INTEGRATION OF ENVIRONMENTAL MONITORING NETWORKS

DRAFT REPORT FOR WMO RA VI

Árni Snorrason, Orkustofnun, Hydrological Service, Iceland, asn@os.is
Markku Puupponen, Finnish Environment Institute, markku.puupponen@vyh.fi

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1. INTRODUCTION

Environmental issues and concerns play an ever-increasing role in our society. This is a path that is laid out by the countries that have, under considerable pressure on the environment, developed an institutional framework that expresses our concerns for the environment and a way of finding solutions that are both acceptable from a technological and ethical standpoint. This is a path that all communities and the world as a whole must follow if the natural resources are to be used in a sustainable manner. This is the concern in the case of fresh water in the five principles contained in the "Bonn Keys", defined at the International Conference on Freshwater in 2001:

1. *The first key is to meet the water security needs of the poor.*

2. *Decentralisation is key. The local level is where national policy meets community needs.*

3. *The key to better water outreach is new partnerships.*

4. *The key to long-term harmony with nature and neighbour is cooperative arrangements at the water basin level, including across waters that touch many shores.*

5. *The essential key is stronger, better performing governance arrangements.*

The key to successful decisions on environmental issues and sustainable development is also a comprehensive knowledge of the natural processes and systems that are under stress or development. The impact of our actions on the environment can only be assessed based on such knowledge, which must again be rooted in the monitoring of the natural processes involved, as well as on systematic scientific inquiry into their nature. This is nowhere more apparent than in the case of Global Climatic Change. In the recent report on the state of the Global Climate, the Intergovernmental Panel on Climatic Change stated (IPCC 2001):

> *"There is new and stronger evidence that most of the warming over the last 50 years is attributable to human activities."*

And:

> *"Human influence will continue to change atmospheric composition throughout the 21st century"*

This prospected change will have global effect on the hydrological cycle as well as on the whole ecological system of the Earth and calls for international co-operation and integration of environmental monitoring strategies to address the impacts and mitigation at both the regional and the global level. Presently there is a gap between the information decision makers need for their decision at all levels of policy and implementation and the current observational networks and information systems. This gap must be closed by all means available and the most important path to success is through systematic application of integrated approaches to environmental information management.

2. TERMS OF REFERENCE

The terms of reference for the rapporteurs are:

- To investigate possible interrelations between hydrological and other environmental monitoring networks.

- To propose procedures to strengthen the co-operation between network operating institutions.

The terms of reference reflect an increased awareness that hydrological monitoring needs to take into consideration the growing complexity of the environmental issues that face present times as well as the need for stronger co-operation at the national and the international level between network operating institutions. The forum for institutions that are responsible for operation of national hydrological networks is within the RA-VI Working Group on Hydrology (WGH), but currently its co-operation with institutes operating other environmental monitoring networks are limited. The call for integrated environmental information, e.g. the EU Water Framework Directive, and the pressure for increased efficiency in the management of monitoring networks demands improved co-operation. Based on the above, the premises of this work can be stated as follows:

- Environmental information is essential for development and implementation of sound public policy.

- Public resources are limited, therefore, efficient management of environmental monitoring and research is essential

The first point addresses the question of the availability of information. The second point addresses the cost of information and the efficiency in the production and management of information. If we narrow our focus on hydrological and other environmental monitoring networks, we can say that the fundamental motive for our inquiry is *improvement in the management of environmental networks* including:

- Improved services including cost effectiveness as well as mapping of the clients needs.

- Generation of new knowledge, ideas and solutions.

- Integration of the demands for hydrological and other environmental information at the national level with the implementation of the EU Water Framework Directive and the global demand due to climate change.

The approach we will take is to analyse the dimensions of integration i.e. what can be integrated, what should be integrated and how can we integrate, referring to case studies on various types of integrations. We will then give a overview and analysis of the role of the EU Water Framework Directive concluding with recommendations and conclusions.

3. BACKGROUND AND ANALYSIS

In this chapter we would like to give background to some of the issues that are basic to the discussion and analysis of the various dimensions of integrated environmental monitoring. First we will dwell on the socio-economics of environmental monitoring and the institutional, organisational and technical issues that are relevant for its development and implementation. This discussion is based extensively on Snorrason (1994a,b). Then we would like to analyse and discuss some of the dimensions of integration including discussion on some recent work in the field of integrated monitoring as well as cases that are a part of the study. Finally we discuss and analyse the evolving European landscape in the management and protection of water, also with a reference to a case study.

3.1. Socio-economics of monitoring

The basic reason for monitoring is the need to reduce the uncertainty in our decisions in a complex and changing world. The future is unknown, and the decisions concerning it must be based on our knowledge of the past and present state of the systems under scrutiny. Raiffa (1968. pp. xxii-xxiii) describes the predicament of the decision-maker:

> *"I have assumed that the decision maker must make a choice, or a sequence of choices among various possible courses of action: that the consequences of any course of action depend on an unpredictable event or "state of the world"; that the decision maker already has some information at hand that bears on the uncertainties of his problem and therefore can make some judgement about these uncertainties; and that he can obtain information, at a cost, that bears on these uncertainties."*

The fundamental issue here is that we can reduce the risk associated with our decisions made under uncertainty by increasing our information. And this is an endless cycle of interplay between information, decisions, actions and consequences which is shown clearly in Fig. 3.1 (Snorrason 1994b).

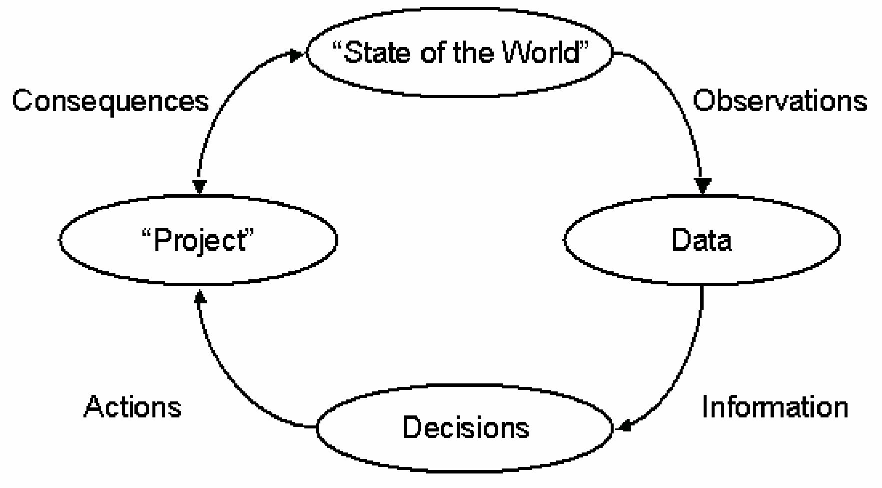

Figure 3.1. The cycle of interaction between decisions and the "State of the World" (Snorrason 1994b).

In the figure, "project" stands for the result of the actions dictated by the decision. It can be a social or institutional entity, e.g. legal act or EU directive, or a physical entity e.g. hydropower plant or sewage treatment plant. The consequences can similarly be a change in the institutional framework, e.g. national implementation of an EU directive, or the stream of benefits and costs from the sewage treatment plant or the externalities associated with that stream. The “project” is, of course, a subset of the “state of the world” and thus influenced by it.

The several phases of water resources utilisation and development can well serve as examples for the cycle of information and decisions. The first phase of the use of water resources generally is a distributed localised use for water supply, irrigation and transport. In many of the ancient river related civilisations, observations and monitoring was formalised but in general it is not till the 19th century that systematic observations and monitoring networks start to form. The main motivation in many countries that initiated the second phase of development was the potential for hydropower generation and large-scale irrigation that called for systematic assessment of the water resources. This often went hand in hand with development of the resource so monitoring of the consequences of development was soon an integral part of the hydrological networks. This interplay is shown in Fig. 3.2, as an application of the model shown in Fig. 3.1. The key issues were on one hand the economics of water resources development and the property rights involved in that development and on the other hand the externalities associated with the development.

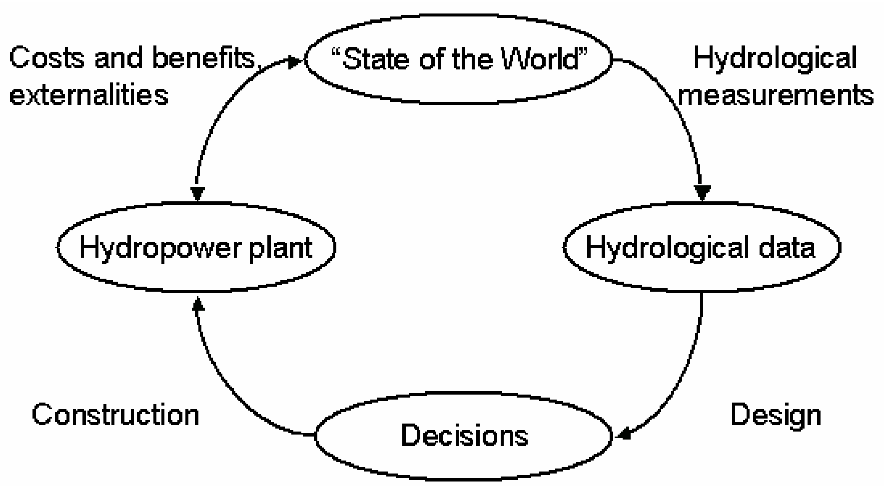

Figure 3.2. Decision cycle for hydropower development.

The third phase of development concerns the mismanagement and pollution of the water resources and their environment, that are the externalities associated with development. This phase has in some instances been the initial phase, e.g. in supplying water for some of the poor and populous cities around the world, but usually it has surfaced as a consequence of rapid development of society not aware of the dramatic consequences that would follow such rapid growth.

In the transformation from development of resources into environmental awareness, the monitoring of water resources has developed from quantitative aspects into qualitative aspects of the resources. Aspects that relate more to the welfare of the public. So the question has been raised if the issue of environmental monitoring is not a social welfare issue relating to the health and prosperity of the public in general, rather than mere question on economic development. This shift to the more general environmental concerns and sustainable development with a long term ecological perspective has called for new approaches in the management and funding of environmental information (Whitfield 1997). These concerns are also well reflected in one of the conclusions of the Advance Research Workshop on Integrated Approaches to Environmental Data Management held in Turkey in 1996 which states:

> *“the question of environmental management is a public welfare question, Therefore, the objective, the institutional framework and organisational structures in data management are public policy issues belonging to the realm of welfare economics but are not internal to the scientific community”* (Harmancioglu *et al.* 1997).

This view is further supported by the fact that most environmental information is in essence public good. Public good is a good that has the quality that the use of one of the good does not, in any way diminish the use of another of the good. For environmental information, this is taken to mean that if the information is produced, everyone should, from an economical standpoint, have access to the information at a marginal cost.

Moreover, since environmental issues concern the public, and decisions concerning environmental impacts should be based on participatory approach, it is an ethical requirement to have an open access to environmental information in order to secure public participation.

3.2. Integrated environmental monitoring

In our terms of reference we are asked to investigate the possible interrelations between hydrological and other environmental networks. As a first step, it is necessary to map out the dimensions of integration and thereby clarify what is involved. We have identified a few dimensions that we will describe in turn:

3.2.1 Policy

At the policy level integration has always been important, but the issues change with time as reflected is some of the discussion above. It is, however, fair to say that the present awareness of environmental issues has resulted in integration at the policy level at global scale. Two developments are important here; on one hand the “looming crises” of water shortages expected globally in the near future and on the other hand the issue of climatic change. Both call for comprehensive integration at the global policy level and will and have resulted in integrated global monitoring policy.

At the national level, policy has also been integrated due to similar pressures, but also due to the complexity of the issues as well as due to the need of improving the cost efficiency in monitoring activities. The international community is also pressing for integration at the national level. A case in point is the EU Water Framework Directive (WFD). This Directive is calling for formulation of integrated policy on environmental monitoring at the European and the national level.

3.2.2 Strategy

The strategy for the implementation of policy at both the international and the national level requires deconstruction and reconstruction of the legal and institutional framework. At the global level the Kyoto Protocol is one such instrument to organise the international community in its response to the threat of global warming. The EU Water Framework Directive is another. Both will call for reformulation of laws and regulations at the national level that must integrate the concerns, the policy and obligations internal to the international agreements.

3.2.3 Institutional and organisational structures

The institutional and organisational means to facilitate implementation of public policy are many but often the present organisational framework dictates the solutions rather than more radical restructuring which integrated environmental policy calls for. This is inherent in the bureaucratic complexities of modern societies were the need to survive is stronger than the need to serve well. This is, in fact, one of the greatest hindrance in successful implementation of integrated environmental policy and stands often in the way of comprehensive integration of environmental monitoring. Even if it is well known that resistance to change is often at the strategy level, this is certainly a major problem when it comes to the institutional and the organisational level. This is in many ways understandable since in many cases organisational structures as well as cultures need to be integrated which is always difficult. The finances and funding is also an issue that does not always go hand in hand with the policy changes, causing uncertainties and risks for the organisations. This resistance to change, will generally however, cause inefficiencies since mismatch between policy and organisational structures will lead to conflicts and redundancies that an integrated approach is aiming at overcoming.

3.2.4 Objectives and tactics

Assuming that a particular organisation or organisations have a defined role in the implementation of monitoring strategy of an integrated environmental policy, it is important that the objectives of each player can be integrated into a comprehensive plan for monitoring. Integration at this level can, in fact, solve some of the problems discussed above since integration of objectives should lead to environmental network design and operational tactics that potentially maximises the benefit-cost ratio of the network operation, given the organisational constraints.

3.2.5 Topical

The hydrological cycle in essentially described by several topical fields that we know as meteorology, hydrology, glaciology and oceanography. The first two have been integrated from the advent of hydrology and the same can be said of glaciology. It is only with the modern Global Circulation Models (GCM) that all the topical fields dealing with the hydrological cycle are integrated into one comprehensive model.

Integration of water quality and quantity has also called for the integration of the fields of chemistry and biology. This integrations of scientific topic areas has been necessary in order to deal with the environmental degradation and restoration of our waters and environment. Integration of hydrology and fresh water fisheries has also a long tradition, but it is not till with the advent of Eco-hydrology that a holistic integration of all the relevant process governing the aquatic environment has been implemented (Whitfield 1997).

3.2.6 Monitoring networks

Environmental monitoring networks can benefit greatly from integrated approaches to their design and management. A model by Moss (Moss 1982, WMO 1991) shown in figure 3.3 can be generalised to encompass design of integrated environmental networks. The same building blocks are necessary, with even stronger reliance on the scientific base and the socio-economic dimension. There are both philosophical and pragmatic reasons for the integration of environmental data networks across various environmental phenomena (Moss 1997). The philosophical basis for this conclusions is that environmental processes are interdependent in nature as discussed above. Thus, if one wants to understand any particular aspect of the environment, the data describing the web of processes whose interactions influence that aspect must be studied to attain adequate understanding (*ibid*.). From a pragmatic point of view, integration of environmental data networks makes sense because the interdependencies of the environmental processes permit information transfer among the processes. Furthermore, integration of networks allows for operational advantages, both within the field operations as well as within the information management systems. Thus, synergy and cost-effectiveness can result from integrated data networks (*ibid.*) and these we will discuss in turn.

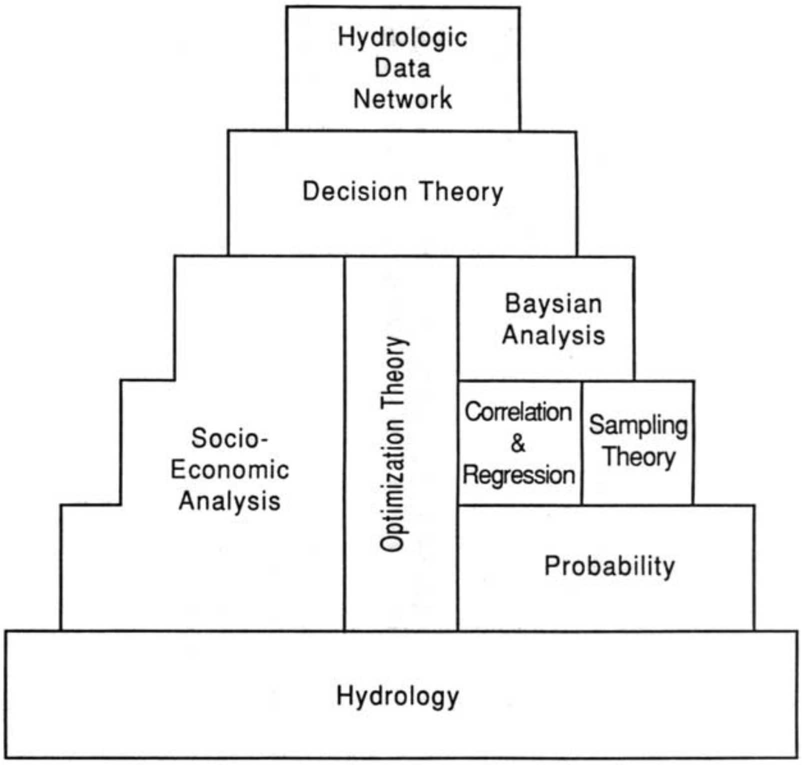

Figure 3.3 The basic building blocks of network design (Moss 1982).

a) Temporal and geographical characteristics.

All environmental variables have temporal and geographical dimensions. The fundamental characteristics of temporal and geographical correlation are shared as well as the fundamental stochasticity of the processes. Therefore, they all require temporally and geographically integrated networks. This will ensure on one hand that adequate coverage in time and space is provided and on the other hand that the correlation should be accounted for in designing the optimal network. If we define any such stochastic variable as $e(\underline{\mathbf{x}},t)$, and the network constructed to measure $e(\underline{\mathbf{x}},t)$ as network N(k) of k stations it is clear that the marginal utility of an additional station k+1 will be a decreasing function with k, due to the spatial correlation in the variables. Furthermore, the marginal utility of each additional temporal observation will also be a decreasing function of t assuming $e(\underline{\mathbf{x}},t)$ to be stationary. If, however, the variable is non-stationary, this marginal utility must be assessed for each individual variable, and can, in fact be increasing with t. One example of increased marginal utility with time are the measurements of variables that define the processes of global warming.

b) Integration of basic hydrometric networks.

The fundamental objective of hydrological monitoring is the hydrology and water balance of a particular watershed as reflected in the vector of hydrological variables $\underline{\mathbf{q}}(\underline{\mathbf{x}},t)$. The traditional core variable are the water levels in rivers, lakes and groundwater systems. The measurements with appropriate transformations and models are the means to quantify the hydrological variables that describe the system. The water levels as such, are in many cases also of value, e.g. for navigational purposes as well as for the purpose of flood zone mapping and planning. The measurements of these three variables with the models and transformations need to be considered all together to be able to design an efficient integrated hydrological network for mapping of the hydrology and the hydrological balance of the watershed.

c) Integration of hydrometric and meteorological networks.

In some of the European countries, the hydrological service is a part of, and integrated into a single hydrometeorological service with meteorology. In most cases, however, there is a long tradition to integrate with the hydrological network a climatological network, e.g. on precipitation and air temperature. This integration is necessary for the definition and the monitoring of the hydrological balance of the watershed. An example of integrated network of discharge, groundwater and precipitations is given in the case study on the Spanish networks in Appendix 1 (Meteorological and Hydrological Monitoring Networks in Spain by Teodoro Estrela and Mirta Dimas). The Spanish example of integration offers synergies both at the operational level as well as in the hydrological analysis and assessments.

The integration of meteorological and hydrological variables is also fundamental to any successful flood warning system. With technological developments in the area of digital measurements and data transmission, flood forecasting systems have successfully been integrated into the traditional systems. In fact, the technological development that has taken place to meet the requirements for flood warning purposes has been extended to include the traditional monitoring networks as the cost and flexibility of the systems has improved (Elefsen *et al.* 2001). The potential of the technological dimension of integration should not be underestimated since it allows for integration of the observation of many variables within one monitoring station with low marginal cost, both in investment and operation.

d) Integration of hydrometric and water quality networks.

There is a long tradition to integrate water quality sampling in the operation of traditional hydrometric networks. Sediment sampling is a case in point, but the same can also been said of sampling for chemical analysis even if such programmes have often been planned without due consideration of the basic hydrometric networks. An example of successful integration of this type of integration at the operational level is given in the case study from UK in Appendix 2 (Integration of Environmental Monitoring Networks by Phil Procter).

When the water quality variables require or allow for continuous monitoring, they should, in general, be integrated into the traditional network, since the marginal cost of monitoring additional variables would, in most cases, be considerably lower than establishing new monitoring network. This is especially true, were digital systems with many measuring channels have already been installed, so the water quality sensors are only an addition to the existing system. Furthermore, sites with long hydrological data series should also allow more easily for generalisations of water quality variables outside of the monitoring period. This type of integration will in the near future increase the efficiency of the monitoring systems, since synergies and cost savings are apparent in the capital costs, installations, field operations, data management and the scientific knowledge based on these integrated systems.

f) Integration of biology and ecology – Eco-hydrological networks.

Integration of biological sampling and ecological monitoring with traditional networks is not common. The reason for this (which is also true for the lack of integration in general) is that biological and Eco-hydrological monitoring is usually the responsibility of other groups, organisations or agencies than operate the hydrometric networks. There is, however, much to gain from integration of ecological monitoring into the more classical one, if we extend the experience from integrating water quality monitoring into the hydrometric networks (Whitfield 1997, Wilkinson *et al.* 1997). This is not only efficient at the operational level, but even more so at the information management level. At the scientific level, it is essential to integrate these cultures into holistic paradigm of Eco-hydrology. Eco-hydrology must then serve as the bases for monitoring strategies and methodological development that can respond to the ever increasing demand on environmental monitoring in general and its efficiency, as, e.g. reflected in the EU Water Framework Directive.

3.2.7 Integrated information systems

An integrated information system has the function of networking together the producers and users of data. It supplies the framework to draw together relevant or potentially relevant data and information on the environment both within the same or across disciplinary boundaries. Within the realm of geographical information systems (GIS) a new paradigm with the integration of GIS-hydrology and hydraulics has emerged, often referred to as hydroinformatics. Within this framework, spatial and temporal dimensions of a vector of environmental variables $\underline{\mathbf{e}}(\underline{\mathbf{x}}, t)$ are integrated into one comprehensive system of hydroinformation. This forms a bases for inquiry by the scientific community, decision and policy makers and the public into environmental issues of local, regional or international interest or concern. This integration, exchange and dissemination of information is facilitated by the development of the internet technologies as well as rapid development in the field of database and meta-database management. This specific area of integration is covered comprehensively in Davis (1999), both for the national and regional level as well as for the international scene.

Two models are discussed by Davis, on one hand a centralised approach where one agency is given the mandate to integrate information from various sources into centralised datebase. On the other hand is a distributed nodes non-hierarchical approach shown in Fig. 3.4 (*ibid.*).

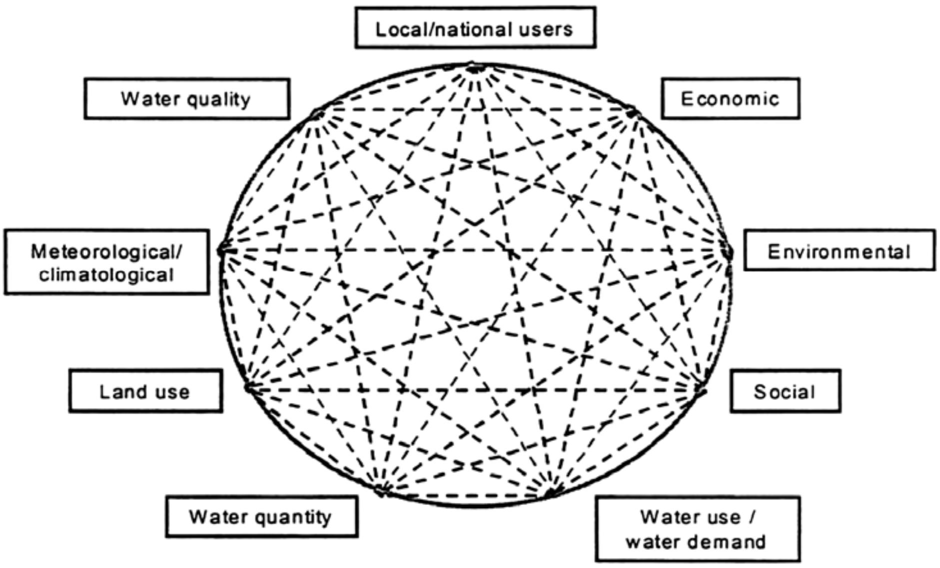

Figure 3.4. Distributed information networks (Davis 1999).

The figure shows the interaction between the nodes within a distributed network of environmental and socio-economical information. In practice, the distributed approach seems to be much more applicable and relevant for the actual complexities within modern society, but metadata and virtual database technologies within the framework of the World Wide Web should in the future be able to integrate the information to the extent that the users can have an access to comprehensive environmental information systems over the Web.

3.3. Analysis – emerging European landscape

3.3.1 Background

Till the early 1990s, European hydrological observation systems were mainly developed and operated on the grounds of local, national or regional objectives and practices. Several pan-European organisations had been established, but they were mainly focused on the economic and social sectors, and their guidance and need for information, concerning the water resources, was very limited.

The most important community, that had formed an umbrella for the national hydrological services or corresponding bodies, was the WMO and its regional association for Europe. The membership and activities of WMO had created some uniform hydrological practices, but on the other hand, there were many factors that had resulted in individual forms of operation. Perhaps the most important feature was the fragmented field of water resources research and management. As a result, hydrological work has been carried out by a high number of organisations, that differ very much, e.g. by their field of administration, duties, geographic coverage, operational programmes, size, and technical standards. This complex flora of Hydrological Services are described in a recent WMO report (WMO 2001).

These characteristics pictured the European landscape, when the Community policy in the field of environment started to develop towards its current state. The establishment of the European Environment Agency (EEA) in 1994 was a major step towards more standardised data collection. EEA was established under EEC Council Regulation with the objective to ”provide objective, reliable, and comparable information on the state, pressure and sensitivity of the environment in the European Union and its surroundings”. EEA is an independent institute, but its strategy is to assist the European Community in its environmental policy.

The operational activities of EEA have been organised through Topic Centres. The European Topic Centre on Inland Waters (ETC/IW) was appointed in late 1994 to act as the centre of expertise, that is – among other duties - responsible for hydrology (expressed by the terms surface and ground water quantity). In 1997, ETC/IW published the general guidelines of ”European Freshwater Monitoring Network Design” (EEA 1997).

This publication gives rather detailed recommendations on the extent and structure of surface water quality and groundwater networks that would form the national contributions of EEA’s EUROWATERNET – the monitoring system that will be used for the collection of surface and groundwater data and information. However, the role of surface water quantity was not well defined, because ETC/IW did not have sufficient information on the hydrological monitoring networks. On one hand, this is the result of the fragmented field of actors within water research. On the other hand, the national focal points, that were in most cases responsible for water quality monitoring, were not able to collect enough information on hydrological monitoring systems. The low level of hydrological impact and ”dialogue” has been typical of the development of EUROWATERNET that became operational in the first member countries in 2000.

During the late 1990s, the European Commission and the European Community carried out a large process to develop a new type of directive, that would cover several aspects of water resources: their protection, and the administration, monitoring, planning and implementation mechanisms that would be needed. This directive: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy – or briefly the Water Framework Directive (WFD) - entered into force in December 2000.

3.3.2 EU Water Framework Directive

The Water Framework Directive will have a deep effect in the whole water resources sector. The process will be both long lasting and extensive, and it will influence most actors that work in this field. The main objective of the directive is to guarantee ”good ecological status” of surface and ground waters. The duration of the first programme phase is 15 years, starting from the date of entry into force.

WFD has a strong hydrological ”component”, even if the main tasks are not described in any detail. The directive merely gives objectives and targets, and the member states, or administration responsible for the implementation, have to develop methods and use expertise that support the process. The above flexibility means, that the hydrological contribution can be expressed in different ways. Below is one classification of duties that require hydrological and water resources information:

- The main characteristics of ”water bodies” – rivers, lakes and ground waters (also transitional and coastal waters) – have to be mapped and registered in a user-friendly form. Information is needed on the central features of catchment areas and river and lake morphology.

- The current and future status of water bodies has to be assessed. This calls for hydromorphological information as well as knowledge of flow conditions in rivers and water balance of lakes. Also the status of ground waters has to be assessed. This knowledge must be based on hydrological data and modelling – at least at the level of spatial estimates.

- The above assessment has to be based on ”reference conditions”. From the hydrological point of view it means, that hydromorphological and hydrological conditions, that characterise different classes of status, have to be established.

- Criteria have to be made for the definition of ”artificial and heavily modified water bodies”.

- The member states shall establish programmes for the monitoring of water status. Some hydrological variables play an important role in these programmes.

- The control of diffuse sources pollution requires models for run-off in the catchment scale.

In most European countries, the national hydrological services – or the corresponding bodies – will have the main responsibility for the hydrological contribution, related to WFD. The implementation of this task, taking into account the present duties and programmes, requirements for their development, data services and reporting, and budget pressures will require new solutions on hydrological monitoring and its integration in the very near future.

The implementation of WFD will require great efforts from the hydrobiological community, and in some countries also from the hydrochemical community. This allocation of resources may not always cover the new components of hydrological programmes, especially if the current status of hydrological data collection is estimated to be better than that of the chemical and biological monitoring. This aspect of resource allocation within water research may create additional pressures to the hydrological institutes.

4. CONCLUSIONS AND RECOMMENDATIONS

In the following paragraphs we have tried to summarise the discussion above and we have also relied heavily on the conclusions from Harmancioglu *et al.* 1997, which has an excellent and comprehensive list of conclusions and recommendations for integrated approach to environmental information management.

4.1. General aspects

There is a significant gap between information needs on the environment and information produced by current systems of data collection and management. The presence of this gap contradicts the nature of the Information Age we live in. That is, we now have developed the most sophisticated means of collecting, processing, storing and communicating data; yet we still suffer from poor information when we attempt to use the available data. This gap between the needs and the production of information can be filled in by appropriate collection and management of data. In view of numerous problems encountered in monitoring and information production, the adoption of integrated approaches to data management appears to be only means by which the existing gap can at least be minimised (Harmancioglu *et al.* 1997).

There are number of dimensions of integration that can be formulated and implemented on many scales. These dimensions have been discussed in some detail, but further work needs to be carried out and specific examples described and implemented. The following are examples of integrations that are considered to be relevant and practical:

- Integration of the networks that are needed to assess the water balance.
- Integration of models and data.
- Integration of monitoring of many environmental parameters into a single monitoring station, possibly operated in real time.
- Integration of tasks in the joint operation of a hydrological, chemical and biological monitoring networks.
- Integration of information on the whole of the aquatic environment within the framework of GIS, relational databases and the www.
- Integration of data, models, remote sensing and GIS into hydroinformatic framework.

The solution to environmental problems often requires data exchange at local, national and global (international) level. Such an exchange may be needed for: (1) data of the same type, e.g., water quality data collected by different methods; (2) data of different types of one discipline, e.g., physical, chemical, biological, and other Eco-hydrological data types; and (3) data of different disciplines, e.g., hydrological, meteorological, geophysical, or demographic data. We live in a decade when computer and communication technologies have made significant advances in terms of technical capability and connectivity. Such advances facilitate data exchange on various levels; however they also impose significant demands on our capacity to handle environmental data so that information flow can be properly realized at local, regional and global levels. The development of computer and communication technologies have changed fundamentally the way in which data and information can be managed and made available. These demands imply the requirement for integrated approaches to data handling. In this respect, data exchange appears to be another keyword within the framework of integration (Harmancioglu *et al.* 1997).

The various programmes on the monitoring of European water resources and the aquatic environment have a multidisciplinary national, regional or global character, e.g. Ospar, Helcom, Eurowaternet, MED-HYCOS, The Danube Commission and the Rhine Commissions. They need strengthening of collaboration between data management activities of different organisations to ensure proper coordination of environmental data collection, data flow and archiving and to avoid duplication of efforts on both national and international levels. Such collaboration can only be realised by integrated approaches to data management.

4.2. Scientific and technical aspects

The hydrological community can give a very valuable contributions in the integration of environmental monitoring. Stochastic nature of the resource, collection and analysis of time-series, modeling and spatial estimation, well established databases, and the use of geographic information are all features, that will be needed in the community policy. This scientific background, together with networking between the institutes, can give the hydrological community a strong position.

The hydrological contribution that will be needed for the implementation of the EU Water Framework Directive may exert considerable influence on the design of the future environmental monitoring networks. The suggestions above should increase the likelihood of successful integration of hydrological and other environmental networks since it facilitates a dialogue between the actors and stakeholders in the European arena.

4.2.1 At the technical level, integrated management of the environment relies on two basic tools: modelling and data. The adoption of an integrated approach has also imposed new requirements on these tools. With respect to modelling, for instance, we now see more of comprehensive integrated watershed models, comprising soil, water quality and quality components, than rather simpler water balance models based on assessment of water quantity only. With respect to data, the probes that must be addressed today require interdisciplinary approaches and hence much more sharing of data and information than in the past.

4.2.2 Basic understanding of environmental phenomena is the starting point for the design and integration of environmental data networks. Knowledge of the phenomenon of interest is required to select an appropriate suite of network design and network integration tools. Feedback from data collected in the initial networks permits more complete descriptions of the environmental phenomena and the subsequent use of more complex approaches to redesign the environmental information network.

4.2.3 Network design is but one link in an integrated environmental data management by the complementary links. The design of data networks should not be performed in isolation from the technologies that will be used to convert the data to environmental information. There currently is a paucity of robust technologies for the design of integrated environmental data networks, and technology transfer for the existing technologies is not being carried out satisfactorily on an international scale because of the great interest in collection of environmental data. With the lack of adequate network design support, many of the data collection programmes probably are not being conducted in a cost-effective manner.

4.2.4 Since a data collection system designed today has to function for several decades and since the principle of sustainable development requires consideration of the needs of future generations, the objectives that the current systems have to meet are almost impossible to specify since the objectives of future generations are not known. The only possibility seems to be to define today's objectives, to try to anticipate potential objectives of generations to come, and to define objectives of a data collection system on the basis of both.

4.2.5 Remote sensing allows for acquisition of area information instead of point measurements of some parameters relevant to environmental and hydrologic monitoring and management. It has the potential of global coverage, i.e., it provides information also on remote areas, where no measurement can be acquired. Furthermore, remote sensing allows for acquisition of information on state variables relevant to environmental modelling, e.g., soil moisture status, snow cover etc. in hydrological modelling.

4.2.6 The growth of computer technology and GIS systems into a framework of hydroinformatics is enabling comparisons of environmental data sets to be made in a way that was impossible few years ago. This is leading to new insights into many areas of environmental science. There is, however, a danger in that the images from GIS are so powerful and seductive that they may mask an inadequate database(s).

4.3. Recommendations

4.3.1 With regard to objectives, constraints and institutional aspects the following points were considered significant:

- Principles and values of the international agreements on free and open access to environmental data must be confirmed as being critical to the integrated approach to data management systems

- The principle that environmental data is a public good must be recognised

- The principle of public participation in decisions on environmental issues requires, from an ethical standpoint, a free and open access to relevant integrated environmental information

4.3.2 Today, the European hydrological community should make a comprehensive analysis of its current status and future demands. The leading actors are the European Community (including e.g. the Commission, the member states at the administrative level, and EEA), WMO (and its regional organisation, especially the Working Group on Hydrology), and the Hydrological Services at the national or regional levels. It is very important to make sure, that a balance and integration can be found within the various hydrological programmes, such as basic national, local, sectoral, operational, EUROWATERNET, other international reporting, and WFD. The multidisciplinary demand is clearly increasing due to WFD. This objective is probably in line with various environmental goals, related to water resources.

4.3.3 There is a growing need for closer co-operation between network operating institutions. The forum for institutions that are responsible for operation of national hydrological networks is within the RA-VI Working Group on Hydrology (WGH), but currently its co-operation with institutes operating other environmental monitoring networks are limited. The call for integrated environmental information, e.g. the EU Water Framework Directive, and the pressure for increased efficiency in the management of monitoring networks demands improved co-operation. It is, therefore, suggested that:

- WGH should meet annually at an informal meeting for discussion and consultation among the members.

- WGH should formalise co-operation with EU regarding the EU Water Framework Directive.

- WGH should establish a dialog with those responsible for the European implementation of the EU Water Framework Directive. The annual meeting of WGH can a forum for this dialogue.

- WGH should emphasise the hydrological dimension and contribution to the EU Water Framework Directive at all levels including the European, the international river basins, the national and the river basin district level

4.3.4 When national hydrological services (or corresponding hydrological network operators) are being reorganised, integration aspects should be carefully considered. Organisation structures should reflect the new roles and cooperative arrangements of the services, and important linkages that support integration at various levels can be strengthened. Flood warning arrangements, assessment of freshwater ecology, and technical development are examples of issues that can be focused on.

4.3.5 Environmental data networks should be designed in an integrated manner to take advantage of the informational synergies that exist among environmental phenomena. Furthermore, integrated environmental data networks should be redesigned periodically to incorporate the new knowledge that is contained in the added data.

4.3.6 The development of more robust technologies for the design of integrated environmental data networks should be supported by international environmental agencies. New vehicles for the transfer of the technologies of data network analysis, design and integration should be sought and implemented as they are demonstrated to be effective.

4.3.7 There should be standardised protocols for sampling procedures of water quality and ecology. Methods of presentation of results should be such that not only the values themselves are given but also the relevant statistics, e.g. the number of samples, mean, variance, confidence limits, etc., should be presented. Furthermore, documentation is essential to enable the data to be quality controlled.

4.3.8 It is invaluable to have close links between personnel who are collecting and managing the environmental data resources and the communities who are using such data for operational or research purposes

4.3.9 Knowledge of existing environmental data is important at regional, national and international levels. More effort is needed to collect metadata. This initiative should be at a national level. Integration of databases is difficult without an appropriate institutional structure in place. It is recognized that a number of international organisations have taken the lead in developing and publishing protocols (e.g., WMO, UNESCO, EEA, etc). However, these protocols are generally not given sufficient publicity or widespread dissemination.

4.3.10 Standards exits for different levels of the data management process. However, the important issue in this respect is to develop an agreement on which standards to apply, e.g., the case of transboundary monitoring programs. Regarding standards, organisations like WMO have developed standards for hydrological measurements including water quality. However, one of the problems with international organisations is that they do not advertise the fact that such information is available. There is a need to encourage these organisations to disseminate information about the availability of standards which are dependable and acceptable as those related to water, particularly to water quantity. In case of biological and ecological monitoring, there is a lack of universally accepted standards.

4.3.11 Integration has to be attained via close links between data collectors, managers and researches. As an essential element for realizing the required integration, international, interdisciplinary joint working bodies, meetings, and conferences should be implemented. This is never more relevant now when the EU Water Framework Directive is being implemented.

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ANNEX 1

METEOROLOGICAL AND HYDROLOGICAL MONITORING NETWORKS IN SPAIN

Authors:

Teodoro Estrela (CEDEX)
Mirta Dimas (CEDEX)

1. METEOROLOGICAL MONITORING NETWORK

The Spanish Environment Ministry is responsible through its Meteorological National Institute (INM) of the acquisition, management and dissemination of meteorological data.

The national meteorological network has around 9,200 gauging stations with historical data; from which 5,200 only measure precipitation, 3,700 measure precipitation and temperature, 200 are complete stations that register data of precipitation, temperature, atmospheric humidity, hours of sunlight, wind speed, etc., and finally 80 of them are automatic (Figure 1.1.). This last type is quite recent and it records the same data as the complete network but its main characteristic is the automatic transmission of data through the telephone network.

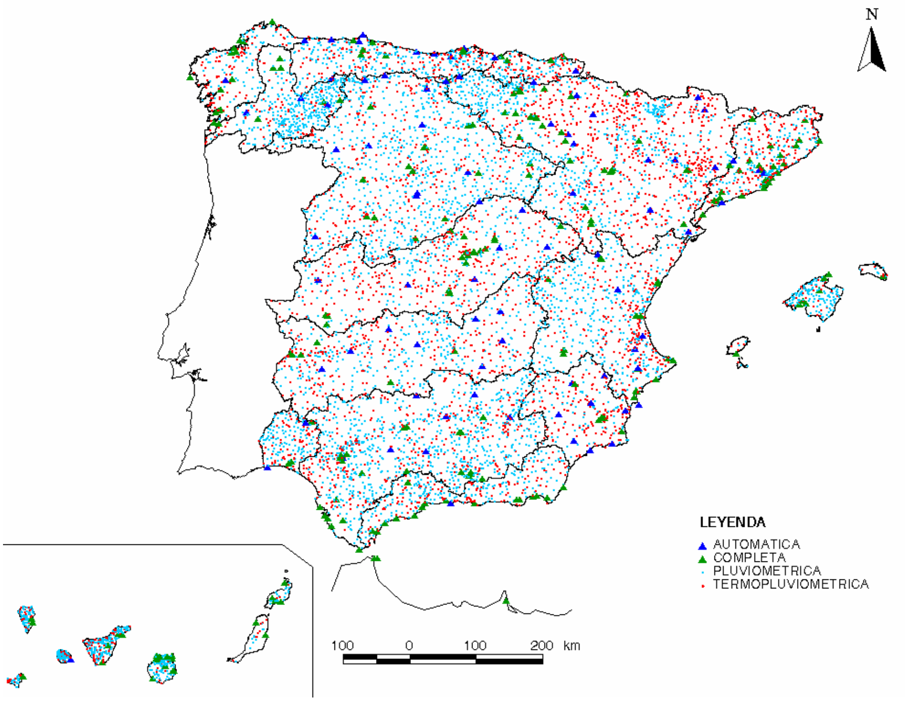

Figure 0.1 Meteorological gauging station network of INM in Spain

Within the 9,200 meteorological stations 5,080 are currently in service (Table 1.1.); 2,520 of them measure precipitation, 2,320 precipitation and temperature, 160 are complete stations and 80 of them are automatic.

River basin	Precipitation	Rainfall-Temperature	Complete	Automatic	Total
Norte	213	268	23	18	522
Duero	339	215	12	10	576
Tajo	105	177	15	6	303
Guadiana	153	206	6	10	375
Guadalquivir	385	198	13	7	603
Sur	166	54	14	1	235
Segura	70	156	5	8	239
Júcar	180	193	15	5	393
Ebro	214	498	16	14	742
C.I. Cataluña	70	132	15	4	221
Baleares	134	43	7	0	184
Canarias	485	183	18	0	686
Total	2514	2323	159	83	5079

Table 0.1 Distribution of meteorological gauging stations in operation in Spain

Another meteorological network at national level is the Tank evaporation network. This network was developed and supported by the General Directorate of Hydraulic Works and Water Quality (DGOHCA) and comprises 75 gauging stations (Figure 1.2.).

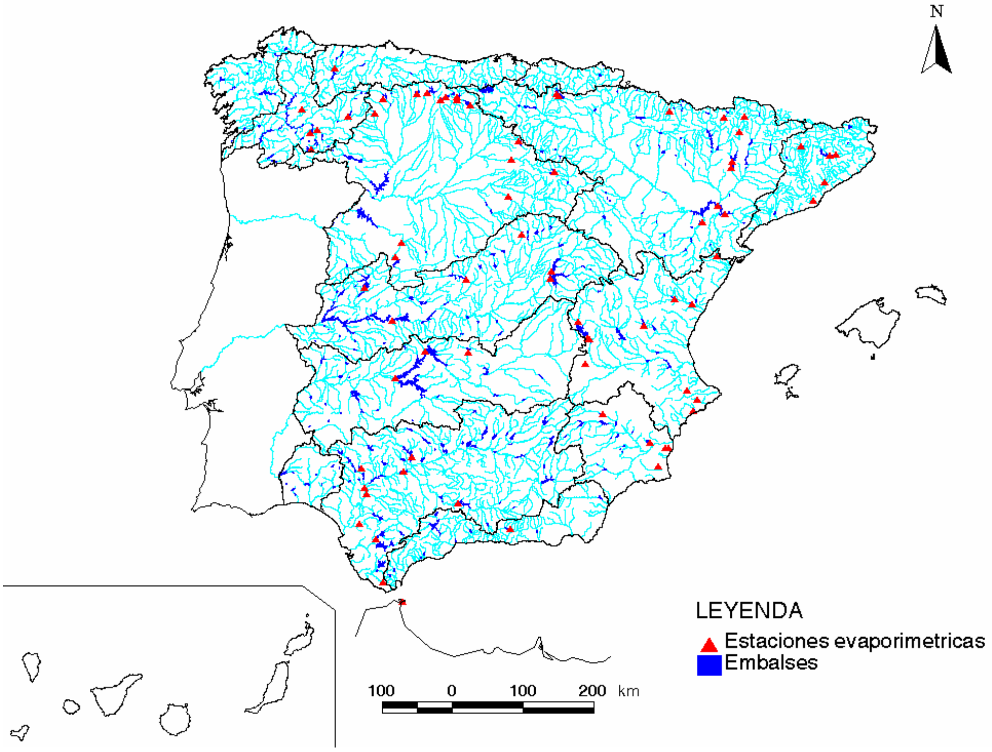

Figure 0.2 Tank evaporation monitoring network in Spain

They are also other meteorological networks at a regional level that are managed by the River Basin Authorities or other organisms of the Central or Autonomic Administration, which contribute to complete the national network.

2. SURFACE WATER MONITORING NETWORK

River Basin Authorities manage and support the official surface water network (ROEA) and the Environment Ministry is responsible of filing and disseminating the data through its General Directorate of Hydraulic Works and Water Quality (DGOH). In the case of the Cuencas Internas of Cataluña, Galicia Costa, Baleares and Canarias river basins, the institution responsible of the surface water network depend on its respective autonomic government.

The official surface water network (ROEA) provides information of water levels and discharges for several locations at rivers and at the main reservoirs and channels. It comprises about 1,200 gauging stations at rivers (from which 730 are currently in service), around 300 control points in reservoirs with a capacity greater than 10 million m^3 and 180 control points approximately in channels (Figure 2.1. and Table 2.1.).

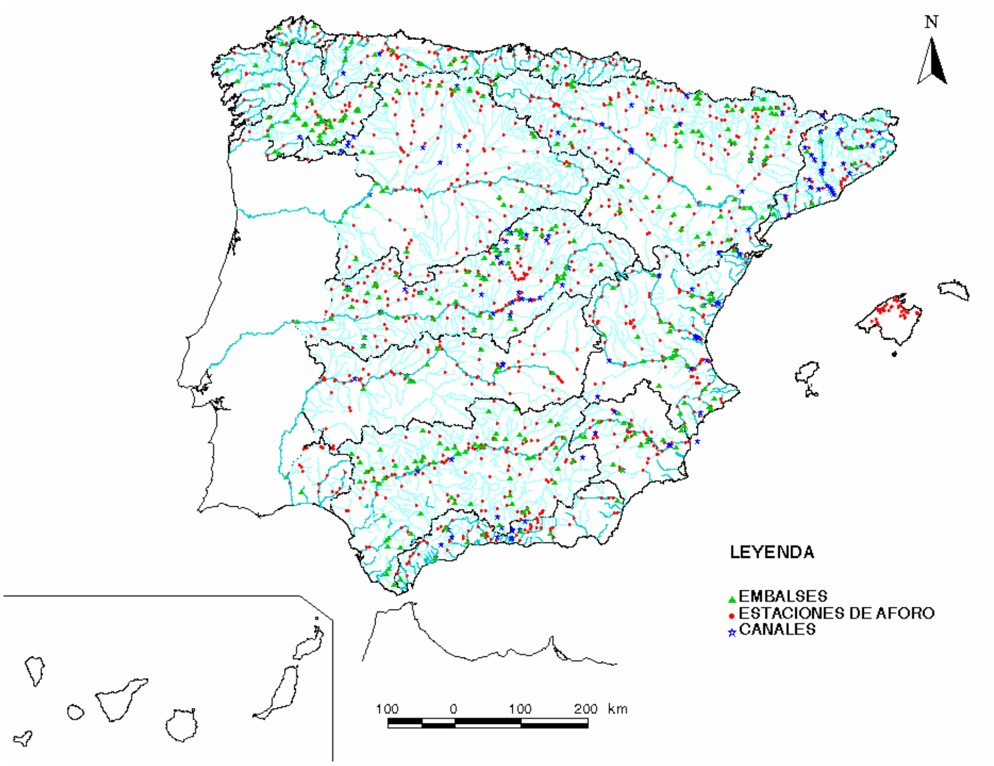

Figure 0.1 Surface water-monitoring network in Spain

River basin	Area (km²)	Number of stations in rivers	Density of stations in rivers (1/km²)	Control points in reservoirs > 10 hm³	Number of stations in channels
Norte I	17.600	14	1/1257	25	2
Norte II	17.330	32	1/541	8	1
Norte III	5.720	10	1/572	4	0
Duero	78.960	104	1/759	27	1
Tajo	55.810	96	1/581	46	36
Guadiana I	53.180	29	1/1833	24	8
Guadiana II	7.030	11	1/639	6	0
Guadalquivir	63.240	71	1/891	57	6
Sur	17.950	48	1/374	12	22
Segura	19.120	17	1/1125	13	11
Júcar	42.900	44	1/975	19	22
Ebro	85.560	171	1/500	46	35
Galicia Costa	13.130	14	1/938	10	1
C.I. Cataluña	16.490	40	1/412	6	31
Baleares	5.010	31	1/162	0	0
Canarias	7.440	-	-	-	-
Total	506.470	732	1/692	303	176

Table 0.1 Distribution of surface water gauging stations in operation, Spain

Another network is the Hydrological Information Automatic System (SAIH) which is implemented by the River Basin Authorities. This network provides awareness of the meteorological and hydrological situation on real time (by hour and by minute) and enables the prediction of variables at a very short time with suitable models.

Currently the SAIH network is extended partially over the Spanish territory although it is intended to spread it over the mainland basins in short term. This network is operating in the Jucar, Segura, Sur, Ebro, Cuencas Internas of Cataluña and Guadalquivir river basins (Figure 2.2.) and the network in Tajo, Guadiana, Norte and Duero river basins is in a different development process.

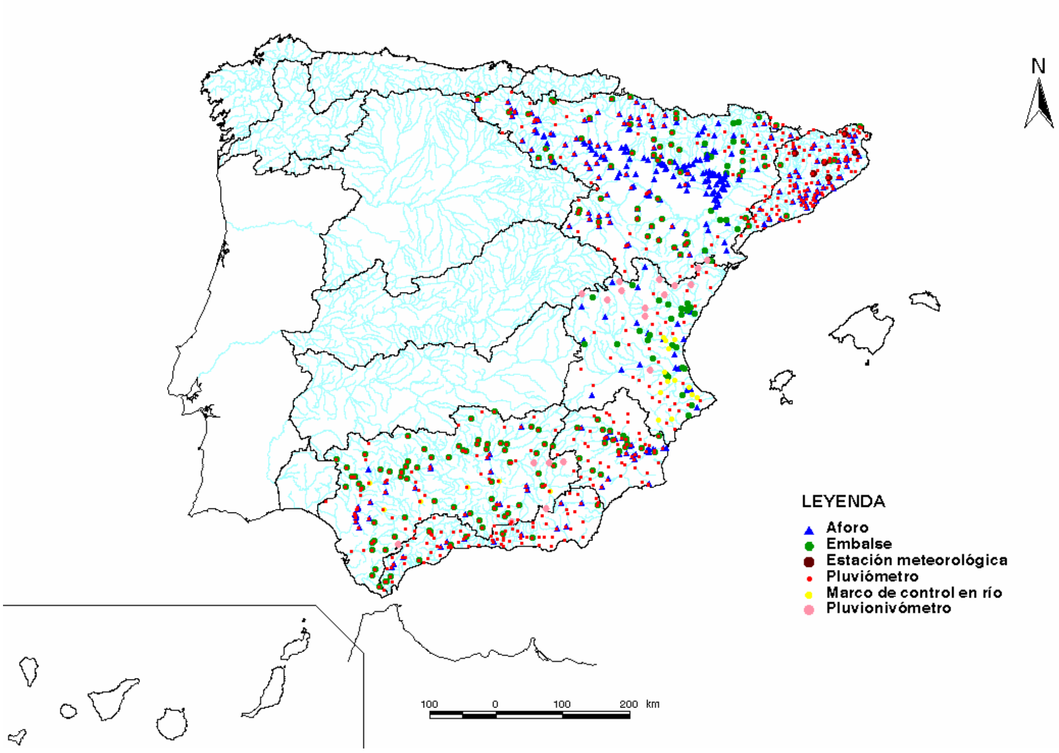

Figure 0.2 SAIH network (Hydrological Information Automatic System), Spain

3. GROUNDWATER MONITORING NETWORK

The Groundwater monitoring system, developed by the 'Instituto Geominero'(ITGE) from the late sixties, includes a piezometric and a hydrometric network at a national level.

The piezometric network is defined by more than 3,000 groundwater points of water level measurements covering about 135,000 km^3, the 80 % of the permeable surface of the territory (Figure 3.1. and table 3.1.). Each gauging point registers at least 2 measurements per year, although it is usual that the reading are quarterly or even monthly.

The hydrometric network covers a surface of about 42,000 km^3 and includes 500 spring discharge observation points.

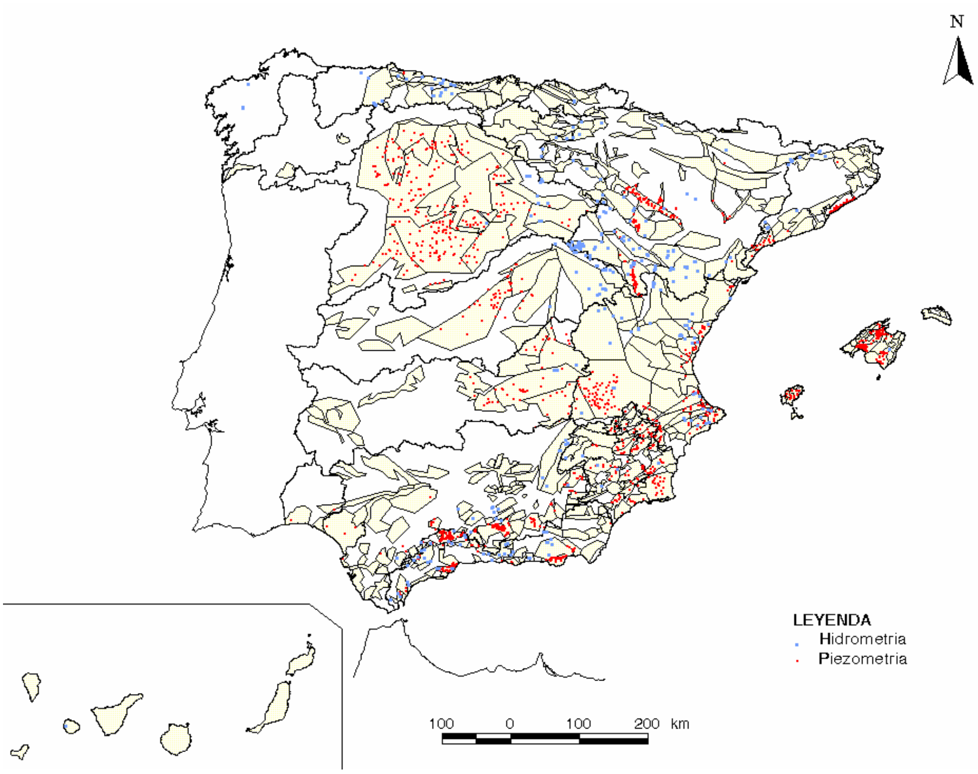

Figure 0.1 Groundwater level and spring discharges networks

River Basin	Aquifer surface (km²)	Number of points of groundwater level control (1996)	Density of groundwater level network (1/km²)	Number of points of spring discharge network (1996)	Density of spring discharge network (1/km²)
Duero	52.798	284	1/186	-	-
Tajo	17.473	84	1/208	75	1/233
Guadiana	14.740	228	1/65	18	1/819
Guadalquivir	15.157	433	1/35	109	1/139
Sur	5.215	779	1/7	134	1/113
Segura	7.023	170	1/41	35	1/201
Júcar	23.787	334	1/71	22	1/1081
Ebro	17.047	237	1/72	72	1/237
C.I.Cataluña	6.596	257	1/26	12	1/550
Baleares	3.675	150	1/25	-	-
Total	163.511	2.956	1/55	477	1/343

Table 0.1 Number of points of groundwater levels and spring discharge networks

In next years, a new development plan carried out by the Public Administration will increase the number of observation points to constitute the Official Groundwater Control Network. Table 3.2. shows the new distribution of gauging points distinguishing the new proposed ones from the pre-existent. Results will settle up 1,910 control points, covering around 160,000 km^3, obtaining a mean density of one point per 85 km^3.

River basin	Aquifer surface (km²)	Number of control points			
		New execution	Pre-existing	Total	Density (1/km²)
Norte	5.548	58	20	78	1/71
Duero	52.798	280	93	373	1/142
Tajo	17.473	93	38	131	1/133
Guadiana	14.740	118	86	204	1/72
Guadalquivir	15.157	184	122	306	1/50
Sur	5.215	76	67	143	1/36
Segura	7.023	75	41	116	1/61
Jucar	23.787	121	137	258	1/92
Ebro	17.047	107	71	178	1/96
Baleares	3.675	57	66	123	1/30
Total	162.463	1.169	741	1.910	1/85

Table 0.2 Proposal of a new groundwater level network

4. REFERENCE

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ANNEX 2

INTEGRATION OF INLAND WATERS ENVIRONMENTAL MONITORING NETWORKS

Case Study - Latvian Hydrometeorological Agency

Authors:

1. Background

1.1. National legal basis of inland waters monitoring

- Law “On environmental protection” (1991, updated 1997 and 2000) defines the term of environmental monitoring and states its role within the whole environmental protection system;
- National Environmental Action Plan (1995) states the priority issues concerning surface waters;
- National Environmental Action Program (1996-1997) sets up the measures for enforcement of environmental protection policy in Latvia;
- Regulation “On the state Environmental Monitoring” of the Cabinet of Ministers (1997) defines the structure of the state environmental monitoring system, principles of financing and exchange of monitoring information;
- “Latvian surface water monitoring programme” (1998) provides an information on status of Latvian inland waters.

1.2. Institutional development

The first state institution was found in 1920 to provide the regular meteorological and hydrological information to various sectors of the national economy. It was the Weather Bureau that had worked under the Ministry of Agriculture until 1941.
1941 - the Hydrometeorological Agency was launched.
1970 – 1976 - the agency started designing of a water quality monitoring network (hydrochemical and hydrobiological).
1996 - the Latvian Hydrometeorological Agency was transferred under the Ministry of Environmental Protection and Regional Development. Besides LHMA, many state institutions responsible for environmental monitoring and protection entered the Ministry.

The Latvian Hydrometeorological Agency (LHMA) carries out meteorological, hydrological and environmental quality monitoring, provides meteorological and hydrological forecasts and warnings of dangerous phenomena to governmental bodies municipal institutions, emergency services, to the media and private sector.

The Sate Geological Survey (SGS) ensures the rational use of subsurface resources and their protection.

The Latvian Environment Agency (LEA) implements governmental policy in the area of environmental data and information compilation, processing and dissemination.

The Environmental State Inspectorate (ESI) controls and supervises the implementation of legislation framework in the field of environmental protection and use of natural resources within Latvia’s territory.

The Marine Environmental Board (MEB) implements the state policy in the field of marine environment protection, development of coastal areas and use of marine natural resources.

1.3. Structure of monitoring performed by LHMA

One of the main tasks of the LHMA is to provide inland waters monitoring which includes hydrometric, hydrochemical and hydrobiological observations under the State monitoring programme.

The functions of the **Hydrological Department** cover all tasks regarding the surface water and marine coastal network management and data analysis. The department has three operational units – Surface Hydrology Division, Marine Hydrology Division and Field Measurement Unit. 4 Regional Hydrological Divisions and the Field Measurement Unit share the responsibility in managing the network, provision of the required field measurements and water sampling in 5 regions of the country.

The Environmental Quality Observations Department provides for surface water quality monitoring, methodological supervision of water sampling and the water quality data analysis. Chemical and hydrobiological tests are performed at the Environmental Quality Testing Laboratory that was accredited in 2000 by the National Accreditation Body in accordance with the requirements of the LVS EN ISO/IEC 17025 standard.
The Technical Department is in charge of installation and maintenance of telemetry stations and the instrumentation.

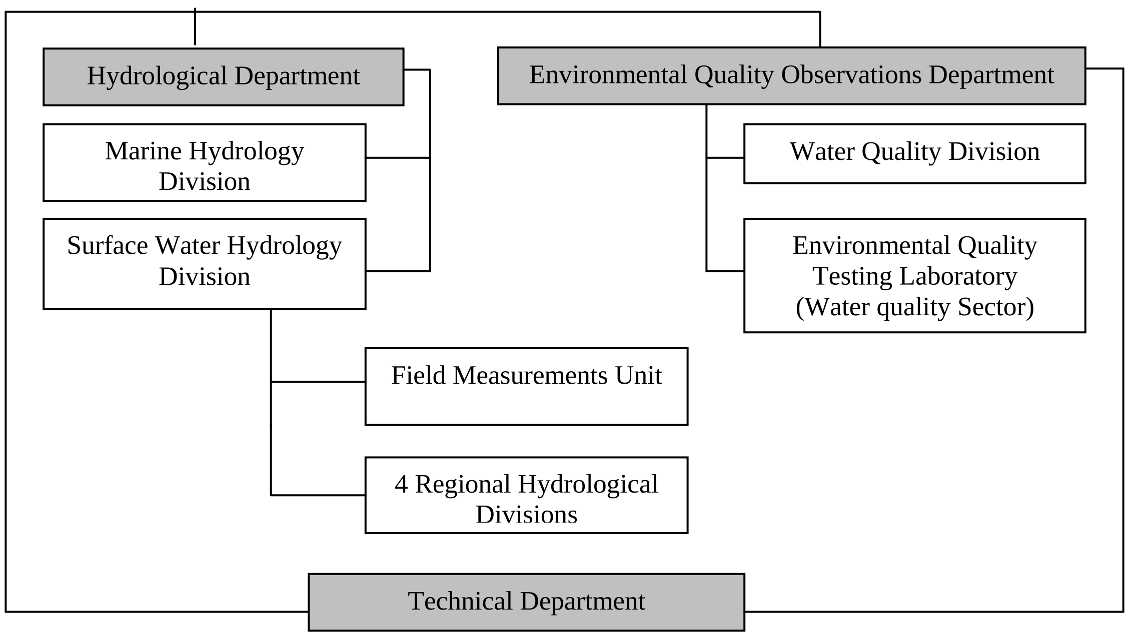

Figure 1.1

1.4. Range of data

At present the LHMA implements, on a regular basis, the water monitoring programme that covers:

- Water level in rivers, lakes, reservoirs and sea-coast;
- Water temperature in rivers, lakes, reservoirs and sea-coast;
- River flow;
- Rainfall;
- Ice conditions;
- Hydrochemical parameters (pH, oxygen, BOD, COD, nutrients, major ions, oil hydrocarbons, heavy metals);
- Hydrobiological parameters (phytoplankton and zoobenthos).

2. Integration and development of inland waters monitoring

2.1. Objectives and the ways of implementing

The technical guidelines of the EUROWATERNET and the principal water policy provisions of the European Water Framework Directive provide for further integration of qualitative and quantitative monitoring of surface waters aimed at their comprehensive study and efficient management.
The process towards integration of the inland water monitoring system maintained by LHMA is focussed on the network optimisation, technical re-equipment and integration of databases.

2.2. Institutional advantages of the hydrological and water quality network design

It is worth mentioning that the Hydrometeorological Agency is a single institution in Latvia that maintains state water quality and hydrometeorological observation networks. Since set up of environmental quality observations, the environmental quality network has been built based on the existing hydrometeorological network.

The hydrological network is characterised by the following:

- a basic network of stations that provides information to conduct an overall assessment of national water resources;
- good integration with the meteorological network;
- all stations in the basic network have been operating for a relatively long period;
- uniformity in timing of the observations.

The existing water quality monitoring network operates on the principle of basins and meets the following requirements:

- sampling sequence from head water to estuary;
- uniformity in timing of the hydrochemical observations with the hydrological phases;
- running of uniform and recognised water sampling and analysis methods.

Water pollution and dynamics assessments are made on the basis of regime-forming hydrometeorological parameters and water quality data.

Implementation of integrated monitoring by one institution has an advantage in terms of making and implementation of monitoring programmes, more effective management of the network and data analysis.

2.3. Monitoring structure improvement

The year of 1999 saw optimisation arrangements: one of the Regional Hydrological Divisions was closed and its functions were taken over by three other.

The laboratories in Liepaja, Daugavpils, Ventspils and Valmiera and 3 laboratories in Riga were closed, and one re-equipped and accredited laboratory in Riga took over the implementation of the environmental quality testing programme. The existing network and the laboratory provide for implementation of the surface water monitoring programme (hydrological measurements, water sampling and laboratory testing).

2.4. Technical modernisation

A 5-year project was launched in 1998 within the framework of the State Investment Program to equip the hydrological network with water level and temperature telemetry stations. At present, 20 stations (more than 1/3 of the hydrological network) are equipped with dataloggers and modems. An Acoustic Doppler Current Profiler (ADCP) mounted on the boat is used for accurate discharge measurements in previously problematic sites on large and medial Latvian rivers. The project is going on and will result in the changes in the observation practices (4 mobile field measurement units, instead of 56 observers, will carry out measurements).

In 2000, the Environmental Qality Testing Laboratory was equipped with up-to-date analytic digitised systems that improved the accuracy of testing.

2.5. Integration of databases

An active work has just started to integrate different meteorological, hydrological and water quality databases used in the agency in the up-to-date ORACLE-based database system. It will allow for more effective interrelated data management and analysis.

2.6. Economic benefits

The staff who fulfill the programme of hydrological measurements, simultaneously makes water sampling. As a result, expenses for surface water quality monitoring born by one institution is about 5 times lower the costs covered by several organisations involved in the implementation of the programme.

Steps taken for the modernisation of the monitoring network first will be concerned with the staff engaged in the perfomance of observations. It is planned that by the end of 2002 11 hydrology professionals will conduct the measurements, instead of 64 in 1996. Wage expenses are expected to be reduced approximately by 67%. The economic benefit is expected also in the network daily maintenance costs. However, in changing national economic situation, a more precise calculation of economic benefit could not be made.

3. The potential for further integration

Further actions to implement the European Water Framework Directive provisions on integrated monitoring networks will be directed towards continuation of the technical re-equipment of the network, optimisation of the monitoring programmes, more effective use of equipment and personnel.

ANNEX 3

INTEGRATION OF ENVIRONMENTAL MONITORING NETWORKS

Case Study - NE Region of the Environment Agency for England and Wales

Author: Phil Procter

1. BACKGROUND

1.1. Reasons for Integration

The Field Data Services Unit (FDS) was created in 1993 as a business efficiency initiative following from the merger of two regions (Northumbria and Yorkshire) to form a single North East Region of the National Rivers Authority (NRA). FDS continues to provide a service to the NE Region of the Environment Agency for England & Wales (EA) which was formed by joining the NRA with other environmental bodies in 1996.

The creation of FDS followed recommendations from a Project Team set up to establish the most appropriate framework for the management of telemetry and associated systems in the newly merged region. The Project Team concluded that, rather than focus on telemetry, it would be more effective to create one group with responsibility to provide all functions within the business with data relating to field measurements. Until then, field measurement had been carried out by teams which mixed data provision with analysis, modelling and other uses of the data. These teams were not only geographically divided (i.e., between Northumbria & Yorkshire) but also by function. For example, rainfall and river level/flow measurement for Flood Warning & Flood Defence Design was handled by different teams than the same measurement for the Water Resource Management function. Groundwater level measurement and instrumented water quality measurement were also dealt with by separate functional teams. There was also a separate team with particular responsibility for the maintenance and installation of telemetry field units and instrumentation.

FDS therefore represents integration of environmental data provision in the following ways:

- Geographical integration – as a result of the merging of regions.
- Functional integration – providing field measured data for Flood Defence, Flood Warning, Water Resource Management (both surface & ground), Environmental Protection and Fisheries.
- Process integration – with responsibility to collect, transmit, archive, validate and make available all recorded measurements, i.e. the full field data provision process "from sensor to desktop computer" including site installation and top end telemetry support.

1.2. Scope of work

FDS handles the following data types:

- River flows and levels (fluvial and tidal).
- Groundwater levels and pumped quality sampling.
- Rainfall and automatic climate station data.
- River and groundwater temperature.
- Continuous water quality monitors.

The Unit carries out regular servicing of handheld temperature, pH and dissolved oxygen meters for the Region which are used by Environmental Protection Officers in their river and effluent compliance monitoring and enforcement work. Collection of surface water and effluent samples for laboratory analysis is not included in its scope.

1.3. Structure of the Unit

FDS currently consists of 34 fulltime employees organised as follows.

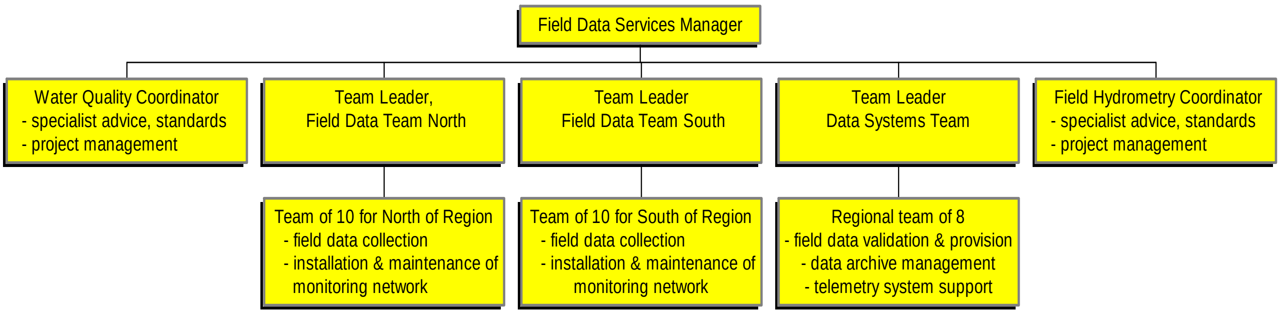

Figure 1.1

The Unit is run as an internal commercial partnership within the business. The service to be provided is agreed and specified annually in a **Partnering Agreement**. The client's interests throughout the year are represented by a single **Client Management Board** (CMB) and three **Business User Groups** (BUGs) for the following business areas:

- Surface water measurement.
- Groundwater measurement.
- Environmental Quality measurement.

The **CMB** is chaired by a non-functional Area Manager and comprises the three BUG chairs, a financial representative and the FDS Manager. It has the following main tasks and responsibilities:

- Represent the Region or client in the provision of Field Data Services.
- Monitor the cost and quality of the overall service provided by Field Data Services against the Partnering Arrangement and its compliance.
- Facilitate the resolution of issues where available resources are not adequate to meet all business needs.

The three **BUGs** comprise user representatives from the Areas and Regional Head Office. They have the following main tasks and responsibilities:

- To co-ordinate requirements and provision of field data within the business area.
- To monitor the cost and quality of performance against the Partnering Arrangement within the business function and identify areas for continual improvement.
- To assist FDS to define, approve and carry out sitework projects.
- To encourage dialogue within the business function across the Areas.

2. MAJOR OPERATIONAL BENEFITS OF THE APPROACH

2.1. Clarity of responsibility and purpose

Bringing the full field data provision process into a single team leaves Flood Warning, Water Resource Management, Environmental Protection & Planning and Fisheries staff to focus their effort without becoming distracted by the need to gather data.

In areas of the business dealing with emergencies, such as Flood Warning, this clear, single line of responsibility reducing the risk of "interface" problems for telemetered data is particularly important.

2.2. Consistency and quality of service

In 1995, FDS gained certification to the international Quality Standard ISO9000 and, every 6 months since then, has been given re-certification by independent accredited auditors. Customer focus and continuous improvement are both fundamental to ISO 9000. External certification gives the clients assurance that work is consistently being carried out to required standards and ensures that proper documentation and audit trails for data exist should they be required.

Internal EA policy and national or international technical standards are more easily applied to all appropriate work activities within a single team than between diverse parts of separate teams.

2.3. Spread of good practice

Integration has encouraged a wider & quicker spread of good practice. For example, best practices of Northumbria and Yorkshire teams in various work areas have been adopted throughout the whole Unit.

Integration has also acted as a driver towards the adoption of a common data validation and archiving system for surface, groundwater and water quality data.

At the same time, areas of the business which had not traditionally used telemetry, such as Environmental Protection, were made aware of its potential to support their activities.

2.4. Better use of skills

Specialist expertise can be more widely used and more easily called upon within a single integrated team reducing unnecessary duplication of training and skill development.

FDS has found through experience that pushing staff too far towards multiple roles ca be counter-productive. However, an appropriate degree of multi-skilling gives the team flexibility and is especially useful to provide short-term cover against sick leave, holidays and other absences.

2.5. Disadvantages and risks

The following disadvantages and risks need to be recognised and understood. They can be alleviated using appropriate staff management methods and a well thought out Partnering Arrangement between Client and Provider.

- The potential for FDS staff to lose touch with functional issues.
- The potential for customers to lose touch with practical monitoring issues.
- Limited staff development opportunities within FDS.

3. ECONOMIC BENEFITS

3.1. Direct

Upon formation of FDS in 1993, the NRA was able to reduce the number of staff involved in field measurement and data provision work from 41 to 27 fulltime staff equivalents (a 34% saving compared to the previous mixed teams) and its salary bill from £632k to £462k.

A regional review of FDS produced in October 2000 shows that, since 1993, the workload has increased by 27% whilst funding has reduced by 3.5% in real terms. This increased efficiency has been achieved through a commitment to continuous improvement which is a direct result of the single, integrated team approach.
For example:

- the reduction in total miles travelled by increasing the breadth of staff skills so that geographical areas of individuals can be reallocated.
- the use of internal benchmarking to raise performance in level measurement (surface & ground) and water quality measurement to match that achieved in river flow measurement.

3.2. Indirect

In general, provision of a regional Service Level Agreement, showing the clear relationship between levels of service and cost, enforces better financial discipline than with the previous mixed teams and allows clearer understanding of how much different parts of the service cost. This supports value-for-money decision making and prioritised budgetting.

Additionally, by splitting out field data provision into a single, integrated team, performance can be much more closely monitored against agreed targets. FDS produces monthly performance reports which are used to highlight areas of concern to clients and redirect effort & resources if necessary.

4. THE POTENTIAL FOR FURTHER INTEGRATION

- Within NE Region, the FDS scope does not extend to the collection of surface water and effluent samples for laboratory analysis. The potential benefits from this further integration are being examined.
- Within NE Region, the FDS scope has not been extended to non-water field measurement (air and land). There are potential benefits from this further integration.
- Nationally, the EA has not adopted the FDS integrated approach. A current national project, BRITE (Better Regulation to Improve the Environment), is looking at work processes and appropriate staff structures within Environmental Protection and Water Management functions. FDS is recognised as a potential model to be examined.