Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Groundwater body characterisation

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Technical report on groundwater body characterisation issues as discussed at the workshop of 13th October 2003

11 April 2004[1]

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[1] This document has to be developed on the basis of the Horizontal Guidance on Water Bodies and contributions from the participants of the Groundwater Body Characterisation workshop of 13th October 2003

Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (hereafter referred to as Common Implementation Strategy (CIS) for the Water Framework Directive (WFD)). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In this framework, a working group on Groundwater Body Characterisation and Monitoring has been established, with the aim – during the period 2003-2004 - to exchange information/experience on groundwater issues covered by the WFD (e.g. characterisation, risk assessment, monitoring, chemical status and trends) in the form of workshops and technical reports gathering the participant's experience. The workshop of 13th October 2003 on Groundwater Body Characterisation is the first one of the series of this CIS working group activity. The technical report summarises important aspects of groundwater body characterisation as they are already discussed in the relevant CIS guidance documents, and includes examples of practices presented at the national, regional or Pilot River Basin levels by the participants.

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1 Introduction

1.1 Background – The Common Implementation Strategy of the WFD

The Water Framework Directive (2000/60/EC)[2] is a comprehensive piece of legislation that sets out, *inter alia*, clear quality objectives for all waters in Europe. The Directive provides for a sustainable and integrated management of river basins including binding objectives, clear deadlines, comprehensive programme of measures based on scientific, technical and economic analysis including public information and consultation. Soon after the WFD adoption, it has become clear that the successful implementation of the Directive will be, at the least, equally as challenging and ambitious for all countries, institutions and stakeholders involved. Therefore, a strategic document establishing a Common Implementation Strategy (CIS) for the Water Framework Directive (WFD) was developed and finally agreed under the Swedish Presidency in the meeting held in Sweden on 2-4 May 2001. Despite the fact that it was recognised that implementing the WFD is the full responsibility of the individual Member State, there was a broad consensus amongst the Water Directors of the Member States, Norway and the Commission that the European joint partnership was necessary in order to:

- ✓ develop a common understanding and approaches;
- ✓ elaborate informal technical guidance including best practice examples;
- ✓ share experiences and resources;
- ✓ avoid duplication of efforts;
- ✓ limit the risk of bad application.

Furthermore, the Water Directors stressed the necessity to involve stakeholders, NGOs and the research community in this joint process as well as to enable the participation of Candidate Countries in order to facilitate their cohesion process. Following the decision of the Water Directors, a comprehensive and ambitious work programme was started of which the first phase, including ten Working Groups and three Expert Advisory Fora, was completed at the end of 2003[3] and led to the availability of thirteen Guidance Documents which are publicly available[4]. The second phase of the Common Implementation Strategy (CIS) now involves four working groups, namely on ecological status (WG 2A), Economics and Pilot River Basins (WG 2B), Groundwater Body Characterisation and Monitoring (WG 2C) and Reporting (WG 2D). The present workshop has been held under the auspices of the WG 2C of which the mandate is described in a separate document[5].

1.2 Groundwater Directive

In parallel of the drafting activities of CIS Guidance documents, an Expert Advisory Forum (EAF) on Groundwater has contributed to the development of the draft proposal for a Groundwater Directive, which has been adopted by the Commission in its final form on 19th September 2003[6]. In the period

[2] European Parliament and Council Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy (OJ L 327, 22/12/2000, p. 1) as amended by European Parliament and Council Decision 2455/2001/EC (OJ L 331, 15/12/2001, p.1)

[3] Common Implementation Strategy for the Water Framework Directive, European Communities, ISBN 92-894-2040-5, 2003. Final CIS document available under: http://europa.eu.int/comm/environment/water/water-framework/implementation.html

[4] All Guidance Documents are available on http://europa.eu.int/comm/environment/water/water-framework/guidance_documents.html

[5] Mandate of the CIS Working Group 2C on Groundwater Body Characterisation and Reporting

[6] COM(2003)550

between the adoption of the proposal and the adoption of the future groundwater directive by the European Parliament and the Council, it has been decided to organise regular workshops to exchange information and experiences among the newly formed Working Group 2C on "Groundwater body characterisation and monitoring". In this framework, a workshop on groundwater body characterisation was held in Brussels on 13th October 2003, gathering more than 80 participants from both the WG 2C and the WG 2B.

1.3 Aim of the workshop

The aim of the workshop was to share national and regional experiences on groundwater body characterisation, taking into account the CIS guidance. The present workshop report summarises key elements of groundwater body characterisation as they are summarised in the Horizontal Guidance on Water Bodies[7] and reports on case studies and the current state of implementation, either at the national level (Austria, Denmark, Finland, Germany, Hungary, Italy, Lithuania, the Netherlands, Norway, Portugal and the United Kingdom) at the regional level (Hesse in Germany, Po and Umbria both in Italy) or within Pilot River Basins (Guadiana, Jucar, Odense, Scheldt, Shannon, Tevere and Pinios, see section 1.4).

1.4 Some words on the Pilot River Basins

The network of Pilot River Basins (PRBs) has been established to test and validate guidance documents developed under the CIS of the WFD. In this respect, fourteen out of a total of fifteen PRBs agreed to test the Horizontal Guidance Document on Water Bodies. The PRBs involved in this exercise were: Odense (Denmark), Oulujoki (Finland), Moselle-Sarre (Germany, France, Luxemburg), Marne (France), Neisse (Germany, Czech Republic, Poland), Somos (Romania, Hungary), Scheldt (Belgium, France, the Netherlands), Pinios (Greece), Shannon (Ireland), Jucar (Spain), Tevere (Italy), Cecina (Italy), and Suldal (Norway).

[7] Guidance Document No 2. Identification of Water Bodies. ISBN 92-894-5122-X. All Guidance Documents are available on http://europa.eu.int/comm/environment/water/water-framework/guidance_documents.html

2 Background

2.1 Identification of groundwater bodies

The Water Framework Directive covers **all** waters, including inland waters (surface water **and groundwater**) and transitional and coastal waters up to one sea mile (and for the chemical status also territorial waters which may extend up to 12 sea miles) from the territorial baseline of a Member State, independent of the size and the characteristics[8].

This totality of waters is, for the purpose of the implementation of the directive, attributed to geographical or administrative units, in particular the **river basin**, the **river basin district**, and the "**water body**"[9]. In addition, **groundwaters** and stretches of coastal waters **must be associated with a river basin (district).** Whereas the river basin is the geographical area related to the hydrological system, the river basin district must be designated by the Member States in accordance to the directive as the "**main unit for management of river basins**"[10].

One key purpose of the WFD is to prevent further deterioration of, and protect and enhance the status of aquatic ecosystems, and with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems. The success of the Directive in achieving this purpose and its related objectives will be mainly measured by the status of "water bodies". With regard to groundwater, "groundwater bodies" are therefore the units that will be used for reporting and assessing compliance with the Directive's principal environmental objectives. However, it should be emphasised that the identification of "groundwater bodies" is a tool not an objective in itself.

The "groundwater body" should be a coherent sub-unit in the river basin (district) to which the environmental objectives of the directive must apply. Hence, the main purpose of identifying these bodies is to enable the (quantitative and chemical) status to be accurately described and compared to environmental objectives[11].

The Horizontal Guidance Document on Water Bodies stresses that flexibility should be ensured for the delineation of groundwater bodies considering the diversity of circumstances within the European Union[12]. It should however be clear that the identification of groundwater bodies must be consistent and co-ordinated within a river basin district. In particular, international river basin districts need to develop common approaches for the whole river basin.

In the Scheldt PRB the first harmonization need was the management of the different approaches applied by each partner (BE, FR, NL) for the delineation of groundwater bodies. The partners came to several agreements along the borders to take into account the continuity of groundwater bodies. Several new bodies or new inner limits were defined in order to achieve a consistent map. Some difficulties are still remaining, relating to how taking into account groundwater bodies which are partly laterally feeding another body (e.g. the unconfined chalk aquifer along the border between the Scheldt and the Meuse districts) or how to represent superposed bodies on the map.

[8] Articles 2 (1), (2) and (3)

[9] Articles 2 (13), (15), (10), and (12) respectively

[10] Article 2 (15)

[11] An estimate of the status of groundwater bodies will be required to assess the likelihood that they will fail to meet the environmental quality objectives set for them under Article 4 [Article 5; Annex II 2]. The status of groundwater bodies must be classified using information from the monitoring programmes [Article 8, Annex V 2.2 & 2.4]. The status of groundwater bodies must be reported in the river basin management plans [Article 13, Annex VII] and, where necessary, measures must be prepared [Article 11, Annex VI].

[12] Guidance Document No 2. Identification of Water Bodies. ISBN 92-894-5122-X.

2.2 Groundwater body characterisation and WFD requirements

Article 5 of the Water Framework Directive requires that, by 22 December 2004, characteristics of the river basin districts be analysed and a review of the environmental impact of human activity, as well as an economic analysis of water use, be undertaken. With regard to groundwater, the characterisation process involves:

An initial characterisation of all groundwater bodies (Annex II.2.1) to assess their uses and the degree to which they are at risk of failing to meet the objectives of Article 4 of the WFD, namely the achievement of good (quantitative and chemical) status of groundwater at the latest by the end of the year 2015. Groundwater bodies may be grouped for the purposes of this initial characterisation, which may be based on existing hydrogeological, geological, pedological, land use, discharge, abstraction and other data. In particular, the first step will be to identify the location and boundaries of the groundwater body or bodies. Then, pressures to which the groundwater bodies are liable to be subject to shall be identified (including diffuse and point sources of pollution, abstraction, and artificial recharge). In addition, the general character of the overlying strata in the catchment from which the groundwater body receives its recharge shall be described, as well as the groundwater bodies for which there are directly dependent surface water ecosystems or terrestrial ecosystems.

Following this initial characterisation, ***a further characterisation*** has to be carried out for those groundwater bodies or groups of bodies which have been identified as being at risk in order to establish a more precise assessment of the significance of such risk and identify any measures to be required under Article 11 of the WFD. Accordingly, this characterisation shall include relevant information on the impact of human activity[13] and, where relevant, information on:

- Geological characteristics of the groundwater body including the extent and type of geological units;
- Hydrogeological characteristics of the groundwater body including hydraulic conductivity, porosity and confinement;
- Characterisation of the superficial deposits and soils in the catchment from which the groundwater body receives its recharge, including the thickness, porosity, hydraulic conductivity, and absorptive properties of the deposits and soils;
- Stratification characteristics of the groundwater within the groundwater body;
- An inventory of associated surface systems, including terrestrial ecosystems and bodies of surface water, with which the groundwater body is dynamically linked;
- Estimates of the directions and rates of exchanges of water between the groundwater body and associated surface systems;
- Sufficient data to calculate the long term annual average rate of overall recharge; and
- Characterisation of the chemical composition of the groundwater, including specification of the contributions from human activity. Typologies for groundwater body characterisation may be used when establishing natural background levels for these bodies of groundwater.

Specific provisions concern those bodies of groundwater which cross the boundary between two or more Member States, focusing mainly on quantitative aspects. In particular, the following information is requested for each groundwater body:

a) The location of points in the groundwater body used for the abstraction of water with the exception of:

   ✓ Points for the abstraction of water providing less than an average of 10 m³ per day; or

   ✓ Points for the abstraction of water intended for human consumption providing less than an average of 10 m³ per day or serving less than 50 persons.

[13] Guidance Document No 3. Analysis of Pressures and Impacts. ISBN 92-894-5123-8.

b) The annual average rates of abstraction from such points;

c) The chemical composition of water abstracted from the groundwater body;

d) The location of points in the groundwater body into which water is directly discharged;

e) The rates of discharges at such points;

f) The chemical composition of discharges to the groundwater body; and

g) Land use in the catchment or catchments from which the groundwater body receives its recharge, including pollutant inputs and anthropogenic alterations to the recharge characteristics such as rainwater and run-off diversion through land sealing, artificial recharge, damming or drainage.

Connected to this further characterisation, the WFD also requires the identification of those bodies of groundwater for which lower objectives are to be specified under Article 4, including as a result of consideration of the efforts of the status of the body on[14]:

i. Surface water and associated terrestrial ecosystems

ii. Water regulation, flood protection and land drainage

iii. Human development.

Finally, Member States have to identify those bodies of groundwater for which lower objectives are to be specified under Article 4(5) of the WFD where, as a result of the impact of human activity, and as determined in accordance with the analysis of pressures and impacts under Article 5(1), the body of groundwater is so polluted that achieving good groundwater chemical status is infeasible or disproportionately expensive (Annex II.2.5 of WFD).

It should be clear that the identification of groundwater bodies is, first and foremost, based on geographical and hydrological determinants. However, the identification and subsequent classification of water bodies must provide for a sufficiently accurate description of this defined geographic area to enable an unambiguous comparison to objectives of the Directive. This is because the environmental objectives of the Directive, and the measures needed to achieve them, apply to "water bodies". A key descriptor in this context is the "status" of those bodies. If water bodies are identified that do not permit an accurate description of their status, Member States will be unable to apply the Directive's objectives correctly. This is illustrated by Figure 1, taking surface water bodies as an example. At the same time, an endless sub-division of water bodies should be avoided in order to reduce administrative burden if it does not fulfil any purpose as regards the proper implementation of the Directive. In addition, the aggregation of water bodies may, under certain circumstances, also help to reduce meaningless administrative burden, in particular for smaller water bodies (cf. chapter 5).

[14] Annex II.2.4

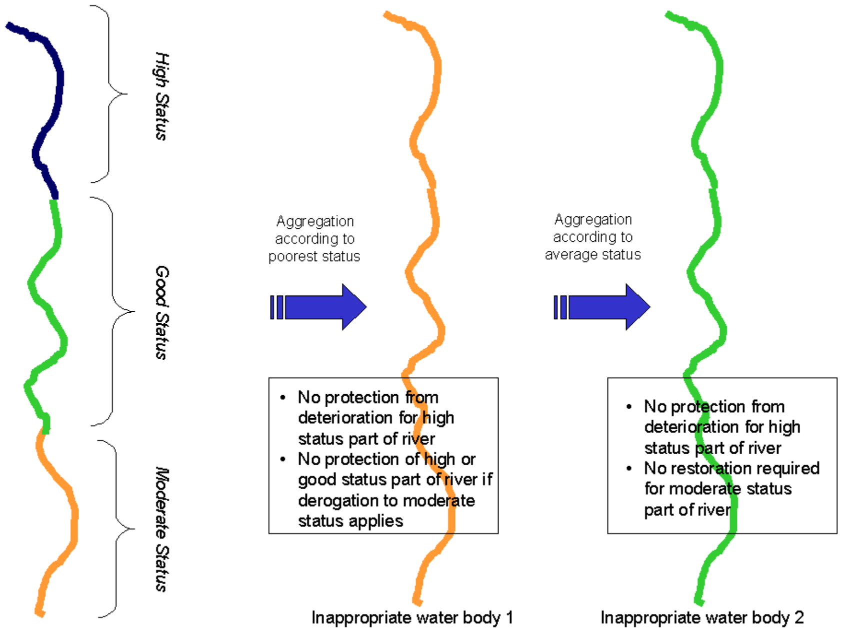

Figure 1: Illustration of the implications for the objectives of the Directive if "water bodies" do not provide for the accurate description of surface water status

Examples taken from the countries, the PRBs and some case studies are summarised in Table 1. From these, it can be seen that the size of the groundwater bodies varies widely, i.e. from some square kms to some thousands of square kms. In many cases the delineation of groundwater bodies is still under discussion and therefore the figures are preliminary. Taking into account only the geological aspect for the delineation, there would be, for example, in the Netherlands just one large sandy groundwater body with some clay and peat layers. Applying additional criteria, there will be a minimum of 20 bodies delineated. In Norway, on the other hand, between 8000 to 10000 groundwater bodies are estimated in 262 River Basin Districts which are going to be grouped to less than 1000. The scale of the groundwater bodies will indeed have implications on the design of the monitoring programme and management aspects. In case the scale is too large, it might be difficult to describe the quantitative and chemical status properly and to work out an appropriate plan for fulfilling the environmental objectives for the groundwater bodies. In case the number of groundwater bodies is too large, it might be difficult to elaborate an effective and economic management. Further guidance on what would be a reasonable scale for groundwater bodies was requested by the PRB participants.

Table 1 Examples of number of River Basin Districts (RBD), groundwater bodies (GWB) and size of groundwater bodies (km²) – Countries, Pilot River Basins and case studies

Countries	**RBD**	**Number of aquifers**	**GWB**	**Min (km²)**	**Max (km²)**	**Incl. Transboundary**
Austria	3		138 (incl. groups)	7	9600	1 GWB, 3 RBD
Denmark	(12)					
Finland			~ 3700	1–2	100	
Hungary	1		102			49 GWB, 1 RBD
Lithuania		4	6	3.7	20.2	
The Netherlands	4		(20)			
Norway	262	8000–10000	(<1000)		73	4 RBD
Portugal			63	5.1	54778	
United Kingdom	17		600–900			3 RBD
PRB						
Odense (1160 km²)		(34)	(50–100)	(0.4)	(56)	
Oulujoki (22841 km²)		210	ND	0.2	41	
Moselle-Sarre (28152 km²)			(12 + 6)	(209)	(8150)	6 GWB
Marne (12730 km²)			11	500	5000	
Lausitzer Neisse (4403 km²)			(5)	(24)	(557)	
Scheldt (37170 km²)			48	(42)	(6086)	14 GWB
Pinios (9500 km²)			14	36	380	
Shannon (18000 km²)			97	5	1400	
Guadiana (12000 km²)			9	9.6	6312	4 GWB
Jucar (43000 km²)			52	48	7421	
Case studies						
Hesse (Germany			127			
Umbria (Italy)		8		16	1076	

Notes:

Figures in brackets are preliminary. ND= not yet defined

Several countries reported that the characterisation of groundwater bodies is based on already available inventories and studies, used for water management purposes for many years, and that this available information corresponds well to the requirements of the initial characterisation. The characterisation comprises and is derived from geological, hydrological and hydrogeological information and maps, descriptions of overlying strata (e.g. soil maps), vulnerability maps (Hungary, Hesse and the United Kingdom), information on abstractions, inventories and statistics of diffuse sources of pollution (e.g. land stock, fertilizer and pesticide use, land use, urban land use cover, CORINE Landcover) and point sources of pollution (e.g. register on contaminated sites, landfills, IPPC permits).

During the initial implementation phase several countries elaborated national strategies and guidance documents based on CIS documents and previous existing national guidance. Austria and Norway developed and tested their methodologies and procedures in pilot studies at the level of RBDs or sub RBDs. In the United Kingdom the trialling of groundwater body characterisation methods in the Ribble catchment was conducted on relatively small "initial screening units" – quite small potential GW-bodies (100 km² or less). Scoring systems were then employed to assess pressures. However, the risk categorisation proved complex and it became clear that this system could not be practically employed on a national basis. Data collation and assessment is now being undertaken at a larger scale (using CAMS catchments and four geological sub-divisions) and scoring systems have been abandoned in favour of the assessment of GIS data against known impacts and expert judgement.

In the Scheldt PRB a review of existing methods among the different partners was done leading to a harmonized method, which is going to be validated and calibrated.

Austria, Finland, Hungary, Norway and the United Kingdom hold most of the information in databases and these databases are reported to be continuously updated and currently adapted and supplemented in order to fully meet the requirements and needs of the WFD. In several countries the characterisation data are kept together with the monitoring data on groundwater quantity and quality.

GIS based tools are common instruments for the characterisation of groundwater bodies. Norway and the United Kingdom reported to make extensive use of GIS assessments.

In Lithuania the initial characterisation refers to the chemical status of the groundwater bodies which is based on the drinking water standards.

2.3 Timetable and refinement for the identification of water bodies

The identification of groundwater bodies should be an iterative and on-going process. The water bodies that Member States are required to identify by 22 December 2004[16] and report to the Commission by 22 March 2005[15] will be only a first step. Where necessary, water body identification should be verified and refined in the period before the publication of each river basin management plan.

The Directive requires Member States to identify "water bodies" as part of the analysis of the characteristics of the river basin districts[16]. The first such analysis must be complete by 22 December 2004. The analysis must be reviewed, and where necessary, updated by 22 December 2013 and then every six years.

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[15] Article 15.2

[16] Article 5, Annex II 1.1 & 2

However, identifying water bodies that will provide for an accurate description of the status of surface water and groundwater will require information from the Article 5 analyses and reviews, and the Article 8 monitoring programmes. Some of the necessary information will not be available before 2004. The information that is available is likely to be updated and improved in the period prior to the publication of each river basin management plan.

It is evident that for the first RBMP, all waters must be assigned to water bodies and their status must be described[17]. However, practical approaches may be required in particular for large numbers of pristine waters in remote areas where it can be demonstrated that no significant pressure exist (see also section 5).

In conclusion, verification and refinement steps of water body identification should be foreseen in the implementation process.

3 Specific guidance on bodies of groundwater

3.1 Definitions

The application of the term body of groundwater must be understood in the context of the hierarchy of relevant definitions provided under Article 2 of the WFD.

- Article 2.2: ***Groundwater*** *means all water, which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil.*
- Article 2.11: ***Aquifer*** *means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.*
- Article 2.12: ***Body of groundwater*** *means a distinct volume of groundwater within an aquifer or aquifers.*

A body of groundwater must be within an aquifer or aquifers. However, not all groundwater is necessarily within an aquifer.

The environmental objectives of preventing deterioration of[18], and protecting, enhancing and restoring,[19] good groundwater status apply only to bodies of groundwater. However, all groundwater is subject to the objectives of preventing or limiting inputs of pollutants and reversing any significant and sustained upward trend in the concentration of any pollutant[20].

3.2 Aquifers

As a consequence of the hierarchy of definitions (Section 3.1), the **suggested first step** in the identification of bodies of groundwater requires a general interpretation of the term aquifer, in respect what constitutes a significant flow of groundwater and what volume of abstraction would qualify as a significant quantity.

[17] Guidance Document No 7. Monitoring under the Water Framework Directive. ISBN 92-894-5127-0.

[18] Article 4.1(b)(i)

[19] Article 4.1(b)(ii)

[20] Article 4.1(b)(iii)

3.2.1 Significant flow

The significance of groundwater flow should be understood in the context of the purpose and provisions of the Directive. Accordingly, a significant flow of groundwater is one that, were it from reaching an associated surface water body or a directly dependant terrestrial ecosystem, would result in a significant diminution in the ecological or chemical quality of that surface water body or significant damage to the directly dependent terrestrial ecosystems.

A key purpose of the Directive is to prevent further deterioration of, and protect and enhance the status of aquatic ecosystems, and with regard to their water needs, terrestrial ecosystems directly depending on aquatic ecosystems[21]. The objective of protecting and restoring good groundwater status[22] is designed to help achieve this purpose. It applies to all bodies of groundwater. Consequently, to ensure that the purpose of the Directive can be achieved, the definition of significant flow must encompass all groundwater flow that is important to aquatic and terrestrial ecosystems. Geological strata that permit such flow should therefore qualify as aquifers.

3.2.2 Abstraction of significant quantities of groundwater

Article 7 of the WFD requires the identification of all groundwater bodies used, or intended to be used, for the abstraction of more than 10 m^3 of drinking water a day as an average. By implication, this volume could be regarded as a significant quantity of groundwater. Geological strata capable of permitting such levels of abstraction (even only locally) would therefore qualify as aquifers.

If either of the criteria described in Paragraphs 3.2.1 or 3.2.2 are satisfied, the geological strata should be regarded as an aquifer. Most geological strata would be expected to qualify as aquifers as most supply or are intended to supply 10 m^3 a day as an average or could serve 50 or more people.

However, it is clear that the requirements are different as regards those groundwater bodies which are being used or are intended to be used for drinking water abstraction (cf. Article 7) and those bodies where groundwater is abstracted for other uses (cf. Annex II 2.3). For the latter, not all groundwater bodies would be identified. The criteria in Annex II 2.3 specify, that only those groundwater bodies must be addressed "*which cross the boundary between two or more Member States or are identified [...] as being at risk of failing to meet the objectives set for each body under Article 4*".

[21] Article 1(a)

[22] Annex V 2.1.2 & 2.3.2

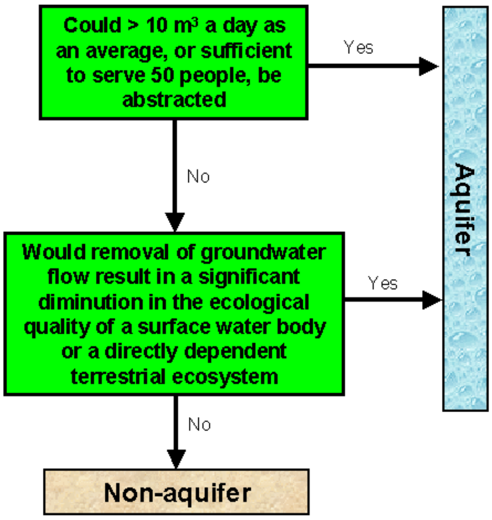

Figure 2: The Directive's definition of aquifer requires two criteria to be considered in determining whether geological strata qualify as aquifers. If either of the criteria is met, the strata will constitute an aquifer or aquifers. In practice, the criteria mean that nearly all groundwater in the Community would be expected to be within aquifers.

In some countries the differentiation between aquifer and groundwater body is not that clear at the moment. In most cases aquifers were distinguished according to resource potential which is tightly linked to lithological properties respectively flow regimes (e.g. porous media, karst, and fractured media).

In Austria all geological structures are considered as relevant aquifers capable of permitting the abstraction of significant quantities of groundwater in order to serve at least 10 m³ drinking water a day, respectively 50 persons. As the general aim of the Austrian water policy is to keep all groundwaters as clean as possible to be used for drinking water purposes, the whole territory is assigned to be covered by groundwater bodies.

In Finland all aquifers supplying at least 10 households (approximately 50 persons) and all aquifers suitable for water supply but without water abstraction are considered as relevant aquifers. Their number is huge whereas their size is quite small. They cover about 4 % of the total land area.

In the Netherlands groundwater bodies are currently delineated as very small areas around the wells. Most sandy groundwater bodies are in use or partly in use for drinking water according to the applied methodology. Around pumping stations, groundwater protection zones can be found with several restrictions in order to protect groundwater. The provinces, however, are reluctant to these large groundwater bodies as they worry that all kind of restrictions have to be assigned to these very large areas. They rather prefer groundwater bodies for drinking water use as very small areas around the wells, as they are delineated currently.

Within the PRB exercise, apart from the Odense PRB (which identified aquifers in relation to their use as drinking water supply), most pilot river basins have only considered aquifers with 'significant flow' when identifying bodies of groundwater. Clarity was required regarding the criteria of identification of aquifers that could or are intended to be used for the abstraction of 10 m³, in particular for those aquifers that could be used for abstraction but are not due to pollution. In addition, there were differences in interpretation of the definition of significant flow, which did not follow the horizontal guidance document. Examples of criteria used are e.g. 250 m³/day (Oulujoki PRB), >10 m³/s (Moselle-Saar PRB) and >100 m³/day (Scheldt PRB).

3.3 Delineation of bodies of groundwater

The Directive's definition of the term body of groundwater does not provide explicit guidance on how bodies should be delineated.

The delineation of bodies of groundwater must ensure that the relevant objectives of the Directive can be achieved. This does not mean that a body of groundwater must be delineated so that it is homogeneous in terms of its natural characteristics, or the concentrations of pollutants or level alterations within it. However, bodies should be delineated in a way that enables an appropriate description of the quantitative and chemical status of groundwater.

The delineation of bodies of groundwater should ensure that groundwater quantitative status[23] can be reliably assessed. In some circumstances, quantitative status may be determined using long-term monitoring data. In other cases, an estimation of the available groundwater resource will require a water balance calculation (see Guidance document No 7, Chapter 4)[24]. Delineating bodies of groundwater in such a way that any groundwater flow from one groundwater body to another (a) is so minor that it can be ignored in water balance calculations; or (b) can be estimated with adequate precision will facilitate the assessment of quantitative status.

Member States will need to take into account the particular characteristics of their aquifers when delineating bodies of groundwater. For example, the flow characteristics of some geological strata, such as karst and fractured bedrock, are much more complex and difficult to predict than others. The delineation of water bodies should therefore be regarded as an iterative process, refined over time to the extent needed to adequately assess and manage risks to the achievement of the Directive's objectives.

It may also be the case that there is substantial flow between strata with very different characteristics (e.g. karst and sandstone). The properties of these different strata may mean that they require very different management approaches to achieve the objectives of the Directive. In such cases, Member States may wish to delineate water body boundaries that coincide with the boundaries between the strata. In doing so, Member States should ensure that their ability to adequately assess quantitative status is not compromised.

Within the implementation process of the WFD in most of the countries a set of criteria is being considered for the delineation of groundwater bodies. The most important aim of the countries is to achieve efficient and practical inventory and management units and to keep the administrative burden and the financial efforts within practicable dimensions. In several countries the delineation process has followed the horizontal guidance on water bodies and is still under discussion. It is mainly based on previous surveys, already existing delineations, maps and studies. In several countries (e.g. Austria, Denmark, Germany, Hungary, the Netherlands, Portugal, Sweden) the delineation predominantly started with the identification of geological boundaries, followed by hydrogeological features and topography and took into account actual and potential utilisation, protection needs, risk potential, economic importance and water management aspects such as already existing water management units, administrative borders or the borders of the River Basin Districts.

In the Netherlands there are hardly any geological boundaries, therefore status and protection aspects as well as water management aspects were predominantly taken into account for the delineation of groundwater bodies.

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[23] Annex V 2.1.2. Quantitative status requires assessment of the available groundwater resource [Article 2.27]. This requires a water balance calculation.

[24] Guidance Document No 7. Monitoring under the Water Framework Directive. ISBN 92-894-5127-0.

The quantitative aspect for the delineation of groundwater bodies is rather dominant in Lithuania where a groundwater body is identified as an entire groundwater flow system or boundary dynamic system. In Finland groundwater flow directions were the basis for the delineation of boundaries between groundwater areas. In the United Kingdom the delineation started with the hydraulic borders to ensure that groundwater quantitative status could be readily assessed (cross-body groundwater flows would otherwise have considerably complicated this assessment). Subsequent combining or subdivision into the final reported groundwater bodies will then be made following the results of the pressures and impacts assessment and also the synchronisation of bodies with administrative boundaries.

Groundwater body delineation is regarded as an iterative process, at least in its early stage, the focus being to use the bodies as management units to concentrate attention on the most serious groundwater management and pollution problems in the first RBMP.

Within the PRB exercise, most pilot river basins undertook the delineation of groundwater bodies on the basis of existing aquifer maps or previous studies. Examples of subdivision (e.g. in the Odense PRB) are based on chemical data including nitrate concentrations, conductivity and concentrations of selected pesticides. Flow data were also used but it was not clear whether this criterion refers to the separation of different aquifers or the subdivision on groundwater bodies within an aquifer. The Oulujoki PRB has divided aquifers into two classes: class I which corresponds to important sources for water supply, and class II which is water suitable for supply (both corresponding to separate groundwater bodies). In other cases (e.g. Moselle-Saar, Neisse, Marne, Shannon and Pinios PRBs), geological and hydrological criteria were predominantly used for the identification of groundwater bodies. A series of criteria were used in the Scheldt PRB: main geological features (lithology) and geological boundaries (clay layers, underground flow separation lines), significant flow, hydrology (basin limits) for superficial water bodies, management features (protected areas, known chemical or quantitative status). Pressure based on supply demand was also considered in some instances (e.g. French part of the Moselle-Saar and Jucar PRBs), including data on abstraction possibilities and information on rationale and efficient use of water. In Jucar the starting point is the already existing system of hydrogeological units corresponding to a single or a group of aquifers which can be managed as a single administrative unit by means of rational and efficient water use. These units are treated as groundwater bodies and their delineation is currently refined.

3.3.1 Geological and hydraulic boundaries

Bearing in mind the above, the starting point for identifying the geographical boundaries of a groundwater body should be geological boundaries to flow, unless the description of status and the effective achievement of the Directive's environmental objectives for groundwater require sub-division into smaller groundwater bodies.

Sub-divisions of an aquifer or aquifers that cannot be based on geological boundaries should be based initially on groundwater highs or, where necessary, on groundwater flow lines (Figure 3).

As already mentioned above, most countries started with the identification of geological and hydrogeological boundaries but applied a comprehensive set of further criteria like vulnerability maps, subsoil properties, risk potential, utilisation and protection need, economic importance and water management aspects.

Hungary additionally considered subsurface catchments, water temperature and considerable vertical upward flows for the delineation of groundwater bodies.

As underlined above, the delineation methodology followed within the PRB exercise was not solely based on geological and hydraulic criteria. However, flow data, topography, soil maps, litho-stratigraphic boundaries, geological limits, hydrogeological boundaries (e.g. based on hydraulic conductivity) were considered in most cases by all PRBs.

3.3.2 Taking account of differences in status

The objectives for bodies of groundwater, and the measures required to achieve these, depend on the existing status of the bodies. The bodies should be units of one chemical and one quantitative status that can be characterised and managed to allow the effective achievement of the Directive's objectives. Major changes in the status of groundwater should therefore be taken into account when delineating groundwater body boundaries to ensure that, as far as practical, water bodies provide for an accurate description of groundwater status. In doing so, Member States should bear in mind the need to ensure that groundwater quantitative status can be reliably assessed (see Section 2). Where status is consistent, large bodies of groundwater may be delineated. Where status differences are reduced during a planning cycle, Member States may recombine subdivisions of groundwater of the same status for the purposes of subsequent planning cycles. **However, water bodies must at least be fixed for each plan period.**

Initially, Member States will not have sufficient information to accurately define the status of groundwater. Consequently, especially during the period prior to the publication of the first River Basin Management Plan, it may be appropriate to use the analysis of pressures and impacts[25] as an indicator of status. As understanding of status improves, the boundaries of groundwater bodies should be reviewed as part of the analyses required under Article 5 prior to the publication of each river basin management plan.

It is clearly possible to progressively subdivide the groundwater in aquifers into smaller and smaller units and thereby create significant logistical burdens. However, it is not possible to define a universally applicable scale below which subdivision is inappropriate.

The degree of subdivision of groundwater into bodies of groundwater is a matter for Members States to decide on the basis of the particular characteristics of their River Basin Districts. In making such decisions, it will be necessary for Member States to balance the requirement to adequately describe groundwater status with the need to avoid the fragmentation of aquifers into unmanageable numbers of water bodies.

[25] Article 5 and Annex II(2)

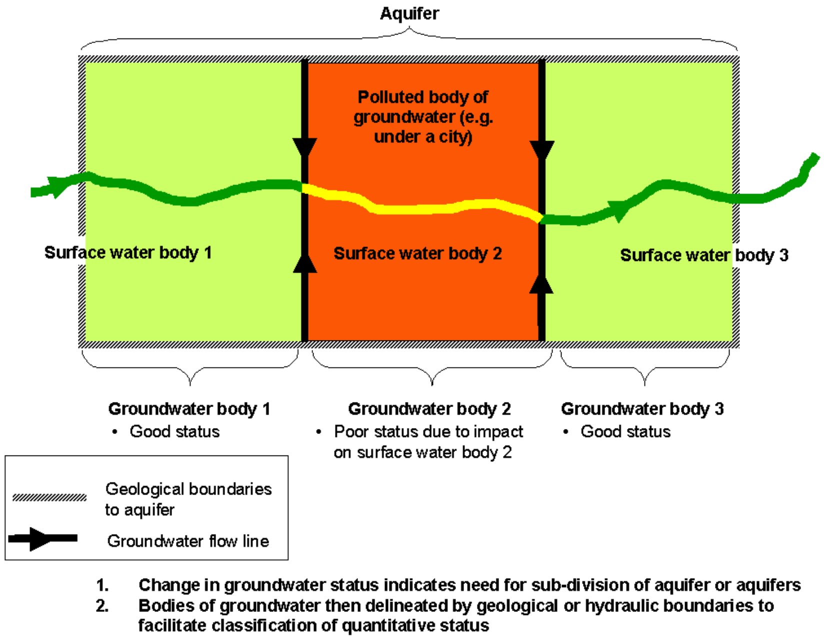

Figure 3: Sub-division of aquifers into bodies of groundwater using hydraulic boundaries

In Lithuania a groundwater body is identified as an entire groundwater flow system or boundary dynamic system which comprises a set of associated aquifers and confining units. Such systems have natural boundaries which encompass the areas of groundwater recharge, transition and discharge. With regard to the status assessment GW-sub-bodies will be treated as separate GW-bodies in order to avoid that a complete GW-body is characterized as failing to meet good quality.

Within the PRB exercise, differences in status were only used in one case (Odense PRB) for the delineation of groundwater bodies, on the basis of chemical (nitrates, selected pesticides) and conductivity data.

3.4 Upper and lower boundaries to bodies of groundwater

Groundwater bodies should be delineated in three dimensions[26].

The depth of groundwater within an aquifer or aquifers that needs to be protected and, where necessary, enhanced through its inclusion in a body of groundwater should depend on the risks to the Directive's objectives. This is a matter for Member States to decide based on their assessments of groundwater characteristics and the risks to the Directive's objectives[27]. It should be noted that all groundwater is subject to the 'prevent or limit' objective [Article 4.1(b)(i)] whether or not it is identified as being part of a body of groundwater.

Although most pressures will affect the relatively shallow component of a groundwater flow, groundwater flow at depth can still be important to surface ecosystems - even though this may be over an extended timescale. Human alterations to groundwater flow at depth can affect shallow groundwater and thus potentially the chemical and ecological quality of connected surface ecosystems. Deep groundwater may also be an important resource for drinking water or other uses. However, Member States would not be expected to identify deep groundwater as water bodies

[26] e.g. Annex II 2.2

[27] Article 5 and Annex II 2

where that groundwater (a) could not adversely affect surface ecosystems; (b) are not used for groundwater abstraction; (c) was unsuitable for drinking water supply because of its natural qualities or because its abstraction would be technically unfeasible or disproportionately expensive; and (d) could not place the achievement any other relevant objectives at risk.

The Directive's definitions of aquifer and body of groundwater (see Section 3.1) permit groundwater bodies to be identified either (a) separately within different strata overlying each other in the vertical plane, or (b) as a single body of groundwater spanning the different strata. This flexibility enables Member States to adopt the most effective means of achieving the Directive's objectives given the characteristics of their aquifers and the pressures to which they are subject. For example, where there are major differences in status of the groundwater in strata at different depths, it may be appropriate to identify different bodies of groundwater (i.e. one on top of another) to ensure the status of groundwater can be accurately described, and the Directive's objectives appropriately targeted.

Similar criteria should be applied in defining the upper and lower boundaries of the groundwater body as to the geographical boundaries (Section 4.3). In other words, to facilitate the estimation of quantitative status, the upper and lower boundaries should be based first on geological boundaries and then on other hydraulic boundaries such as flow lines.

3.5 Assignment to River Basin Districts

Groundwater bodies must be assigned to a River Basin District[28].

3.6 Targeting measures within bodies of groundwater

The analyses undertaken in accordance with Article 5 and Annex II of the Directive (see Guidance Document No 3)[29], and supplemented by information from the monitoring programmes established under Article 8 (see Guidance Document No 7)[30] will identify those bodies at risk of failing to achieve the Directive's objectives because of specific pressures. This information together with the identification of Protected Areas under Article 6 will enable Member States to target measures on the right pressures in the right parts of their bodies of groundwater. To assist this targeting, Member States may establish zones within which specific measures are required to achieve the Directive's objectives. For example, Article 7 indicates that Member States may establish safeguard zones to help protect water intended for human consumption[31].

3.7 Suggested process for the practical application of the term body of groundwater

Figure 4 suggests an iterative, hierarchical process for identifying bodies of groundwater based on the principles described in this guidance paper.

[28] Article 3.1

[29] Guidance Document No 3. Analysis of Pressures and Impacts, ISBN 92-894-5123-8

[30] Guidance Document No 7. Monitoring under the Water Framework Directive. ISBN 92-894-5127-0

[31] Article 7.3

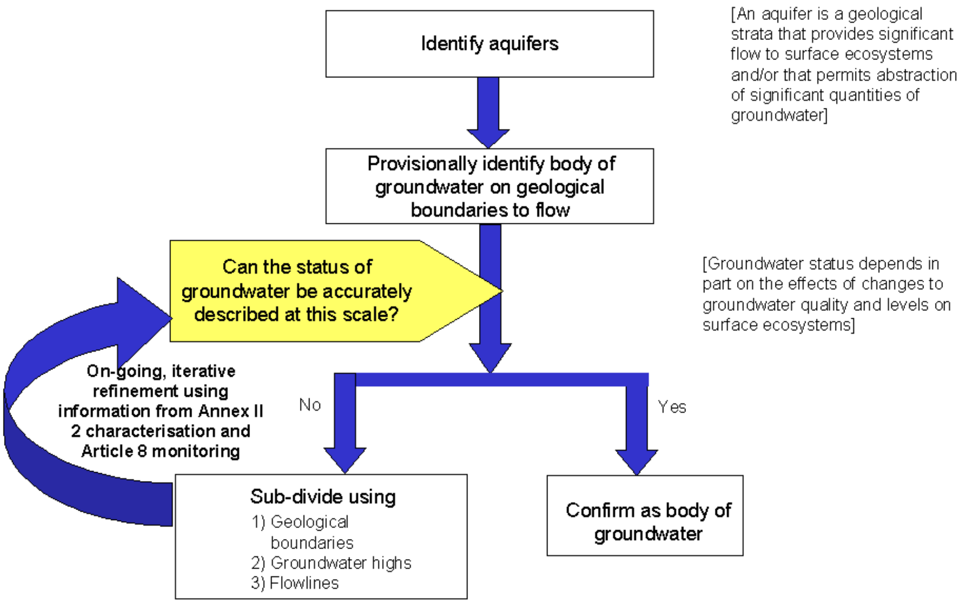

Figure 4: Summary of the suggested hierarchical approach to the identification of bodies of groundwater

3.7.1 Protected areas

Protected areas are identified under various pieces of legislation such as *inter alia* Natura 2000 sites designated under the Habitat Directive - (92/43/EC). Under the Water Framework Directive, all the protected areas must be considered for an integrated river basin management[32]. Specific objectives[33] were defined and various provisions specify more specific requirements for protected areas (e.g. monitoring[34]). In consequence, there are additional objectives to be considered for water bodies which are also fully part of a protected area. Hence, the existing boundaries of protected areas may be considered for the identification of water bodies under the Water Framework Directive.

The boundaries of water bodies and protected areas will, in most cases, not coincide because both geographical areas are being defined for different purposes on the basis of different criteria. In case a water body would not fully be inside or outside a protected area, it may be considered to sub-divide the water bodies into two parts so that the boundaries coincide.

[32] Article 6, 7 and Annex IV

[33] Article 4 (1) c

[34] Annex V, point 1.3.5

4 Aggregation of water bodies

Surface water bodies or bodies of groundwater may each be grouped for the purposes of assessing the risk of failing to achieve the objectives set for them under Article 4 (pressures and impacts)[35]. They may also be grouped for monitoring, reporting and management purposes where monitoring sufficient indicative or representative water bodies in the sub-groups of surface water or groundwater bodies provides for an acceptable level of confidence and precision in the results of monitoring, and in particular the classification of water body status[36].

It is clear that, for management purposes, it may be useful to aggregate water bodies. First practical indications suggest that such an aggregation will also be inevitable when it comes to reporting to the European Commission. At the same time, there are no criteria whether and when such an aggregation is acceptable. In addition, it will be necessary to apply this aggregation on the basis of clear criteria agreed on river basin district level and in a transparent way. Further details on whether and how aggregation of water bodies for the purpose of reporting is possible need to be discussed and elaborated in the context of the CIS Working Group on "Reporting" (WG 2.D). In the meantime it is recommended to focus particular attention on this issue when testing this guidance document, e.g. in the pilot river basins.

In Norway the grouping of individual aquifers (8000–11000) into less than 1000 groundwater bodies is based on the analogous principle (both quantitatively and qualitatively), and on the aim to reduce the number of GW-bodies to a more realistic level for effective and economic management.

In Austria all groundwater bodies in porous media larger than 50 km² or of economic importance or with considerable risk potential were treated as single groundwater bodies. All other groundwater bodies were grouped together considering the hydrogeological situation (aquifer type) and the borders of the sub-river basin districts.

Within the PRB exercise, most pilot river basins have reported their intention to group very small groundwater bodies with larger neighbouring bodies of similar characteristics or subject to similar pressures. Options proposed by the Shannon PRB were to either incorporate a small area of one aquifer into a larger one if the flow system and continuity are not disrupted or to retain as a small hydrogeological significant groundwater body if there is an ecosystem dependency. The Odense PRB reported that a large number of small water bodies were close to ground surface and were thus strongly influenced by agricultural use of fertilisers and pesticides and from urban pollution point sources. As these are not intended to be used for drinking water abstraction, there were not mapped out. Finally, the Moselle-Sarre PRB reported that the methodology used in France does not identify groundwater bodies smaller than 300 km².

[35] Annex II 1.5, 2.1 & 2.2. Guidance Document No 3. Analysis of Pressures and Impacts, ISBN 92-894-5123-8

[36] Annex V 1.3, 2.2 & 2.4. Guidance Document No 7. Monitoring under the Water Framework Directive ISBN 92-894-5127-0

5 Interactions with aquatic and terrestrial ecosystems

Linked to the section 3.3 on groundwater body delineation, important aspects to be considered for the characterisation of groundwater bodies are the interactions with associated surface waters and terrestrial ecosystems. Indeed, the definition of good groundwater chemical status[37] implies that the concentrations of pollutants in a defined groundwater body should not result in failure to achieve the environmental objectives under Article 4 of the WFD for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body.

In most countries the identification of groundwater dependent ecosystems is more or less under discussion. Only Hungary, the United Kingdom and Hesse reported details on the current state of identification.

In Hungary a list of groundwater dependent ecosystem-types is ready and the delineation of areas with groundwater dependent ecosystems based on maps (protected areas, RAMSAR areas, natron lakes, marshes, ecological network, CORINE biotope mapping, NATURA 2000 mapping) is in progress. The delineation of small and therefore probably more sensitive surface water bodies (lakes < 50 ha, water courses with a catchment area < 10 km^2) has also started.

The United Kingdom highlights that scale is also an issue when looking at the impact on some receptors e.g. wetlands. It will be a matter of judgement as to whether an entire large groundwater body should be placed at risk because of the possibility of an impact on a small wetland. Constructing strict rules for this assessment is difficult. In some cases, where an impact is proven or highly probable and the wetland is significant, it may be appropriate to create a small groundwater body around the wetland to deal with what might be regarded as a 'local, small scale' management issue. However, this could not be undertaken routinely, otherwise large numbers of groundwater bodies would be created.

In this respect, within the PRB exercise, the Shannon PRB mentioned that the presence of wetlands could influence the delineation of groundwater bodies. In the Pinios PRB, the interconnection between groundwater and surface waters including terrestrial ecosystems is high (both groundwater and surface water are exploited for irrigation). However, most PRBs indicated that additional studies were necessary to decide on the methodology to adopt to consider the interactions among groundwater bodies and associated aquatic/terrestrial ecosystems. This should lead to the development of a new guidance document or a revision of the existing one.

6 Conclusions

Lessons learnt from the Pilot River Basin exercises on groundwater body characterisation are that the Horizontal Guidance Document on Water Bodies Identification represents a good support to Member States, but that it is not sufficient to carry out the identification of groundwater bodies in a harmonised way.

Most PRBs undertook the delineation of groundwater bodies on the basis of existing aquifer maps or previous studies. Criteria used were mainly geological and hydrological criteria and/or hydraulic ones. Some PRBs (e.g. Odense, Scheldt) mentioned that they also used chemical status to subdivise aquifers.

A high variation in the size of the groundwater bodies has been reported, which would require additional case studies/real examples. In the case of small bodies, most PRBs have grouped very small bodies with bigger neighbouring bodies of similar characteristics or subject to similar pressures.

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[37] Annex V.2.3.2

In general, PRBs have only considered aquifers with 'significant flow' when identifying bodies of groundwater. However, PRBs have applied a wide range of scale when defining significant flow and some were opposed to the recommended 10 m^3/day criteria.

Furthermore, the way to deal with transboundary groundwater bodies is not yet clarified and should be further developed (some PRB used national borders to separate water bodies while others defined transboundary bodies). Finally, clarification on how to deal with the relationship among groundwater bodies and associated aquatic surface waters has been requested.

Annex 1:
Summaries of the Workshop on Groundwater Body Characterisation

Introduction

The key activities of Working Group on "Groundwater" (WG 2.C) for the period 2003–2004 are, according to the draft mandate, focusing on the exchange of experiences/information on issues covered by the WFD. These key activities will consist of four workshops. The first workshop was held in Brussels 13 Oct, 2003 and focused on the *identification and characterisation of groundwater bodies*. Due to the restricted timeframe at the workshop only a limited number of participants were invited to give presentations whereas all participants were invited to provide written summaries to be integrated into the workshop report. This annex focuses on the identification and characterisation of groundwater bodies only, the state of implementation and experiences gained.

Additional information might be found in the presentations and summaries on CIRCA: http://forum.europa.eu.int/Members/irc/env/wfd/library?l=/working_groups/new_groundwater/characterisationsworkshop

The summaries and descriptions from the countries, the Pilot River Basins and from case studies are structured (as far as possible) as following:

- Geology
- Groundwater bodies / River basin districts
- Delineation methodology
- Initial characterisation
- Groundwater dependent ecosystems
- Remarks

Countries
Austria
Denmark
Finland
Hungary
Lithuania
The Netherlands
Norway
Portugal
United Kingdom

Pilot River Basins
PRB Jucar (Spain)
PRB Odense (Denmark)
PRB Pinios (Greece)
PRB Scheldt (Belgium, France, The Netherlands)
PRB Guadiana (Portugal)
PRB Shannon (Ireland)
PRB Tevere (Italy)

Case Studies
Case Study Hesse (Germany)
Case Study Po (Italy)
Case Study Umbria (Italy)

Austria

Geology

The geology of Austria is characterised by a very differentiated and tiny structure, typical for the alpine region, with intensive tectonic imprint and the consequential morphological variability. Geological structures vary from crystalline basement of the Bohemian Mass over younger sediments of the Molasse, the Flysch, Mesozoic sediments, Central Alpine Crystalline to Tertiary basement fillings.

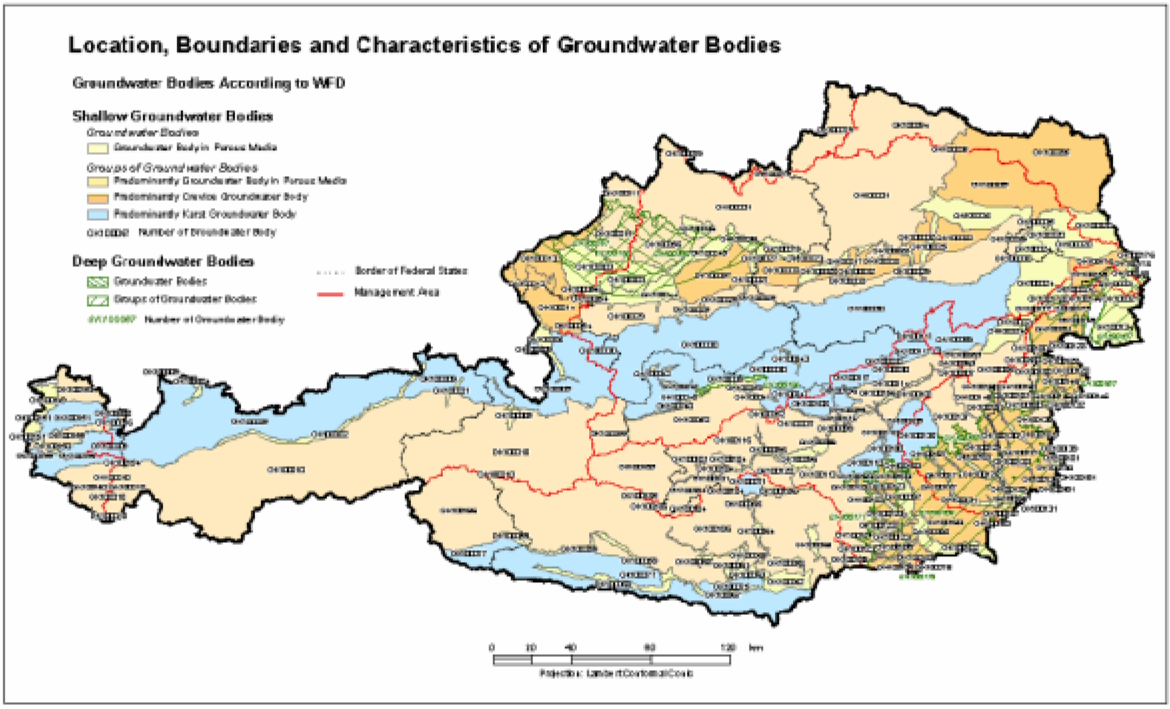
Larger 3-dimensional contiguous GW-bodies are found in the valleys and basins only.

Groundwater bodies / River basin districts

Shallow GW-bodies are covering the whole territory of Austria. In total 138 GW-bodies within 3 RBDs which are international RBDs. The main RBD Danube is divided into 7 sub-RBDs.

The size of single GW-bodies ranges from 7 to 1.200 km², for groups of GW-bodies from 9 to 9.600 km²

	Shallow GW	Deep GW
Single GW-bodies in porous media	64	1
Groups of GW-bodies - Predominantly porous media	18	8
Groups of GW-bodies - Predominantly fractured media	31	
Groups of GW-bodies - Predominantly karstic media	15	1
Total	**128**	**10**



Delineation methodology

As groundwater is the major source of drinking water in Austria (99 %) and as the general aim of the Austrian Water Act is to keep all groundwaters as clean as to be used for drinking water purposes, the whole territory of Austria is being assigned to be covered by GW-bodies.

Delimitation of GW-bodies is laid down in a national strategic guideline and took regard of following criteria:

- Size, homogeneity (geological / hydrogeological)
- Utilisation (actual and potential), economic importance, risk potential
- Existing delimitation of GW-bodies and national monitoring network

All porous GW-bodies > 50 km² or of GW-bodies of economic importance or with considerable risk potential were treated as single GW-bodies. All other GW-bodies were grouped together considering the hydrogeological situation and the borders of the sub-RBDs.

All GW-bodies were assigned to one of three aquifer types (porous, fractured, karstic media).

Deep GW-bodies were delimitated as far as they are utilised and information is available.

Initial Characterisation

Initial characterisation is laid down in a national strategic guideline. It comprises a verbal description of each GW-body respectively each group of bodies (3–4 pages description, geological sketches, profiles) and a standardised data sheet (online web form) which is pre-filled with nationally available data and is going to be validated and completed by the Provincial Authorities. All available data which were used for the characterisation of GW-bodies and for the risk assessment are kept in a database together with the groundwater quality data.

Currently, a pilot study for a selected management unit was finalised which comprised the development and testing of the procedure, the methods and the presentation (maps, tables, report) for the GW-body characterisation and the risk assessment.

Following sources of information were taken into regard:

Characterisation the National Hydrological Atlas (Precipitation, Hydrogeology,…), geological surveys and expert judgement.

Point source pollution Austrian statistics (Live stock units, land use, settlements…), CORINE Landcover.

Diffuse pollution sources Register on contaminated sites, IPPC,…

Overlying strata FAO soil map, Austrian soil map, Surveys and expert judgement for confining layers.

Groundwater dependent ecosystems

A strategy is currently under development

Denmark

Groundwater bodies / River basin districts

Currently there are 12 RBDs. This number is subject to some debate, as there is a reform of the administrative structure of the regional counties and municipalities in Denmark. And the outcome of this is likely to have some consequences for this number.

The number of GW-bodies within these districts has not been decided, except for the Funen-PRB (see PRB Odense (Denmark). The actual number will of course be decided by the competent authorities for the districts.

Finland

Geology

The aquifers occur mainly in superficial deposits of glacial origin such as eskers. The most common type is a water table aquifer, but towards the edges and topographically lower parts of the formations confined groundwater also occurs.

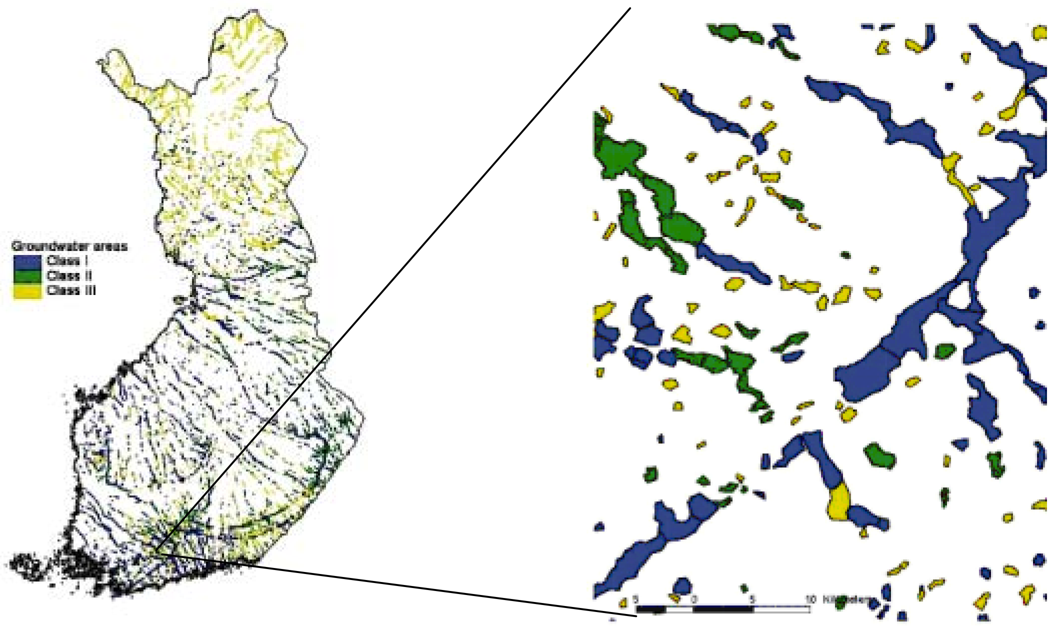
The estimated average recharge in a typical small Finnish groundwater area of 1–2 km² is from 100 to 500 m³ /d. The large areas can provide groundwater up to thousands of m³/d.

Groundwater bodies / River basin districts

The Finnish groundwater areas are quite small by the area. The total area of classified groundwater areas is 14 100 km² and the area of the ground surface regarded as recharge area is 7 619 km². The largest groundwater area in Finland is about 100 km², but the most of common extent of the groundwater areas is 1–2 km².

GW-areas classified as important for water supply (class I)*	2 258
GW-areas classified as suitable for water supply (class II)*	1 454
Total GW-bodies according to WFD	**~ 3 700**
Other GW-areas where further investigations are needed (class III)*	3 188

* Classification on the basis of suitability for water supply and the need for protection.



Delineation methodology

In general the determination of the outer boundaries of groundwater areas (outer boundary) were based on the subsoil and the conceptual types of formations. The boundary of the groundwater area was extended to the low permeable superficial material. The recharge areas (inner boundary) are delineated in the basis of the permeability of subsoil which should be equal to fine sand or higher. The boundaries between two groundwater areas were delineated based on the groundwater flow directions. For example, in an esker chain the boundary between two groundwater areas was placed in a watershed area.

Groundwater resources in Finland have been mapped since the 1970s. The most extensive and, so far, most detailed survey was made in 1988–1995.

Aquifers have been also classified on the basis of suitability for water supply and the need for protection into three classes

- *Class I:* areas important for water supply. From these areas water is extracted and is used by a water works which supplies at least for 10 or more households (approximately 50 persons).
- *Class II:* areas suitable for water supply. These aquifers are suitable for water supply, but for the time being, the areas are needed neither for the municipal water supply nor for households in the sparsely populated areas.
- *Class III:* other groundwater areas, which need further studies to find out the suitability of the area for water supply.

During the next few years the aim is to reduce the number of groundwater areas or GW-bodies by grouping them to bigger units to avoid the administrative burden to the authorities.

Initial Characterisation

Activities and land use possibly causing risk to the groundwater quality were also mapped by the inventory of groundwater resources. Information on abstraction and permits concerning water intake were collect from each of the Class I areas. The boundaries for the safe guard zones for water intakes were also included in the aquifer maps. In cases where aquifers border on surface waters possible connections and the water exchange direction were roughly estimated.

The information on the groundwater area (aquifers) is stored in a database. The database contains information on the location, area, aquifer type, hydrogeological conditions and land use of each of the groundwater areas. Furthermore, the database includes monitoring data on GW levels and quality and the maps of aquifers which are digitized in ArcInfo format in scale 1:20 000. Updating to the mapping data and to classifications of the areas has been made continuously since the 1990´s when the project was finished.

Remarks

The present data on the groundwater areas, which is largely based on the result of the mapping and classification project that is updated in regular basis, corresponds well the requirements of the initial characterization.

There are already voluntary arrangements for protecting groundwater. It has recently become customary for local authorities and waterworks to draft protection plans to ensure the quality and quantity of groundwater. These are not sent for ratification but are for guidance purposes. Such plans may cover entire GW-bodies, and they may also be drafted for GW-bodies which are not yet exploited. The protection plan may also be made for a group of GW-bodies. The plans will include regulations on the protection of groundwater. The protection plan procedure contains detailed hydrogeological mapping, and mapping and evaluation of risk activities. As a result of the work a monitoring programme and programme of protection measures is prepared. The follow-up plan for the protection measures is made and follow-up group will be established. At present there are about 300 protection plans available, which cover about 500 groundwater areas.

In the groundwater protection point of view the protection plan procedure is highly comparable with aims of the further characterization and review of the impact of human activity on groundwaters stated in the WFD.

Hungary

Geology

Hungary is located in the deepest part of the closest basin of Europe, in the Carpathian basin. The large rivers have transported a huge amount of sediment during the Pliocene and Pleistocene Ages, forming a thick alluvial deposit. Except fissured rocks, groundwater is available throughout the country in considerable quantity, which is the main source of drinking water.

Groundwater bodies / River basin districts

Hungary's entire territory lies in the Danube RBD which is an international one.

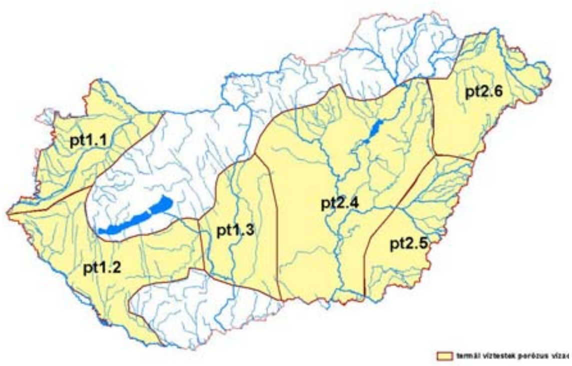
Type of the GW-body	*Number of GW-bodies.*	*Transboundary*
Porous aquifers in basins	47	24/17*
Thermal porous aquifers	6	5
Karstic aquifers	13	5
Thermal karstic aquifers	16	9
In mountainous regions	20	6
Total GW-bodies	**102**	49/42

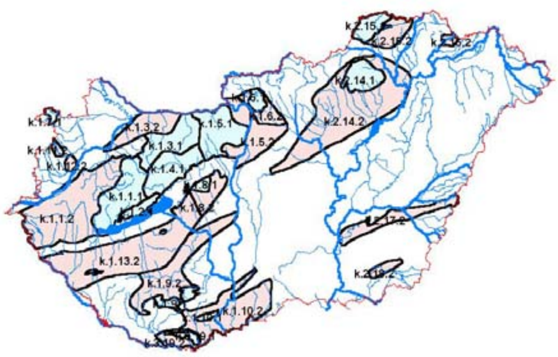
* number of GW-bodies without separating GW-bodies with upward flow system

Since Hungary is surrounded by seven neighbours, the number of transboundary aquifers is high representing a considerable task for harmonization.

Groundwater bodies in mountainous region and cold porous aquifers in basins

Groundwater bodies in mountainous region and cold porous aquifers in basins





🡐 Water bodies in karstic aquifers

(open karstic zones are at the same level with mountainous water bodies, otherwise below the first and the second layer

Delineation methodology

Groundwater bodies in Hungary have been designated according to a hierarchical approach, in harmony with the horizontal guidance on water bodies. Criteria for the delineation are:

- *Type of the geological features* (karstic aquifers, porous aquifers in the basins and mixed mountainous aquifers);
- *Subsurface catchments* (in porous aquifers), *hydrogeological units* (in karstic aquifers) and *water management units* (in mountainous region);
- *Aquifers containing water above 30 °C* further separated (vertical in the case of porous aquifers, horizontal in the karstic aquifers);
- In the plain regions water bodies with *characteristic large scale upward flow* system are further separated, in order to make distinction in chemistry and in the sensitivity of groundwater dependent ecosystems.

Initial Characterisation

Initial characterization will be based on the following information:

- Soil-type maps
- Covering layers - formations of the upper 10 m (in basin areas only), depth of cover of main aquifer (in basin areas only)
- Recharge conditions - vertical hydraulic conductivity maps (m/d) based on the covering layer map
- Depth of shallow groundwater table
- Geological formations: thickness of Quaternary deposits, depth of Upper-Pannonian sediments.

Point source pollution In Hungary inventories on human activities endangering groundwater (incl. data on load, pollutants, etc.) and on polluted sites (incl. information on the activity, pollutant, affected area, endangered receptor, measures etc.) together with monitoring data has been set up several years ago and are under development in order to meet the requirements and needs of environmental and water administration. Entering the data into the databases is carried out continuously.

Data of these databases and the vulnerability map of Hungary give the base for the characterization of point sources. Criteria for selection of significant pollution sources and the method for risk assessment are under elaboration.

Diffuse pollution sources

Emission: Data on agriculture from the Ministry of Agriculture and Land Development (fertilizer use, type and number of animals, manure, and sewage sludge), statistical data at country level, CORINE Landcover and data on non-sewered population are available for the characterization of diffuse pollution sources. No data are available on household agriculture.

Immission: Data on routine parameters are available for most parts of Hungary. Relatively few data are available on pesticides and other organic pollutants. Beyond these data maps on nitrate sensitive areas and the vulnerability map of Hungary can be used for the characterization and risk assessment. Initial characterization is in progress.

Groundwater dependent ecosystems

- The list on groundwater dependent ecosystem-types is ready.
- Delineation of areas with groundwater dependent ecosystems based on maps (protected areas, RAMSAR areas, natron lakes, marshes, ecological network, CORINE biotope mapping, NATURA 2000 mapping) is in progress.
- Delineation of small and therefore probably more sensitive surface water bodies (lakes < 50 ha, water courses with a catchment area < 10 km²) has also been started.

Remarks

Hungary is assisted by a twinning project (DE, NL) in the implementation of the WFD (delineation, characterisation, etc).

Lithuania

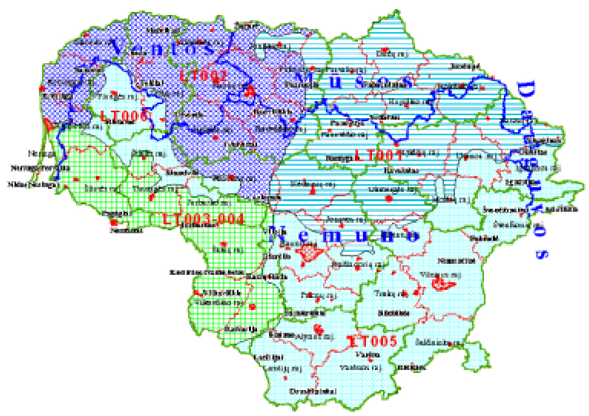
Geology

The territory of Lithuania is covered by 4 groundwater flow systems (GWFS). They are: Middle–Upper Devonian, Upper Devonian–Permian, Mezo–Canozoic and Quaternary.

Groundwater bodies / River basin districts

There are 6 main GW-bodies with a size between 3.7 km² and 20.2 km².

Regional groundwater bodies (boundary dynamic systems) and the national monitoring network



Local GW-bodies (water works)

Delineation methodology

In Lithuania at the national level a GW-body is identified as an entire groundwater flow system (GWFS) or boundary dynamic system (BDS). GWFS comprise a set of associated aquifers and confining units which act hydraulically as a single aquifer system on a regional scale. It may be treated as a regional GW-body. GWFS have natural boundaries which encompass the areas of groundwater recharge, transition and discharge.

This division of territory might be too rough, e.g. with regard to the assignment to river basins. Further subdivision of GWFS can be based on differences in hydraulics (recharge and discharge areas) or on diversity of aquifers lithology, which might be applied to the Quaternary GWFS. Dealing with a large number of small units is also a matter of financial resources.

With regard to the status assessment GW-sub-bodies will be treated as separate GW-bodies in order to avoid that a complete GW-body is characterized as failing to meet good quality.

Initial Characterisation

Initial characterization refers to the chemical status of GW-bodies, which is based on the drinking water standards.

Remarks

WFD and EUROWATERNET employ a concept "groundwater body". According to the WFD GW-body means hydrogeologically distinct volume of groundwater within an aquifer or aquifers. But in the large artesian basins such definition of GW-body can hardly be applied without problems especially on the national level. In Lithuania at the local level a GW-body is identified as a single water work according to the definition above.

At the national (international) level the mentioned concept of a GW-body is unlikely to be satisfactory, primarily because of different monitoring purposes at this level. The main target object at national level is usually the entire aquifer as the unit of understanding and evaluation of impacts. The evaluation of groundwater recharge and available yield is also only possible within the entire aquifer or a system of hydraulically linked aquifers.

The Netherlands

Geology

Most parts of the Netherlands are covered by unconsolidated Quaternary and Tertiary sediments. Consolidated rock only reaching the surface at the most southern part.

Groundwater bodies / River basin districts

The Netherlands cover 4 international RBDs.

Based on the delineation approach there is a minimum of 10 GW-bodies:

4	sandy aquifers
4	clay/ peat aquifers
1	limestone aquifer
1	sandy aquifer in dune areas

Delineation methodology

The delineation of GW-bodies, which is still in discussion, is based on the horizontal guidance on water bodies.

The first criteria "geological boundaries" might not be very relevant as there are hardly any geological boundaries in the Netherlands to separated GW-bodies except the southern part (in purple). In fact, the Netherlands comprise one large sandy GW-body with some clay and peat layers.

Due to the fact that for each RBD a RB management plan needs to be developed it is intended to distinguish at least one GW-body per district where the borders of the RBD are used for the delineation of these GW-bodies.

The type of sediment in the top system is used as a further delineation criterion. The hydraulic conductivity of the top system differs considerably between the peat/clay and sandy GW-bodies which affects the interaction between groundwater and surface water, the impact of land use on the groundwater and the interaction between groundwater and directly dependent ecosystems.

Groundwater dependent ecosystems

All GW-bodies harbour directly groundwater dependent ecosystems.

The focus is on the areas related to the habitat and bird directive. However, not all of these areas are actually groundwater dependent but many areas are, but a lot of them are small and scattered throughout the Netherlands. It is still in discussion on whether to make a selection and how.

Remarks

According to Art. 7 all GW-bodies used for drinking water or human consumption purposes have to be identified. According to the applied methodology most sandy GW-bodies are in use or partly in use for drinking water. Around pumping stations GW protection areas can be found with several restrictions in order to protect groundwater.

The provinces, however, are reluctant to these large GW-bodies as they worry that all kind of restrictions have to be assigned to these very large areas. They rather prefer GW-bodies for drinking water use as very small areas around the wells, as they are delineated currently.

Norway

Geology

Norway's unique recent geological history has shaped the country into a mountain chain consisting of freshly exposed bedrock with a discontinuous thin cover of young sediments. Since the bulk of the ice cover had melted about 10 000 years ago, the land has slowly risen up because of the removed weight of the thick ice cover. Along the coast of Norway, marine sediments are thus found at elevations of up to 200 m above current sea level because of this land rise.

Important groundwater resources occur in young glacial- and fluvial sediments, primarily within river valleys and topographic depressions where sufficient thickness of these sediments have been preserved. This means that many of the important groundwater aquifers have an elongated shape and are relatively small on a European scale.

Minor groundwater resources occur all throughout the country within fractured permeable bedrock and within minor occurrences of young glacial and fluvial sediments. Only a handfull can be considered a groundwater resource.

Groundwater bodies / River basin districts

262 RBDs incl. 15 transboundary. It is foreseen to combine individual RBDs to so called 'water regions' resulting in a more practical number of management entities.

The estimated 8 000–10 000 aquifers are going to be grouped to less than 1 000 GW-bodies.

Norway's largest single groundwater body, located under the main international airport just north of Oslo, has a surface area of 73 km².

Delineation methodology

The total number of individual aquifers is estimated to be 8 000 to 10 000.

The grouping of individual aquifers into GW-bodies is based on the analogous principle (both quantitatively and qualitatively), and on the aim to reduce the number of GW-bodies to a more realistic level for effective and economic management. The current approach aims at identifying GW-bodies per RBD according to the main resource categories "important" and "of minor importance", that the country's inventory will total less than 1 000 GW-bodies.

Initial Characterisation

A combination of existing data on the Quaternary geology and hydrogeology, together with data from local groundwater resource evaluations is used and organized as follows:

- *Phase 1* – (early 2002 to Sep 2003) Pilot studies in two RBDs with the objective of developing a national guideline for characterization of GW-bodies. Additionally, an approach for the classification and grouping of groundwater aquifers, and a GIS-based tool and database were developed.
- *Phase 2* – (Oct to Dec 2003) Testing of the national guideline and the GIS-tool in the characterization of groundwater bodies in 8 of the 262 RBDs.
- *Phase 3* – (2004) Characterisation of groundwater in the remaining 254 river basins.

Where detailed information is currently not available, additional characterisation on a local level might be needed. This will be the responsibility of the regional water management authorities, to be established in 2004 aimed at a revision of the inventory according to the WFD revision period of 6 years.

The initial characterization is carried out over the Internet using a GIS interface and data-capture application, where all relevant information is registered in Norway's national database for groundwater located at the Geological Survey of Norway. The GIS interface provides also access to other relevant national databases and registries located at various departments and institutions across the country. Information from all these sources is then captured and processed, together with locally-derived information, to assess quantitative and qualitative status for each identified groundwater body.

Portugal

Groundwater bodies / River basin districts

In total 63 GW-bodies were identified.

Aquifer type	GW-bodies	min. area (km²)	max. area (km²)
karstic	29	5.1	767.6
fractured*	4	15.3	54,777.8
porpous	30	6.4	6,875.4
Total	**63**	**5.1**	**54,777.8**

* For the fractured media there was an aggregation of groundwater bodies

Delineation methodology

Bearing in mind the objectives and the scale, the identification and delimitation of the aquifer systems was targeted towards efficient inventory and management units.

Beside this concept of aquifer systems and aquifers as the basis of their determination, additional geographical conditions were considered that allowed for the delimitation of distinct aquifer systems:

- Geological limits, coincident with boarders between lithological units with different hydraulic behaviours. These limits may more or less deviate from geological boundaries e.g. due to digitizing constraints (generalisation)
- Limits derived from borehole information, corresponding essentially to the extension of aquifer systems bellow recent deposits.
- Supposed limits, based on geology, structural, geophysical and other criteria. These types of limits bare a considerable amount of uncertainty and will be revised once further information is available.

This methodology was developed in the 1990´s, to identify and characterise all existing aquifer systems. Based on the groundwater body's guidance individual GW-bodies in porous and karstic media are going to be identified. Concerning the fractured media (igneous and metamorphic rocks) it was decided to consider them a single body, or a group of bodies.

As the boundaries of GW-bodies do not coincide with the boundaries of the basins and hydrographic regions, the bodies were assigned to as a whole except for the fractured media and those of little importance, taking into regard the location of the larger area of the GW-body as well as the flow direction.

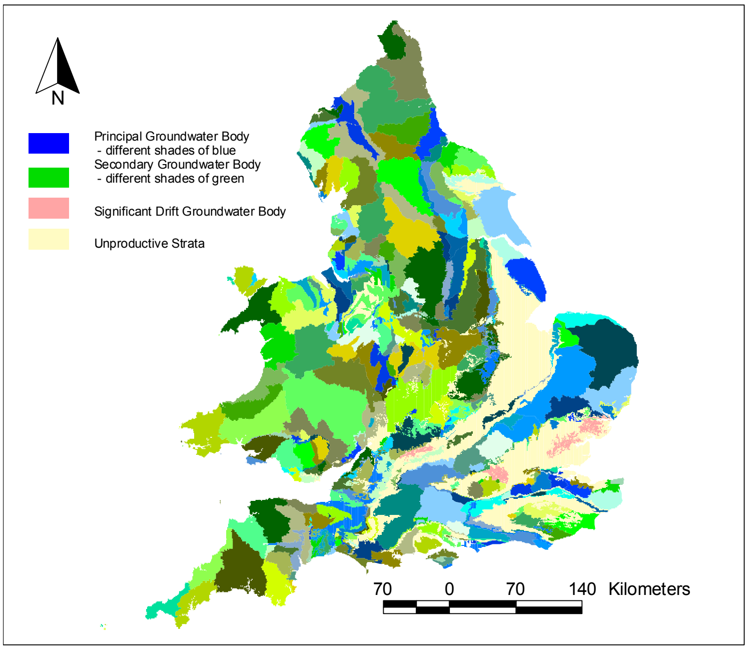
United Kingdom

Groundwater bodies / River basin districts

There are 11 RBDs in England & Wales, subdivided into 126 CAMS catchments, containing an estimated 500–800 GW-bodies in total. Initial data screening and assessment is being conducted on CAMS catchments. There are likely to be 4 or 5 GW-bodies on average initially in each of the CAMS catchments.

Note: CAMS – Catchment Abstraction Management Strategies is an existing water resources management programme that seeks to balance the needs of abstractors with environmental needs – it thus helps to deliver a large part of the Water FD's quantitative requirements in England & Wales.

There are two RBDs in Scotland. Just over 100 GW-bodies will be used for Initial Characterisation.



In Northern Ireland three IRBDs and one Northern Ireland-only RBD are currently proposed to which GW-bodies will be assigned. A diverse geological/hydrogeological setting within a relatively small land area combined with limited regional exploitation of groundwater resources means that only limited datasets are currently available to assist with characterisation.

Delineation methodology

The initial delineation is based on hydraulic units to ensure that groundwater quantitative status can be readily assessed (cross-body groundwater flows would otherwise considerably complicate this assessment). Subsequent combining or subdivision into the final reported GW-bodies will then be made following the results of the pressures and impacts assessment and also the synchronisation of bodies along administrative boundaries (for example, between Scotland and England). GW-body delineation and characterisation is regarded as an iterative process, at least in its early stages, the focus being to use the bodies as management units to concentrate attention on the most serious groundwater management and pollution problems in the first RBMP.

Initial Characterisation

Due to the relative timescales of the WFD and the proposed Groundwater Daughter Directive (GWD) it has been recognised that it will not be possible to fully complete characterisation by Decr 2004 as not all the components of good groundwater chemical status will be fully defined. Thus groundwater characterisation will need to be refined in the period between the agreement of the GWD and well before the publication of the draft RBMP in Dec 2008, at which time the results of the quite distinct process of classification will need to be finalised.

Following a period of guidance preparation and desk studies during 2002, initial characterisation is proceeding and will be completed during 2004. This includes a trial of some of the characterisation procedures that has been undertaken in the Ribble catchment in Northern England. The same basic approach to delineation of GW-bodies and characterisation is being adopted throughout the UK, based on CIS and UKTAG guidance.

Rapid assessment techniques have been developed to meet the needs of this first phase of characterisation and through time it is intended to refine these "fit for purpose" techniques for the long term purposes of the WFD. Work on further characterisation will be phased, as noted above, but due to the variation in available datasets around the UK, will proceed at differing speeds around the country and will proceed beyond Dec 2004.

Extensive use is being made of GIS in the characterisation work. In England & Wales there are large existing national data sets for many point sources (e.g. landfills, petrol stations, PPC permits etc.). Most of these point sources are covered by existing permits that have been issued in compliance with the Groundwater Directive. Diffuse sources have been assessed by reference to land use and vulnerability data. There are existing groundwater vulnerability maps for the whole of England & Wales at the 1:100 000 scale and there are existing tools for the assessment of the risks to groundwater from nitrates and pesticides. Due to the multitude of potential urban diffuse sources of pollution, urban land use cover has been used as a surrogate for such sources.

In Scotland, a dataset has been compiled, as part of Initial Characterisation, of relevant point sources that have been issued in compliance with the Groundwater Directive. Diffuse sources have been assessed by reference to land use, along with newly-developed maps of aquifers and groundwater vulnerability. Further Characterisation in Scotland will use tools specifically developed for assessing key contamination issues in urban and rural areas. As with England & Wales, urban land use cover has been used as a surrogate for the large number of point and diffuse sources that can occur in these areas.

Remarks The scale of assessment has implications for both workload and final risk categorisation. There is a danger that, particularly where some data sets are intensive, the assessment will be undertaken on an unrealistically small scale. For example, initially, trialling of groundwater characterisation methods in the Ribble catchment was conducted on relatively small "initial screening units" – quite small potential GW-bodies (100 km² or less). Scoring systems were then employed to assess pressures. However, the risk categorisation proved complex and it became clear that this system could not be practically employed on a national basis. Data collation and assessment is now being undertaken at a larger scale (using CAMS catchments and four geological sub-divisions) and scoring systems have been abandoned in favour of the assessment of GIS data against known impacts and expert judgement.

Groundwater dependent ecosystems

Scale is also an issue when looking at the impact on some receptors e.g. wetlands. It will be a matter of judgement as to whether an entire large GW-body should be placed at risk because of the possibility of an impact on a small wetland. Constructing strict rules for this assessment is difficult. In some cases, where an impact is proven or highly probable and the wetland is significant, it may be appropriate to create a small groundwater body around the wetland to deal with what might be regarded as a 'local, small scale' management issue. However, this could not be undertaken routinely, otherwise large numbers of GW-bodies would be created.

Remarks

Characterisation is to an extent an iterative process. Body delineation should be refined following the pressures and impact analysis to ensure that the management units created are addressing the main problems for groundwater protection and management.

Characterisation is a continuing process and is distinct from classification, which can only take place once the results of the monitoring programme are available.

With respect to chemical pressures, characterisation will need to be refined following the agreement of the Daughter Directive so that is provisions can be taken into account.

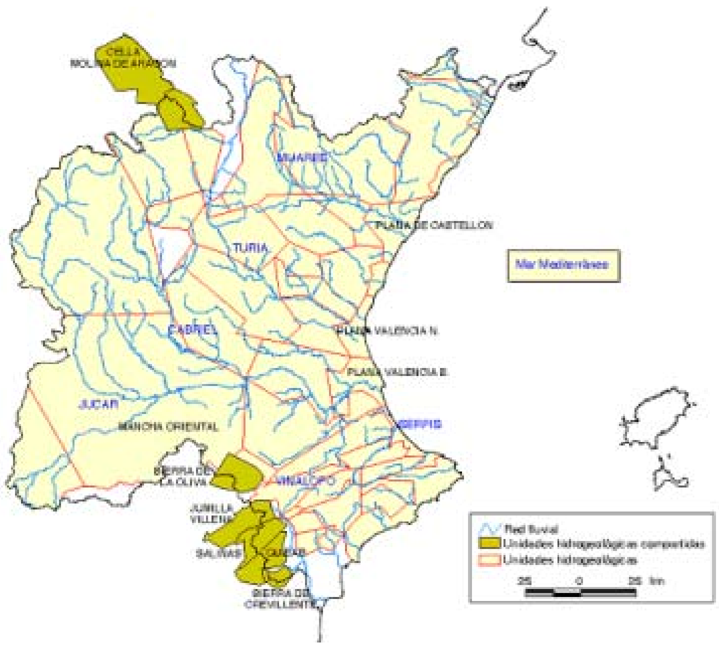
PRB Jucar (Spain)

Groundwater bodies / River basin districts

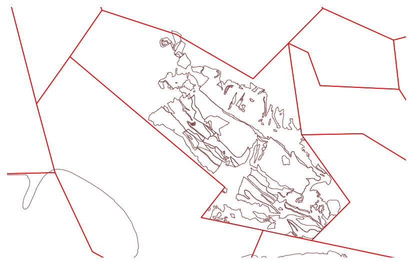
The adopted GW-bodies correspond to 52 hydrogeological units (HGU) defined in the Júcar River Basin Plan. The Plan adopted these GW-bodies from a national project in 1989.

Six of the HGUs (dark coloured) are managed commonly with the neighbouring basin districts (Ebro, Guadiana and Tajo).

There is a disparity of HGU sizes which corresponds to the hydrological characterisation only. The GW-body size ranges from 48 to 7 421 km².



Aquifers on HGU 8.18 "Las Serranías »



Delineation methodology

Basically the concept of hydrogeological units (HGU) corresponds to a single or a group of aquifers which can be managed as a single administrative unit by means of rational and efficient water use. The delimitation of HGUs considered different lithographic groups as carbonated, detritic and alluvial aquifers, followed by a study for the determination and clustering according to the lithology of pervious materials, physical properties of the aquifers related to hydrodynamics (unconfined, partly confined or confined), composition (simple or multi layer), mean thickness and hydraulic parameters (hydraulic conductivity, storability of aquifers) and finally differentiating GW-bodies.

To refine the definition of GW bodies a number of specific studies are being currently conducted for those HGU that present complex geomorphology and lack of information in several aspects. These studies will define the borders three-dimensionally and will determine the main characteristics of the system of aquifers which will allow for determining the balance of water resources. Once the balance on the aquifer system is established, the overall balance can be extrapolated for each HGU.

PRB Odense (Denmark)

Groundwater bodies / River basin districts

34 aquifers used for drinking water supply (size: 0.4–187 km²)

Delineation methodology

The identification of aquifers is based on the horizontal guidance and the mapping is based on geology and geophysics.

The considerations on the size of GW-bodies include:

- not too many GW-bodies, they should be possible to be administrated
- not be too large GW-bodies, the status should be possible to be described.

Groundwater dependent ecosystems

It is intended to use a simple approach to describe the exchange between surface water and groundwater.

PRB Pinios (Greece)

Geology

Impermeable geological structures cover 30.6 % of the total area, karstic aquifers cover 14.5 % and permeable structures which occur mainly on the plain cover 42.7 %.

The aquifers of the plain are dominated by sand intercalations separated by layers of clay to silty-clay and Neogene deposits consisting of marls and conglomerates and is bounded by schists and karstic limestones or marbles

Groundwater bodies / River basin districts

2 hydrogeological sub-basins. There is substantial flow between the sub-basins.

14 GW-bodies in both sub-basins.

Delineation methodology

The delineation is based on geological boundaries to flow, hydraulic boundaries and groundwater evolution mechanisms.

PRB Scheldt (Belgium, France, The Netherlands)

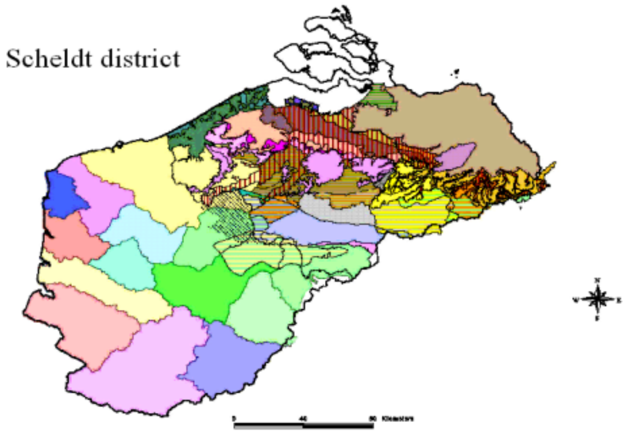
Geology

Schematically, the geological substrate of the Scheldt district can be divided into 4 distinct regions.

- To the north (Netherlands, Flanders), the lowest area composed of horizontal quaternary deposits together with the Rhenan lowland;
- In the central part (Flanders, Brussel), horizontal loose deposits originating from the successive Neogene (Tertiary) seas;
- In the central part, underlying tertiary deposits (Flanders, Netherlands, Brussel, Wallonia) as well as to the south, outcropping (France), slightly dipping chalky deposits from the Paris basin;
- At the south-eastern limit of the district (Wallonia, Flanders and France), folded carboniferous deposits from the extreme part of the Ardennes ("massif schisteux-rhénan"). Although their extension is proportionally weak, they contain one of the most important aquifers in the district, the carboniferous limestones aquifer.

Hydrogeology is of course impacted by these significant regional differences, ranging from thin superficial sandy aquifers to deep fissured, even karstic, aquifers. Aquifers may also show different status whether the same layers are confined or unconfined.

Groundwater bodies / River basin districts



Delineation methodology

A first concern in harmonization was the management of the different approaches applied by each partner for delineating GW-bodies within their region/country.

France had a pre-existing delineation based on a methodology developed at the national scale. Using an aquifer-based typology together with surface water divides, 16 GW-bodies (mainly chalk) were delineated. Where locally present, superficial aquifers were usually linked to the main aquifer below, so that only huge (max. 3 075 km²) GW-bodies were defined.

In Flanders (also in Brussels region), the delineation was fairly different, according to the different hydrogeology. A first division into 6 systems was made by considering, horizontally, main geographical entities, and, vertically, the existence of two regional aquitards (clays). Further, each system was divided into a large number of GW-bodies by considering more local aquitards as well as known impacts of water abstraction, groundwater divides, the limit between saline and fresh water etc.. A distinction was also made between the phreatic and non-phreatic part of an aquifer, leading to the formation of two separate GW-bodies. The result is a large number of superposed and intricated bodies.

In Wallonia, an intermediate situation was adopted. Where relevant, superposed aquifers were treated independently. Where significant communications are recognized or where abstraction may not be significant in the superficial aquifers, these latter may be considered together with the main deeper aquifer. Along the borders between France and Wallonia, for instance, there are 3 superposed GW-bodies corresponding to 3 distinct aquifers: a deeper carboniferous limestone aquifer, an intermediate chalk aquifer and a phreatric eocene sand aquifer.

Harmonisation The partners came to several agreements along the border to take into account the continuity of GW-bodies. Several new bodies or new inner limits were defined in order to achieve a consistent map.

Some other difficulties are still remaining, relating to how taking into account GW-bodies which are partly laterally feeding another body (e.g. the unconfined chalk aquifer along the border between the Scheldt and the Meuse districts) or how to represent superposed bodies on the map.

Setting the criteria for delineating GW-bodies was obviously the opportunity to collect characteristic data for each GW-body. These data were collected in a common district table. Examples of data are the position of the body within the tectonic/stratigraphic context of the region, the type of flow and porosity, the lithologies or the aquifer setting (confined, unconfined).

Initial Characterisation

Prerequisites for a consistent initial characterisation of GW-bodies in the Scheldt district have been achieved, despite the high heterogeneity of existing approaches among the partners.

As for delineation, a review of existing methods among the different Scaldit partners was done. Vulnerability assessment was conceptually replaced in the more general context of the impact assessment. Then a vulnerability assessment method was proposed using several factors corresponding to the attenuation of the pressures through the different sub-reservoirs of the recharge zone. These factors relate to the characteristics of the amount of recharge, the attenuation through soils, through sub-soils and finally in the saturated zone. The degree of heterogeneity of each process is also taken into account. This method has not yet been calibrated or validated, and will be probably adjusted through the practical evaluation of GW-bodies that is going to be done by the experts.

PRB Guadiana (Portugal)

Groundwater bodies / River basin districts

In total 9 GW-bodies were identified in the Pilot River Basin Guadiana with a total area of about 12 000 km²

Aquifer type	GWB	min. area (km²)	max. area (km²)
karstic	3	113.2	202.1
fractured*	3	347.4	6,312.35
porpous	3	9.6	176.1
Total	**9**	**9.6**	**6,312.35**

2 GW-bodies might be transboundary. A study between Portugal and Spain is going to clarify.

Delineation methodology See chapter Portugal

Initial Characterisation

Within a first assessment of all 9 identified GW-bodies diffuse pollution, point source pollution and abstractions have been identified as potential pressures.

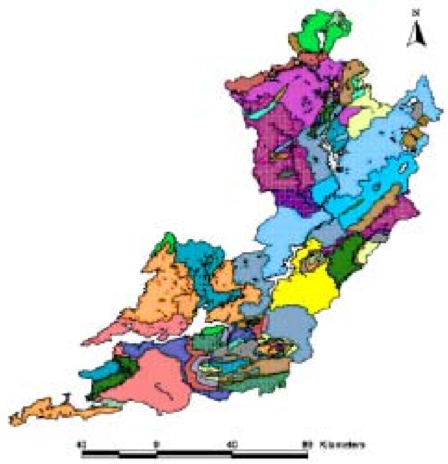
Detailed pressure evaluation will be performed according to the Guidance document No 3[38], taking into account that there is a need of updating the base information.

Groundwater dependent ecosystems

Within this river basin there are no wetlands associated to GW-bodies

[38] Guidance document No 3. Analysis of Pressures and Impacts. ISBN 92-894-5123-8

PRB Shannon (Ireland)



Geology

- Carboniferous rocks dominate
- Pure bedded limestones in upper catchment
- Namurian shales & sandstones in lower reaches

Groundwater bodies / River basin districts

About 97 GW-bodies with:

- Median size = 53 km²,
- Max size = 1 400 km²,
- Min size = 5 km²

Delineation methodology

Step1:

- Produce a seamless geological map at 1:100 000 scale. Combine 1 100+ rock units into some 28 Rock Unit Groups anticipated to have similar hydrogeological properties.

Step2:

Rock Unit Groups are assigned one or more of 8 aquifer classes:

- Regionally Important Aquifers:
  Karstic aquifers with predominantly conduit flow (Rkc); Karstic aquifers with predominantly diffuse flow (Rkd); Fissured aquifer (Rf)
- Locally Important Aquifers:
  Bedrock: generally moderately productive (Lm); Bedrock: moderately productive only in local zones (Ll)
- Poor Aquifers:
  Bedrock: generally unproductive except for local zones (PI); Bedrock: generally unproductive (Pu)

Sand & Gravel Aquifers (Rg Lg)

Step 3:

The Aquifers Classes are grouped into 4 types based on similar groundwater flow regimes:

- Karstic aquifers
- Gravel aquifers
- Productive fractured bedrock aquifers
- Poorly productive bedrock aquifers

Step 4 :

Preliminary GW-bodies are delineated using the following hierarchy

- No flow, or relatively low flow, geological boundaries
- Boundaries based on groundwater highs
- Boundaries based on differing flow
- Boundaries based on flow lines

Step 5 :

Final GW-bodies are delineated incorporating surface water catchment boundaries

Exceptions where the influence of topography on groundwater flow is diminished:

- Karstic aquifers
- Confined aquifers

Further assessment will be required once surface water bodies are completed

For **small GW-bodies** there are two responses:

- Incorporate a small area of one aquifer into a larger one if the flow system and continuity is not disrupted
- Remain a small hydrogeologically significant GW-body if:
  - There is ecosystem dependency
  - Provides groundwater supply
- There is a significant impact on the flow system

Initial Characterisation

The Geological Survey Ireland provides detailed hydrogeological information for each GW-body:

- Hydrometric area, catchment and associated surface water bodies
- Groundwater dependent terrestrial ecosystems
- Topography
- Geology & Aquifers (incl. main lithologies, structures, properties, thickness)
- Overlying strata (incl. thickness, vulnerability)
- Recharge
- Discharge (spring systems, abstractions)
- Groundwater flow paths
- Groundwater and surface water interactions
- Conceptual Model summarising main information
- Identification of all monitoring sites (quality, levels, river gauges)

Protected areas

Article 6 Register of Protected areas

Approx. 500 GW abstractions

43 source protection areas

PRB Tevere (Italy)

Geology

The Tevere River Basin is composed of four main geomorphological sectors:

- the Karst Apennine Mountains located in the eastern and southern sector, composed of carbonate rocks;
- the Tevere's graben and its marine and continental facies deposits, the intermountainous depressions;
- the volcanic structures of the Vulsini, Cimini, Sabatini, and Albani Mountains located in the south-western sector;
- the upper part of the Tevere River Basin, occupied mainly by terrigenous Flysch facies deposits from Tuscany (on the right bank, north of the Trasimeno lake) and the Umbrian and Marches Regions (left bank).

Groundwater bodies / River basin districts

Karst aquifer: 14 hydrogeological structures

Volcanic aquifers: 3 volcanic structures and 15 aquifers

Alluvial aquifers: 9 alluvial structures

Case study - Hesse (Germany)

Groundwater bodies / River basin districts

127 GW-bodies with an average area of 173 km² have been delineated by intersecting River catchment areas of 1 500–5 000 km² (groups of GW-bodies) with hydrogeological sub-zones.

The delimitation of GW-bodies at the Hessian borderline has been coordinated with the neighbouring states.

Delineation methodology

Entire Germany has been divided into large hydrogeological regions and sub-regions by the geological surveys and the BGR in close cooperation. The sub-regions are determined by the common and most important hydraulic and geochemical characteristics of the geological strata. 25 hydrogeological sub-regions are covering Hesse.

Initial Characterisation

A map, reports and tables have been elaborated, describing the characteristics of the hydrogeological units in each sub-region (e.g. rock type, consolidation, hydraulic conductivity, geochemical type of rocks, type of porosity and intensity of groundwater abstraction). The map is part of a project for establishing a hydrogeological map of Germany in scale 1:200 000 to meet the needs of the WFD. The map is based on a vulnerability map of Hesse, 1:300 000. The 5 vulnerability classes of aquifers had been derived from the geological strata presented in the Geological Map of Hesse, 1:300 000. The protection property resulted from a division into 3 classes according to the LAWA working aid recommendations. In this map, only the properties of lithological units have been estimated empirically, the soil properties and the depths to water table have not been taken into consideration. Therefore, this map is to be understood as a general survey only.

Point source pollution The Hessian register of contaminated sites and former waste disposal sites (ALTIS) has been evaluated. The risk assessment concentrated on the sites where a need for remediation was found. As a result, 457 contaminated sites and 222 former waste disposal sites were selected. To refer to an area of impact of these contaminations on the groundwater, a circle of 1 km² around each site was related to the area of the GW-body.

Groundwater dependent ecosystems

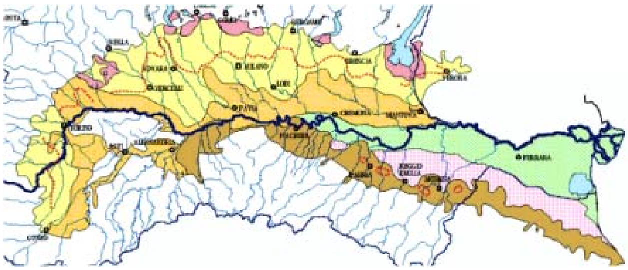
Several different layers have been considered, e.g. nature protection areas, FFH-areas groundwater dependent biotopes, groundwater influenced soils etc.. The assessment showed that there is no GW-body without groundwater dependent biotopes. This means that further characterisation is needed to be carried out for each GW-body in Hesse.

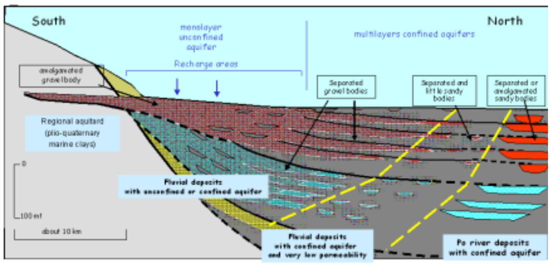
For the further characterisation, only groundwater dependent biotopes in nature- and FFH-protection areas and in areas of influence of artificial GW-abstraction, combined with depths to water table less than 10 m, will be examined.

Case study - Po (Italy)

Geology

The hydrogeological units comprise fluvial–glacial and fluvial deposits, with differing permeability and hydraulic conditions. A geological scheme of the south margin of the basin shows in more detail the relation between the different units with the depth. In this case the aquifer thickness is about 300 meters.





Initial Characterisation

Very intense human pressures (settlements, agriculture, industry)

Characterisation of hydrogeology via quantity and quality monitoring network,

Case study - Umbria (Italy)

Groundwater bodies / River basin districts

7 calcareous aquifers (16–1 076 km²), 1 volcanic aquifer (500 km²)

Delineation methodology

ARPA Umbria (Environment Protection Agency of Umbria Region) started new activities:

- The integration of the drinking water abstraction points to the monitoring network;

The definition of water bodies inside the aquifers by hydrogeological, geochemical, qualitative and pressure analysis;

Initial Characterisation

PRISMAS Project (1996–2000) to reorganise, develop and optimise the knowledge on regional hydrogeology. The aquifer characterisation was based on the analysis of hydrogeological and environmental elements:Hydrogeological data: geology, stratigraphy and structural information, hydrodynamic parameters, water table conditions and flow paths, relations with superficial bodies, chemical behaviour and pollutants.

Environmental data: quantitative pressures (water abstraction) and qualitative pressures (sewers, industrial areas, dumps, diffuse pollution, agriculture).

Annex 2:
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