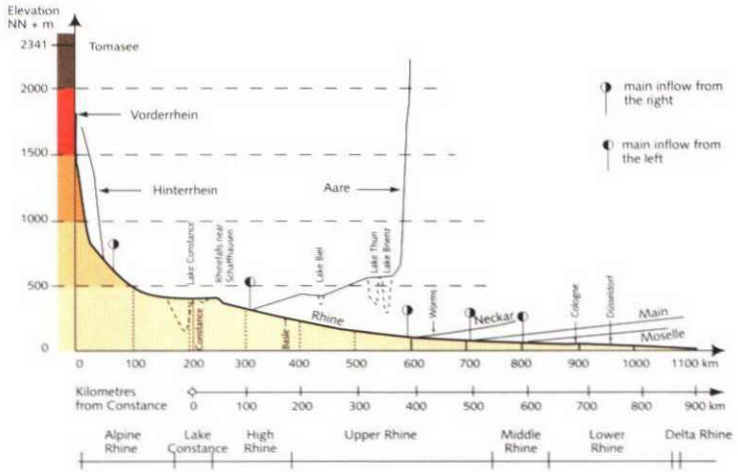
River Rhine

Alpine Rhine and High Rhine
The Rhine has its origins in the Swiss Alps, where two tributaries (the Hinterrhine and the Vorderrhine) join together at Reichenau and flow as one river to Lake Constance. This part of the Rhine is called the Alpine Rhine. After leaving Lake Constance, the river down to the city of Basle is known as the High Rhine. Along these parts of the river - which also include the famous falls at Schaffhausen - frequent inundations, large sediment depositions and the shifting of watercourses have time and again endangered human life. Local measures were often unsuccessful, but large scale engineering works provided a solution for many of the problems when the Alpine and High Rhine were regulated and provided with a stable and regular bed. Many dams have been built, mainly for electricity generation. The largest tributary of the Rhine, the Aare, joins the main stream in the High Rhine.

Upper Rhine
The reach of the river between Basle and Bingen at the Rhenish Slate Mountains is called the Upper Rhine. This part of the Rhine was originally wide and dynamic, consisting of multiple channels and meanders. Eventually, the river was regulated, mainly to stop frequent flooding. The channel was fixed between dikes and ten weirs were constructed to utilise water power. The first four of these were located in a specially constructed channel alongside the Rhine, the Grand Canal d'Alsace. After the reconstruction of the Upper Rhine, navigation with large ships became possible up as far as Basle.
The weirs have interrupted sediment transport. To compensate, gravel is added to the river downstream of the last weir at Iffezheim to stabilise the river bed.



Composed map of the Rhine basin



↑ Longitudinal section of the Rhine and main tributaries

The length of the Rhine in kilometers compared with that of other great rivers.

Nile	**6,650 km**
Amazon-Ucayali-Apurimac	**6,400 km**
Yangtze	**6,300 km**
Mississippi-Missouri-Red Rock	**5,971 km**
Volga	**3,530 km**
Danube	**2,850 km**
Rhine	**1,320 km**
Meuse	**935 km**
Rhône	**812 km**

Middle and Lower Rhine

Where the Rhine tries to find its way through the Rhenish Slate Mountains, the river is known as the Middle Rhine, and the following stretch down to the German-Dutch border is called the Lower Rhine. The bed of the Middle Rhine is mostly rocky. In the past, the stretch presented dangerous obstacles to shipping and claimed numerous victims. The great tributaries have now been regulated with weirs and power stations with locks. Along the Lower Rhine, flood protection has become a top priority as land and river bed subsidence has increased the danger of flooding. Subsidence has also had negative effects both on shipping and on ground water levels and the ecology. River engineering measures have been taken in an attempt to combat subsidence. It has recently been halted but parts of the main dikes have had to be raised several times.

Delta Rhine

At the German-Dutch border, the Rhine changes from an erosion to a sedimentation river, meaning that the Rhine Delta lies almost totally in the Netherlands. Just after entering the country, the river splits into three river branches : the Waal, the Nederrijn and the IJssel. About half of the Netherlands lies below sea level and is therefore dependent on a comprehensive, planned water management system. The land has been protected by dikes ever since the 11th century. The first measures to regulate the discharge through the three branches of the Rhine were taken in the 19th century. Most water is discharged through the Waal. During much of the 20th century, protection against the North Sea was the main focus in the field of Dutch flood prevention but this has now changed as a result of the severe flooding along the Rhine and Meuse in 1993 and 1995. Measures are now planned to increase the discharge capacity of the river bed.

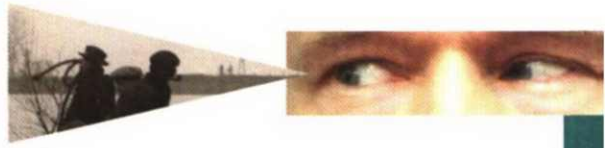
Rainfall, discharge and erosion:

Annual rainfall in the Rhine basin is more or less evenly distributed throughout the year. Most of the precipitation (as much as 70% in summer) falls in the Alpine Rhine region. Due to high runoff and sharp differences in altitude, the Alpine Rhine is a wild and meandering river.

Average annual discharge into Lake Constance is 250 m^3/s. The average discharge of the Rhine at the Dutch-German border is 2300 m^3/s, with a record peak discharge of 12,600 m^3/s (1926) and a record low discharge of 620 m^3/s (1947).

The maintenance of the navigation channels is becoming more difficult in the Lower Rhine because of the continuing erosion of the river bed and the subsequent decline in the water level, amounting in some places to as much as 2 metres over the past decade. As a result, access to harbours and secondary waterways is becoming difficult. Maintenance dredging is needed to keep the profile in shape for shipping.

At the point where the Rhine leaves Lake Constance, it carries an average annual sediment load of 3 million m^3. One third of this reaches the North Sea. The rest is deposited in the rivers.



4 Lessons learned

Introduction

In order to plan for the future, we must learn from the past. Over the last two hundred years, the rivers in the Rhine basin have faced an unprecedented series of threats: industrialisation, regulation and canalisation, construction of barriers, rapid population growth, the confining of their floodplains, water pollution, habitat destruction, etc. Potential future threats include dramatic climate changes. In retrospect, the solutions adopted may not always have been effective. Some may even have increased the problems (for example, engineering measures to prevent flooding). Since the late 1960s and early 1970s, the situation has started to improve. Many successful measures have been taken to restore the river. Nowadays the Rhine faces fewer problems than in the past.

Useful lessons can be learned both from the mistakes of the past and from management and restoration operations that have proved successful. These lessons can be of inestimable value in developing a vision of the river's future. Even though the Rhine is unusual in being located in a particularly densely populated and industrialised area with a large degree of manipulation of water systems, other people and rivers may profit from these experiences. Countries with river basins still facing rapid economic development may be able to combine that economic development with the wise use of water systems and preservation of valuable ecosystems. Countries grappling with a degree of pollution comparable with that in the Rhine 20 years ago may find inspiration in the rehabilitation achieved in the case of the Rhine.

This section contains a retrospective survey of successes and failures in the history of the Rhine and Rhine basin water management. What lessons can be learned from the mistakes of the past and from successful operations to put them right or prevent their recurrence?
The next few pages contain a chronological table of major events in the history of the Rhine and international cooperation in water management.

The Rhine since 1800

The history of the Rhine over the last two hundred years (illustrated by the chronological table on pages 34 and 35) includes a number of milestones which demonstrate the changing nature of the problems facing the river. Recognition of the importance of international cooperation in tackling the problems of the Rhine basin dates back to the early 19th century. Its emergence was clearly signalled in 1815, when the Central Commission for the Navigation of the Rhine ensured freedom of navigation on the Rhine. In 1900, a committee was founded to regulate salmon fishing in the river, but only a few decades later, large dams and pollution had completely eliminated the species from the Rhine. Pollution also made it increasingly difficult to extract drinking water of acceptable quality from the river. In 1950 the International Commission for the Protection of the Rhine (ICPR) met for the first time to define structural improvements in water quality. In the initial decades of its work, it invested much time and effort in the improvement of water quality. This process was rudely interrupted by the Sandoz disaster in 1986. Since then, more attention has been paid to the ecological restoration of the river and its floodplains. Over the last decade, a series of river floods and flood threats has made flood prevention an urgent item on the international agenda.

↑ Salmon caught in the Upper Rhine

↑ Dike breach on the Linge, Delta Rhine, in 1809

← Schaffhausen falls

Major events in the history of the Rhine and water management

1800 — 1850 — 1900 — 1925 — 1950 — 1960

International political and societal events

1816
First meeting of the Central Commission for the Navigation of the Rhine (CCR)

1868
Mannheim Convention guarantees free navigation on the Rhine and its branches between Basle and the North Sea

1885
Salmon Treaty

1892
State treaty between Switzerland and Austria, foundation of the 'Internationale Rheinregulierung' organisation to regulate the Alpine Rhine

1950
Switzerland, France, Luxembourg, Germany and the Netherlands create a common forum for water pollution questions: the International Commission for the Protection of the Rhine against Pollution (ICPR), founded in Basle on 11 July 1950

1956
International treaty for training the Moselle river

1961
Establishment of the International Commission for the Protection of the Moselle and the Saar (France, Luxembourg and Germany)

1960
Convention for the protection of Lake Constance (Austria, Liechtenstein, Switzerland and Germany)

Major infrastructure measures in the Rhine and its tributaries

1817
Start of river regulation works on the Upper Rhine by Tulla

1830
Start of river regulation works on the Main

1832
Start of river regulation works on the Alpine Rhine

1866
First hydropower dam in the High Rhine at Schaffhausen (Moser dam), electricity generation for a cable car across the Rhine, start of canalisation of the High Rhine

1880
Start of river regulation on the Middle and Lower Rhine

1897
Start of construction of the first major hydropower station at Plessur in the Alpine Rhine

1898
First major turbine hydropower station (Rheinfelden) goes into operation in the High Rhine

1906
Further regulation of the Upper Rhine by Honsell

1920
Start of regulation of the Neckar (Germany)

1927
Start of the construction of the Grand Canal d'Alsace

1932
- First weir for electricity generation in the Upper Rhine at Kembs, start of canalisation
- Closure of Zuyder Zee, creation of Lake IJssel (NL)

1934
Completion of regulation of the largest part of the Rhine Delta

Events and situations

1808
Start of systematic water level monitoring in the Rhine at Basle

1816
First steamship arrives at Cologne

1852
One of the worst floods ever experienced in central Switzerland

1867
Current measurements at Basle by an international team of experts

1868
Epidemic of cholera and typhus in Zurich and floods on the Alpine Rhine

1869
First limnographic station in Switzerland, Rhein-Basel Schiffländе

1876
Catastrophic flooding in northern and eastern Switzerland

1882
Catastrophic floods in the German section of the Rhine

1910
- Catastrophic flooding on the north side of the Alps
- Water quality monitoring: sampling 8 times per year at 35 locations between Basle and Koblenz

1926
Catastrophic floods in the Rhine Delta

1953
Catastrophic coastal flooding in the Dutch provinces of Zeeland and South Holland, thousands of hectares inundated and over 1800 people drowned

1959
Last salmon caught in late 50s

1963
Signing of the Convention on the Protection of the Rhine against Pollution (Berne Convention): international law on future cooperation.

1970
- Foundation of the International Association of Waterworks in the Rhine river basin (IAWR)
- Establishment of the International Commission for the Hydrology of the Rhine basin (CHR)

1972
- First Rhine ministers conference on pollution of the Rhine (ICPR)
- Establishment of the International Conference on the Bodensee (Lake Constance)

1974
Foundation of the Stichting Reinwater (The Netherlands)

1976
- Signing of the Convention for the Protection of the Rhine against Chemical Pollution
- Signing of the Convention for the Protection of the Rhine against Chloride Pollution (Salt Treaty)
- The European Economic Community becomes a contracting party to the Berne Convention
- European directive on pollution caused by dangerous substances in the aquatic environment of the Community. (Based on this crucial directive, the EU agreed on 7 subordinate directives containing emission limits, water quality objectives and monitoring requirements)

1983
International Water Tribunal (Rotterdam, The Netherlands)

1987
Ministers approve implementation of the Rhine Action Programme

1991
- Publication of ICPR 'masterplan', Salmon 2000
- EU directive on urban waste water treatment
- EU nitrate directive
- Signing of supplementary protocol concerning the Rhine Salt Treaty

1992
First IPCC report (climate change)

1996
- EU directive on integrated pollution prevention and control (IPPC)
- EC Water Framework Directive proposed

1998
Rhine Ministers approve action plan on flood prevention

1999
Signing of a new Convention for the Protection of the Rhine integrating water quality, quantity and ecological issues

2000
50th anniversary of the ICPR

1970 **1980** **1990** **2000**

1970
Completion of Haringvliet Dam as part of the Dutch Delta Project

1977
Last weir for electricity generation in the Upper Rhine at Iffezheim, canalisation of the Upper Rhine complete

1988
Start of flood retention measures in the Upper Rhine, floodplain restoration and improvement of the ecological situation

1969
Major fish mortality in the Rhine due to spill of endosulfan

1970
- Start of artificial sediment supply to mitigate erosion in the Rhine
- Catastrophic flooding in the German section of the Rhine

1971
Rhine water quality at one of its worst levels ever, deoxygenation and chemical spills

1976
Extremely low Rhine discharge

1978
Catastrophic flooding in Switzerland: 9 deaths

1983
Catastrophic floods in the German section of the Rhine

1986
- 1-11-1986, Sandoz fire (Basle, Switzerland) causes environmental disaster
- Introduction of six-unit multiple barge sets on Rhine

1987
Catastrophic year in Switzerland: natural disasters include multiple flooding

1988
Catastrophic floods in the German section of the Rhine

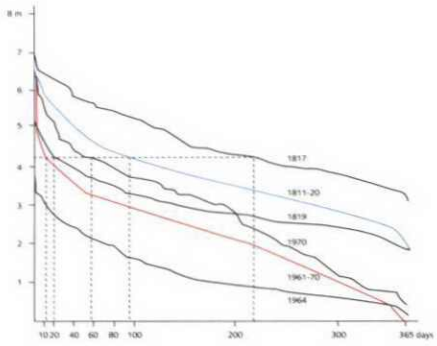
1990
Catastrophic floods in the German section of the Rhine

1993
Catastrophic floods in the lower section of the Rhine

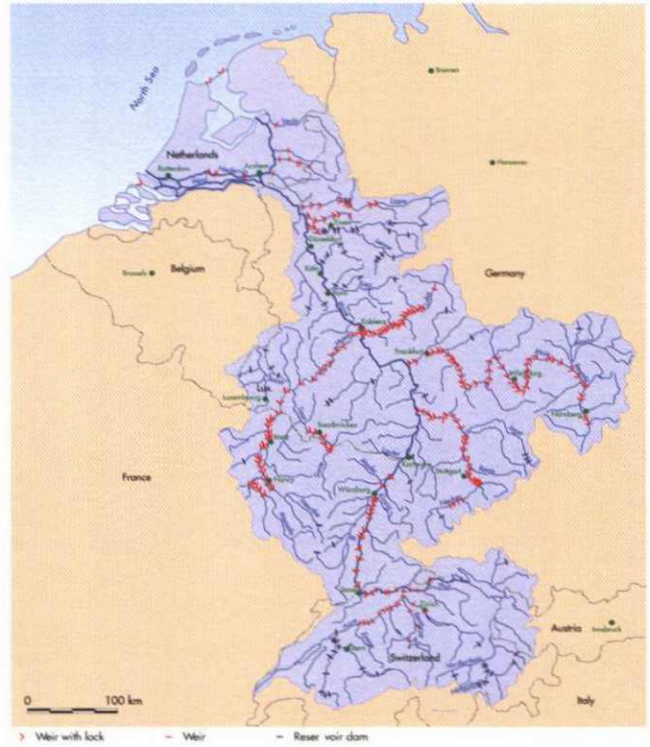
1994 / 1995
Catastrophic floods in the upper and lower sections of the Rhine

1997
First salmon caught at weir at Iffezheim (700 km from the sea)

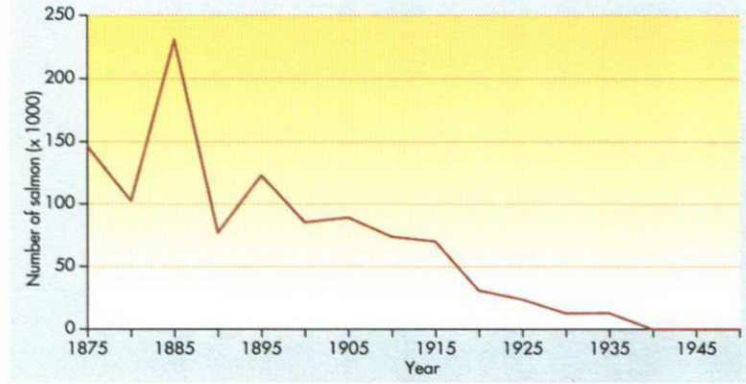
1999
Catastrophic winter and spring in Switzerland, extreme snowfall causes avalanches and flooding, with highest water levels in over a century



↑ Typical water level duration curves before and after river training measures near Erfelden



↑ Obstacles in the Rhine basin



↑ Decrease in salmon catches

Flood problems

Flood problems are as old as the Rhine itself. Heavy rainfall or sudden snow melts have always caused high water levels in the Rhine basin. In former centuries, the formation of ice-walls posed a serious risk in winter. Although the regulation of the rivers in the 19th and 20th century has considerably reduced the risk of ice-walls, human activities on and around the river have hugely exacerbated the adverse impact of higher water discharges. Huge changes in the course of the river and the river bed due to canalisation, the increased use of the whole river basin, erosion, urbanisation and changes in water management have seriously increased the risk of flooding in the Rhine area. At the same time, more and more people and businesses have settled in endangered areas, thus increasing the potential damage resulting from high water levels. In 1993 and 1995, exceptional floods afflicted the middle and lower Rhine areas. Many cities along the Rhine and Moselle were again flooded. In 1995 dikes were at risk of bursting in the Netherlands. As a precaution, several hundred thousand people were evacuated. Damage was estimated at several billion euro.

River "corrections"

To enable the use of alluvial areas for agriculture and other purposes, to improve shipping conditions and to reduce the risk of the formation of ice-walls in winter, the course of the river was drastically changed in the 19th and 20th century. As a result, the length of the river between Basle and the border of Hessen was reduced by almost 20% (80 km). Meanders and alluvial areas were cut off, causing great changes in the river ecosystem. The flow velocity was increased, leading to erosion of the river bed and a consequent drop in the level of both river water and ground water.

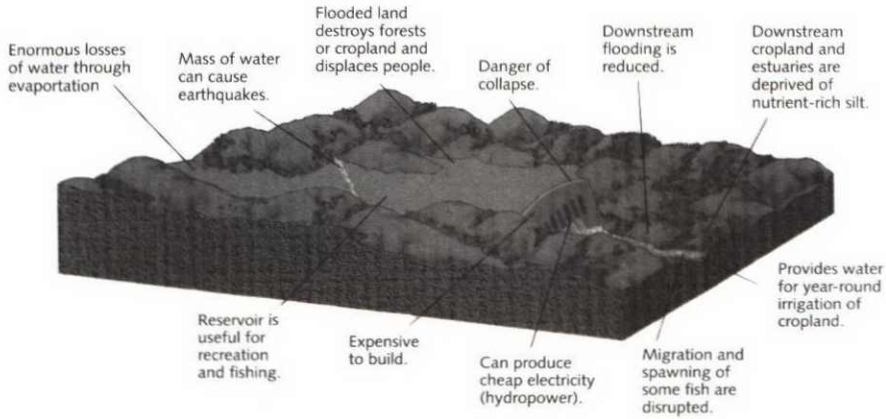
The drastic reduction of the floodplain area led to a sharp increase in the risk of flooding. Nowadays only 15% of the Rhine's original floodplains remain, and only 8% of its typical floodplain forests are left. As a further consequence, many populations of plants, birds, mammals and other animal species have been wiped out or greatly reduced.

To serve functions like shipping and power generation, over 450 dams and weirs were constructed in the Rhine and its tributaries. These physical barriers made it almost impossible for the most important fish species in the Rhine, such as the Atlantic salmon, to reach their spawning grounds. Catches of Rhine salmon declined steadily, from more then 280,000 around 1870 to zero in 1959. Many other migratory fish species suffered the same fate.

Necessity is the mother of invention

In the past, decisions have often been taken in the immediate aftermath of a flood disaster to increase the height of dikes in order to reduce the risk of repetition.

It was eventually realised that this approach could not be continued indefinitely, since the continuing deposition of sediment in and along rivers in the Rhine Delta inevitably causes the river beds to rise in relation to the surrounding polders. Alternative solutions had to been found and these needed to pay more attention to aspects of river management other than pure flood prevention.



Integration

The whole exceeds the sum of the parts

It is preferable to take an integrated approach to hydraulic design and management measures, with choices being made on the basis of a full consideration of all the social and other functions of the water system and all the associated interests, as well as all the properties of the water system itself, the quality and quantity of the water and the relationship between its different parts.

The river is part of an overall catchment area. Local measures like dike-building, regulation of the summer bed and dredging out of the main channel increase the speed at which peak discharges travel down the river and produce more serious flooding downstream. To prevent this, plans are needed which encompass the entire river basin. Land use is reflected in discharge levels. In recognition of this fact, legislation was passed over a century ago to limit deforestation in Switzerland and southern Germany. In Switzerland this took place in 1876 and was the result of a series of extreme events throughout the Swiss mountain region between 1860 and 1875.

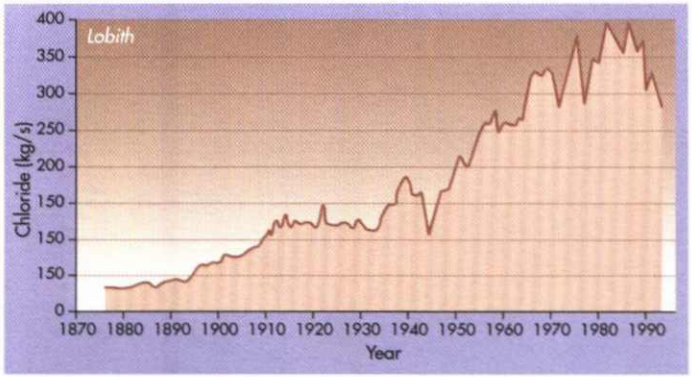
The long-term effects of flood control measures in the Rhine are often substantial. The benefits in terms of reducing flood damage may ultimately be completely negated by more intensive use of the winter bed (expansion of urban areas, industry, agriculture, etc.). This process may be accelerated by erosion (in the higher part of the basin) and sedimentation and by subsidence (in the lower part of the basin) due to drainage, so that flood control measures have to be constantly stepped up almost from the beginning.

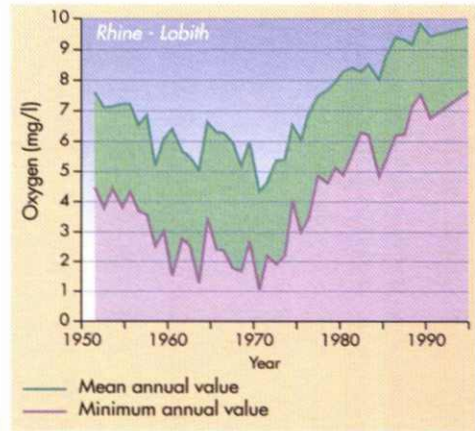
For this reason, it is desirable to produce the best possible advance estimate of potential long-term effects by including in the analysis the possible consequences both for physical planning and for all the various interests involved. It will then be possible to plan any necessary complementary physical planning measures or to modify the intended river works.

Over recent decades, farmers have increased their productivity through technical innovations and better management of farm inputs. Industrialisation has raised the general standard of living and mechanisation has been introduced to prevent the economic marginalisation of the agricultural community and reduce the number of farm workers. In areas with shallow ground water tables, the use of farm machinery requires lower water tables in the spring (trafficability), but this increases the risk of drought damage in summer and the demand for (often external) water supplies to prevent it. Because of the negative impacts on wildlife and the countryside, this "engineering" of the local environment by the agricultural sector is attracting more and more public criticism.

There is a particular problem where water tables are lowered in peat soil areas (mainly found in the Netherlands). The measure initially increases the productivity of land by producing a longer growing season and enhanced fertility due to oxidation of the soil material. However, this in turn results in lower land levels, requiring water tables to be lowered further until all the peat material has eventually been oxidised.

↑ Advantages and disadvantages of large dams and reservoirs





Water quality

Water quality problems in the Rhine were recognised as far back as the 15th century, but it was not until the 1950s that the deteriorating quality of the river became universally apparent (people downstream had already been worried about the water quality in the 1930s) when the pollution of the Rhine with organic substances led to acute deoxygenation of the river.

Water quality was also being greatly reduced by the discharge of (untreated) waste water from industries, agriculture, households and traffic. Large amounts of toxic compounds such as heavy metals, pesticides, hydrocarbons and organochlorine compounds were being discharged into the river, causing severe ecological problems, deterioration of water quality and pollution of sediments. The production of good quality drinking water was increasingly difficult and by the end of the 1960s the Rhine had the doubtful reputation of being the sewer of Europe.

Between 1970 and 1985, successful action was taken to reduce inputs of polluted municipal and industrial waste water and between 1970 and 1990 more than 40,000 million Euro were invested in the construction of communal and industrial treatment plants. As a result, the quality of the Rhine water slowly improved. Oxygen levels rose steadily and some improvement could be observed in the situation with regard to pollutants, even though efforts were concentrated at this time mainly on "end-of-pipe" techniques involving the treatment of waste water rather than preventive measures.

Severe water quality problems were also caused by accidental pollution. Many industrial complexes are located directly on the banks of the river and enormous amounts of dangerous substances are transported over the Rhine every day. The Sandoz accident of 1986 clearly illustrates the disastrous impact that accidental pollution can have on the whole river: on that occasion, a fire in a Swiss factory producing chemical and pharmaceutical products sent 20 tons of organophosphors (precursors of insecticides) flowing into the river. This extinguished almost all life in a 15-kilometre stretch of the river downstream of Basle (400 tons of dead fish were collected) and affected fauna down as far as the confluence with the Moselle.

↑ The chloride load of the Rhine at Lobith on the Dutch-German border

↑ Oxygen content

↑ Waste in surface water

Prevention is better than cure

A genuinely integrated approach to water management requires consideration not only of different locations and measures, but also of different time-scales. It must look to the future and remember that prevention is better than cure. After all, it always takes more time, expense and effort to correct mistakes once they are made than to avoid them in the first place - and they can never be completely corrected anyway. On the other hand, it is true that accidents often produce the necessary momentum and support to achieve within a short time progress which would otherwise have taken many years. Skill in exploiting these opportunities is a useful quality when managing a river system.

Sluices

An example of the huge impact the construction of sea defence measures can have on the estuary of a river has been provided by the construction of the Volkerak dam (1969) and Haringvliet dam and sluices (1970) in the south-west of the Netherlands. Part of the Delta Project, these two major engineering works had the effect of cutting off from the sea the Haringvliet and the Hollandsch Diep (the waters into which the Waal and the Meuse discharge). Sluices were incorporated in the Haringvliet dam to allow a proportion of the water to be discharged directly into the North Sea on the ebb tide, while the rest is diverted through Rotterdam via the New Waterway. The result of the engineering works and the initial sluice management regime has been the formation of a fresh water 'reservoir' and the consequent elimination of both the tidal action and the gradual transition between salt and fresh water in the Haringvliet/Hollandsch Diep area. In addition, the dam bars a major fish migration route. In the mid-1990s investigations were carried out concerning the feasibility of operating the Haringvliet sluices in such a way as to restore part of the natural transition between the sea and the river while still preserving the possibility of extracting fresh water for drinking water production (begun after the construction of the dams and sluices). A decision about the future management of these sluices will be taken in 2000.

Polluted sediment

The sediment in the river floodplains of the Rhine Delta and deposited behind weirs and dams upstream is more or less seriously polluted by toxic compounds such as heavy metals, PAHs, PCBs, pesticides, etc. Sediment contamination leads to the loss of species (reduced biodiversity), the disruption of normal processes in the soil and sub-optimal populations and ecological communities.

It also reduces the environment's ability to withstand stresses, especially when faced by a combination of stress factors such as flooding, severe winters, eutrophication, salinity, etc. Both laboratory experiments and circumstantial evidence in the field suggest that these threats are real and their implications are serious enough to be worth taking seriously. Evidence of the problem includes: the disappearance of the otter, reduced breeding success of several bird species, and reduced species diversity and small numbers of individuals in various macrofauna communities.

The cost of a total clean-up of polluted sediments throughout the basin are huge. In the Netherlands, it is estimated that action through to 2010 to clean up the most severely polluted sediment will cost over 300 million euro.

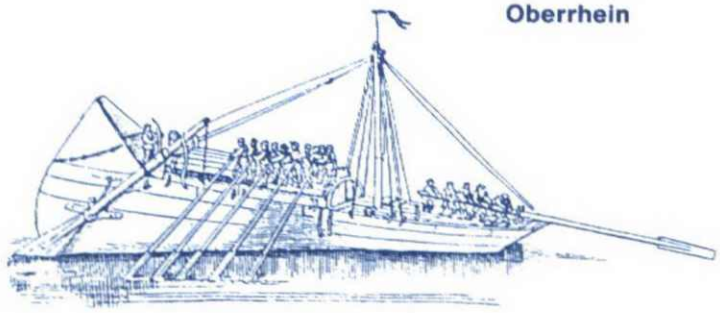
Agriculture

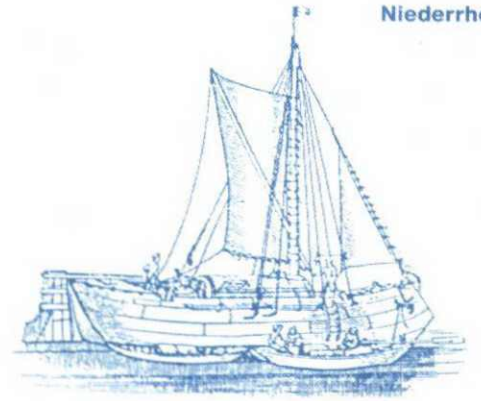
Polluted sediment in the Rhine basin is not the only legacy of unbalanced water management in the past. Drainage water from farms is polluted by intensive agricultural practices since excess rainfall not taken up by crops discharges to ground and surface water, carrying with it excess farm inputs. The intensification of agriculture for the sake of increased productivity has therefore had the side-effect of polluting ground water and surface water. This not only prevents the use of these resources for other purposes, such as drinking water and recreation, but also poses a threat to aquatic life. The impact is serious because agriculture is the major function of rural areas.

↑ Otter

↑ Dredging of polluted sediments

↑ The first closure of the storm surge barrier in the Rotterdam Waterway, May 1997





Strength in unity

The International Commission for the Protection of the Rhine (ICPR)

During the 1970s and 1980s there was a rapid growth in the number of non-governmental organisations (NGOs) representing different categories of stakeholders. These have played a major role in the development of policy in many fields. Over the years there has been a growing conviction among civil servants and politicians that stakeholders should be involved in the development of policy. In this way, stakeholders can indicate their wishes at an early stage of decision-making, making it easier to arrive eventually at a policy which enjoys wide support.
It is therefore logical that stakeholders - often represented by international NGOs - have over recent years been admitted to the meetings of international organisations like the ICPR. The experience both of the members of the commission and the NGO representatives has been very positive.

During the 19th century, it was cooperation between the riparian states that led to free and unimpeded navigation on the Rhine. The first meeting of the Central Commission for the Navigation of the Rhine (CCR) took place in 1816 and the first legislation on the subject dates from 1831. The basic principles of the Mannheim Convention of 1868 (freedom of navigation, equal treatment of all vessels and their masters, simplification of customs procedures, etc.) foreshadow the common market measures introduced by the European Community almost a century later. The CCR still exists and the Rhine is now the busiest inland shipping route in Europe.

Problems of water quality, flooding and ecology cannot be solved effectively by individual riparian states acting in isolation. Switzerland, France, Germany, Luxembourg and the Netherlands decided as early as 1950 to cooperate in a new international forum: the International Commission for the Protection of the Rhine (ICPR). A firmer basis for this cooperation was created in 1963 by the signing of the Berne Convention on the Protection of the Rhine against Pollution (to which the European Union also became a signatory in 1976).
The first years of the ICPR's life were dedicated to gaining a common understanding of the problems of the Rhine and creating a legal and institutional basis for cooperation. Joint monitoring programmes had to be developed and it was around 1970 before the first cooperative measures could be taken to protect the river against the effects of organic pollution.

Between 1970 and 1985, successful action was taken to reduce inputs of polluted municipal and industrial waste water. In 1976 the ICPR went further by agreeing an International Convention for the Protection of the Rhine against Chemical Pollution. A very important part of this Convention was the introduction of a system of black and grey lists, intended to reduce the input of dangerous substances. However, up to 1986 the Convention had relatively little impact on the condition of the river. As so often in environmental decisionmaking, it took a serious accident to achieve progress.

↑ Ships from the 16th century

A fire in a Swiss chemical factory in 1986 provided painful proof of the continuing vulnerability of the Rhine ecosystem. The accident, at the Sandoz plant near Basle, sent a host of toxic substances into the river and killed off almost all aquatic life downstream as far as the Lorelei near Koblenz. The disaster triggered a wave of revulsion in all the riparian states. Political awareness was raised and within a very short time no less than three ministerial conferences addressed the issue of Rhine pollution. The result was the Rhine Action Programme (RAP) of 1987. This clearly defined the goals to be achieved by the year 2000:

- the ecosystem of the Rhine was to be improved to such an extent that higher species, such as salmon and sea trout, could once again become indigenous;
- the production of drinking water from the Rhine was to be guaranteed in the future;
- pollution of river sediments was to be reduced to such an extent that sludge could be used at any time for land filling or dumped at sea;
- the North Sea ecology was to be improved.

The implementation of the Rhine Action Programme was highly successful. All along the river, measures were taken to prevent pollution and by 1994 the ICPR could report that most of the reduction targets had already been achieved. The 50% target for industrial sources was almost universally achieved and inputs of many substances were reduced by as much as 90%. Difficulties in implementation are still reported with regard to diffuse sources of pollution (especially agricultural emissions of pesticides and nutrients) and additional measures are now being formulated to tackle these problems. The present state of the river shows that an enormous improvement in water quality has been achieved in a very short time. From being the sewer of Europe in 1970, the Rhine is now one of the cleanest transboundary rivers anywhere on the continent.

Perhaps the most challenging goal of the Rhine Action Programme is to improve the Rhine ecosystem to such an extent that migratory species can return to their spawning grounds and once again become indigenous: this is symbolised by the targeted return of the salmon to the Rhine by the year 2000.
The ICPR decided a range of measures to be implemented in a very short time. The improvement of river water quality was of course a first prerequisite but extensive engineering works were also designed and implemented to enable salmon to return to their spawning grounds. This entailed both the construction of costly fish passages bypassing many physical barriers in the Rhine and its tributaries and habitat improvement measures to restore spawning grounds. At the same time, action was required to create a new stock of Rhine salmon. Salmon eggs were bought and hatched in special fish hatcheries. Thousands of young salmon were released into the river and a behaviour monitoring programme was developed.

The results of this "Salmon 2000 Programme" have been extremely encouraging. Ever since 1990, salmon and sea trout have been returning from the sea to the Rhine and its tributaries, and since 1992 natural reproduction has been recorded. Salmon returning from the Atlantic Ocean can actually migrate upstream as far as the weir at Iffezheim, more than 700 kilometres from the sea. It is estimated that the river has a current population of up to 1000 adult salmon, though it is not known what percentage of these actually spawn. All along the river, people are working to achieve the same goal and have positive results to show for it. In short, the most apparently utopian of the political goals of 1987 seems to be approaching speedy realisation, although it is clear that it will never be possible to return to the situation as it was in the early 19th century (a recovery of up to 2% of the original population is expected).

↑ Olivier, the first salmon in the Upper Rhine after nearly 40 years

↑ Female salmon lays eggs in a sieve

The 1993 and 1995 floods

In 1994 the Rhine ministers decided to broaden the scope of their cooperation to include the quantitative aspects of river management. This decision paved the way for the further integration of qualitative, quantitative and ecological aspects of river management.
The concept of further integration received an extra boost and even more political commitment after the extreme floods in the middle and lower Rhine area in 1993 and 1995. On the basis of the very positive results of the Rhine Action Programme, the ministers involved charged the ICPR with the development of an international action programme for the management of flood problems. The proven spirit of cooperation between the riparian states and the efficient, holistic and programmatic approach adopted by the ICPR were expected to produce similarly impressive results with regard to reducing international flood problems.
By the end of 1995 the ICPR had agreed an initial international strategy for the management of flood problems and in early 1998 an overall Action Plan on Flood Defence was decided by the 12th Ministerial Conference on the Rhine. This Action Plan defines targets and measures to reduce flood damage in the Rhine area. It is based on the following five main principles:

- water must be taken into account in every field of policy relating to the Rhine basin;
- water must be retained in the catchment area as long as possible;
- the river should be given room to expand;
- everyone must be aware of the possible risks connected with living in the vicinity of the river;
- success depends on integrated and concerted action along the whole length of the river.

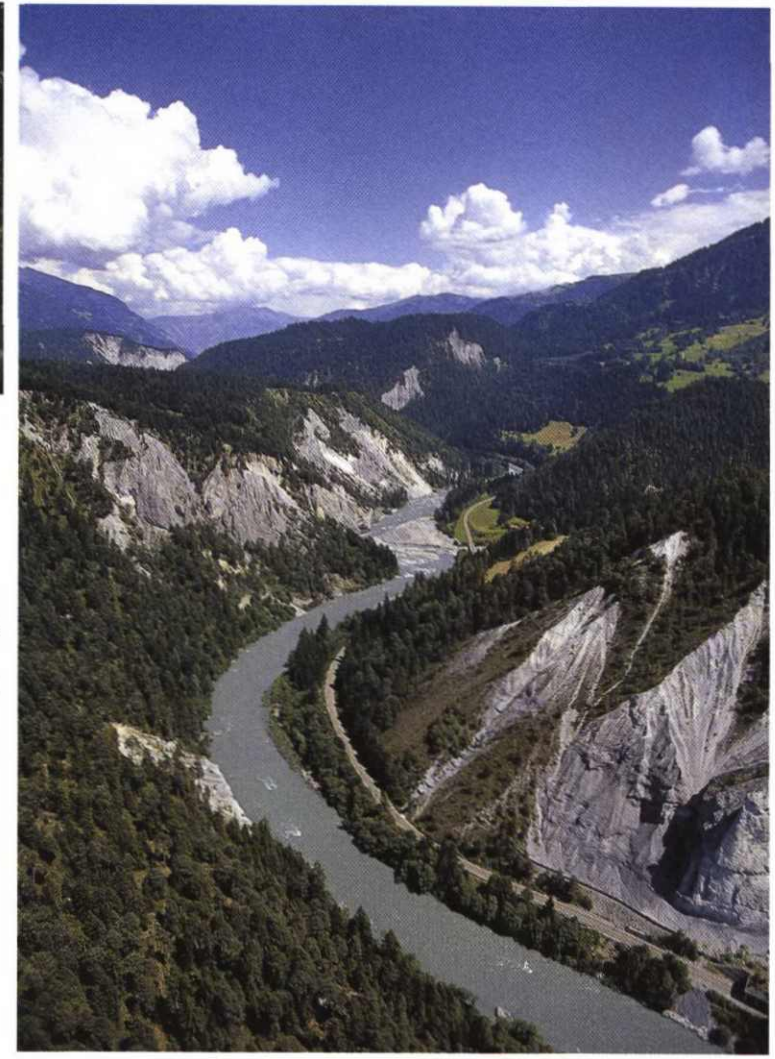
Measures relate in particular to the reactivation of floodplains and the construction of polders to store excess water. Implementation of the Action Plan is expected to cost approximately 12,000 million euro.

Present organisation of the International Commission for the Protection of the Rhine (ICPR)

The organisation of the ICPR has been modified on several occasions to accommodate changes in policy. The present legal basis for the work of the Commission is the 1963 Berne Convention, although it is expected that the ICPR will soon be able to base its work on the new Rhine Convention, signed in Berne in April 1999 and now awaiting ratification.
Ministerial conferences every two to three years formulate the political goals of the Commission and provide an opportunity for assessment and evaluation of past activities. The Commission itself consists of top-level officials from the various member states. It meets annually and decides programmes of work, financial arrangements and formal procedures. A coordination group, meeting four times a year, is responsible for actually planning and coordinating the work of the ICPR.
There are three permanent working groups on water quality, ecology and emissions, while two project groups deal with the Action Plan on Flood Defence and the preparation of a new Programme for the Sustainable Development of the Rhine. Expert groups deal with specific problems relating to the work of the working and project groups. All groups consist of government experts from the ICPR member states. At many meetings, non-governmental organisations can participate directly in the work of the ICPR.
The work of the Commission is supported by a small international secretariat with a permanent base in Koblenz, Germany.

↑ Flood

↑ Construction of an emergency dike in Kampen



In the past a great deal of attention has focused on the protection of clean, safe drinking water supplies. Drinking water companies have joined forces in non-governmental organisations and represented their interests with great energy.
The salt problem in the Rhine has a long history and originates mainly from potassium mining activities in France. Following heavy pressure from water companies, a special agreement was negotiated and agreed in 1976. Under this initial agreement, the salt from these activities had to be stored at the French potassium mines. Later, in 1991, a protocol to this "Salt Treaty" was signed. This stipulated additional storage measures whenever the chloride level at the German-Dutch border exceeded 200 mg/l and prescribed special measures in the Wieringermeer polder in the Netherlands, where saline seepage water was no longer to be discharged into Lake IJssel.

Several factors have contributed to the progressive development of the Rhine regime:

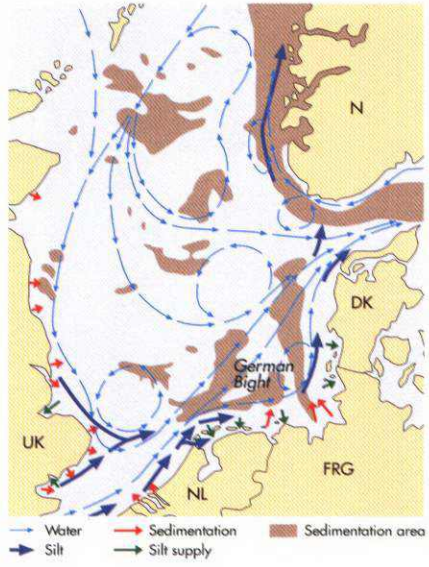
- the presence of an active and alert downstream government commanding sufficient means to support its arguments and able to offer upstream governments some form of compensation (financial or otherwise);
- a large measure of comparability between the riparian states;
- a basin-wide organisation to help resolve transboundary conflicts over water quality issues.

↑ Potassium mines

↑ Alpine Rhine near Reichenau

Cooperation between local residents

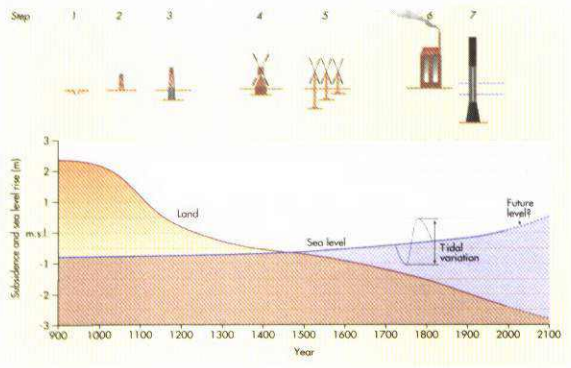
...History shows that close cooperation between local residents has been a highly effective way to achieve common goals (e.g. in the fields of flood protection and ground water control).
In the Netherlands, agricultural land reclamation has been achieved since ancient times through (initially informal) mutual cooperation within the local community. This led at a relatively early date to the establishment of local water boards to coordinate the necessary water control activities.
The farming community still manages large parts of the rural area. Especially where farmers own the land, they are highly motivated to protect the interests of future generations. For this reason, the farming community sees the imposition of water quality norms on agricultural drainage water as a motion of lack of confidence. The active involvement of the farming community in decisions on the improvement of drainage water quality will promote awareness and 'ownership' of the problem within the sector and will be a more effective way to solve the problem.

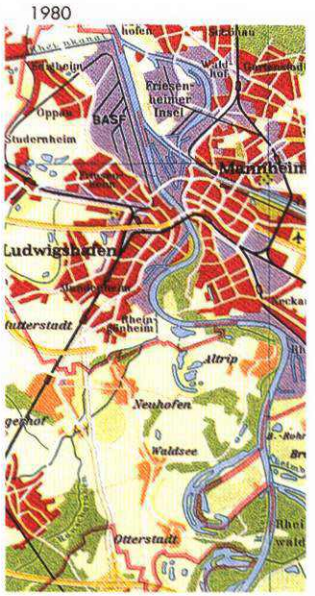


Water and sediment movements in the North Sea

Upstream - downstream

Cooperation between riparian states demands solidarity and trust, based for example on an awareness of mutual dependence, their upstream - downstream relationship.
The restoration and preservation of a river system, including it's natural ability to discharge water, requires such cooperation and solidarity.
In the Rhine basin, as in most other river systems, the greatest concentration of population is in the downstream areas. This is where the accumulated effects of all other functions make themselves felt. Sensitive functions like drinking water supply and nature are especially vulnerable to pollution upstream. In these areas, therefore, the advantage of a plentiful supply of water is counterbalanced by deficiencies in water quality.
In some other respects, the upstream - downstream relationship is reversed. For example, Germany lies "downstream" of the Netherlands as regards the transportation of sediments in the North Sea, where silt is carried eastwards from the mouth of the Rhine to the German Bight. Salmon swim up the river, or not, if they are prevented downstream by impediments like the nets laid by late-19th century Dutch fishermen or the remaining weirs and dams still barring their way today. Similarly, CO_2 emissions cause "global warming" and so increase both the risk of flooding along the Rhine and in the Dutch Delta and the danger of mountain rockfalls and mudslides through the melting of the permafrost in Switzerland. We are all in the same boat.
Every region and sub-region along the Rhine has upstream and downstream neighbours and we need to avoid the kind of transferred problems caused by local flood protection measures in the past. In short, our mutual dependence gives us every reason to display solidarity and engage in close cooperation in a wide variety of fields besides that of the economy.





Room for the river: water as a basic principle of physical planning

The water system itself needs room to function, to change and to evolve. Man should work with it, not against it. We must make room for the river and treat water as a basic principle of physical planning, in order to be able to live and work safely and sustainably with it and alongside it. Physical planning should be based on water systems and the functions allocated to them, with due regard to the limitations imposed by the location. Nature is ungovernable and the river is a living part of it. This is an important part of the knowledge we have to impart. We need to replace our present fail-safe systems by systems which are relatively safe even if they fail. These will be sufficient to protect us against flooding almost all of the time and, while their occasional failure may cause economic loss, it will not pose a threat to human life: in other words, it will do no irreparable damage.

In most countries in the Rhine basin, organisations and platforms are being formed with the aim of discovering, understanding and explaining the natural constraints which water systems impose on rural planning and land use.

Reason suggests that we need to accept the forces of nature and live with them, rather than attempt to govern them with a rod of iron. The river needs room to live. If we deny it that space, we shall find ourselves trapped in a vicious circle of:

- investing by building, working and living in flood-prone areas, and so constantly increasing the risk, damage multiplied by probability,
- thus creating a greater need to confine the river (raise the dikes, etc.),
- and so generating an illusion of safety,
- leading to still more investment, etcetera.

The value attached to public goods like flood safety, nature and agriculture may change over time. Likewise, the future may bring unforeseen new developments. For these reasons, measures taken now should be capable of modification without any great trouble or expense and physical planning should also take account of this possibility. The river system must remain sufficiently flexible to permit future adaptation.

↑ Phased response to continuing land and sea level rise

↑ The last major river flood in the Netherlands due to a dike breach (1926)

↑ The Upper Rhine in 1850 and 1980

Familiarity makes the heart grow fonder

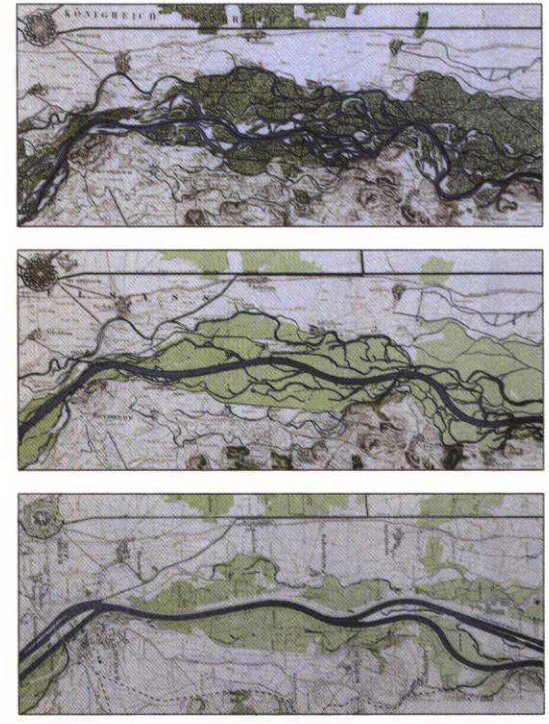
Society will only be prepared to sacrifice that space to the water if there is a keen public awareness of the need to do so. To create this requires information, knowledge and understanding, not only about the partnership between ourselves and the water system/ecosystem, but also about the other states and functions involved. This information should be available to all.

Public acceptance requires knowledge: not only information but also understanding and identification with each other's interests. The first step in this direction is scientific cooperation, including the development of a uniform system of monitoring. However, the resultant knowledge must not be confined to specialists but must be shared broadly among all those concerned. After all, familiarity makes the heart grow fonder.

In the 1970s, specific sewerage taxes were introduced (e.g. the Dutch 'WVO-heffing' and the German and Swiss 'Abwasserabgaben'). Since there was widespread public awareness of the importance of these measures, there was little resistance to the new charges. The media gave extensive coverage to the state of the Rhine, which was then a dead river. They focused on fish mortality and the poor taste of drinking water in Rotterdam, and published time series of the loads of heavy metals like cadmium and lead carried by the river.

Restoration requires initiative

What is needed first and foremost is a (downstream) country or stakeholder eager to take the initiative, prepared to go through the trouble of improving the water crossing its borders, and able to go to the negotiation table with something to offer in return. Beyond that, there is a need for pioneers in the form of non-governmental organisations. Without one of these, the Stichting Reinwater, the chlorine problem would never have been tackled as it was.
Another NGO, the International Association of Waterworks in the Rhine river basin (IAWR), uses data from its own monitoring network to negotiate directly with industry. The enormous public appreciation of drinking water of undoubted quality is a very powerful instrument in convincing polluters of the necessity of cooperating and so preventing publication of results damaging to their reputation.



↑ Reinforcement of river dikes facing flood threat

↑ Upper Rhine: before regulation (1828), after regulation (1872) and after regulation and canalisation (1963)

Summary of lessons learned

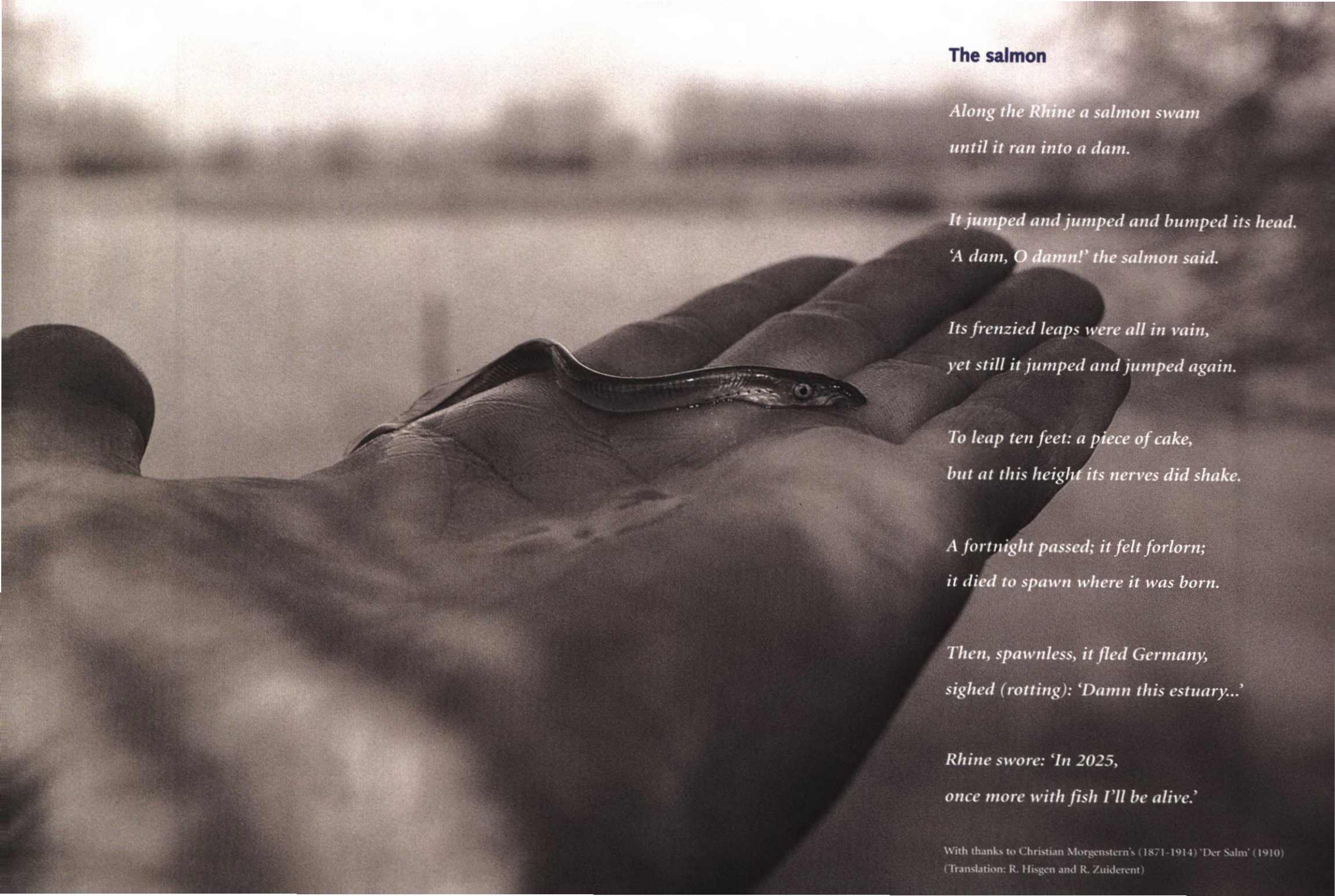
Action is often taken on the basis of an emergency or single interest, when decisions are heavily influenced by the immediate priorities and anxieties of the particular moment or period in time. It is preferable to take an integrated approach to hydraulic design and management measures, with choices being made on the basis of a full consideration of the interests involved and the social functions of the water system, as well as the relationship between the different parts and properties of the water system itself. The whole exceeds the sum of the parts. The future must also be considered: prevention is better than cure.

All stakeholders should be involved in decisionmaking. This provides the basis for later cooperation. Cooperation always pays off, whether it is between different interests or between different regions.
Cooperation between riparian states demands solidarity and trust, based for example on an awareness of mutual dependence (their upstream - downstream relationship).

The water system itself needs room to change and evolve. We must work with it, not against it. We must make room for the river and treat water as a basic principle of physical planning, in order to be able to live and work safely and sustainably with it and alongside it. Society will only be prepared to sacrifice that space to the water if there is a keen public awareness of the need to do so. To create this requires information, knowledge and understanding.
Restoration requires initiative and balanced decisions need to be based on research. It is obviously preferable for plans to be developed by a range of stakeholders taking account of the specific characteristics of the particular river basin. For that reason, encouragement should be given for basin-wide academic research on future scenarios and the long-term effects of human interventions.

The most important lesson of all is the need to cooperate on the basis of mutual solidarity and familiarity with each other's interests.

↑ The Roman rivergod Rhenus



The salmon

Along the Rhine a salmon swam
until it ran into a dam.

It jumped and jumped and bumped its head.
'A dam, O damn!' the salmon said.

Its frenzied leaps were all in vain,
yet still it jumped and jumped again.

To leap ten feet: a piece of cake,
but at this height its nerves did shake.

A fortnight passed; it felt forlorn;
it died to spawn where it was born.

Then, spawnless, it fled Germany,
sighed (rotting): 'Damn this estuary...'

Rhine swore: 'In 2025,
once more with fish I'll be alive.'

With thanks to Christian Morgenstern's (1871-1914) 'Der Salm' (1910)
(Translation: R. Hisgen and R. Zuiderent)

5 Postscript

The Rhine runs through five different countries. Each of them is increasingly aware of its responsibility towards the entire river, and not simply for the section within its own borders. The navigation agreement signed as far back as 1815 and the cooperative effort to combat pollution in the 20th century are both shining examples of action inspired by this awareness of a shared responsibility. During the early decades of the 21st century, attention will focus on the achievement of a further attitudinal change prompting greater effort to expand the sustainable management of the river to include the entire catchment area. A transboundary river must become a shared stream.

That is the vision, but how can we achieve it? There is more than one way to do most things and there are a host of ways to work towards a clean, safe Rhine able to meet the economic and ecological needs of the European heartland. Opinion is divided even on whether the chosen approach should be ecocentric or market-oriented. But whatever the preferred option, a radical change in thinking will be indispensable. Education and training, public information campaigns and a clear political commitment will all be necessary to persuade the general population of the need to make choices and accept the consequences of the decisions made.

This kind of public awareness will be all the more influential if it is coupled to public participation in the decisionmaking process. Decisionmaking by the ICPR is swayed not only by the traditionally strong influence of riparian governments but also by the sometimes conflicting views of stakeholders like water companies and other individuals and agencies who deal with the river from day to day, but whose interests certainly do not always neatly coincide.

Many decisions have already been made and implemented: the potential for water retention and storage has been increased throughout the basin; room is once again being given to the river in all the Rhine riparian states; in policy documents at least, spatial planning is increasingly being based on the characteristics of natural water systems; national and European legislation is being developed to permit the realisation of integrated water management; and governments and NGOs are endeavouring to enhance public awareness of natural risks and of the constraints which water inevitably imposes upon society.

But more choices will have to be made. The various interests of today must be weighed against each other, but also against those of future generations. And decisionmakers must also give equal regard to interests able to apply less immediate economic pressure, like those of the environment and human health. However, these decisions will not be made at the World Water Forum; they will be made in the ICPR, which is due to meet in January 2001. The choices to be made there deserve our universal interest and involvement. Because visions are at their best when achievement is slow but sure.

← Not a salmon but a young river lamprey

Acknowledgements

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Consultations during the Rhine Basin Vision proces

April 1999
- *Workshop in Arnhem, The Netherlands*

July 1999
- *Brainstorm and Interviews in Koblenz, Germany*
- *Brainstorm and Interviews in Bern, Switzerland*

August 1999
- *Presentation and Discussion in Stockholm, Sweden*
- *Presentation and Discussion in Delft, The Netherlands*

September 1999
- *Scenario Development in several Brainstorm Sessions*

October 1999
- *Brainstorm and Interviews in Metz, France Discussion in Brussels, Belgium*
- *Start of consultation of stakeholders throughout the basin*

November/December 1999
- *End of consultation of stakeholders throughout the basin*

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Netherlands Ministry of Transport, Public Works and Water Management.
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Netherlands Ministry of Agriculture, Nature Management and Fisheries.
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- *Ir. Jan Bouwhuis*

Netherlands National Institute of Public Health and Environment (RIVM). Laboratory for Water and Drinking Water Research.
- *Ir. Ton A.H.M. Bresser*

Netherlands Ministry of Housing, Spatial Planning and the Environment, DGM/DWL.
- *Drs. Juliaan E. Prast MBA*

The Winand Staring Centre for Integrated Land, Soil and Water Research.
- *Ir. Coen W.J. Roest*

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and many, many more persons and organisations.

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Some ICPR Brochures
- Ecological Master Plan for the Rhine (1991)
- The Rhine, an ecological revival (1994)
- Salmon 2000 (1994)
- The Rhine, a river and its relations (1998)
- Action Plan on Flood Defence (1998)

Colophon

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International Commission for the Protection of the Rhine against pollution + Central Commission for Navigation on the Rhine + International Commission for the Hydrology of the Rhine Basin + EU Interreg-Rhine-Meuse-Activities + World Wildlife Fund + Alsace Nature + Vereniging tot behoud van Natuurmonumenten + Stichting Reinwater + International Association of Waterworks in the Rhine basin + European Union of National Associations of Water Suppliers and Waste Water Services + Arbeitsgemeinschaft Rhein-Wasserwerke + Verband Schweizerischer Elektrizitätswerke + Kraftwerk Laufenburg + Wasserkraftverband + European Chemical Industry Council + Bureau Voorlichting Binnenvaart + Havenbedrijf Rotterdam + Duisburg Ruhrorter Häfen AG + European Anglers Alliance + Nederlandse Vereniging Van Sportvissersfederaties + Organisatie ter Verbetering van de Binnenvisserij + Committee of Agricultural Organisations in the European Union + Deutsche Landwirtschafts-Gesellschaft + Land- en Tuinbouw Organisatie Nederland + Deutsche Bauernverband + Vereniging van Nederlandse Riviergemeenten + Hochwassernotgemeinschaft Rhein + Deutscher Tourismus Verband + Delft Hydraulics + Waterschap Polderdistrict Tieler- en Culemborgerwaarden + Stichting Het Geldersch Landschap + Landeshydrologie und Geologie + Bundesanstalt für Gewasserkunde + Ports de Mulhouse-Rhin + Rijks Planologische Dienst + Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit + Landesanstalt für Ökologie, Bodenordnung und Forsten Nordrhein Westphalen + Landesamt für Agrarordnung Nordrhein Westphalen + Conseil Supérieur de la Pêche Délégation Regionale de Metz + Naturschutz Bund Koordinationsstelle Rhein + UNESCO International Hydrological Programme + WMO Operational Hydrological Programme + Unie Van Waterschappen + University of Siegen + University of Twente + Utrecht University + Floron + Ministerie van Landbouw, Natuurbeheer en Visserij + Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieu + Provincie Gelderland + Resource Analysis + Agence de l'eau Rhin-Meuse + Rijkswaterstaat + ...