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N°6 - January 2013

Groundwater monitoring over the decades

The launch and evolution of groundwater monitoring in France are intimately linked to the regulatory context. The first major water law was voted in 1964[1], paving the way for comprehensive and decentralised water management organised along the lines of the major river basins. The law also triggered the establishment of the first monitoring networks for groundwater levels and quality, networks that subsequently were modified in step with the changing regulations. This document presents the considerable work put into groundwater monitoring over several decades.

1964, the first Water Law and the launch of monitoring networks

Certain basic elements in water policy (e.g. power generation) date back to the 1500s, but the first step in the modern legal context was the 1964 law dealing with water regimes and distribution, as well as efforts to fight its pollution. The law reinforced the protection of water resources and consequently that of consumers. It instituted a number of essential principles:

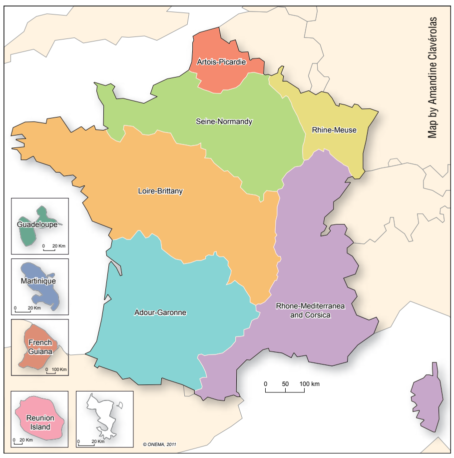
> Decentralised management along the lines of the major river basins;

> Collaboration between the various stakeholders;

> Economic incentives;

> Creation, in each major river basin, of an advisory group, the Basin Committee, and of an executive entity, the Water agency, in order to organise collaboration and the sharing of responsibilities.

It also stipulated the creation of organised networks for monitoring both groundwater levels and quality.



[1] Law 61-1245 (16 December 1964).

Monitoring - Piezometry - Quality - Groundwater

eaufrance
Public water information system

The descriptive data of the monitoring networks hereafter are drawn exclusively from the ADES databank, which serves as the repository for data on groundwater levels and chemical quality. The data are collected by the Health, Ecology and Risk-Management ministries, the Water agencies and offices, local authorities, water boards, industrial companies and BRGM (French geological survey). The number of measuring stations indicated may not be entirely accurate because some were never declared in the database and their data not recorded. The data presented here thus provide an image of the monitoring stations and networks effectively declared by the station managers over the years.

The first known measurements of groundwater levels in France were carried out in wells drilled in the Albian aquifer near Paris in 1840. Since the early 1900s, regular measurements have been carried out on several wells around the country, but in the 1970s, true monitoring of groundwater became necessary for the new management systems stipulated by the 1964 Water Law. The law marked a shift in outlook from rules on resource uses (distribution of drinking water, industrial use, irrigation, etc.) to monitoring of its overall status. During the 1970s, the Ministry of Industry assigned BRGM with the task of monitoring groundwater levels throughout continental France. A number of networks were created to monitor groundwater levels over different scales, but particularly on the local scale, e.g. monitoring of specific groundwater bodies.

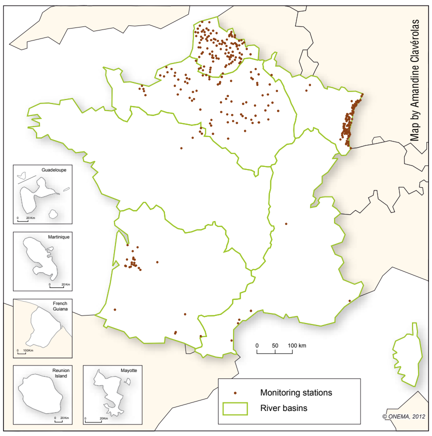
In the early 1970s, few observation wells for monitoring groundwater levels, called **piezometers**[2], existed in France. The 336 piezometers were located primarily in the Paris and Aquitaine basins, filled with sedimentary rocks and alluvial deposits. This is because these very large aquifers were pumped well before the «basement» aquifers, located primarily in the Loire-Brittany and Rhone-Mediterranean and Corsica basins, in which access to water resources is less direct. In the overseas territories, no organised monitoring networks had yet been set up, though the first measurements in Guadeloupe and Martinique date back to 1971.

Monitoring stations for measuring the quality of groundwater, using **qualitometers**[2], came later. The first such networks were set up at the end of the 1970s at the request of the Water agencies and regional councils, notably to track the increasing pollution of groundwater by nitrates (resulting largely from intensive farming) observed in certain parts of the country, e.g. Alsace, Paris region, Nord-Pas-de-Calais region, etc. In 1970, only about 60 qualitometers were in operation, essentially in the Rhine-Meuse basin and a few on Reunion Island. Over the 1970s and the early 1980s, approximately 20 so-called «Heritage» knowledge networks were also set up in areas of various sizes (river basins, departments, and smaller). Their purpose was two-fold: To collect basic data on groundwater quality and its evolution over time, and to serve as a management tool for projects aiming at protecting or restoring the quality of water resources.

At that time, 48 parameters were monitored. Most were physico-chemical parameters (temperature, acidity (pH), potassium, nitrates, chlorides, calcium, etc.). Other parameter groups are relatively little represented, essentially because they were not monitored at that time.

Piezometer distribution in 1970

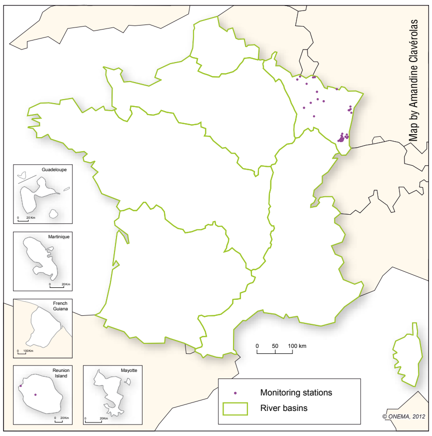
Source: ADES (BRGM) - WIS-FR partners, March 2012



N.B. The map shows all piezometers that produced at least one measurement in 1970

Qualitometer distribution in 1970

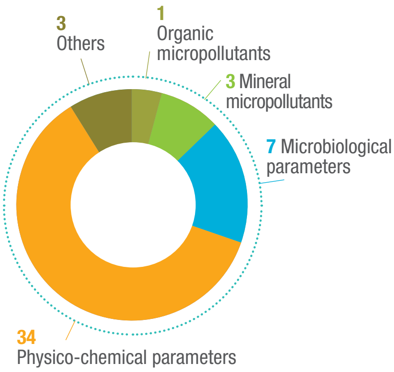
Source: ADES (BRGM) - WIS-FR partners, March 2012



N.B. The map shows all qualitometers that produced at least one measurement in 1970 (not including health monitoring and sites subject to special environmental monitoring for industrial use)

Number of parameters monitored in each major chemical group in 1970

Source: ADES (BRGM) - WIS-FR partners, March 2012



[2] In this document, monitoring stations are called piezometers (groundwater level) or qualitometers (groundwater chemical quality), regardless of the network to which they belong.

The main types of aquifer in France are presented below.

> Primarily sedimentary. The Paris and Aquitaine basins, Alsace, and the Saone-Rhone corridor consist of a stack of more-or-less permeable layers.

> Alluvial. Sand and gravel along the valley bottoms form a vast network of more-or-less continuous aquifer corridors along and in close contact with the rivers.

> Volcanic edifice. Volcanic-edifice aquifers are complex and, due to hydrogeological properties that are locally very good, constitute resources of regional importance (Massif Central, Reunion Island, Mayotte, Caribbean islands, Polynesia).

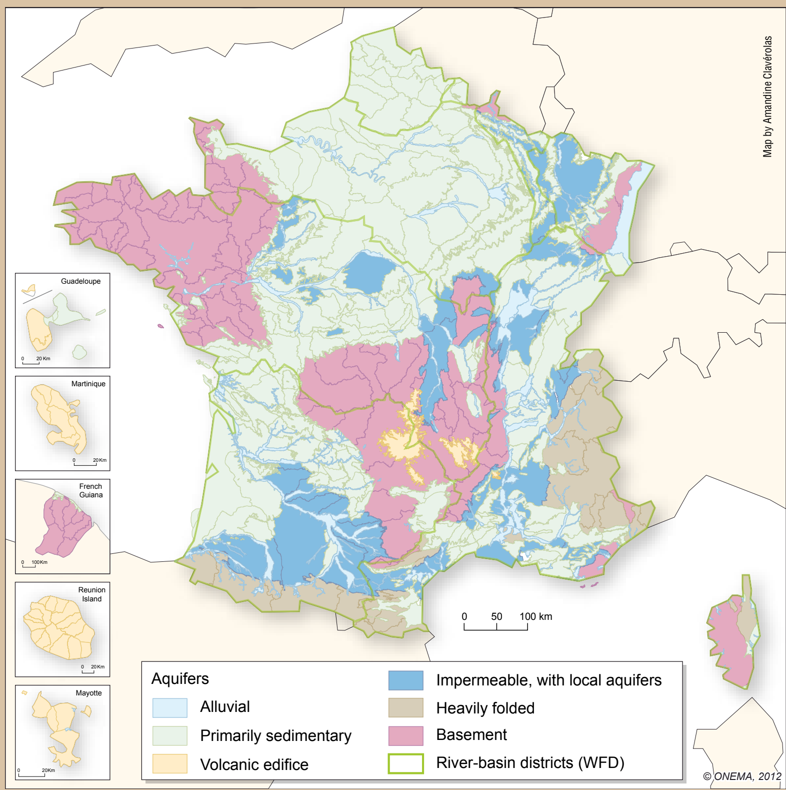
> Basement. Hardrock basement formations are remains of old mountain ranges, e.g. the Armorican massif, the Massif Central, Vosges and Ardennes regions. Hardrock is also found in the Pyrenees, the Alps and on Corsica. These environments are characterised by high densities of cracks and fractures, allowing water to flow.

> Heavily folded. These systems, located in heavily folded mountain regions, consist of alternating aquifers and impermeable layers of highly variable size. They are characterised by sudden variations in the thickness of layers caused by the tectonic activity specific to such mountain regions.

> Impermeable, with local aquifers. These systems consist of sedimentary formations comprising few or no large aquifers, but a number of small, disconnected and dispersed aquifers.

The different types of aquifers

Source: BRGM, SANDRE



1992, a jump in the number of monitoring stations following the second Water Law

At the end of the 1980s, the growing number of inhabitants in France, their migration to the cities and industrial development made necessary a new legal and regulatory system: the second Water Law voted in January 1992[3]. This law laid the foundation for true, integrated water management:

> Declaration of water as a vital resource, elevated to the status of «national heritage»;

> Balanced management of all water uses (agriculture, industry, household, drinking water);

> Comprehensive management of all types of water (subsurface, surface, marine and coastal);

> Preservation of aquatic ecosystems and wetlands;

> Recognition of water as an economic resource;

> Priority accorded to the provision of drinking water.

Management of water resources and the goals set for water quality and quantities were subsequently organised and planned in the framework of action and development programmes. The law effectively created two new planning tools, namely the river-basin management plans (RBMP) for each of the major French river basins and sub-basin management plans (SBMP) for smaller basins.

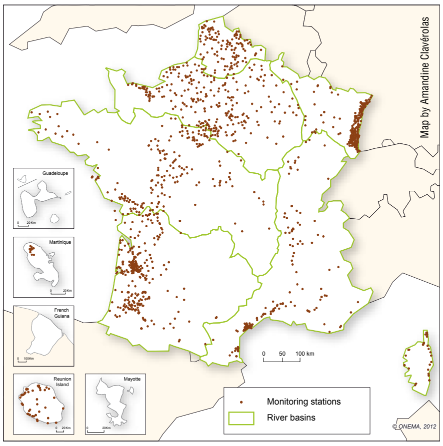
To attain the goals set by the law and, in particular, adapt the monitoring networks, funding provided to local authorities and the Water agencies increased during the 1990s. As a result, a series of networks was established and managed by local authorities and the number of monitoring stations increased by a factor of four or five compared to the situation in 1970.

[3] Law 92-3 (3 January 1992).

The number of piezometers was four times higher in 1993 (1,432 units) than in 1970 (336). Numbers in the sedimentary basins increased significantly and the «basement» aquifers (Loire-Brittany, Rhone-Mediterranean-Corsica basins) received their first units. Some zones, however, still had no piezometers whatsoever, notably northern Brittany, the western Loire region, most of the Lower-Normandy region and large parts of the Massif Central. Overseas, Reunion Island was the only department equipped and its network increased in density.

Piezometer distribution in 1993

Source: ADES (BRGM) - WIS-FR partners, March 2012

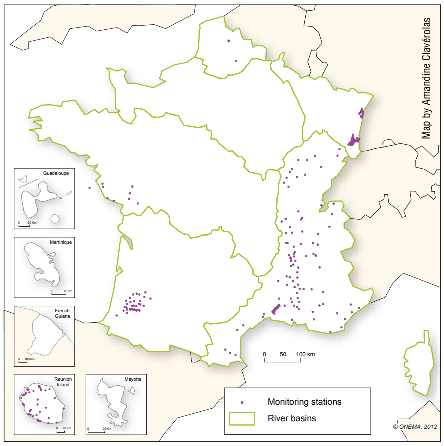


N.B. The map shows all piezometers that produced at least one measurement in 1993

The monitoring network for groundwater quality developed in step with that for groundwater levels. By 1993, 368 qualitometers (five times more than in 1970) had been installed in a limited number of regions. The Rhone-Mediterranean basin, with an increase of approximately 100 between 1973 and 1990, represented about one third of all the new units. Other river basins had not yet begun quality monitoring or had not started sending their monitoring data to the ADES databank. Generally speaking, qualitometers were installed near large cities, in highly urbanised areas, or in industrial regions, e.g. along the Rhone River. Overseas, only Reunion Island had any qualitometers.

Qualitometer distribution in 1993

Source: ADES (BRGM) - WIS-FR partners, March 2012

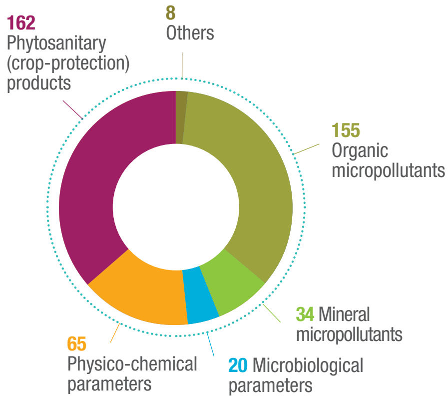


N.B. The map shows all qualitometers that produced at least one measurement in 1993 (not including health monitoring and sites subject to special environmental monitoring for industrial use)

By 1993, the qualitometers monitored 450 parameters, i.e. nine times more than in 1970. The number of physico-chemical parameters doubled over the 20-year period, yet they no longer represented the largest group of parameters. That role was taken over by crop-protection products (also called phytopharmaceutical products including DDT, Lindane, Dieldrin and Aldrin), followed by organic micropollutants (notably PCBs, polychlorinated biphenyls). These two groups, which were absent or virtually absent in 1970, represented 70% of the parameters monitored in 1993. The monitoring networks were effectively obliged to respond to new problems, such as pollution caused by industrial and agricultural development.

Number of parameters monitored in each major chemical group in 1993

Source: ADES (BRGM) - WIS-FR partners, March 2012



In parallel with the new goals, the amounts of data on groundwater produced by the various stakeholders progressively increased and the Ministry of Ecology decided in 1992 to create a network of water-data producers, the national water-data network (RNDE). The main goal was to coordinate data producers and how data are collected, stored and disseminated. The main producers and users of public water data (Ministry of Ecology, Water agencies, BRGM, High Council on Fisheries which became ONEMA, EDF, Ifremer, French Environmental Institute, Météo France, International Office for Water, etc.) signed an agreement setting goals for RNDE and defining its structure and organisation. In addition, data exchanges between participants imply certain rules defining both data content and format. SANDRE, the national water-data management centre, was created in 1993 to set up the necessary rules. Its mission is to encourage standardisation of data and to promote a common language for automated data exchanges between the various data producers.

1999 : the first two national networks for groundwater monitoring

Most river basins installed true monitoring systems for both groundwater levels and quality in the middle of the 1990s (1995 for Seine-Normandy, 1997 for Adour-Garonne, etc.). But seven years after the 1992 Water law and three years after the creation of the first RBMPs in 1996, the need to restructure groundwater monitoring country-wide had become clear. In 1999, a common approach, in the form of a protocol, was established between the Water agencies under the auspices of the Ministry of Ecology. For quality monitoring, among other aspects, it set the minimum density of monitoring stations and sampling frequencies for each type of aquifer, with a list of required chemical parameters; and for water-level monitoring, it set a minimum density of stations for each groundwater body and each river basin. This approach ensured a minimum level of consistent coverage by the monitoring stations now making up a structured national network, the RNES (national network for groundwater monitoring). For each type of monitoring (water level and chemical quality), a national network was created comprising the stations in each river basin in continental France and overseas (with slight delays in the latter):

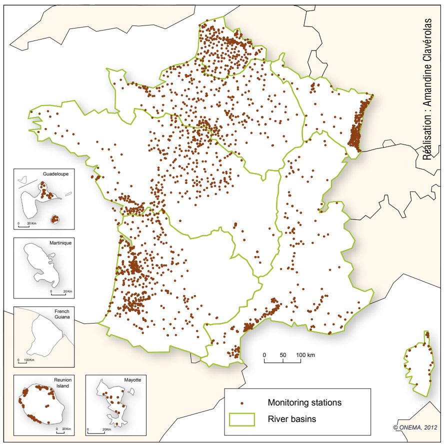
> RNES-P (piezometry) for monitoring of groundwater levels;

> RNES-Q (quality) for monitoring the chemical quality of groundwater.

The launch of RNES-P contributed to an increase in the number of piezometers (2,200 in 2001 compared to 1,432 in 1993), again primarily in the sedimentary basins. The number in the Rhine-Meuse basin remained fairly stable, whereas numbers increased sharply in the Loire-Brittany and Adour-Garonne basins. Similar to 1993, however, some zones still had no piezometers at all, notably northern Brittany, the western Loire region, most of the Lower-Normandy region and large parts of the Massif Central. Efforts to identify existing, representative monitoring stations not requiring the installation of new piezometers were still underway at that point. Overseas, French Guiana was the only department without any piezometers. In general, monitoring of groundwater levels took place later in the overseas territories because of a lack of technical personnel. Initial efforts were made to monitor the more easily accessible surface waters. However, the degradation of surface waters led to increased abstraction of groundwater, first from the sedimentary aquifers, then from the volcanic-edifice and basement aquifers.

Piezometer distribution in 2001

Source: ADES (BRGM) - WIS-FR partners, March 2012



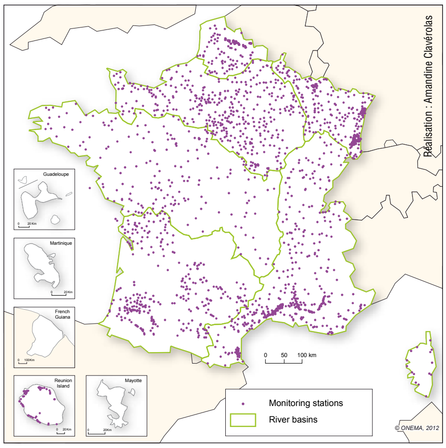
N.B. The map shows all piezometers that produced at least one measurement in 2001

The creation of RNES-Q also provoked a sharp increase in the number of qualitometers (2,149 in 2001 compared to 368 in 1993), but their distribution was more even. Very few areas were poorly equipped, primarily in the Adour-Garonne and the Loire-Brittany basins where not all the installed qualitometers were yet operational. These two basins encountered difficulties in locating qualitometers in the requisite (e.g. deep) aquifers and in zones outside depletion areas. The RNES protocol requires coverage of different water uses (particularly agriculture and industry, and not only drinking water), while ensuring the stability of the network. Some basins found it difficult to set up a balanced network in terms of the spatial density while covering all types of environment (agricultural, urban, industrial).

At that time, the basins with the most qualitometers were Rhine-Meuse and Rhone-Mediterranean-and Corsica (approximately 500 each). In the other river basins, the numbers varied between 220 and 350. Overseas, only Reunion Island had any qualitometers in operation (approximately 60). Although qualitometers had been set up in Mayotte, no measurements were carried out in 2001.

Qualitometer distribution in 2001

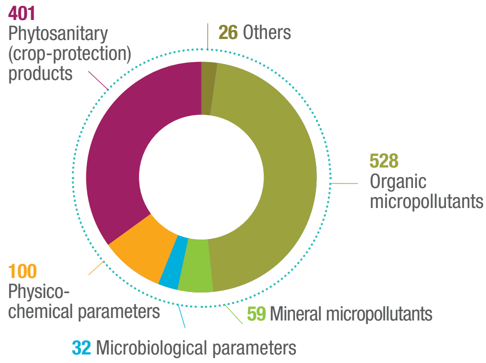
Source: ADES (BRGM) - WIS-FR partners, March 2012



N.B. The map shows all qualitometers that produced at least one measurement in 2001 (not including health monitoring and sites subject to special environmental monitoring for industrial use)

Number of parameters monitored in each major chemical group in 2001

Source: ADES (BRGM) - WIS-FR partners, March 2012



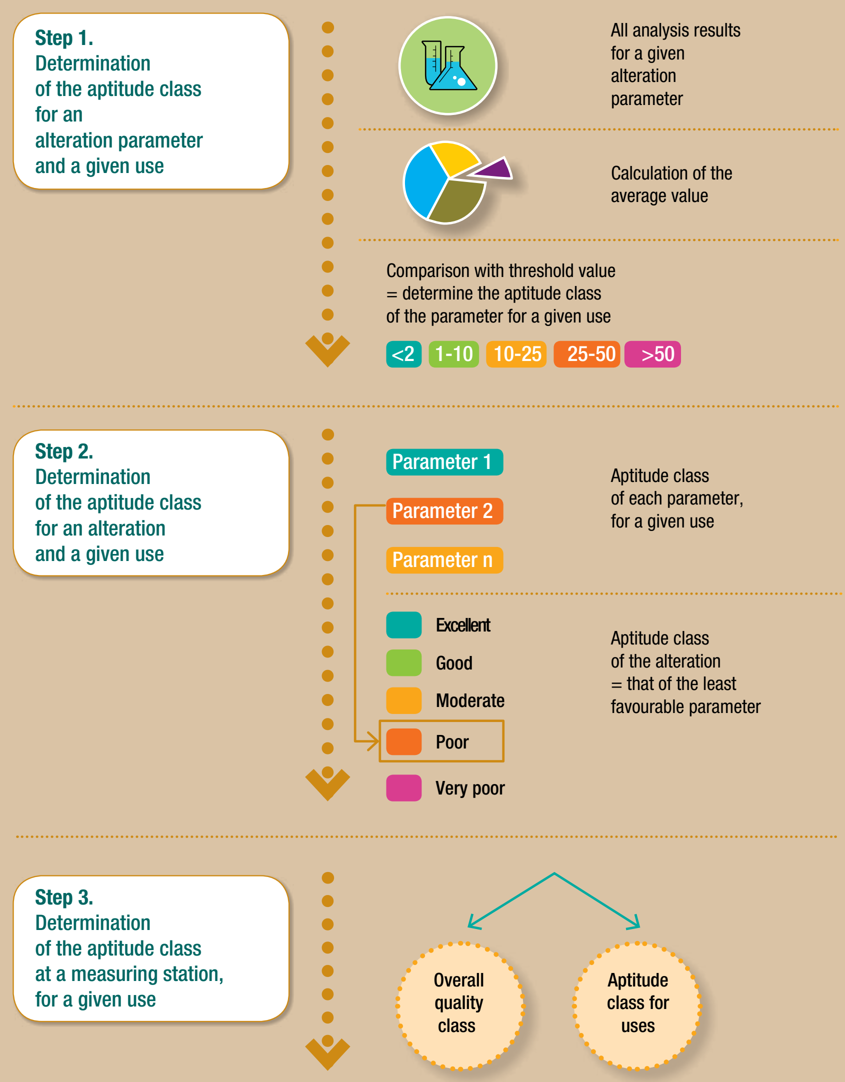
At the same time, the number of parameters monitored approached 1,150, i.e. 2.5 times more than in 1993. Scientific progress and new products made it possible to target organic micropollutants, which represented almost half of all the parameters monitored. Phytosanitary (crop-protection) products made up the second group with 401 different parameters monitored in 2001, compared to 162 in 1993. Increases in the other groups were less significant.

The purpose of the RNES knowledge network was to provide a comprehensive view of groundwater status. It therefore differed from the impact networks that monitor for instance specific types of pollution, and those monitoring water uses, such as the surveillance of untreated water intended for use as drinking water. RNES-P and RNES-Q collected the data required for a fundamental assessment of groundwater status levels and quality. The quantitative aspects of the assessment complied with the guidelines that were subsequently set by the Environmental Code[4]. For example, the quantitative status of groundwater is considered good when abstractions do not exceed the turnover capacity of the available resource, taking into account the quantities required for surface ecosystems and any directly dependent wetlands, in compliance with the principles of balanced management[5]. Status is thus determined by analysing abstraction rates compared to the interannual mean recharge. It provides information on the main groundwater trends based on the general trends in piezometric level and on fluctuations in groundwater recharge (annual and interannual variations). The quality assessment system for groundwater (QAS-Groundwater), developed in 2002-2003, implemented the same method and calculation process for assessing the quality status in all basins. It determined the aptitude of groundwater to satisfy various uses selected according to their relative importance, such as drinking water supply, industry (not including the agri-food sector), energy (e.g. heat pumps and air-conditioning), irrigation and livestock watering. It also provides information on the degree of physico-chemical changes in groundwater due to human pressure, i.e. an assessment of its «heritage status». These assessment criteria, based on national standards and methods, produced consistent assessment results on the quantity and quality of groundwater throughout the country.

[5] Article R. 212-12 in the Environment code.
[6] Text drawn from article L. 211-1 in the Environment Code.

QAS guidelines for assessing groundwater quality

To assess groundwater quality, QAS-Groundwater distinguished 17 alterations to quality, e.g. taste, odour, presence of microorganisms and organic micropollutants, mineralisation-salinity, etc., each type of alteration comprising a number of parameters of similar nature or producing similar effects. For each water use, impacting alterations were listed. Threshold values assigned to each parameter helped defining aptitude classes of the water to meet certain uses, i.e. excellent, good, moderate, poor and very poor aptitude. The classic colour code (blue, green, yellow, orange, red) was also used, except for drinking water, for which only four classes existed. In addition, quality indices were set up as well. For each quality-assessment parameter, the concentration level was transformed into a dimensionless unit ranging from 1 to 100. These results provided more precise information on each class. Water quality over a given period was determined for each alteration by the worst parameter for the alteration, i.e. that resulting in the lowest quality class.



At the end of the 1990s, RNDE and SANDRE intensified their efforts to meet the increasing need for data exchange among professional entities, but also for data accessibility to the general public. The Aarhus[6] Convention reinforced the obligation to facilitate access to environmental information in general and the data on groundwater levels and quality in particular. To meet the above requirements, the water-information system for France (WIS-FR) was created in 2003 to replace RNDE. This water-policy tool, for which ONEMA, the French National Agency for Water and Aquatic Environments, assumed technical management under the authority of the Ministry of Ecology, organises the production, storage, use and dissemination of the vast quantities of water data. The national framework for water data (SNDE)[7] stipulates the role and responsibilities of each data producer as well as the components making up WIS-FR. It also includes a multi-year action plan.

To meet growing needs in terms of data processing and dissemination on both the French and EU levels, in 2001 the Ministry of Ecology assigned BRGM the task of administering ADES, the national groundwater database. ADES centralises the groundwater-level and chemical-quality data collected from the Water agencies and overseas offices, the local services of the Health, Ecology and Risk-Management ministries, local authorities, water boards, industry and BRGM. Since its founding, ONEMA has co-managed ADES.

[6] Agreement signed 25 June 1998.
[7] Decree 2009-1543 (11 December 2009).

The Water Framework Directive of 2000: a turning point in groundwater monitoring

The RNES had just been launched when EU water legislation took a giant step forward in 2000. The European Water Framework Directive[8] (WFD) set a framework for EU water policy and completely restructured the abundant legislation comprising some 30 topical directives and regulations since the 1970s. The WFD set goals and a timetable, and stipulated common work methods for the 27 EU Member States. It stated that water is not a commercial product like any other but, rather, a heritage that must be protected, defended and treated as such. Among its main goals, the WFD set the following for groundwater:

> Restoration by 2015 of good water status, particularly for groundwater;

> Protection of water resources and implementation of strategies to improve their chemical quality, particularly by reversing trends toward an increasingly poor groundwater quality;

> A policy of long-term abstractions not exceeding the available groundwater resources and considering the links between terrestrial ecosystems and groundwater.

The directive confirmed the central role of the natural environment in water policy and the role of stakeholders in each river basin. Its innovative aspects concern essentially the environmental goals set with precise time limits and the programme for continuous improvement organised in six-year cycles, but also the inclusion of economic and territorial-development aspects at each step in WFD implementation as well as reinforced participation of the general public. For groundwater, the WFD established a new assessment unit: **groundwater bodies**. These are distinct and homogeneous volumes of groundwater in one or more aquifers (with a 10-level classification system of groundwater bodies depending on their depth), and stipulated that a good groundwater status depends on both good quantitative and good chemical (qualitative) factors.

Assessment criteria for good groundwater status and its precise goals are all contained in the WFD. A groundwater body is not in good condition unless the following goals are met:

> A long-term balance between the volumes flowing to other environments or other groundwater bodies, the abstracted volumes and recharge of each body;

> No significant alteration in the chemical and/or ecological conditions of surface waters caused by excessive abstraction;

> No significant degradation of terrestrial ecosystems dependent upon groundwater, caused by a drop in water levels;

> No saline or other intrusion of groundwater bodies caused by man-made modifications in flow, e.g. major pumping in coastal areas, reversing of groundwater-flow direction, etc.

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[8] Directive 2000/60/EC (23 Oct. 2000), transposed to France by Law 2004-338 (21 April 2004).

The assessment criteria for good groundwater status and its precise goals were specified by the Daughter Directive[9], the objective of which is to avoid and combat groundwater pollution and deterioration *via*:

> Criteria for evaluating the chemical status of water and classification of groundwater condition in two classes, either good or poor, and not four or five classes as proposed by QAS-Groundwater;

> Criteria for detecting significant and lasting increases in pollutant concentrations in groundwater as well as reversals in such trends;

> Goals in terms of preventing and limiting the indirect transfer (following percolation through soil or subsoil) of pollutants to groundwater;

> Considering the potential impact of groundwater on the ecological and/or chemical status of rivers in contact with the groundwater;

> Taking into account resource use, i.e. ensuring that the quality of groundwater does not compromise its use by humans for various needs, notably drinking water.

To meet these criteria and goals, the WFD imposes action plans and in particular:

> River Basin Management Plans (RBMP) setting the goals to be reached after six-years;

> Programmes of measures (action plans) defining the work required to meet the goals, e.g. reducing the pressure on aquatic environments, management or restoration of environments, etc.;

> Monitoring programmes to keep tabs on programme results (dash boards) and to redirect programmes if necessary.

Groundwater monitoring thus addresses both quantity and quality. The means to achieve WFD goals were provided for by the 2006 Law on Water and Aquatic Environments[10].

[9] Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration.
[10] Law 2006-1772 (30 December 2006).

Groundwater-status assessment in compliance with the WFD

Groundwater must achieve good quantitative and chemical status. Assessment of the chemical status takes place in several steps:

> Identify potentially dangerous substances and set threshold values for each water body;

> Determine the chemical status in the RCS surveillance-monitoring network and the CO operational-control network based on the threshold values set previously or the standards in the 2006/118/EC Daughter Directive;

> Determine the overall chemical status of groundwater bodies via an «appropriate investigation» (whenever a station signals a poor status) in view of transposing the results obtained from the monitoring stations to the entire groundwater body and checking that WFD environmental goals are reached.

Assessment of the quantitative status of groundwater bodies also takes place in several steps:

> Analysis of trends in water-level changes of groundwater bodies at risk;

> If the trend is downward, checks based on suitable tests (balance between abstractions and resource, links with surface waters, links with terrestrial ecosystems, salt-water intrusion, etc.) and expert opinion to determine the actual degradation of available water resources;

> Assessment of the quantitative status of groundwater bodies.

Step 1.
Determine
the status class
of a parameter at
a monitoring station

Step 2.
Determine
the chemical status class
at a monitoring station

Step 3.
Determine
the chemical status class
of a water body

Step 4.
Determine
the status class
of a water body

Groundwater monitoring over the decades

Quality monitoring

All analysis results for a parameter

Calculate the average of the annual average values over the duration of the management plan and/or the frequency of overruns

Comparison with threshold value or quality standards = determine the status class of the parameter

<5 | 5

Parameter 1

Parameter 2

Parameter n

Status class of each parameter

Chemical status = compliance with threshold values (status = poor if a single parameter exceeds threshold)

Good

Poor

Quantity monitoring

Analyse trends in groundwater levels and climatic conditions

Calculate the interannual cycles

Assessment of trends = additional tests

Up | Down

Step 1. Identify trends in the water-level variations of groundwater bodies

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If all monitoring stations of a water body indicate good status

Good

If a single monitoring station indicates poor status: appropriate investigation (tests and expert opinion)

Test 1

Test 2

Test n

Checks and expert opinion for each appropriate test

Chemical status = tests on pressures affecting water bodies (status = poor if results of a single test are poor)

Good

Poor

Quantitative status = tests on pressures affecting water bodies (status = poor if results of a single test are poor)

Good

Poor

Step 2. Determine the quantitative status class of a water body

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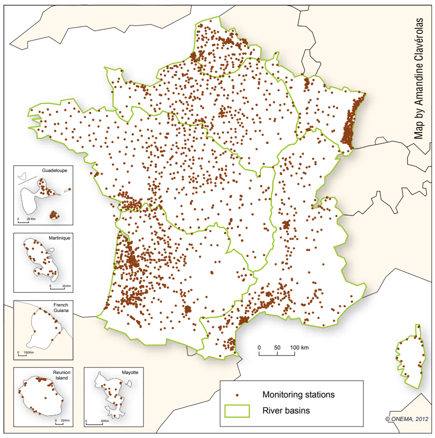
Chemical status		**Quantitative status**
Good	☺ and ☺	Good
Poor	☹ ☹	Poor

The programme for **monitoring the quantitative status** of groundwater for WFD compliance calls essentially on the RCS monitoring-control network, which was set up to provide a reliable assessment of the overall quantitative status of all groundwater bodies or groups of bodies, including an evaluation of resource availability. The RCS network became operational on 1 January 2007 in continental France (2008 and 2009 overseas) and replaced the RNES-P. Several entities monitor the quantitative status of groundwater, in particular BRGM, which acts as the overall national operator. ONEMA, the French National Agency for Water and Aquatic Environments, oversees the consistent implementation of the networks monitoring groundwater quantitative status.

Piezometer distribution in 2008

Source: ADES (BRGM) - WIS-FR partners, March 2012



N.B. The map shows all piezometers that produced at least one measurement in 2008

The 2,839 piezometers inventoried in 2008 were distributed evenly in France (continental and overseas), in terms of both their density per water body and accurate representation of river basins. Certain «basement» aquifers that had been poorly covered (northern Brittany, western Loire region, Lower-Normandy region and large parts of the Massif Central) were now better equipped. Guadeloupe, Martinique, French Guiana and Mayotte all received their first piezometers, though official monitoring started only in early 2009.

After 2008, the number of piezometers remained fairly stable. Most new piezometers entering the monitoring networks replaced other units that had to be abandoned (dry sites, damaged installations, difficult access, etc.). In 2010, there were 2,968 piezometers in the network monitoring quantitative status.

The programme for **monitoring chemical status** of groundwater for WFD compliance comprises:

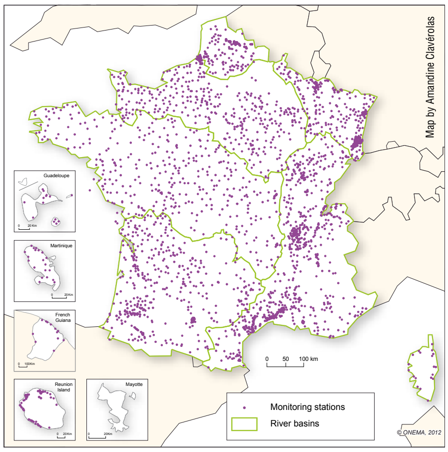
> The RCS monitoring-control network, which collects and validates the data describing the water body (including the identification of a potential risk that the water body may not be in good condition), and provides data for the assessment of long-term trends. The RCS network came on stream on 1 January 2007 in continental France (2008 and 2009 overseas), covering all water bodies and replacing the RNES-Q network;

> The CO operational-control network for water bodies at a clear risk of not reaching good status by 2015 (based on the report on water-body conditions). The network became operational on 1st January 2008.

The creation of the chemical-status monitoring programme for groundwater was a chance to analyse in depth the existing national networks for groundwater monitoring (RNES). The result was a reorganisation of the monitoring stations in well-equipped areas and an increase in numbers in poorly equipped areas, as well as identification of monitoring stations in areas that had none and of monitoring stations for purposes other than the supply of drinking water.

Qualitometer distribution in 2008

Source: ADES (BRGM) - WIS-FR partners, March 2012



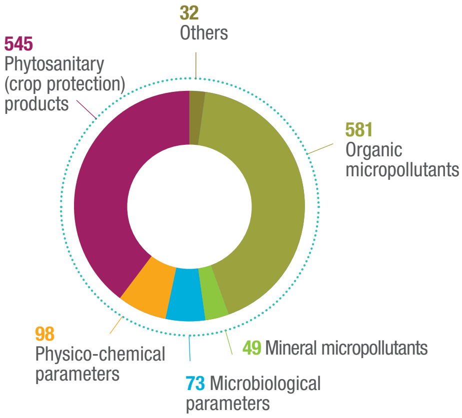
N.B. The map shows all qualitometers that produced at least one measurement in 2008 (RCS, CO and non-WFD networks, not including health monitoring and sites subject to special environmental monitoring for industrial use)

Between 2001 and 2008, the number of qualitometers increased by almost one third, from approximately 2,100 in 2001 to 3,000 in 2008. Their distribution was relatively even throughout the country. The areas identified in 2001 as being underequipped were, overall, better equipped in 2008. The Rhone-Mediterranean-and Corsica basin saw the greatest increase in qualitometers, from 500 to 800, and is currently the basin with the most units. In the other river basins, the increase in numbers varied between 65 and 150. All river basins pursued their efforts concerning the selection of monitoring-stations locations, taking into account measurement frequencies, an even spatial distribution and representative uses. By 2010-2011, the organisational goals had been met.

Approximately 200 additional parameters are now monitored, i.e. almost 1,400. Once again, new knowledge and methods made it possible to better measure certain parameters. Phytosanitary (crop-protection) products saw the greatest increase in numbers over the 7-year period, from 401 to 545. With organic micropollutants, they represented over 80% of the monitored parameters in 2008.

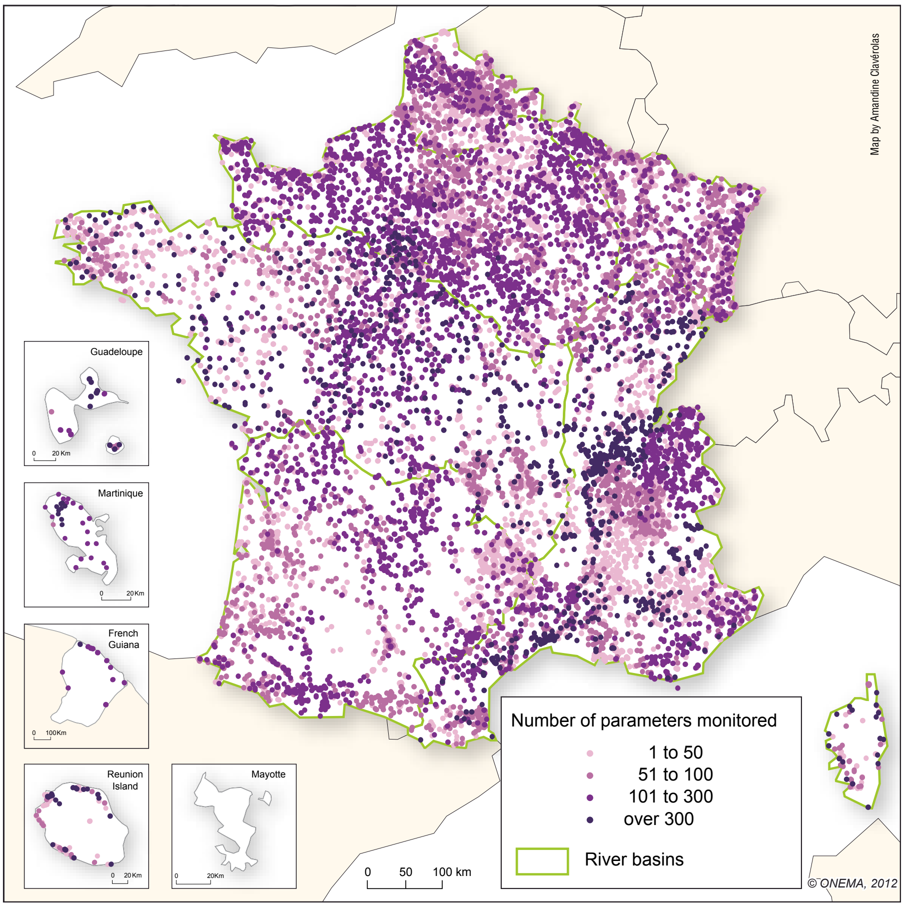
Number of parameters monitored in each major chemical group in 2008

Source: ADES (BRGM) - WIS-FR partners, March 2012



Distribution of parameters monitored in 2007

Source: ADES (BRGM) - WIS-FR partners, March 2012



N.B. The map shows all qualitometers that produced at least one measurement in 2007 (all networks)

Over 100 parameters can now be measured per monitoring station and per measurement campaign. In 2007, the Water agencies undertook the most complete analysis to date of the molecules found in groundwater, in order to obtain a comprehensive view of the situation (the WFD requires a complete analysis every six years), which explains the high number of parameters measured at many stations. In addition, the health regulations now also require monitoring of a larger number of parameters.

The WFD requires that assessment of groundwater status considers its links with continental surface waters (rivers, lakes, wetlands) and the many interactions between its uses and functions, thus laying the groundwork for integrated management of groundwater. It was in this context and to accompany implementation of the new assessment rules that, in 2009, the Ministry of Ecology and ONEMA launched the development of SEEE, the water-status assessment system, designed to ensure consistent assessments of groundwater conditions (chemical and quantitative status) throughout the country.

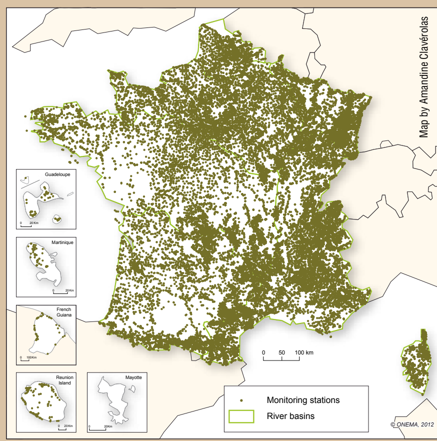
The other national monitoring networks

In addition to the groundwater-quality monitoring networks already mentioned, there are two other networks. These came gradually into existence and now comprise a large number of monitoring stations that may also belong to one or more other networks. The two networks are: 1) The national monitoring network for water intended as drinking water (the data are stored in SISE-Water, the Health-environment information system for water, under the responsibility of the Health ministry), and 2) The national monitoring network for water quality at or near ICSP sites (classified installations and potentially polluted sites), under the responsibility of the Ministry of Ecology.

Monitoring for health purposes was launched in the 1960s by the Ministry of Health, which set up and managed the regular collection of data on untreated, treated and distributed waters, for monitoring all waters intended for drinking-water use. These first steps toward the future national network provided information on the water abstracted from catchment works for human consumption. The network was supplied with data by the local services of the ministry throughout France. It evolved over time, growing in step with new abstractions of drinking water. In 2008, the network comprised approximately 40,000 qualitometers for public monitoring of untreated water, though some were no longer operational.

Distribution of qualitometers specifically for SISE-Water in 2008

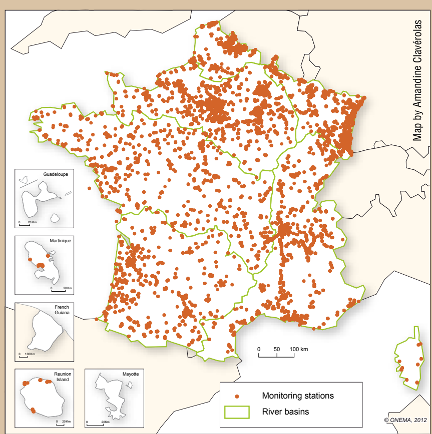
Source: ADES (BRGM) - WIS-FR partners, March 2012



N.B. The map shows all SISE-Water qualitometers as of 31 December 2008, whether or not they were in operation

Distribution of qualitometers specifically for ICSP in 2008

Source: ADES (BRGM) - WIS-FR partners, March 2012



N.B. The map shows all ICSP qualitometers as of 31 December 2008, whether or not they were in operation

In addition, the groundwater both upstream and downstream of over 4,000 installations subject to special environmental inspections[11] must be monitored. This legal obligation also applies to past and presently polluted sites and soil, monitored by the public authorities to ensure suitable management of pollution sources and sufficient control over any impacts. The national monitoring network for water quality at or near ICSP sites was launched in 1998, though industrial companies have been collecting analysis data since 1976. The network consists of regional networks established by the Industry and Ecology ministries as part of the national policy against industrial pollution, but also to comply with WFD requirements. On the regional level, each network is managed by the Service for Classified Installations for Environment. The data are supplied by the industrial companies, operators or entities in charge of each industrial site and potentially polluted site. The data acquired by this network pertain to industrial sites (location, identification, activity), monitored wells (location, characteristics, hydrogeological water body tapped) and groundwater quality (results of long-standing analyses, essentially those since 1998). In 2008, this network comprised over 25,000 qualitometers.

[11] In compliance with article 65 of the ministerial decree dated 2 February 1998 (modified) and other specific ministerial decrees.

Constant improvements in groundwater monitoring

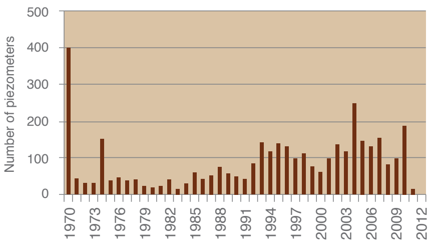
For over 40 years, the various stakeholders in the water sector have made increasing efforts to monitor the levels and chemical quality of groundwater.

With the exception of the increase in 1970, the number of new piezometers installed each year has varied from 50 to 200. The sharp increases in 1970 and 1974 corresponded to the setting up of the first piezometer networks, and the increases starting in 1993 correspond to the networks funded by the Water agencies in compliance with the 1992 Water law.

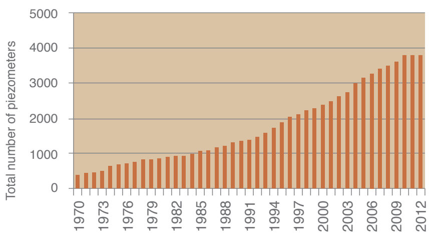
Numbers of piezometers between 1970 and 2012

Source: ADES (BRGM) - WIS-FR partners, March 2012

New piezometers



Total number



Starting in 2004, with the creation of the national network monitoring the quantitative status of groundwater for WFD compliance, new monitoring stations were created to reinforce the surveillance of groundwater bodies. In 2012 and for all networks combined, over 4,000 piezometers made at least one measurement during the year.

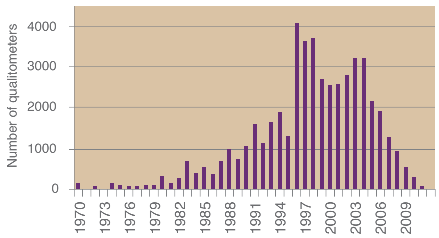
It should be noted that the new monitoring stations generally do not correspond to new wells, but to new sites selected specifically for monitoring and integration in the networks.

Qualitometers have increased in number much more than piezometers over the past 40 years. In the early 1990s, almost 1,500 new units were identified (and included in the ADES database) each year.

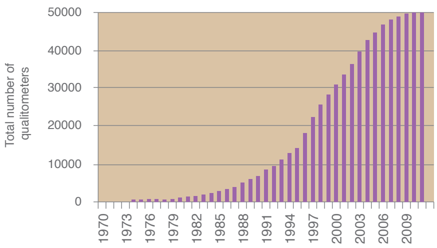
Numbers of qualitometers between 1970 and 2012

Source: ADES (BRGM) - WIS-FR partners, March 2012

New qualitometers



Total number



Subsequently, this growth in numbers continued, but for a number of different reasons:

> Creation of RNES, then of the WFD networks;

> Strengthening of inspections on untreated water intended as drinking water. Almost 25,000 drinking-water abstractions supply the ADES database with data that contribute to monitoring of groundwater quality;

> Integration of the data from classified installations subject to special environmental monitoring.

In 2012 and for all networks combined, almost 50,000 qualitometers made at least one measurement during the year.

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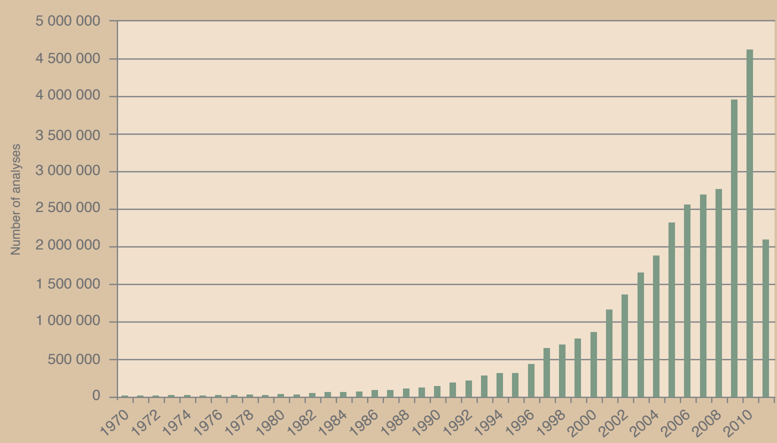
The increasingly ambitious monitoring goals led to an increase in the number of qualitometers, but also in the number of analyses carried out each year and in the number of parameters monitored. The number of analyses carried out each year exceeded 500,000 in 1997 and one million in 2001. The progression continued rapidly and reached over 4.5 million analyses in 2010.

The number of parameters also increased sharply over the years. The number of parameters monitored approached 400 in 1990 and exceeded 1,000 just ten years later. Since 2005, approximately 1,500 parameters have been monitored each year.

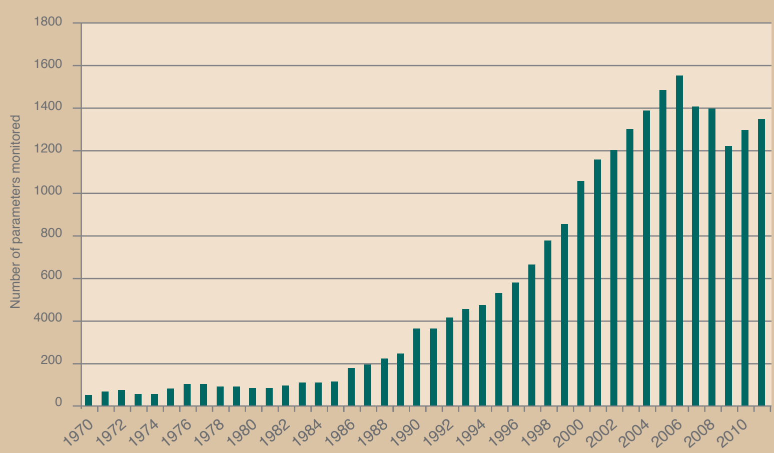
Number of analyses between 1970 and 2011

Source: ADES (BRGM) - WIS-FR partners, March 2012



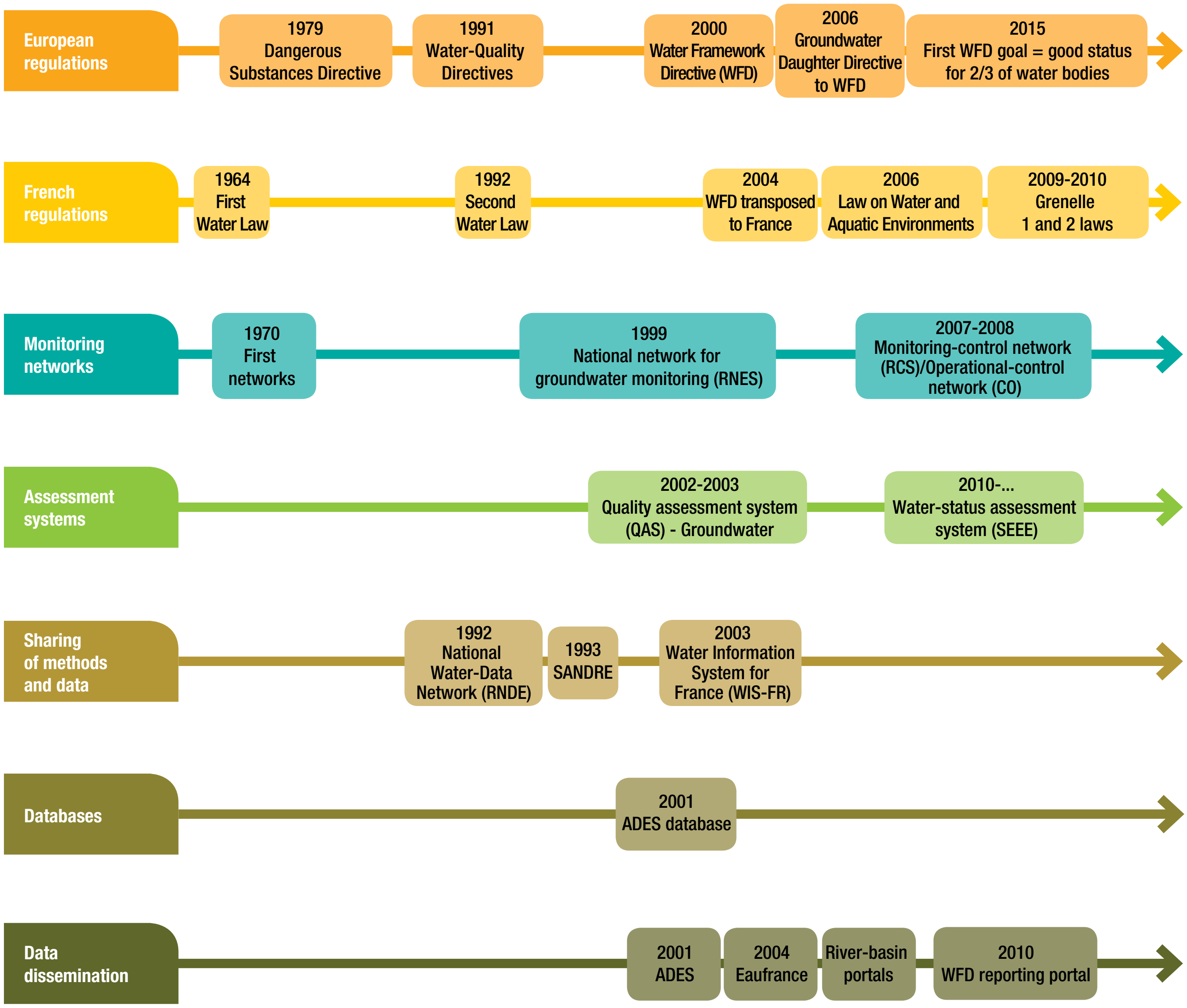
Number of parameters monitored between 1970 and 2011

Source: ADES (BRGM) - WIS-FR partners, March 2012



The 1964 Water Law resulted in the establishment of the first monitoring networks on groundwater levels and quality. Subsequently, the changes in EU and French regulations (1992 Water Law, WFD in 2000, French Water Law and Daughter Directive in 2006) provoked profound changes in groundwater monitoring and assessment strategies, in terms of both groundwater levels and quality.

Groundwater monitoring over the decades



Beyond monitoring, the work since WFD launch has addressed several difficulties. These include those involved in identifying for each water body a set of representative, long-term monitoring stations that are correctly distributed spatially; in signing agreements with land owners, in analysing groundwater bodies (hydrodynamic characteristics, flow direction, origin of the water, estimated volumes, exchanges between aquifers, groundwater-river links, etc.); in assessing their quantitative and chemical status; and in monitoring the effectiveness of the programmes of measures. All this work must be taken into account in future efforts to rationalise monitoring networks and improve their representativeness over space and time. Considerable new knowledge has been gained thanks to the WFD, notably concerning the hydrodynamic and hydrogeochemical functioning of certain aquifers and the fate of diffuse pollution in groundwater, and it must be put to good use in future monitoring and assessment work.

January 2013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Note on methods

The information presented briefly here is drawn from a study that may be consulted on the Eaufrance web portal. The study was based on methods shared by ONEMA (funding entity), BRGM (who carried out the study) and IOWater (who carried out a similar study on rivers). All numerical data in this document were drawn on 15 March 2012 from the ADES databank, which centralises the groundwater-level and chemical-quality data (see www.ades.eaufrance.fr). The data were collected by the Health, Ecology and Risk-Management ministries, the Water agencies and offices, local authorities, water boards, industrial companies and BRGM. The maps of monitoring stations (piezometers and qualitometers) for a given year show only those stations where at least one measurement was carried out during the year. The graphs, however, include all monitoring stations, whether or not a measurement was carried out during the year. Concerning the older data on the monitoring networks, the number of monitoring stations indicated may not be entirely accurate because some were never declared in the database and their data not recorded. The data presented here are therefore representative of the monitoring stations and networks effectively declared by the managing entities over the years.

For more information…

See groundwater data at
www.ades.eaufrance.fr

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the Briefs

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