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Groundwater protection in selected countries

Point sources

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1. Summary

The purpose of this report is to describe and discuss policies and strategies for groundwater protection in five selected countries in relation to soil contamination and remediation of point sources. These five countries are Austria, Denmark, England, Spain and the USA.

Today, most industrialised countries have developed laws on the protection of groundwater. These laws may be based on the precautionary principle and be very stringent, requiring that groundwater maintain all of its beneficial uses (multifunctionality). Implementation of these laws may in turn present great financial challenges. With respect to contaminated sites management, it is therefore valuable to examine these laws and to consider the role of the precautionary principle in groundwater protection.

In 1995, the European Environment Agency prepared the first pan-European State of the Environment Report, the Dobris Assessment. This report identified and reviewed 12 environmental problems of particular European concern. Two of these concerns were Inland Waters (including groundwater) and Soil Degradation (including contaminated sites). The Dobris Assessment emphasises, therefore, the importance of this subject.

In order to reach the goal of successfully protecting the groundwater resource from point source contamination, a number of milestones must be passed. Exactly which milestones are passed depends partly on the path taken but usually include prevention of future release of contaminants, identification of existing point sources which may contaminate the groundwater resource and remediation of these sites. Milestones can be viewed as falling into one or more of three categories: legislative, technological and implementary. This milestone approach can be helpful in several ways, such as determining the current status of a country's protection efforts, or in discussing the merits of new groundwater protection strategies.

The precautionary principle has been a part of the environmentalists language for only 2 decades. Groundwater protection legislation is generally based on this principle. In this report, the precautionary principle is defined, and it is noted that according to the precautionary principle, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In addition, the report describes various pitfalls in implementing the precautionary principle.

In this report, various comparisons of the five countries with respect to contaminated sites, water supply and groundwater protection are made. In general, the report found that much data collected in the individual countries is heterogeneous in nature and therefore not suitable for comparison.

Simple calculations are made for the five countries in the report to determine environmental pressures and groundwater resources. These calculations do not include regional variations within each country and are intended only to give a general backdrop. Through these calculations, it was found that Austria is in an apparent positive situation while England and Denmark face the greatest challenges of the five countries.

Data collected on the number of contaminated sites in each country could not be compared due to a number of reasons. Most countries prioritise contaminated sites for remediation on the basis of a risk assessment. However, some countries start this process by an initial division of aquifers into two categories. Financing of remediation is approached in various ways; through the polluter pays principle, through general or specific taxes, or through landowner liability.

Groundwater accounts for between 20% (Spain) and 100% (Denmark) of the water supply in the countries in this study. Austria obtains a significant portion of its water

supply from spring water. Agriculture is a major water consumption category for Spain, USA and Denmark. This indicates that agricultural use is highly dependent on the intensity of agriculture as well as on precipitation.

In the five countries studied, implementation of groundwater protection initiatives is carried out on various scales, ranging well field initiatives to recharge areas to initiatives on the scale of an entire country. Specific distances or groundwater travel times are used by all countries to determine zones around specific well fields. National overviews vary greatly, some based on aquifer vulnerability and some on aquifer value. Initiatives on the recharge area scale are perhaps the most challenging, due to data requirements and the size of the areas affected. No countries have yet completed zoning on the recharge area scale.

The report concludes by describing three groundwater protection strategies: mulitfunctionality, water treatment and combined strategy. These strategies are discussed to illustrate the challenges which can be a consequence of selecting a groundwater protection strategy for a country. Finally, a number of open questions suitable for discussion are listed.

2 Introduction

2.1 Background

The purpose of this report is to describe policies and strategies for groundwater protection in selected countries in relation to soil contamination and remediation of point sources. The report is also intended for use in discussions at the 4th meeting of the "Ad Hoc International Working Group on Contaminated Land", an international forum for collaboration and exchanges between international experts working for governments from industrialised nations in the field of contaminated land policies. This meeting is to be held in Copenhagen on June 14-15, 1999.

At its most recent meeting, the Ad Hoc Group made the following statement:

"Most industrialised countries have developed laws on the protection of groundwater. Following the principle of precaution, most of these laws require the maintenance of the "multifunctionality" of all groundwaters. These requirements are mostly very stringent, but their implementation pose enormous financial problems, as complete decontamination and the "aftercare" measures to ensure continued effectiveness of the long-term in cases of only partial decontamination or containment of the contaminants are very expensive. It is therefore necessary to examine these laws from the point of view of the contaminated sites management and to consider another "philosophy" of groundwater protection:

- Is it acceptable to drop these high demands of multifunctionality of the groundwater in cases where a contamination is already existing, and to define tolerable site specific and usage dependant remediation goals on another level?
- What policies and strategies should be followed in such cases, taking into account all aspects necessary to reach sustainability?
- Which implementation tools have to be developed?
- How are these strategies administered over long periods?"

In the following chapters, various aspects of contaminated sites, water supply and groundwater protection strategy are discussed. The report also includes 5 attachments, one for each country. In these attachments, details on these subjects can be found for the specific countries.

2.2 Europe's Environment: The Second Assessment

In 1991, European environment ministers met in the Dobris castle in the Czech Republic and launched a number of initiatives. As a result of this meeting, the European Environment Agency prepared the first pan-European State of the Environment Report, the Dobris Assessment. This report identified and reviewed 12 environmental problems of particular European concern. Two of these concerns were Inland Waters (including groundwater) and Soil Degradation (including contaminated sites). A follow-up report to the Dobris Assessment was prepared for the 1998 Ministerial conference in Aarhus (EEA, 1998). This report is entitled Europe's Environment,: The Second Assessment and focuses on the same 12 problems.

In its chapter on soil degradation, the Assessment mentions that data on contaminated sites from different European countries is heterogeneous and not suitable for aggregation in a reliable or consistent manner, a finding which was found to be true during the preparation of this report on five selected countries. The Assessment also mentions the following:

Chapter 9: Inland Waters

- There has been a general reduction in the total water abstraction in many countries since 1980.
- In Mediterranean countries, abstraction of water for irrigation has increased since 1980.

Chapter 11: Soil Degradation

- Most countries are in an early phase of site identification and registration.
- Information on drinking water impacts due to contaminated sites is fragmentary.
- In the majority of European countries, the management of contaminated sites is handled at a regional level.
- Most countries in Western Europe have recently established regulatory frameworks aimed at preventing future problems and cleaning up existing contamination.
- Only a few countries have specific clean-up legislation.
- Remediation techniques typically involve excavation, capping or pump-and-treat whereas in-situ techniques are seldom used because of their greater uncertainty of success.
- In most Western European countries, remediation measures are funded out of general taxation. Specific taxes on waste, fuel or petrol is used to increase the public budget in some countries.
- Figures for the costs for clean-up on a national basis are based on different assumptions and cannot be compared. They do indicate, however, that enormous costs are involved.

2.3 Selection of countries and acknowledgements

The countries selected for this study are Austria, Denmark, England, Spain and The United States. This selection has ensured that countries with a wide variety in climates has been treated. In addition, the selected countries exhibit differing traditions for water abstraction and approaches for the remediation of point sources. Finally, certain individuals from the involved countries have backgrounds and involvements in other programmes which made selection of their country desirable.

A contact person was appointed in each of the five countries to assist in the preparation of this report. Their contributions are gratefully acknowledged.

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3 Groundwater protection milestones

3.1 Pathways to groundwater protection

In order to reach the goal of successfully protecting the groundwater resource from point source contamination, a number of milestones must be passed. Exactly which milestones are passed depends partly on the path taken. Some milestones, however are common for all paths. These include obtaining public awareness of groundwater contamination, permitting activities which involve a risk of polluting groundwater, identification of existing point sources which may contaminate the groundwater resource and remediation of these sites.

Other milestones passed on the road to groundwater protection strategy. Different countries may emphasise different milestones, depending on their specific needs, their available financial resources and the maturity of their protection programme.

3.2 Categories of milestones

Milestones can be viewed as falling into one or more of three categories: legislative, technological and implementary. These aspects do not always coincide time-wise. For example, legislative drivers for remediation of contaminated sites may be in place without this directly resulting in implementation.

Legislative milestones

Legislation provides the driver necessary to initiate progress towards a milestone. To be effective, certain elements must be present in the legislation. Firstly, the legislation must identify the authority who is responsible for the area in question. Secondly, the legislation must of course, describe the authorities duties. Thirdly, the legislation must provide for financial responsibilities (polluter, state, landowner). Finally, the legislation must include provisions for enforcement. Variations on this theme can occur. For example, some voluntary programs without provisions for enforcement have been successful. An example of a voluntary agreement is the OM-programme in Denmark, in which the oil industry investigates and remediates former petrol stations which are potentially contaminated.

Technological milestones

Many of the milestones which must be reached in order to achieve adequate groundwater protection are of a technological or scientific nature. A good example of an increase in technology is in the field of remediation techniques. Here rapid advances have been made in recent years, making it possible to remediate sites which were previously not solvable. Recent technological advances have been made, for example, in remediation techniques which use reactive walls with zero-valent iron and which use steam stripping. The need for new technology means that research and development programmes are vital to achieving groundwater protection. A well known example of such a program in the field of remediation techniques is the USEPA's Superfund Innovative Technology Evaluation (SITE) programme. Other countries also have research and development programmes. There is important to ensure that results from these programmes are shared effectively through various means of communication (conferences and the like).

Implementation milestones

There is not always the same focus on implementation milestones as on legislative milestones. However, in order for legislation to have an effect, proper implementation is necessary. One requirement is that the legislation itself it suitably specific for implementation. Another major requirement for proper implementation is an infrastructure of environmental authorities which have the capability of carrying out their duties. This is typically carried out on the regional scale.

Implementation strategies are not static and should be viewed as an on-going process. Implementation should frequently be assessed, and the results should lead to adjustments in the implementation process.

4 Precautionary Principle

4.1 Background

New principle

The precautionary principle has been a part of the environmentalists language for only 2 decades. It's origins are generally attributed to Germany where guidelines discussing the Vorsorgeprinzip were published by the federal government in 1986.

In this document a distinction is made between identifiable risks and risks which are not yet proven. Adherence to the precautionary principle would require authorities to act on risks, even if they are not yet proven.

Brundtland Report

The first international statement of the precautionary principle was made by Ministers from 34 countries in the Bergen, Norway, declaration in 1990 as a following to the Brundtland Report (Brundtland, 1987). In this statement, sustainable development was coupled to the precautionary principle.

" In order to achieve sustainable development, policies must be based on the precautionary principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation."

Rio conference

The UN Conference on Environment and Development in Rio de Janeiro in 1992 included developing countries. In Principle 15 of the declaration (UN, 1992), it was agreed upon that the precautionary principle is to be widely applied by States *according to their capabilities*. The intention was to allow developing countries to apply the principle less rigorously, but could be extended to include the fact that all countries have a limit to their capabilities.

More recently, a conference dedicated to the precautionary principle was held in Copenhagen (Danish Ministry of Environment and Energy, 1998).

Groundwater protection legislation is generally based on the precautionary principle.

4.2 Definition

Many uncertainties exist in relation to environmental issues. This is especially true in the field of groundwater protection from point source contamination where the environmental fate of contaminants and their unwanted effects on target organisms are difficult or impossible to determine, but alone to anticipate. Environmentalists have urged the adoption of the precautionary principle as a means to cope with this uncertainty.

The precautionary principle addresses two problems: the problem of evidence and the problem of response (Badansky, 1994).

Evidence

Indisputable evidence of harm is rare in environmental fields due to the complexity of nature and to the built-in time delays between contaminant release and measurable effect. Since this is the case, how strong must our evidence be that harm is occurring before we take action? In the lack of evidence what risks for harm are we willing to take? The precautionary principle requires that we err on the side of caution.

Response

Once harm or risk of harm is established the next question is one of response. What level of harm is acceptable? Spend to reduce the harm? The precautionary principle requires that we emphasise benefits rather than insisting on proportionality between cost and benefit.

Burden of proof

An important aspect of the precautionary principle is the question of who must bear the burden of proof. In a traditional reactionary view, environmental regulators would have to prove that actual harm had been done before imposing restrictions. In the precautionary principle the burden of proof is shifted from the regulators or pollution victims to the polluters. Under the precautionary principle, potential polluters must show that their activities do not cause harm. This is a ”negative" proof and is therefore not possible. However it does relieve the regulator of a major burden.

4.3 Implementation pitfalls

The use of the precautionary principle in environmental legislation is in keeping with the current public conception of what is appropriate. However, implementation of stringent precautionary measures is not easy. Implementation of legislation is closely tied to the actual financial resources available. Implementation may require a level of expenditures that is unacceptable and may even give environmental backlash.

For example, the Clean Air Act of 1970 in the USA is very precautionary in requiring an ”ample margin of safety” in regulating the emissions of hazardous pollutants, even if this means applying a zero emission standard. To avoid having to apply the rule, the USEPA delayed designating substances as ”hazardous”. After 14 years only 7 substances were therefore regulated (Dwyer, 1990).

Similar difficulties can be encountered by many in-situ techniques in the remediation of point sources of groundwater contamination. Since these techniques often exhibit an asymptotic clean up curves, desired clean-up levels are often unattainable. This may be in sharp contrast to stringent clean-up levels which are based on the precautionary principle. This may result in the in-situ remedial techniques being discarded, despite other possible advantages, such as lower exposure of workers to contaminants.

Efforts to maintain the precautionary principle may result in a natural reluctance on part of environmental authorities to identify certain groundwater resources as less important or valuable than others (designating groundwater classes). Theoretically, strict adherence to the precautionary principle would seem to require that all groundwater must be protected. Designation of groundwater classes can, however, be a valuable tool in prioritising remediation of point sources of contamination and in land-use planning.

Austria has intentionally avoided the designation of classes with respect to the groundwater resource. England has focussed on vulnerability of the resource rather than the designation of classes. Denmark has recently carried out such a designation into three classes. In the USA, designation is determined by the individual states: Some have designations and others do not. For more information on the designation of classes for the individual countries see the respective attachments. More comparisons on these designations are found in the next chapter.

5 Comparisons

5.1 Environmental pressures and resources

Table 5.1 gives some basic information about the five countries selected for this study.

Country	Pop. (mill.)	Area (10^3 km^2)	Net precip. (mm/yr.)	* GDP (10^9 USD)	Pop. density pr. km^2	GDP (USD/-person)	Precip. range mm pr. year	* net precip. (10^9 m^3)
Austria	8,0	84	650	178	95	22,300	600-2000	55
Denmark	5,3	43	140	151	123	28,500	500-900	6
UK	58,7	225	640	1,092	261	18,600	600-1200	145
Spain	39,2	506	230	551	77	14,100	70-1600	116
USA	264,2	9,363	NA	7,270	28	27,500	200-1400	NA
NA = not available * EEA, 1998								

Table 5.1 Basic information for the selected countries.

Gross Domestic Product (GDP) is a measure of a country's production of goods and services. In general, there is a positive coupling between GDP and environmental pressures: the higher the GDP, the greater the depletion or deterioration of natural resources such as groundwater. Theoretically, a negative coupling could be envisioned since a high GDP would seem to indicate adequate welfare for stringent environmental policy. Effective strategies for the protection of groundwater resources is an example of attempts to reduce environmental pressures independently of the GDP.

Population density also has a positive coupling to environmental pressure. In recent decades, there has been a general trend towards smaller households in industrialised countries (from 3.5 to 2.6 between 1950 and 1990 in western Europe for example). This trend also increases environmental pressure since heated buildings, lighting, appliances and durable goods such as cars are shared by fewer people. Therefore, household density may be a more appropriate measure of environmental stress the population density.

In Europe, GDP and population density are relatively high and expected to increase further in the coming years. Household size is expected to continue its decreasing trend. These facts and expectations indicate that environmental pressures are of concern and will continue to be a concern in the future (EEA, 1998).

A measure of the environmental pressure is the pressure factor. This factor is defined here by the equation below in which the gross domestic product is normalised by geographical area:

$$P = \frac{\text{GDP (USD)}}{\text{area (km}^2\text{)}}$$

Environmental resources

In general, the quantity of a country's environmental resources is positively coupled to the area of the country. In the case of groundwater, the quantity is further coupled to the net precipitation (precipitation minus evaporation).

A measure of the groundwater resource is the resource factor. This factor is defined here by the equation below in which the amount of the groundwater resource is normalised pr. person since this resource must be shared:

$$R = \frac{\text{area } (m^2) \text{ x net precipitation } (m/yr)}{\text{population}}$$

Comparisons

The five countries included in this study can be compared using the very simple factors for the groundwater resource and environmental pressures defined above. The results of these calculations can be seen in table 5.2 below.

	Resource factor 10^6 km^2 x m^3/yr	**Pressure factor** 10^6 USD/km^2	**Protection needs**
Austria	High (6.8)	Low (2.1)	Moderate
Denmark	Low (1.1)	High (3.5)	High
UK	Low (2.5)	High (4.9)	High
Spain	Low (3.0)	Low (1.1)	Moderate
USA	(NA)	Low (0.8)	NA

Table 5.2
Calculation of the resource and pressure factors.

According to table 5, Austria enjoys the most positive results of a relatively high resource factor and relatively low environmental pressure factor. Furthermore, the UK and Denmark are faced with the greatest challenge, having a relatively low resource factor and a relatively high environmental pressure factor.

This comparison is obviously very rough and therefore of limited value. Improvements could be made by including additional factors and by weighting the existing factors.

Even more significantly the comparison above does not take in to account the tremendous regional variations in population density, rainfall and GDP that occur within the borders of each country. An example of regional variations can be seen in the very uneven distribution of rainfall in Austria, Spain and the USA (net precipitation in Spain ranges from over 1,000 mm pr. year in the north Atlantic coastal region to <50 mm pr. year in the southern Mediterranean coastal region). Regionally, the scores shown in table 5.1 would vary considerably. The comparison above is therefore only intended to give a general backdrop of basic information for the other results in this report.

5.2 Number of contaminated sites

Information regarding the number of contaminated sites which has been obtained from the five countries in this study is not suitable for comparison. There are several reasons for this.

Numerous programmes

Firstly, some countries have a variety of programmes for remediation of point sources. For example, Denmark has at least 6 distinctive programs related to orphaned sites, currently-operating sites, petroleum industry sites, military sites, railway sites, and sites causing property value loss for home owners. A second example is that programmes exist at different levels. For example, in the United States, there are programmes at the national level as well as at the level of the 50 separate states. In this study, it was not possible to collect information on all of these numerous programmes for the individual states.

Contaminated site definition

Secondly, there are differences between the individual countries in the requirements for listing a point source as a contaminated site. Some programmes, such as the American Superfund programme, require a high ranking (only those sites with a score of 28.5 on the Hazard Ranking System scale from 0 to 100 are eligible for placement on the national priorities list) resulting in a relatively low number of sites in this programme, whereas other programs require only technical evidence of contamination (for example, chemical analysis showing elevated contaminant concentrations in a soil or groundwater sample). Unless an international agreement on the definition of a contaminated site is made, comparisons between countries will continue to be difficult.

Legal drivers for listing

In England, legal drivers which require local authorities to "cause its area to be inspected from time to time for the purpose of identifying contaminated land" are not yet implemented.

Status of listing

It is evident that most countries which do have legal drivers for identifying and listing contaminated sites are in an early phase of the work. After initially identifying 370 contaminated sites, Spain is currently carrying out a considerably more ambitious third phase of listing. Austria has identified approximately 29,000 sites out of an estimated 80,000 sites.

Voluntary clean-ups

Finally, voluntary clean-ups are important in most countries. Reporting requirements for these clean-ups can, however, be lacking.

5.3 Prioritisation of remediation

Several different things can be meant by the "prioritisation of contaminated sites". For example, contaminated sites can be prioritised according to various geographical scales such as a regional prioritisation or a national prioritisation. Point sources can also be prioritised for a specific phase of work. For example, one prioritisation could be for which sites are to be investigated first and another prioritisation could be for which sites are to remediated first.

National vs. regional

Austria is an example of a country in which prioritisation is carried out at a national level by the Federal Environment Agency. In Denmark, prioritisation was previously carried out on a national scale by the Environmental Protection Agency, but is now done individually by each regional environmental authority.

Groundwater vs. land use

Prioritising of contaminated sites with respect to groundwater protection often takes place in parallel with prioritising of contaminated sites with respect to land use. In most countries, administration and financing of these two parallel programmes are not separate. Short term land use interests are therefore weighed against long term groundwater interests. In Denmark, a proposed new soil law takes the first steps in separating these two areas. If these two areas were totally separated, it would be possible to have contaminated sites which threaten land use be prioritised and remediated according to the normal political boundaries, while groundwater could be administered according to aquifer boundaries.

Risk assessments are used

Most countries describe some type of risk assessment as the basis for prioritising which sites are to be remediated first.

Initial division into classes

There is a difference, however, in whether an geographical division of the groundwater resource into classes according to value is carried out prior to the risk assessment. In Denmark, so-called "particularly valuable water abstraction areas" have now been mapped. This enables the regional authorities to concentrate remediation efforts of sites which threaten the groundwater to these particularly valuable areas. After this initial division into two categories of sites (those within and those outside the particularly valuable areas) further prioritising of the sites within the particularly valuable water abstraction areas can take place.

5.4 Financing the remediation of point sources

Polluter pays principle

The polluter pays principle is cherished by western countries. It was stated in the European Council Recommendation 75/436 on cost allocation and action by public authorities on environmental matters as well as the Environmental Protection Act of 1991. The principle is now incorporated in Article 130 of the Treaty of Rome. An example of partial use of the polluter pays principle is the Superfund programme in the USA. Here, about 70% of the programme costs are recovered from the polluters.

Barriers

Difficulties in implementing the polluter pays principle can arise as is seen by the Superfund example above. A number of barriers occur, which can make it difficult to place liability on the polluters. These barriers are listed below:

- In some cases, it may not be technically possible to determine who the polluter is. In England, the source, pathway and target of contamination are said to be linked. If no linkage can be established, then there is not adequate technical evidence for determining liability.
- In other cases, it may not be possible to show that the polluter has been negligent. In order to be held liable, the polluter must have known or, at the least, should have know, that his activities would cause pollution at the time of the event.
- In many cases, the polluting entity may no longer exist.
- In other cases, the polluting entity may not have the financial resources to remediate.
- Finally, statutes of limitations mean that recovering costs from polluters in cases where the polluting activity has ceased many years prior is not legal.

Financing through taxes

Due to these reasons, a need arises to finance remediations from other sources. Various methods have been used by the five countries in this study. The Capital Projects Scheme in England is financed from the central pot of taxes. The 30% of the Superfund programme in the USA which is not financed by the polluters, is obtained through a specific tax on the chemical and petroleum industries.

Buyer beware

A final possibility for a source of funds is from the landowners of contaminated sites. In England, for example, the buyer beware principle is in effect, so that one speaks of "problem holders" rather than polluters. According to Part IIA of the Environment Act of 1995, problem holders can be held responsible for remediations if no appropriate person who caused or knowingly permitted contamination to occur can be found. In Denmark, the Lost Value Act allows for homeowners who have unknowingly purchased a contaminated site to finance the first 5,400 EUR, while the remaining expenses are covered by the state.

5.5 Water source and use

A comparison of the water supply sources used in the five countries included in this study are shown in figure 5.1. As can be seen, there are large differences in the reliance on groundwater as a supply source from one country to another. Neither Austria nor Denmark have significant reliance on surface waters.

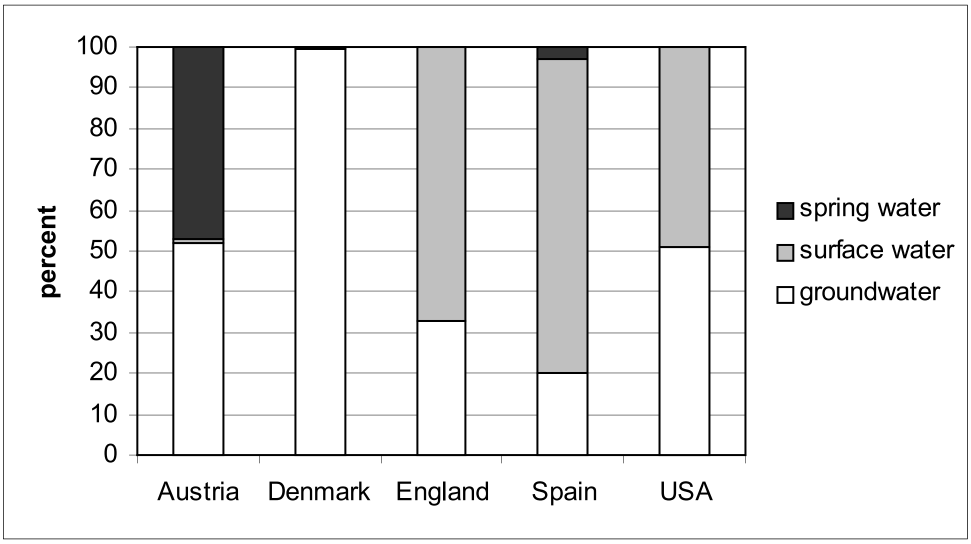

Figure 5.1
Sources of water supply in percent (see appendixes and EEA, 1998).

It is important to realise, that this graph only illustrates the present reliance on the groundwater resource. There are presumably differences in whether this reliance is mandatory, or whether this water supply could be used without incurring undo expense. Most major cities (like London and Vienna) are situated on a major rivers, while Copenhagen has limited surface water sources in the vicinity. In Spain, aqueducts were necessary in Roman times to transport surface water long distances.

There are also large differences in the use categories from country to country. Figure 5.2 gives an overview of these uses.

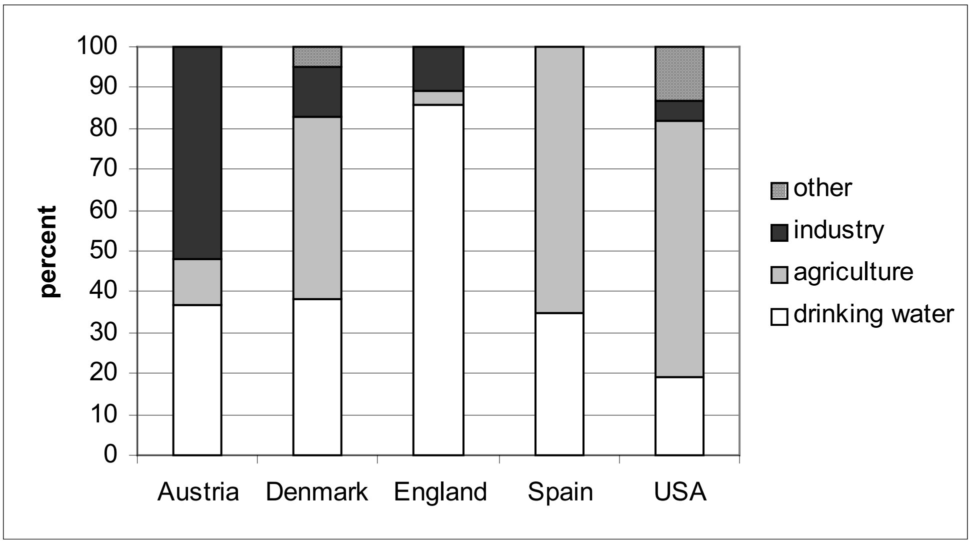

Figure 5.2 *Water consumption categories in percent (see appendixes and EEA, 1998).*

As with contaminated sites, these numbers are difficult to compare, due to differences in which water uses are included. For example, the numbers shown for industrial water use in England do not include cooling water, which often is the major part of industrial use. The numbers for agricultural water use in England do not include fisheries.

As expected, a large percent of water consumption in Spain and the USA (mainly the western states) is for agriculture. Despite a relatively high rainfall, Denmark also uses a significant percent of water for irrigation, due to the intensity of agricultural practices. The amount of water actually used for drinking is relatively small.

In order to obtain a sustainable water policy, levels of consumption must be controlled and the groundwater resource must be protected.

5.6 Treatment of groundwater

In general, the methods used to treat groundwater for drinking water purposes are limited to aeration, filtration and disinfection. In the case of Austria, much of the spring water has low enough content of iron to make aeration and filtration unnecessary. In Austria and Denmark, disinfection is very seldom used.

In no countries are advanced methods such as stripping, carbon filtration or reverse osmosis in general use for the treatment of groundwater. For the treatment of surface waters, however, advanced methods are in more general use.

5.7 Milestone status

When comparing the five countries in this study, major differences can be seen in the progress made in relation to various milestones. An extreme example is the listing of sites. In England, where legal drivers requiring local authorities to list contaminated sites in not yet implemented, no official list yet exists. In Denmark, over 90% of the estimated total of contaminated sites has already been listed (EEA, 1998).

An interesting point to note is the sharing of technical know-how. If one country carries out a research and development programme, results are often used immediately in other countries. In this way, countries can benefit from the fact that other countries have reached a technical milestone.

The internet is a very fast and efficient method of transfer of know-how. Of the five countries in this study, the USA was superior in the amount and relevance of information made available on the internet. A systematic international method for transfer of relevant data would be advantageous.

5.8 Methods for groundwater protection

In all of the five countries studied, implementation of groundwater protection initiatives is carried out on various scales, ranging from areas in the immediate vicinity of individual well fields to areas on the scale of an entire country, which can supply overviews. Table 5.3 gives an overview of some of the various initiatives of the five countries.

Country	**Present water supply**		**Resource protection (future use)**
	Well field	**Recharge area**	
Austria	60 days travel time	Conservation areas	Conservation areas and water management decrees
Denmark	300 m	plans in the making	Particularly valuable water abstraction areas identified
England	50 days travel time	Source Catchment Zone III	Vulnerability maps completed
Spain	none defined	Zones may be defined in Hydrological Basin Plans	Some vulnerability maps prepared
USA	100-400 ft	Zone II in Wellhead Protection Plans	Some states have comprehensive protection plans

Table 5.3 *Overviewof the groundwater protection initiatives of the five countries.*

Well field initiatives

As can be seen by the overview, all countries with the exception of Spain have initiatives in relation to individual wells. Often, these mention the risk of bacterial contamination as a motivating factor for defining circular well field protection zones. England notes that these zones are not necessarily used for abstractions in confined aquifers.

Two similar methods for determining the radius of the circular zones are used: a specific distance and a specific travel time. Neither of these methods involves a high data requirements and are therefore practicable. The travel time method simple requires an estimate of the permeability and groundwater gradient of the aquifer.

The area of these zones is relatively limited. This means that the cost of implementing various protection measures (including remediation of contaminated sites) is economically manageable.

Resource initiatives

At the other end of the scale, there are also initiatives on the scale of an entire country. These are generally related to one or both of the following aspects of the groundwater resource; aquifer value or aquifer vulnerability.

In the Danish example, mapping of particularly valuable water abstraction areas has just recently been completed. As the name indicates, this mapping is based on aquifer value as it relates to population density and on the current water supply structure, such that there is focus on aquifers in current use. In the English example, a combination of potential yield and vulnerability have been used to prepare maps on a scale of 1:100,000. These maps are now complete for all of England And Wales.

These overview initiatives are tools which can be used for prioritising remediation of contaminated sites, local planning, etc.

Recharge area initiatives

The middle column in table 5.3 involves initiatives on the scale of recharge areas for individual wells or well fields. This type of initiative is perhaps the most challenging for two reasons.

Firstly, data requirements for determining recharge areas are great. Often, water level measurements must be collected from the field, pump test data evaluated and groundwater modelling carried out. For this reason, England notes that source catchment areas will be defined only for the larger water supplies. Secondly, since the areas here are large (compared to well field zones), protection initiatives such as remediation can be very expensive. Therefore, there is a need to further divide these areas into sub-areas. One example of this subdivision is to use aquifer vulnerability, which in turn requires yet more data.

These recharge area initiatives are not completed yet in any country. In Denmark, a guidance document for detailed zoning of recharge areas is under preparation. After designation especially vulnerable areas, the document has provisions for direct protection measures such as limitations of farming practices as well as indirect measures such as future land use planning.

6 Discussion

Selecting the most appropriate groundwater protection strategy for a country can be difficult. This protection strategy is a kind of statement of the country‘s level of ambition. It is the implementation of the strategy, however, that provides the actual protection.

The level of ambition of most industrialised countries has been to maintain/return all groundwaters to their beneficial uses or functions resulting in the multifunctionality of groundwater. This approach poses enormous financial problems. A lower level of ambition is to focus on treatment of contaminated groundwater prior to use rather than to be concerned about groundwater protection. This approach may lead to the rapid degradation of the quality of groundwater. Neither of these approaches is necessarily appropriate.

Below, several groundwater protection strategies are discussed to illustrate the challenges which can be involved. Following the strategies, a number of open questions suitable for discussion are listed.

6.1 Multifunctionality strategy

In this approach, the level of ambition is to maintain/return all groundwaters to multifunctionality. For the sake of argument, this approach is here carried to its extreme.

No aquifer distinctions

In this approach, no distinction is made regarding the value of the resource. An aquifer with inferior natural quality, low yield, or a location in a sparsely populated region is treated equally with more valuable resources. The basis for this lack of distinction is the precautionary principle. The most cautious approach is to ensure that the entire resource is protected, since it is not possible to accurately predict the demographics and water needs of the future.

Straight-forward approach

An advantage of the multifunctionality approach is that it is very straight-forward. Since there are no distinctions made between cases, there is very little risk of a polluter being able to lobby his way out of liability or of an environmental authority to carry out a vendetta against one specific polluter.

Clean-up methods limited

The criteria which must be used for the remediation of contaminated sites in this approach are necessarily criteria based on health effects with an adequate safety margin. No allowances can be made for using alternate criteria. This favours certain remediation techniques over others, regardless of price. For example, traditional excavation of contaminated soil is preferable over in-situ techniques, which are unable to meet the most stringent clean-up criteria.

Expensive approach

A major disadvantage to this method is the high cost involved. Whether or not these costs are warranted is a political question and will not be discussed here. The fact is, however, that current budgets typically are inadequate for this approach.

Implementation vacuum

When an adequate budget is lacking, it is naturally very challenging to implement the protection strategy. If the strategy designers have not predicted this situation, an “implementation vacuum” can easily arise. In this vacuum, no guidance is given in how to proceed in the case when the stated level of ambition can not be met with the funds provided. This can result in large regional disparities of approach, as each authority is left to implement in the way they see best fit. In Denmark, for example, some regional authorities give contaminated sites which threaten land use the highest priority for remediation, while other regional authorities focus on groundwater threats. In all fairness, this "implementation vacuum" can also be considered an intentional decentralisation of decision-making.

To fulfil this vacuum, the Environmental Protection Agency (EPA) in the USA often takes a direct approach by recognising areas in which compliance to stated ambition levels may be difficult or impossible and proceeding to describe less ambitious goals. For example, the EPA states,

> " [Superfund] program experience has shown that removal of DNAPLs [dense non aqueous phase liquids] from the subsurface is often not practicable, and no treatment technologies are currently available which can attain ARAR [standards] or risk-based cleanup levels where subsurface DNAPLs are present. Therefore, EPA generally expects that the long-term remedy will control further migration of contaminants form subsurface DNAPLs to the surrounding ground water and reduce the quantity of DNAPL to the extent practicable." (USEPA, 1996).

6.2 Water treatment strategy

In this approach, the level of ambition is limited to avoiding significant contamination of surface waters, while no attempt to avoid groundwater contamination is made. Instead, focus is placed on the treatment of abstracted groundwater prior to use.

Psychological barriers

This strategy is associated with significant psychological barriers. Few of us feel that proper stewardship of our natural resources can include an approach where no reaction is taken towards contamination. It would appear that this strategy does not encompass the goal of sustainability, since the state of the groundwater resource will deteriorate with time. It can also be argued that this strategy is not in keeping with the precautionary principle, since all of the consequences may not be apparent at this time.

Treatment methods exist

However, is can be difficult to argue that this approach is impossible. Advanced water treatment techniques do exist which are capable of removing all kinds of contaminants, even though the methods may be difficult to operate properly, may be expensive and may lower the quality of the water. These methods include adsorption on activated carbon or other materials, stripping, precipitation, biological degradation, ion exchange, neutralisation, etc. If no other technique exists for a specific compound, various membrane filtering techniques such as reverse osmosis can often be used.

Expensive approach

This strategy involves increased expense with respect to water treatment. However, since groundwater protection is unnecessary, decreased expenses with respect to investigation multifunctionality and water treatment strategies and no attempt is made here.

Robust criteria

A prerequisite for this strategy is that robust criteria for treated water must be set. Since increasing numbers of contaminants must be treated in this approach, these contaminants must be adequate to ensure that the criteria are observed.

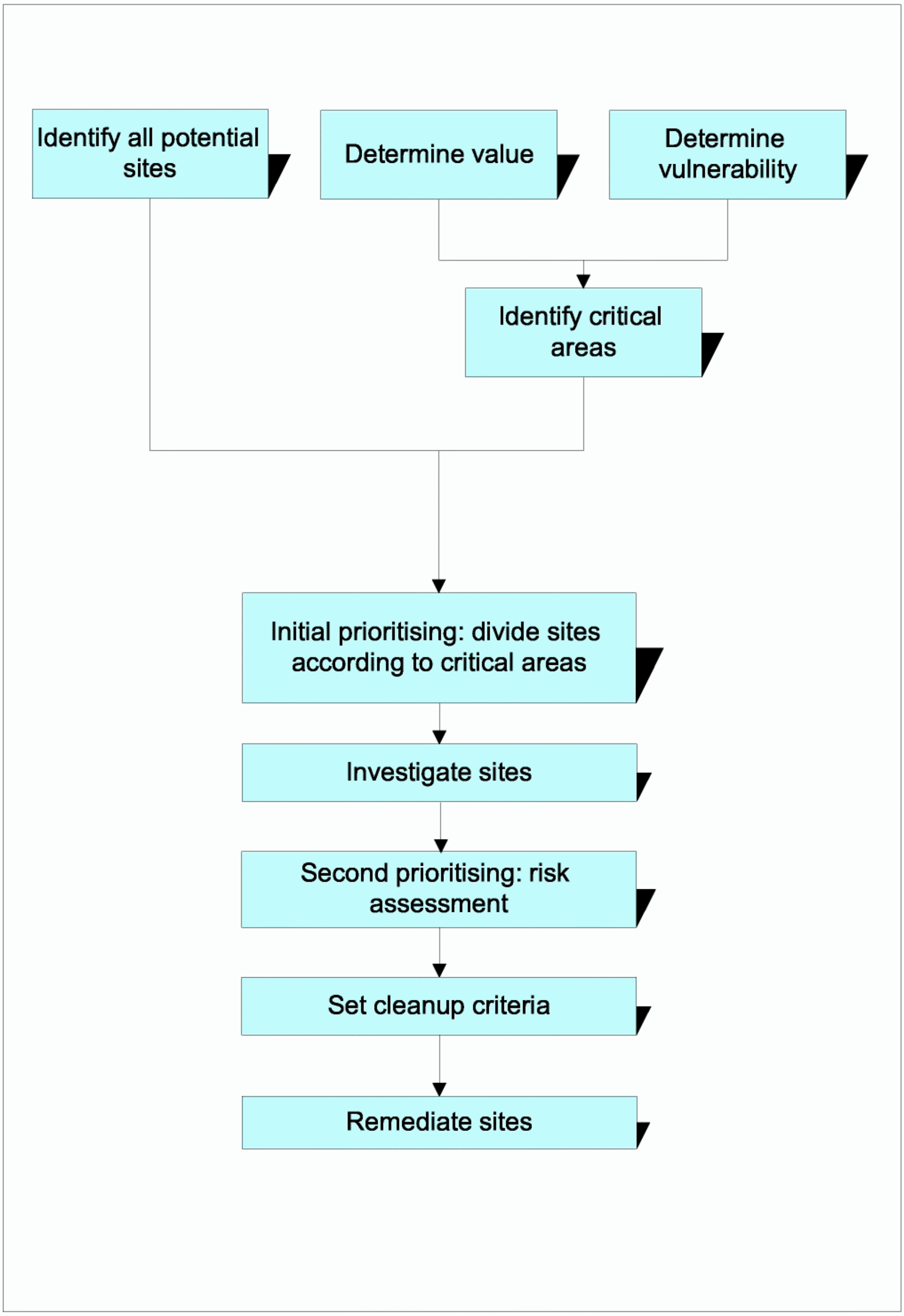

Figure 6.1: Milestones and pathway in the combined groundwater protection strategy

6.3 Combined strategy

A combined strategy includes elements from the multifunctionality strategy and the water treatment strategy. One possible combined strategy is described below.

Aquifer value

A key element in the combined strategy is the differentiation of groundwater aquifers according to their present value and perceived future value. Aquifer value is related to the population density in the vicinity, the natural groundwater quality and the sustainable yield of the aquifer. Aquifers with high value can subsequently be prioritised higher than aquifers with low value. In the United States, differentiation of aquifers is left up to the individual states, resulting in state variations in the approach to groundwater protection.

Aquifer vulnerability

The combined strategy also includes a determination of aquifer vulnerability. There a various methods of carrying out this determination. In England, much focus has been placed on aquifer vulnerability and maps on a scale of 1:100,000 have been prepared for the whole of England and Wales. The maps are based on the two major parameters, geological classification and soil classification. Additional parameters which could be included in the determination of vulnerability include hydrogeology and groundwater chemistry. Use of mapping with geophysical techniques is of great value here.

Maps of aquifer value and vulnerability are then overlaid to determine critical areas with respect to groundwater protection.

Prioritising sites

In the combined strategy defined here, all contaminated sites are identified and listed, without reference to aquifer value or vulnerability. The listed sites are then divided into two categories: those falling within the critical areas, and those in less critical areas. This initial prioritisation determines which sites must be investigated. Following investigation, a new round of prioritising must take place to determine which sites are to be remediated first. This second prioritisation is based on a risk assessment or scoring system.

Setting cleanup criteria

Prior to remediation, it is necessary to determine cleanup criteria. This can be done in a number of ways. One extreme is to simply use drinking water standards or to require the use of best available technology. A second method is to outline various remedies, the costs involved and the criteria which are expected to be reached. In this way, the criteria are related to the remediation technology selected.

Use of contaminated water

In many cases, remediation of contaminated groundwater takes place with the pump-and-treat technique. Treated water is often discharged to a surface water body. Alternatively, other uses (such as industrial uses) could be made of this water in order to reduce the amount of pristine groundwater which must be abstracted and hereby conserve the groundwater resource.

Groundwater protection strategies can be visualised by a flowchart which shows the major milestones and the pathways between these milestones. Figure 6.1 shows a flowchart for the combined strategy described above.

6.4 Discussion questions

Further discussions will undoubtedly reveal new insight into the question of groundwater protection strategy as it relates to point sources of contamination. The following list of questions are intended to provide a starting point for ensuing discussions.

- In this report, a number of legislative, technical and implementation milestones were identified. These milestones can be used to determine the status of a country's groundwater protection program. Questions: Have any milestones reached 100% completion? Have any of the milestones identified not yet been addressed?

- It can be argued that there is a great disparity between legislation and implementation. What appears to be appropriate legislation may be in place, but implementation of the legislation appears to be permanently stuck in the initial phases. Question: Can specific examples of this phenomenon be identified?

- International literature is full of estimates as to how long a remediation programme will be necessary in order to clean up the contamination problems of the past. Initially, these estimates were relatively short, often around 10 years. As we learn more, these time estimates tend to lengthen. Question: Are remediation programmes for point sources a permanent part of our society?

- Groundwater protection strategies have changed through the years. As an example, hydrocarbon contamination was previously thought to be one of the very greatest threats to the groundwater resource. Currently, recalcitrant contaminants such as chlorinated solvents and pesticides are in focus while hydrocarbons are thought to present only local threats. Question: Is there any value in a long-term strategy, or must a strategy be reactionary, such that when new information is available, a new strategy is prepared?

- Decision-making in relation to contaminated sites, water supply and groundwater protection can be made at various levels. Many countries make decisions about these subjects at the regional, local and national scales, respectively. Questions: Should groundwater questions be administered on an aquifer basis rather than the typical political boundaries? Should sites which threaten groundwater and sites which threaten land use be administered separately?

- A combined strategy for groundwater protection is described in a general way in section 6.3. Question: Is there a need to develop a detailed paradigm of this strategy at an international level?

7 Literature

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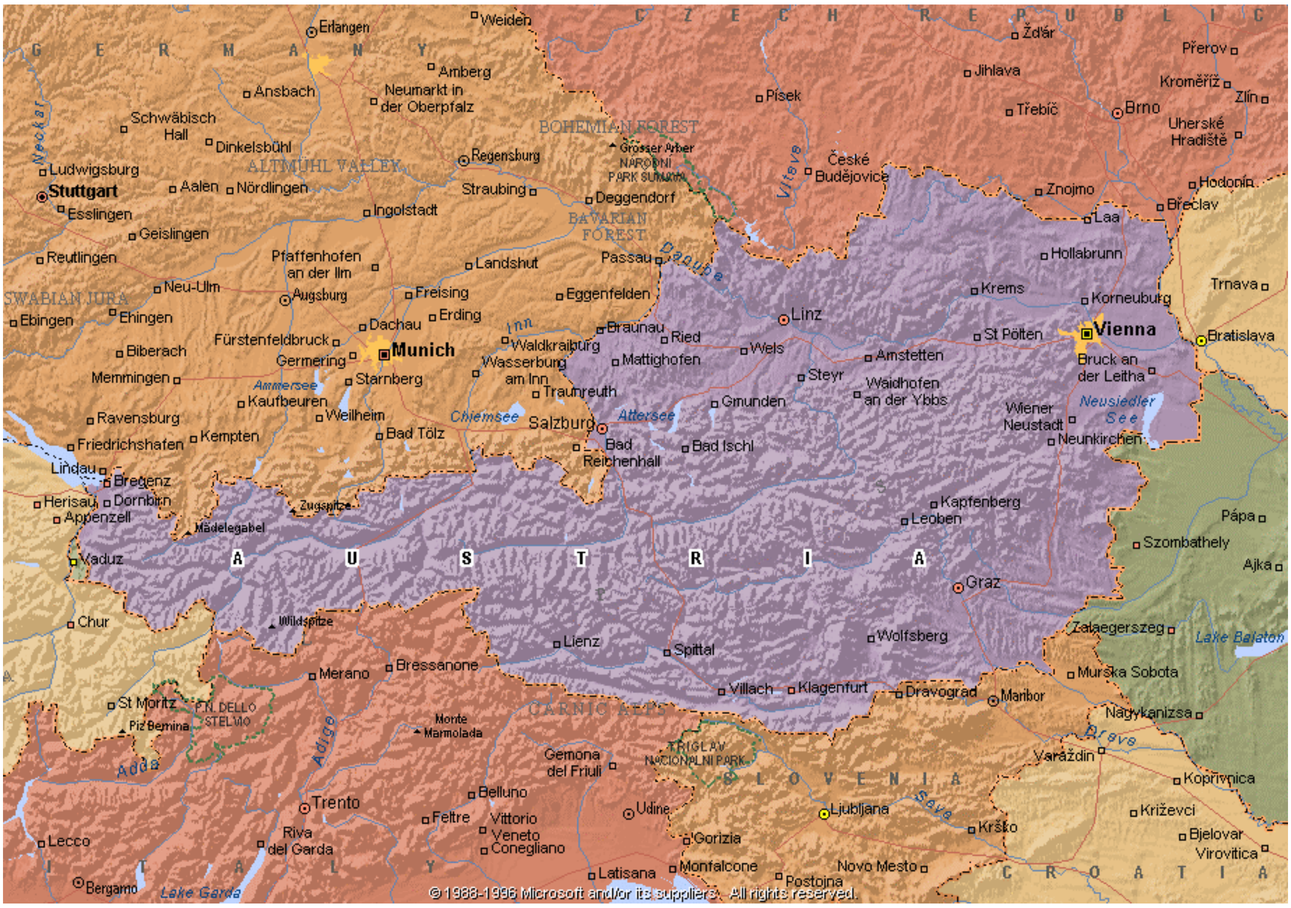
Attachment 1: Austria



1 Background information

1.1 Basic facts

Austria has a population of 8,055,000 (1996) and an area of 83,900 km^2. This gives a population density of 96 persons pr. km^2.

GDP

The gross domestic product (GDP) in Austria is 2,352,000 mill. Austrian shillings (quarterly rate for 1995: OECD, 1998). The current exchange rate is approximately 13.8 ATS pr. EURO. The annual gross domestic product pr. person is therefore approximately 85,000 EURO.

Precipitation

The range of precipitation is from more than 2,000 mm/year in mountainous regions to less than 600 mm/year at pannonic climates in the north-east near Vienna. The average of precipitation for the whole country is 1,170 mm/year. The range of evaporation is also greatly varied. Evaporation is negligible in the mountains and exceeds precipitation in the warm pannonic climate in the north-east. The average of evaporation for the whole country is about 510 mm/year. Therefore, the total net precipitation in Austria can be estimated at 84 billion m^3 (Draft RSEA).

1.2 Structure of environmental authorities

Austria is a federal republic with a Federal Assembly composed of 2 chambers, the Federal Council (Bundesrat) and the National Council (Nationalrat). The most important instrument of the Assembly is the passing of legislation.

Two ministries involved

Soil and water protection falls within the responsibility of the Ministry of Agriculture and Forestry. The Ministry of Environment was introduced in the late 70'ies. This Ministry has the responsibility for waste management, for the outlines of environmental impact assessment and the funding of environmental projects in Austria (sewage plants, remediation of contaminated sites) and in the CEE-countries.

Federal Environment Agency

The Federal Environment Agency, founded in 1985, is a specialist institution under the Ministry of Environment and was privatised in the beginning of 1999. The Federal Environmental Agency deals with all areas of environmental protection on a nation-wide basis and the main task is to observe and document the state of the environment and tendencies of development. Additionally, predisposing works for legislation are done and in certain fields as the remediation of contaminated sites executive tasks are attended.

Regional authorities

Although the environmental legislation is focused at a national level, the regional authorities located in each of the 9 states (Bundeslaender) have full executive power and can do additional legislation in certain fields.

Figure 1.1 shows the relationship between these authorities.

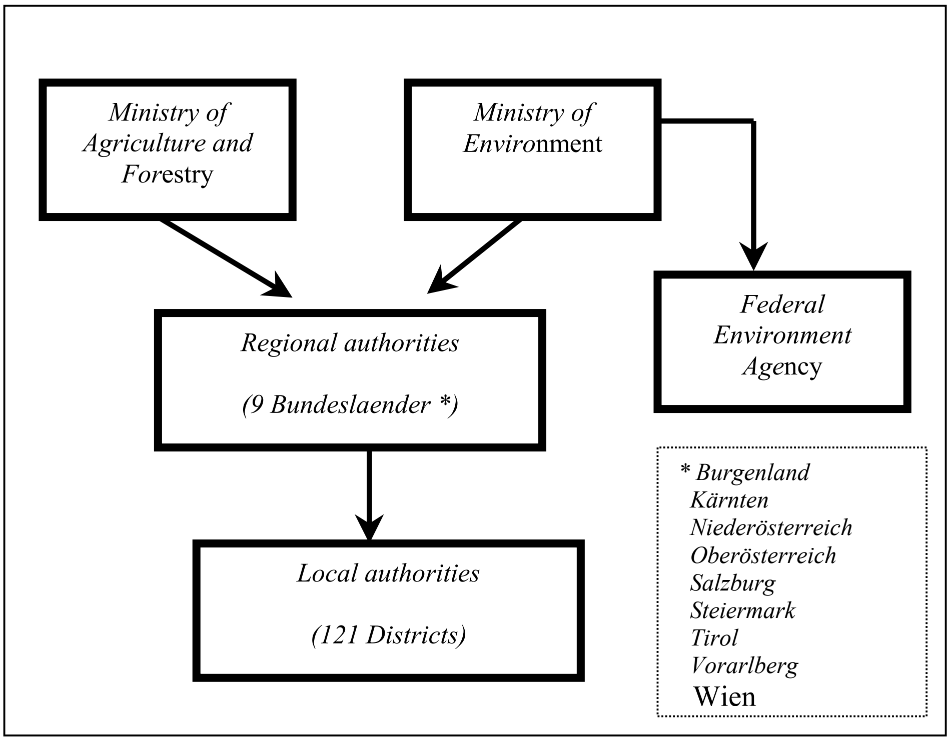


Figure 1.1. Relationship between the various environmental authorities.

1.3 Statutory and advisory information

With regard to groundwater protection and contaminated sites, there are four major laws of concern:

1) Water Act, 1959
2) Industrial Code, 1973
3) Act on the Clean-Up of Contaminated Sites (ALSAG), 1989
4) Waste Management Act, 1990

The Water Act

The Water Act is characterised by its use of the precautionary principle. The legal goal of keeping water resources clean has been defined as "Maintaining water in its natural condition". Since more than 99% of Austrian drinking water is supplied by groundwater, groundwater protection is fundamental. Pursuant to the Water Act, groundwater has to be kept as clean as necessary for use as drinking water.

Industrial Code & Waste Management Act

Apart from the Water Act, there are two other main pieces of legislation containing provisions that have to be taken into account dealing with contaminated sites; namely, the Industrial Code and the Federal Waste Management Act. In connection with approving industrial activities or closing down industrial sites, the Industrial Code mainly aims to protect the interests of neighbours and water bodies. The Waste Management Act is used to determine when waste collection and treatment is required in the public interest.

ALSAG

The Act for the Clean-Up of Contaminated Sites, or ALSAG, was primarily intended to be a means of funding clean-up measures. Charges levied for disposal or export of waste are put into a fund from which grants for remediation projects are available. The fund covers costs of site investigation at abandoned sites and - to some extent - covers the costs of remediation measures.

The major features of ALSAG are:

- funds are provided for abandoned and operating landfill sites and industrial sites

- only contamination at sites that existed before 1989 are taken into consideration, since current legislation is supposed to cover the problems of recent sites
- the provision of funds is carried out according to priorities set at national level.

Furthermore, the Ministry of the Environment, Youth and Family is obliged to survey, investigate and assess contaminated sites on a national scale and to co-ordinate corresponding measures, Consistent with the legal background, the Federal Environmental Agency implements listing, investigation and assessment according to ALSAG. Local authorities execute the basic laws of the Water Act and implement remediation projects. The Ministry co-ordinates the activities related to this act and is responsible for the allocation of money to fund clean-ups.

2 Point Sources

According to the Act for the Clean-up of Contaminated Sites (ALSAG), the Provincial Governors have to inform the Environment Minister about potentially contaminated sites. Corresponding to a preliminary assessment sites which are suspected to cause a serious threat are listed in the Register of Potentially Contaminated Sites. Due to the results of investigations and a risk assessment performed by the Federal Environmental Agency sites which are shown to constitute a considerable threat to human health or the environment are identified as contaminated and listed in the Register of Contaminated Sites (Altlastenatlas). Furthermore, a priority class proposed by the Federal Environment Agency indicates the urgency for remedial measures.

This results in three lists of sites in Austria:

- The Register of Contaminated Sites
- The Register of Potentially Contaminated Sites
- The Register of landfills and industrial sites which existed before 1989

Information from the registers is only disclosed on specific request and after assessment of the confidentiality of the requested data.

2.1 Number of Sites

Listed sites

The total number of sites listed in the Register of Contaminated Sites (Altlastenatlas) is 145, of which 78 are landfills and 67 are industrial sites (Umweltbundesamt, 1999). More sites are expected to be listed in the future. The latest estimation of the total number of contaminated sites dates back to 1994 and gives a number of 1,500 contaminated sites (ETCS, 1998). As there is a lack of an appropriate target of environmental policies on the theme of contaminated sites and since criteria for assessment and remediation may be revised in the near future, the magnitude of the problem may range from 1,000 to 5,000 contaminated sites.

The total number of sites listed in the Register of Potentially Contaminated Sites (Verdachtsflächenkataster) is 2,476, of which 2,303 are landfills and 173 are industrial sites. Preliminary assessments have resulted in giving 234 sites a high priority for investigation. In 1998, investigations were under progress at 164 of these sites (Umweltbundesamt, 1999).

Information on potentially contaminated sites which has been passed by the Provincial Governors to the Environment Minister is listed at a total of 29,493 (4,125 landfills and 25,368 industrial sites; Umweltbundesamt, 1999). It is expected that the total number of abandoned landfills and industrial sites is approximately 80,000 (ETCS, 1998).

Delisted sites

As of 1998, 12 sites were delisted from Register of Contaminated Sites (Altlastenatlas) and classified as remediated. At the same time, remediation was in progress at 42 sites.

In 1998, a total of 108 sites were delisted from the Register of Potentially Contaminated Sites. This delisting was the result of revised preliminary assessments, contamination investigations or voluntary remediation.

2.2 Time frame for clean-up

In 1989, when the Act on the Clean-Up of Contaminated Sites was prepared, an estimate of the funding of clean-up activities was made. This estimate took into account a time frame for clean-up of 10 years. Currently, there is no published official estimation on this subject.

At the moment, amendments to the ALSAG are being prepared. Experience has shown that the magnitude of the problems posed by contaminated sites have been underestimated. It has become clear that the remediation of contaminated sites within a national programme is a long-term task.

2.3 Costs

In 1989, the cost of cleaning up all of the contaminated sites in the registry was estimated at 5,000 to 10,000 mill. ATS. In 1994, the costs for remediating 300 priority sites was estimated at 20,000 mill. ATS (ETCS, 1998).

The annual budgets for investigations in 1998 and 1999 are ATS 89 million and ATS 114 million. The annual budgets for funding of remediations 1998 and 1999 are ATS 507 million and ATS 646 million.

In 1998, the political commission for remediation of contaminated sites approved 17 projects. The range of the project costs was from ATS 0,83 million up to ATS 155 million, and the range of the grants was between 30 % and 95 % from ATS 0,42 million up to ATS 78,4 million. The sum of the project costs was ATS 607 million, the sum of the grants was ATS 256 million.

This mentioned costs do not include costs associated with voluntary remediation. There is no overview of the number and extent of voluntary clean-up.

3 Water Supply

3.1 The groundwater resource

Renewable resource

The groundwater resource in Austria stems from precipitation in Austria and from inflow of groundwater from other countries. Approximately 98,000 mill. m^3 water stem from precipitation (1,170 mm) and 29,000 mill. m^3 water stem from inflow from abroad. With an estimated evaporation of 43,000 mill. m^3, a total of about 84,000 mill. m^3 renewable water has been calculated (Draft RSEA, 1998).

From these resources, a total of 2,600 mill. m^3 or only 3 % is used for water supply.

Major aquifer types

The most important aquifers used in Austria for water supply are:

- aquifers in quaternary sediments consisting of sandy gravels and located in the major basins along the big rivers,
- karst aquifers and spring waters within carbonate rocks of the Northern and the Southern Alps

In mountain regions, there is often a lack of cover layers and the cover layers of the quaternary aquifers are usually very shallow. These aquifers are generally presumed to be very vulnerable. The age of spring waters in the karst aquifers of the Alps is very young in general (less than 1 year). In general, the age of the water in quaternary sediments is also presumed to be young.

Minor aquifer types

In addition to the major aquifers above, the following aquifers are found in Austria and have regional importance:

- aquifers in tertiary sediments, consisting of sand
- aquifers in diverse sedimentary bodies as the quaternary deposits including the moraines of the Pleistocene alpine glaciers, that extended far into the foreland
- aquifers in fractured rocks of the Bohemian massif and the Central Alps (granite and gneiss)

3.2 Supply statistics

More than 99 % of the drinking water supply in Austria is based upon groundwater, including spring water and bank infiltration. Less than 1 % is based on surface water (Draft RSEA, 1998).

In 1993, the total water consumption in Austria was estimated to be 2,6 billion m^3. The following water consumption rates were calculated (Draft RSEA, 1998):

- industry — 38 % - groundwater
- industry — 27 % - surface water
- drinking water — 37 % - groundwater
- irrigation — 11 %.

The total of the public water supply with drinking water (including domestic use, commerce and small enterprises) was 0,7 billion m³. Household consumption is about 145 l pr. person pr. 24 hours (Draft RSEA, 1998) and is stagnant to slightly decreasing through the last decade.

3.3 Water supply structure

The water supply structure in Austria exhibits features of centralisation as well as features of decentralisation. The total number of waterworks is estimated to be about 3,000. These waterworks supply 86 % of the Austrian population. In 1995, 188 large suppliers where within the Austrian Association of waterworks and provided drinking water for 65 % of the population (ÖVGW, 1995). The largest utility supplies Vienna (> 1,7 million people or > 20 % of Austrian population). More than 95% of the drinking water for Vienna is produced from to spring waters in the Alps. In contrast, 14 % of the households obtain their drinking water from private wells.

There is no specific policy for centralisation or decentralisation. There is, however, a centralisation tendency. The percentage of the households supplied by the common utilities has increased slightly throughout the last decades, as in many regions waterworks merged in clusters in order to provide drinking water at high quality, which is permanently controlled. Although the suppliers merged, very few utilities have been closed. On the other hand, tendencies for centralisation is limited naturally in many regions in Austria (e.g. little valleys in the Alps with a very low population density).

3.4 Water treatment

The great majority of water supplies in Austria (especially those providing spring waters for drinking water) can use their raw water without treatment or by using simple treatment methods like filtration or aeration. At a number of supplies, disinfection is necessary. In general, there is no use of any advanced treatment methods like stripping and adsorption.

3.5 Drinking water criteria

Two types of criteria are used in Austria. The actual criteria for drinking water are given by an Ordinance on the Quality of Drinking Water (TWV, 1998) while the Groundwater Threshold Value Ordinance (GSWV, 1991) provides threshold values to assess environmental challenges from diffuse sources of pollution (see 4.1.3) In general, the intervention values for groundwater at contaminated sites are set equal to the drinking water standards and the screening values are set equal to the threshold values for groundwater both of these criteria are given in Appendix 1.

Firstly, guidelines for the quality of raw water used for production of drinking water are given for a large number of parameters (WGEV, 1991). Secondly, drinking water criteria are given (GSWV, 1998). Both of these criteria are given in Appendix 1.

3.6 Costs

The average price charged per m³ to the consumer in 1995 was ATS 12,21. There is no special water tax. The usual range of the price was from ATS 6,50 up to ATS 18,-, with a minimum at ATS 3,- and maximum at ATS 30.

There is no number for the specific energy consumption for the production of drinking water in Austria, as there are great differences between waterworks producing out of spring waters in the mountains which need hardly any energy and waterworks producing out of sediment aquifers.

4 Groundwater Protection

In the following sections, measures which are used in Austria for the protection of groundwater are given. To improve the overview, these measures are divided into measures which can be utilised to prevent contamination from happening (prevention) and measures which are used to tackle existing contamination problems (remediation).

4.1 Prevention

Preventive measures are centred around the definition of wellhead protection zones and aquifer protection zones and pollution from diffuse sources as described below.

4.1.1 Wellhead protection zones

In addition to a physical protection area on a smaller scale, protection zones around individual supply wells are usually set. These protection zones are declared by the local authorities under the Water Act. The size and shape of this protection zone are related to the catchment area of the well and a period of 60 days of groundwater flow. Originally, this was meant as a sanitary protective area. The authorities can define restrictions for current and future land-use within a wellhead protection zone.

4.1.2 Conservation areas

The Water Act also defines so-called conservation areas with the aim to protect water resources on a larger scale and to guarantee future water supply in general. The size and the shape of a conservation areas which has groundwater of importance for present and future water supply can be determined by special studies or can focus on river basins.

Conservation area declaration

Under the Water Act, a conservation area can be declared by federal authorities as well as by local authorities. Within this declaration, restrictions for current and future land-use can be defined. The declaration of a conservation area usually instructs the local authorities to give special consideration to water protection with respect to industrial operations and urban development.

Mapping

Since a declaration of a conservation area must include the delineation of its borders, there is a map for every conservation area. In addition, a general map of conservation areas in Austria is available.

4.1.3 Environmental challenges from diffuse sources of pollution

Quality of groundwater in porous media is endangered by both diffuse and point sources. In order to assess pollutants from diffuse sources, a Groundwater Threshold Value Ordinance has been issued. The threshold values in this ordinance were determined in accordance with the precautionary principle and are below (60 %) or equal to the drinking water standards. If these threshold values are exceeded in more than 25 % of the sampling sites within a groundwater body over a longer period, the provincial authorities have to co-ordinate remediation measures.

4.1.4 Mapping of vulnerability

A mapping of groundwater resources according to vulnerability has not taken place so far.

4.2 Remediation

4.2.1 Prioritising contaminated sites

Priority classes

Any site which threatens the groundwater or the environment in general must be declared as contaminated and listed in the Register of Contaminated Sites. This national inventory distinguishes between three classes of priorities which are described below. Since it is the intent of ALSAG to finance or fund remediation projects, the classification is a means to qualify environmental risks and to determine the urgency of financing and remediation of individual projects. Groundwater protection strategy and the targets of the Austrian Water Act are integrated in the overall process of risk assessment and prioritising.

The Act on the Clean-Up of Contaminated Sites (ASLAG) mentions five general aspects (e.g. actual and future spreading of contaminants; threatened objects and current use) for setting priorities. According to these aspects, contaminated sites are prioritised on a national scale by placement into one of the following three classes (simplified):

Class I (highest priority):
- Actual groundwater contamination with significant emissions of pollutants.
- Actual or potential contamination of public drinking water supplies, specially protected groundwater resources, or large areas. Risk of rapid spreading of pollution.

Class II:
- Actual groundwater pollution with significant emissions of pollutants.
- Groundwater resources polluted by a small area and the possibility of a further future spreading of the pollution is low.
- No special protection of the local groundwater resource.
- No future damages to drinking water wells expected.

Class III (lowest priority):
- No actual pollution of groundwater or pollution of a groundwater resource of low flow rate and a low emission rate for pollutants.
- No special protection of the local groundwater resource, no future damages to public water supply wells expected.

Priority class proposal

Classifying a contaminated site requires a risk assessment and a proposal of a specific priority class by the Federal Environmental Agency. The risk assessment has to describe risks according to four receptors (groundwater, surface water, soil, air). The proposal of a priority class is an expert judgement, which includes the results of a scoring procedure. The threats a contaminated site poses to the four receptors of concern are judged and scored autonomously. The proposal must pass a public hearing of a political commission and comments of the local authorities.

At the end of 1998, the Register on Contaminated Sites contained 145 contaminated sites. A total of 110 of these sites has been prioritised. 34 sites have been assigned to priority class 1, 47 sites to priority class 2 and 29 sites to priority class 3. At these sites, receptors which were threatened are as follows:

- groundwater - 140 sites
- surface water – 10 sites
- gas (landfill gas) – 10 sites
- soil (land use) – 9 sites

Groundwater conservation zones, groundwater protection zones, affected wells and drinking water plants are all taken into account during the prioritising of contaminated sites. The actual practice of prioritising is in line with the intentions of the Federal Environment Agency since is carried out at a national level by the Agency itself. Nevertheless, difficulties are often experienced in initiating an urgent clean-up on short notice. This is due to the current legislation, which makes it possible for polluters to delay legal proceedings and also due to the fact that the regulations for the financial compensation of clean-ups driven by the authorities are not adequate.

4.2.2 Criteria

Current criteria

There is no federal law for soil protection. The Act on the Clean-up of Contaminated Sites (ALSAG) focuses on the funding of remediations. There are hardly any regulations defining targets or criteria for assessment and remediation within this act. Criteria for assessment and remediation are therefore basically driven by corresponding legislation such as the Water Act. This act sets out the targets for groundwater protection, as it generally demands the preservation of drinking water quality. Therefore, all contaminated sites must currently be cleaned up to an extent at which groundwater quality is returned to drinking water standards and at which no significant pollution of the soil remains.

Future criteria

Since the Water Act is dominated by the precautionary principle, there is an ongoing discussion to introduce the repair principle as a second approach with regard to contaminated sites. There are three possible targets or levels for the remediation of contaminated sites (ÖNORM S 2088-1):

- natural quality of groundwater
- quality which allows for the multifunctional and sustainable use of groundwater
- restoration with regard to current and future use

Table 4.1 gives an overview of criteria as they relate to the three mentioned remediation targets.

Remediation Target	**Leachate or Porewater**	**Downgradient groundwater**
Natural quality	should meet drinking water standards	Should meet a value of 60% of the drinking water standards
Mulitfunctional use	should not release significant amounts of pollutants to groundwater	Should meet drinking water standards
Current and future Use	-	Should not release significant amounts of pollutants to groundwater

Table 4.1. Remediation targets and their criteria for clean-up.

It is planned to include these targets in future legislation for contaminated sites. This will require introducing “alternate concentration limits” for pore water and to define “release of significant amounts” for both pore water and groundwater.

Types of criteria

In the Water Act there is no differentiation between “intervention values” and “target values” for the clean-up. In general, groundwater and pore water should meet drinking water standards. With respect to specially protected groundwater resources, the criteria for groundwater can be lowered to 60 % of the drinking water standard.

The ÖNORM S 2088-1 differentiates between “trigger values” and “intervention values”. ”Trigger values” mark concentration limits demanding further investigation and assessment whereas ”Intervention Values” mark concentration limits which usually demand remediation activities. The derivation of “clean-up values” can take place site-specifically within the range between “trigger values” and “intervention values”. The criteria set out in the ÖNORM S 2088-1 are included in Appendix 1.

4.3 Costs

There are no data available on the total costs of the management of the groundwater resources nor on the costs of land-use restrictions.

5 Literature

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Appendix 1: Groundwater Criteria, Austria

Parameter	Units	Detection limit	Difference value A [1]	B [2]	Screening Value [3]	Intervention Value [4]
Conductivity	µS/cm	-	+25%	-	-	-
pH		-	-	-	<6,5 / >8,5	-
Dissolved oxygen	mg/l	0,2	-50%	-	-	-
Hardness	°dH	1	+25%	-	-	-
Carbonate hardness	°dH	1	+25%	-	-	-
HCO_3	mg/l	3	+100%	+50	-	-
Ca	mg/l	3	+100%	+50	240	-
Mg	mg/l	1	+100%	+50	30	-
Na	mg/l	1	+100%	+50	30	-
K	mg/l	2	+100%	+50	12	-
NO_3	mg/l	1	+100%	+50	50	-
NO_2	mg/l	0,01	+200%	+100	0,1	-
NH_4	mg/l	0,01	+200%	+100	0,3	-
Cl	mg/l	1	+100%	+50	60	-
SO_4	mg/l	1	+100%	+50	150	-
Fe	mg/l	0,02	+300%	+150	-	-
Mn	mg/l	0,02	+300%	+150	-	-
Al	mg/l	0,01	+300%	+150	0,12	0,2
B	mg/l	0,02	+100%	+50	0,6	1
$KMnO_4$	mg/l	0,5	+100%	+50	12	20
DOC	mg/l	0,5	+100%	+50	-	-
Cyanide (total)	µg/l	5	+200%	+100	30	50
Fluoride	µg/l	100	+200%	+100	900	1500
Arsen	µg/l	1	+300%	+100	30	50
Lead	µg/l	1	+300%	+100	30	50
Cadmium	µg/l	0,2	+300%	+100	3	5
Chromium (total)	µg/l	1	+300%	+100	30	50
Copper	µg/l	1	+300%	+100	60	100
Nickel	µg/l	1	+300%	+100	60	100
Mercury	µg/l	0,2	+300%	+100	1	1
Zinc	µg/l	20	+300%	+100	1800	-
AOX	µg/l	5	+100%	+50	-	-
∑ Mineral Oil	µg/l	50	+100%	+50	60	100
∑ LHKW [5]	µg/l	0,1 [6]	+200%	+100	18	30
∑ BTX	µg/l	0,5 [7]	+200%	+100	30	50
Benzene	µg/l	0,5	+200%	+100	1	5
Phenol	µg/l	10	+100%	+50	10	50
∑ PAH [8]	µg/l	0,05	+200%	+100	0,1	0,2
∑ PCB [9]	µg/l	0,01	+300%	+100	0,05	0,1

[1] Difference value for (X) < 5 * detection limit

[2]) Difference value for (X) > 5 * detection limit

[3] The Vaules have been established in order to the „groundwater (BGBl. Nr. 502/1991), the publication "Orientierungswerte für die Bearbeitung von Altlasten und Schadensfällen" Baden-Württemberg 1993 Germany and the LAWA-Recommandations 1/94 (Germany)

[4] The Values have been established in order to the drinking water standards (Chapter B1 "Trinkwasser" , Austrian Codex, 1993), the publication "Orientierungswerte für die Bearbeitung von Altlasten und Schadensfällen" Baden-Württemberg 1993 (Germany) and the LAWA-Recommandations 1/94 (Germany)

[5] total of the halogenated C1- und C2-Hydrocarbons

[6] detection limit for one substance; some of the LHKW meet higher detection limits up to 0,3 µg/l

[7] detection limits gelten jeweils für Einzelsubstanzen

[8] total of 6 (DIN 38409-13)

[9] total of 6 (Ballschmiter)

Appendix 2: Leachate Criteria, Austria

Criteria for the mobilisation of pollutants to groundwater – Leachates.

	Units	Screening Value [1]		Intervention Value [2]	
		a	b	a	b
Group 1 (general parameters)					
Conductivity	µS/cm	1000	1500	3000	3000
pH	-	< 5,5/ > 10	< 5,5/>11	<5,5/>12	<5,5/>13
NO_3	mg/l	30	50	[3]	[3]
NO_2	mg/l	0,1	0,5	1,0	[4]
NH_4	mg/l	0,5	2,0	5,0	[4]
Cl	mg/l	200	[3]	[3]	[4]
SO_4	mg/l	250	[3]	[3]	[3]
P	mg/l	0,5	2,0	2,0	5,0
AOX as Cl	mg/l	0,01	0,05		
CSB	mg/l	20	40	50	80
Mineral oil	mg/l	0,1	0,5	0,5	[4]
Group 2					
Cyanide (total)	mg/l	0,05	0,1	0,5	[4]
Fluoride	mg/l	1,5	3,0	5,0	[4]
Aluminium	mg/l	0,2	2,0	10,0	[4]
Arsenic	mg/l	0,05	0,1	0,1	[4]
Lead	mg/l	0,05	0,1	0,5	[4]
Cadmium	mg/l	0,005	0,005	0,05	[4]
Chromium (total)	mg/l	0,05	0,1	1,0	[4]
Iron	mg/l	1,0	2,0	2,0	20,0
Copper	mg/l	0,1	1,0	1,0	[4]
Manganese	mg/l	0,1	1,0	1,0	10,0
Nickel	mg/l	0,1	0,5	0,5	[4]
Mercury	mg/l	0,001	0,002	0,005	[4]
Zinc	mg/l	3,0	3,0	3,0	[4]
BTX (Benzene, toluene, xylenes)	mg/l	0,03	0,05	0,1	[4]
Benzene	mg/l	0,001	0,003	0,01	[4]
Phenol	mg/l	0,01	0,1	0,1	1,0
PAH (total of 6)	mg/l	0,002	0,002	0,003	[4]
PCB (total of 6)	mg/l	0,0005	0,0001	0,0002	[4]

a ...areas with specially protected groundwater

b ...other areas

Appendix 3: Soil Vapor Criteria, Austria

Criteria for the mobilisation of pollutants to groundwater – soil vapor.

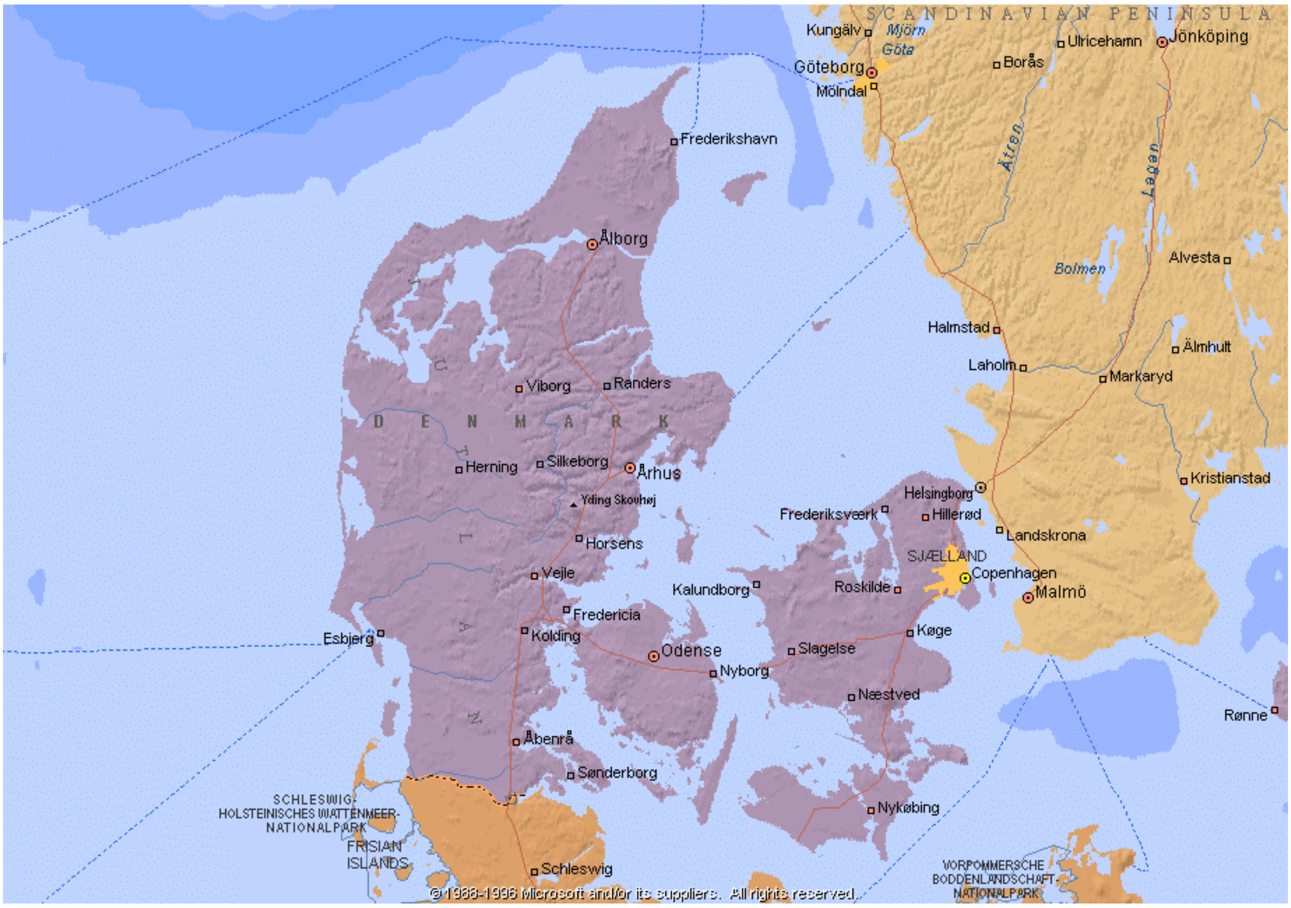
	Units	Screening Value [1]		Intervention Value [2]	
		A	B	A	b
Chlorinated hydrocarbons	mg/m^3	5	10	10	50
BTX	mg/m^3	5	10	10	50
Mineral Oil (C_2 bis C_{10})[1]	mg/m^3	10	50	50	100

Appendix 4: Soil Criteria, Austria

Criteria for the mobilisation of pollutants to groundwater – soil.

	Units (dry weight)	Screening Value	Intervention Value
Arsenic	mg/kg	40	100
Lead	mg/kg	100	1000
Cadmium	mg/kg	2	20
Chromium (total)	mg/kg	100	600
Copper	mg/kg	100	1000
Nickel	mg/kg	100	500
Mercury	mg/kg	2	20
Zinc	mg/kg	300	2000
Fluoride	mg/kg	500	3000
Cyanide (total)	mg/kg	25	500
Mineral oil	mg/kg	500	1.000
Light mineral oil	mg/kg	100	250
BTX	mg/kg	10	30
Benzene	mg/kg	0,5	3
Phenol	mg/kg	10	25
PAH (total of 6)	mg/kg	10	100
PCB (total of 6)	mg/kg	1	10

Attachment 2: Denmark



1 Background information

1.1 Basic facts

Denmark has a population of 5,251,000 (1996) and an area of 43,100 km^2. This gives a population density of 122 persons pr. km^2.

GDP

The gross domestic product (GDP) in Denmark is 1,013,640 million crowns (quarterly rate for 1995: OECD, 1998). The current exchange rate is approximately 7.4 Danish crowns (DKK) pr. ECU. The annual gross domestic product pr. person is therefore approximately 104,000 ECU.

Precipitation

Precipitation is measured at 400 stations throughout the country and varies from approximately 500 mm/year in northwest Zealand to 900 mm/year in southern Jutland (annual average for the period 1961-1990). The amount of evaporation depends on soil, plant cover and weather conditions. The net precipitation (defined as precipitation minus evaporation) varies regionally even more than precipitation alone, namely from approximately 150 mm/year to 400 mm/year. The total net precipitation in Denmark is approximately 12 billion m^3 (Miljøstyrelsen, 1992).

1.2 Structure of environmental authorities

The Danish Parliament is composed of only one chamber. The most important instrument of the Parliament is the passing of legislation.

Ministry

The Ministry of Pollution Control was introduced in 1971. Since 1994, the relevant ministry is named the Ministry of Environment and Energy. The Minister has the political responsibility for all matters within his field of responsibility. He also has the full power of instruction in relation to the Danish Environmental Protection Agency (Danish EPA). These acts delegate certain tasks to the Environment Ministry of Environment and Energy

Agency

The Danish Environmental Protection Agency was established in 1972. The principal tasks of the Agency include serving the Minister (preparing draft regulations, parliamentary replies, etc.), negotiations with EU, and advising local authorities)

The environmental administration in Denmark is decentralised into 14 counties. These counties have the responsibility for the majority of implementation tasks regarding groundwater. These tasks include listing, investigating and remediating contaminated sites, monitoring groundwater quality, providing water abstraction permits, protecting groundwater resources, etc.

Figure 1.1 shows the relationship between these authorities.

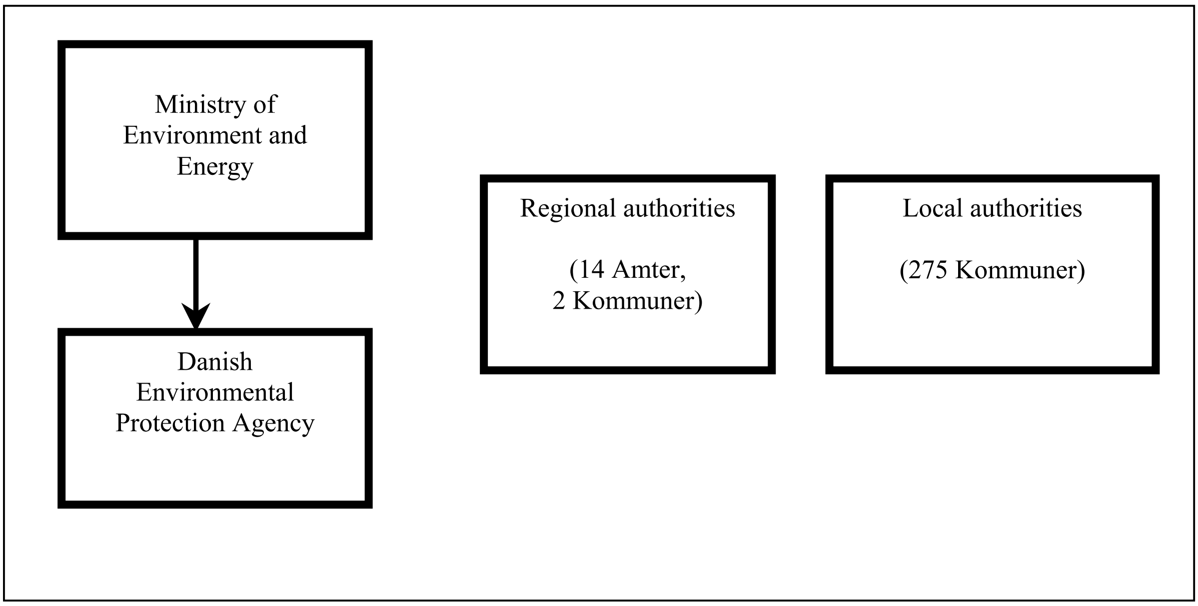


Figure 1.1. Relationship between the various environmental authorities.

1.3 Statutory and advisory information

With regard to groundwater protection and contaminated sites, there are 3 major laws:

5) The Waste Deposit Act,1996
6) Environmental Protection Act, 1996
7) Water Supply Act

The Waste Deposit Act defines orphaned contaminated sites and provides for the listing, investigation and remediation of these sites.

The focus of the Environmental Protection Act is the prevention of contamination and requires certain industries to obtain a permit for operation. In this permit, specific requirements for protecting the groundwater can be made.

Main goals of the Water Supply Act are to ensure the planned use of groundwater resources and that the nation's water supply is adequate with respect to quality and quantity. A regulation under this law describes actual drinking water quality criteria.

In December 1994, the Ministry prepared a "10-point plan for the protection of groundwater and drinking water". Point 5 of this plan requires the Ministry to identify groundwater resources that are of particular interest for water supply. Point 6 states that remediation of contaminated sites must be intensified. The need for a comprehensive Contaminated Soil Act was also stated.

A draft of the new Contaminated Soil Act has now been prepared (Miljø- og Energiministeriet, 1999). This Act includes all aspects of contaminated soil including protection of groundwater resources, prevention of health risk through land use of contaminated areas, transport of contaminated soil, as well as remediation of sites.

2 Point Sources

In Denmark, there are 6 distinct programmes regarding contaminated sites, each with its own administrative practice for listing and prioritising. The largest of these programmes falls under the Waste Deposit Act and the Danish Petroleum Industry's Association for Remediation of Retail Sites (OM-programme). The other programmes stem from the Danish Defence Construction Service and the Danish National Railway Agency, the Lost Value Act, and the Environmental Protection Act. These categories are described briefly below:

Waste Deposit Act

The "Waste Deposit Act" (Miljøministeriet, 1990) has required the listing of contaminated sites since the program was initiated in 1983. The list is prepared by the regional authorities (Danish: amt) in co-operation with the local authorities (Danish: kommune). The programme is funded nationally, but voluntary remediations of listed sites are also carried out with private funds in cases where the site owner needs immediate clean-up. In order to be placed on this list, the following requirements are among those which must be met:

- the site must be contaminated in such a way that it can be hazardous and have a negative effect on people or the environment
- the contamination must have occurred prior to 1976 (for oil contamination, the date is 1972 while for landfills, operation of the landfill must have started before 1974 and abandoned by 1990)
- the regional authorities must document that the site is actually contamination by historical information (desk study) as well as information from collecting and analysing samples from the site (technical investigations) (Miljøministeriet, 1993)

Petroleum Industry (OM)

The OM-programme was initiated in 1992. OM's activities are financed through the sale of petrol (currently 0,05 DKK pr. litre). The program lists, investigates and remediates former petrol stations.

Defence Construction Service

Since the preparation of an environmental strategy in 1993, the Defence Construction Service has listed, investigated and remediated contaminated sites at military bases.

Railway Agency

The Railway Agency has since about 1992 listing, investigating and remediation of sites in connection with railways.

Lost Value Act

This programme was initiated in 1993 for home owners who unknowingly have purchased property with contamination which may cause the value of the property to fall. This programme requires that the homeowner finance the first 40,000 DKK of the remediaton while the remainder is paid for by public funds. If the remediation which is carried out is inadequate to cancel the listing of the site, the homeowners money is returned. If the annual budget for public funds are inadequate, the site is placed on a list for clean up the following year.

Environmental Protection Act

This act relates to sites where contamination has occurred after the mid-1970's deadline given in the Waste Deposit Act.

2.1 Number of Sites

Listed sites

Information regarding the number of sites listed in Denmark as of 1997 is shown below:

- The total number of sites listed under the Waste Deposit Act is 4048 (Miljøstyrelsen, 1998). Of these, 2440 are regarded as threats to the groundwater.
- In 1997, OM had 5649 sites listed as potentially contaminated. Since no previous investigation has been carried out for the majority of these sites, the sites are not necessarily contaminated.
- The Defence Construction Service has listed 230 sites, 78 of which have been delisted following technical investigations and 35 of which have been delisted following remediation. This leaves a total of 117 contaminated sites.
- The Railway Agency has carried out technical investigations at 310 sites. A total of 139 sites were delisted following investigation and 23 are delisted following remediation. This leaves a total of 148 contaminated sites.
- The Lost Value Act has no large number of sites listed since they are remediated as soon as possible after being reported.
- New contaminations listed under the The Environmental Protection Act were reported for the first time in 1997. The number of sites is therefore not complete. Preliminary numbers, however, show that a total of 298 sites are listed, but not yet remediated.

The total number of all types of contaminated sites which eventually will be identified is estimated at 30,000 (Miljø- og Energiministeriet, 1999). Of these, it is estimated that 9,000 are a threat to groundwater.

Delisted sites

As of 1997, 692 sites were delisted according to the Waste Deposit Act in part or in total. An additional 437 were released for a specific land use, but not delisted.

The OM programme has delisted 829 sites. Since this programme does not differentiate between delisting a site that was found to be uncontaminated and delisting a contaminated site by way of remediation, this number is deceptively high.

The Defence Construction Service has delisted 35 contaminated sites and an additional 78 sites which were shown to be uncontaminated. The Railway Agency has delisted 23 sites. An additional 139 were delisted after being shown to be uncontaminated. The Property Value Act has caused a total of 77 sites to be remediated in 1996 and 1997, while the Environmental Protection Act has remediated 564 sites.

Figure 2.1 shows an overview of listed and delisted sites.

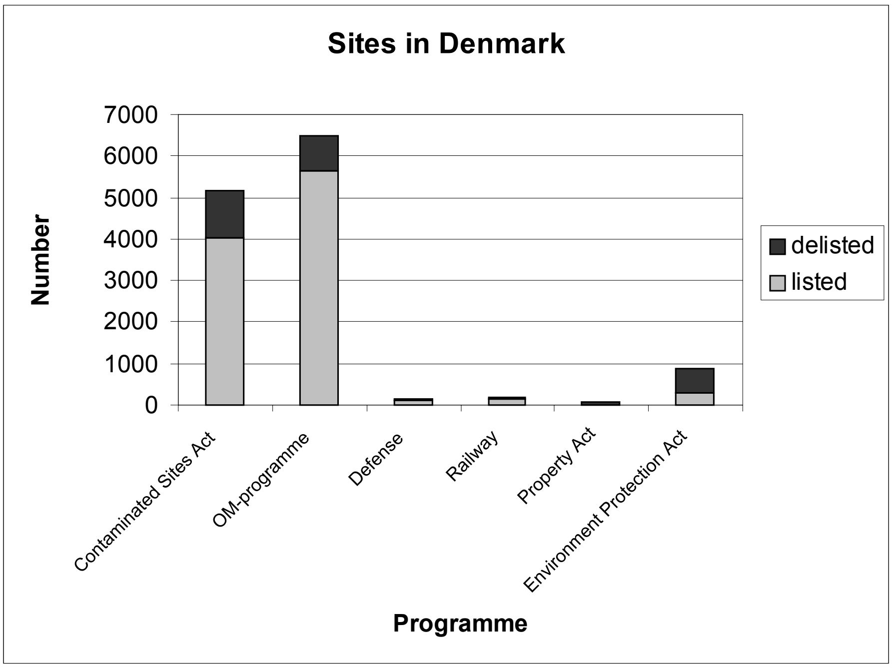


Figure 2.1 Listed and delisted sites in Denmark as of 1997. Note that sites under the OM-programme are not necessarily contaminated.

2.2 Time frame for clean-up

Point 6 in the government's 10-point plan (Miljø- og Energiministeriet, 1994) states that all sites which threaten groundwater and which are located in areas with special drinking water interests must be remediated within a 10 year period. The Danish EPA interprets this time period as starting from 1997/98, when the areas of particular value for drinking water were mapped and designated.

2.3 Costs

The total cost of the various programmes regarding contaminated sites is shown for 1997 in the table below. This total does not include costs of the voluntary remediation or sites under the Environmental Protection Act.

Waste Deposit Act	200	
OM-programme	143	
Property Value Act	102	
Railway	15	
Defence	64	
Total	525	mill. DKK

According to the proposed soil law (Miljø- og Energiministeriet, 1998), the total cost of managing the contaminated site problem in the future will be 4,700 mill. DKK. This number does not including costs of activities carried out by the OM-programme.

3 Water Supply

3.1 The groundwater resource

The Water Board estimated in 1992 that the viable exploitable groundwater in Denmark is 1,800 mill. m^3 pr. year (Miljøstyrelsen, 1992). This estimation was based on net precipitation, and experience in the exploitable percent of this precipitation in various groundwater aquifers types. Reductions in the exploitable groundwater due to extended climate variations and groundwater pollution were not included in this number. It has been estimated that between approximately 20 and 80 mm/year are exploitable in different regions of the country.

Resources model

A mathematical model based on the commercially available software MIKE SHE is currently being prepared by the Geological Survey of Denmark and Greenland (Vandmodel, 1999). This National Water Resources Model has the purpose of determining the size of the exploitable groundwater resource and is intended to be appropriate for analysing effects of time-dependent climate variability, groundwater-surface water interaction, regional distribution and future water consumption scenarios. The first estimates are expected in the year 2000.

Major aquifer types

Groundwater in Denmark is abstracted from a variety of aquifer types. The most important are:
- aquifers in Quaternary glacial melt water deposits, consisting of sand and gravel
- aquifers in Tertiary marine and fresh water deposits, consisting of sand and gravel
- aquifers in Tertiary and Cretaceous marine deposits, consisting of fractured limestone.

The vulnerability of these aquifers depends on the nature of the cover layers. These cover layers can often be glacial deposits, consisting of clayey tills. In some fewer cases the cover layers can consist of buried Tertiary clay deposits.

The age of groundwater in Denmark varies from aquifer to aquifer but is generally thought to be quite young. Estimates suggest that nearly half of the groundwater used for water supply is less than 50 years old.

3.2 Supply statistics

Water supply in Denmark is based almost entirely upon groundwater. Although surface water is utilised in a limited number of cases for industrial purposes, only two waterworks, Sjælsø and Regnemark utilise surface water for drinking water purposes. Thus, 99.6% of the water abstracted by the common utilities in Denmark in 1997 came from groundwater.

The amount of water abstracted by the common water supplies in 1997 was 457 mill. m^3. Although only 6% of the common utilities are public, they accounted for 64% of the water abstraction. Household use comprises 60,4% of consumption and is by far the largest consumption category. Household use is followed by industrial use (22.6%), institutions (8.5%) and water loss (8.6%).

The amount of water abstracted for irrigation purpose in 1997 was 369 mill. m^3 and is therefore nearly as large as the other consumption categories put together. Included in this amount is irrigation for agriculture/nurseries, fisheries, athletic fields and parks (GEUS 1998). The amount of irrigation varies considerably from year to year, primarily due to varying need for irrigation.

Figure 3.1 is a graphic representation of these categories.

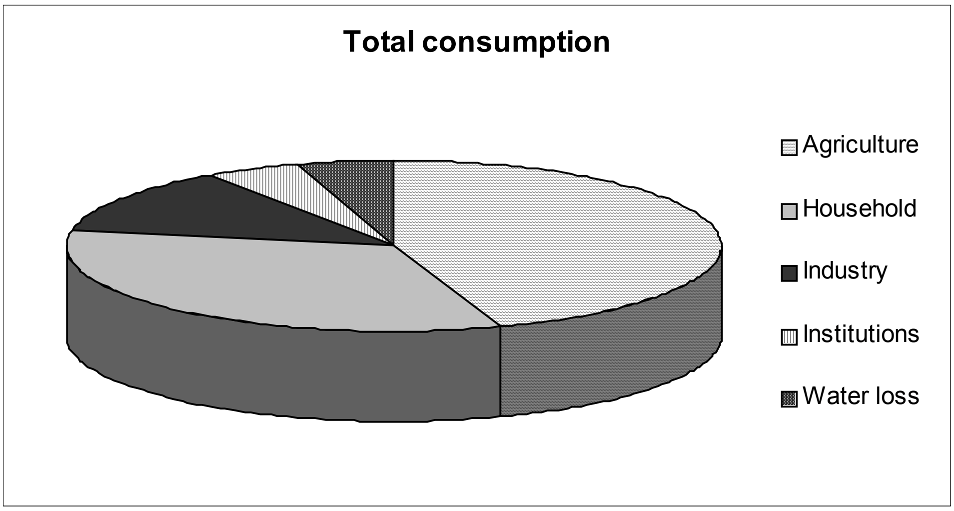


Figure 3.1.
Water consumption in Denmark by category, 1997.

In 1997, household consumption was 136 litres pr. person pr. 24 hours, a reduction of 21% over the past 10-year period. In the same time period, industrial use has fallen 12% and institutional use has fallen 21%.

Water loss has also fallen the past years from approximately 10.6% go 8.9%. The specific water loss has fallen from 5.2 to 2.7 m^3 pr. kilometre pipeline pr. 24 hours. Due to variations in the which water supplies have reported, these numbers are not exact.

The specific energy consumption for the production of drinking water has been nearly constant over the past years at 0.40 kWh pr. m^3.

3.3 Water supply structure

The water supply structure in Denmark exhibits a high degree of decentralisation. In 1997, there was a total of 2,919 common utilities, composed of 2,743 private and 176 public suppliers. The number of suppliers has dropped 13% over the last 10 years and 25 % over the last 17 years. According to a recent report (Miljøstyrelsen, 1997a), the number of suppliers is expected to continue to decline in the coming years, largely due to increasing finds of pesticide contamination.

It should be noted that the highly decentralised structure is somewhat deceptive since there are a few large suppliers and a great many small suppliers.

In addition to the common utilities, it was estimated that an additional 93,000 private wells and small utilities were in existence in 1995.

In 1997, the Drinking Water Committee initiated an analysis of the water supply structure in Denmark with the purpose of determining if the current regulations afford an adequate protection of the groundwater. A prerequisite for this analysis set forth by the Committee was that the current decentral structure be maintained as much as possible.

The analysis concluded that it is possible to maintain the decentralised structure. However, over the next 10 years an estimated 345 common utilities will be forced to close and 10% of the remaining will require advanced water treatment (Miljøstyrelsen, 1997)

3.4 Water treatment

The great majority of water supplies in Denmark treat their raw water using only aeration and filtration. In a number of supplies, calcium carbonate is added. Only a handful of supplies use other processes. These include disinfection with UV-irradiation, methane removal by stripping and adsorption with granular active carbon.

3.5 Drinking water criteria

Two types of criteria are used in Denmark. Firstly, guidelines for the quality of raw water used for production of drinking water are given for a large number of parameters (Miljøstyrelsen, 1998a).

In addition, quality criteria for drinking water are given in the regulations (Miljøministeriet, 1988). Both of these criteria are given in Appendix 2.

3.6 Cost

The average price charged to the consumer in 1997 was 26.0 DKK pr. m^3. Of this total, 5.1 DKK went to the suppliers and 4.0 DKK to a special water tax. The remainder was shared by sewage treatment plants (11.6 DKK) and state (5.2DKK). The total price charged in 1997 ranged from 13 DKK pr. m^3 to 45 DKK pr. m^3, a factor greater than 3.

Using the sum of the price to the suppliers and to the special water tax (9.1 DKK), and assuming a total abstraction of 457 mill. m^3, a total of 4,159 mill. DKK was used for water supply in 1997.

4 Groundwater Protection

In the following sections, measures which are used in Denmark for the protection of groundwater are given. To improve the overview, these measures are divided into measures which can be utilised to prevent contamination from happening (prevention) and measures which are used to tackle existing contamination problems (remediation).

4.1 Prevention

4.1.1 Well field protection zones

A number of protection zones around individual supply wells or well fields have been set for a variety of types of contamination. These zones are not intended to be used with respect to prioritising the remediation of contaminated sites, but are listed below since they are related to point sources.

- A physical protection area with a 10 m radius around individual supply wells is described by the Environmental Protection Act (Miljøstyrelsen, 1988). Within this area, only supply related activities are permitted.
- A hygiene protective area with a radius of 300 m is described by the Environmental Protection Act. Within this area, discharge of wastewater via leach fields is not allowed. The size and shape of this area can be altered, depending on the local geological conditions.
- A code of practice (Normstyrelsen, 1988) lists recommended distances between water supply wells and various potential sources of contamination.

Detailed zoning

A more detailed zoning is currently under preparation. A guidance document specifying this detailed zoning is under preparation by the Danish EPA (Miljøstyrelsen, 1999).

In this draft guidance document, it is suggested that the hygiene protective area should be redefined as an area in which any form for pollution should be avoided, if possible.

4.1.2 Aquifer protection zones

Particularly valuable areas

According to the government's 10- point plan from 1994, particularly valuable water abstraction areas must be designated. A later guidance document prepared by the Danish EPA (Miljøstyrelsen, 1998a) specifies that all groundwater in Denmark must be divided into 3 categories: particularly valuable areas, valuable areas, and abstraction areas of limited value. This designation was carried out by the regional authorities and was completed in 1997.

In order to designate these areas, assessments in the following areas were carried out:

- amount, quality and natural protection of the groundwater resource
- estimation of the future water supply needs
- point sources
- current water supply structure
- effect on surface water bodies
- potential land use conflicts

Finally, a political assessment was carried out and the particularly valuable water abstraction areas were designated. In the actual designation, the aim was to designate large cohesive areas such that significant portions of the regional demand could be covered and such that entire water sheds were included.

Detailed zoning

A more detailed zoning is currently under preparation. A guidance document specifying this detailed zoning is under preparation by the Danish EPA (Miljøstyrelsen, 1999).

In this draft guidance document it is suggested that 2 zones be designated on the basis of existing knowledge. These zones are:

- Sensitive Source Water Areas, which are especially sensitive to one or more types of contamination. Primarily, it is suggested to designate areas, which are sensitive to nitrate.
- Response-Demand Areas, in which it is necessary to actively respond to the threat of a contamination source.

Vulnerability

In addition, it is suggested that vulnerable zones are designated, but only after detailed mapping has been performed. The methods for detailed mapping and the procedure for the following designation of the vulnerable zones is outlined.

Presently, detailed mapping which leads to the designation of vulnerable zones has been implemented in very few areas. It is intended that detailed mapping should be performed within a period of 10 years.

4.1.3 Costs

The costs of detailed mapping is assessed to about DKK 54,000 pr. km^2. Including the designation of zones this amounts to a total of about DKK 92 mill. for mapping and zoning of all particularly valuable areas (Miljø- og Energiministeriet, 1998b).

The costs of making agreements to diminished agricultural impacts on groundwater is assessed to be about DKK 1,000 pr. ha. On this basis, it is assessed that the total yearly costs for diminishing the agricultural impacts will be about DKK 600 mill.

4.2 Remediation

4.2.1 Prioritising contaminated sites

When discussing the prioritisation of contaminated sites, it is important to define what type of prioritisation is meant. For example, contaminated sites can be prioritised according to various geographical scales such as a regional prioritisation or a national prioritisation. Point sources can also be prioritised for a specific phase of work. For example, one prioritisation could be for which sites are to be investigated first and another prioritisation could be for which sites are to remediated first.

In this section, prioritising means the determination of an order for remediation on a national scale.

As described earlier, there are currently 6 distinct programmes regarding remediation of contaminated sites in Denmark. The method of prioritising varies with these programmes. Each method is described briefly below.

Waste Deposit Act

Prioritising and remediation of contaminated sites under this act are responsibilities of the regional authorities. Therefore, a number of differences due occur. Guidelines, however, have been prepared by the national authorities.

In 1992, guidelines were prepared which identified threats to groundwater, land use and surface water recipients as the major problems which require remediation. Of these, groundwater and land use are to be treated as parallel in importance, while surface water recipients takes a secondary role (Miljøstyrelsen, 1992). As previously mentioned, guidelines on identifying particularly valuable water abstraction areas were made in 1995 (Miljøstyrelsen, 1995). Of the contaminated sites that threaten groundwater, these guidelines prioritise those that lie within the particularly valuable areas.

The most recent results show that 822 sites were remediated due to groundwater threats, 360 due to land use threats and 203 due to both.

A ranking system for prioritising contaminated sites within each risk group (groundwater, land use and surface water recipients) has been developed (Miljøstyrelsen, 1995). With respect to groundwater, the system takes the following into account: vulnerability, exposure, contaminant hazard, site specific conditions, and landfill gas risks. This system, however, does not have advisory or statutory status and is not in widespread use.

OM-programme

Sites within the competence of the OM-programme are prioritised nationally by a specially formed Environmental Council of the Association for Remediation of Retail Sites. Here, a ranking systems has been developed. Threat to groundwater and threat to land use are each scored on a point scale of 1, 2, 4, 7, 11. If the contaminated site lies in a particularly valuable area, 7 additional points are awarded. The sum of these 3 subjects is totalled to give the ranking. A maximum of 22 points is awarded. The tie is broken for all sites which are awarded 22 points by carrying them through a second step. The second step includes 3 subjects, each of which gives a score of 1 to 5 points. These subjects are: 1) distance to a supply well, 2) distance to a surface water recipient, and 3) probability of the site being contaminated.

Other programmes

The Defence Construction Service and The Railway Agency prepare action plans and clean-up plans respectively, which involve the prioritising of sites. In both cases, these plans are prepared with the co-operation of the regional authorities to ensure an overall co-ordination.

The Lost Value Act appropriates money on a first come, first served basis.
In principle, newer contamination within the competence of the Environmental Protection Act must all be remediated, as the responsible party can be required to finance the clean-up. No system of prioritising is therefore required.

4.2.2 Criteria

Soil

In Denmark, so-called “soil quality criteria” have been set, for use at contaminated sites in which the soil contamination presents a threat to the intended land use through direct exposure (skin contact, ingestion of soil or breathing of dust). Here, the soil quality criteria have been set low enough to ensure that even very sensitive land-use (for example gardening and children’s play grounds) will not present a toxicological problem with regard to land use.

In addition to the soil quality criteria, a limited number of cut-off criteria, which refers to values which, when exceed, should result in remedial activities which cut off the exposure pathway. The reason for setting more than one soil criteria is that large areas in cities have soil concentrations which exceed the soil quality criteria due to diffuse contamination (such as lead contamination from traffic). Higher criteria are thought admissible if certain recommendations (such as avoiding growing vegetables, direct contact with bare soil, and dust) are followed (Miljøstyrelsen, 1998b).

According to the Danish EPA, however, these soil quality criteria and cut-off criteria are not intended to be used for assessing the risk for groundwater contamination since they are based on exposure in the case of very sensitive land-use. Leaching and mobility in relation to the groundwater resource are not built into the criteria.

Instead of using these soil criteria, the Danish EPA recommends applying a risk assessment that relates groundwater concentrations to soil concentrations. The Danish EPA has developed a 3-stage risk assessment, with each stage requiring additional data. A risk assessment is site specific and should include the following elements:

- results of site investigations
- assessment of the contaminants present
- assessment of contaminant transport and exposure pathways

A risk assessment can estimate whether existing soil concentrations present a threat to the groundwater. In this way, a risk assessment can be used to determine trigger/intervention values. In addition, these same values can be used as clean-up/target values for a remediation. In Danish terminology, these values are referred to as the “acceptable” level of contamination

The soil quality criteria and cut off criteria are included in Appendix 1 (Miljøstyrelsen, 1998a).

Groundwater

In Denmark, groundwater criteria have been established which ensure that groundwater can be used for drinking water after a traditional water treatment comprised of aeration and filtration. These criteria are therefore closely related to drinking water criteria.

The groundwater quality criteria are not to be exceeded in aquifers which may be exploited for water supply purposes nor in shallow aquifers (with only secondary importance with respect to water supply), if this may cause exploitable aquifers to exceed the quality criteria. In general, groundwater quality criteria must not be exceeded at the source of contamination. When carrying out a risk assessment, however, it may be exceed at a distance of up to one-year’s groundwater travel (though a maximum of 100 meters).

The multifunctionality of groundwater is considered to be maintained if the groundwater quality criteria are not exceeded. Appendix 2 lists these criteria (Miljøstyrelsen 1998a). It may be noted that no separate pore water criteria have been set.

Soil gas

As in the case of soil criteria, soil gas criteria which would ensure the protection of the groundwater resource would be practical. Soil gas criteria for this purpose, however, have not been set at the present time.

So-called “air quality criteria” have been set, however, for use at contaminated sites in which contaminated soil gas presents a threat to indoor air quality in buildings or outdoor air quality in open areas.

Even though these air quality criteria are not intended in theory for use in groundwater protection from point sources, the criteria have been included in Appendix 3 (Miljøstyrelsen, 1998a).

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Appendix 1: Soil Criteria, Denmark

Contaminant	*Soil Quality Criteria mg/kg dry weight*	*Cut-off Criteria mg/kg dry weight*
Acetone	8	
Arsenic	20	20
Benzene	1.5	
Petrol	25	
Lead	40	400
BTEX, total	10	
Cadmium	0.5	5
Chloroform	50	
Chlorophenols, total	3	
Pentachlorophenol	0.15	
Chromium, total	500	1000
Chromium (VI)	20	
Copper	500	500
Cyanide, total	500	
Cyanide, acid volatile	10	
DDT	1	
Detergents, anionic	1500	
1,2-dibromomethane	0.02	
1,2-dichloroethane	1.4	
1,1-dichloroethene	5	
1,2-dichloroethene	85	
Dichloromethane	8	
Fluoride, inorganic	20	
Gas oil, total, hydrocarbons	100	
Mercury	1	3
Molebdenum	5	
MTBE	500	
Naphthalene	1	
Nickel	30	30
Mononitrolphenols	125	
Dinitrophenols	10	
Trinitrophenols	30	
PAH, total	1.5	15
Benz(a)pyrene	0.1	1
Dibenz(a,h)antracene	0.1	1
Petroleum	25	
Phenols, total	70	
Phthalates, total	250	
DEHP	25	
Styrene	40	
Terpentine, mineral	25	
Tetrachloroethylene	5	
Tetrachloromethane	5	
1,1,1-trichloroethane	200	
Trichloroethylene	5	
Vinyl chloride	0.4	
Zinc	500	1000

Appendix 2: Water Criteria, Denmark

Parameter	*Groundwater Quality Criteria µg/l*	*Drinking Water Criteria Recommended Value µg/l*	*Drinking Water Criteria Max. Allowable Value µg/l*
Acetone	10		
Arsenic	8	< DL	50
Benzene	1		
Lead	1	< DL	50
Bor	300		1
Butylacetates	10		
Cadmium	0.5	< DL	5
Chlorinated solvents (+vinyl chloride)	1		
Chloroform	as low as possible		
Chromium, total	25	< DL	50
Chromium VI	1		
Copper	100		3
Cyanide, total	50	< DL	50
DEHP	1		
Detergents, anionic	100		
1,2-dibromethane	0.01		
Diethylether	10		
Isopropylalcohol	10		
PAH	0.2		
Methylisobutylketone	10		
Methyl-tert-butylether (MTBE)	30		
Mineral olie, total	9		
Molybdenum	20		
Naphthalene	1		
Nickel	10		50
Nitrophenols	0.5		
Pentachlorphenol	< DL		
Pesticides, total	0.5		
Pesticides, individual	0.1		
Pesticides, persistent, chlorinated	0.03		
Phenols	0.5		
Phthalates (-DEHP)	10		
Styrene	1		
Toluene	5		
Vinyl chloride	0.2		
Xylenes	5		
Zinc	100		5
Colour		5	15
Turbidity		0.3	0.5
Odour			2 at12^{0}C
Taste			3 at.25^{0}C
Temperature			12
PH		7.0-8.0	8.5
Conductivity		> 30	
Permanganate number		6	12
Total dissolved solids			1.500
Calcium			
Magnesium		30	50
Hardness, total			
Sodium		20	175
Potassium			10

Ammonium		0.05	0.5
Iron		0.05	0.2
Manganese		0.02	0.05
Bicarbonate		> 100	
Chloride		50	300
Sulfate		50	250
Nitrate		25	50
Nitrite		< DL	0.1
Total phosphorous content		< DL	0.15
Flouride			1.5
Oxygen			
Agg. carbon dioxide			< DL
Hydrogen sulfide			< DL
Methane			< DL
Chlorine, free and total			
Aluminium		0.05	0.2
Antimony		0.05	0.2
Barium		100	
Mercury		< DL	1
Selenium		< DL	10
Silver		< DL	10
Suspended solids		< DL	
Kjeldahl-nitrogen			1
Anion active compounds		< DL	0.1

< DL = below detection limit

Appendix 3: Air Criteria, Denmark

Parameter	*Air Quality Criteria Mg/m³*
Acetone	0.4
Aromatic hydrocarbons	0.03
Benzene	0.000125
Butylacetates	0.1
Chloroform	0.02
Cyanide, acid volatile	0.06
Diethylether	1
Isopropanol	1
Hydrocarbons, total	0.1
Methylisobutylketone	0.2
MTBE	0.03
Naphthalene	0.04
Phenol	0.02
Methylphenols (cresoler)	0.0001
Dimethylphenols (xylenoler)	0.001
Chlorophenols, sum	0.00002
Pentachlorophenol (PCP)	0.000001
Nitrophenols	0.005
Styrene	0.1
Tetrachloromethane	0.005
Tetrachloroethylene	0.00025
Toluene	0.4
Trichloroethylene	0.001
Vinyl chloride	0.00005
Xylenes	0.1

Attachment 3: England

1 Background information

1.1 Basic facts

The United Kingdom has a population of 58,700,000 (1996) and an area of 224,880 km^2. This gives a population density of approximately 260 persons pr. km^2.

GDP

The gross domestic product (GDP) in England is 712,500 million pounds sterling (quarterly rate for 1995: OECD, 1998). The current exchange rate is approximately 1,5 pounds sterling (GBP) pr. euro (EUR). The annual gross domestic product pr. person is therefore approximately 32,000 EUR.

Precipitation

The total annual rainfall in England varies from 600 mm in the Anglian region in the eastern part of the country to 1,200 mm in the North West region. Even greater variations are found locally (Water Services Association, 1998).

Where the main aquifers crop out in the lowlands of England the potential infiltration is less than 500 mm pr. year and in the extreme east less than 150 mm pr. year (UK Groundwater Forum, 1998).

1.2 Structure of environmental authorities

The British Parliament is composed of two chambers, the House of Commons and the House of Lords. The most important instrument of the Parliament is the passing of legislation.

DETR

As with other departments, The Department of the Environment, Transport and the Regions (DETR) is headed up by a Secretary of State. The Secretary has the power of instruction in relation to the Environment Agency.

Environment Agency

The Environment Agency was established by the Environment Act of 1995 and is composed of a main office in Bristol, and 8 regional offices. It has jurisdiction throughout England and Wales. There are separate Agencies for Scotland and Northern Ireland.

The Environment Agency carries out many of the duties previously relegated to the Inspectorate of Pollution, the National Rivers Authority and local Waste Regulation Authorities. Its powers and duties are set out in the Environment Protection Act of 1990, the Water Resources Act of 1991 and the Environment Act of 1995.

The National Groundwater and Contaminated Land Centre is the primary technical focus within the Environment Agency for groundwater resource management, the protection of groundwater, and the remediation of polluted groundwater and land contamination.

Area offices

Each of the 8 regions of the Environment Agency is subdivided into area offices. These operating units carry out much of the work related to the regulation of contaminated sites, often in partnership with local authorities.

Figure 1.1 shows the relationship between the various authorities.

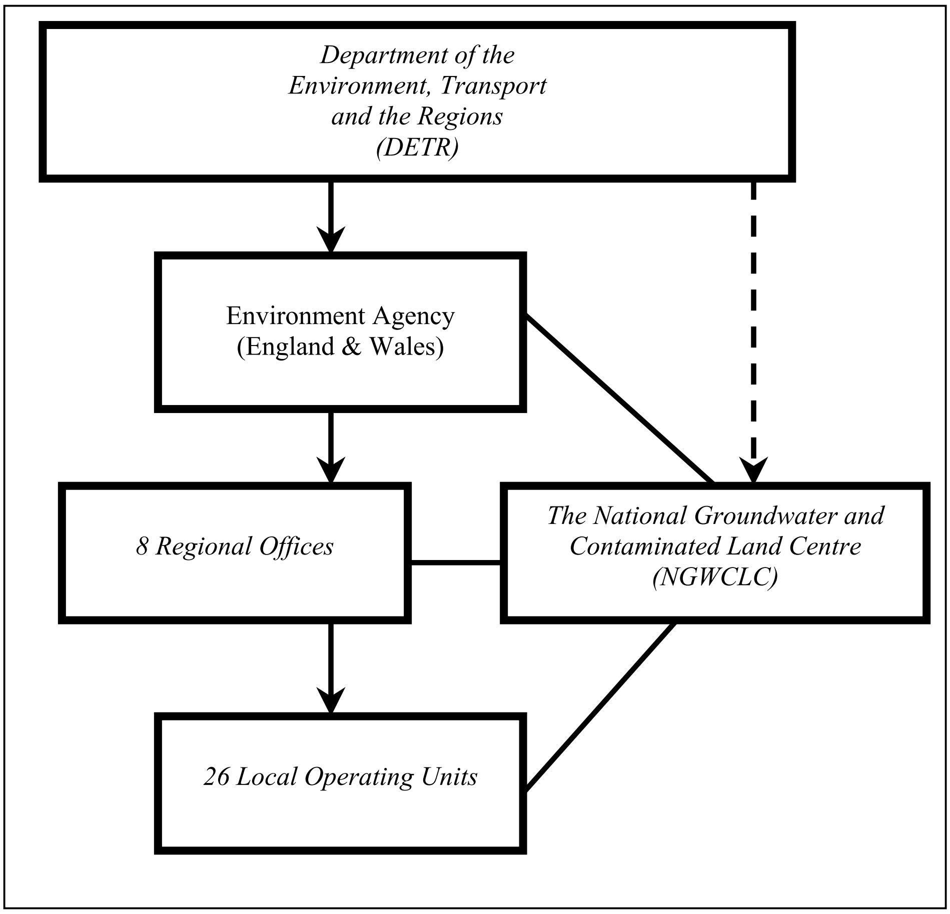

Figure 1.1. Relationship between the various environmental authorities.

1.3 Legislation

With regard to groundwater protection and contaminated sites, the most important legislation is:

1) **The Environmental Protection Act, 1990**
   revised by the insertion of Part IIA from the Environment Act, 1995
   (implementation of this revision is expected in December 1999).

Among other subjects, this Act provides for the following:

- Local authorities shall cause their areas to be inspected for the purpose of identifying contaminated land. These authorities must also designate a subgroup of this contaminated land as "special sites" where serious harm would or might be caused, or if serious pollution of controlled waters would be, or would be likely to be, caused.
- Local Authorities or the Environment Agency (for special sites) shall serve Remediation Notices to polluters or, if the polluter can not be determined, the present owner of the site. A Remediation Notice requires that contaminated sites are cleaned up, but the authority must have regard to the seriousness of the harm, or pollution of controlled waters in question.
- The Environment Agency shall prepare and publish a report on the state of contaminated land in England.

2) Water Resources Act, 1991

Among other subjects, this act provides for the following:

- Abstraction of water from any source of supply requires a licence granted by the Environment Agency.
- The Environment Agency may serve a Work Notice on problem holders in order that groundwater pollution can be addressed. This Act specifically addresses historic cases in which the link between source-pathway-target has been broken, such as an old spill, where overlying soils bear no trace of the event.

3) Groundwater Regulations, 1998

These regulations provide for groundwater protection by preventing the granting of an authorisation for activities which may cause the direct or indirect discharge to groundwater of substances on two lists of chemical substances. These regulations do not apply for discharges already covered by pre-existing legislation (e.g. waste licensing controls under the Environmental Protection Act, 1990).

2 Point Sources

In England, there are currently no legal drivers for remediation of contaminated sites. These drivers will be supplied when Part IIA from the Environment Act, 1995 is implemented. This regulation will enable the Environment Agency to serve Remediation Notices.

In addition to the lack of drivers for remediation, there is also a lack of requirements for identifying and reporting of contaminated sites. Therefore, there is no national list of contaminated sites.

Currently, the best information on point sources stems from a recent study carried out by Entec UK Ltd, commissioned by the National Rivers Authority (the predecessor to the Environment Agency). The data in this study was collated in 1995 and was collected from water companies, Waste Regulation Authorities, the National Rivers Authority itself, and a literature search. The information below is largely based on this study (Environment Agency, 1996).

DETR Capital Fund

Even though Part IIA from the Environment Act is not yet implemented, there are some funds available from the central government via the DETR Capital Fund. This fund was originally established in 1990 to provide finance for the local authorities in connection to remediation of hazardous situations arising from migrating gas from closed landfills. In 1997/98 the Environment Agency was given access to the fund to deal with unacceptable pollution of water resources where there are problems of establishing liability and ownership of affected land, where the site owner is unable to pay, or where the situation identified demands urgent action.

2.1 Number of Sites

The study referred to above identified 1205 point sources of pollution which threaten groundwater. Of these, a total of 777 were known to have caused some groundwater pollution. A total of 210 have had an impact on a groundwater abstraction.

These numbers are considered to be gross underestimates. It is now assumed that the number of sites with significant groundwater contamination is around 5,000. It is estimated that 2,000 of these will require a significant remediation effort (Harris, 1999).

Remediated sites

Since remediation activities have been undertaken privately, official documentation of the number of sites remediated is not collected. The study mentioned above, however, found that remediation has been initiated at 44% (or 530 sites) of the identified sites in 1995.

2.2 Time frame for clean-up

Since the regulation for remediation of contaminated sites has not yet been implemented, official estimates of time frame for the clean-up of sites posing threats to the groundwater have not yet been made. However, the Environment Agency predicts that all sites can not be dealt with within a period much less than 20 years. In addition, use of slower remediation techniques such as natural attenuation will require additional time.

2.3 Costs

The total cost of remediation is not known since remediation is largely financed by site owners and not reported. A total of 1.9 mill GBP was allocated in 1998/99. Expenditures from the DETR Capital Fund are estimated to increase to 3 mill GBP in 2000/01.

The majority of this money has up to this point been spent on site investigation in preparation for remediation.

3 Water Supply

3.1 The groundwater resource

Principle aquifers

The principle aquifers in England belong to the geological sequence called the Younger Cover (from the Permian and the Quaternary sequence) and are found in the Lowlands of England (southeast). The most important aquifers are found in:

- Cretaceous chalk
- Permo-Triassic sandstones
- the Jurassic limestones
- Lower Greensand from the Cretaceous period.

It should be mentioned, that the specific yield of these aquifers varies greatly from about 1% in chalk to 20-25% in sandstones, meaning that more than 20 times as much water can be stored in the sandstones.

Replenishment

The average annual replenishment to the main aquifers of the Younger Cover is 7 billion m^3 (UK Groundwater Forum, 1998). The total groundwater abstraction in England and Wales in 1995 was 2.4 billion m^3 (Water Services Association, 1998), or about one-third of the exploitable resource. Figure 3.1 shows an overview of replenishment and abstraction for the principle aquifers.

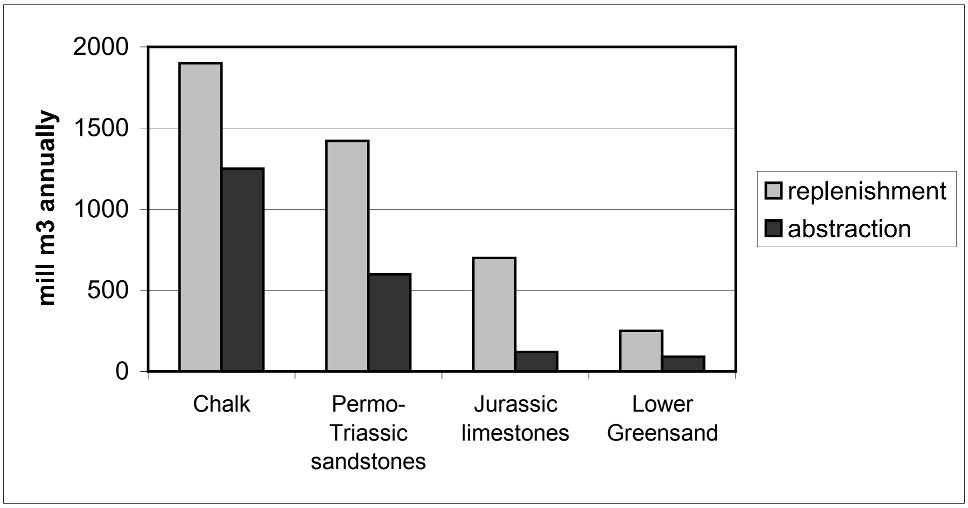

figure 3.1
Comparison of replenishment and abstraction of groundwater for the principle aquifers of the UK (UK Groundwater Forum, 1998).

Artificial recharge

Artificial recharge of the groundwater is used in the London area where surplus surface water from the river Thames and Lee is treated and recharged into the Chalk. In dry summers, the stored water is pumped from the aquifers, treated once again and then distributed. The use of artificial recharge is expected to be increasingly used in the future. Climate changes in connection with the greenhouse effect may also cause even greater seasonal changes (drier summers, wetter winters), making this scheme even more valuable.

Groundwater stored in the Triassic sandstones aquifer in Shropshire is used to regulate the flow of the River Severn and thereby supply water for many communities.

Groundwater age

The age of groundwater in England varies from aquifer to aquifer but a significant proportion is quite old. For example, groundwater in the Chalk in the centre of the London Basin contains a component that is some 20,000 years old.

3.2 Supply statistics

Groundwater provides about one-third of public water supplies in England. There are, however, large geographical variations. In the southeast, over 70% of the public supply stems from groundwater, while in the north, use of surface water prevails. In Scotland, for example, only 3% stems from groundwater. This is largely due to the location of the primary aquifers mentioned above.

The public water supply accounts for the greatest consumption of groundwater, while industry, fish farming, mineral washing and spray irrigation also use significant amounts. Figure 3.2 is a graphic representation of these categories.

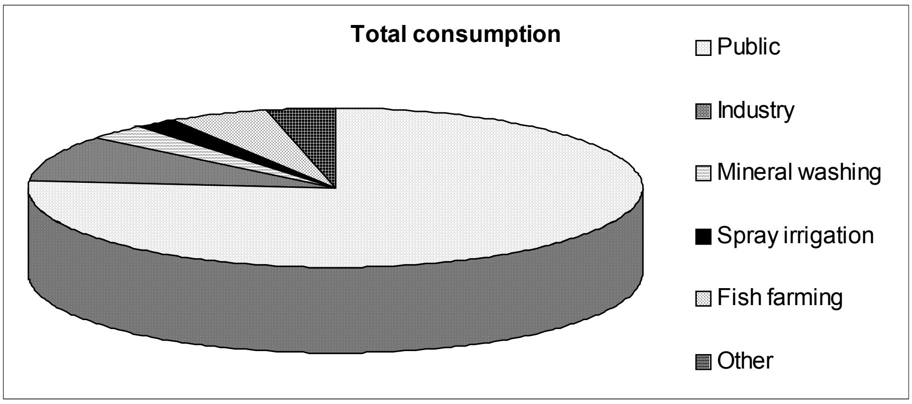

Figure 3.2.
Water consumption in England by category, 1995 (Water Services Association, 1998).

In 1997, domestic consumption was 160 l pr. person pr. 24 hours. In 1961, the domestic consumption was 85 l pr. person pr. 24 hours.

3.3 Water supply structure

In England and Wales, there are approximately 2,000 public groundwater supply sources. These are operated by private companies. There are no policies to centralise or to decentralise these sources. However, the pattern of public supply is generally based on large abstractions supplying communities through relatively long distribution networks.

3.4 Water treatment

Typical treatment

Typical treatment of groundwater is a precautionary chlorination followed by dechlorination, both at the source. There is some filtration of sources with high natural iron or manganese content. There is little use of activated carbon.

Advanced treatment

About 30 sources have been affected by industrial contamination and have either been abandoned or treated by air stripping or carbon filtration. Elevated levels of nitrate are generally dealt with by blending whereas ion exchange is used at a very few sources.

3.5 Drinking water criteria

The Drinking Water Regulations include criteria for drinking water and reflect the European Drinking Water Directive. The actual criteria are included in the appendix1.

3.6 Cost

The annual water charge in London is approximately 125 ECU (Water Services Association, 1998). This charge is for a use of approximately 200 m^3, meaning that the price pr. cubic metre is about 0,62 ECU.

4 Groundwater Protection

4.1 General strategy

The GPP document

The Environment Agency has published the document "Policy and Practice for The Protection of Groundwater" (GPP) which is composed of 3 key elements:

1. a series of statement on policy with respect to protection of groundwater
2. a classification of groundwater vulnerability to assist in the protection of aquifers as a whole
3. the delineation of groundwater protection zones in connection with specific major water supplies.

The GPP is perhaps the single most important tool used in England for the protection of groundwater from point source contamination. It is, however, non-statutory in nature and is therefore used only in a consultative manner. The Environment Agency makes use of the GPP in carrying out its own areas of statutory authorisation as well as in attempting to influence decisions of other regulatory bodies as well as parties with interest in or influence on groundwater.

Statutory information

In addition to this non-statutory tool, groundwater protection is effected through the following Acts and Regulations:

- EC Directive on the Protection of Groundwater Against Certain Dangerous Substances (80/68/EEC)
- Environmental Protection Act 1990
- Town and Country Planning Act 1990
- Water Resources Act 1991
- Water Industry Act 1991
- Environment Act 1995
- Groundwater Regulations 1998

Control is also exerted through the planning development process enacted by the Town and Country Planning Acts. In the following sections, the key elements in the GPP will be described.

4.2 Policy statements

Objectives

The GPP sets out a number of policy objectives of the Agency (Environment Agency, 1998). These objectives are divided into 8 groups as follows:

- control of groundwater abstractions
- physical disturbance of aquifers and groundwater flow
- waste disposal to land
- land contamination
- disposal of liquid effluent, sludges and slurries to land
- discharges to underground strata
- diffuse pollution of groundwater
- additional activities or developments which pose a threat to groundwater quality

Policy statements

Of special interest to this report are the policy statements with respect to waste disposal to land (9 policy statements) and land contamination (8 policy statements). Examples of policy statements with respect to these two groups are:

"The Environment Agency will liaise with Planning Authorities and others to entourage the location of new landfill sites in areas where groundwater is least vulnerable to pollution."

"The Environment Agency will encourage the implementation of effective remedial measures to prevent pollution of groundwater by existing direct or indirect discharges from any contaminated site. Where pollution occurs the Agency will prosecute in appropriate cases under Section 85 of the Water Resources Act 1991."

4.3 Vulnerability maps

In connection with implementation of the GPP, groundwater vulnerability maps on a scale of 1:100,000 have been prepared for the whole of England and Wales (National Rivers Authority, 1995a). The purpose of these maps is to aid developers planning new activities and planners assessing new proposals to make more informed judgements. The maps also have a use in the prioritising of investigations and subsequent remedial actions in locations where contamination has occurred. In this way, the vulnerability maps relate to the protection of the groundwater resource as a whole.

The maps have been prepared by the Soil Survey and Land Research Centre and the British Geological Survey and are overlayed on regular Ordnance Survey maps. They are based on the two major parameters, geological classification and soil classification.

Geological classification

The geological classification defines 3 categories as follows and refers to the unsaturated zone between the soil and the water table where leaching of contaminants to the groundwater may occur:

Major aquifer: Formations with a high primary permeability and a known or probable presence of significant fracturing. These formations may be able to support large water abstractions.

Minor aquifer: Formations which are fractured or potentially fractured but which do not have a high primary permeability. These formations are important for local water abstractions and supplying base flow to rivers.

Non-aquifer: Formations which are generally regarded as containing insignificant quantities of groundwater.

Leaching potential

Each of the 700 soil series (types) which have been established in England have been assigned a leaching potential based on texture, structure, soil water regime and the presence of distinctive layers such as raw peaty topsoil and rock or gravel at shallow depth. The soil classification subdivides areas with major and minor aquifers into 3 categories as follows. Areas designated as non-aquifers are not subdivided.

High leaching potential: Soils with little ability to attenuate diffuse source pollutants and in which non-adsorbed diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater.

Intermediate leaching potential: Soils which have a moderate ability to attenuate diffuse source pollutants or in which it is possible that some non-adsorbed diffuse source pollutants and liquid discharges could penetrate the soil layer.

Low leaching potential: Soils in which pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal, or they have the ability to attenuate diffuse pollutants.

Mapping practices

These two major parameters result in 7 different categories, each of which has been assigned a separate colour. The 3 soil leaching potential categories described above are further subdivided into subclasses (3 for high leaching potential, 2 for intermediate, and no subclasses for low leaching potential). These subclasses are denoted on the maps by means of closed curves with encircle the subclass number.

The final piece of information on the maps is the presence or absence of low permeability drift deposits (unconsolidated superficial deposits such as fluvioglacial and alluvium) overlying major and minor aquifers. These deposits are denoted on the maps by means of a stipple ornament.

4.4 Groundwater protection zones

In order to allow a sensible balance to be struck between the protection of the groundwater resource as a whole and the protection of specific water supplies, an additional tool of groundwater source protection zones has also been prepared (National Rivers Authority, 1995b). The primary use of these zones is to signal that within specified areas there are likely to be particular risks to groundwater quality should certain land use activities take place. Delineating these zones can therefore influence land use practices and prioritise investigations according to the greatest risk.

It is estimated that protection zones will be necessary for over 2,000 water supplies, where as it will not be practicable or efficient to define zones around 76,000 smaller sources due to lack of data.

3 concentric zones

The Environment Agency has adopted a tripartite zonation in which 3 generally concentric zones are defined. These zones are described below.

Inner Zone I is related to the decay of bacterial contamination. It includes the area immediately around the wellhead which is subject to especially strict controls. It is defined by a 50 day travel time, though minimum 50 meters from the source. This zone is usually not defined for confined aquifers.

Outer Zone II is based on the delay, dilution and attenuation of slowly degrading pollutants. It includes the area around the wellhead which is within a 400 day travel time (or 25% of the source catchment area, whichever is larger). This zone is usually not defined for confined aquifers.

Source Catchment Zone III is simply defined as the area needed to support a certain yield with long-term groundwater recharge. For confined aquifers, this zone may be located some distance from the actual abstraction.

Zone delineation

Delineation of the zones can be carried out using a variety of techniques depending on the quality of data available, the operational importance of the source concerned and the human and financial resources available. The simplest technique is to define circular protection zones based on the recharge area required to support the abstraction. Where data is available, mathematical models have been used including a semi-analytical model WHPA, a 2D steady-state numerical flow model FLOWPATH and the well-known MODFLOW/MODPATH. In the case of Karstic aquifers, the assumption of regional darcian flow is unlikely to be valid and computer simulation of groundwater flow based on standard models is inappropriate.

4.5 Criteria

No criteria

In England, no “trigger or target values” for soil, groundwater or soil gas have been established because of the need to take a site-specific approach.

ConSim software

The intention is to use the newly developed software “Contamination Impact on Groundwater: Simulation by Monte Carlo Method” (ConSim), which has been developed on behalf of the Environment Agency and will be sold commercially, starting in 1999. Issues which may be addressed using ConSim include the following (ConSim Manual, 1999).:

- to help assess the plausibility of a significant pollutant linkage existing for a site with respect to its potential to cause pollution of controlled waters
- to assess whether or not the collection of additional site investigation data is required in order to quantify the risk to groundwater posed by the land contamination
- to determine the extent of remediation that is required in order to reduce the risk of contamination of controlled waters to an acceptable level
- to compare the viability of various remedial techniques to successfully reduce the risk of pollution to controlled waters.

5 Literature

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Attachment 4: Spain

1 Background information

1.1 Basic facts

Spain has a population of 39,242,000 (1996) and an area of 505,800 km^2. This gives a population density of 78 persons pr. km^2.

GDP

The gross domestic product (GDP) in Spain is 69,780 billion pesetas (quarterly rate for 1995: OECD, 1998). The current exchange rate is approximately 166 pesetas (ESP) pr. EUR. The annual gross domestic product pr. person is therefore approximately 10,600 EUR.

Precipitation

The total precipitation in Spain depends greatly upon the region. In the coastal areas of the north and north-west, the precipitation exceeds 1600 mm pr. year. In the south-east, precipitation is around 70 mm pr. year. The values for evapotranspiration are reversed, with high evaporation in the south (1200 mm pr. year) and low evaporation in the north (400 mm pr. year). Large areas of the country therefore have a net precipitation as low as 0 to 50 mm pr. year.

The average annual precipitation is 680 mm pr. year while the evaporation average is 460 mm pr. year, giving an average net precipitation of 220 mm pr. year (Ministerio de Medio Ambiente, 1998).

1.2 Structure of environmental authorities

The Spanish Parliament is composed of two chambers. The most important instrument of the Parliament is the passing of legislation.

Ministry

Environmental matters are handled directly by Ministerio de Medio Ambiente (Ministry) as there is no Environmental Agency. The current Ministry was established in 1996, taking over functions handled by its predecessor. The Ministry has the competence to prepare environmental legislation and to co-ordinate activities with the autonomous regions. The Ministry relies on the groundwater department of the Instituto Tecnológico de Geominero de España (ITGE) for much of the technical expertise regarding groundwater.

Autonomous regions

Spain is divided into 17 autonomous regions (Comunidades Autónomas), each with its own government. The administration of these autonomous regions include environmental departments.

Drainage Basin Authorities

In addition, there are Drainage Basin Authorities. This authority is divided into 9 basins that are independent of the autonomous regions and is organised at a national level.

Figure 1.1 shows the relationship between these authorities.

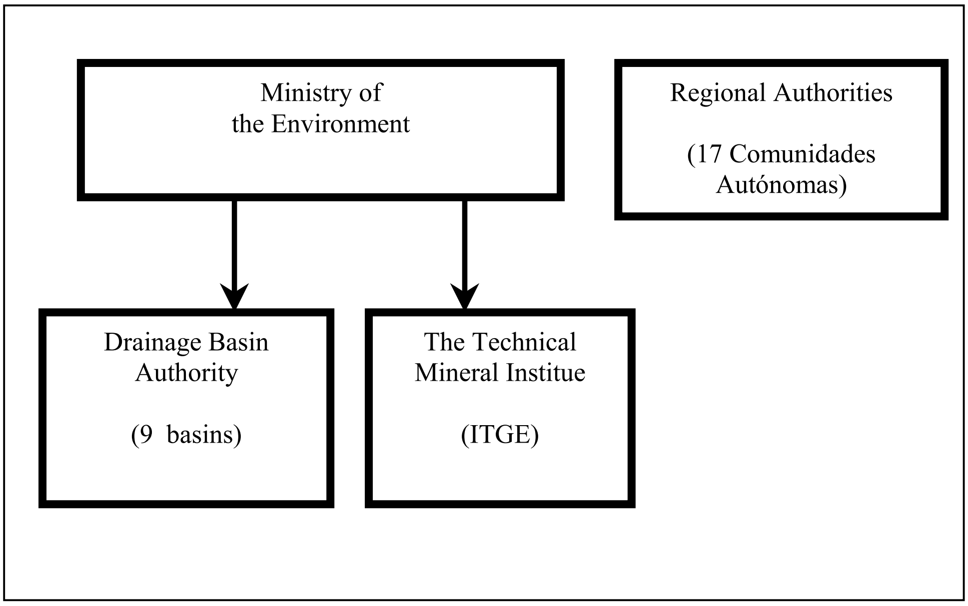

Figure 1.1. Relationship between the various environmental authorities.

1.3 Statutory and advisory information

Current legislation

The major laws and regulations with regard to groundwater protection and contaminated sites are given below:

1) Soil Act, 1998
   This Act assigns special protection to certain soils due to historical, cultural or environmental value. Environmental value can include the situation where the soils are know to overlay important groundwater resources.

2) Law of Waters, 1985
   This law makes general statements that contamination is not allowed and it identifies the Drainage Basin Authority as the responsible body to determine protection zones for water supplies. The law, however, does not provide for the implementation of the general statements. The legislation is not being further developed since it is expected to be replaced by the "Framework for European Community Water Policy (draft dated 1996) when this is translated into Spanish law.

3) Assessment of Environmental Impact, 1986
   These regulations require the study of the environmental impact of a limited number of listed activities such as oil refineries, large chemical industries, highway construction, etc. and requires the authorisation of the activity. A minimum list is administered at a national scale, while regional authorities administer additional activities which they may add to the list.

4) Legislation of disturbing, unhealthy and dangerous activities, 1961
   This legislation is administered locally by municipalities. It requires permits for all disturbing, unhealthy and dangerous activities. A shortcoming with this legislation is that local authorities often lack the technical expertise required to make adequate assessments of groundwater protection needs. Some regional authorities have passed laws involving them in this administration.

5) Wastes Act, 1998
   This Act defines contaminated soils. However, this definition is based on soil criteria which are not yet set and is therefore currently impracticable

(Aguilar, 1999). The Act states the basic principle that the polluter must remediate for remediation. If the polluter can not be found, the landowner must finance the remediation. The Act also obligates the autonomous regions to make an inventory of suspected contaminated sites.

6) Hydrological Plans of Basins, 1998
This regulation is the theoretical instrument for defining zones of protection within recharge areas of well fields. It gives priority to larger cities.

7) Technician Sanitary Regulation, 1990
This regulation describes the control of the quality of the public drinking water supply.

National remediation plan

In addition to these laws and regulations, a national policy concerning contaminated sites is defined in the National Plan for the Remediation of Contaminated Soils (El Plán Nacional de Recuperación de Suelos Contaminados, 1995 – 2005). The objectives of this plan are:

- Prevention of further contamination
- To continue the identification of polluted sites
- To investigate 1,650 potentially contaminated sites
- To remediate 274 priority sites
- To develop clean-up technologies
- To lay down specific national legislation and technical regulations

Future expectations

Two European documents are expected to have impact on Spanish regulations. These are as follows:

- the approved "Integrated Prevention and Control of Contamination (no. 257/26) and
- the proposed "Framework for European Community Water Policy" (draft from 1996).

The first is expected to strengthen the current legislation with regard to permitting industrial activities which may cause soil and groundwater contamination. The second takes the approach of protecting groundwater aquifers.

2 Point Sources

2.1 Number of Sites

Phase 1 and 2

Efforts to quantify the number of contaminated sites began in 1990, resulting in a database on contaminated soils (Inventario de Suelos Contaminados). The efforts have been carried out in phases. The first phase was carried out in the period 1991-93 and paid for by the Ministry of the Environment. During this phase, 250 contaminated sites were placed on the list. The second phase was carried out in 1994-95 and was also financed by the Ministry. In this phase, 120 additional contaminated sites were identified. At this stage, 18,142 industrial activities were identified and 4,902 sites were considered potentially contaminated. The 370 sites which were listed were all been investigated, generally including the collection and analysis of soil and/or groundwater samples.

Phase 3

The third phase began in 1995 and is still in progress. In this stage, the Ministry has made a bilateral agreement with each of the autonomous regions and will finance 50% of the work. The actual investigations are administered by the individual autonomous regions. In phase 3, a much larger number of sites will be identified. For example, the region Andalucia alone has now identified 300 new sites. It is estimated that approximately 10,000 sites will be listed when phase 3 is complete (Lopez de Velasco, 1999). At present, 11 of the 17 regions have begun or completed phase 3 and work is expected to continue during the next approximately 3 years.

2.2 Time frame for clean-up

There exists no official time frame for the remediation of contaminated soils. The Ministry is aware that the cleanup will depend on the financing available, see below.

2.3 Total costs and financing

Calculations of the cost for remediating the 370 contaminated sites is estimated to be 1,849 mill. ECU (EEA, 1997).

The Waste Act of 1998 identifies the polluter as liable. If the polluter is unknown, the landowner is responsible. The Ministry has the option to fund a remediation and later recover the costs. Costs can be recovered either directly or by the transfer of an appropriate portion of the remediated property. Cost recovery is to take place over a 10-15 year period.

3 Water Supply

3.1 The groundwater resource

According to the White Book of Groundwater (Ministerio de Obias Publica, Transportes y Medio Ambiente, 1994), the major aquifers in Spain are approximately equally divided between unconsolidated sedimentary sand aquifers and carbonaceous aquifers. In some limited areas, volcanic rocks must be used for small water supplies. This is the case, for example, on the Canary Islands.

Sand aquifers

There are 4 major basins of unconsolidated sands: Duero, Tajo (Madrid) and Ebro in the central part of the country and Guadalquivir in the south-west. These aquifers are up to 3,000 meters thick. In the largest basin, Duero, measurements indicate a travel time from the recharge area at the edges of the basin to the river discharge at the centre of the basin of 11,000 – 15,000 years. This results in a saline water quality unusable for water supply in the deeper parts of the aquifer close to the discharge. In the Tajo basin, the groundwater is not capable of yielding a sustainable water supply for the large population in the Madrid area. Water table levels have fallen as much as 200 metres in some areas. The extent of the usable aquifers in the Ebro basin in limited due to the presence of low-permeable sediments.

Carbonaceous aquifers

The carbonaceous aquifers are predominantly located in the eastern half of the country and generally contain younger waters. These aquifers are considered very vulnerable.

Dependence on Groundwater

In arid regions, the dependence on groundwater is high, due to the lack of surface water sources. This dependence varies with rainfall. For example, the drought period of 1991-95 resulted in a great dependence on groundwater in the southern part of the country.

3.2 Supply statistics

The main source of water supply in Spain is surface waters. Groundwater supplies between 30 and 35% of the urban supply (Ministerio de Medio Ambiente, 1998). Approximately 2% of the population is supplied with water from desalination.

There are major differences, however, in how much groundwater is used in communities of different sizes. Water supply in communities over 20,000 inhabitants uses only 22 % groundwater while water supply in communities under 20,000 inhabitants uses 70 % groundwater.

The amount of groundwater abstracted in 1994 is estimated at 150 mill. m^3 (ITGE, 1999).

Desalination

Desalination is becoming increasingly important in the Mediterranean coastal areas. The desalination process results in the need for discharge of brine wastes. Discharge takes place in some areas by way of injection wells in dolomite rock.

Consumption categories

Consumption of all waters can be divided as follows (Ministerio de Obias Publica, Transportes y Medio Ambiente, 1993):

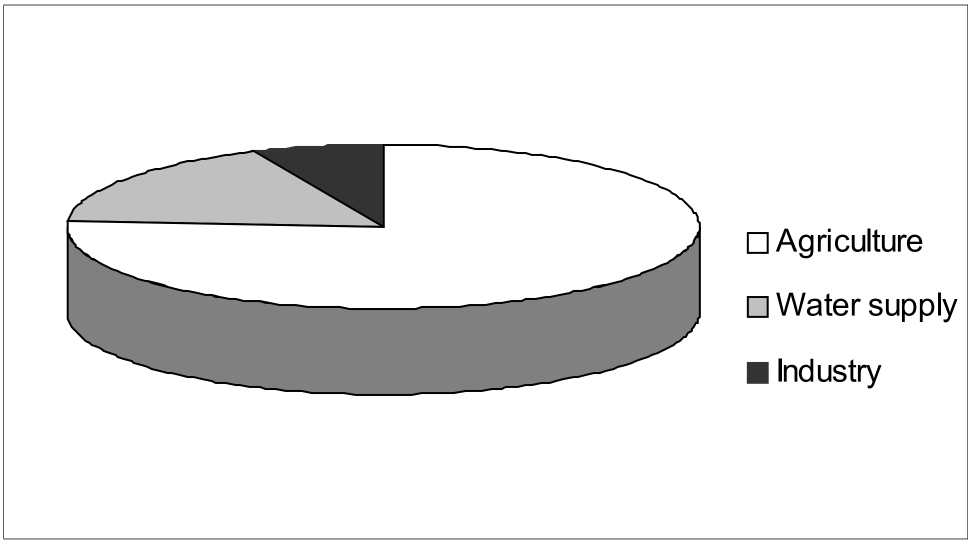

Figure 3.1.
Total water consumption in Spain by category, 1993.

Consumption of groundwater alone has the following consumption percentages (Ministerio de Obias Publica, Transportes y Medio Ambiente, 1994):

Urban supply.	1,080 hm^3 pr. year
Industrial supply	360 hm^3 pr. year
Agricultural supply	3,504 - 4,664 hm^3 pr. year

The average water consumption pr. person is approximately 330 litres pr. day (Ministerio de Medio Ambiente, 1998).

Bottled water

A description of drinking water in Spain is not complete without a mention of bottled water (Baeza, 1999). The use of bottled water has developed rapidly in the last 20 years from 394 mill. litres in 1977 to 3,200 mill. litres in 1998. The national average consumption of bottled water is 72 litres pr. person pr. year, but various greatly with the region. In the Canary Islands, for example, bottled water provides approximately 100 % of the water which is ingested.

3.3 Drinking water criteria

Drinking water criteria in Spain are derived from the European Directive 80/778/CEE.

3.4 Cost

The average price charged to the consumer in 1994 was 168 pesetas (White Book, 1998). Of this price, approximately 68 pesetas is used for the actual treatment of the water.

4 Groundwater Protection

4.1 Preventive measures

4.1.1 Well field protection areas

There are currently no direct provisions in legislation nor practice of defining an area in the immediate proximity of a well field for the purpose of protecting the well field.

4.1.2 Aquifer protection zones

The Hydrological Plans of Basins, 1998 is the theoretical instrument for implementing protection zones as defined in the Water Law. These zones are to be determined according to a schedule which depends on the number of people that the water supply serves:

> 15,000 people10 years
2,000 – 15,000 20 years
< 2,000 not defined

Since these regulations are new, zones have not yet been defined and approved.

There are 12 Hydrological Plans made by the Drainage Basin Authorities and 4 additional plans prepared by certain autonomous regions. These Plans have been prepared prior to the preparation of a Nation Plan for Basins. A National Plan is currently under preparation by the Ministry and may result in the need for some revisions of the 16 basin plans mentioned above.

This National Basins Plan will not likely be specific in exactly how the zones are to be defined. In an example for the Guadalquivir plan, however, mention is made of a zone of 1-2 km radius, which is to be defined for certain water supply wells.

Following the delineation of zones, the major challenge of implementing certain restrictions within these zones will have to be met. This will be the responsibility of the municipalities, who will find it difficult or impossible to find the financial resources necessary to carry out these restrictions.

4.1.3 Mapping of vulnerability

Already in the 1980's, a number of maps showing the vulnerability of groundwater have been prepared through contracts directly between the some of the Drainage Basin Authorities and the Instituto Tecnológico de Geominero de España. Maps for a total of 5 of the 9 basins in Spain have been prepared (Fernandez, 1999). The maps are on a scale of approximately 1:50,000. The two factors which have been used to determine the vulnerability are lithology and depth to water.

An additional study of various methods for determining vulnerability has been prepared in the region of Guadalquivir. Here, international methods such as DRASTIC and GOD were used.

4.2 Remediation of existing problems

4.2.1 Prioritising contaminated sites

The contaminated sites that are listed on the national inventory have only undergone a limited investigation. On the basis of this investigation, an initial risk assessment is made in order to place sites into one of three categories with respect to the acuteness of the problem: short term medium term and long term. Official de-listing of contaminated sites has not yet taken place.

Two motivating factors for remediation are aquifer contamination and the possibility of the site being urbanised after clean-up. The autonomous regions decide how to weight these factors. Due to the lack of financing, it is likely that the remediation of sites which have the possibility of being urbanised after clean-up will be most frequent.

To date, remediations have mostly involved capping of landfills and urbanisation of brownfields.

4.2.2 Criteria

The Waste Act of 1998 states that the government must set minimum clean-up criteria for contaminated soils. The current intention is to develop these soil criteria for 100-120 hazardous substances. The first criteria are expected to be set in the fall of 1999.

No groundwater or soil gas criteria have been set.

5 Literature

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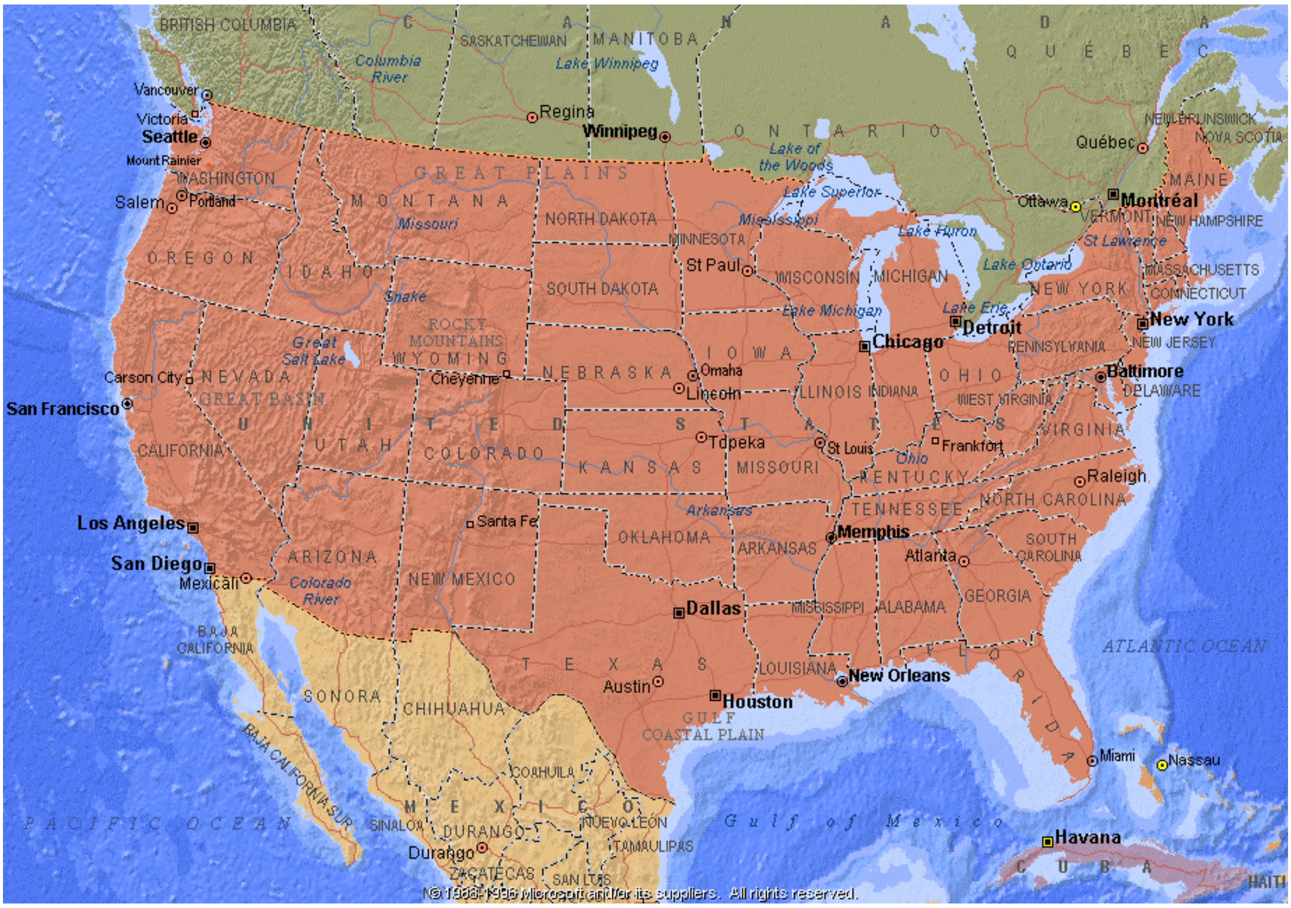
Attachment 5: USA



1 Background information

1.1 Basic facts

The United States has a population of 264,200,000 (1996) and an area of 9,363,000 km^2. This gives an average population density of 28 persons pr. km^2. The actual population density varies widely from region to region.

GDP

The gross domestic product (GDP) in the US is 7,270 billion dollars (annual rate for 1995: OECD, 1998). The current exchange rate is approximately 1.06 USD pr. EUR. The annual gross domestic product pr. person is therefore approximately 27,500 EUR.

Precipitation

Precipitation varies widely from state to state as well as within the boundaries of each state. The national average annual precipitation is 30 inches (760 mm). With the exception of Washington state, states to the east of a line from Texas to Wisconsin receive more than the average, while states to the west receive less than the average. The smallest average annual precipitation for a state is 9 inches (230 mm) in Nevada while the largest is 53 inches (1350 mm) in Louisiana (WIC, 1973).

1.2 Structure of environmental authorities

The US Congress is composed of two bodies, the Senate and the House of Representatives. The most important instrument of the Congress is the passing of legislation.

Each of the 50 states has one or more department for the protection of natural resources and/or the environment. Much of the work regarding groundwater protection and remediation of point source contamination is carried out at the state level.

Figure 1.1 shows the relationship between these authorities.

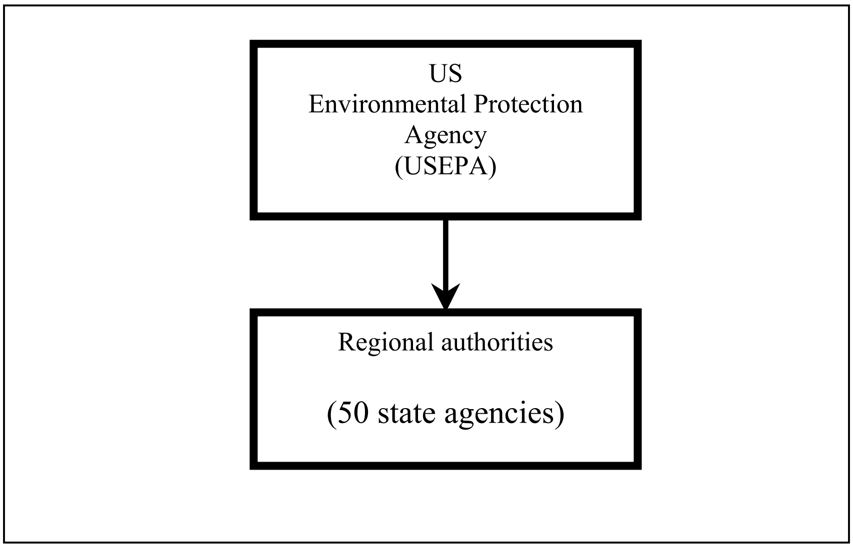


Figure 1.1.

Example of the relationship between main environmental authorities.

1.3 Statutory and advisory information

With regard to groundwater protection and contaminated sites, there are 4 major law complexes:

1) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) also known as Superfund, 1980.

2) The Resource Conservation and Recovery Act (RCRA), 1976.

3) Clean Water Act (CWA), amended in 1977.

4) Safe Drinking Water Act (SDWA), amended in 1996.

Both of these Acts include provisions for empowering the individual states to administer parts of the programs. In connection with the actual statutes, a large volume of advisory information has been prepared.

1.3.1 Superfund

Superfund was enacted in 1980 in response to dangers from abandoned and uncontrolled hazardous waste sites such as Love Canal in Niagara Falls, New York. The law provided for liability of responsible parties (polluter pays principle) and established a trust fund for cleanup when no responsible party could be found. The fund is financed through a tax on the chemical and petroleum industries.

In the Superfund program, potential sites are entered into a database (CERCLIS) and then undergo a preliminary assessment to determine if an immediate removal action is required. If not, a site inspection is carried out and the data is used to rank the site using the Hazard Ranking System which uses a scale from 0 to 100. The exposure pathways that can be scored are groundwater, surface water, soil exposure and air. Sites scoring 28.5 or above are placed on the National Priorities List (in some instances, sites may be placed on the list through different mechanisms). It should be noted that the site score is only used for placement on the list and not for prioritizing site actions, once on the list.

After being listed, additional work is carried out. A remedial investigation and feasibility study are carried out, a remedy is selected and this remedy is documented in a public record of decision. Next, remedial design and remedial action is carried out. Finally, operation and maintenance of the remedy is often required. The site is deleted from the list when cleanup goals are reached.

1.3.2 RCRA

RCRA was enacted in 1976 as an amendment to the Solid Waste Disposal Act of 1965. The main focus of RCRA is the management of wastes including subjects such as waste minimization, recycling, proper management of wastes from generation to final disposal. To ensure high standards, RCRA regulates waste generators and transporters as well as requiring permits for treatment, storage and disposal facilities. In this way, the main intent of RCRA is to prevent contamination from occurring.

RCRA addresses three programs, solid wastes, hazardous wastes and underground storage tanks. Of special interest here are the provisions in Subtitle C which involves management of hazardous wastes. Chapter 9 of this subtitle addresses corrective action to clean up hazardous waste contamination. This corrective action is financed by the responsible parties (polluter pays principle).

1.3.3 Clean Water Act

The CWA encourages groundwater protection, recognizing that groundwater provides a significant proportion of the base flow to streams and lakes. An important aspect under the CWA is the development of State Comprehensive Ground Water Protection Programs.

1.3.4 Safe Drinking Water Act

The SDWA authorizes the EPA to ensure that water is safe for human consumption. The Act describes four programs for the protection of groundwater: the Wellhead Protection

Program, the Sole Source Aquifer Program, the Underground Injection Control Program and the Source Water Assessment Program.

2 Point Sources

In the USA, there are federal agency-based programs, state-based programs and voluntary clean-up programs for contaminated sites. In the following, the federal programs Superfund and RCRA are discussed.

2.1 Number of Sites

Listed sites

Information regarding the number of sites listed in the above-mentioned federal programs is shown below:

- The total number of sites on Superfund's National Priority List (NPL) in March 1999 was 1,446. It is expected that approximately 200 additional sites will be listed during the next 5 year period (Evison, 1999).

- The total number of RCRA sites is currently about 5,500. Of these, 1,700 are considered high priority (Donovan, 1999).

Remedy completion

In March 1999, construction of the remedy was completed at 599 of the Superfund NPL sites. At some of these sites, operation such as pump and treat or cap maintenance is continuing. (Means, 1999).

Few RCRA sites have obtained "clean closure" requirements.

2.2 Time frame for clean-up

Superfund receives a budget annually and a specific time frame for the length of the program is not available. The current feeling is that a Superfund Program, possibly in a reduced form, will be necessary for many years to come (Means, 1999). Current estimates suggest roughly 40 new NPL site proposals each year.

Since its focus is on proper management of wastes, the RCRA is considered an on-going program.

2.3 Costs

Superfund

Funding of the Superfund program varies from year to year. In 1999, 1,0 billion USD were received to maintain central headquarters and 10 regional offices as well as site specific work such as:

- screening sites for further study
- listing sites on the NPL
- studying risks at these sites
- evaluation the feasibility and deciding among clean-up options
- conducting the clean-up work itself
- overseeing activities carried out by other parties
- conducting emergency response actions at NPL or other sites

About 70% of the clean-ups in the Superfund program are paid for by the responsible parties (polluters). Overall, 15,5 bill USD have been contributed to the program by polluters. This means that about 1,0 bill. USD pr. year is directed to the program in addition to the federal Superfund budget.

Finally, approximately 0,5 bill. USD are appropriated for the following Superfund related activities:

- addressing enforcement issues (settling with polluters)

- research and development activities
- supporting other federal agencies that play a role in clan-up work

RCRA

Clean-up under the RCRA program is financed by the individual polluters. Specific data on costs were not obtained.

3 Water Supply

3.1 The groundwater resource

Aquifer regions

On the basis of geological settings, a subdivision of the United States in 4 major aquifer regions can be made:

1) The western mountainous region (including Alaska and Hawaii)
2) The Midwest plains
3) The eastern mountainous region
4) The coastal plains of the Atlantic and the Gulf of Mexico.

The character of the aquifers in these regions is highly variable and relates closely to the regional geological formations. The aquifers range from low-yielding bedrock such as granite and shale, to high-yielding sand, gravel and limestone. The most widespread aquifers of the United States are found in the Midwest region between the mountain ranges to both the east and the west. Sediments from the mountains have been transported to the lower lying plains for a long period of geologic time.

A general overview of the aquifers of the 4 regions is given below (USGS, 1998):

1) The western mountainous region

   In this region, the unconsolidated aquifers of the mountain ranges dominate. In Alaska and other large areas, however, only low-yielding bedrock aquifers can be found. In the northwest and Hawaii, basaltic and volcanic aquifers are found.

2) The Midwest plains

   In this region, sandstones of the Colorado Plateau and unconsolidated sands of the High Plains dominate. In large areas, only low-yielding bedrock aquifers can be found.

3) The eastern mountainous region

   Carbonate and sandstone aquifers of the mountain ranges can be found in this region, but very large areas have only low-yielding aquifers.

4) The coastal plains of the Atlantic and the Gulf of Mexico.

Unconsolidated sands of the Mississippi Valley and surrounding areas and semiconsolidated sandstones of the coastal plains dominate. Only a small percentage of the area has low-yielding aquifers. In the south-eastern most part of the region the aquifers are primarily surficial.

The vulnerability of the aquifers depends on the nature of the cover layers and because of the geological variability a general overview can not be made.

3.2 Supply statistics

Groundwater supplies the overall population of the USA with 51% of its drinking water. In rural area, groundwater supplies 95% of the population with drinking water (data from 1990).

Approximately 63% of the groundwater use in the USA is for irrigation purposes. Water supply represents 19% of groundwater use while industry represents only 5%. Figure 3.1 shows the groundwater consumption in the USA by category.

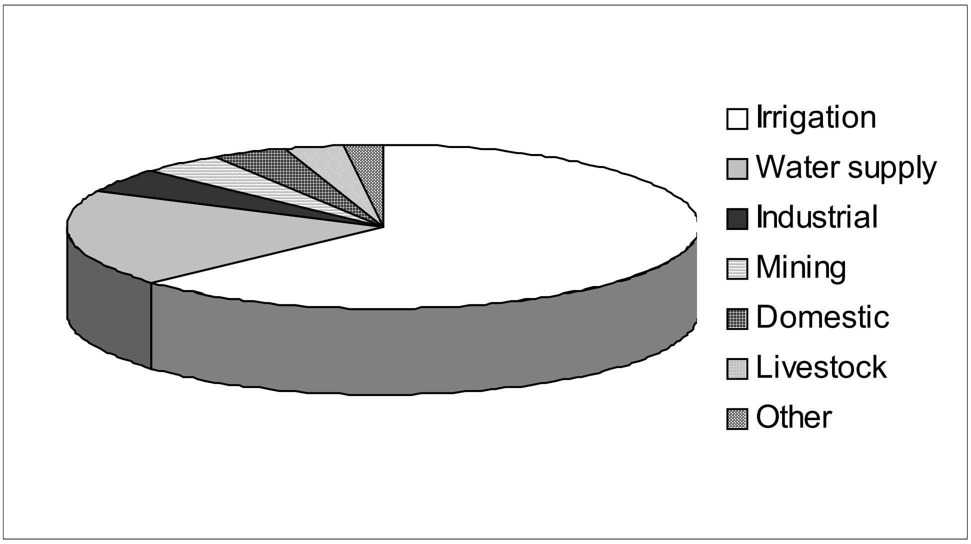


Figure 3.1.
Water consumption in the USA by category.

3.3 Drinking water criteria

There are two main categories of drinking water standards: primary and secondary.

MCLs

Primary standards are enforceable standards that apply to public water systems. They limit the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in water. The primary standards are called maximum contaminant levels or MCLs.

Secondary standards

Secondary standards are non-enforceable guidelines. They refer to levels of contaminants that may cause cosmetic or aesthetic effects. The individual states may choose to adopt these standards as enforceable.

MCLGs

A third standard is the maximum contaminant level goal. This is a non-enforceable public health goal at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. MCLGs are based only on health risks and may exceed current capabilities of treatment technology and analytical detection limits.

Appendix 1 is a list of MCLs.

3.4 Cost

The 1997 National Utility Service International Water Price Survey examined water costs for public water supplies based on 51 cities throughout the united States (Water Well Journal, 1998). In this survey, costs were found to range from 0.20 USD pr. m^3 to about 1.00 USD pr. m^3. The survey showed that water prices in the USA are among the lowest of the countries surveyed, with Germany being the most expensive and Norway the least expensive.

4 Groundwater Protection

In the following sections, measures which are used in the USA for the protection of groundwater are given. To improve the overview, these measures are divided into measures which can be utilized to prevent contamination from happening (prevention) and measures which are used to tackle existing contamination problems (remediation).

4.1 Preventive measures

The protection of the groundwater resources in the USA is addressed under both the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) (EPA, 1998). The CWA describes the development of State Comprehensive Ground Water Protection Programs. The SDWA describes the Wellhead Protection Program, the Sole Source Aquifer Program and the Underground Injection Control Program and the Source Water Assessment Program. These programs are described below.

4.1.1 Comprehensive State Ground Water Protection Programs

Section 102 of the Clean Water Act grants states the authority to develop comprehensive state groundwater protection programs (CSGWPP). This program is voluntary and intends to improve the management of the groundwater resource through a cooperative, multi-agency approach. A guidance document has been provided by the EPA in how to prepare such a program and obtain approval (EPA, 1992).

The guidance document requires that a submitted CSGWPP must adequately deal with each of the following six strategic activities in order to be approved:

- Establish groundwater goals
- Establish priorities based on local needs
- Clarify roles and responsibilities across relevant federal, state, and local programs
- Implement management strategies
- Provide information and monitoring
- Improve public participation and support

As of early 1999, EPA has approved programs for 11 states (Evison, 1999).

Nevada example

The State of Nevada, located in the Basin and Range province, is the most arid in the USA. It is characterized by geographically isolated aquifers and a large variation in the depth to groundwater. Nevada has a very small population density.

Nevada achieved approval for a CSGWPP in 1997 (NDEP, 1998). Several points of this program – which addresses the six activities above - have special interest in regard to this report.

- All groundwater in Nevada is considered to be a potential source of drinking water, and is therefore protected to drinking water standards. This means that the State has no plans to develop a groundwater classification system with a differentiation of quality standards for each class as is recommended by the EPA.
- The identification of the inherent vulnerablility of the resource and potential sources of contamination are included in the duties of the Bureau of Water Quality Planning. A Work Group is also determining critical hydrographic basins in terms of groundwater quality concerns..
- Nevada’s knowledge of potential point source contamination sites is derived from inventories via permitting programs.
- Nevada’s CSGWPP relies primarily on addressing specific potential sources of contamination for protection of groundwater. This is largely implemented through existing programs such as RCRA, mining regulations, underground storage tank regulations, etc.

4.1.2 Well head protection plan

The 1986 Amendments to the Safe Drinking Water Act grants states the authority to develop well head protection (WHP) plans. Protection is achieved through the identification of areas around public water supply wells that contribute groundwater to the well and through the management of potential sources of contamination in these areas to reduce threats to the resource. As of May 1997, 43 States had achieved approval for their WHP Programs.

In order to achieve approval, WHP programs must address the following:

- roles and responsibilities of state and local governments
- delineation of wellhead protection areas
- potential contaminant source inventory procedures
- contaminant source management and control procedures
- contingency plans for alternative water supplies
- new well/well siting standards
- public participation

Massachusetts example

The State of Massachusetts has prepared a guide for developing local groundwater protection controls. This guide walks one through a process for developing a wellhead protection regulatory program that has been found to be successful in Massachusetts communities.

This guide explains that the areas that must be protected include Zone 1 (typically a circular area with a 100 to 400 foot radius) and zone II (the recharge area around a well that is determined by means of hydrogeologic modelling studies). Regulation of land use in these areas can be effected by zoning bylaws (address only future land use activities), general bylaws (regulates new and existing activities), health regulations (adopted by Boards of health rather than city councils).

The guide also describes steps that can be taken to build local support for land use controls. These steps include many possible activities including public education campaigns, open house at the treatment plant, forming a committee, etc.

The wellhead protection process is completed for example by passing a by-law and preparing a wellhead protection map to show which areas are regulated.

4.1.3 Sole Source Aquifer Program

The Sole Source Aquifer Program was established under the SDWA of 1974. The program allows communities, individuals, and organizations to petition EPA to designate aquifers as the "sole or principal" source of drinking water for an area (EPA, 1996). In 1996, there were 67 designations nation-wide.

Once an aquifer is designated, EPA has the authority to review and approve Federal financially assisted projects that may have the potential to contaminate the aquifer. Typical projects include housing and construction of roads. During the period of 1990-96, a total of 1,342 projects were reviewed. Of these, 1,095 projects were approved without modification, 117 projects were modified and 11 projects were either not recommended or disapproved. Remaining projects were withdrawn. These numbers indicate that implementation of the Sole Source Aquifer Program has been successful in reducing the risk for groundwater contamination.

4.1.4 Underground Injection Control Program

This program was initiated in 1974 under the SDWA in order to regulate underground injection wells used for fluid disposal (hazardous waste, waste from oil production and mining, etc). In the USA, there are approximately a half a million injection wells

Approval of a state program gives the State primacy (primary enforcement responsibility). The majority of the States now have approved programs.

4.1.5 Source Water Assessment Program

The 1996 amendments of the SDWA established the possibility for states to develop a State Source Water Assessment Program (SWAP). A SWAP must be approved by the USEPA and must do the following:

- delineation of a source water protection area (such as fixed radius, watershed area, etc) for public water systems
- identify significant potential sources of contamination within the protection area and map these sources
- analyze hydrogeological aspects of the protection area (depth to water, flow rates, etc. but no monitoring or modeling) to determine susceptibility of public water systems to such contaminants

Within 2 years of approval, assessments must be completed for all public water systems. In 1997 EPA published guidance for States for the development of SWAPs.

4.2 Remediation of existing problems

4.2.1 Prioritizing contaminated sites

The need for prioritizing contaminated sites under the Superfund and the RCRA programs is limited. As described earlier, the Superfund program includes the Hazard Ranking System, which means that only the most contaminated sites are entered onto the National Priorities List. Work at all sites on the list is initiated within a relatively short time period. There are, of course, limits to how much work can be carried out at one time, so work at some sites moves faster than at others. The 10 EPA regional offices are central in determining site priorities.

Since the RCRA program involves sites at which the polluter (who must pay for the clean-up) operates the facility, there is not the same need to prioritize as there would be where financing of the work must come from a central fund and projects must compete for limited financial resources.

4.2.2 Criteria

The Superfund program generally expects to return contaminated groundwaters to their beneficial uses wherever practicable. The clean-up levels for a given site are defined as whatever values are relevant (so-called applicable or relevant and appropriate requirements - ARARs). Drinking water standards are generally relevant and appropriate as clean-up levels for groundwater that is a source for current or future drinking water. These levels, however, are not appropriate if the groundwater is not expected to be a future source of drinking water. Other examples of ARARs are water quality criteria established under the Clean Water Act for surface waters.

In order to provide flexibility, the Superfund program allows for the use of a variety of policy tools, including the setting of so-called Alternate Concentration Levels (ACL) for clean-up.

4.3 Monitoring groundwater quality

In section 106(e) of the Clean Water Act, each state is requested to monitor groundwater quality and report the finding to Congress in so-called 305(b) State Water Quality Reports. Results from 1996 are available, with 40 States, 1 Territory and 2 Indian Tribes reporting.

The reporting styles for these reports were varied. Data sources for the reports were based on finished water quality data, ambient monitoring networks, raw water quality data and other sources. It is expected that the reliance on finished water quality data will decrease in the future as the states develop new sources of groundwater data.

For the 1996 reports, guidelines for assessing groundwater quality were developed for the first time. The most significant change was provision of data for selected aquifers or hydrogeologic settings (a total of 162 were reported in 1996).

For their reports, the states were requested to indicate the 10 top contaminant sources threatening groundwater quality. Factors that were considered by States in their selection included:

- Number of sites
- Size of population at risk
- The risk posed
- Hydrogeologic sensitvity

The four most frequently cited sources were underground storage tanks, landfill, septic systems and hazardous waste sites, in that order.

5 Literature

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Appendix: Water Criteria, USA

Parameter	**MCLG** 1 **(mg/L)** 4	**MCL** 2 **or TT**3 **(mg/L)** 4
Inorganic Chemicals		
Antimony	0.006	0.006
Arsenic	none 5	0.05
Asbestos (fiber > 10 micrometers)	7 million fibers per liter	7 MFL
Barium	2	2
Beryllium	0.004	0.004
Cadmium	0.005	0.005
Chromium (total)	0.1	0.1
Copper	1.3	Action Level = 1.3; TT
Cyanide (as free cyanide)	0.2	0.2
Fluoride	4.0	4.0
Lead	zero	Action Level = 0.015; TT
Inorganic mercury	0.002	0.002
Nitrate (measured as nitrogen)	10	10
Nitrite (measured as nitrogen)	1	1
Selenium	0.05	0.05
Thallium	0.0005	0.02
Organic Chemicals		
Acrylamide	zero	TT
Alachlor	zero	0.002
Atrazine	0.003	0.003
Benzene	zero	0.005
Benzo(a)pyrene	zero	0.002
Carbofuran	0.04	0.04
Carbon tetrachloride	zero	0.005
Chlordane	zero	0.002
Chlorobenzene	0.1	0.1
2,4-D	0.07	0.07
Dalapon	0.2	0.2
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.002
o-Dichlorbenzene	0.6	0.6
p-Dichlorbenzene	0.075	0.075
1,2-Dichloroethane	zero	0.005
1–1-Dichloroethylene	0.007	0.007
cis –1, 2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1
Dicholomethane	zero	0.005
1-2-Dichloroethylene	0.007	0.007
Di(2-ethylhexyl)adipate	0.4	0.4
cis-1,2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1

Dichloromethane	zero	0.005
1-2-Dichloropropane	zero	0.005
Di(2-ethylhex)adipate	0.4	0.4
Di(2-ethylhexy)phthalate	zero	0.006
Dinoseb	0.007	0.007
Dioxin (2,3,7,8-TCDD)	zero	0.00000003
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Epichlorohydrin	zero	TT
Ethylbenzene	0.7	0.7
Ethelyne dibromide	zero	0.00005
Glyphosate	0.7	0.7
Heptachlor	zero	0.004
Heptachlor epoxide	zero	0.002
Hexachlorobenzene	zero	0.001
Hexachlorocyclopentadiene	0.05	0.05
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Oxamyl (Vydate)	0.2	0.2
Polychlorinated biphenyls (PCBs)	zero	0.0005
Pentachlorophenol	zero	0.001
Picloram	0.5	0.5
Simazine	0.004	0.004
Styrene	0.1	0.1
Tetrachloroethylene	zero	0.005
Toluene	1	1
Total Trihalomethanes (TTHMs)	none5	0.10
Toxaphene	zero	0.003
2,4,5-TP (Silvex)	0.05	0.05
1,2,4-Trichlorobenzene	0.07	0.07
1,1,1-Trichloroethane	0.20	0.2
1,1,2-Trichloroethane	0.003	0.005
Trichloroethylene	zero	0.005
Vinyl chloride	zero	0.002
Xylenes (total)	10	10
Radionuclides		
Beta particles and photon emitters	none5	4 millirems per year
Gross alpha particle activity	none5	15 picocuries per Liter (pCi/L)
Radium 226 and Radium 228 (combined)	none5	5 pCi/L
Microorganisms		
Giardia lamblia	zero	TT
Heterotrophic plate count	N/A	TT
Legionella	zero	TT
Total Coliforms (including fecal coliform and E. Coli)	zero	5.0%
Turbidity	N/A	TT
Viruses (enteric)	zero	TT

1 MCLG = maximum contaminant level goal
2 MCL = maximum contaminant level
3 TT = treatment technique
4 units in mg/l unless otherwise noted

5 MCLGs were not established before the 1986 Amendments to the SDWA. Therefore, there is no MCLG for this contaminant.