European Union

Spain/Portugal hydrological appraisal

European Commission

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Luxembourg: Office for Official Publications of the European Communities, 1998

ISBN 92-828-2513-2

Printed in Italy

PRINTED ON WHITE CHLORINE-FREE PAPER

Preface

Each year, the Directorate-General for Regional Policy and Cohesion of the European Commission launches a number of studies in the field of regional policy, cohesion and regional planning. These studies mainly aim at providing a basis for policy formulation internally, as well as the preparation of programmes, projects and initiatives and a basis for analysing the impact of current or planned activities.

With this series, the Directorate-General hopes to stimulate discussion and action in a wider sphere on the research results received. The publication of the studies is addressed to politicians and decision-makers at European, regional and local level, as well as to academics and experts in the broad fields of issues covered.

It is hoped that by publicising research results the Commission will enrich and stimulate public debate and promote a further exchange of knowledge and opinions on the issues which are considered important for the economic and social cohesion of the Union and therefore for the future of Europe.

Readers should bear in mind that the study reports do not necessarily reflect the official position of the Commission but first and foremost express the opinion of those responsible for carrying out the study.

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1. Introduction

1.1. Objectives

The mission set out to cover the following points, on the basis of available reports and information:

- to understand the regional water resource availability, utilisation and quality implications in the river basins;
- to provide an analysis of the water resource development schemes in Spain and Portugal;
- to identify real regional problems independently of institutional constraints and individual country needs;
- to analyse the main environmental consequences of present and planned water resource schemes for the river basins common to Spain and Portugal;
- to identify areas of potential difficulties within each country, and in relation to cross-border issues;
- to assess the project investment programmes and their compatibility in Spain and Portugal;
- to analyse the monitoring and control systems, their proposed developments and their compatibility;
- to identify shortfalls of information and the need for further quantitative or qualitative studies or investigation on the river basins or other related issues.

The mission has involved an examination of selected existing documents and reports and a review of plans for future water resource development. The mission has not undertaken any new engineering or environmental studies. The main output from this mission is therefore to give a first response to the issues listed above.

The scope of the mission concentrated on the basins of the main rivers common to both Spain and Portugal, which are illustrated in Figure CF/11, namely:

- Duero/Douro (Spanish/Portuguese),
- Tajo/Tejo (Spanish/Portuguese),
- Guadiana,
- Miño/Minho (Spanish/Portuguese).

Other river basins have also been examined, and in particular their relationships to the abovementioned basins have been identified, as a part of national planning.

Further steps will be decided by the Cohesion Fund, on the basis of the findings of this mission.

1.2. Main activities

The mission has been subdivided into the following three main stages:

- development of the terms of reference;
- data collection;
- review and analysis of available data.

Each stage is briefly summarised below.

1.2.1. Terms of reference

- Montgomery Watson (MWL) representatives visited the Cohesion Fund on 3 November 1994 to discuss the terms of reference.
- MWL prepared a project definition report in November 1994.
- The report was discussed in a meeting with the Cohesion Fund on 18 November 1994.
- The terms of reference for the project were sent to MWL by the Cohesion Fund on 25 November 1994. The project was subdivided into Stage 1, 'Data collection', and Stage 2, 'Review and analysis'.

1.2.2. Stage 1: Data collection

- Initial meetings between MWL, Cohesion Fund and country representatives took place in Lisbon on 12 December 1994 and in Madrid on 13 December 1994.
- Investigation of data sources in Portugal commenced in December 1994.
- The MWL Spanish team was approved by the Cohesion Fund in February 1995.
- The draft interim report on data collection was prepared by MWL and forwarded to the Cohesion Fund in March 1995.
- The report was discussed in Brussels with the Cohesion Fund on 6 April 1995.

1.2.3. Stage 2: Review and analysis

- At the meeting on 6 April 1995 it was agreed that Stage 2 would be subdivided as follows:
  (i) Review and analysis — Preparation of separate interim reports for Spain and Portugal.
  (ii) Integration of results.
  (iii) Draft final report followed by the final report.
- Guidelines for Stage 2 were prepared by MWL and sent to the Cohesion Fund on 13 April 1995.
- Approval for Stage 2 was received from the Cohesion Fund on 19 May 1995.
- The MWL mission manager visited Spain and Portugal in June 1995 to supervise Stage 2.
- The interim reports on Spain and Portugal were sent to the Cohesion Fund on 17 and 18 July 1995 respectively.
- A meeting was arranged by the Cohesion Fund on 20 July 1995, to review the interim reports.
- A revised version of the interim report for Portugal was forwarded to the Cohesion Fund at the end of September 1995.
- Integration of results between Spain and Portugal took place in October 1995, leading to the preparation of the draft final report.
- A presentation meeting was arranged by the Cohesion Fund on 13 October 1995 in Brussels to review the findings of the draft final report with the country representatives.
- Responses were received from the Spanish and Portuguese authorities by early December 1995 and incorporated into this final report.
- The final report was completed in December 1995 in English and translated into Portuguese and Spanish and submitted in January 1996.
- On 28 February 1996, the report was presented to the Cohesion Fund and representatives of Spain and Portugal at a meeting in Brussels. Both countries had further comments on the final report.
- In March 1996, meetings were held in Madrid and Lisbon to discuss the report. Further consideration was given to the respective country comments.
- A revised version of the final report was completed and submitted in September 1996.
- Further minor comments were received and incorporated into the final report, which was reissued in January 1997.

1.3. Approach

In order to ensure a common approach in both Spain and Portugal, guidelines were developed and discussed with the Cohesion Fund, prior to commencing Stage 2. Work then proceeded, leading to the preparation of an interim report in each country. The main issues from both countries have been integrated and

summarised in the present document together with our recommendations for further studies.

In Stage 2, the main approach has been to examine the present and future situation with regard to water resources and water quality in both Spain and Portugal, and to prepare separate interim reports for each country.

The separate reports for Portugal and Spain have been compared to assess the main similarities and differences between the countries and, in particular, to address common basic issues.

The present document summarises the results in both countries and discusses the main issues resulting from the study objectives.

This report should therefore be read in conjunction with the Stage 2 review and analysis interim reports — Volume 1: Portugal and Volume 2: Spain — with the final version of this document as the governing document.

Further information was also provided by both countries during the review period, and, if not included in the main text of this report, is presented in Appendix C.

As a result of the meeting of 28 February 1996, it was considered necessary to include comments in this revised report that reflected the opinions of each country, if they differed from each other and/or from Montgomery Watson's own conclusions.

1.4. Responses to the draft final report

The Spanish and Portuguese authorities commented as noted above on the draft final report. Their main concerns are listed below, with comments on how they have been addressed in this final report.

1.4.1. Spanish responses

Comments from the Spanish authorities were sent to the Cohesion Fund in a letter dated 8 November 1995 from Mr Adrián Baltanas García.

The main comments, as listed in the letter were:

- consideration of extreme hydrological events such as droughts and floods;
- transfer of resources between basins to address the serious structural problems faced by many regions of Spain;
- recognition of the efforts made by Spain in terms of improving the investment and operation of sewage treatment facilities;
- adding more emphasis to the monitoring of water resource systems.

Montgomery Watson has responded to these comments by:

- recommending further studies to assess the resource availability under drier conditions and also to consider the requirement for ecological flows in all the basins of Spain and Portugal;
- including, as a possible solution to the low reliability of water resource systems, the use of water transfers, as proposed in the Spanish preliminary national hydrological plan;
- providing more detail to support comments made regarding the operation and investment by Spain in sewage treatment facilities;
- adding further comments to recognise the potential for coordination between Spain and Portugal regarding the monitoring of water resource systems, especially in the international basins.

1.4.2. Portuguese responses

Comments from the Portuguese authorities were initially received by the Cohesion Fund in a letter dated 23 October 1995 from Mr Pedro Cunha Serra, with further comments received by Montgomery Watson via the Cohesion Fund on 15 December 1995. The main comments in the letter of 23 October 1995 were:

- consideration of extreme hydrological conditions and ecological/environmental flows;
- impacts to downstream users from increased artificial influence of water resource projects on water resources and the environment;
- the importance of the existing conventions between Spain and Portugal regarding water resource allocation along the international rivers;

- the need to assess the cumulative impacts of water resource developments in Spain and their impacts on the environment and Portugal.

In the further comments received by Montgomery Watson on 15 December 1995, these concerns were repeated. Montgomery Watson has responded to these concerns in the final report by:

- recommending further studies to assess resource availability under drier conditions, including estimation of ecological flows in the rivers and basins of the Iberian Peninsula. This will supplement the results already derived in the Portuguese interim report;

- recognising the need for integrated management of the international basins to ensure that the water resources are used and developed in a manner that is beneficial to both countries and meets environmental requirements;

- Including and commenting on the importance of the conventions between Spain and Portugal in defining water resource allocation in the international basins;

- recommending that water resource developments should be assessed in a global rather than piecemeal manner, so that cumulative impacts can be identified and addressed.

1.5. Responses to the final report

As stated earlier, further comments regarding the final report as presented at the meeting on 28 February 1996 were made by both Spain and Portugal. As a result of these comments, further meetings were held in Lisbon, Madrid and Brussels to discuss the contents of the final report. Following these meetings, further revisions were made to the final report, which was reissued in September 1996. Minor comments were received and added to the final report, which was again reissued in January 1997. Where either or both countries had opinions that differed from each other and/or Montgomery Watson, these were included in the report in italics.

1.6. Water resources definitions

Spain and Portugal have differing definitions related to water resources. The Spanish use the term guaranteed resources, based on the criteria laid down in the 'Instrucciones y recomendaciones técnicas complementarias para la elaboración de los planes hidrológicos de Cuenas Intercomitas'. In brief, the concept of guaranteed resources is associated with a determined demand which can be satisfied with available hydraulic resources at specified levels of maximum water deficits. These levels of maximum water deficits vary from 5 % in one year for urban water supply to large cities to 15 to 20 % in one year for agricultural irrigation water demands.

The Portuguese use the term usable resources, which are the annual volumes of water that can be used when and where they are required, and that are associated to a need that is satisfied with a given level of reliability. This varies from between 95 and 100 % for urban and industrial water supply to 80 % for agricultural water demands.

It should be noted that these definitions are not identical, and result in different estimates of water resources. This should be borne in mind when reading this report. Both definitions are expanded upon in Appendix A to this report.

2. Spain

2.1. Overview

During the preparation of the Spanish interim report (SIR), the following available public information and reports were used:

- Anteproyecto del Plan Hidrológico Nacional (Moptma, 1993);
- Atlas Nacional de España (Moptma, 1993);
- Plan Nacional de Saneamiento y Depuración (Moptma, 1995);
- Libro Blanco de las Aguas subterráneas (Moptma-MINER, 1995);
- Informe del Consejo Nacional del Agua;
- Data obtained from the national hydrological plan as part of its revision.

None of the many detailed studies and projects that have been carried out in support of the preliminary document for the national hydrological plan (NHP) have been analysed, nor the proposals for the basin hydrological plans, which are now being prepared.

It is important to note that at the time of the preparation of the SIR the work required to finalise the national hydrological plan was still being carried out. Only after this has been finalised will the document be presented to the Spanish Parliament for discussion and approval. As such, the scope and the content of the information analysed are likely to undergo modification. In particular, it is likely that:

- the figures for demand established in the original document are likely to be adjusted to a lower level;
- there will be enhanced detail covering the irrigation plan;
- the analysis of the feasibility of the proposed transfers will be studied in greater depth;
- the understanding of the possible availability of underground water resources will be studied in greater depth, including their coordinated use with surface water.

Independently of any of these adjustments to the preliminary national hydrological plan, the correction of the imbalances between the hydrographic basins, caused by the irregular temporal and geographic distribution of the water resources in Spain, suggests that the transfers between the basins should be considered the most stable and adequate solution, provided that the volumes to be transferred are shown not to significantly affect the international rivers.

Spanish comment

The analysis of the hydraulic resources regime that has occurred in the last few years confirms the need for the measures proposed in the Spanish national hydrological plan. From the autumn of 1990 to the autumn of 1995, half of the Spanish territory — the Guadiana, Guadalquivir, Sur, Segura and Júcar basins — has suffered a severe drought with run-off well below average values and the Guadiana basin has virtually dried out with hardly any run-off at all in the last three years.

In 1990, the reserves in the Spanish part of these five basins were more than 10 000 hm^3, which guaranteed urban supplies (with certain restrictions and the use of groundwater) and a reduced supply for irrigation in the first years of the drought. In 1995, these reserves

were reduced to 1 700 hm³, which only allowed irrigation for those crops which were permanent (fruit trees).

The drought cycle was broken in late 1995, raising stored volumes to 11 600 hm³, although this recovery has been much less in the Júcar and Segura basins. As well as filling the reservoirs, an important volume of water has been passed to Portugal — 10 000 hm³ in the Miño, 7 000 hm³ in the Duero, 9 000 hm³ in the Tajo and 2 000 hm³ in the Guadiana. The operation of the Spanish dams of the Tajo river basin during the floods that occurred in December 1995 and January 1996 reduced flood flows significantly. This reduced damages and flooding that would have occurred in Portugal under natural conditions, and was a result of the coordination in the operation of the water resource systems.

The actions within the preliminary national hydrological plan include proposed transfers whose general effect on the international rivers at present is thought to be limited. At this stage, it is considered that, overall, the environmental balance will be positive, for the following reasons:

- the increase in treatment of waste waters;
- the elimination of overexploitation and saline intrusion into the aquifers;
- the protection of the wetlands;
- the recovery of the public hydraulic domain, flood defence, etc.

However, it is recognised that it will be necessary to analyse in more detail the environmental impact on the international rivers of the actions proposed in the plan.

Portuguese comment

The overall environmental balance of the national hydrological plan has not yet been determined and it could be either positive or negative. It should, however, be noted that the Portuguese have conducted numerous studies on the potential impacts of the transfers as proposed in the preliminary national hydrological plan. These studies have raised a number of issues, including the importance of water needs estimates and how they relate to the justification for the transfers. Also, these studies have noted that increasing the regulation of river flows as part of the transfer schemes has the following consequences:

- *reduction of river flows;*
- *modified flow regimes;*
- *increases in the severity and frequency of dry years and the duration of the sequences of dry years;*
- *modified water quality;*
- *retention of sediment/reduction in sediment delivery.*

Moreover, the real effects of the transfer schemes depend upon the design and the rules adopted for their operation.

In order to achieve the objectives of the plan, it is essential that for each one of the measures proposed, detailed studies are undertaken and that the budgets are structured in such a way as to allow the preparation of suitable projects before any construction starts.

The main hydrographic basins in Spain are shown in Figure CF/01.

The main conclusions of the SIR are summarised below.

2.2. Water resources

2.2.1. Main conclusions

From the information provided, the following main conclusions have been drawn:

- Although Spain nationally has a positive balance between resources and demands, there are resource problems in the south and east of Spain, as well as locally in other regions in terms of both quantity and quality. There also exists the risk of flooding and flood damage.
- There is an important irregularity both in the temporal and geographic distribution of the rainfall in Spain. The annual average precipitation throughout Spain is shown in Figure CF/02.
- Without regulating elements, the guaranteed resources would be very much reduced.
- A high level of regulation already exists on all the rivers, except the Duero and Ebro, which means that there is little possibility for additional regulation in the basins with the highest deficit.
- There is a high concentration of increasing demand in the areas of lowest rainfall (coastal, east and south), and greater resource deficit.

- There are problems of overexploitation and saline intrusion into the aquifers in the areas of lowest rainfall.
- There are a large number of different administrations with competency in the area of water resources.
- There is good hydrographic information and automatic data recording systems are already in position.

2.2.2. Present situation

- The water demands used for this study have been obtained from the 'Proyectos de Directrices' (Phase 2 of the planning process), which in some cases were prepared in 1989.
- The Norte, Duero, Tajo and Ebro basins have positive balances but with some local deficits.
- The remainder of the basins are deficient in water resources and have important local deficits.
- There are serious problems of overexploitation of aquifers in the Guadiana basin (Tablas de Daimiel), Segura, Júcar and Sur (Almeria).
- The total water demand is 37 000 hm^3/year. The distribution by use is shown in Table 2.1.
- The usable water resources are estimated at 47 340 hm^3 (excluding return flows and desalination/reuse), although their geographic distribution is very distinct from the demand distribution.

Table 2.1
Present water use in Spain

Water use category	hm^3	%
Urban supply	4 305	11.6
Independent industrial uses	1 944	5.3
Agricultural uses	24 245	65.4
Other uses	6 598	17.7
Total	37 092	100

- There is nationally a positive hydraulic balance, but local deficits total 3 000 hm^3/year. Some basins have global deficits, the largest of which is in the Segura basin.
- The agricultural sector utilises the largest amount of water. Increased agricultural development in the southern part of Spain is considered to be important for the future economy of the country.
- A number of studies and actions have been initiated to improve the efficiency in water use, especially in irrigation. Plans for desalination and reutilisation are also being developed. These studies should have been completed in 1996-97 and the transfer volumes required in the future should have been confirmed.
- There is likely to be a reduction in annual average flows reaching Portugal in the four international rivers.

2.2.3. Future situation

(i) Overview

- Very extensive hydrological investigations at both the river basin and national levels have been undertaken, and are currently in progress, to identify appropriate solutions. The main outcome is the possibility of developing further resources by increased regulation of river flows, and transferring surplus water from the northern part of Spain to the south and east.

Spanish comment

In the future, the variation in flows with respect to the existing situation will be greatly reduced, as the increases in consumption and transfers in Spain are reduced.

In effect, according to the existing treaties, Spain is authorised to transfer some 1 500 hm^3/year from the shared rivers (1 000 hm^3/year from the Tajo and volumes from the head waters of the Tua and

Chanza basins that are estimated at 180 hm³/year and 300 hm³/year, respectively, although at the present time only 440 hm³/year are transferred — 320 hm³/year and 120 hm³/year from the Tajo and Chanza respectively). According to the proposals in the national hydrological plan, the maximum volumes that would be transferred are given in Table 2.2.

Table 2.2
Summary of transfers according to existing treaties and proposed under the Spanish national hydrological plan

Basin	Average run-off in Spain	Transfers according to the treaties		Transfer according to Spanish NHP	
	hm³/year	hm³/year	%	hm³/year	%
Duero	15 000	180	1.2	1 100	7.3
Tajo	12 200	1 000	8.2	350	2.9
Guadiana	5 000	300	6.0	400	8.0
Total	32 200	1 480	4.6	1 850	5.7

If, in the new treaty (between Spain and Portugal), the transfers are eliminated in the dry periods (summer) and there is coordination in dry years, the additional effects of the transfers would be very much reduced.

At the same time, the increase in consumption in Spain would be very much reduced as is shown in Table 2.3.

Table 2.3
Estimated current and future water demands and consumption

Basin	Average run-off in Spain	Actual demand	Actual consumption (1)	Future demand	Future consumption (1)	Increase in consumption (1)	
	hm³/year	hm³/year	hm³/year	hm³/year	hm³/year	hm³/year	%
Duero	15 000	3 900	2 900	5 400	4 100	1 200	8.0
Tajo	12 200	2 750	1 750	3 100	1 920	170	1.5
Guadiana (2)	5 000	2 020	1 500	2 450	1 810	310	6.2
Total	32 200	8 670	6 150	10 950	7 830	1 680	5.2

(1) Equivalent to demand minus return flows.
(2) This does not include demand satisfied from non-renewable resources.

Portuguese comment

An analysis carried out by the Portuguese authorities indicates that the transfers and associated hydraulic works will have a significant impact on the flows reaching Portugal from Spain in the international rivers. Table 2.4 summarises the results of these studies for the rivers Tajo/Tejo, Duero/Douro and Guadiana for the reconstructed natural flow, the average flow based on the current levels of water resource development, and the average flow based on the proposed levels of development under the preliminary national hydrological plan.

Table 2.4
Estimated mean annual flows in the international basins

(hm³/year)

River basin	Location	Period of analysis	Status of basin			
			Natural	Current	Predicted for 2012	
					Without transfer	With transfer
Duero/Douro	Barca d'Alva	1940-89	13 900 14 990(1)	10 600 11 690(1)	9 270 10 360(2)	8 190 9 280(2)
	River mouth	1940-89	23 130	18 880	16 160	15 020(3)
Tajo/Tejo	Cedilho	1940-85	12 440 12 230(6)	9 800(4) 9 680(6)	— —	9 300(5) 9 180(6)
	River mouth	1940-85	18 650	13 320(4)	—	12 140
Guadiana	Caia	1946-85	3 995(6)	2 090(6)	1 540	—
	Alqueva	1946-85	4 960 4 250(6)	2 765 2 310(6)	2 195 1 760(6)	— —
	River mouth	1946-85	6 670 4 970(6)	4 095(7) 2 880(6)	— —	2 040(8) 2 090(6)

(1) Including the upstream parts of the Tua and Sabor river basins.
(2) Including only the transfer of 900 hm³/year.
(3) Including the transfers of 900 hm³/year plus 180 hm³/year (Tuela/Perreira) plus 60 hm³/year (Sabugal).
(4) Including the present transfer of 320 hm³/year.
(5) Including the transfer of 600 hm³/year.
(6) Considering only the Spanish part of the river basin.
(7) Including the transfer of 120 hm³/year (Chança), without returns.
(8) Including the transfer of 300 hm³/year (Chança), without returns.

As can be seen, the results indicate an overall reduction in annual average flows entering Portugal from Spain by 2012 compared with the current situation. These reductions are estimated to be 12.6 and 26.3 %, without transfers, on the Barca d'Alva and Caia sections of the Duero/Douro and Guadiana river basins respectively, and 21 and 5.1 %, with transfers, on the Barca d'Alva and Cedilho sections for the Duero/Douro and the Tajo/Tejo river basins respectively. Considering the mouth of the rivers, the reductions are expected to be 14.4 % for the Duero/Douro river basin, without transfers, and 21, 8.9 and 50 % for the Duero/ Douro, Tajo/Tejo and Guadiana river basins, with transfers, respectively.

The analysis also indicates a general increase in the frequency and duration of low flows and a reduction in the seasonal character of the flow regime due to increased river regulation.

It is recognised, however, that the operation of the proposed transfers will have a significant impact on the average annual flows and other aspects of the flow regime of the international rivers.

(ii) Growth of resources

- An increase of 14 % of the usable resources (6 691 hm³) is proposed in the period under consideration (up to the year 2012), after having suppressed the overexploitation of aquifers by the following actions:

  (a) improvement in the efficiency of uses;

  (b) improvement in the infrastructure, thus reducing losses;

  (c) completion of the regulation works proposed at present in the different basins;

  (d) reutilisation of waste water;

  (e) improvement in the management of resources and demands;

  (f) conjunctive use of surface- and groundwater resources.

- This will achieve a total national guaranteed water resource of 54 031 hm^3.

- At the present time, there is little possibility of increasing the capacity for regulation in the deficit basins (Segura and Júcar); however, there is more capacity for action in the Duero and Ebro basins.

- Resource problems will remain even with the adoption of the measures described above. Thus, the policy of transfers would appear to be necessary to compensate for the resources' imbalance between the basins of the north, south and west.

Spanish alternative

Overall, the result is that it is essential to have a policy of transfers to compensate for the resources' imbalance between the basins.

Portuguese comment

The new policy of water transfers in Spain will only be accepted by Portugal if the new convention between both countries will guarantee the actual and the potential uses of the water resources of the shared river basins and that the environment will not be significantly affected.

(iii) Growth in demands

- Significant increases in population, economic and agricultural activity are occurring in the southern areas of Spain and along the Mediterranean coastline.

- The future demands initially proposed in the preliminary national hydrological plan are based on the estimates made by the different basin organisations, which, in some cases, could lead to an overevaluation of the requirements. Later revisions have been made, that tend to reduce the demands estimated for each basin.

- The overall rate of demand growth estimated for each use up to the year 2012 is as follows:

Water supply and urban industrial use:	46 %
Independent industrial uses:	24.9 %
Agricultural uses:	14 %
Other demands:	11 %
Total increase in demand	17.7 %

- The total estimated demand in the year 2012 is 43 678 hm^3. The distribution by use is shown in Table 2.5.

Table 2.5
Predicted water demand in the year 2012

Water use category	hm^3	%
Water supply and urban industrial uses	6 285	14.4
Independent industrial uses	2 429	5.5
Agricultural uses	27 637	63.3
Other demands	7 327	16.8
Total	43 678	100

- A recommendation of the National Water Council is that the demand levels should be reconsidered and they have recommended six different levels of demand which have been compared with four hypotheses for resource availability.

(iv) Hydraulic balance

- The hydraulic balance under average conditions in the horizon year of 2012 is expected to be practically the same as at the present time with a positive balance of resources in the Norte, Duero, Tajo, Guadiana and Ebro basins, but with some local deficits, and a shortage of resources in the Guadalquivir, Guadalete-Barbate, Júcar, Segura and Sur basins and the Cuencas Internas Catalanas.

- The summary analysis of each basin is as follows:

Norte:	This is one of the hydraulic reserves of the country. It is vulnerable because of the difficulty of regulating its resources in the centre and eastern areas.
Duero:	It is necessary to regulate the resources from the upper zones.
Tajo:	It is necessary to guarantee water supply to Madrid.

Guadiana:	It is necessary to recover the Tablas de Daimiel aquifer.
Guadalquivir:	This is a deficit basin.
Sur:	This is a deficit basin particularly in the eastern part, which is also an important tourist and agricultural area.
Segura:	This is a deficit basin.
Júcar:	This is a deficit basin.
Ebro:	This is a basin with excess flows, but has local deficits in the upper area.
Cuencas Internas Catalanas:	These are deficit basins.

(v) Planned development

Two main types of action are proposed to correct the deficit situation in some of the basins:

- increase the available resources of each basin by increasing the regulation and improving the operating conditions;
- redistribute water between the basins by transfers.

The possibility of constructing new regulating works is limited to the Duero and Ebro basins.

The only real possibility to solve the problems of the deficit basins is the construction of works for the transfer of water resources.

The planned transfers are the Norte-Duero scheme, and the Ebro scheme and a series of local transfers of lesser importance. An example of the proposed future water transfer scheme in the year 2012 is shown in Figure CF/03.

The Norte-Duero scheme consists of the joint operation of both basins regulating excess flows of 1 130 hm^3/year which would be transferred to the head waters of the Ebro, to Jalon, to the Tajo, to the head of the Guadiana and to the Guadalquivir, Sur, Júcar and Segura basins.

The Ebro scheme will transfer 1 855 hm^3/year from the lower part of the river to the Cataluña, Júcar, Guadalquivir, Sur and Segura basins.

If all these actions are completed, the deficits and the overexploitation will be eliminated and the hydraulic balance of all the basins will be improved, except for the Duero, whose excess flows will reduce from 4 521 hm^3/year at the present time to 4 322 hm^3/year in the year 2012.

2.3. Water quality

Plans exist for the management of the public hydraulic domain, the main objectives of which are the protection of water quality and the hydraulic environment. There are a number of instruments, each with specific objectives and lines of action, as follows:

- The national plan for sewerage and sewage treatment aims to provide adequate treatment of waste waters and sludges. Results indicate that at present only 41 % of the population have access to adequate waste water treatment, although plants under construction will increase this to 54 %. There still exists a large requirement for further investment in order to comply with the directives of the European Community.

  Some of the existing plants, principally the smaller ones, function inadequately, resulting in poor river water quality. The situation is generally more acute in the drier areas and adjacent to towns and cities. Agricultural and industrial discharges can result in localised pollution problems.

  Similarly, again generally in the smaller plants, there is an insufficient level of management in some of the treatment works and certain design problems in some of the existing plants.

  The national plan for sewerage and sewage treatment has a planned investment during the period 1995 to 2005 of ESP 1 896 985 million and aims to prioritise work on treatment of urban and industrial waste discharges to cross-border rivers, areas of high ecological value and rivers which discharge into the Mediterranean. This plan also requires the setting of a tax to cover the operation and maintenance of the plants.

- Poor groundwater quality occurs in many areas of Spain due to the overabstraction of groundwater and a lack of policies for the protection of groundwater. The main problems are saline intrusion in coastal areas and high nitrate levels in aquifers located in agricultural areas.

- Existing monitoring programmes provide information on water quality and discharges. The SAICA project will be a large advance in this area, and has already received financial support from the Cohesion Fund. Recent surface water quality results are shown in Figure CF/04.

- Other instruments directed towards improving water quality are the LINDE and Pichra programmes, which have also received financial support from the Cohesion Fund. These aim to define and restore the public hydraulic domain. Finally, there is the national plan for the reuse of waste waters to promote more efficient use of water.

2.4. Environment

Within the national hydrological plan, a series of actions have been identified for the restoration and conservation of the hydraulic environment.

The main objectives identified are:

- to eliminate hydraulic deficits;

- to provide environmentally acceptable river flows to maintain the environmental and ecological condition of the main rivers and estuaries;

- to restore river banks and margins;

- to control soil erosion and attenuate floods;

- to protect existing wetland areas;

- to improve the recreational use of rivers and reservoirs;

- to improve river water and groundwater quality.

At this stage, it is likely that further detailed studies will be necessary to assess the requirements to meet each of these environmental objectives. For instance, as a general principle, assigned environmental flows have been assumed to be at least 1 % of the basin natural resources. In a number of basins, this is 2 % or higher. Although use of these figures assists in basin planning, more detailed assessment of the environmental and ecological needs of the major Spanish rivers and their estuaries will be necessary. This will help to ensure that the developments proposed in the Spanish preliminary national hydrological plan have a minimal environmental impact. This process has already started with a major joint study between Spain and Portugal on the lower reaches and estuary of the River Guadiana.

Nevertheless, at this time, the overall global balance of the environmental actions included in the preliminary national plans for treatment and hydrological planning are considered to be positive.

However, it will be necessary to analyse in more detail the environmental impact of the specific actions proposed within the plan.

2.5. Planning and investment

The planning process is complex involving many different institutions, different levels of the administration and the autonomous communities covering the whole country.

The financing of the investment is shared between various institutions. That part corresponding to the central administration is made via the general State budget which has to be approved annually.

Investment and infrastructure for the improvement of water resources, water quality and the water environment is contained within two main plans, each of which is briefly summarised below.

- The largest is the national hydrological plan, which contains provision for a wide range of improvements, the main components of which are listed in Table 2.6. The overall investment programme is for ESP 3.6 billion over the period 1993-2012. The distribution of the investment by sector is shown in Figure CF/05.

- The second is the framework for the management of the public hydraulic domain, the main objective of which is the protection of water quality and the hydraulic environment. This plan contains several important instruments relevant to this study:

  (a) preventive measures include the national water quality control network, SAICA;

  (b) the national plan for sewerage and sewage treatment, to comply with Directive 91/271/EEC, has an overall investment programme of ESP 1.9 billion;

  (c) Improvement of the public hydraulic domain includes the LINDE and Pichra programmes;

  (d) the national plan for the reuse of waste waters.

The funds available for these investments come from financial budgets and depend upon the financial/economic regime in Spain over the implementation period.

Table 2.6
Proposed infrastructure investment

Programme	Investment (10^9 ESP)
Increase in hydraulic resources and transfers	1 450
Sewerage and sewage treatment (22 % of final cost)	325
Defence against flooding	490
Improvement and environmental protection	225
Irrigation	525
Hydroelectric equipment	20
Water conservation	525
Research and development	40
Total	3 600

3. Portugal

3.1. Overview

For the preparation of this report, the main sources of data and information are listed in Chapter 3 of the draft interim report, prepared as part of Mission A in March 1995. This information has been supplemented by recent discussions with the main organisations responsible for the activities relevant to this study.

The national water plan for Portugal is about to commence under the supervision of INAG. The plan has a similar purpose to the Spanish national hydrological plan, and will be concerned with water resource evaluation, the prediction of future water demands, the development of additional water resources and protection of the aquatic environment, as well as future planning and development within the water sector. The locations of the main hydrographic regions in Portugal are shown in Figure CF/06.

As this report precedes the findings of the national water plan, which is receiving financial support from the Cohesion Fund, data and information relevant to the main components of the plan have not yet been developed or published. It is considered likely that longer-term water resource planning and development will probably undergo modifications and be revised as a result of the plan.

Further information has been provided by INAG and is presented in Appendix C. The results presented in this report should be considered as preliminary, and may undergo significant revision as the national water plan is developed and later finalised.

The present main conclusions are summarised below.

3.2. Water resources

3.2.1. Main conclusions

From the available information, the following main conclusions have been drawn:

- There are important differences in both the temporal and geographic distribution of rainfall within Portugal. The southern half of the country is particularly dry, receiving 60 to 65 % of the Portuguese mean annual average. Within the year, about 75 % of the rainfall occurs from October to March.

- Due to this uneven distribution of rainfall, surface flows also display variability, both between and within basins.

- There is generally a low level of reservoir storage regulation on the rivers in Portugal, which affects the usable water resources, particularly in the dry period of the year, and especially during prolonged droughts. This is a reflection of the lack of suitable dam sites.

- Portugal depends on the hydraulic resources of the international basins, and as such on the volumes that come from Spain and their temporal distribution.

- The Spanish regulation of flows reduces the risk of flooding and at the same time could increase the usable resources for Portugal with coordinated management.

- The largest water demands are in the Tejo basin, followed by the Douro, Mondego and Vouga regions, as defined in Figure CF/11.

- Agriculture represents the largest water demand. The smallest water demands are for thermal energy and public water supply.

- There is good hydrometric information on rainfall, climate and stream flow. The location of climatological and stream-flow gauging stations is shown in Figures CF/07 and CF/08 respectively.

3.2.2. Present situation

- All hydrographic regions have surplus water resources during average conditions, but low regulation due to a lack of reservoir sites can lead to localised problems of maintaining water supplies during dry conditions, particularly in the Guadiana, Sado/Mira, and Algarve regions.

  The Alqueva, Odeleite-Beliche and Odelouca-Funcho projects thus address these water resource problems in southern Portugal.

- The total water demand is estimated at 10 849 hm^3/year. The distribution by water use category is shown in Table 3.1 (these values are based on estimates supplied by INAG in March 1996 and included in Appendix C to this report).

Table 3.1
Present water use in Portugal

Water use category	hm^3	%
Domestic and public supply	1 017	9
Industry	779	7
Irrigated agriculture	8 570	79
Energy	483	5
Total	10 849	100

- The usable resources are estimated to be approximately 12 910 hm^3, including return flows. Of these, approximately 4 270 hm^3 are from Spain. (These are preliminary estimates provided by INAG and are included in Appendix C to this report.)

- The agricultural sector utilises the largest amount of water, accounting for approximately 79 % of the water demand. The largest agricultural demands occur in the Tejo, Douro, Mondego and Sado regions. The demand for this water is concentrated in the driest period of the year.

- Domestic and public water supplies are below the European average in terms of per capita demand and the proportion of the population served by piped water supplies.

3.2.3. Future situation

(i) Overview

- Extensive hydrological investigations at both the river basin and national levels are expected to be undertaken as part of the national water plan, to identify appropriate long-term solutions for water resource development in Portugal.

- The main outcome is likely to be the development of additional regulatory reservoir storage, localised water transfers, conjunctive use of groundwater and surface water, improved operating policies, increased monitoring, and improved environmental protection.

- The actions proposed in the Spanish preliminary national hydrological plan are expected to have overall negative impacts on the flow regimes but an overall positive impact on the water quality of the international river basins. As currently proposed, there will be a reduction in mean annual flows as well as other changes to the river flow regimes.

Spanish alternative

The improvements proposed in Spain as part of the Spanish national hydrological plan are generally expected to have a beneficial global impact on the flows and quality of water in the international rivers.

(ii) Growth of resources

Chapter 6 of the Portuguese interim report lists many proposed water resource schemes which are either under development or proposed for the future.

Most of the schemes are multipurpose dam developments involving provision of water for domestic water supply, irrigation, hydropower, flood control, industrial water supply, etc.

INAG provided preliminary estimates of usable resources for the year 2015. The estimates indicate an increase in usable resources from 12 900 hm^3 to 15 100 hm^3, which constitutes a 17 % increase. Of these, 3 900 hm^3/year are from Spain.

A significant part of this increase is related to the Alqueva scheme, which will provide usable resources to the Guadiana, Algarve and Sado hydrographic regions. Other important water resource developments in southern Portugal which aim to increase the security and reliability of supplies include the Odeleite-Beliche and Odelouca-Funcho schemes.

Significant increases in usable resources in the following rivers are proposed: Guadiana, 1 127 hm^3/year; Douro, 547 hm^3/year; Vouga, 200 hm^3/year; Tejo 63 hm^3/year; and Sado 56 hm^3/year.

(iii) Growth in demand

Water demands for the future for each sector are summarised in Table 3.2, and these estimates are based on preliminary information provided by INAG in March 1996.

Table 3.2
Estimated future water demand

(hm^3/year)

Water use sector	Present	2000	2015
Irrigation	8 570	9 383	12 077
Industry	779	785	803
Domestic and public supply	1 017	1 052	1 156
Total	10 366	11 220	14 036

Water demands are expressed in hm^3/year under average conditions.

The estimated rate of demand growth for each use is summarised as follows:

Irrigation: 41 % increase by the year 2015

Industry: 3 % increase by the year 2015

Domestic: 14 % increase by the year 2015

(iv) Hydraulic balance

- Using preliminary data, it is possible to assess initially the future hydraulic balance of each hydrographic basin for the year 2015. These estimates are based on known planning information, and thus provide an initial indication of where resource problems may need to be addressed in the near future.

- In summary, the following comments can be made for the defined hydrographic regions (see Figure CF/11):

Norte: In the very long term, this would be one of the hydraulic reserves of the country, requiring, however, huge hydraulic works to transfer water, although its resources are shared with Spain. It does have some local deficits in the Ave and Leça areas.

Douro: This hydrographic basin has a small deficit between needs and usable resources and is likely to require measures to remove this deficit.

Vouga: This basin is projected to be in balance, but is still likely to require measures to improve the situation.

Mondego: This basin is also projected to be in balance, but is still likely to require measures to improve the situation.

West: This is a deficit basin, with projected water needs greatly surpassing usable water resources. Measures to correct this imbalance are likely to be needed.

Tejo: This basin is projected to have a small deficit overall. Large deficits in the southern part of the region will need to be addressed.

Sado/Mira: This is projected to be a deficit region. With developments associated with the Alqueva scheme, some of these deficits will be addressed. Nevertheless, further measures are likely.

Guadiana: This is a hydraulic resource for southern Portugal because of the Alqueva and other schemes, which will transfer water to the Sado/Mira and Algarve hydrographic regions to address their resource deficits.

Algarve: This is projected to be a deficit basin, and although transfers from the Guadiana basin will address these deficits, problems are likely to remain.

(v) Planned development

A large number of water resource schemes are currently under development or planned for future development. It is expected that schemes currently under development will proceed. However, planned schemes may be reviewed and revised as part of the national water plan, and, from the preliminary comments made above, projected water resource deficits in a number of hydrographic regions will need to be addressed.

3.3. Water quality

- A network of stations exists on all main rivers in Portugal to monitor water quality. Many of the stations have been installed in the last 10 years. The locations of these stations are shown in Figure CF/09.

- The total pollution load for both domestic and industrial effluent is estimated at approximately 40 million inhabitant equivalents, of which approximately 11 million inhabitant equivalents derive from domestic effluent.

- The highest pollution load occurs from industry, and the most polluting industries i.e. the textiles, cellulose and tannery industries, are located on the coastal zone.

- It is estimated that approximately 76 % of domestic effluent is discharged mainly into the Atlantic Ocean but also into water courses, without adequate treatment.

- Agriculture-related pollution can give rise to localised point-source pollution problems, as well as diffuse pollution from elevated nitrate concentrations.

- Reservoirs generally contain good quality water, but may occasionally suffer from eutrophication.

- Groundwater pollution is mainly the result of domestic and industrial contamination, high nitrates from agriculture, overexploitation and saline intrusion.

- Localised water quality problems occur in the Norte catchment area due to waste water discharges. In the Tejo catchment area, surface water flows from Spain can, on occasion, have poor water quality. Intensive agriculture in the catchment area is also leading to high-nitrate problems locally. The Guadiana catchment area has poor water quality. In the Algarve region, the overexploitation of groundwater has resulted in saline intrusion, and intensive agriculture and pig farming has caused high nitrate levels.

- There exists a large requirement for further investment in the treatment of domestic and industrial effluent, increased water quality monitoring, restoration of contaminated water courses and aquifers, and the implementation of a groundwater protection policy, in order to improve water quality in accordance with the directives of the European Union.

3.4. Environment

- There is a network of national environmentally protected areas covering approximately 6 % of Portugal, and additional sites with special interest for nature conservation covering a further 18 % of Portugal. The locations of these sites are shown in Figure CF/10.

- The estuaries of the international rivers are particularly sensitive, due to their functions as spawning areas, nurseries and nutrient stores for fisheries.

- Specific environmental actions included in the Spanish preliminary national hydrological plan are considered in general to have a positive impact on the final section of the rivers. These include investment in sewerage and sewage treatment facilities,

dedicated environmental improvements and protection, and the operation of hydroelectric power (HEP) facilities in the Spanish Tajo which regulate the flows and attenuate flood flows entering Portugal. It is, however, important that the impacts of the measures proposed in the Spanish national hydrological plan are analysed globally and in detail to produce a complete assessment of the environmental impact of the plan on Portugal, including the estuaries and associated coastal zones, in line with existing European Union legislation. If necessary, mitigation measures will be required where negative impacts are identified.

- Within the water resource planning process, there is specific provision for protection of the environment.

3.5. Planning and investment

- The main powers in water resource management are assigned to the Ministry of Environment and Natural Resources, which comprises central and regional directorates, and institutes. There are five regional directorates covering the whole of Portugal and five specialist institutes.

- Planning actions involve the water resource planning process and the preparation and approval of water resource plans.

- INAG is responsible for the preparation of the national water plan and international river plans and works closely with the regional directorates for the development of national river basin plans.

- The projects identified for each river basin are summarised in Chapter 6 of the Portuguese interim report. Proposed investments are on a yearly basis up to 1999, and the total investment until the completion of the hydraulic schemes is estimated at PTE 530 000 million.

- The funds available for these investments mainly come from financial budgets and depend upon the financial/economic regime in Portugal over the implementation period.

4. Compatibility

The information obtained for both Spain and Portugal has been closely examined to identify the similarities and differences between the two countries in terms of water resources, water demands, water balance, water quality, environment, planning and investment.

4.1. Water resources

4.1.1. Available water resources

Within the water resources sector, information has been compared regarding water resources, water demands and the overall water balance for the present day and the future planning horizon. Basic water resource information is presented in Table 4.1.

Both countries have significantly more rainfall in the north than in the south, resulting in a noticeable north-south rainfall gradient. There is also a minor rainfall gradient from west to east, with the result that, on average, Portugal receives approximately 37 % more rainfall than Spain.

Potential evapotranspiration is similar in both countries, and with higher rainfall in Portugal, actual evapotranspiration is slightly higher in Portugal than Spain. The resulting balance, often termed effective rainfall, i.e. rainfall - actual evaporation, is approximately 84 % higher in Portugal than in Spain.

In both countries, rainfall occurs almost entirely in the winter period (October to March), hence a significant amount of reservoir storage is required to utilise reliably a high proportion of the potential resource.

Spanish comment

According to the available information, the usable resources for Portugal under present conditions coming from Spain are far greater than would exist under natural conditions. In the Duero and Tajo, this is due to the Spanish hydroelectric dams (Ricobayo, Almendra, Valdecañas and Alcantara) which discharge during dry periods water stored in the wet periods. In the Guadiana, the effect of return flows from Spanish irrigation gives a marked increase to the natural flows in the dry periods.

In this way, we go from minimum natural flows in the dry (summer) period of 30 m^3/second (Duero), 10 m^3/second (Tajo) and 1 m^3/second (Guadiana) to figures for usable values that are 65 m^3/second, 25 m^3/second and 5 m^3/second respectively. In the Guadiana, this latter figure reduces when it is necessary to introduce restrictions on irrigation.

In summary the usable volume for Portugal in these three basins at the present time is approximately double that which would be usable under natural conditions.

Reservoir storage is higher in Spain than Portugal, and the own-country usable resource is correspondingly lower in Portugal than Spain.

Both countries are susceptible to prolonged low rainfall events lasting several years which severely reduce the reliable water supplies which can be maintained.

Groundwater is available in similar proportions in both countries, and there are significant problems of local overexploitation and saline intrusion in Spain and the coastal aquifers of Portugal.

Table 4.1
Present day water resources under average annual conditions

Characteristic	Unit	Spain	Portugal
Catchment area	km^2	506 000	89 000
Annual average rainfall	mm	670	920
	hm^3	340 000	82 000
Rainfall stations	No	3 000	800
	km^2/station	169	111
Actual evaporation	mm	445	502
Effective rainfall	mm	225	415
	hm^3	114 000	37 000
Gross water supply	m^3/ha/year	3 000	3 900
Surface water run-off	mm	185	348
	hm^3	94 000	31 000
	%	83	84
Stream-flow stations	No	968	250
	km^2/station	523	356
Groundwater	mm	40	67
	hm^3	20 000	6 000
	%	17	16
Usable water resources	%	41	35
• Own country	hm^3	47 340	8 640(1)
• International	hm^3	—	4 270
Total	hm^3	47 340	12 910(1)
Actual water supply	m^3/ha/year	1 200	1 370

(1) Preliminary INAG estimates including Spanish resources from the rivers Miño/Minho, Limia/Lima, Duero/Douro, Tajo/Tejo and Guadiana.

Some river basins in Spain have water resource deficits. Similarly in Portugal there are a number of basins with water resource deficits.

In both countries, the hydrometric network to measure rainfall, climate and stream-flow is well developed. There are 3 000 rainfall stations in Spain and 800 stations in Portugal. In Spain, 968 stream-flow stations are operated, whereas 250 stations are utilised in Portugal.

It should also be noted that Spain and Portugal agree on the basic hydrological data for the international basins of the Iberian Peninsula.

4.1.2. Present day water balance

The current estimated water demand and present day water balance are shown in Table 4.2. In both countries, by far the largest water demand is due to irrigated agriculture. Urban water supply and industry amount to approximately 16 % of the total water demand.

The results in Table 4.2 suggest that the overall water balance, under annual average conditions, is significantly higher in Spain than in Portugal. In Portugal, based on the INAG estimates, approximately 33 % of the usable resource is derived from flow in the international rivers originating in Spain.

Spanish comment

Although in Spain the global balance at the present time has a positive result of 18 300 hm^3/year, there exists a deficit in various Mediterranean and South Atlantic basins which requires the transfer of external hydraulic resources.

At the present time, including the transfers that the treaties allow, the shared basins have a positive balance under average conditions as shown in Table 4.3.

In the shared basins, Spain at the present time has 141 large dams in operation with a storage capacity of around 30 000 hm^3. As net consumption in these basins does not reach 9 000 hm^3/year, the regulating effect on flows over and above this figure has a positive repercussion in Portugal.

Table 4.2
Present day annual average water balance

Characteristic	Unit	Spain	Portugal
Annual water demand:			
• Urban supply	hm^3	4 305 (11.6 %)	1 017 (9 %)
• Industry	hm^3	1 944 (5.3 %)	779 (7 %)
• Agriculture	hm^3	24 245 (65.4 %)	8 570 (79 %)
• Other	hm^3	6 598 (17.7 %)	483 (5 %)(1)
Total	hm^3	37 092 (100 %)	10 849 (100 %)
Gross irrigation supply	m^3/ha	7 300	9 500
Water demand	hm^3	37 100 (1992)	10 800 (1990-94)
Usable water returns	hm^3	8 100	710
Usable water resources			
• Own country	hm^3	47 340	7 930(2)
• International	hm^3	—	4 270(2)
Total	hm^3	55 400	12 910
Water balance	hm^3	+18 300	+2 100

(1) Water demand for thermal energy.
(2) Preliminary INAG estimates.

Table 4.3
Present day estimated flows entering Portugal from Spain

(hm^3/year)

Basin	Generated run-off	Consumption	Transfer as per treaty	Evaporation in reservoirs	Total	Balance
Miño	12 000	100	180	90	10	11 990
Limia	1 200	—	—	10	10	1 190
Duero(1)	15 000	2 900	180	260	3 340	11 660
Tajo(2)	12 200	1 750	1 000	370	3 120	9 080
Guadiana(3)	5 000	1 500	300	430	2 230	2 770
Total	45 400	6 250	1 300	1 160	8 710	36 690

(1) If the Tua/Sil transfer is not carried out, the present average run-off is estimated at 11 840 hm^3/year.
(2) If only 320 hm^3/year is transferred, rather than 1 000 hm^3/year, the present average run-off is estimated at 9 760 m^3/year.
(3) If only 120 hm^3/year is transferred, rather than 300 hm^3/year, the present average run-off is estimated at 2 950 hm^3/year.

4.1.3. Future water balance

The water demand and water balance for the period 2012-15 is shown in Table 4.4. The results presented are based on available information, and have, where necessary, been estimated. Also shown are increases by sector in demands and resources compared with the current situation.

In Spain, additional planned resource development, together with increased returns to the water resource system, is expected to result in an increasing positive balance and the elimination of deficits in nearly all of its river basins.

Usable inflow to Portugal from Spain is expected to decline by about 9 %. The overall water balance in Portugal is expected to fall from about + 2 110 hm^3 to + 600 hm^3 based on currently available information.

In both countries, water demand is expected to increase significantly in the next 20 years. Spain proposes an increase of 14 % in agricultural demand, while Portugal is planning an increase of 41 % against current levels. The total demand increase is 18 % in Spain and 34 % in Portugal.

Table 4.4
Estimated future annual average water balance

Characteristic	Unit	Spain	Portugal
Annual water demand:			
• Urban supply	hm^3	6 285 (14 %)	1 156 (8 %)
• Industry	hm^3	2 429 (6 %)	803 (6 %)
• Agriculture	hm^3	27 637 (63 %)	12 077 (83 %)
• Other	hm^3	7 327 (17 %)	483 (3 %) (1)
Total	hm^3	43 678 (100 %)	14 519 (100 %)
Increase in demand above present day	%	18	34
Water demand	hm^3	43 700 (2012)	14 500 (2015)
Usable water returns	hm^3	10 000	870
Usable water resources			
• Own country	hm^3	54 000	10 330 (2)
• International	hm^3	—	3 900 (2)
Total		64 000	15 100
Water balance	hm^3	+ 20 300	+ 600

(1) Water demand for thermal energy.
(2) Preliminary INAG estimates.

Spanish comment

Spain considers that in the future the increases in consumption and the variations in the transfers relative to the shared basins will not appreciably reduce the usable flows for Portugal nor will they affect the environment in a significant manner. This observation is based on the fact that both the increases are moderate and on the proposed regulating infrastructures (dams) that would store water in the wet periods. The estimated future average annual run-off for Portugal is presented in Table 4.5.

Table 4.5
Future flows to Portugal in the major international basins

Basin	Actual run-off	Variation in consumption	Variation in transfers	Variation in run-off		Run-off estimated for the year 2012
	hm^3/year	hm^3/year	hm^3/year	hm^3/year	%	hm^3/year
Miño	11 900	—	—	—	—	11 990
Limia	1 190	—	—	—	—	1 190
Duero	11 660	+ 1 200	+ 920	− 2 120	− 14.1	9 540
Tajo	9 080	+ 170	− 650	+ 480	+ 3.9	9 550
Guadiana	2 770	+ 310	+ 100	− 410	− 8.2	2 360
Total	36 690	+1 680	+370	− 2 050	−4.6	36 640

Note: The proposed figures for the future should be the result of a new treaty between Spain and Portugal.

It is reiterated that the reduction in run-off in the future will be low (of the order of 2 000 hm^3/year) and that this will not produce a significant reduction in the summer flows at the Spanish/Portuguese border, given that the Spanish national hydrological plan proposes the construction of some nearby dams that will retain water during the wet periods for later use for irrigation.

Portuguese comment

These percentage changes in run-off are obtained with respect to the estimated annual average natural flow and the actual run-off figures are based on those stipulated in the current treaties.

4.1.4. Basin water balances

The estimated average year guaranteed/usable water resources and demands for the whole of the Iberian Peninsula are presented in Figure CF/11 for each basin. The figures include estimates for the present day and for the future situation (2012-15) without and with the implementation of the Spanish preliminary national hydrological plan. It should be noted, however, that in the process of revision, there has been a tendency to reduce the planned transfer volumes.

For Spain, the estimates of demand and resources are based on the Spanish preliminary national hydrological plan. For Portugal, preliminary estimates for basin-by-basin resources and demands were provided by INAG (see Appendix C). The current demand estimates presented in Figure CF/11 for Portuguese basins do not include those associated with irrigation schemes currently under construction.

Figure CF/11 clearly illustrates the water resource benefits for Spain of the proposed transfers under the Spanish national hydrological plan when compared with the balance of resources and demands without adoption of the plan. For instance, for the Júcar hydrographic region, under the national hydrological plan, a resource deficit of 673 hm^3/year for the year 2012 becomes a resource surplus of 237 hm^3/year under average conditions.

The contrast with the potential situation for some of the southern Portuguese basins is also clear from Figure CF/11. For instance, the situation in the Algarve will worsen from an estimated current resource deficit of 33 hm^3/year to 619 hm^3/year by 2012-15. For the Sado/Mira hydrographic area, the resource balance is projected to be – 548 hm^3/year by 2015, from an existing situation of a positive balance of 184 hm^3/year. The Guadiana basin is a special case, given that the usable resources are projected to increase significantly, due to the reservoir storage created by the Alqueva scheme. Resources from this scheme will be transferred to the Sado basin and, in the long run, to the Algarve region, to help address the projected resource deficits in these basins.

Thus, Figure CF/11 highlights the variation in usable water resources across Portugal when compared with existing and projected water demands. Given that these values are based on average years, the balance between resources and demands would be expected to worsen in drier or drought situations.

The importance of Spanish contributions to the Portuguese available water resources is presented in Table 4.6. The table illustrates the contributions from the main rivers of the international basins, for a range of hydrological scenarios and for the present and future conditions. Not all the available or excess water resources from the Spanish part of the main rivers of the international basins are usable in Portugal.

This is due to the variability in the distribution of water resources both within and between years. These excess flows from the Spanish parts of the river basins need to be regulated by reservoirs. However, with the exception of the Guadiana basin, it is not possible to build dams with significant reservoir storage to regulate river flows in the main international basins. Therefore, the usable water resources in Portugal are, in fact, much lower than the excess or available water resources from the Spanish part of the basins.

Table 4.7 presents the estimates of usable water resources from the Spanish part of the main rivers of the international basins for the present and future situations, with in-basin estimates of usable water resources.

Comparing Tables 4.6 and 4.7, it is clear that a significant amount of excess/available water resources from Spain are not usable water resources. For instance, for existing conditions, only 33 % of dry-year excess flows entering the Portuguese Douro basin are usable water resources. This is due to a lack of suitable dam sites in these basins.

Nevertheless, the international resources do make a significant contribution to the existing total usable Portuguese water resources of approximately 48 %. This varies from 64 % in the Minho basin to 16 % in the Guadiana basin, under existing conditions.

For the future (2015), this total reduces to 36 % of Portuguese usable water resources, varying from 64 % in the Minho basin to 5 % in the Guadiana basin. This proportion has reduced mainly due to the planned water resource developments within Portugal, especially within the Guadiana basin due to the Alqueva scheme.

Spanish alternative

In the hypothesis shown in Table 4.8, the Spanish parts of the key international rivers in normal conditions supply around 54 % of the usable resources of the Portuguese parts of the international basins (excluding return flows). Under natural conditions, without any form of regulation, the average annual flows, the annual dry-year flows, and the guaranteed dry-year demand that can be supplied in Portugal are also shown.

Table 4.6
Excess water resources over water uses in the Spanish parts of the international river basins

(hm³/year)

International basin (1)	Hydrological year type (2)	Present day	Future situation under proposed NHP (3)
Miño/Minho	Average	9 900	10 510
	Dry	4 790	4 960
Duero/Douro	Average	11 520	9 810
	Dry	4 520	4 320
Tajo/Tejo	Average	9 820	9 720
	Dry	3 730	4 140
Guadiana	Average	2 430	1 940
	Dry	600	750
Total	Average	33 670	31 980
	Dry	13 640	14 170

(1) Excesses are computed for the whole areas of the Spanish parts of the river basins and include reservoir evaporation.
(2) Dry year type: occurs 1 in 5 to 1 in 10 years.
(3) Spanish national hydrological plan.

Table 4.7
Portuguese usable water resources in the international river basins

(hm³/year)

International basin	Present			Future (1) (2015)		
	Own	Spain	Total	Own	Spain	Total
Miño/Minho	694	1 258	1 952	696	1 258	1 954
Duero/Douro	545	1 495	2 040	1 436	1 151	2 587
Tajo/Tejo	2 652	1 088	3 740	2 715	1 088	3 803
Guadiana	438	84	522	1 569	80	1 649
Total	4 329	3 925	8 254	6 414	3 577	9 993

(1) Without consideration of the Spanish NHP.

Table 4.8
Usable resources in the international rivers in Portugal

(hm³/year)

Basin	Natural flows			Current flows		As proposed in the Spanish NHP			
						Without transfer		With transfer	
	Average	Dry year	Guaranteed demand	Average	Guaranteed demand	Average	Guaranteed demand	Average	Guaranteed demand
Duero (2)	15 200	5 500	450	11 970	4 530	11 260	5 160	10 360	4 530
Tajo	12 200	750	170	10 000 (1)	4 000 (1)	9 690	4 130	8 690	3 130
Guadiana	4 200	440	120	2 500	600	2 000	760	2 000	760
Total	31 600	6 690	740	24 470 (1)	9 130 (1)	22 950	10 050	21 050	8 420

(1) These figures reduce by 1 000 hm³/year in accordance with the terms of the existing treaty.
(2) Not considering the Tua/Sil transfer.

4.2. Water quality

As a result of the Spanish national hydrological plan, there is a much greater volume of published water quality information for Spain than for Portugal.

In Spain, there is the COCA surface water quality monitoring network, and, more recently, the SAICA automatic monitoring and alarm network is being progressively developed and implemented. There is also a groundwater quality monitoring network.

In Portugal, there is a network of 106 surface water quality monitoring stations operated by the Instituto da Água. There are no published maps showing the surface water quality classification in Portugal.

Basic information related to water quality is shown in Table 4.9.

The proportion of domestic and industrial sewage receiving adequate treatment is higher in Spain than in Portugal, but is relatively low in both countries. This reflects a historical lack of investment, both capital and operating and maintenance, in treatment facilities.

Additionally, some of the existing treatment plants in Spain and Portugal function inadequately, with the result that quality in certain sections of rivers does not reach the required standard. The situation is generally more acute in the drier areas and adjacent to towns and cities. Agricultural and industrial discharges can result in localised pollution problems.

There are deficiencies in the levels of management, which are generally limited to the smaller sewage treatment works, and some existing works have identified design faults. The financing and economics of the treatment works are, with a few exceptions, inadequate. A similar situation exists in Portugal.

Table 4.9
Water quality

Characteristic	Unit	Spain	Portugal
Resident population	Million	39 (1991)	9.4 (1991)
Pollution load	Inhabitant equivalent (IE)		
• Domestic	IE	—	11 million
• Industry	IE	—	29 million
Total	IE	85 million (1)	40 million
Sewage treatment			
• Present day	% population	41	24
• Under construction (1995)	% population	53	—

(1) As defined in the EEC directive but on a different basis to Portugal.

Poor groundwater quality occurs in both Spain and Portugal due to the overabstraction of groundwater and a lack of policies for the protection of groundwater. The main problems are saline intrusion in coastal areas, high nitrate levels in aquifers located in agricultural areas and localised industrial pollution.

4.3. Environment

In Spain, environmental concerns have been fully integrated within the Spanish national hydrological plan. A total of seven major actions have been identified, with two actions being developed into specific programmes, i.e. LINDE and Pichra. There are no similar programmes in Portugal.

Portuguese comment

Portugal considers that social and economic concerns have been fully integrated into the Spanish preliminary national hydrological plan, but that some environmental aspects have been less successfully included. Because of this, a global evaluation is not possible.

Specific environmental actions included in the Spanish preliminary national hydrological plan are considered in general to have a positive impact on Portuguese rivers. These include investment in sewerage and sewage treatment facilities, dedicated environmental improvements and protection, and the operation of HEP facilities in the Spanish Tajo which regulate the flows and attenuate flood flows entering Portugal. It is, however, important that the impacts of the measures proposed in the Spanish national

hydrological plan are analysed globally and in detail to produce a complete assessment of the environmental impact on Portugal of the plan, including the estuaries and associated coastal zones, in line with existing European Union legislation. If necessary, mitigation measures will be required where negative impacts are identified.

In Portugal, there is specific provision within the water resource planning process for protection of the environment. Spain and Portugal share responsibility for the estuaries of the international rivers and associated coastal zones, which are considered to be particularly important, due to their function as spawning areas, nurseries and nutrient stores for fisheries.

4.4. Planning and investment

In both countries, planning and investment within the water sector is carried out at local, river basin and national levels.

The development of the national hydrological plan in Spain means that, in general, long-term water sector planning is well advanced in Spain.

In Portugal, the national water plan is about to commence, and is expected over the next two years to address many of the issues already examined within the Spanish national hydrological plan.

As a precursor to this, INAG has recently published a report entitled 'The hydraulic resources of continental Portugal and their utilisation'. This report provides general reference information on water quality, quantity, uses and surface- and groundwater resources. Investment scenarios and projects are discussed to meet future water needs, which leads to the definition of the objectives of the national water plan, including the basin plans.

In Spain, investment in the water sector has been estimated at ESP 3 600 billion up to the year 2012. In Portugal, investment in ongoing and proposed water resource projects has been estimated at PTE 530 000 million. This sum does not include provision for sewerage and sewage treatment systems.

In both countries, it is expected that funds for these investments will largely be made available from financial budgets, and will depend upon the financial/economic regime in each country over the implementation period.

5. International agreements

5.1. International river basins

The international river basins shared between Spain and Portugal (Miño/Minho, Limia/Lima, Duero/Douro, Tajo/Tejo and Guadiana) occupy approximately 45 % of the land area of the Iberian Peninsula and contain 32 % of the population.

The distribution of these river basins in each country is summarised in Table 5.1.

Table 5.1
Distribution of Spanish-Portuguese river basin areas

River basin	Area (km^2)			Percentage	
	Portugal	Spain	Total	Portugal	Spain
Miño/Minho	846	16 235	17 081	5.0	95.0
Limia/Lima	1 177	1 303	2 480	47.5	52.5
Duero/Douro	18 710	78 954	97 682	24.0	76.0
Tajo/Tejo	24 860	55 645	80 629	30.8	69.2
Guadiana	11 700	55 260	71 573	16.3	83.7
Mainland	57 293	211 236	268 529	21.3	78.7

The results shown in Table 5.1 indicate that approximately 79 % of the catchment area occurs in Spain, and the remaining 21 % in Portugal.

The frontier between Portugal and Spain is approximately 1 000 km long and is defined by rivers for approximately 653 km.

5.2. Conventions

Details of existing conventions are contained in Annex 6 to the Portuguese interim report of September 1995 and Appendix 1 to the Spanish interim report of July 1995. A summary of the conventions is shown in Table 5.2.

The early conventions defined the rivers forming the international boundary between Spain and Portugal, and assigned half the flow in these rivers to each country.

Later conventions focused on the development of hydroelectricity, initially in the Duero/Douro river, and later including the international tributaries of this river.

A convention was then developed to include hydroelectricity on the Miño/Minho, Limia/Lima, Tajo/Tejo, Guadiana and Chanza/Chança rivers. In general, both countries were assigned equal rights to half of the gross energy potential. In the case of the Guadiana and Chanza/Chança, a multiple objective was contemplated including urban water supply, industrial water supply and irrigation.

Table 5.2
Conventions

Title	Date	River	Water use	Summary
Treaty of Limits	1864	International frontier	Common use	Defines the rivers along the international boundary and states that these are for common use by Spain and Portugal (Article 28)
Regulations governing border rivers (Annex 1 to the Treaty of Limits)	1866	International frontier	Common use	Defines that half the flow belongs to Spain and half to Portugal (Article 1)
Notes exchanged between the Governments of Spain and Portugal between 29 August and 2 September 1912 approving the regulations governing the industrial development of the rivers bordering the two countries	1912	International frontier	Industrial development	Spain and Portugal to have the same rights and may use half the flow of water during various seasons of the year (Article 1)
Convention for regulating the hydroelectric development of the international section of the River Duero/Douro	1927	Duero/Douro	Hydroelectric development	Spain and Portugal to have equal share regarding the hydroelectric development
Rules of Procedure, Decree Law 39252	1953			
Regulations, Decree Law 41531	1958			
Convention between Portugal and Spain for regulating the hydroelectric development of the international sections of River Duero/Douro and its tributaries	1964	Duero/Douro	Hydroelectric development	Replaced the 1927 convention. Includes international tributaries, excess flow, and diversions to secondary regulating reservoirs
Decree Law 45991	1964	Duero/Douro International tributaries	Hydroelectric development	
Rules of Procedure, Decree Law 200/71	1964			
Convention between Portugal and Spain to regulate the use and hydraulic development of international sections of Miño/Minho, Limia/Lima, Tajo/Tejo, Guadiana and Chanza/Chança rivers and their tributaries.	1968	Miño/Minho Limia/Lima Tajo/Tejo Guadiana Chanza/Chança	Hydroelectric development Common uses Multiple uses	Wider scope than the 1927 or 1964 conventions. Aimed at the beneficial use of these rivers by both nations. Each country to have rights to half the gross energy potential
Decree Law 48661				

This 1968 convention also agreed river flows for each basin along Spanish, Portuguese and international reaches on which estimation of gross energy potential for each river was made, and how this would be distributed between Spain and Portugal. These values are given in Tables 5.3 and 5.4 respectively. It should be noted that these agreements took into account existing and planned water uses in Spain and Portugal, i.e. in the Tajo/Tejo and Guadiana basins respectively. For example, the 1968 convention includes specific provision for each State to have the right to divert flows on their sections of the rivers Guadiana and Chanza/Chança. This was added in order to recognise the irrigation plan for the Alentejo-Alqueva scheme in Portugal and the water supply to Huelva in Spain. It is therefore important that both Spain and Portugal respect these existing agreements when undertaking water resource developments until any future conventions are agreed.

Hydroelectricity does not result in a loss of water, i.e. it is a non-consumptive use; however, the development of hydroelectric schemes often requires water storage, diversions, flow modification and regulation.

The production of energy and the overall operation of such schemes control the amount of water released and hence river flows within the border zone of the international rivers.

These treaties have been beneficial to both Spain and Portugal. However, with the passage of time and changing circumstances in both countries, it was agreed at the Mallorca 1994 conference to widen the scope and objectives of the cooperation between the two countries with respect to the shared river basins. This negotiation process was started at the Oporto 1994 conference with the signing of the summary agreement (a copy, with translation, is included in Appendix B). The aim of the process is to sign a new treaty for the sustainable development and protection of the hydraulic resources of the international basins.

Although good progress has been made in reaching agreement, there are still some important differences to be resolved. It is desirable, however, that these bilateral discussions continue and that a new treaty is signed in the near future.

The generally good relations between Spain and Portugal regarding the international basins was illustrated during the period of sustained heavy rainfall from December 1995 to February 1996.

Bilateral coordination during this period resulted in the use of the reservoirs in the Spanish Tajo basin for flood control and storage, and thus a reduction in the impact of the floods in the Portuguese part of the basin.

Table 5.3
Calculation of the gross energy potential of the international sections of the frontier rivers and adjoining national sections under the 1968 convention

RIVER Section	Head (m)	Natural annual flow (hm^3/year)	Usable volume upstream (hm^3/year)	Modified annual flow (hm^3/year)	Gross energy potential (GWh/year)
MIÑO/MINHO	26.59	10 401 (1)	157 (2)	10 244	724.2
LIMIA/LIMA					
Spanish section	86.00	914.5 (3)		914.5	214.3
International section	104.00	373.5 (4)		373.5	105.8
Castro Laboreiro International section	18.00	914.5		4.5	44.9
TAJO/TEJO					
International section	28.94	9 776 (5)	3 996 (6)	5 780	455.0
Erges international section	7.85	245		245	5.2
Sever international section	36.79	180		180	18.0
Ponsúl Portuguese section	36.85	318		318	32.0
Aravil Portuguese section	22.75	71		71	4.4
GUADIANA (Caia)	47.32	3 347 (7)	1 277 (8)	2 042	270.5
Spanish tributaries (between Caia and Alqueva)				379	7.4
CHANZA/CHANÇA	139.67	277		277	103.0

(1) The flows were calculated at the beginning of the international section of the Miño/Minho river, using the records of the Puente Filguera gauging station for the period 1945/46 to 1961/62.

(2) In the case of the Miño/Minho river, irrigation of 24 648 ha upstream of the international stretch was calculated to use an annual allocation of 8 500 m^3/ha and provide 25 % of surplus irrigation water, which brings the annual volume used to 157 hm^3.

(3) Flows on the international section of the Limia/Lima river were calculated by using the records of the Lindoso development for the period 1933/34 to 1960/61.

(4) Flows on the international section of the Castro Laboreiro river were calculated by using the records of the Ameijoeira gauging station for the period 1948/49 to 1958/59.

(5) Flows on the international section of the river Tajo/Tejo river were calculated by using the records of the Alcântara gauging station for the period 1945/46 to 1961/62.

(6) In the case of the Tajo/Tejo river, irrigation of 470 040 ha upstream of the international section was calculated to use an annual allocation of 8 500 m^3/ha and provide 25 % of surplus irrigation water, which brings the annual volume used to 2 996 hm^3. In addition, diversion of an annual volume of 1 000 hm^3 from the Tajo/Tejo river basin in Spain was forecast, starting from the Bolarque reservoir and running through the Tajo-Segura transfer system.

(7) Flows in the international section of the Guadiana river were calculated by using the records of the Benavides gauging station for the period 1945/46 to 1961/62.

(8) In the case of the Guadiana river, irrigation of 179 293 ha upstream of the international section was estimated to use an annual allocation of 9 500 m^3/ha and provide 25 % of surplus irrigation water, which brings the annual volume used to 1 277 hm^3.

Table 5.4

Division of the gross energy potential of the international sections of the frontier rivers and adjoining national sections under the 1968 convention

RIVER Section	Gross energy potential (Gwh/year)			Gross energy potential attributed (GWh/year)		Balance (GWh/year)	
	International	Portugal	Spain	Portugal	Spain	Portugal	Spain
MIÑO/MINHO	742.2			151.8	590.4	75.9	295.2
LIMIA/LIMA							
Spanish section			214.3	214.3		214.3	
International section	105.8			105.8		52.9	
Castro Laboreiro International section	44.9			44.9		22.4	
Added value	66.0		91.0	157.0		124.0	
TAJO/TEJO							
International section	455.0				455.0		227.5
Erges international section	5.2				5.2		2.6
Sever international section	18.0				18.0		9.0
Ponsúl Portuguese section		32.0			32.0		32.0
Aravil Portuguese section		4.4			4.4		4.4
Added value	20.0		8.0		28.0		10.0
GUADIANA	270.5			270.5		135.3	
Spanish tributaries			7.4	7.4		7.4	
CHANZA/CHANÇA	103.0				103.0		51.5
Total	1 830.6	36.4	320.7	951.7	1 236.0		
Grand total	2 187.7			2 187.7		632.2	632.2

6. Key issues

The available information has been reviewed and evaluated to identify the key issues described below.

Issue 1: Low reliability of water resource systems

Problem

Due to the seasonal nature of rainfall and the relatively low proportion of regulation storage, the guaranteed/usable resource in both countries at the present time is generally a low proportion of the gross resource. In Spain this figure is approximately 41 %, whereas in Portugal this figure is estimated at 35 %.

Water demands generally constitute a large proportion of the guaranteed/usable water resource. In Spain the present figure is 78 %, whereas in Portugal the figure is estimated at 66 %. The above values are quoted for annual average conditions, whereas, in practice, resources are limited by the amount of regulation storage and flows within dry periods.

Flows reduce significantly during dry conditions, hence in both countries it is generally not possible to maintain supplies to all water users during droughts. By using only regulating structures is it possible to overcome this situation.

Low reliability is thus related to both usable water resources and water demands. Thus, it is important to consider both sides of the hydraulic balance. The solutions proposed below are related to improved operation of existing resources or the development of new resources, while issues 4 and 5 address the topics of water conservation and demand management.

Portuguese comment

The development of any new water resources must be based on a broad discussion of a number of issues. These include economics, including the unit costs of the water resources, cumulative environmental impacts of further developments, and thus the balance between economic development and acceptable levels of environmental impact. Other issues that need to be considered include social, regional and national impacts.

Solutions

- Reinforce the guarantee of supply by increased regulation of river flows, but with consideration of environmental impacts, both at the sites of regulation and downstream, including the coastal zone.
- In view of the difficulty of developing surface water regulation schemes, encourage continued development of a better understanding of groundwater systems in both countries, for potential conjunctive use schemes.
- Consider ways of improving the operation of all water resource systems, together with increased monitoring and control. The existing network for obtaining real-time information on the quantitative hydrological information (SAIH) on Spanish rivers could be coordinated with a Portuguese network.
- Develop adequate levels and guarantee of service for each water use category in each country, taking into account dry conditions.
- Utilise these criteria to assess the priorities for additional resource development.

- Increase the connections between both hydraulic systems and basins in order to transfer excess resources to deficit basins, but always taking into account environmental impacts.

Issue 2: Poor surface water quality

Problem

Many of the surface waters at the present time receive large quantities of untreated sewage effluent. The result, in both these waters and affected groundwaters, is a level of quality that does not comply with EU directives. In Spain, approximately 41 % of effluent is treated, and work in progress will increase this to 54 %, whereas in Portugal approximately 24 % of effluent is adequately treated.

The result of this is that the problem of poor surface water quality is most acute in water courses adjacent to some of the larger towns and cities, and in drier areas.

Cultivated areas contribute to the diffuse contamination of both surface- and groundwater.

Solutions

- Increase the number of treatment works in compliance with Directive 271/91/EEC and act upon the Spanish national plan for sewerage and sewage treatment.
- Improve the design, operation and maintenance of sewage treatment works by providing technical assistance and training, and thereby focus on key areas for improvement.
- Improve water quality monitoring. The existing network for obtaining real-time information on the water quality of Spanish rivers (SAICA) could be coordinated with a Portuguese network and this network could possibly be operated jointly with the SAIH network to avoid duplication of equipment.
- Utilise the results to identify priority areas for improvement.
- Improve agricultural practices.

Issue 3: Overexploitation and degradation of aquifers

Problem

Groundwater is widely used for water supplies in both countries, and, in many cases, abstraction exceeds the sustainable yield of aquifers. This has resulted in saline intrusion within the drier coastal areas in both Spain and Portugal. It should be noted that the White Paper already published in Spain sets out the proposals, planning and investment required in Spain to improve groundwater resources.

Groundwater has become polluted by agricultural chemicals, particularly nitrates, and point-source pollution has occurred from industry and other sources.

Groundwater resources are important in that they may be the only local resource available, and groundwater outflow provides baseflow to rivers during dry periods and may be important in many wetland areas.

Solutions

- Eliminate overexploitation, producing alternative resources.
- Consider aquifer storage and recovery schemes as an alternative to further reservoir development.
- Develop policies for the protection and control of groundwater.
- Improve the monitoring of groundwater levels and quality to ensure sustainable development.

Issue 4: Irrigation water requirements

Problem

Irrigated agriculture represents the largest single water use category in both Spain and Portugal. During irrigation, approximately 80 % of the water applied corresponds to evapotranspiration, and only approximately 20 % returns to the water resource system.

The water resource systems in both countries have been largely influenced by the need to provide very large quantities of irrigation water.

Spain has recently published an irrigation plan which seeks to modernise the infrastructure and management of 1.6 million hectares of the total 3.4 million

hectares of irrigated farmland. This will therefore assist in reducing unit irrigation demands.

Solution

Encourage the prompt execution of the Spanish irrigation plan and the development of similar plans in Portugal for upgrading existing infrastructure, operation and management of irrigation systems. This would have the potential benefit of reducing irrigation water demands, or increasing the area which may be irrigated or increasing the reliability of irrigation supplies.

Issue 5: Water conservation

Problem

There are finite resources available within the Iberian Peninsula, and the seasonal nature of the rainfall, together with the difficulty of providing adequate regulatory storage, means that it is difficult to increase the reliable usable water resources. Both Spain and Portugal have experienced problems in the enforcement of demand management measures during the recent drought.

Solution

To introduce water conservation programmes which should be reviewed prior to the implementation of new resource developments.

Spanish and Portuguese alternative

Establish a programme for conservation of water, taking into account the existing plans for improvement of irrigation in both countries and the improvements that have already taken place. The water conservation programme may include the following elements:

- *improved enforcement procedures for existing demand management measures during times of drought;*
- *effective leakage reduction in water supply systems through detection, repair and pressure control techniques;*
- *promotion of low water use appliances at municipal level;*
- *revised water pricing structure, with higher charges for greater water use;*
- *industrial water reuse and waste minimisation.*

It would be appropriate to develop evaluation procedures, prepare guidelines and promote pilot schemes in both countries.

Issue 6: Funding for the water sector

Problem

Most of the funding for water resource and water sector projects is derived from within each country, supplemented by external funding. National funding is uncertain as it depends upon the economic performance of each country during the implementation period.

The regulating and transfer infrastructures, because of their complexity and size (which result from the adverse hydrological characteristics of both countries), require an important level of investment.

Both countries have experienced historical funding problems and are thus starting from relatively low levels of existing infrastructure.

The available information for both Spain and Portugal suggests that the requirement for funding is likely to considerably exceed the EU funds available.

EU funds are not (currently) conceived to finance hydraulic infrastructure with multiple uses.

Solutions

- Prioritise the water sector projects in both Spain and Portugal. This could be achieved by developing comprehensive guidelines for external funding of all categories of projects within the water sector. Such guidelines could be used by both Spain and Portugal to identify priority projects and thereby seek appropriate levels of EU funding assistance.
- Closely monitor project progress, spending and the resulting improvements within the water sector. It would be helpful for the EU to assist countries to reassess priorities on an annual basis.

Issue 7: International agreements between Spain and Portugal

Problem

Portugal is highly reliant on the flows within the international rivers for water supplies. Current international agreements have been developed prior to the proposals within the Spanish national hydrological plan, and may not contain sufficient provision to protect the water resources available to Portugal, particularly during dry periods.

Solutions

- Continue the existing dialogue between Spain and Portugal in the area of sustainable supply and the protection of the hydraulic resources in the shared basins.
- In view of the perceived shortage of existing or potential regulatory storage within Portugal, and the potential problems related to downstream storage control, consider jointly the needs of both countries for regulatory storage in the international rivers to meet the defined needs of both countries. This may require joint development, operation and management of the resources for the mutual benefit of both countries and the environment
- Encourage joint technical studies on the international basins to follow the first study on the lower reaches and estuary of the River Guadiana, which has just started.

Issue 8: Compatibility of water resource planning horizons

Problem

The complex nature of water resource investigations and planning means that such studies are often very time-consuming and lead to a series of project stages before implementation. The projects put forward by Spain for implementation by the year 2002 and 2012 may be delayed by the requirements of the overall planning process and international discussions.

Portugal has not yet commenced its national water plan, hence long-term planning information is not currently available.

It would be advantageous if the planning horizons adopted by Spain and Portugal were similar, as this would help during international discussions.

Solutions

Coordinate the water resource planning in Spain and Portugal to provide results for compatible planning horizons.

Issue 9: Long-term water resource planning

Problem

At present in Portugal there is uncertainty regarding the reliable yield of existing water resources, future water demands and the additional future development of water resources.

There is also an urgent need to address water quality and environmental issues, and to develop longer-term implementation and investment programmes.

Solution

Review and update the scope of the Portuguese national water plan and encourage its prompt execution. Also encourage the prompt execution of the Spanish national hydrological plan, whilst ensuring that both plans are coordinated to provide the best overall long-term solution for the Iberian Peninsula. This should be in accordance with the overall planning requirements of the European Union and its directives.

Issue 10: International rivers and their estuaries

Problem

Spain and Portugal have joint responsibility for the estuaries of the international rivers. All these estuaries are environmentally very important due to their function as spawning areas, nurseries and nutrient stores for fisheries and, as such, both countries have a great interest in their adequate protection. Water resource developments within Spain and Portugal may have longer-term cumulative impacts on the flow regime and fisheries.

Solutions

- Obtain a detailed understanding of the ecological balance of the estuaries and the factors which may result in detrimental impacts. This may require additional data collection and increased monitoring. This should include estimation of ecological flows for international rivers and their estuaries, and how these compare with river flows in average, dry and very dry years and semesters.
- Check the potential impacts on the rivers and estuaries of water resource development proposals put forward by both Spain and Portugal and, if necessary, include mitigation measures to reduce any potential impacts which are identified. This should be done in a 'global' rather than a piecemeal manner to ensure that the cumulative and total impacts of all the proposed developments are considered.

7. Recommended studies

As a result of this mission, the key issues and problems identified and possible solutions suggested, it is recommended that the Cohesion Fund should commission the following further studies which would help to resolve some of these issues, and assist with water resource planning in both Spain and Portugal.

(1) Extreme flow conditions

Estimate river flows for the Spanish hydrographic regions in dry and very dry years and seasons, for the present and future scenarios. Also estimate ecological flows for Spain and Portugal, including the estuaries of the international rivers, and compare with drought flows to allow estimation of available water resources to meet water demands. Ensure a consistent approach is adopted for both country analyses. Consider and recommend any suggestions to the water transfer proposals under the Spanish national hydrological plan and to the international agreements.

(2) Integrated basin management

Investigate the requirements for the integrated management of the international river basins. This would include a review of existing institutions and technical assets and recommendations for measures to bring into being the required management bodies.

(3) Monitoring of the water resources

Assess the requirements of coordinating the monitoring networks of Spain and Portugal, based on the Spanish SAICA and SAIH systems. Investigate the further monitoring requirements for the aquifers of both Spain and Portugal. This would increase understanding of the aquifers, allow improvements to estimates of resource availability and increase knowledge of the water quality status of these aquifers.

(4) Water conservation

Investigate the options, for both Spain and Portugal, which can assist with the introduction of water conservation measures within the agricultural, municipal and industrial sectors. This would include an assessment of the best practice measures that could be transferred to both countries and the likely levels of savings in water use that they would introduce. Pilot studies could then be set up. Based on the results of these studies, water conservation programmes for both countries, covering the sectors identified above, would be recommended.

(5) The Guadiana basin

Evaluate and investigate the water resources and water quality of the Guadiana basin. This would include an assessment of the existing balance between usable water resources and demand, the impacts of existing projects, the Spanish preliminary national hydrological plan and the Alqueva project on water resources and the current bilateral agreements. In terms of water quality, the problems of the basin and its estuary should be investigated, with a programme of measures to reduce pollutant loadings. Finally, recommendations should be made concerning the institutional requirements for integrated management of the Guadiana basin.

(6) Estuary environmental flows

Review and summarise existing data and information related to studies carried out on estuary

environmental flows for the major basins of the Iberian Peninsula. Where possible, comment on the impacts of known water resource developments, including the Spanish preliminary national hydrological plan, on the estuary flow requirements. Recommend further studies for those estuaries where further information is required.

Spanish comment

Analyse the effects on the estuaries of the actions contemplated by both countries and proposed solutions (conditioning and corrective measures) to minimise these effects.

Portuguese comment

Portugal considers that studies (1), (2) and (6) should be carried out within a single framework, given that integrated basin management has to respond to the needs of the environment by considering in-stream river and estuary flow requirements, as well as meeting water needs related to human activities. This is especially relevant in terms of the cumulative impacts of existing and planned projects.

(7) Inter-basin transfers

Undertake the necessary environmental impact assessments of the agreed inter-basin transfers as proposed in the Spanish national hydrological plan. This will involve assessments of both donor and recipient basins, and assessments of existing transfers. Once complete, recommendations will be made concerning the need for remedial measures, including operation of the transfers.

Spanish recommended studies/actions

(8) Analysis of the financing of hydraulic works

Evaluate and prioritise water sector projects in both Spain and Portugal by developing comprehensive guidelines for external funding. Such guidelines could be used by both countries to identify priority projects and seek appropriate levels of EU funding and flexible financing options whereby the EU could support multiple-use hydraulic developments.

(9) Immediate actions

- *Actions to increase the availability of hydraulic resources, both surface- and groundwater.*
- *Infrastructures to guarantee urban and industrial water supply.*
- *Installations to improve water quality by sewerage and sewage treatment of waste waters.*
- *Infrastructures for connection between river basins and operating systems.*
- *Automatic control systems for hydrological parameters (quantitative and qualitative).*
- *Desalination plants for urban and industrial water supply.*
- *Installations for the reutilisation of treated waste water.*
- *Actions to improve the efficiency of use of water in various contexts.*
- *Forestation of areas at risk from erosion and recuperation of river banks and wetlands.*

Appendix A — Water resources definitions

Spain — Definition of guaranteed resources

1. Preliminary Ideas

1.1. The concept of guaranteed volumes is associated with a determined demand which can be satisfied with available hydraulic resources, whose quantity is variable in time and is achieved using regulating infrastructures.

1.2. The demand could be constant in time (for example water supply) or could be concentrated in certain periods (for example irrigation) normally the most dry.

1.3. It is assumed that the historical series of the resources' distribution in the past represents statistically the distribution in the future of the resources. The series are on a monthly basis and cover a period of at least 40 years.

1.4. In general, on an average basis, 80 % of the demand in Spain is destined for irrigation and 20 % for water supply. The operation of the regulating infrastructures should be guided by rational criteria.

2. Guarantee in the satisfaction of demand

2.1. It is considered that it is uneconomical to secure the totality of the supply during every year and so a determined level of guarantee is required.

2.2. The guarantee with which resources and infrastructures satisfy a demand is the division between the number of years in which these resources and infrastructures satisfy the demand without failure and the total number of years which make up the series, expressed as a percentage.

2.3. The guarantee levels in Spain are:

supply to large cities ≥ 95 %.

supply to medium cities ≥ 90 %.

irrigation ≥ 80 — 85 %.

2.4. Definition of a year with a failure:

When any month in the year has:

for water supply: 85 % of demand greater than available resource;

for irrigation: 75 % of demand greater than available resource;

or when on an annual basis:

for water supply: 90 % of demand greater than available resource;

for irrigation: 80 % of demand greater than available resource.

3. Guaranteed volumes

3.1. Definition

For a defined basin and for determined infrastructure, the guaranteed volume is the maximum demand that is satisfied with the level of guarantee previously fixed.

3.2. Methodology

In practice, for a monthly historical series of resources the levels that satisfy various growing values of demand are calculated and the guaranteed volume is taken as the highest demand that applies with the previously fixed levels of guarantee.

3.3. Guaranteed volume in natural flow regime

This type of calculation can be made for the basin without any type of regulating structure in which case one obtains the guaranteed volume under natural flow regime.

3.4. Guaranteed volume in the present situation

If this methodology is applied with the regulating structures (large dams) that exist at the present time, one obtains a value (higher than the previous) that is the guaranteed volume in the present situation.

3.5. Guaranteed volume in the future situation

Finally, applying the same methodology to the regulating structures that would exist at a certain date in the future, one obtains another value that is the guaranteed volume at that date.

4. Comment

The methodology used recognises the succession in the past of wet and dry periods. As such, the criteria adopted guarantee the sufficient satisfaction of the demand even in dry periods. Only in the case of extreme periods (very dry periods) do supply failures occur in a very small number of years (5 % of years for water supply to large cities, 10 % to medium-sized cities and 15 to 20 % for irrigation).

Definition of average supply

Average supply is the average value of the annual run-off, extended to a representative number of years. It corresponds to the product of the effective precipitation (rainfall less evaporation) for the surface area of the basin. It is equally the average value of the renewable resource.

Portugal — Definition of usable resources

INAG have adopted the concept of usable water resources. Thus, usable water resources in a river basin are that fraction of the potential water resources that can meet water demands with given levels of guarantee. For urban and industrial water demands these levels are between 95 and 100 % guarantee, while for agricultural water demand these levels are at 80 % guarantee. The estimates of usable water resources made by INAG for each river basin take into account:

- the distribution of water resources in natural conditions;
- the active storage of reservoirs;
- the natural recharge of aquifers;
- water returns.

Appendix B — The Oporto 1994 conference summary agreement

The Minister of Public Works, Transport and the Environment of Spain and the Minister for the Environment and Natural Resources of Portugal in recognition of the excellent political relations between Spain and Portugal:

1. Confirm their satisfaction with the advance of the preparatory work for a future Hispano-Portuguese treaty for water resources, based on the Palma de Mallorca Conference which has required a considerable technical and political effort;

2. Wish to create suitable conditions for the optimum use of the hydraulic resources of the shared basins whilst at the same time considering environmental protection and water quality;

3. Consider cooperation between the two countries is necessary for the defence of their respective interests through a systematic exchange of information;

4. Recognise that it is fundamental to analyse in advance the effects in Spain and Portugal of significant actions in the other country;

5. Agree to coordinate the planning and management of the hydraulic resources of the shared basins from the point of view of their sustainable use by both States.

Agree to conclude in the shortest possible time, a Hispano-Portuguese treaty for hydraulic resources based on:

1. the principles of international and Community law;

2. the recognition of the reasonable and equitable right of both countries to the hydraulic resources in the shared basins;

3. a cooperation mechanism that ensures the regular and systematic exchange of information;

4. a bilateral institutional model that allows the permanent evaluation of the hydrological situations that are of common interest.

Oporto, 19 November 1994

Minister for Public Works,
Transport and the Environment

Minister for the Environment
and Natural Resources

Appendix C — Updated Portuguese water resources data

Table A3.1: Usable water resources in the Portuguese river basins

(hm³/year)

River basin	Portugal		Spain		Total	
	Present	2015	Present	2015	Present	2015
Minho	694	696	1 258	1 258	1 952	1 954
Lima	150	158	342	342	492	500
Cávado	957	974	0	0	957	974
Ave	456	471	0	0	456	471
Leça	58	62	0	0	58	62
Douro	545	1 436	1 495	1 151	2 040	2 587
Vouga	509	709	0	0	509	709
Mondego	950	950	0	0	950	950
Liz	46	46	0	0	46	46
Ribeiras do Oeste	119	119	0	0	119	119
Tejo	2 652	2 715	1 088	1 088	3 740	3 803
Sado	726	882	0	0	726	882
Mira	92	97	0	0	92	97
Guadiana	438	1 569	84	80	522	1 649
Algarve	250	284	0	0	250	284
Total	8 642	11 169	4 267	3 919	12 909	15 088

Notes: Minho, Lima, Cávado, Ave and Leça are all included in the north-west hydrographic region (Figure CF/11).
Liz and Ribeiras do Oeste are included in west hydrographic region (Figure CF/11).

Table A3.2: Estimated water demands for Portugal

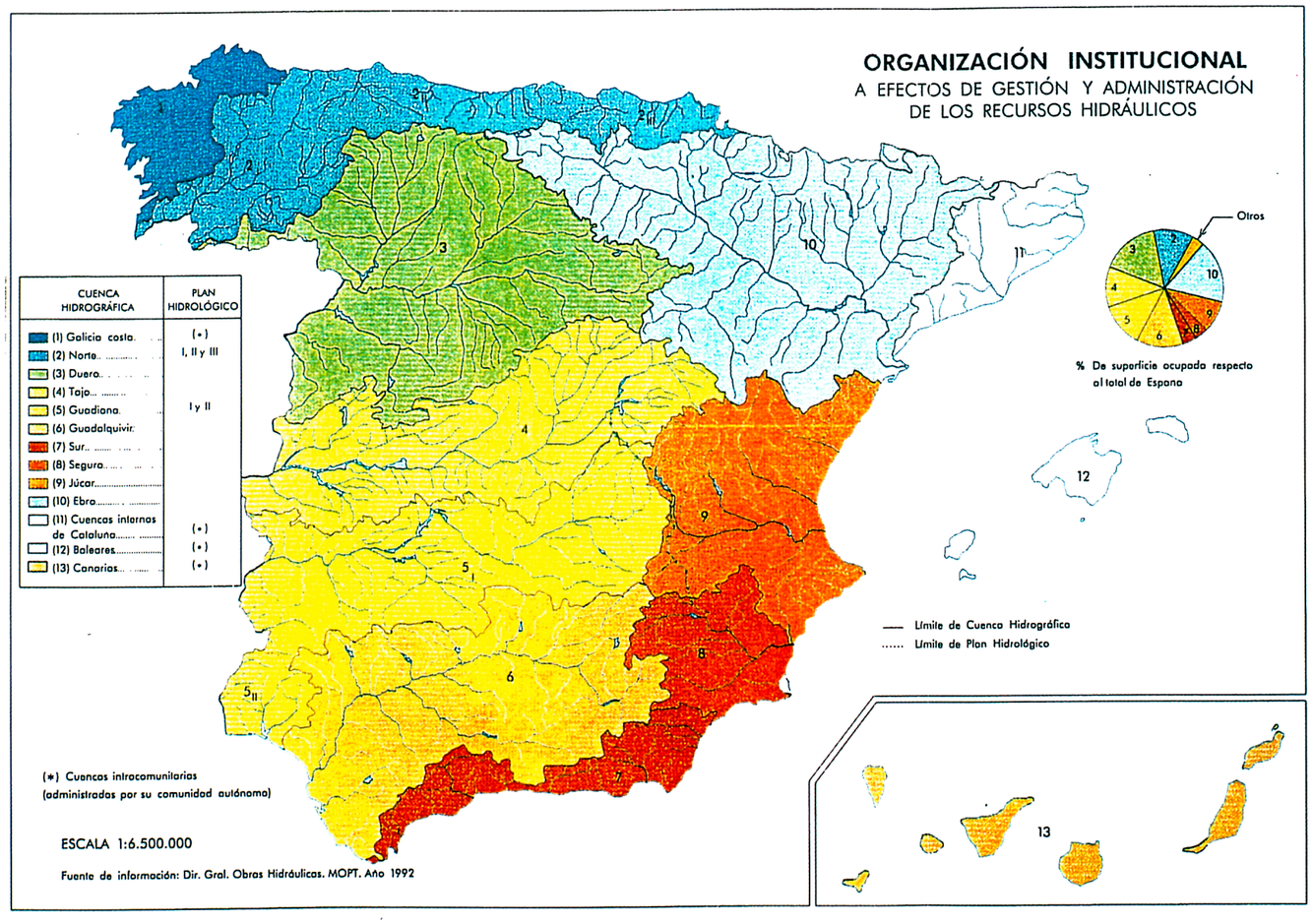
Basin	Resident population		Irrigated area (ha)				Water demands (1 000 m^3)							Total (hm^3)		
			Actual			Medium term	Domestic		Industrial		Irrigation			Actual (1994)	2000	Medium term
	Actual (1994)	Medium term	Equip.	Exec.	Total		Actual (1994)	Medium term	Actual (1994)	Medium term	Actual (1994)	Year 2000	Medium term			
Minho + Âncora	76 454	66 066	15 671	765	16 436	16 952	6 972.58	6 428.98	2 835.00	2 921.90	113 686.71	119 236.43	122 977.75	123	129	132
Lima + Âncora	147 390	128 621	24 598	135	24 733	26 306	14 893.15	13 722.64	6 147.70	6 336.50	178 443.71	179 423.05	190 835.32	199	200	211
Neiva	57 114	57 120	13 396	0	13 396	13 785	6 001.47	6 557.05	6 070.30	6 256.90	97 184.79	97 184.79	100 005.80	109	109	113
Cávado + Ribeira da Costa (1)	247 932	261 084	40 203	525	40 728	42 290	26 942.14	31 470.62	37 014.10	38 151.85	331 933.91	336 268.54	353 635.12	396	400	423
Ave + Ribeira da Costa (1)	646 743	722 693	50 907	130	51 037	51 231	77 527.86	94 105.75	95 778.90	98 722.95	369 308.60	370 251.69	371 659.79	543	544	564
Leça	142 137	161 322	5 937	0	5 937	5 937	16 090.04	20 870.00	18 004.90	18 558.30	43 067.33	43 067.33	43 067.33	77	77	82
Douro + Mangas	2 096 450	2 138 016	215 077	9 684	224 761	253 415	224 022.45	254 397.35	205 115.40	211 416.60	1 969 477.90	2 058 155.09	2 322 516.61	2 399	2 487	2 788
Vouga + Ribeira da Costa (2)	652 597	685 835	57 705	3 314	61 019	62 888	66 212.85	74 783.86	70 579.70	72 748.90	512 290.63	541 710.45	558 951.89	649	679	706
Mondego + Ribeira da Costa (2,3)	654 093	578 469	95 122	678	95 800	96 462	67 167.98	64 156.14	34 329.60	35 385.00	841 916.82	847 917.74	853 434.84	943	949	953
Liz + Ribeira da Costa (3)	151 980	181 540	6 375	0	6 375	6 375	17 129.04	22 688.48	11 562.10	11 917.40	73 267. 29	73 267.29	73 267.29	102	102	108
Ribeiras do Oeste	693 069	819 974	18 834	2 091	20 925	24 969	76 785.43	101 250.96	48 433.40	49 922.10	215 768.85	239 726.36	286 194.33	341	365	437
Tejo + Apostiça e Costa	2 968 270	3 021 855	237 951	24 565	262 516	332 226	330 670.74	375 570.39	201 088.80	207 269.40	2 460 322.01	2 714 314.68	3 453 121.20	2 992	3 246	4 036
Sado + Melides	299 994	271 653	48 519	8 546	57 065	120 347	30 822.85	28 348.35	20 344.10	20 969.40	543 008.24	638 652.18	1 349 646.18	594	690	1 399
Mira	24 623	21 495	10 548	88	10 636	11 093	2 244.42	2 106.56	382.20	393.90	119 819.65	120 819.28	126 019.04	122	123	129
Guadiana	231 155	204 511	29 826	9 285	39 111	89 226	20 624.52	19 789.88	14 274.60	14 713.60	340 468.09	446 457.70	1 016 450.67	375	481	1 051
Sotavento Algarvio	209 621	232 341	16 699	9 184	25 883	41 905	21 053.31	24 739.14	4 438.90	4 575.40	197 501.46	306 123.12	495 613.11	223	332	525
Barlavento Algarvio	52 443	57 512	5 061	25	5 086	9 352	4 650.68	5 839.21	1 092.00	1 125.50	59 852.44	60 148.12	110 606.97	66	66	118
Arade	78 493	87 212	8 725	7 389	16 114	21 074	7 383.69	9 385.71	1 636.80	1 687.00	103 176.79	190 554.81	249 220.87	112	200	260
Total	9 430 557	9 697 318	901 154	76 404	977 558	1 225 833	1 017 195.21	1 156 211.06	779 128.50	803 072.60	8 570 495.18	9 383 278.65	12 077 224.10	10 367	11 180	14 037

(1) Minho, Lima, Neiva, Cávado, Ave and Leça are included in the north-west hydrographic region (Figure CF/11).

(2) Liz and Riberas do Oeste are included in the west hydrographic region (Figure CF/11).

(3) Sotavento Algarvio, Barlavento Algarvio and Arade are included in the Algarve hydrographic region (Figure CF/11).

DO NOT SCALE



Source: **Atlas Nacional de España**

WATSON ESPAÑA SA

MIEMBRO DE MONTGOMERY WATSON

COHESION FUND: SPAIN/PORTUGAL HYDROLOGICAL APPRAISAL

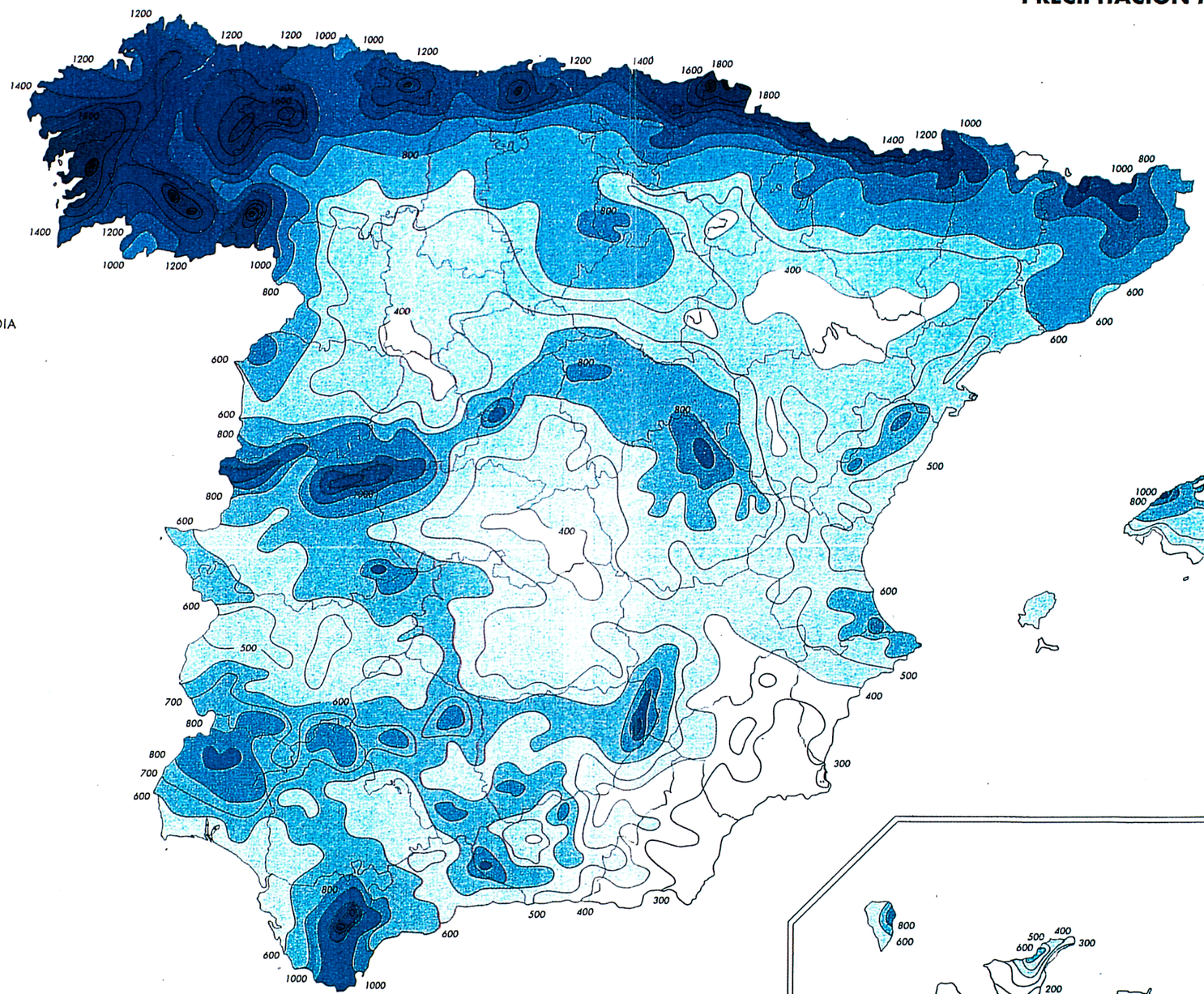
INSTITUTIONAL ORGANISATION

RIVER BASIN AUTHORITIES

Scale	Cad Ref.

Sketch No. CF/01 | Rev.

PRECIPITACIÓN MEDIA ANUAL



ESCALA : 1:4.500.000

Fuente de Información: Instituto Nacional de Meteorologia (MOPT)

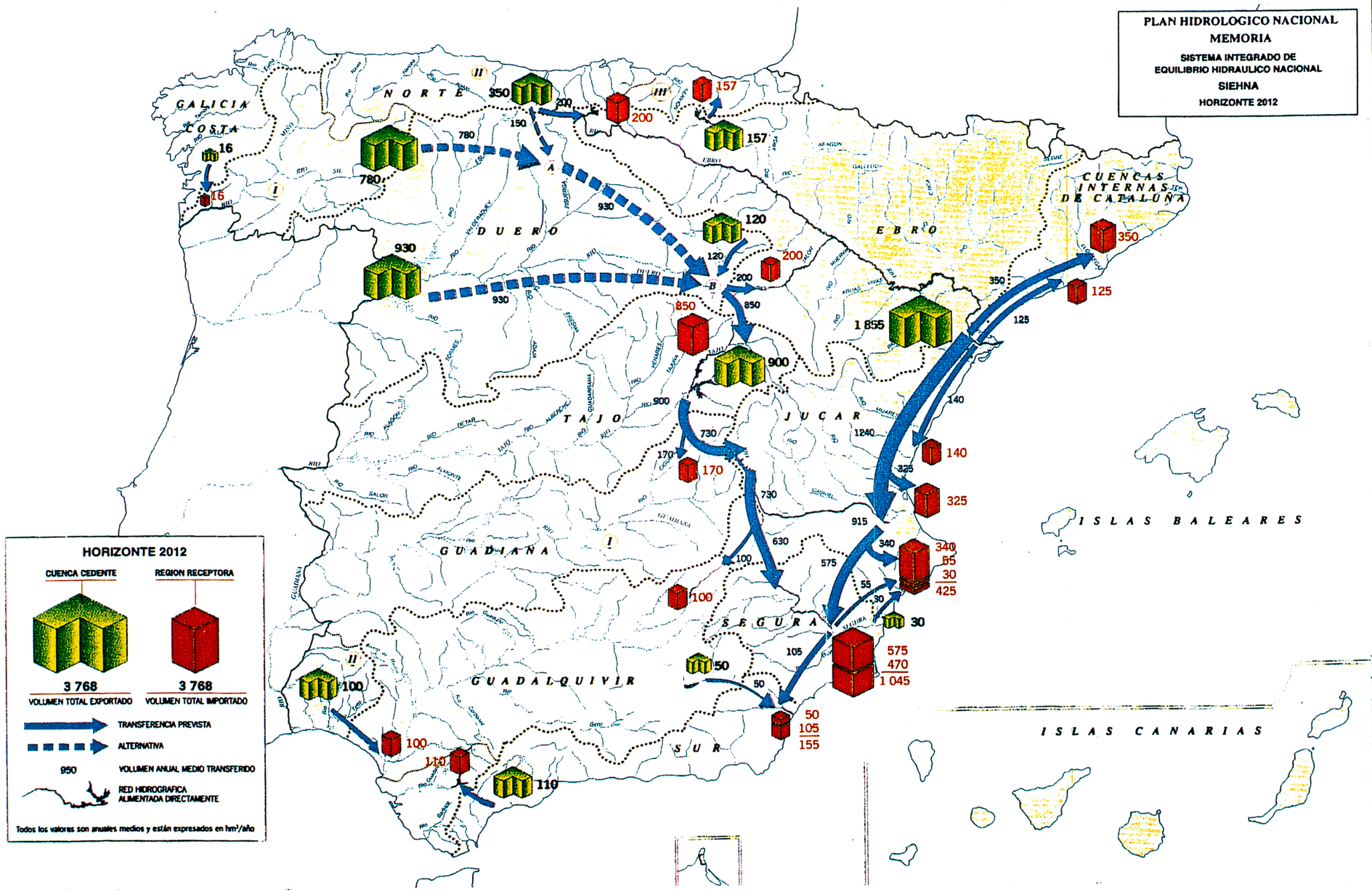
COHESION FUND:
SPAIN /PORTUGAL
HYDROLOGICAL APPRAISAL

AVERAGE ANNUAL PRECIPITATION
Source: Plan Nacional de Depuración

WATSON ESPAÑA S.A

MIEMBRO DE MONTGOMERY WATSON

Scale	Cad. Ref.
Sketch No. CF/02	Rev.



DO NOT SCALE

Source: National Hydrographic Plan

WATSON ESPAÑA SA

MIEMBRO DE MONTGOMERY WATSON

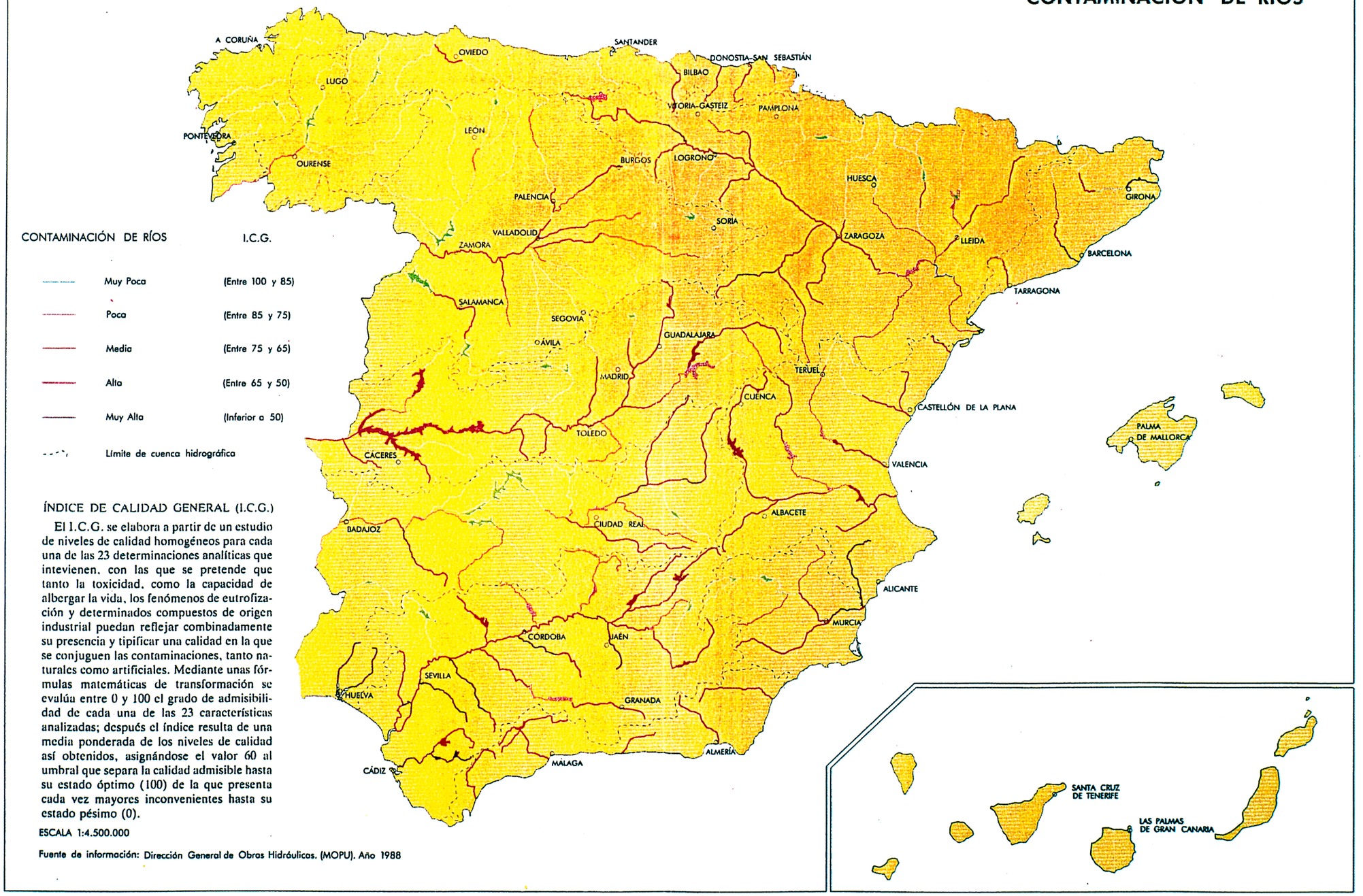
COHESION FUND: SPAIN/PORTUGAL HYDROLOGICAL APPRAISAL

WATER TRANSFER SYSTEM (SIEHNA)

Scale	Cad Ref.

Sketch No. CF/03 | Rev.

CONTAMINACIÓN DE RÍOS



CONTAMINACIÓN DE RÍOS — I.C.G.

Muy Poca	(Entre 100 y 85)
Poca	(Entre 85 y 75)
Media	(Entre 75 y 65)
Alta	(Entre 65 y 50)
Muy Alta	(Inferior a 50)
Límite de cuenca hidrográfica	

ÍNDICE DE CALIDAD GENERAL (I.C.G.)

El I.C.G. se elabora a partir de un estudio de niveles de calidad homogéneos para cada una de las 23 determinaciones analíticas que intevienen, con las que se pretende que tanto la toxicidad, como la capacidad de albergar la vida, los fenómenos de eutrofización y determinados compuestos de origen industrial puedan reflejar combinadamente su presencia y tipificar una calidad en la que se conjuguen las contaminaciones, tanto naturales como artificiales. Mediante unas fórmulas matemáticas de transformación se evalúa entre 0 y 100 el grado de admisibilidad de cada una de las 23 características analizadas; después el índice resulta de una media ponderada de los niveles de calidad así obtenidos, asignándose el valor 60 al umbral que separa la calidad admisible hasta su estado óptimo (100) de la que presenta cada vez mayores inconvenientes hasta su estado pésimo (0).

ESCALA 1:4.500.000

Fuente de información: Dirección General de Obras Hidráulicas. (MOPU). Año 1988

COHESION FUND: SPAIN /PORTUGAL HYDROLOGICAL APPRAISAL

Source: Atlas Nacional de España

RIVER POLLUTION

WATSON ESPAÑA S.A

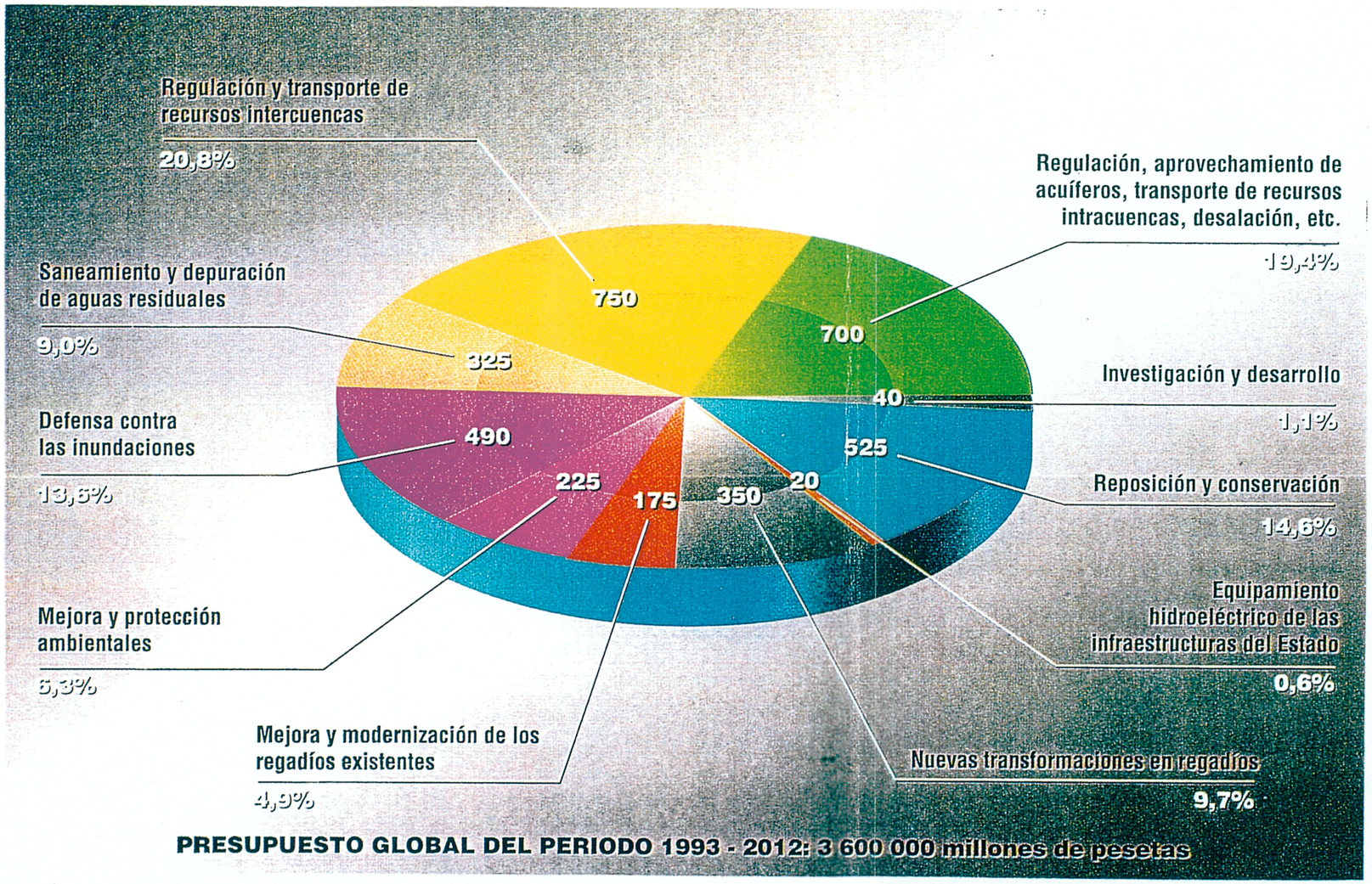
MIEMBRO DE MONTGOMERY WATSON

Scale

Cad. Ref.

Sketch No. CF/04

Rev.



DO NOT SCALE

Source: National Hydrographic Plan

WATSON ESPAÑA SA

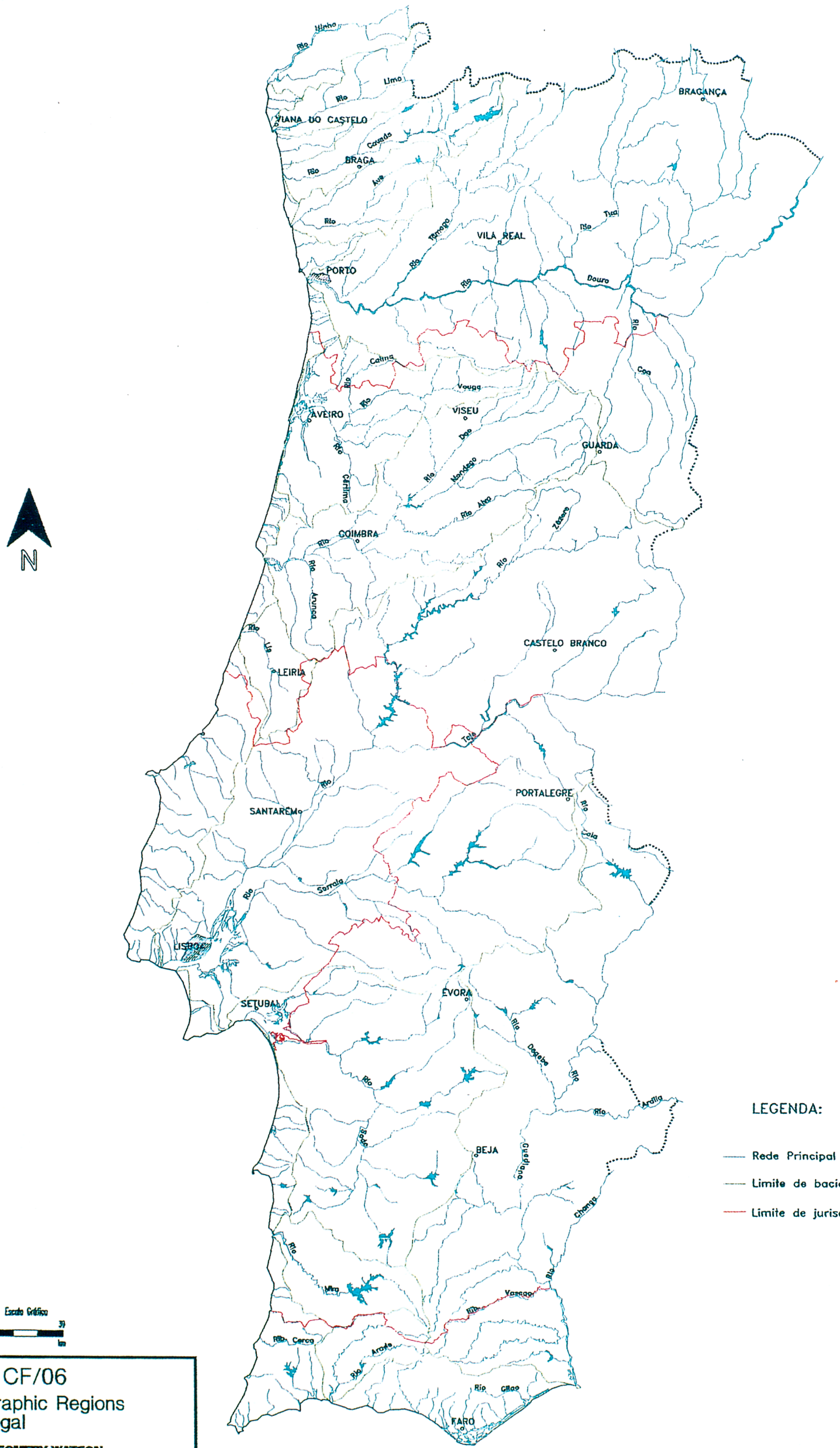
MIEMBRO DE MONTGOMERY WATSON

COHESION FUND: SPAIN/PORTUGAL HYDROLOGICAL APPRAISAL

PROPOSED INVESTMENT DISTRIBUTION

Scale	Cad Ref.

Sketch No. CF/05 | Rev.



LEGENDA:

- Rede Principal
- Limite de bacia hidrográfica
- Limite de jurisdição das DRARN'S

Figure CF/06
Hydrographic Regions in Portugal

MONTGOMERY WATSON

REDE HIDROGRÁFICA

Base Cartográfica: Atlas do Ambiente (1:1000000)

Projecção de Gauss – Elipsóide Internacional

INSTITUTO DA ÁGUA INAG, DSRH 1994

MARN

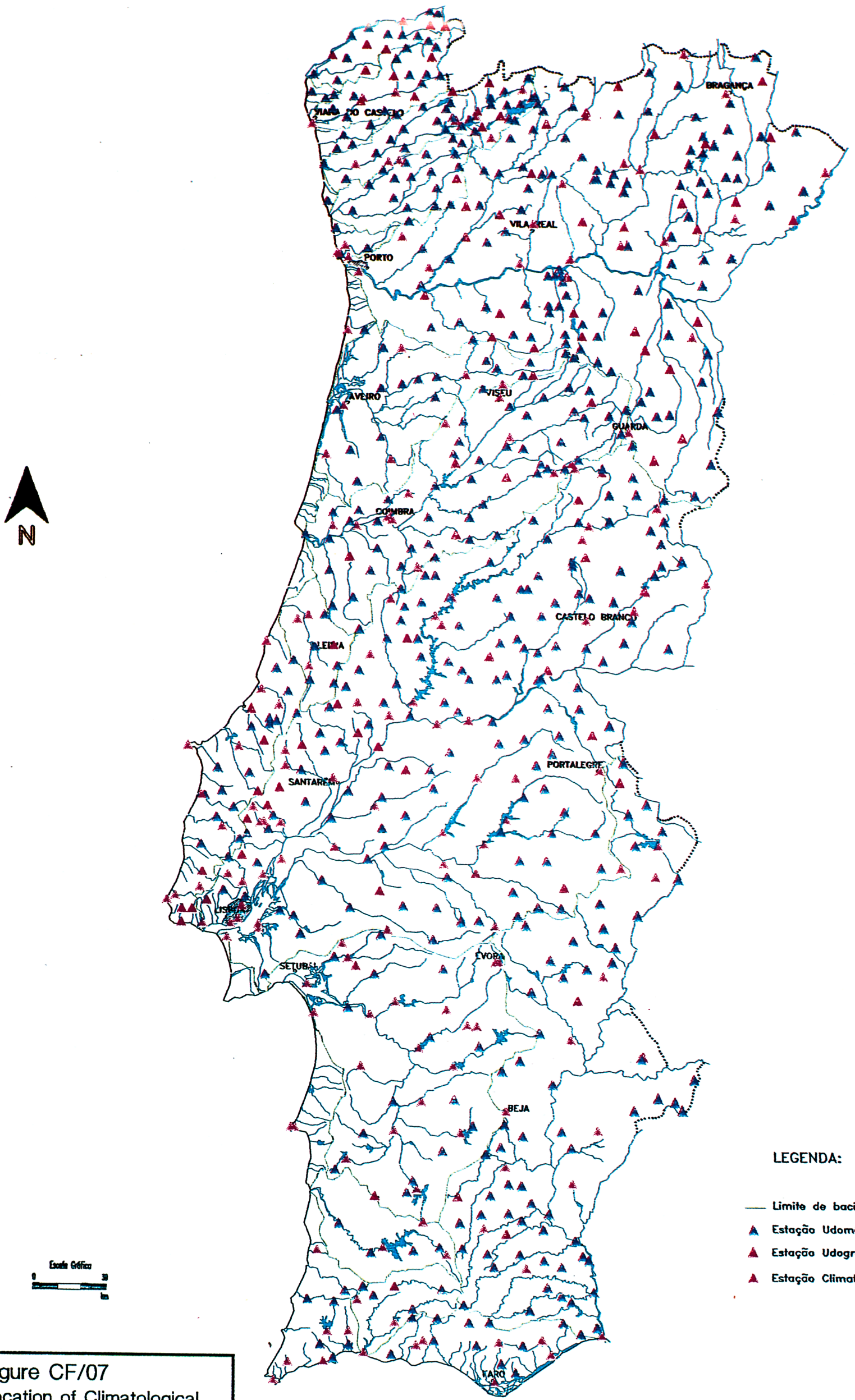


Figure CF/07
Location of Climatological Stations

MONTGOMERY WATSON

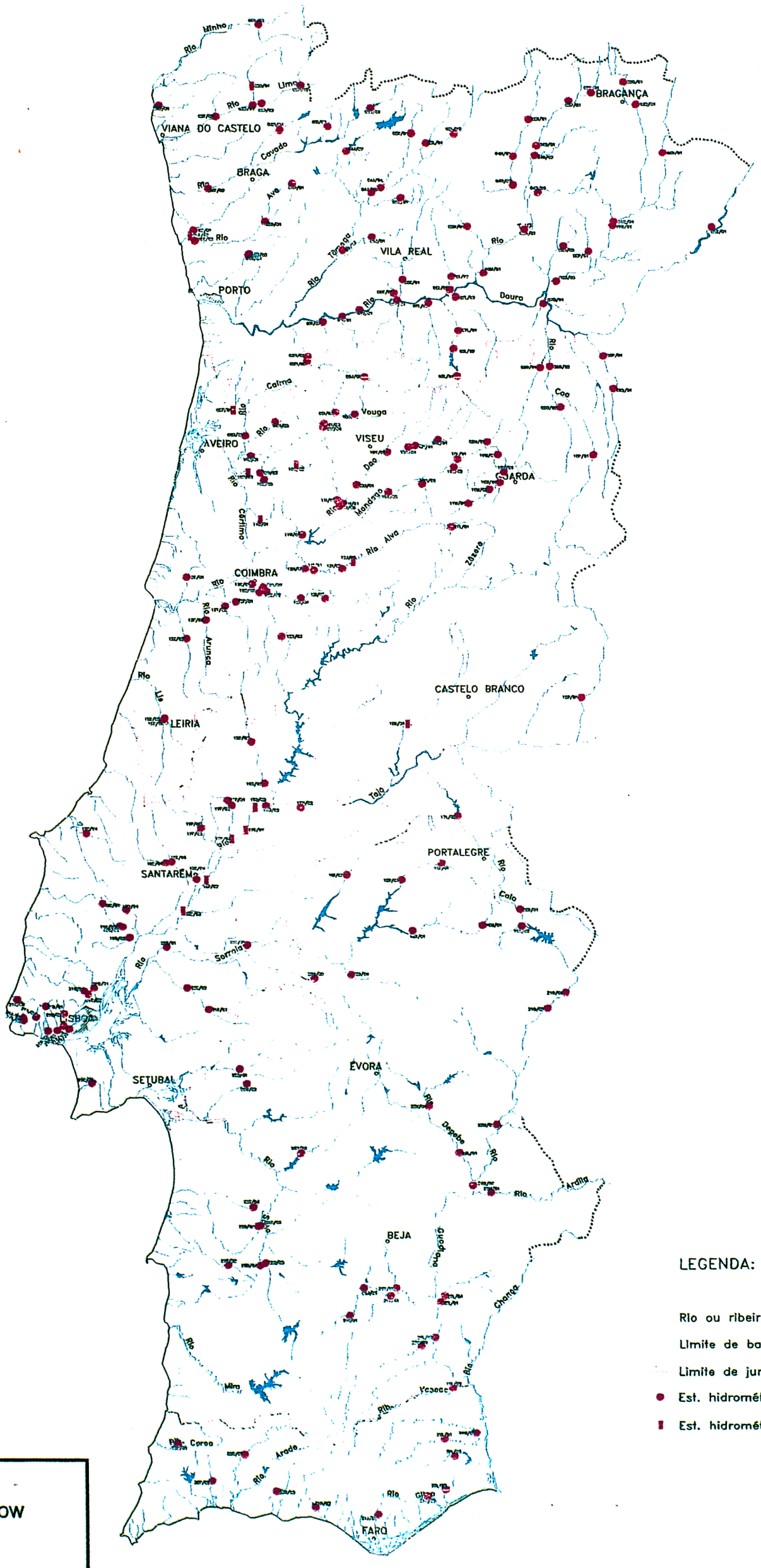
REDE UDOMÉTRICA

Estações do Instituto da Agua, Instituto de Meteorologia e da EDP

Base Cartográfica: Atlas do Ambiente (1:1000000)	Projecção de Gauss – Elipsóide Internacional

INSTITUTO DA ÁGUA INAG, DSRH 1994

MARN



LEGENDA:

- Rio ou ribeira
- Limite de bacia hidrográfica
- Limite de jurisdiçao das DRARN'S
- Est. hidrométrica – Limnígrafo
- Est. hidrométrica – Escala

Escala Gráfica
0 30
km

Figure CF/08
Location of Streamflow Stations

MONTGOMERY WATSON

REDE HIDROMÉTRICA

Base Cartográfica: Atlas do Ambiente (1:1000000)

Projecção de Gauss – Elipsóide Internacional

INSTITUTO DA ÁGUA INAG, DSRH 1994

MARN

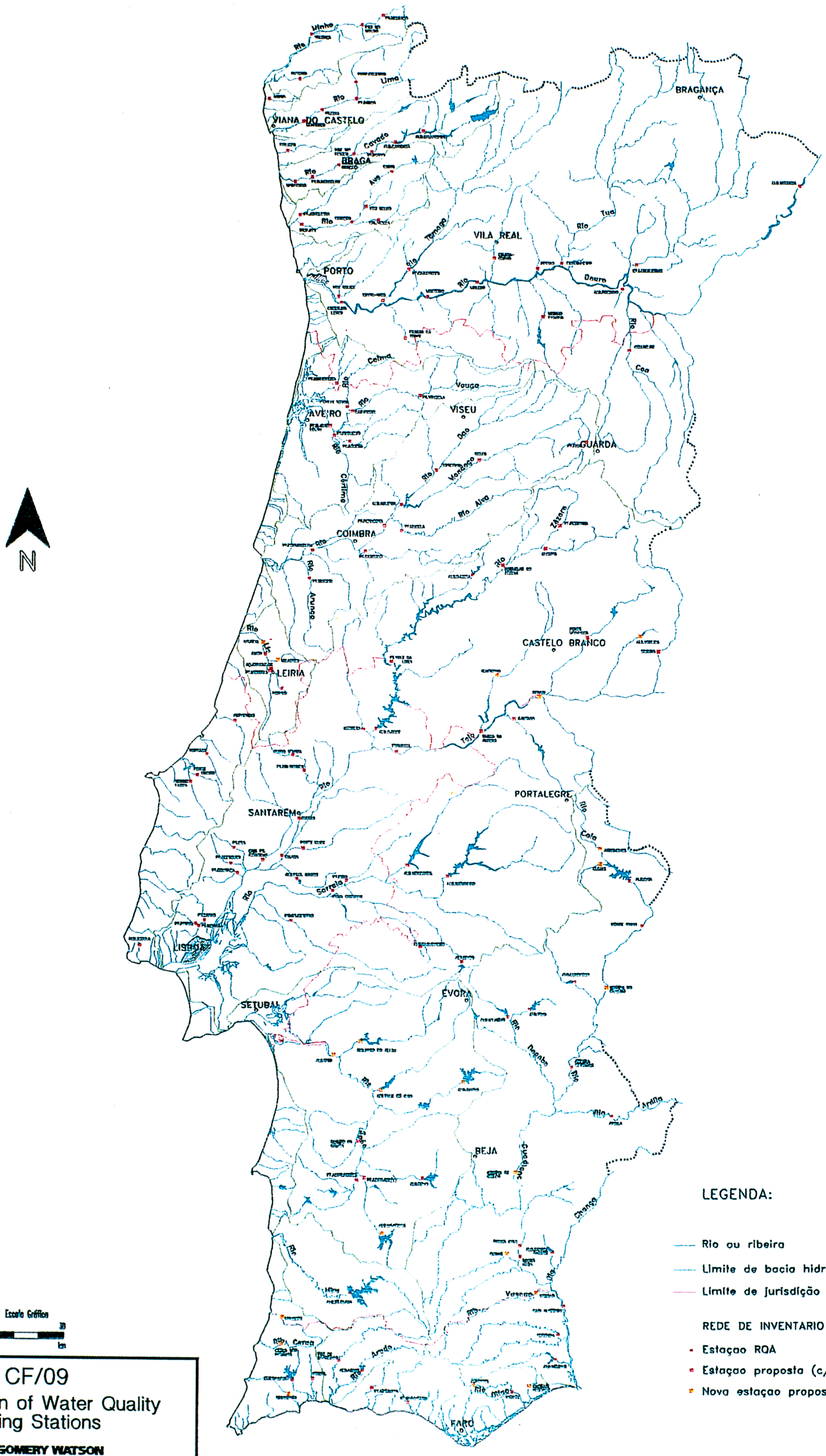


Figure CF/09
Location of Water Quality Monitoring Stations

MONTGOMERY WATSON

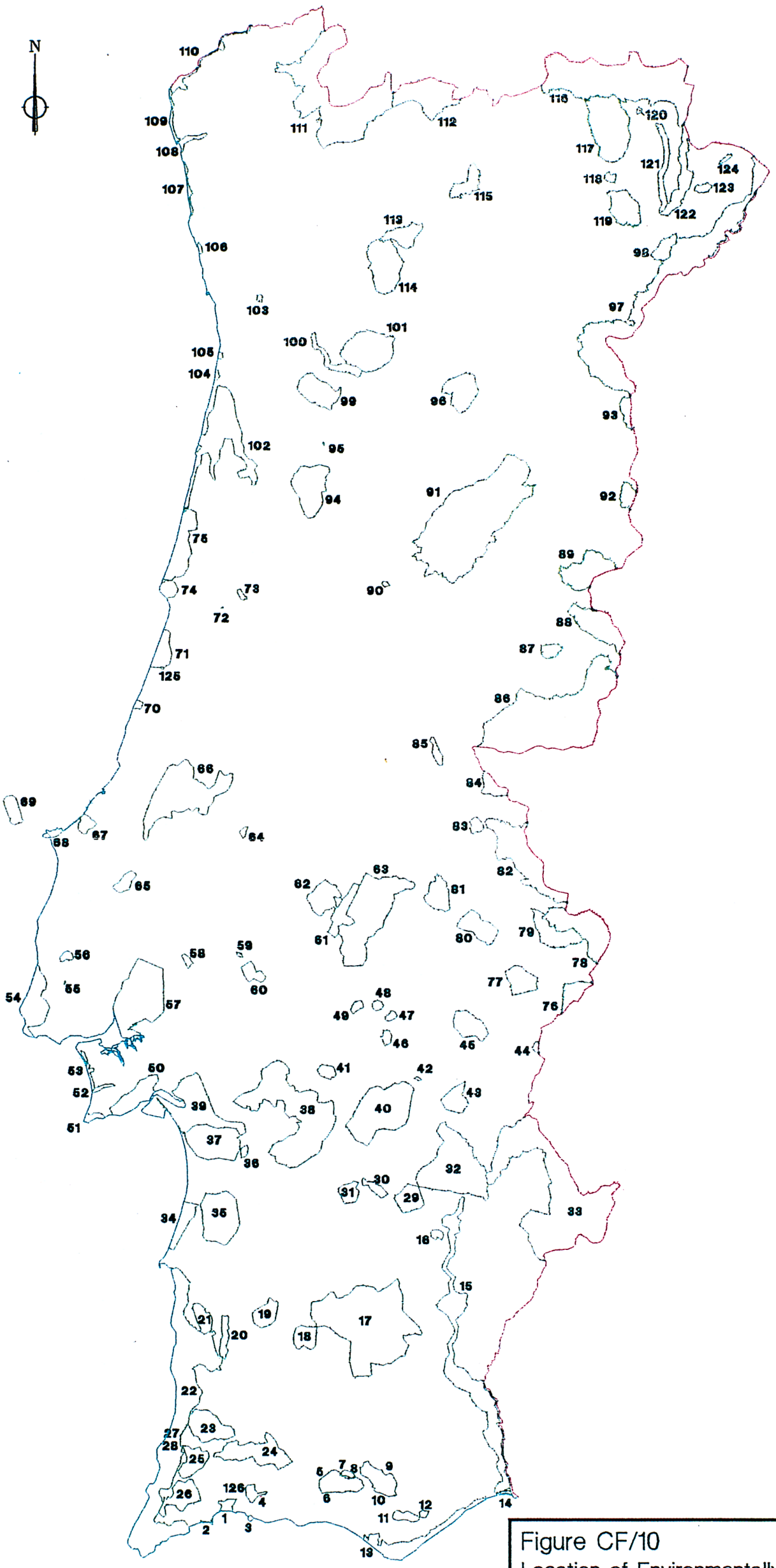
REDE DE QUALIDADE DA ÁGUA

Base Cartográfica: Atlas do Ambiente (1:1000000)

Projecção de Gauss – Elipsóide Internacional

INSTITUTO DA ÁGUA INAG, DSRH 1994

MARN



LEGENDA:

1 – Ria de Alvor
2 – Ponta da Piedade
3 – Leixão da Gaivota
4 – Gruta de Ibna/Hammar
5 – Gruta da Igrejinha dos Soidos
6 – Barrocal de Alte
7 – Rocha da Pena
8 – Gruta da Rocha da Pena
9 – Serra do Caldeirão/Barranco Velho
10 – Grutas da Salustreira
11 – Serra de Monte Figo
12 – Cerro da Cabeça
13 – Parque Natural da Ria Formosa
14 – Mata Nacional das Dunas de Vila Real de Santo António
15 – Vale do Rio Guadiana (Inf.)
16 – Baleizão
17 – Castro Verde
18 – Albufeira do Monte da Rocha
19 – Colos/Ribeira de Gema
20 – Ribeira do Torgal
21 – Serra do Cercal
22 – Área de P.P. da Costa Vicentina e Sudoeste Alentejano
23 – Ribeira de Seixe
24 – Serra de Monchique
25 – Serra de Espinhaço de Cão
26 – Bensafrim
27 – Gruta Amarela
28 – Gruta de Monte Clérigo
29 – Vidigueira
30 – Alvito
31 – Albufeira de Odivelas
32 – Serra de Portel
33 – Mourão/Barrancos
34 – Costa da Galé
35 – Serra de Grândola
36 – Mata Nacional de Valverde
37 – Comporta
38 – Cabrela/Torrão
39 – Estuário do Sado
40 – Évora
41 – Serra de Monfurado
42 – Monte do Perdigão
43 – Montoito/Requengos de Monsaraz
44 – Moinho da Abóbada
45 – Serra de Ossa
46 – Albufeira do Divor
47 – Mendo Marques
48 – Serra da Laranjeira
49 – Herdade da Mata
50 – Parque Natural da Arrábida
51 – Cabo Espichel
52 – Lagoa da Albufeira
53 – Área de P.Prot. da Arriba Fossil da Costa da Caparica
54 – Área de Paisagem Protegida de Sintra–Cascais
55 – Pedra Furada
56 – Tapada de Mafra
57 – Estuário do Tejo
58 – Paúl de Trejoito
59 – Acude da Agolada
60 – Monte da Barca
61 – Albufeira de Montargil
62 – Foros de Arão
63 – Cabeção/Aldeia Velha
64 – Reserva Natural do Paúl do Boquilobo
65 – Serra de Montejunto
66 – Parque Natural das Serras de Aire e Candeeiros
67 – Lagoa de Óbidos
68 – Peniche–Papoa–Ilha das Pombas
69 – Arquipélago da Berlenga
70 – Pinhal de Leiria
71 – Mata Nacional do Urso
72 – Paúl de Madriz
73 – Reserva Natural do Paúl de Arzila
74 – Cabo Mondego
75 – Costa de Quiaios–Mira
76 – Torre da Bolsa
77 – Vila Fernando
78 – Campo Maior
79 – Albufeira do Caia
80 – Monforte
81 – Alter do Chão
82 – Parque Natural da Serra de S.Mamede
83 – Ribeira de Nisa
84 – Póvoa e Meadas
85 – Vila Velha de Rodão
86 – Tejo Internacional
87 – Idanha–a–Nova
88 – Penha Garcia
89 – Reserva Natural Parcial da Serra da Malcata
90 – Área de Paisagem Protegida da Serra do Acor
91 – Parque Natural da Serra da Estrela
92 – Nave de Haver/Aldeia da Ponte
93 – Almeida
94 – Serra do Caramulo
95 – Reserva Botânica do Cambarinho
96 – Serra da Lapa
97 – Alto Douro (Internacional)
98 – Mogadouro
99 – Serra da Freita
100 – Rio Paiva
101 – Serra de Montemuro/Bigorne
102 – Ria de Aveiro
103 – Santa Justa/Pias
104 – Costa do Furadouro (Ovar)
105 – Barrinha de Esmoriz
106 – Mindelo
107 – Litoral de Esposende
108 – Foz do Rio Lima
109 – Costa Verde
110 – Vale do Minho
111 – Parque Nacional da Peneda–Gerês
112 – Larouco/Alto Cavádo
113 – Parque Natural do Alvão
114 – Serra do Marão
115 – Serra da Padrela
116 – Parque Natural de Montesinho
117 – Serra da Nogueira
118 – Azibo (Barragem)
119 – Morais
120 – Monte de S.Bartolomeu (Bragança)
121 – Rio Sabor
122 – Rio Maçãs
123 – Santo Adrião
124 – Rio Angueira
125 – Lagoa da Ervedeira
126 – Rio Arade

Figure CF/10
Location of Environmentally Sensitive Areas

MONTGOMERY WATSON

SÍTIOS DE INTERESSE PARA A CONSERVAÇÃO (BIOTOPOS CORINE)

Base Cartográfica: Atlas do Ambiente (1:1000000)

Projecção de Gauss – Elipsóide Internacional

1580	1695	1695
793	957	957

Galicia Coast
-16

7902	8533	8245
2059	2088	2088

Norte
-177

3915	3961
1436	1526

North West

2040	2587
2314	2788

Douro

Duero
-900

8623	10214	9314
4102	4992	4992

509	709
621	706

Vouga

Ebro
-1612

14364	17796	16636
11451	12937	12937

Cataluna
+475

1572	1927	2355
1302	1877	1877

950	950
937	953

Mondego

7174	7793	8093
3447	3953	3953

Tajo
-50

3582	3609	4519
3547	4282	4282

Jucar
+890

165	165
421	545

3740	3803
2762	4036

West

Tejo

3329	4331	4416
2554	3299	3299

Guadiana
+70

818	979
634	1527

Sado/ Mira

Guadiana

1515	1370	2145
1861	2145	2145

Segura
+1015

3884	4584	4919
4016	4738	4738

Guadalquivir, Guadalete & Barbate
+150

Algarve

250	284
283	903

Sur
+155

1119	1236	1492
1163	1492	1492

522	1649
294	1051

Figure CF/11

Average Year Guaranteed / Useable Water Resources and Demands of the Iberian Peninsula

MONTGOMERY WATSON

LEGEND (All units Hm^3/yr)

SPAIN

Present Resources	2012 * Resources	2012 ** Resources
Present Demands	2012 * Demands	2012 ** Demands

Sources : Tables 18, 20 and 24. Spanish Interim Report

PORTUGAL

Present Resources	2015 Resources
Present Demands	2015 Demands

Source : INAG March 1996

-1612 Net basin transfer (Hm^3/yr) under NHP

* Without NHP

** Proposed under NHP

CAD Ref: : N:\2001\1A\1\FIGCF-11 REV. : B

European Commission

Spain/Portugal hydrological appraisal

Luxembourg: Office for Official Publications of the European Communities

1998 — 77 pp. — 21 x 29.7 cm

ISBN 92-828-2513-2

Price (excluding VAT) in Luxembourg: ECU 29.50

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