Júcar Pilot River Basin

Provisional Article 5 Report

Pursuant to the Water Framework Directive

MINISTERIO DE MEDIO AMBIENTE

CONFEDERACIÓN HIDROGRÁFICA DEL JÚCAR

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FOREWORD

The Directive 2000/60/EC of the European Parliament and of the European Council of 23 October 2000 establishes a framework for Community action in the field of water policy. It is the so-called Water Framework Directive 2000/60/EC or WFD, and it introduces a new perspective from a modern water policy view to all Member States (MS) of the European Union (EU).

Key concepts of this comprehensive legislative piece are: good water status, quality objectives for surface and groundwater, water protection measures, sustainable use, maintenance of aquatic ecosystems, free-pollutant aquatic environment, cost-recovery-based use, water management plans and public participation.

The text of the WFD is not an easy one, and much less is the exercise of its implementation, which raises broad challenges and requirements to MS, in addition to a highly demanding schedule.

Shared interpretation by all countries is the will of the Union, and common issues as diversity of possible solutions to scientific, technical and practical questions require further elaboration and resolution to make the transition from principles and general definitions to a practical implementation successful.

For this reason, in May 2001 all MS and Norway, by means of the EU Water Directors, agreed to develop a Common Implementation Strategy (CIS) to provide a common understanding and awareness of the Directive. The key tool of the CIS is the development of Guidance Documents (GD) on different subjects of the Directive and their subsequent integrated testing in a Pilot River Basins (PRB) network, which was set up for this purpose. In addition, the CIS has other functions such as setting up working groups of experts from MS and candidate members, as well as from stakeholders and non-governmental organisations (NGOs) on different subjects. These groups have, among other tasks, to develop the GDs, exchange information and develop a European information management system called CIRCA. More information on the CIS can be found on the European Commission's web site:
http://europa.eu.int/comm/environment/water/water-framework/implementation.html

The PRB network has as its main objective testing the GDs, and assuring their coherence and crossed application.

Various international and national PRBs have been selected for this purpose. The international basins are the River Basin of *Scheldt* in Belgium, France and Netherlands, the *Moselle-Sarre*, in Germany, France and Luxembourg, the *Somos* in Rumania and Hungary, and the basin of *Neisee* in the Czech Republic, Germany and Poland. In Portugal, the Portuguese drainage area of the *Guadiana* River Basin was selected. Finally, the basins that are located within just one MS are the basins of *Odense* in Denmark, *Oulujoki* in Finland, *Suldalvassdraget* in Norway, *Ribble* in the UK, *Marne* in France, *Shannon* in Ireland, *Pinios* in Greece, *Júcar* in Spain and the basins of *Cecina* and *Tevere* in Italy.

Spain assumed the highest level of involvement in this working group, by proposing to verify and to evaluate, in the territorial area of the Júcar River Basin District (RBD), all GDs that are being developed, and by working on the development of a platform of a Common Geographic Information System.

All Guidance Documents are going to be applied and evaluated, including: 1) pressures and impacts, 2) designation of heavily modified water bodies, 3) classification of continental waters status and identification of reference conditions, 4) types and systems of classification of transitional coastal waters, 5) intercalibration network and intercalibration exercise, 6) economic analysis, 7) monitoring, 8) tools for evaluating and classifying groundwater, 9) best planning practices for the River Basin and 10) development of a Common Geographic Information System.

The development of activities prior to the WFD implementation is considered a key element for the observance of the different Directive requirements and for developing basin hydrological plans in accordance with the criteria established by this Directive.

The WFD came into force on 22 December 2000 and MS had to approve laws, regulations and administrative provisions necessary to comply with this Directive three years after the adoption of the WFD, which occurred on 22 December 2003.

By December of 2004, Member States should have developed, in each RBD, the following issues: analysis and characteristics of the RBD, review of the environmental impact of human activity, economic analysis of water uses and the register of protected areas.

The legal implementation of the WFD into the Spanish national legislation occurred on December 31, 2003 by means of amending the Water Act 1/2001, of July 20. The Act 62/2003 of fiscal, administrative and social measures, of December 30 gives fulfilment in its Title V, Chapter V, Article 129, to the requirements of the WFD in terms of establishing the River Basin Districts, including supervision of inland, transitional and coastal waters. In addition, a new administrative body called the Committee of Competent Authorities is created, where national, regional and local administration are devised for fostering the inter administrative cooperation in the application of the protective water legislation.

Another aspect of the transposition of the Directive is the new regulation that arises for contents, provisions, objectives and procedures for the elaboration of the River District Management Plans. This new regulation meets the requirements of the WFD by fixing the environmental objectives for surface and groundwater, protected areas, and artificial and heavily modified waters and by establishing associated deadlines for those purposes. Finally, public participation procedures have also been incorporated into the new regulations.

This report aims at putting into perspective those tasks developed by the Júcar RBD up to date regarding the implementation of the WFD, and more concisely, each of them pursuant to article 5, which should be developed by all EU River Basin Districts by the end of 2004. It is also a main objective of this document to spread the knowledge acquired on this subject by the Júcar PRB during the short, but otherwise intense, period since the year 2002. This report aims at showing to other river basins the steps and proceedings that have been adopted in order to implement the Directive, the tools and techniques used, where and when the difficulties arose, where efforts should be focused based on this experience, and in summary, its purpose is to expose the path followed and the findings obtained as a PRB.

Although each river basin has its own identity, similar and comparable basins to the Júcar case will have in this material a reference point to start working towards the achievement of article 5 analyses; and for those with a different profile, will find here a document with approaches that will help to tackle distinctive issues of each RBD. It is the wish of the Júcar RBD that many other River Basins may find in this report assistance and guidance for their water management.

Moreover, it is also a major objective of this report to transmit to the broad public and stakeholders the preliminary outcomes of the application of article 5, as a mean to ensure the information supply, since background information, such as the one presented in the document, should be available for anyone at any time.

It is worth mentioning that the results of this report were obtained thanks to a multidisciplinary working staff, comprised, among others, by engineers, biologists, hydro geologists, economists and computer experts, from the Júcar RBD's personnel and from external consultants, who have done their best in order to deal with the diversity of technical and practical questions raised by the WFD. It is clear that the task entailed by the implementation of the new water policy is no longer relying on a single-unique discipline, but on interdisciplinary teams that take into account interactions between water issues and their intricate technical and social complexity.

The main characterisation and analysis requirements of article 5 encompass the following activities:

- Delineation and characterisation of surface and groundwater bodies;
- Establishment of Reference Conditions for surface water bodies;
- Identification of Pressures;
- Impact of human activity on the status of surface and groundwater bodies, by means of a preliminary assessment of the risk of failing to meet the environmental objectives;
- Conducting an economic analysis of water use.

Section 3 of this report also includes a description of the Register of Protected Areas. Although this is actually regulated by article 6, it is included here since the deadline for its establishment is also the end of 2004.

Júcar River Basin Authority, September 2004

SUMMARY AND CONCLUSIONS

The Júcar River Basin District (RBD), with an area of 42 989 km^2, has an irregular hydrology very characteristic of Mediterranean basins. Droughts and floods episodes are highly common within its territory, even during the same year, and the balance between water supply and demand is very fragile. Agricultural water demand accounts for nearly 80% of water demand (2 852 hm^3/year for almost 400 000 ha of irrigated crops in year 2001). In general, agricultural demand appears to be stabilised or is decreasing, whereas urban/industrial demand (653 hm^3 for 4.3 million inhabitants) is forecasted to rise. This situation has triggered an increased use of non-conventional resources in recent years such as reuse of wastewater or desalination of seawater.

The Júcar PRB exercise started at the end of 2002 and since then, much of the benchmark information on the provisions of article 5 of the WFD concerning the current status of the basin, has been acquired, processed, organised and analysed.

The first step of the characterisation process was to identify and delineate surface and groundwater bodies. Intended for the former, several types of geometric and hydrologic criteria had to be jointly considered given the distinctiveness of Mediterranean basins. To apply these criteria, a powerful nationwide GIS (Geographic Information System)-tool model was created by the Spanish Ministry of Environment with the collaboration of a Spanish Research Centre, *Centro de Estudios y Experimentación de Obras Públicas* (CEDEX). This model has been designed as an instrument that will make possible conducting and updating spatial analyses easily for any given variable, if suitable information on the basin is available. Although much effort has been consumed on the creation of the model, it is considered worthwhile for its potential, since it has been a key tool for developing the "pressure analysis".

The process of grouping water bodies (rivers, lakes, transitional and coastal) into distinctive groups of water bodies has to be done by defining, in a preliminary way, the ecotypes (a group of water bodies that present similar characteristics) present within the District with regard to the WFD system B of Annex II. CEDEX, through a nationwide scope, is also developing this process. The Júcar PRB is collaborating on testing and improving those methods being developed to define ecotypes. Some variables of system B adopted for that purpose were chosen after developing semi-hierarchical analyses. By using this system, CEDEX has identified 15 ecotypes for the Júcar case. To improve these results available data in the Júcar RBD have been used and 14 ecotypes have been established. The application of this process to transitional and coastal waters has not been completed yet.

To establish an initial characterisation for groundwater, the concept of the hydrogeological unit (HGU, group of aquifers set for an efficient water management) is used. According to this concept, the configuration of the Júcar RBD has been divided into 52 HGUs adopted from the Júcar Hydrological Plan (JHP), approved by Royal Decree 1664 of 1998 (CHJ, 1998). Nevertheless, the definition of HGU is not completely adequate to develop the further characterisation required by the WFD, thus the units will be redefined in coming months. In order to do this, the Júcar RBD is conducting an investigation to delineate the main aquifers within the HGUs, which will in turn help to estimate their water balances, and to establish more accurate relationships with associated water dependant ecosystems of surface waters (rivers, springs, etc).

Concerning coastal and transitional waters, the General Directorate of Coasts, jointly with the CEDEX and the Júcar RBD, is developing the application of GD 2.4 on *Typology, Reference Conditions and Classification Systems for Transitional and Coastal Waters*. The coming into force of the WFD will positively affect the development of coastal water works because of the creation of future RBD Water Councils, as well as, the Committee of Competent Authorities. These new entities will be in charge of unifying all administrative divisions, improving the coastal water management.

The next step of the characterisation process is to establish reference conditions for the 14 ecotypes defined using available data in the Júcar RBD. For setting these conditions, a spatial based approach seems to be the most desirable way to proceed since it is considered a direct, suitable and trust worthy approach. However, the main drawback for this approach, besides requiring records from monitoring networks, lies on finding water bodies within all the ecotypes with little or no deviation from undisturbed conditions as happens with pristine waters, which may be difficult. Pressure analysis has been very valuable for locating these water bodies. The definition of reference conditions for ecotypes in which all water bodies present a disturbed status is an ongoing process that will be finally based on expert judgment and modelling methods. Analyses of coastal and transitional waters are being carried out in a parallel way.

Heavily modified waters and artificial waters must receive special treatment. The criteria for defining these types of water bodies have not been completely specified. Although it is clear which are the driving forces altering natural waters, it remains unclear how to establish the thresholds for characterising this type of waters. Moreover, there is the feeling that it should not be a particular or specific decision of each district, but rather a consensus resolution adopted in externals forums for providing uniformity, equivalence and consistency among similar basins. This process would be, in a way, comparable to the intercalibration exercise of ecological status to start by 2006. In this sense, the General Directorate of Water (GDW) of the Ministry of Environment is presently conducting a nationwide study concerning hydromorphological alterations of watercourses that should provide homogeneous criteria.

Surface water bodies include the following categories: rivers, lakes, transitional and coastal waters, and heavily modified and artificial water bodies. The number of preliminary surface water bodies is 268, of which 255 are rivers, 10 are heavily modified lakes, 2 are heavily modified coastal lakes and 1 is an artificial water body. The total length of surface water bodies is around 5 600 km, of which 5 095 km are rivers, 479 km are HMWB and 1 500 km are pristine water reaches, which represents 27% of all water bodies. Those reaches are the most adequate to establish reference conditions for the ecotypes to which they belong.

Since an important number of water bodies with slight anthropogenic alteration are left out of the pristine reaches, a second phase for the identification of water bodies with “no or slight anthropogenic alteration” has been developed taking into account the pressures analysis. This action allows broadening the range of reference conditions to almost the total number of ecotypes identified in the Júcar RBD, agreeing with the information obtained through the chemical water quality and biological measuring networks existing in the Júcar RBD. The total length of these reaches is about 3 600 km, representing 71% of the total length of rivers defined as water bodies.

The next step of the characterisation practice encompasses the analysis of pressures and impacts due to anthropogenic activities. Indispensable information needed to proceed at this point, is the precise spatial and temporal featuring of water uses for the different demand units (either agricultural, urban or industrial) enclosed within the RBD. Once this data is available, it is then feasible to conduct a pressure analysis that includes significant water abstraction, regulation works and others hydromorphological alterations, diffuse and point source pollution, as well as land use and other anthropogenic effects.

The pressures and impact assessment related to point source and diffuse pollution of surface water bodies has been carried out following the methodology of the Impact and Pressure Manual concerning surface water pollution (MIMAM, 2003). This Manual was elaborated by the GDW, based on the IMPRESS guidance (made by the CIS working group 2.1 of experts from EU Member States constituted to identify and characterise pressures and impacts according to the WFD).

Mathematical models, based on GIS techniques intended for the assessment of runoff depletion along watercourses due to water abstraction, show that the central and southern part of the Mediterranean coastal strip are subject to considerable stress. The middle and final stretches of the main rivers are suffering high levels of pressure compared with other water bodies within the RBD.

Flow regulation analysis reveals that major rivers, the Júcar as well as its main tributary the Cabriel, the Turia and the Mijares River, are strongly regulated from the upper/middle river stretches to the mouth. Upper parts of rivers and short watercourses are less affected by regulation structures. Since the scope for heavily modified water bodies is not precisely defined, the quantitative assessment of this type of pressure is vague in absolute terms as well as associated impact.

GIS models indicate that point source pollution due to industrial and wastewater discharge are affecting in greater extent middle and final segments of the main rivers (Júcar, Turia and Mijares) that cross the coastal plains, where most of developed areas are established. Furthermore, diffuse source pollution, due to the use of fertilisers, presents similar circumstances, as the vast majority of the crop irrigation area concentrates on coastal plains. However, the degree of dissemination of this pollution is much larger than in the case of point source pollution, since the disturbance is spread through every watercourse ending at the sea. To sum up the pressure occurring throughout the watercourses due to different sources of pollution, a global indicator of five categories was created using adequate weights to each type of pollution.

The assessment of impacts is based mostly on the comparison of the water body status versus the terms of reference or environmental objectives. The use of monitoring surface water networks (quality and biological) is crucial for classifying the type of impact as "sure" or "probable". As a general criterion, a "sure impact" takes place when an effect or status resulting from a pressure is in breach of the legislation in force, whereas a "probable" impact occurs when quality standards and environmental objectives defined by the WFD, or by expected future environment legislation, are not being met. At this early stage of the WFD development, necessary interpretations of the text and some assumptions are needed, as well as adopting terms of reference or specific environmental objectives.

Similarly to the case of pressure analysis, chemical and biological indices have been formulated and combined to assess the impact level of water bodies. The combination approach preserves the WFD principle, which states that the final status is given by the worst possible status, either chemical or biological. However, the work carried out until now is incomplete and must be improved by adding the hydromorphological and water abstraction components as soon as their assessment is set by the ongoing nationwide studies. Naturally, pressures and impacts are coupled in a cause-effect relationship, and expected results appeared when combining the results of their separate analyses, being those few locations found with disparities mostly due to the lack of data.

The final stage for the characterisation process is to evaluate the likelihood of failing to meet the established environmental objectives. At this stage, this goal has been changed to achieve a "good status", since those objectives are not well defined and will be defined in the near future. This risk appraisal is represented through a combined pressure and impact condition that has three associated levels of pressures: high, medium and low.

Pressure and impact analysis for groundwater consists of a quantitative part and a qualitative part. The first one includes the application of the new WFD concept of "available resource". Annex V, section 2.3.2, of the WFD has been considered for developing the qualitative assessment. After the analysis carried out, a significant proportion (around 50%) of groundwater bodies within the Júcar RBD are at risk of not reaching a "good status". Nevertheless, these studies basically set the basis for a further and more complete characterisation needed in all those water bodies at risk of failing to achieve a "good status", which is being carried out nowadays.

Moreover, present piezometric and quality monitoring networks must be adapted and extended within the District to provide the level of reliability, density and guarantee required by the WFD. In this sense, the construction of new control points has recently started.

An economic characterisation of water uses is being carried out to provide inputs into the analysis of cost-effectiveness of measures. For this study, four main sectors are taken into account: agriculture, industry, energy and public service, in which the evolution of variables in the last years, such as the Gross Value Added (GVA) and the employment, is studied. Both of these variables are increasing and have more importance in the industry and public service sectors. In addition, average values of volumes of water supply and discharges and averages of concentrations of polluting agents are estimated whenever they are considered relevant.

From these analyses, the future trends of the four sectors are studied, based on the extrapolation of the evolution of analysed variables, future plans and different meetings with interested parties. In this way, there will be a future vision to facilitate the analysis of cost-effectiveness of measures.

An economic analysis of cost recovery has been performed as a study for a single surface hydraulic system with its associated users. This case has been selected among others, since it is considered highly representative of the whole district, and encompasses two large dams and a conveyance channel as basic infrastructure, in addition to a large metropolitan area and an association of irrigation users. The basic purpose of this study is to assess the accomplishment of the cost recovery principle for water services. Prospective future scenarios concerning the long-term forecasts of supply and demand have been deferred and will be developed in forthcoming analyses.

Two levels of the water supply system have to be included for this analysis and for the interpretation of the results: high and low supply level. Large hydraulic works, such as dams, channels and pipelines, run by River Basin Authorities (RBA) constitute the high supply level. Municipalities and Irrigation Associations run the low level, which is comprised of urban and agricultural distribution networks and water treatment facilities that supply water to the final user: households and farmers.

The methodology used for this economic study is based, for the most part, on carrying out an appraisal between cost and fees charged to the different types of users for every service measured by unit of volume. To make this calculation, much of the effort has been focused on gathering and processing information from Irrigation Associations, local water suppliers and Municipalities, since the low level of supply is not a jurisdiction of the Júcar RBD.

Cost recovery of water services of abstraction, storage, regulation and conveyance of water by means of large dams, channels and pipelines provided by the Júcar RBA was 57.8% in 2001; 12.5% of costs not charged are attributable to warranty for future users; and 29.7% of total costs are subsidised capital costs (2.493 million euros) not charged to users.

On the other hand, one of the outcomes of the analysis reveals that the total cost of the water services is not fully recovered through users' payments. The rate of recovery in the two examples studied, urban and agricultural uses of the Benageber-Loriguilla system, is about 90% for the former and about 45 % for the latter; though these figures must not be generalized to the whole territory of the RBD, where higher figures of cost recovery are being obtained. Complete studies for all unit demands defined at Júcar RBD are presently being carried out and some preliminary results are also presented in this report.

Regarding groundwater, the outcome of a study on financial cost commissioned by the General Directorate of Hydraulic Public Works and Water Quality (present General Directorate of Water) is enclosed in this document. This study shows how the Júcar River Basin District's average cost is 0.06 and 0.09 euros/m^3 for urban and irrigation water supply respectively.

1. JÚCAR PILOT RIVER BASIN DISTRICT

1.1. Administrative framework

The Júcar River Basin District (RBD), located in the eastern part of Spain (figure 1), is made of a group of river basins and covers an area of 42 989 km². From the 17 Autonomous Communities in the Spanish Territory, the Júcar RBD encompasses part of four of them: Valencia, Castilla-La Mancha, Aragón and Cataluña, just including a small area from this latter.

The present population within the District is about 4 360 000 inhabitants (year 2001), which means that about one out of every ten Spaniards lives in the Júcar RBD. In addition to this number, about 1 400 000 equivalent inhabitants have to be added due to the tourism occurring primarily in the Valencian Autonomous Community. Nevertheless, the Júcar RBD is an area of great contrast since population density ranges from over 20 000 inhabitants per square kilometre in the metropolitan area of the city of Valencia at the Mediterranean coast, to less than 2 inhabitants per square kilometre in the mountainous areas of the province of Cuenca at the western part of the District.

Concerning the jurisdictional aspect, since the transposition of the WFD into the Spanish law on December 2003, a Committee of Competent Authorities (CCA) is presently running the Júcar RBD. This Committee is comprised, among other units, of National Administration, Regional and Local Offices in charged of the management of all kinds of waters (inland, transitional and coastal waters) in addition to competencies under the Directive's scope.

Among the CCA members, the Júcar River Basin Authority (RBA) stands out because of its legal competence over surface inland waters and groundwater. The nature of this organisation is public, it belongs to the chart of the Ministry of Environment, and it is within the national administration but functionally autonomous. This organisation carries out the mission of providing public service linked to water resources management over the entire area covered by the District. The principal activities in which this public institution is engaged in are: managing water resources, administrating the hydraulic public domain, elaborating, monitoring and updating the hydrological plan, and constructing and operating hydraulic infrastructures.

National legislation applies to the entire Júcar RBD with respect to inland waters, since its surface lies in more than one Autonomous Com-

Territorial area of the Júcar RBD — Figure 1

munity. The Spanish Constitution determines that the National Administration will be in charge of the management of the hydraulic public domain whenever the river basin lies in more than one Autonomous Community, which is the case of the Júcar RBD.

Nevertheless, the administrative division of the District territory into several Autonomous Communities causes activities related to water management to be regulated under different regional legislations, also in agreement with the Spanish Constitution. Therefore, issues related to territory planning, agriculture, cattle, forestry resources, fishing and wastewater treatment, are regulated by regional acts, since these are exclusive competency of the different Autonomous Community Governments. This multi-jurisdictional feature could be considered as a drawback for water resources management within the Júcar RBD. However, so far, all these regulations have not resulted in difficulties that hamper the District water management, on the contrary, they have allowed the development of legislation particularities accordingly to regional identities.

In concern to coastal waters, since the Valencian Autonomous Community is the only Autonomous Community with coastline, the multi-jurisdictional aspect does not take place. Similarly to the former case, the Spanish Constitution dictates that the maritime public domain must be managed by means of the National Administration and entitles Autonomous Communities with some degree of management authority on protection zones and water quality aspects.

Figure 2 Digital Elevation Model (DEM)

High: 2013 m.
Low: 0 m.

Source: Spanish Army Geographic Service

River Basins | Figure 3

1.2. Physical framework

The Júcar RBD, due to its peculiar landscape and the vast area it covers, is characterised by having diverse climates and landforms. Major geomorphic features found are: mountain systems, a continental plateau and the coastal plain. The orography of the area favours the discharge of waters into the Mediterranean Sea, and thus, the formation of river basins. All the rivers in the Júcar RBD therefore flow into this sea and the main ones are called Cenia, Mijares, Turia, Júcar, Serpis and Vinalopó.

The mountain range found in the Júcar RBD is known as the Iberian System, and it extends beyond the District limits, running from the neighbour Ebro and Duero RBDs to the coastal plain of Valencia, following a 120 km rough course from Northwest to Southeast. The highest peak in the Júcar RBD is called Peñarroya, and it is found in this range with an altitude of 2 024 meters over the sea level.

The Iberian System plays an important role on the water resources cycle in the Júcar RBD. The range acts as a barrier for sea fronts, forcing clouds carrying moist air to rise to colder upper layers of the atmosphere. Once the air is lifted and cooled, it causes drop condensation and eventually, precipitation. The mountain range not only gives birth to the main river of the District: the Júcar (figure 3), which in turn gives name to the District, but also to the Turia and the Mijares Rivers. The three of them provide jointly 80% of the average runoff. Most part of the territory of the Teruel and the Cuenca provinces are located within this mountain range.

Over the South and Southwest part of the District the last mountains of the Betic range extends, and at that point, they somehow disperse. This range runs from the South of Spain (Gibraltar) to the Mediterranean Coast point of the Palos Cape, following then a South-Northeast course. This resultant mountain area also plays an important role in the water supply of the southern part of the District, and it is where the Serpis and Vinalopó Rivers rise (figure 3).

The coastal plain is an alluvial platform along the coastal strip, and it is over 400 km long and

40 km broad in its widest section. This plain is delimited by the Iberian System on the North-west part, the continental plateau on the West and the Betic Range on the South. The coastal plain provides a highly nutrient rich soil that supports the vast majority of the agricultural irrigated production of the Júcar RBD, and it is characterised by the fact that more than 80% of the total population of the District lives on its shore strip.

Finally, the so-called Mancha area is characterised by having a relatively flat surface with an average height of 650 m, and it is located in the western part between the aforementioned mountain ranges. This plateau is featured for nestling a large aquifer called the Mancha Aquifer that is connected to the Júcar River along the plain. The aquifer and the river highly affect each other in terms of drainage and recharge. The Castilla-La Mancha Autonomous Community and more precisely, the province of Albacete together with some parts of the Valencian Community lie over the Mancha plateau.

Figure 4 Júcar River at Alzira

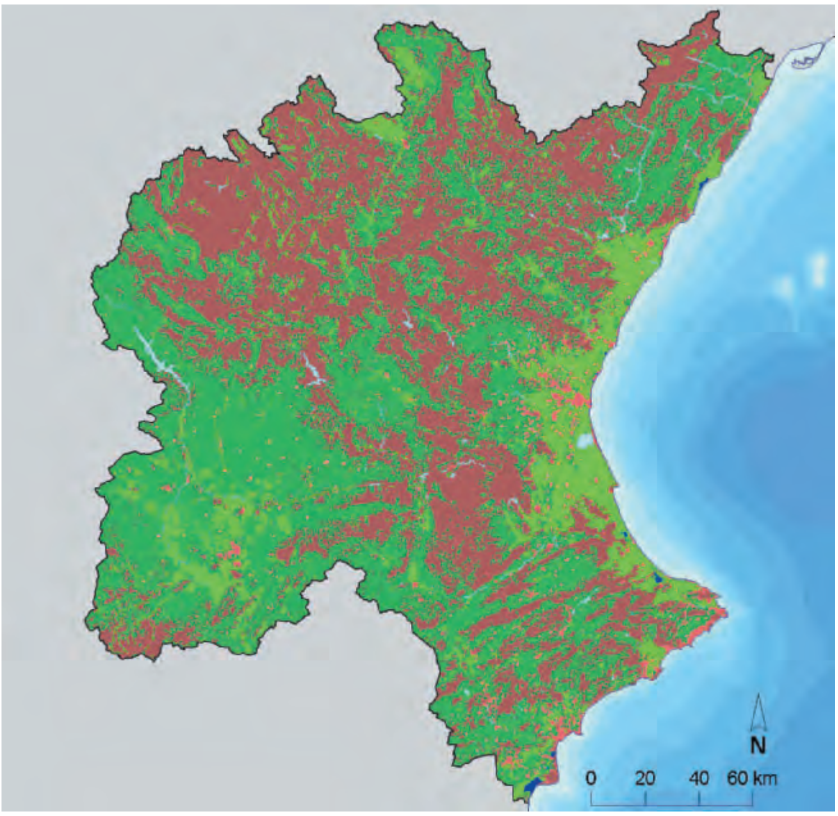
Figure 5 Cenia River at Font de Sant Pere (Castellón)

The Júcar River, the main river in the District, takes its name from the ancient Arabic word "Xuquer", which means "the destroyer". It was labelled with such an adjective due to the numerous and devastating flood events the population suffered during those times mainly at its final reach. This river is 512 km long and presents different types of stretches along its course according to the diverse orography it travels by: from the Iberian System, through the Mancha plateau and finally to the coastal plain. Figure 4 shows the river passing through the town of Alzira, in the middle of the coastal plain and 25 km away from the mouth of the river.

The upper river courses are the stretches featuring the highest ecological value. Orography, geomorphology, climate, hydrology, vegetation, fauna and scenery make these areas unique. These rivers are usually born in the highest peaks, close to the limits of the RBD, and act as ecological passageways or corridors connecting high mountain areas with plains in the middle river courses. Frequently, these rivers run across rugged areas or narrow mountain valleys with hardly any or a very small portion of floodplains, and riverbanks are sometimes just hillsides. These characteristics create incredible defiles. The upper reach of the Cenia River, which follows the administrative border between the Catalonian and Valencian Autonomous Communities, is a clear example of a pristine water body (see figure 5).

Another important characteristic of the basin is the considerable vast coastline, with a total of 481 km, giving the District a ratio of *coastline / surface area* of 0.01 km/km^2. Moreover, there are a large number of small inlands, such as the Columbretes or Tabarca, belonging to the Administrative territory of the Valencian Autonomous Community. The Columbretes islands, of volcanic origin and not inhabited, are located 30 miles off shore from the Castellón Province and include a cluster of small islands and emerging rocks that in total have an extension of 2 500 ha. These islands are protected by the environmental legislation due to the sea bird diversity

Land use map — Figure 6



Artificial surface
Agricultural irrigated areas
Agricultural non-irrigated areas
Forests and seminatural areas
Wetlands
Water surfaces

Source: EEA, Corine Land Cover 1990

they host. The Island of Tabarca is located 11 miles off the shoreline of the city of Alicante and likewise has a volcanic origin. This island is the only one populated within the Júcar RBD, which has become a tourist resort, and has recently been declared Marine Reserve for its richness in sea life diversity.

Land use in the Júcar RBD largely depends on the types of human activities that are developed in each area and the extent to which the land is farmed (figure 6). Both factors have given rise to artificial landscapes that are to a greater or lesser extent unlike the natural landscapes that were a result of climatic, geological and morphological factors specific to each area.

The dominant land use within the District is *forest and semi natural areas*, which cover 50% of the territory (table 1). This percentage is of great significance and shows that there is natural heritage that still covers large areas in the Júcar RBD. This use is followed by *agricultural non-irrigated areas*, covering 40% of the territory and by *agricultural irrigated areas* with an 8 %, being predominant uses in the coastal areas and in the Mancha area. Figure 7 shows typical Mediterranean scenery made of orange tree fields, and example of an agricultural irrigated area. Urban and industrial zones cover 1.8% of the territory and finally, a very small area, which does not even account for 0.6% of the area, is covered by wetlands and water surfaces.

Table 1 summarises land uses according to the Corine Land Cover 1990, a digital map developed by the European Environmental Agency (EEA) based on satellite data. For future works, Corine Land Cover 2000 (not yet available) will be used. The comparison of both maps will allow studying the evolution of land uses in that past decade of intense changes.

Figure 7	Orange tree fields

Another important aspect of the physical framework of the Júcar RBD is the lithology existing in the area. Different lithographic groups can be identified in the District's map as it is shown in Figure 8 and table 2. Calcarenites and marls are the predominant groups, although significant proportions of limestone and alluvial material are found, this latter mainly in areas close to the mouth of major rivers (Mijares, Júcar and Turia).

The 481 km of shoreline belonging to Júcar RBD are featured by several geomorphological elements as beaches, strings of dunes, cliffs and rock bottoms, with very different profiles and which support a high number of rich ecosystems spread all along the coast. It has to be noted that terrestrial systems by means of sedimentary materials, such as sand, clay and pebbles, feed the marine environment located close to the shore. This material is mainly conveyed by the flow of rivers and coastal lakes and once it reaches the shore, sea currents rapidly disseminate it. In this sense, the predominant marine current on the coast goes from North to South, being the Ebro River (out of Júcar RBD limits) the principal source of sedimentary materials.

The basic distinctiveness of the Júcar RBD coast is the coexistence of two types of primary ecosystem, which are characterised by the nature of the substratum: sandy coast with soft bottom, and cliffs with rock bottom (table 3). On the other hand, because of the unstable shoreline due to coastal erosion, some parts of the shore have been protected with man-made structures. This defended coastal structural frontage accounts approximately for 65 km, and two major types of defences (rock armour and offshore breakwater) prevent from erosion and encroachment of sediments.

Table 1	Land Cover in the Júcar RBD

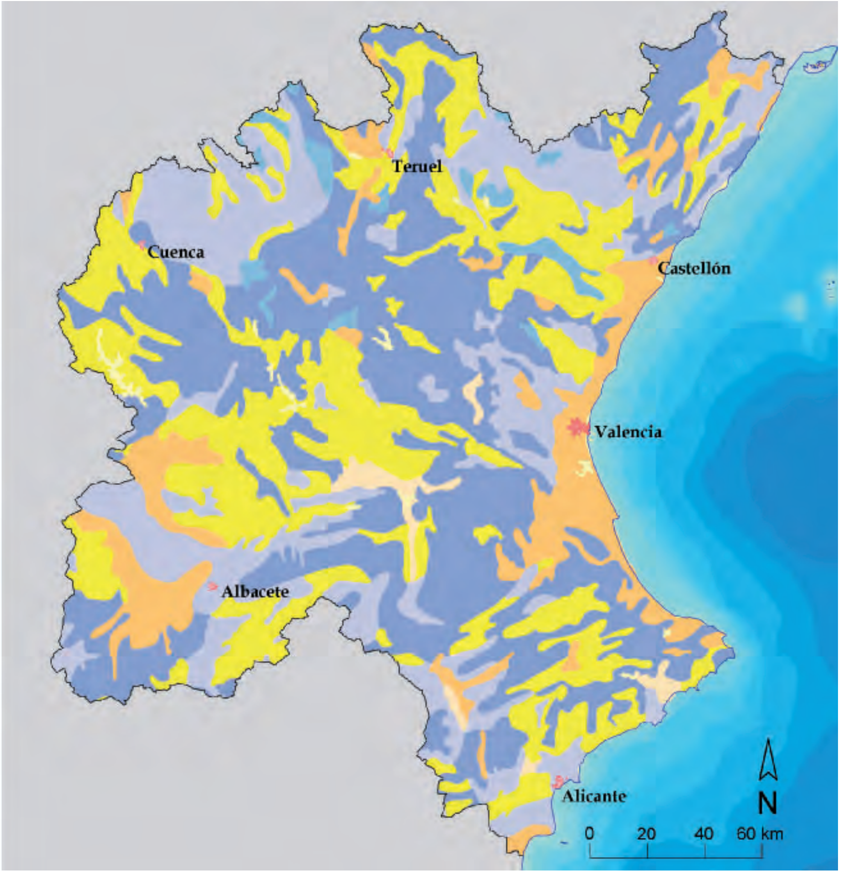
Land use		Area (ha)	%
Artificial surface		76 723	1.8%
Agricultural areas		2 049 939	47.7%
	Irrigated areas	357 455	
	Non-irrigated areas	1 692 484	
Forest and seminatural areas		2 144 314	49.9%
Water surfaces and wetlands		28 784	0.6%

Source: EEA, Corine Land Cover 1990

An example of characterisation of the coastal geomorphologic types is shown in figure 9. Focusing on the stretch around the city of Benidorm, it is possible to notice ports (in black), different types of beaches (yellow, orange), chain of dunes (fuchsia), and cliffs (dark blue).

The harbour of the city of Alicante and the nearby coastline is an example of heavily modified coastal area that is shown in figure 10.

Lithological map	Figure 8



- Calcarenite
- Limestone
- Marl
- Gypsum clays
- Alluvial material
- Slate

Source: EUROSTAT

Júcar RBD Lithology	Table 2

Lithological classes	Area (km²)	Percentage
Alluvial material	4 648	11%
Limestone	9 106	21%
Marl	11 710	27%
Gypsum clays	561	1%
Calcarenite	15 906	37%
Slate	835	2%

Figure 9 **Geomorphological types around the Benidorm coast**

- Emergent flat rock
- Aluvial deposit
- Port
- Pebbles beach
- Sand beach
- Beach with fossil dunes
- Emergent abrupt rock
- Cliff
- Floodplain and dejection cone
- Chain of dunes

Source: Regional Governments

Table 3 **Classification and length of coastal types within the Júcar RBD**

Source: Regional Government: Valencian Autonomous Community

Type of Coast			Length (km)
Natural Coast	Sedimentary	Sand beaches	146
		Sand-pebbles beaches	36
		Pebbles beaches	31
	Erosive	High cliffs	33
		Medium cliffs	32
		Low cliffs	82
		Very low cliffs	9
Defended Coast		by rock armour	26
		by offshore breakwater	35
		by filling of materials	4
Heavily modified coast		Harbours	47
Total length			**481**

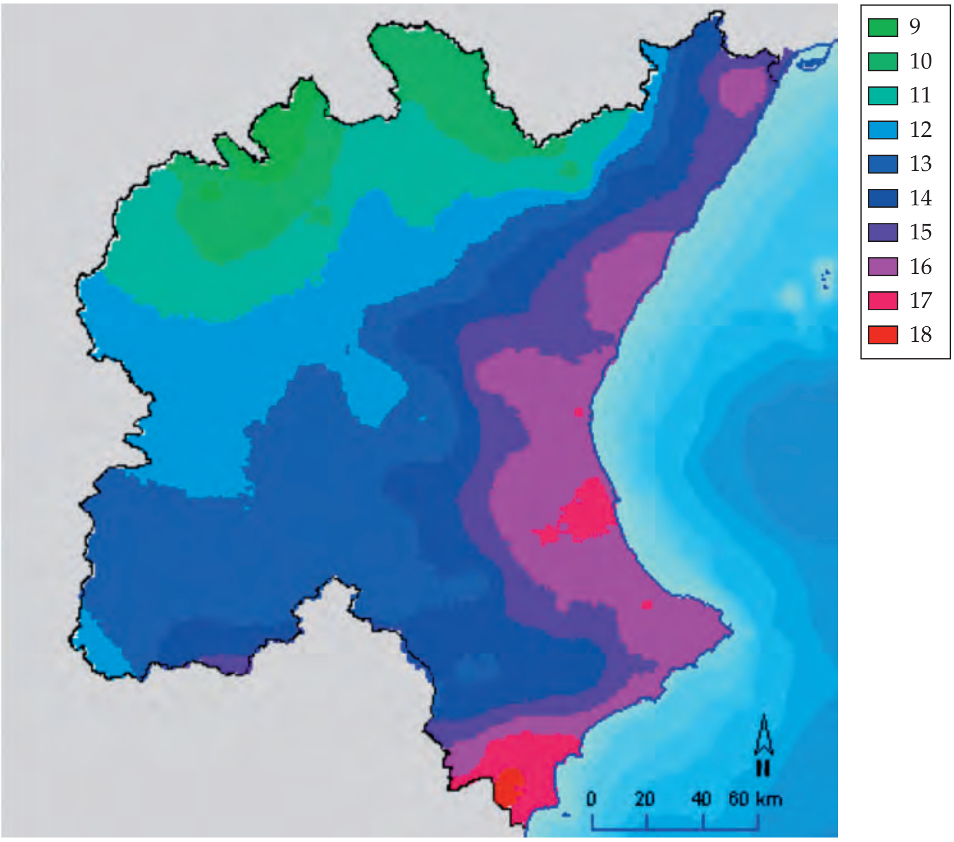
Figure 10 **Harbour of the city of Alicante and nearby coastline**

Source: Regional Government: Valencian Autonomous Community

1.3. Climatic conditions

The Júcar RBD is located between latitudes 38° and 40° north and enjoys a Mediterranean climate with hot-dry summers and mild winters. This is the result of a high-pressure mass covering the Iberian Peninsula coming from the Azores Islands in the Atlantic Ocean, which provides placid weather for most of the year but little precipitation as a normal basis. As an exception to this general description, there is the so-called *cold drop* event, which occurs during autumn, most likely during October or November. This phenomenon occurs when hot masses of water vapour arise from the Mediterranean Sea once summer is over, and are stroked by cold polar currents of air coming from

Mean annual temperature map (°C) — Figure 11



Annual precipitation in the Júcar RBD (mm/year) — Figure 12

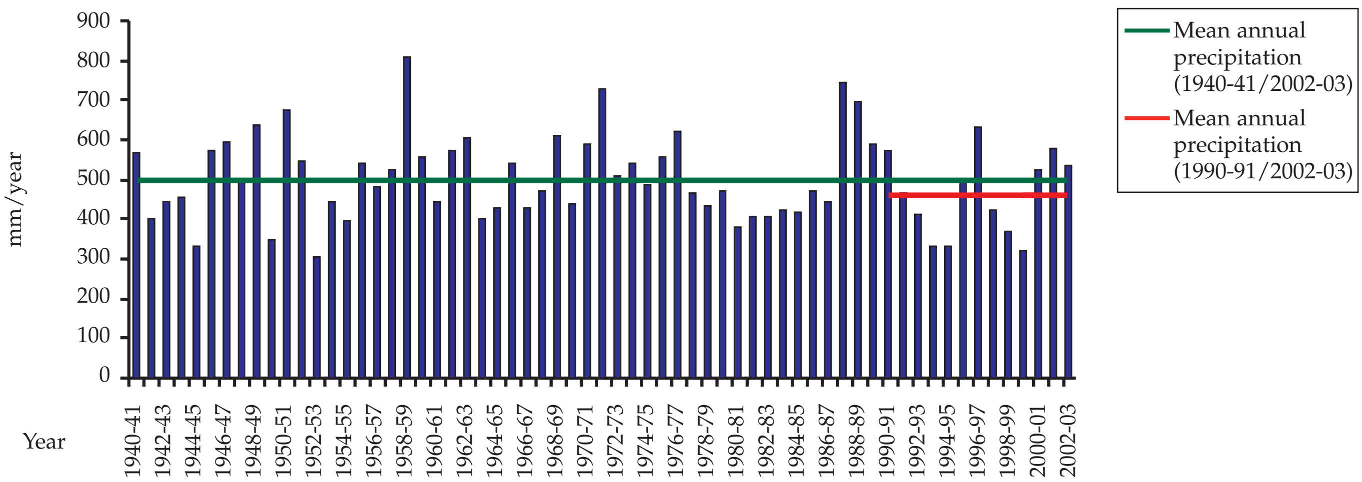


Figure 13 Mean annual precipitation in the Júcar RBD (mm/year)

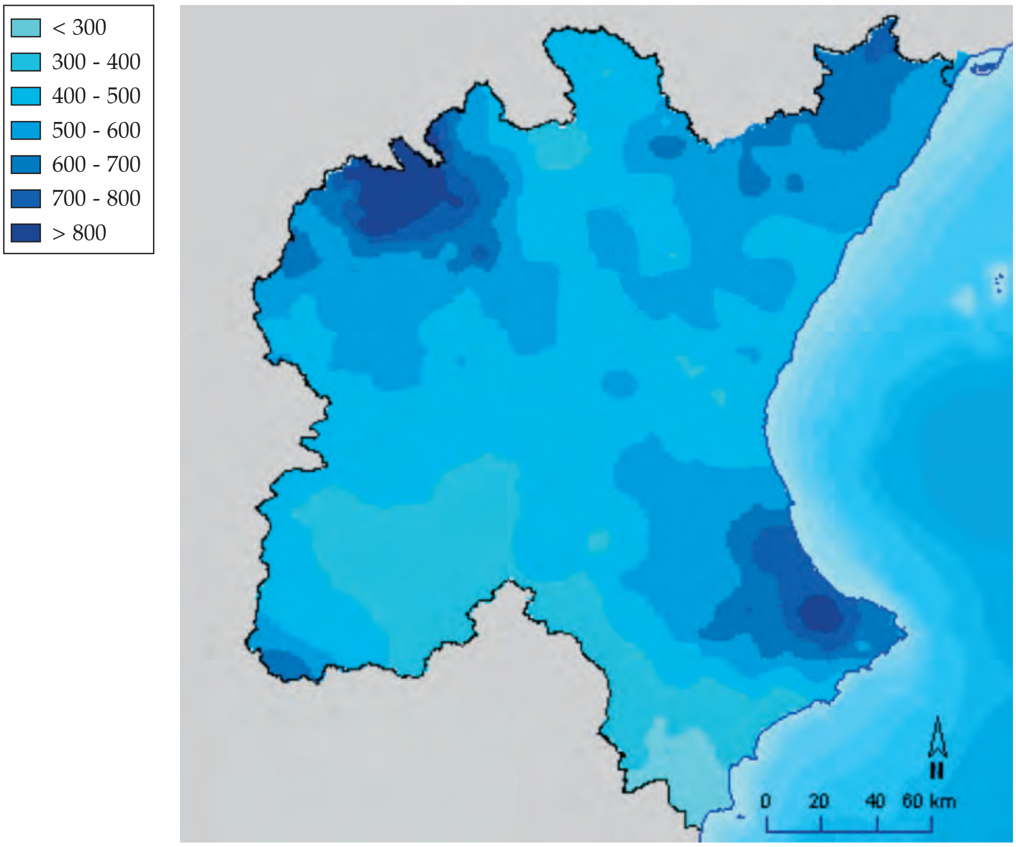
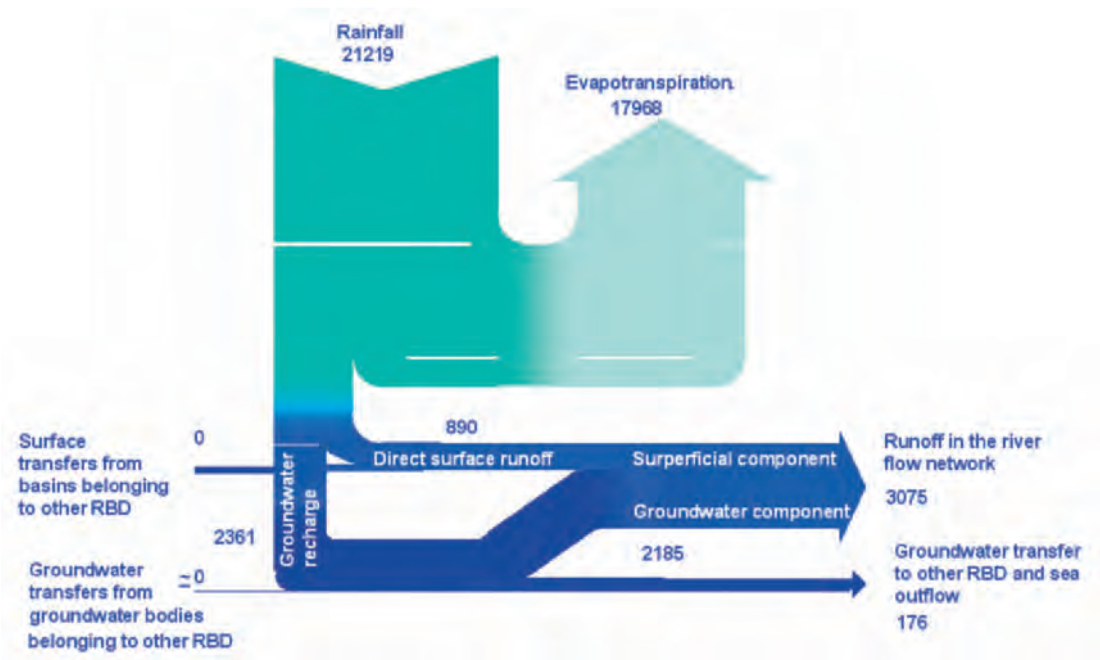


Figure 14 Water cycle in natural regime (hm³/year)



Flood in the Júcar River — Figure 15

the North. The result is the formation of thick clouds, which provoke sudden and violent precipitation that cause devastating floods.

The long periods of sunshine, together with the continuous circulation of hot air masses give rise to high temperatures, ranging the mean annual values (figure 11) from 9º C in the Northwest mountainous areas, to 18º C in the Southern coastal part of the basin.

The rainfall in the Júcar RBD shows a high spatial and temporal variability. Mean annual precipitation for the whole basin is about 500 mm, ranging from 300 mm in the driest years to 800 mm in the most humid ones (see figure 12). The persistence of dry years produces significant drought periods, as the one that has occurred in past years (marked with a red line).

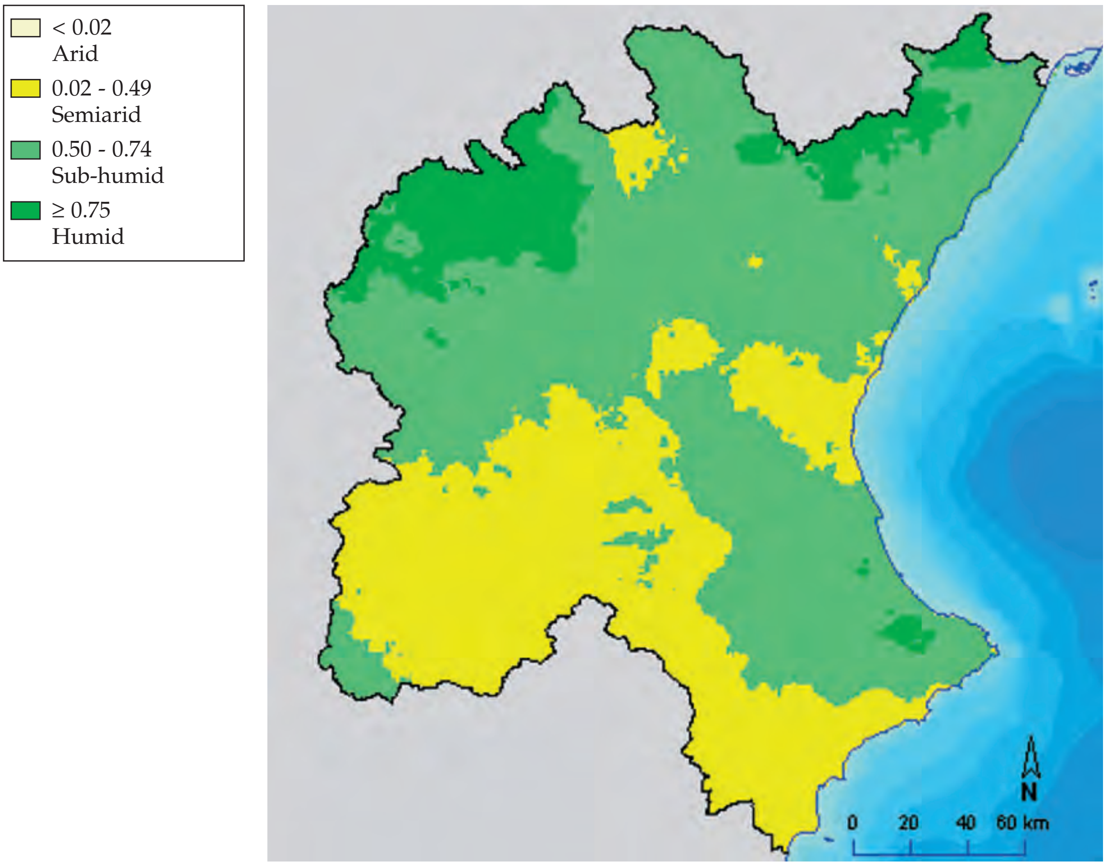
As mentioned, precipitation in the Júcar RBD presents a strong spatial variability. Mean annual values vary from 250 mm/year in the South to about 900/year mm in the North of the basin (figure 13). This variation occurs because the Júcar RBD is comprised between two climatic regions highly different from each other: the European and the North African. These climates provoke differentiated responses in the river basin weather behaviour.

The amount of 500 mm/year corresponds to a volume of 21 220 hm^3/year over the whole land surface of the territory. About 85% of this precipitation is consumed through evaporation and transpiration by the soil-vegetation complex. The remaining 15% comprises the annual runoff of 3 251 hm^3 /year (figure 14).

Another important aspect concerning rainfall and affecting the Júcar RBD is the temporal concentration of the rainy events. In some coastal areas, the maximum rainfall recorded in only one day is close to the mean annual rainfall. Furthermore, short and intense storms often occur locally, and this phenomenon gives rise to extremely high rainfall rates that have a direct effect not only on flooding effects (figure 15), but also in soil erosion. Convective rainfall produces maximum values in autumn, when it is common to exceed 300 mm in 24 hours.

According to the UNESCO climatic index, there are three types of climatic regions in the Júcar RBD: semiarid, sub-humid, and humid. These regions are defined by means of an index that relates precipitation and potential evapotranspiration. Figure 16 shows the importance of the semiarid region that extends throughout most of the Southwest area of the RBD.

Figure 16 **UNESCO humidity index**



1.4. Biotic framework

The biological framework of the Júcar RBD is characterised by presenting a great number of ecosystems that include different habitats and species. Besides the river fluvial network there is a large number of wetland habitats: fluvial environment and associated coastal areas at the mouths of the rivers, such the ones found in the Mijares and the Júcar Rivers, coastal wetlands and associated environment, as L'Albufera of Valencia. Springs, such the ones of the Verde River, inland lakes as Laguna de Uña and coastal saline environment as the Salinas de Santa Pola are also found.

Each ecosystem or habitat has characteristic associated vegetation that varies depending on the lithology, geomorphology and climate. The contrast between the North of Júcar RBD with a more humid climate, and the drier South with a varied lithology, determines a great richness of flora. The riparian forest is, in most riversides, the maximum expression of its biological diversity. Different kinds of trees are distributed in the riparian zones in arrays of diverse species or forming groups, according to the hydrology, altitude and soil type. Riversides with permanent watercourses are formed by willows (*Salix fragilis, Salix alba, Fraxinus angustifolia*), poplars (*Populus alba, Populus nigra,* figure 17) and elm groves (*Hedero-Ulmetum minoris*), while in those ones with no permanent fluvial regime, the vegetation is dominated by saltcedar (*Tamarix gallica, Tamarix canariensis*) and oleander (*Nerium oleander,* figure 18).

Currently, the quality of the riverside environment in some river reaches is not in good status and measures of protection will have to be taken to avoid their deterioration. One of the main objectives of the Júcar RBD is restoring those riverside and riverbanks in worse conditions, in order to recover the natural processes of erosion and sedimentation and the ecological functioning of the fluvial system.

The most common macrophytes in the area are enea (*Typha domingensis*), reeds (*Phragmites sp.*), rushes (*Juncus sp., Scirpus sp.*), and water spikes (*Potamogeton sp.*). There is also a great number of species of algae (Chlorophyceas, Cyanophyceas, Charophyceas, Diatoms), mosses and liverworts, which play an important role as bio indicators of freshwater quality and of transitional and coastal waters. Aquatic vegetation in the final reach of the Júcar is shown in figure 19.

The zoological communities respond, similarly to vegetation communities, to these factors that shape and alter their habitat: environmental, climatic, biological, etc. In the case of aquatic organisms, other important factors are the quantity and quality of water. In addition, the geologic history of the territory has determined the appearance of a high number of autochthonous species as well as endemic, since many fluvial basins have remained isolated for a long time.

There is a rich and diverse ichthyofauna in the RBD rivers mainly comprising cyprinids of the genera *Barbus, Chondrostoma* and *Squalius.* In the case of the salmonids it must be emphasised the presence of the autochthonous trout species *Salmo trutta*, with populations genetically differentiated from the rest of the European populations. Other species with strict and very sensitive environmental requirements are the loaches (*Cobitis sp.*) and blenidos (*Salaria fluviatilis*). There is a reduced number of migratory species, being the most important the eel (*Anguilla anguilla*). However, numbers of this species have been greatly reduced in past years due to the degradation and contamination of the lowlands of rivers. It is also remarkable, the presence of two small freshwater toothcarp species characteristic of the littoral freshwater habitats: the *Aphanius iberus* and the *Valencia hispanica* (figure 20), both endemic of the Mediterranean coast and in danger of extinction. It deserves a special mention the presence of exotic fish species, finding a great diversity in the Júcar RBD so much from the taxonomic point of view as for its origin and antiquity of their introduction. Most of the species have been introduced for sport fishing and their major impact is the resulting increase of competition that takes place with autochthonous species.

Júcar RBD plays an important role in preserving European wet areas, since it presents a large number that stands out qualitative and quantitatively. Only in L'Albufera Lake, 250 species of birds use regularly this ecosystem, and more than 90 for reproducing. One of the most interesting species is the red duck (*Netta rufina*) with more than 10 000 individuals, which makes of L'Albufera one of the most important places for bird hibernation of Western Europe. The populations of black-headed gull (*Larus ridibundus*) are

Riparian forest in the middle course of the Júcar River (Alcalá del Júcar) — Figure 17

Riparian vegetation in an ephemeral water course (Rambla de Bolbaite) — Figure 18

Aquatic vegetation in the final reach of Júcar River — Figure 19

Figure 20	Samaruc *(Valencia hispanica)*

Figure 21	Kingfisher *(Alcedo atthis)*

Figure 22	Autochthonous crayfish *(Austropotamobius pallipes)*

also of high importance, reaching 60 000 individuals in some years. In rivers with relevant riparian forests, there are mallards (*Anas platyrhyncos*), common coots (*Fulica atra*) or common moorhens (*Gallinula chloropus*). However, the most characteristic species are the kingfisher (*Alcedo atthis*) (figure 21), the sand martin (*Riparia riparia*) and the dipper (*Cinclus cinclus*).

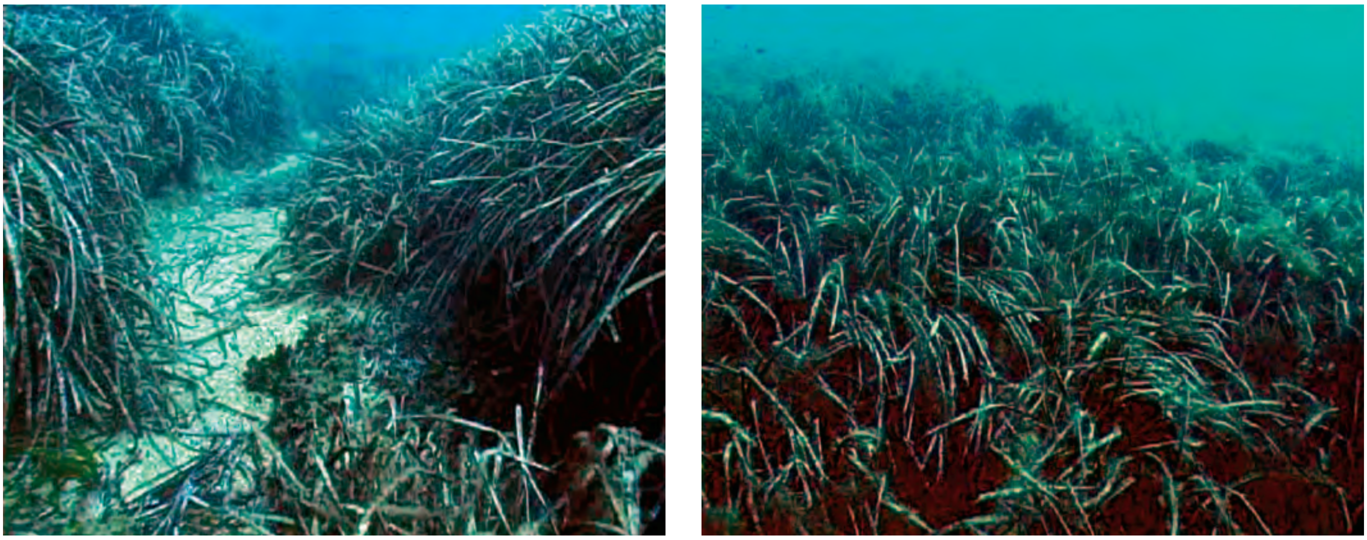
The otter (*Lutra lutra*) is the biggest wild carnivorous found in Júcar RBD, but it has suffered one of the greatest decreases in recent decades because of its dependence on fluvial ecosystems, and their degradation (pollution, canalisation and alteration of riverbanks).

Within the group of macroinvertebrates, we find the most important group of organisms used as water-quality bio indicators in aquatic ecosystems, especially in rivers. There are a great number of different fauna groups: annelids, molluscs, crustaceous and insects. The success of the macroinvertebrates group as bio indicators lies in their quick response to the sightless alterations of the environment quality. Up to date, more than 500 different taxa (families, genuses, species) have been identified in the studies carried out in the framework of the Júcar biological monitoring network. Within this group, we may find endemic species as the shrimp *Dugastella valentina*, the mollusc *Theodoxus velascoi* or species with a very restricted distribution as the mayflies *Torleya major* and *Prosopistoma pennigerum*. There has been a critical decrease of autochthonous species due to the introduction of exotic species and other factors. Some examples of important losses are found in species such as the crayfish *Austropotamobius pallipes* (figure 22) and the freshwater mussel *Anodonta cygnaea*.

Two primary types of ecosystems are found in the coastal areas of Júcar RBD, being both highly related to the nature of the substratum: sandy coast with soft bottom, and cliffs with rock bottom.

The first type of ecosystem, presenting sedimentary features, is associated to shores with a low profile, as beaches, strings of dunes and even coastal wetlands. These shallow waters, in which sunlight reaches the marine bottom, are a good habitat for some plant species as sea grass beds of *Posidonia oceanica* (phanerogam) (figure 23), which is endemic of the Mediterranean Sea. This species forms extensive communities that give up large amounts of dissolved oxygen and

Posidonia oceanica Figure 23



support other animals and marine plants. Thus, contribute with an ideal habitat for reproduction, breeding and sheltering of a great number of fish and selfish species.

The sea grass beds of *Posidonia oceanica* are located in a variable extension of the marine bottom and are formed by rhizomes and leaves. In the Mediterranean coast the inferior limit of sea grass beds is usually located 25 m deep. This type of see grass beds is one of the richest in species diversity and one of the most productive ones.

The second type of coastal ecosystem, of erosive feature, is related to shores with abrupt profiles, such as cliffs and emerging bedrocks, over which seawater waves produce mechanical erosion. Because of the calcareous nature of the rock, which is predominant at the Júcar RBD, shore where practically only limestone is present, the rate of rock dissolution is comparatively higher than in other places with siliceous rock, as it occurs in the northern part of the Iberian Peninsula. The energy of the stroke between wave and rock originates sprays of seawater that reach terrestrial zones, leading to an environment of high salinity, sunshine and wind. This environment represents an important habitat for a high number of plant and animal endemic species (lichens, alga and plants of the genus *Limonium* or *Daucus*, invertebrates as shellfish and birds). Moreover, the rock bottom conditions are regulated by variables as the intensity of sunshine, temperature of water, and physico-chemicals factors, which induce a growing or shrinking effect in biotic species of the submarine communities. Two communities that are commonly found in this type of seabed are coral formations and caves.

Figure 24	Annual runoff in the Júcar RBD (hm^3/year)

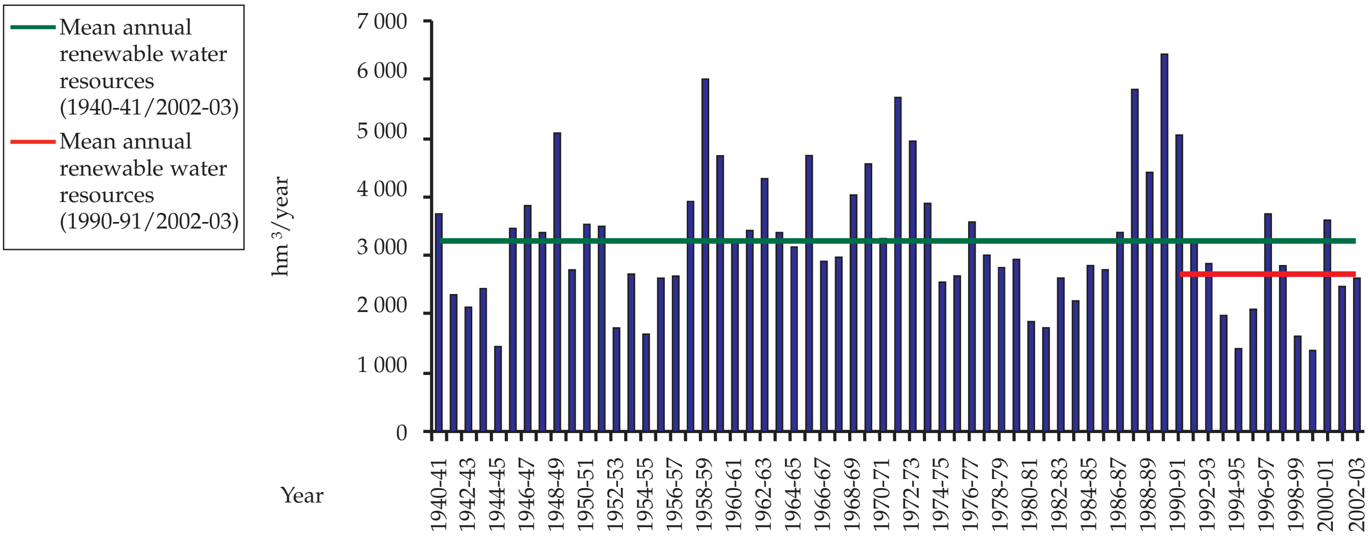
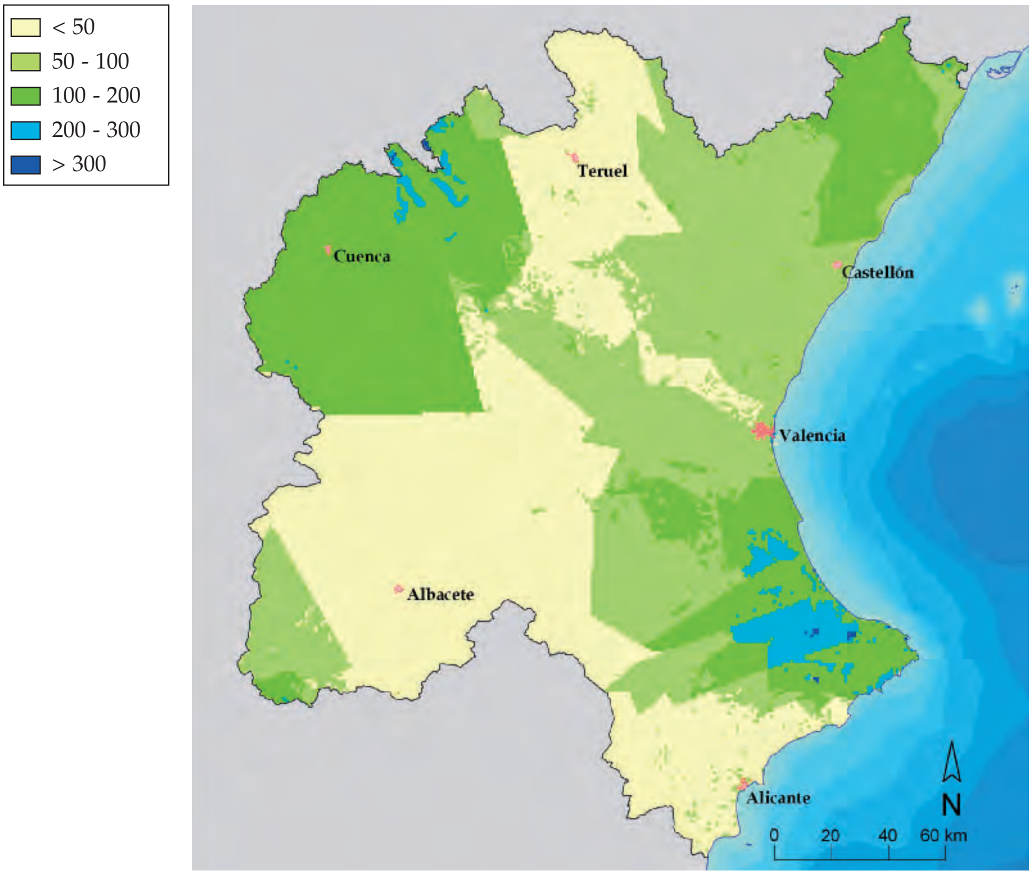


Figure 25	Mean annual runoff (mm/year)



1.5. Water resources

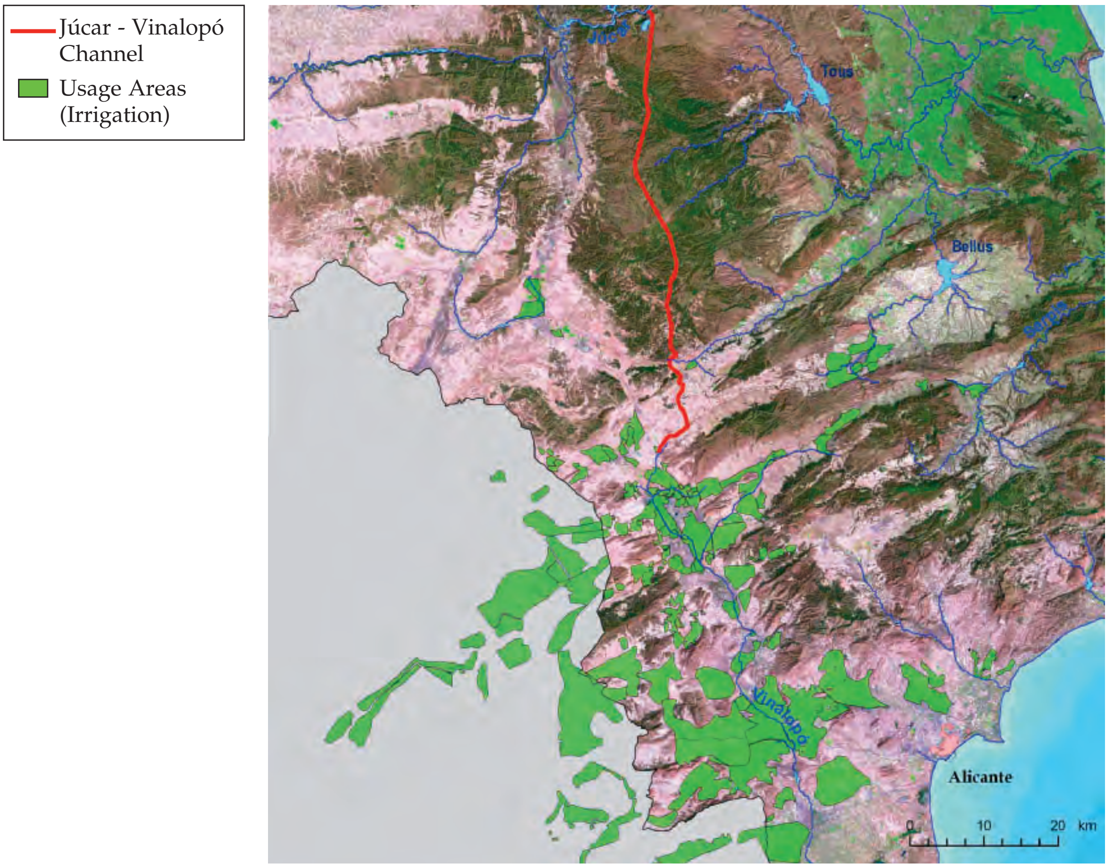
The precipitation volume over the Júcar RBD produces a mean annual runoff of about 80 mm, which represents approximately 15% of the total precipitation. The mean annual renewable resources are 3 251 hm^3/year (data for the period that ranges between the hydrological years 1940/41 and 2002/03, as shown in figure 24). This mean value has decreased to 2 700 hm^3/year during the last ten years, what has produced difficulties on satisfying water demands.

The runoff is distributed spatially as it is shown in figure 25, where two regions with high runoff values are observed, the upper basin of the Júcar River in the western area, and the Marina Alta area in the eastern one.

Acequia Real del Júcar irrigation channel | Figure 26

Main channels in the Júcar RBD | Figure 27

Figure 28	Júcar-Vinalopó water transfer



Water resources of the area come from both surface and groundwater origins. Surface water resources have been used historically, and this use goes back to the Roman and Arab times. As an example, the Acequia Real del Júcar, an irrigation channel, is dated from the XIII century (figure 26)

Main channels present throughout the Júcar RBD are shown in figure 27. The Tajo-Segura Aqueduct carries water from the Tajo RBD to the Segura RBD passing through the Júcar District and its conveyance is about 30 m^3/s. The Canal Júcar-Turia connects the Júcar and Turia Rivers and it is used for public water supply and for irrigation. The Acequia Real del Júcar distributes water for irrigating mainly orange trees and rice fields in final reach of the Júcar River. Other significant channels are the Canal Cota 220, the Canal Cota 100, the Canal Campo del Turia, the Canal Manises-Sagunto, the Canal de Forata, the Canal Júcar-Turia, the water supply to Albacete, the Canal Bajo del Algar, the Canal Rabasa-Amadorio, and the Canal del Taibilla.

Nowadays, a water transfer project between the Júcar River and the Vinalopó-Alacantí and Marina Baja area is being developed (figure 28). It is an intra-river basin water transfer, which was included in the list of infrastructures of the Júcar Hydrological Plan (JHP). After that, this project was included in Annex II of the National Hydrological Plan passed by Act 10/2001.

The purpose of the transfer is to mitigate the overexploitation and water deficit in the areas of Vinalopó-Alacantí and Marina Baja. This project must be considered jointly with two other projects to be meaningful: the groundwater substitution of the Mancha Oriental Aquifer, and the modernisation of irrigation techniques in the Acequia Real del Júcar, which is expected to save 100 hm^3/year in a first phase. While the maximum volume of water to be annually transferred through this channel is 80 hm^3, the average water transfer is around 70 hm^3, although in dry periods this volume could be lower. The construction works started in 2003 and include 67 km of pipelines, 26 kilometres in tunnel and 41 kilometres in siphons (double pipeline of 1.80 m. of diameter).

Reservoirs in the Júcar RBD | Figure 29

Surface water resources in the Júcar RBD are regulated through large dams (figure 29). The total reservoir capacity in the District is about 3 300 hm^3, being Alarcón (figure 30), Contreras and Tous (figure 31) in the Júcar River and Benageber in the Turia River, the largest reservoirs.

Groundwater resources, 2 361 hm^3/year, represent approximately 73% of the total water resources. These numbers reflect the importance of this type of resources in the basin. A typical well for abstraction of water from an aquifer is shown in figure 32.

Figure 30	Alarcón reservoir

Note: storage capacity of 1 112 hm^3

Figure 31	Tous reservoir

Note: storage capacity of 370 hm^3

The conjunctive use of superficial water and groundwater is quite common, with clear examples as the ones of La Plana de Castellón, La Marina Baja or La Ribera del Júcar (Sahuquillo, 1996). On the other side, the intensive use of groundwater has produced overexploitation in some of the hydrogeological units (HGU), such as those from the exploitation system of Vinalopó-Alacantí, from the coastal plains of the province of Castellón or from the HGU of the Mancha Oriental aquifer.

Regarding the use of non-conventional resources, it is important to mention the high potential for reusing treated wastewater, action that represents one of the highest achievements in Spain. Only within the Valencian Region more than 300 wastewater treatment facilities were fully operating in 2002 with a total treated effluent of 389 hm^3/year. The water treatment carried out at the Valencian Region is of great significance since it supports nearly 90% of the population of the RBD.

Table 4 shows the basic figures on reuse of treated wastewater. From 389 hm^3/year of total discharge, about 26% was being reused in year 2002, which it is considered a satisfactory rate. The results of water reuse, in the vast majority of the cases, benefit agricultural irrigation, environmental and recreational practices (for instance, the irrigation of golf courses).

Figure 34 shows the locations of wastewater treatment facilities with direct reuse of the effluent. As shown, most of these water treatment plants are located within the coastal strip, which is indicative of the water scarcity in this area.

Seawater and brackish waters desalination is the other non-conventional resource available together with water reuse. Though it is generally agreed that annual production of desalinated water volume is relatively small in comparison to total water demand, this relatively small production does play an important role at the local scale, meeting part of the municipal and industrial water requirements of several demand units in water shortage areas along the Mediterranean coast. Currently, there are 17 desalination plants within the Júcar RBD between seawater and brackish waters, 7 of them are used for urban supply (Canal de Alicante, Jávea, Denia, Teulada, Benitaxell, Vall D'Uixó and Moncofar), 2 for recreational uses (Alicante-II and San Vicente), 2 for agricultural irrigation (Jacarilla and El Campillo), and finally, the other 6 plants (using brackish waters) are for industrial uses (Benferry, Unión Cervecera, Siderurgia del Mediterraneo, Central de Escatrón, Sivesa and Cofrentes Nuclear Plant). Table 5 summarises the characteristics of desalination plants within the RBD.

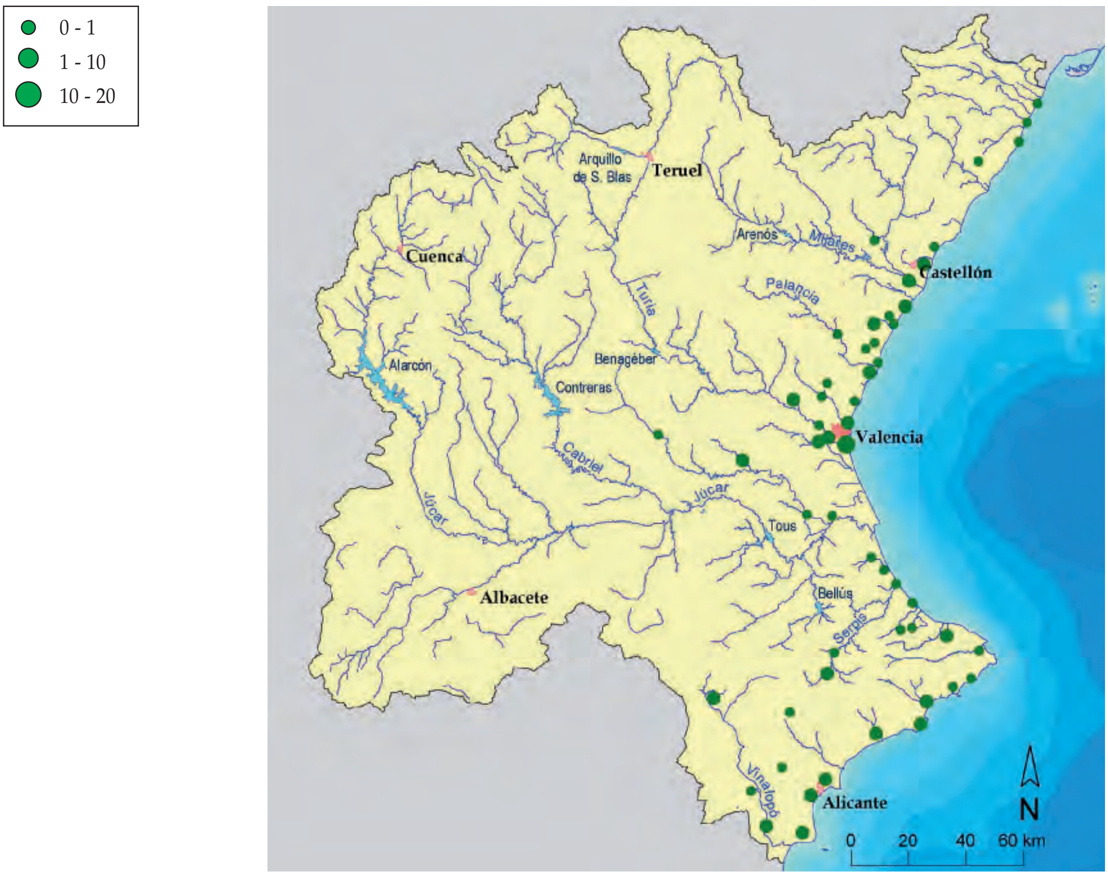
The Canal de Alicante desalination plant is the most recent plant developed to obtain new resources of water in the Júcar Basin. This plant treats about 18 hm^3/year of seawater and produces fresh water for around 600 000 people of the towns of Alicante, Elche, Santa Pola and San Vicente del Raspeig

Well in operation Figure 32

Wastewater treatment plant Figure 33

Table 4	Treated and direct reused volume of water (year 2002) in Júcar RBD		
System	Treated volume (hm^3)	Equivalent inhabitants	Volume of reused waters (hm^3)
Cenia-Maestrazgo	4.6	59 294	0.0
Mijares-Plana Castellón	42.0	504 398	14.0
Palancia-Los Valles	7.0	95 110	4.0
Turia	177.2	2 179 480	35.0
Júcar	35.5	594 045	2.0
Serpis	29.1	380 778	4.0
Marina Alta	14.7	185 590	2.5
Marina Baja	16.1	359 156	12.0
Vinalopó-Alacantí	62.6	1 393 576	28.0
TOTAL	388.8	5 751 427	101.5

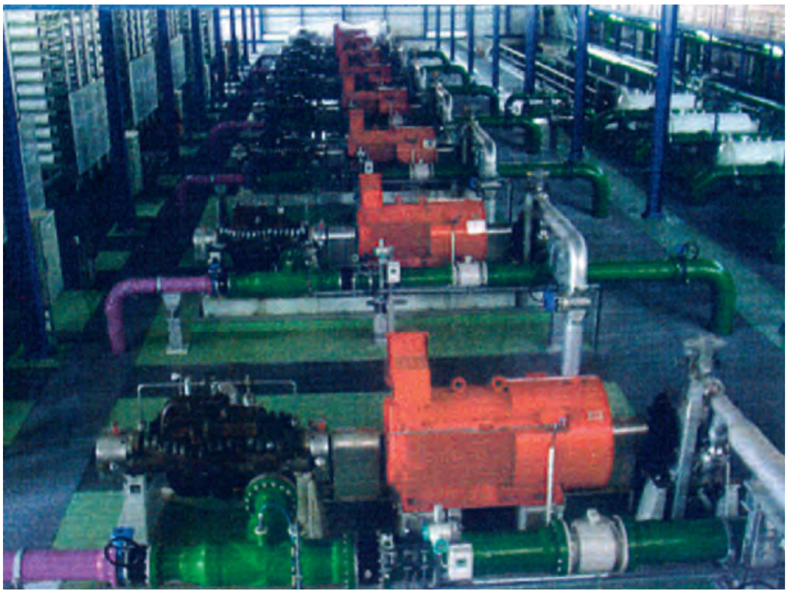
Figure 34 Wastewater direct reuse (hm^3/year)



Desalination plants | Table 5

Name	Municipality	Management System	Purpose	Type	Water Production [m³/year]
Canal de Alicante MCT	Alicante/Alacant	Vinalopó	Urban	Seawater	18 250 000
Javea	Jávea/Xàbia	Marina Alta	Urban	Seawater	6 500 000
Denia	Denia	Marina Baja	Urban	Brackish water	5 256 000
Teulada	Teulada	Marina Alta	Urban	Seawater	2 190 000
Benitaxell	Benitachell	Marina Alta	Urban	Seawater	1 460 000
Vall D'Uixó	Vall d'Uixó	Mijares	Urban	Brackish water	974 144
Moncófar	Moncófar	Mijares	Urban	Brackish water	654 504
Total urban					**35 284 648**
Alicante II	Alicante/Alacant	Vinalopó	Recretional	Seawater	400 000
San Vicente del Raspeig	Alicante/Alacant	Vinalopó	Recretional	Brackish water	126 945
Total recreational					**526 945**
Jacarilla	Alicante/Alacant	Vinalopó	Agricultural	Brackish water	2 299 000
El Campello	Campello (el)	Vinalopó	Agricultural	Brackish water	1 439 340
Total agricultural					**3 738 340**
Benferry	Alicante/Alacant	Vinalopó	Industrial	Brackish water	2 044 000
Unión Cervecera S. A.	Quart de Poblet	Turia	Industrial	Brackish water	525 600
Siderurgia del Mediterraneo	Sagunto/Sagunt	Palancia	Industrial	Brackish water	383 000
Central Escatrón	Teruel	Turia	Industrial	Brackish water	205 000
Sivesa	Manises	Turia	Industrial	Brackish water	182 500
Central Nuclear Cofrentes	Cofrentes	Júcar	Industrial	Brackish water	43 800
Total industrial					**3 383 900**
Total					**42 933 833**

Canal de Alicante desalination plant | Figure 35



1.6. Environmental flows

The Júcar Hydrological Plan (JHP) currently in force (CHJ, 1998) sets out environmental restrictions applicable to watercourses, wetlands and aquifers to allow the preservation and recovery of natural ecosystems, by establishing different types of requirements:

- Specific minimum flow on rivers downstream of nine (9) significant reservoirs.
- General minimum flow criterion for the rest of the river network.
- Minimum annual flows for wetlands, which correspond to 12 500 m^3/ha unless further detailed study determines otherwise, to protect and maintain their significant environmental values.
- Groundwater outflow required to prevent seawater intrusion into the coastal aquifer system.

Table 6 shows specific river flows established by the JHP downstream of reservoirs. It is important to note that the minimum flow is a constant rate set out for any period throughout the whole year, independently of the current season, the climate type of the year (dry/wet) or any other hydro-meteorological variable. Therefore, it is necessary to analyse, in the next years and following the WFD criteria, which is the most appropriate flow regime for the right functioning of ecosystems.

Table 6 Minimum environmental flows set out downstream reservoirs by the JHP

Reservoir	Minimum environmental flow (m^3/s)
Ulldecona	0.150
Sichar	0.200
Benageber	0.700
Loriguilla	0.500
Alarcón	2.000
Contreras	0.400
Forata	0.200
Tous	0.600
Guadalest	0.100

Moreover, for the rest of the river network, the JHP establishes that the environmental flow for each segment must be obtained through specific studies based on biological and hydrological criteria taking into account the specific features of associated hydrologic system, flora and fauna. By default, in the case that no specific study is available, the Plan adopts a provisional solution given by a general criterion that sets the upper limit of the environmental flow as a minimum natural river flow with a maximum of 1 m^3/s. This is adopted, although the interpretation of this term may not always be clear or easy.

However, it is difficult to assign environmental flows, especially on lower stretches of watercourses within the Júcar RBD. This happens since rivers are vastly altered after their course reaches the populated coastal plains. For instance, the hydrological regime of the lower reaches of the Júcar River downstream the Tous reservoir are highly influenced, and are characterised by having diverse natural and artificial mechanisms as regulation infrastructures, weirs, irrigation canal intakes, point returns, diffuse returns and groundwater outflow. These alterations result in a very irregular regime even in consecutive reaches, and are responsible for very strong flow changes in short distances along this course. The criteria to establish the environmental flows (as flow, renovation time of water, depth, mean slope, water quality, good hydro system performance, thickness of the marine wedge, etc.) are being considered by experts and users, but in any case, there must be a trade-off between human benefit and protection of ecosystems.

1.7. Water demands

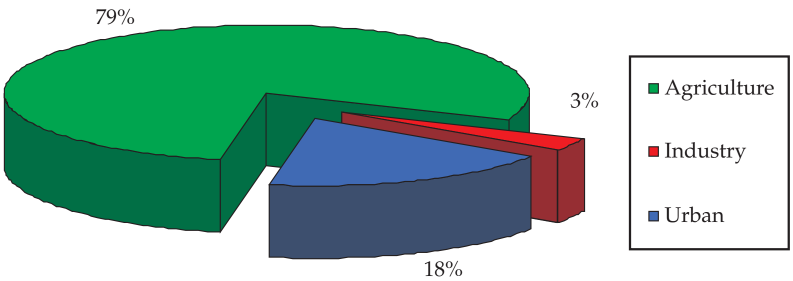
The gross water demand (year 2001) in the Júcar RBD is 3 625 hm^3/year, being distributed into 653 hm^3/year for urban use, 2 852 hm^3/year for agricultural use and 120 hm^3/year for industrial use, including this latter 35 hm^3/year for refrigerating energy plants. As it is shown in figure 36, the agricultural demand is the major one in the Júcar RBD representing 79% of the total demand.

The territorial area of the Júcar RBD is characterised by having, in general terms, a very fragile equilibrium between renewable resources and water demands (CHJ, 1998), occurring water shortages in some areas, especially in the ones located in the coastal strip of the province of Castellón, the Mancha Oriental aquifer and the exploitation systems of Vinalopó-Alicantí and Marina Baja.

Concerning the quality aspect of surface waters, it can be stated that there is a general positive trend for most water standards (drinking waters and fish life support). Only a few locations are in breach of the National/European Legislation. During 2001 there were up to 4 073 km of watercourses under surveillance, of which 424 km correspond to safe drinking water, 2 272 to fish support life and 1 377 to aptitude control for agricultural irrigation.

The water quality monitoring network is called ICA, which is the Spanish acronym for Integral Water Quality, and is comprised of 364 monitoring sites or control stations from which network workers obtained 1 863 samples and carried out 3 203 laboratory tests during 2001 (the tests had a 90-95% confidence interval).

Water demands in the Júcar RBD — Figure 36



In addition, a biological network was developed, and has been functioning since 1999. This network provides the assessment of biological indices along watercourses based on the presence of macroinvertebrates, macrophytes, diatoms and fish life in two annual campaigns of communities, as well as hydromorphological and physico-chemical data. Through the results obtained to date, it is known that half of the 246 fixed sampling sites have an excellent or good biological status. These sites are normally located in the upper reaches of rivers and present high degree of biodiversity and good hydromorphological and physico-chemical profiles. However, less than one fifth of the sites present an unsatisfactory or inadequate status, and these are usually located in lower reaches. In these areas, there is a certain degree of pollution due to discharges; therefore, they present low biodiversity and only resistant-pollution species survive.

Moreover, there are some specific complementary networks as the control of hazardous and radioactive substances networks designed to detect these types of discharge in strategic sites.

Watercourses surveillance length (km) for water standards within Júcar RBD (2001) — Table 7

SAFE DRINKING WATER				FISH SUPPORT LIFE			IRRIGATION	TOTAL
A1	A2	A3	Total	Salmonid	Cyprinid	Total		
19.7	302.9	100.9	423.5	967.8	1 304.6	2 272.4	1 377.4	**4 073.3**

1.8. Extreme events: floods and droughts

A characteristic type of flood in the Mediterranean regions, and specifically in the Júcar RBD, is the so-called *flash flood*, which is featured by having a quick response to rainfall, what makes it difficult to apply early warning measures to protect the population.

The precipitation that causes flood events is usually very intense and has a short duration. For instance, on October 1982 a peak intensity of nearly 1 000 mm in 15 hours was recorded on the Ayora Valley within the Júcar RBD. This was the result of a typical Iberian meteorological phenomenon named the *cold drop* (see section 1.3), which usually takes place every year from September to November.

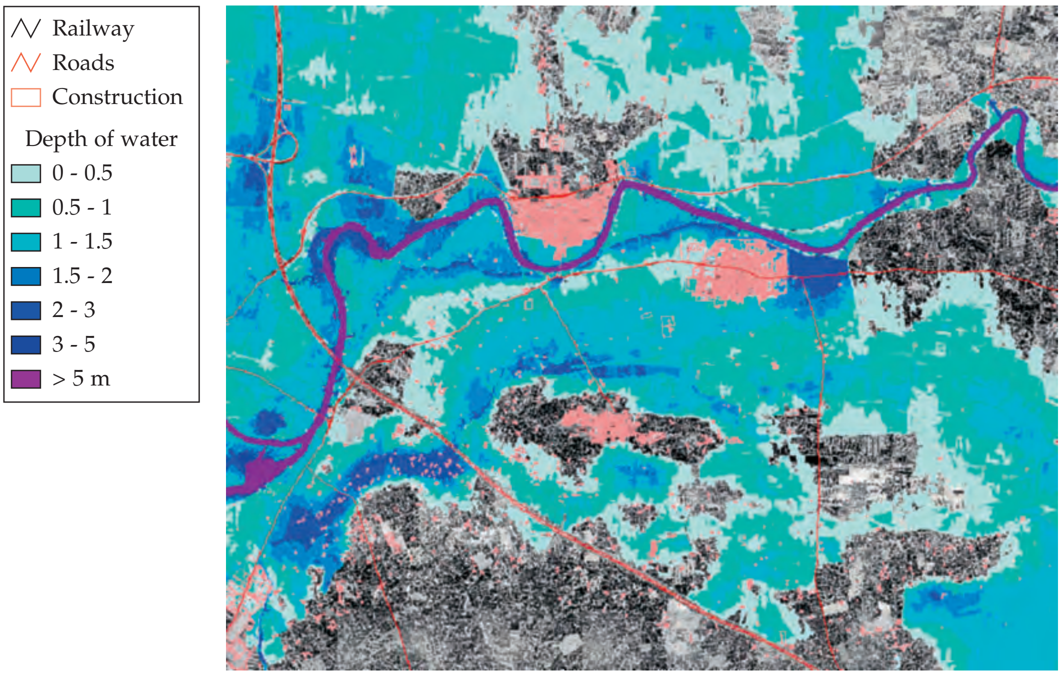
The most important floods have occurred in the Júcar River, two particular historical events are the major floods that have taken place since 1600: the San Carlos Flood on November 4-5, 1864, with an estimated peak flow of 13 000 m^3/s, and the one that occurred on October 20, 1982, which caused the Tous Dam to break down and had a peak flow of about 10 000 m^3/s. This last event had devastating effects from the collapse of the dam. During the 1982 flood, about 100 000 people were evacuated, and a surface area of 24 000 hectares of farmland were affected. The direct damage of this flood was estimated to be 1 450 million of euros (at the 1998 value), as a result of the high population density and the large number of infrastructures in the area.

After the flooding that occurred in October 1982, the decision of studying different structural measures was taken, in order to reduce the effects of flooding on the Júcar riverbank. This decision led to the creation of the General Flood Prevention Plan in the Júcar River Basin ("Plan General de Defensas contra Avenidas en la Cuenca del Júcar") (CHJ, 1985), which included the Escalona, Tous and Bellús Reservoirs.

The construction of these infrastructures did not resolve the flood risk in the Júcar riverbank completely, and therefore, in 1998, it was decided to start a series of further technical studies. These studies were intended to determine necessary actions to develop a process in which the general public would be involved, so that the different administrative authorities and social bodies could voice their opinions on the matter and reach a consensus and a common solution.

To obtain the most effective protection strategies, it is recommended to combine both types of measures, taking into account local circumstances. In this sense, the Global Plan for Flood Prevention on the Júcar riverbank (CHJ, 2000b) "sets certain

Figure 37 **Flood mapping in Júcar River as a result of GISPLANA model (Estrela and Quintas, 1996)**

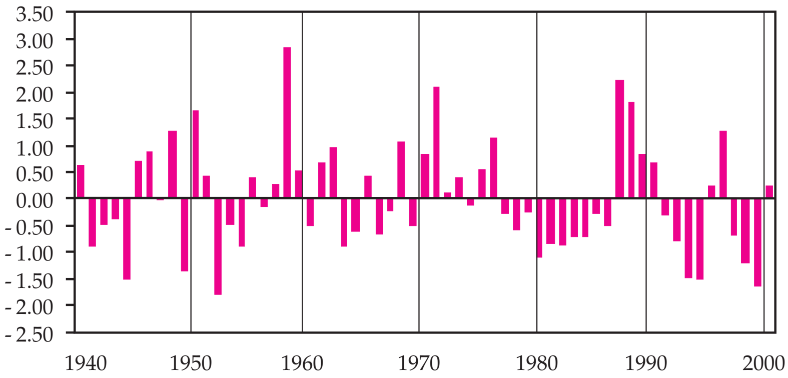


suitable structural protection thresholds as targets that will make it possible to reach homogeneous safety levels throughout the territory and deal with the major risks by means of programmes containing non-structural measures".

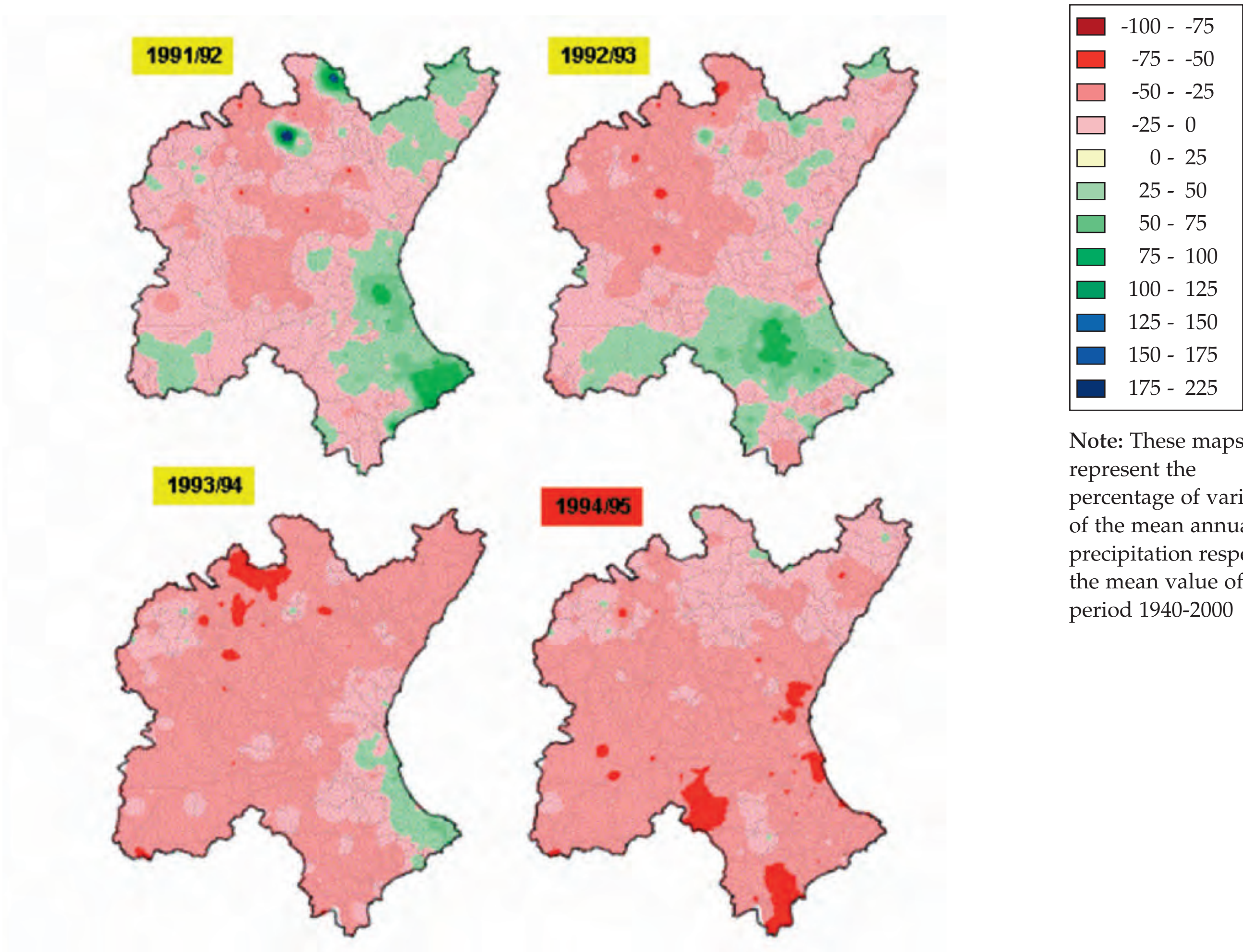
The Global Plan has defined return periods ranging from 100 to 250 years for the flows in urban zones, and from 25 to 50 years for the rural zones when contemplating the structural protections against flooding.

For achieving these objectives, the actions comprised in the Global Plan for Flood Prevention include structural measures, as the constructions of three news dams (on Sellent, Cáñoles and Magro Rivers), the arrangement of riverbeds, hydrological and forestal recovery, and improvement of the drainage for the transport networks. Moreover, non-structural measures have been adopted: flood risk mapping, civil protection, territorial organisation, and insurance of goods and property.

SPI values for annual precipitations in the Júcar RBD — Figure 38



Annual deviations for the years corresponding to the 1991-1995 drought — Figure 39



Note: These maps represent the percentage of variation of the mean annual precipitation respect to the mean value of period 1940-2000

The drawing up of identical mapping that is common to both local and regional authorities, will make possible a better development of the Municipal Plans of Action in face of flood risk. These Plans will have to be prepared in accordance with the Special Flood Risk Plan of the Valencian Autonomous Community and the Basic Directive for Planning Civil Protection on flood risk. Furthermore, this mapping will be extremely useful to Authorities involved in territorial organisation and urban planning.

In opposition to floods, multi-year droughts have occurred during the periods of 1998-2000, 1993-95, and 1980-83, which can be seen in figure 38. The most devastating flood occurring in the Júcar RBD recent history, as mentioned previously, took place on October 1982. This shows that flood conditions are not necessarily indicative of wet years and gives an idea of the irregularity of the Mediterranean hydrology. These drought periods establish the criteria commonly used to design hydraulic infrastructures systems to meet water demand and assess the reliable level of supplies.

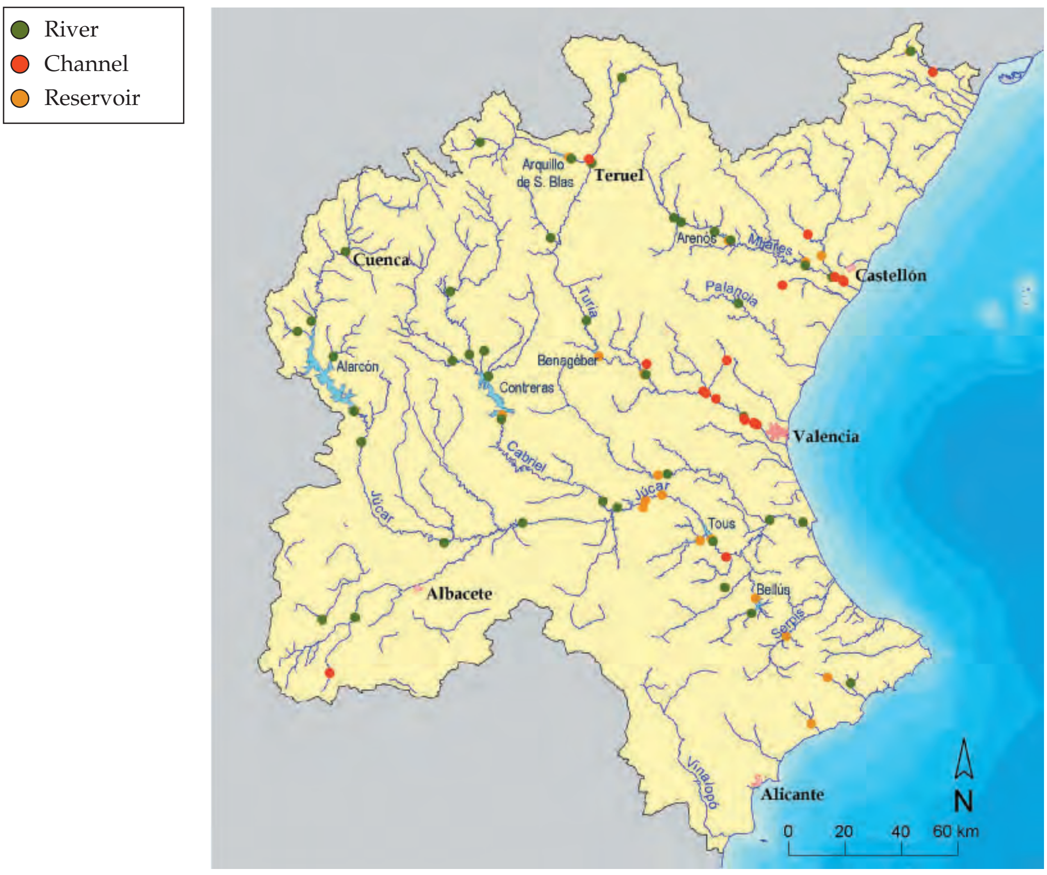
Some of the Júcar RBD drought periods may reach, in some cases, 10 years. An index that reflects the annual deviation from the mean annual rainfall is the Standard Precipitation Index (SPI), shown in figure 38. It is a normalized index that it is used for quantifying the deficit in the volume of precipitation for any given period of time.

The spatial deviation maps for the years corresponding to the 1991-1995 drought period are shown in figure 39. These maps represent, for each year, the percentage of variation of the mean annual precipitation respect to the mean value of period 1940-2000.

1.9. Monitoring networks

The Water Framework Directive (WFD) establishes, in art. 8, that Member States (MS) must design monitoring programmes to provide information for the assessment of water bodies in order to obtain an overview of the water body status within the River Basin District (RBD). These pro-

Figure 40 Surface water monitoring network



SAIH river flow monitoring network | Figure 41

grammes shall include, for surface waters, the monitoring of volume, flow level, and ecological and chemical status. For groundwater bodies, the programmes must include the monitoring of chemical and quantitative status. These monitoring programmes, as described in the Directive, must be designed in accordance with the requirements included in Annex V.

In the following sections, the existing monitoring and surveillance networks within the Júcar RBD are described, distinguishing between the two main water body types, superficial and groundwater, and within these types, between quantitative and qualitative aspects.

Surface water monitoring networks for water quantity

The official water surface monitoring network provides information on levels and volumes for selected points of rivers and on the main reservoirs and channels. This network takes measures continuously, and consists of 44 gauging stations in rivers, about 19 control points in reservoirs bigger than 10 hm^3, and around 19 control points in channels, as shown in figure 40.

There is also the Automatic Hydrologic Information System (SAIH) network (figure 41), which provides information on the basin's hydrometeorological and hydrological status in real time. The oldest data recorded by this network in the Júcar basin is from 1988.

Figure 42	Current piezometric monitoring network

Hydrogeological Units

Impervious surface or local aquifers

Groundwater monitoring networks for water quantity

Concerning groundwater, the piezometric and hydrometric networks provide data on water levels in the aquifers and on springs flows respectively. The hydrometric network occasionally includes flow measures in some streams in addition to the springs.

The hydrometric network consists of 25 points, and some of them have records from the 70's. Nowadays, the Júcar basin has a fully functioning piezometric network with 130 measuring points (figure 42) from which the RBD obtains measurements at least once a month. This network was established on the 60's by IGME (Spanish Geological and Mining Institute). Nowdays it is operated by Júcar River Basin Authority.

Programmed piezometric monitoring network	Figure 43

Hydrogeological Units
Impervious surface or local aquifers

Recently, the Spanish Administration has programmed a number of measures to establish new monitoring networks, which will make up the Groundwater Surveillance Official Network. Within this program, the Júcar RBD has designed a piezometric network, which aims to cover all WFD requirements for groundwater bodies (figure 43). This network has been designed taking into account the most representative points of each hydrogeological unit (HGU), and making use of all historical records available in prior networks when it was possible. The project has been already developed and the construction of new points (a total of 287) is now starting.

Figure 44	Integral Water Quality (ICA) monitoring network

Surface water monitoring networks for water quality

The physico-chemical and ecological status of the surface water bodies belonging to the Júcar RBD are surveyed by the combined action of different networks, as it is described below.

Different networks are used to monitor the physico-chemical status of the water bodies, mainly the Integral Water Quality (ICA) network (figure 44), which is operational since 1993, the Automatic Alert Stations network that provides data in real time (its implementation started in 1993-94 and the first measures date from 1995), the toxic substances surveillance network, which is now being projected and the radioactive substances network.

Biological quality monitoring network | Figure 45

The Biological Quality Indicators network (ICAB) (figure 45) measures the biological status in each one of the river reaches by means of Biological Indices. The analysed biological communities are macroinvertebrates, diatoms, macrophytes and fish. Now that the design stage is almost concluded, the total number of sampling stations that make up the biological network is 246.

Figure 46	Groundwater quality monitoring network

Hydrogeological Units
Impervious surface or local aquifers

Groundwater monitoring networks for water quality

The main goal of the following networks is to assess the qualitative status of aquifers and their possible marine intrusion problems.

The groundwater quality monitoring network (figure 46) analyses every two months the following parameters: pH, temperature, conductivity, oxygen chemical demand, dissolved oxygen, dry remains, turbidity, majority elements, nitrogen compounds, heavy metals and hydrocarbures. This network was established in the 70's by the IGME, and it is made up of 150 control points.

As it happens with the piezometric network, during 2004 it is programmed to improve the current groundwater qualitative network with the construction of new control points.

The Marine Intrusion Monitoring Network identifies aquifers with marine intrusion problems. It carries out weekly sampling and analyses of conductivity and chloride content. This network was established in the 70's by IGME and there are many points that have historical data. Currently data is being gathered from 40 points.

2. CHARACTERISATION OF JÚCAR PILOT RIVER BASIN

2.1. Characterisation of surface water bodies

2.1.1. *Surface water body types*

Delineation of surface water bodies and their classification into ecotypes is being carried out for the whole Spanish territory following the criteria established in the different Guidance Documents (EC, 2002 and 2003). The Centre for Studies and Experimentation in Public Works (CEDEX) of Spain is developing this task. This Centre is an organisation that provides assistance to the Spanish Ministry of Environment in some technical aspects of the WFD. The Júcar RBD has collaborated with CEDEX on testing and improving the methodologies that are being developed.

2.1.1.1. Rivers

The first step in the characterisation stage consists on delineating the "significant rivers" of the Júcar RBD. Rivers have been derived automatically from a 100 m x 100 m Digital Elevation Model (DEM) provided by the Spanish Army Geographic Service, using algorithms developed specifically for this action by CEDEX. In the case of the Júcar RBD the official digital river network of the Spanish National Geographic Institute (IGN) with scale 1:25 000 was used in the burning-in process.

A first map was obtained assuming that the origin of a river starts when it has a draining basin greater than 10 km^2, a WFD criterion. The results showed that a high number of courses that are usually found dried, appeared forming part of the river network, especially in the driest southern areas of the Júcar RBD territory. Figure 47 shows the Rambla de la Castellana at Lliria (province of Valencia), place with a drainage area above 250 km^2 and where no flow usually circulates.

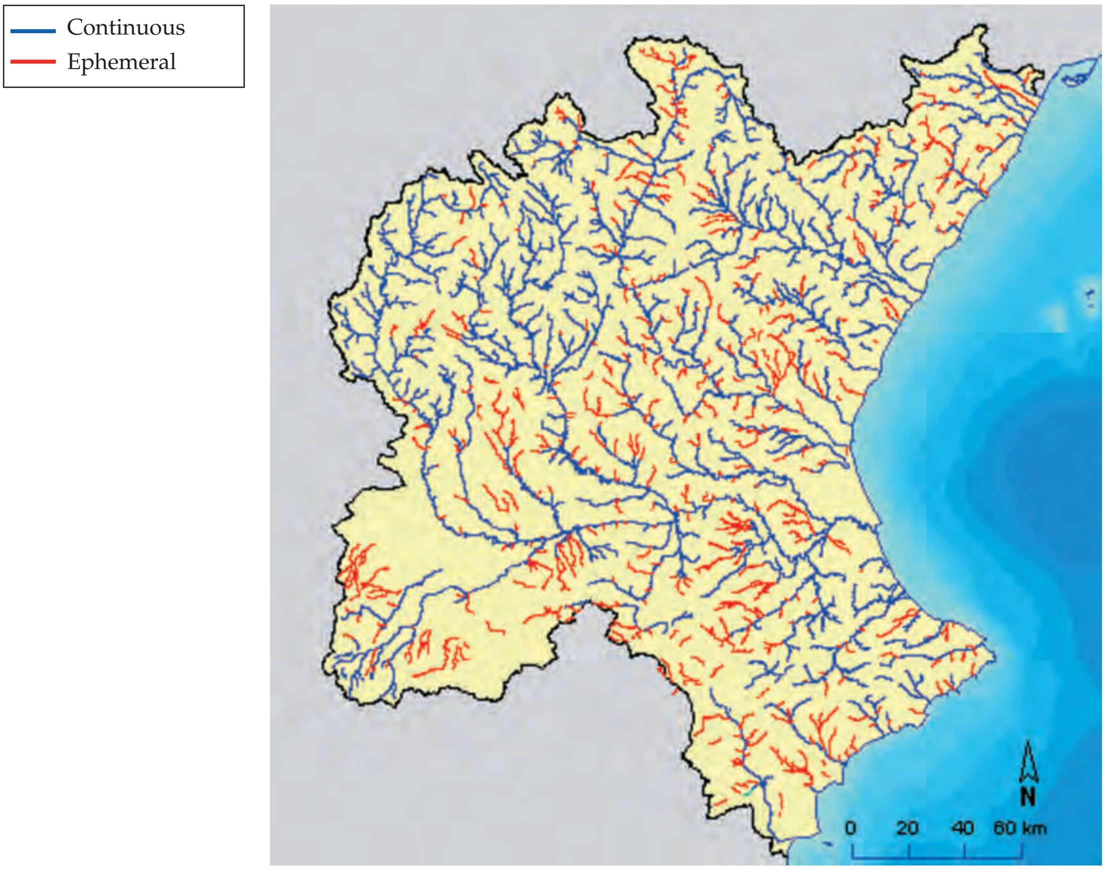
A high time-consuming fieldwork was developed by river guards of the Júcar RBD in order to elaborate a map that classifies, according to the irregularity of flows, the water courses into two main categories: continuous flow and ephemeral flow (figure 48). Wide criteria have been followed for doing this classification, since many rivers defined as continuous do not flow most time of the year, for natural reasons or due to human activities.

The process of delineating the significant river network may be an easier task in countries with more uniform rivers and higher flows. However, in Spain it has required to carry out an important process of analysis and characterisation, which has been developed by CEDEX and with the participation of the River Basin Districts (RBDs) and the Júcar RBD. The criterion based on the basin area (10 km^2) was not enough to define the significant river network, because, as mentioned before, in many areas of the District, there are no rivers flowing given this draining basin size. Additional variables to the basin size had to be considered: mean annual flow, variation coefficient and percentage of months with no flow. The results were then tested with the different monitoring networks in the District (quantitative, qualitative and biological), which, in some extent, reflects the management interest of the RBD.

A significant river network for the Júcar PRB was obtained from the DEM. This map was then adjusted to the map of watercourses with continuous flow derived from the fieldwork and the monitoring networks formerly mentioned. The specific criterion adopted was to define the river's origin when they had a basin greater than 10 km^2 and received a mean annual inflow greater than 100 l/s (3.2 hm^3). The flows below the defined thresholds are considered intermittent or ephemeral, and consequently not significant as water bodies for the WFD purposes.

Ephemeral water course Rambla de la Castellana — Figure 47

Figure 48	Categories of rivers according to the irregularity of flows



The preliminary delineation of significant rivers for the Júcar RBD according to the mentioned criteria is shown in figure 49. The total length of significant rivers in the Júcar RBD is about 5 600 km.

The preliminary typology for rivers in Spain has been developed by CEDEX using a DEM with a 500 x 500 m resolution derived from the original 100 x 100 m model. Annex II of the WFD establishes two possible systems of classification for surface water bodies: System A and System B, both of them have been used to determinate the ecotypes.

Table 8	Typologies according to System A of river classification

Altitude	Catchment area	Geology
High: > 800 m	Small: 10 to 100 km^2	Calcareous
Mid: 200 to 800 m	Medium: 100 to 1 000 km^2	Siliceous
Lowland: < 200m	Large: 1 000 to 10 000 km^2	Organic
	Very large: >10 000 km^2	

System A allows defining the different types within each Ecological Region defined in map A of Annex XI. The resulting types are a combination of three characteristics and their classes (see table 8). Three classes of altitude (lowland, mid-altitude and high), four classes of size (small, medium, large and very large) and only one class of geology (calcareous) are found in the Júcar RBD (figure 50).

The classification according to System A gives a map with 12 possible classes, finding just 11 in the Júcar RBD (figure 51). All ecotypes found are calcareous.

The results obtained, showed some of the problems of using System A. For instance, not having included climatic variables or flows variations made that rivers of different bio-geographical environments were included in the same class. In addition, the three levels proposed for geology (calcareous, siliceous and organic) provided an excessive simplification of the geologic characterisation, given that for the whole territory of the Júcar RBD only 1 class was found (calcareous), while materials are highly diverse in the District.

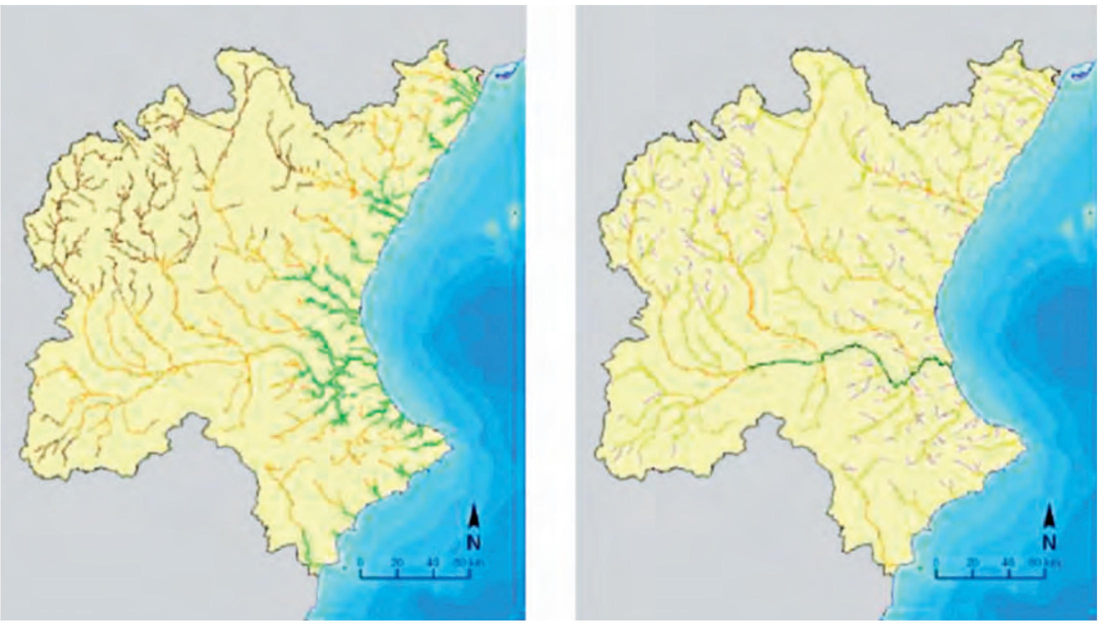
Preliminary surface water bodies: significant rivers | Figure 49

Source: CEDEX

Altitude and size typologies according System A classification | Figure 50

Altitude criteria

Surface criteria



Altitude criteria

- Lowland
- Mid
- High

Surface criteria

- Small
- Medium
- Large
- Very large

Figure 51	Ecotypes for rivers according to System A classification

- Lowland-small
- Lowland-medium
- Lowland-large
- Lowland-very large
- Mid-altitude-small
- Mid-altitude-medium
- Mid-altitude-large
- Mid-altitude-very large
- High-small
- High-medium
- High-large

Note: all ecotypes are calcareous
Source: CEDEX

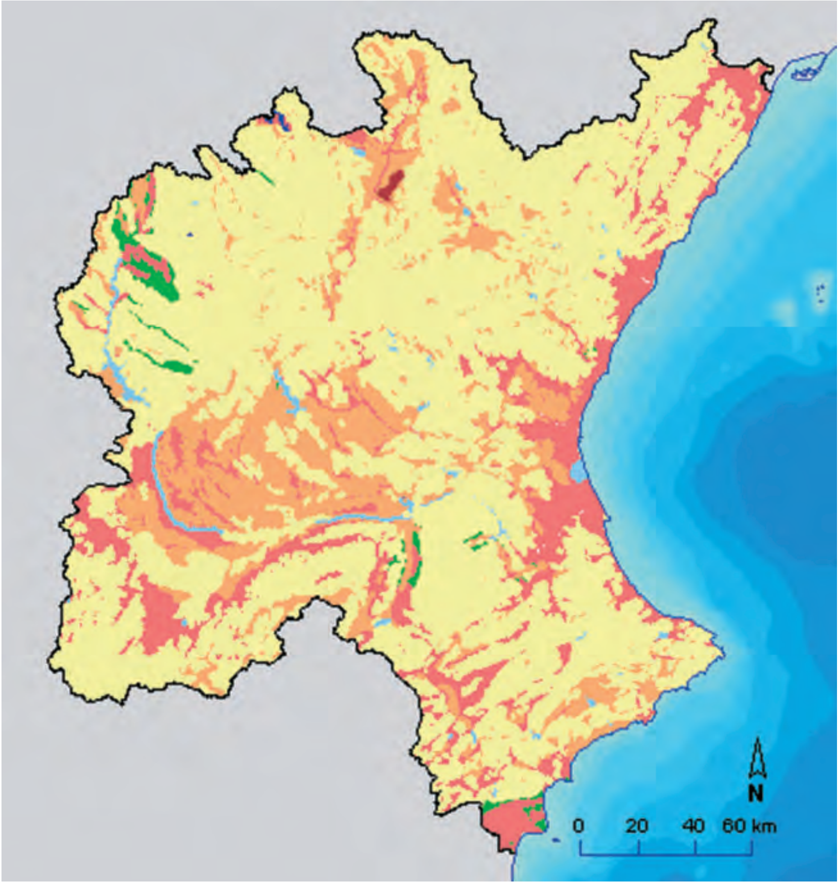
Due to these serious limitations of System A, CEDEX decided to use System B to characterise rivers. This system offers a list of five mandatory descriptors and fifteen optional ones. The WFD does not specify the way of combining these descriptors, but it indicates that at least the same degree of discrimination as it would be achieved by using System A must be reached.

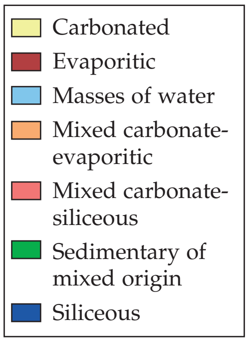
It must be considered the importance of geology and its influence in the mineralisation of water in river biological communities. Therefore, one of the first steps to apply system B was to reclassify the geologic map. The result was a 500 m x 500 m resolution raster map with 6 geologic categories: carbonated, siliceous, evaporitic, mixes carbonate-siliceous, mixes carbonate-evaporitic, and sedimentary of mixed origin (figure 52). In absence of human impacts, the lithology of the basin reveals the ionic composition of water. Siliceous basins, for example, are characterised by presenting a weak mineralisation in the water (low conductivity), while in calcareous ones, the conductivity is high, with presence of carbonates. Finally, in evaporitic basins, sulphates are predominant. According to the studies carried out in France by Meybeck (1986) and those carried out by CEDEX on chemical composition of waters in mono-lithological basins, different values were obtained for the conductivity and the alkalinity as a function of the dominant lithology.

The preliminary system B of classification obtained by CEDEX is based on the application of a semi-hierarchical classification with a few selected variables: specific mean annual flow, mean annual flow, slope, altitude corrected with latitude values, and conductivity.

The procedure of this classification establishes thresholds for the different variables, which are sequentially applied in order to differentiate ecotypes. The classification proposed by CEDEX has been carried out through a model based on a GIS river network. Several variables have been used in the model to divide significant rivers in

Geological classes | Figure 52





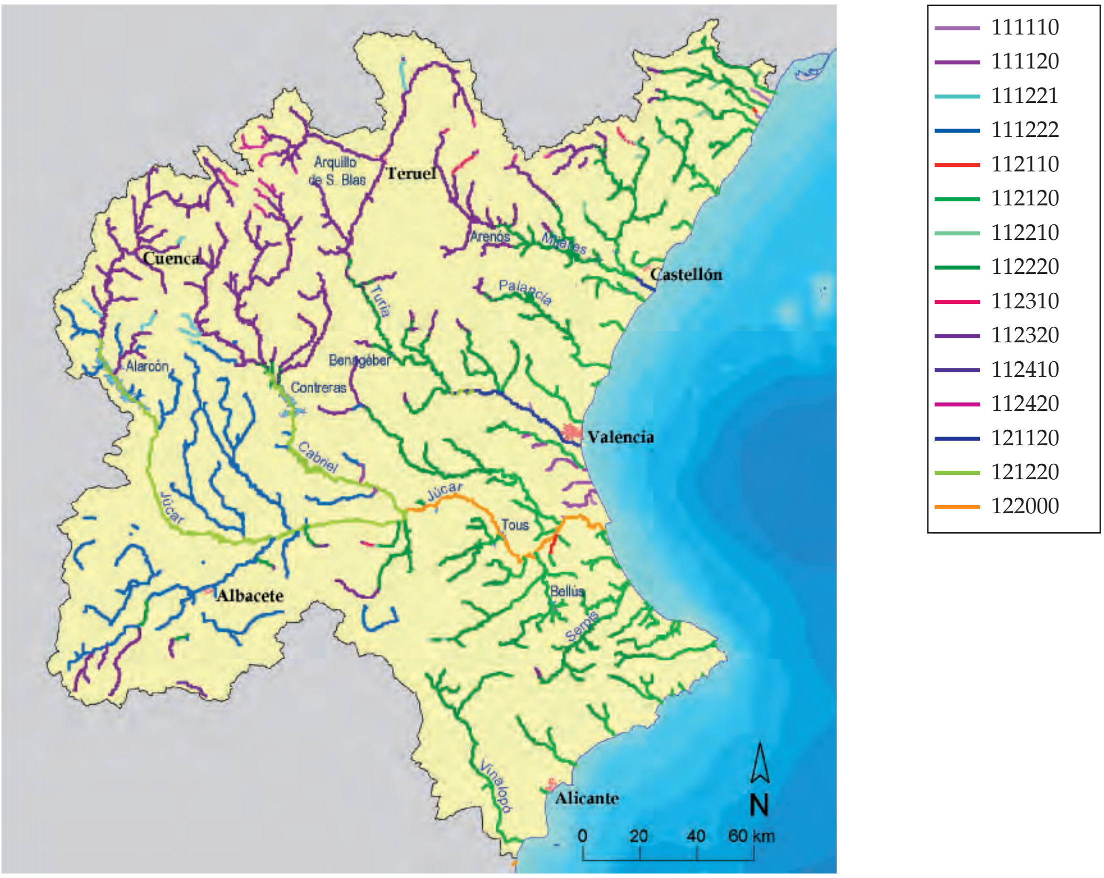
Source: CEDEX

successive levels to finally obtain 29 different environmental types for the Spanish rivers of the Peninsula and the Balearic Islands. The classification consists in the progressive segregation of subsets of the river network, by means of the establishment of thresholds for the variables. The subsets are identified by means of a key number of six digits. The value of the first digit indicates that the river reach belongs to one of the subsets of the first level of segregation of the hierarchical tree. The second digit determines that the river reach belongs to a subset of the second level and so on, until the sixth digit of the code. An ecological type can be defined by a maximum of six variables, although most of the types have been defined using just five variables. As a result of this classification, 15 different ecotypes have been obtained for the Júcar RBD, as can be observed in figure 53. The variables and the thresholds used are shown in table 9.

Table 9 The 15 ecotypes in the preliminary typology developed by CEDEX

Type	Code	Denomination	Variables
1	111.110	Lowland rivers, low mineralisation, in Mediterranean environment	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope < 2% Altitude (corrected) < 700 m (S) Conductivity < 320 µS cm^{-1}
2	111.120	Lowland rivers, high mineralisation	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope < 2% Altitude (corrected) < 700 m (S) Conductivity >320 µS cm^{-1}
4	111.221	High mineralisation, sedimentary plains of the North Plateau rivers	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope < 2% Altitude (corrected) > 700 m (S) Conductivity > 320 µS cm^{-1} Mean annual temperature < 12 ºC
5	111.222	High mineralisation, sedimentary plains of the South Plateau rivers	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope < 2% Altitude (corrected) > 700 m (S) Conductivity > 320 µS cm^{-1} Mean annual temperature > 12 ºC
6	112.110	Low mineralisation, low Mediterranean mountain	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope > 2% Altitude (corrected) < 400 m (S) Conductivity < 320 µS cm^{-1}
7	112.120	High mineralisation, low Mediterranean mountain	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope > 2% Altitude (corrected) < 400 m (S) Conductivity > 320 µS cm^{-1}
8	112.210	Low mineralisation, low-mid Mediterranean mountain	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope > 2% Altitude (corrected) 400-950 m (S) Conductivity < 320 µS cm^{-1}
9	112.220	High mineralisation, low-mid Mediterranean mountain	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope > 2% Altitude (corrected) 400-950 m (S) Conductivity > 320 µS cm^{-1}
10	112.310	Low mineralisation, high-mid Mediterranean mountain	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope > 2% Altitude (corrected) 950-1650 m (S) Conductivity < 320 µS cm^{-1}
11	112.320	High mineralisation, high-mid Mediterranean mountain	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope > 2% Altitude (corrected) 950-1650 m (S) Conductivity > 320 µS cm^{-1}
12	112.410	Low mineralisation, high Mediterranean mountain	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope > 2% Altitude (corrected) > 1650 m (S) Conductivity < 320 µS cm^{-1}
13	112.420	High mineralisation, high Mediterranean mountain	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q < 9.5 m^3s^{-1} Slope > 2% Altitude (corrected) > 1650 m (S) Conductivity > 320 µS cm^{-1}
15	121.120	High flow, high mineralisation, lowland in Mediterranean environment	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q > 9.5 m^3s^{-1} Order (Stralher) < 6 Altitude (corrected) < 400 m (S) Conductivity > 320 µS cm^{-1}
17	121.220	High flow, high mineralisation, high-mid Mediterranean environment	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q >9.5 m^3s^{-1} Order (Stralher) < 6 Altitude (corrected) > 400 m (S) Conductivity < 320 µS cm^{-1}
18	122.000	Large size rivers	Specific Q < 0.0165 $m^3s^{-1}km^{-2}$ Mean Q >9.5 m^3s^{-1} Order (Stralher) > 6

Preliminary ecotypes by CEDEX — Figure 53



More details about the procedures followed by CEDEX (2004b) can be found in the draft document entitled *"Tipología de ríos (River typologies)"*.

The analysis of the distribution of the 15 ecotypes in the Júcar RBD shows the following preliminary conclusion: ecotypes 5, 7, 9, 11, 15, 17 and 18 are widely represented in the Júcar RBD, while the rest are hardly represented. All ecotypes are characterised by presenting high mineralisation values, which seems to be one of the most important variables within the Júcar RBD.

As can be observed in figure 53 some ecotypes have a broad distribution, this is the case of ecotype "112120" that contains rivers along all the Mediterranean littoral area. Although this rivers share some characteristics, there are also substantial differences among them.

To make a more precise typology, data from the biological monitoring network of the Júcar RBD that is not available to the whole Spanish territory has been used in addition to other data. Two types of variables were selected, the variables derived from geographic and hydro-meteorological maps: altitude (m), specific slope (ºac km^{-2}), air temperature range (ºC), mean annual temperature (ºC), river longitude (km), Latitude (ºN), Longitude (ºW), surface (km^2), specific Q ($m^3/s/km^2$); and the mean values of the variables measured from 1999 to 2003 at the biological monitoring sites: conductivity (μS/cm), flow (m^3/s), width (m), depth (m), dissolved oxygen (mg/l), pH, water temperature (ºC), sulphates (mg/l), alkalinity (meq/l), ammonium (mg/l), calcium (mg/l), chlorides (mg/l), biochemical oxygen demand (mg/l), chemical oxygen demand (mg/l), total hardness (mg/l), phosphates (mg/l), magnesium (mg/l), nitrates (mg/l), potassium (mg/l), silica (mg/l) and sodium (mg/l). All variables were normalised by means of a process of standardisation, and later, an exploratory analysis was carried out to determinate the most relevant variables.

In the first place, a simple lineal correlation analysis between all the couples of variables was obtained. The results were expressed by means of the coefficient R of Pearson that indicates the correlation degree among all variables. The vari-

Figure 54	Hierarchical cluster analysis carried out with the 12 selected variables

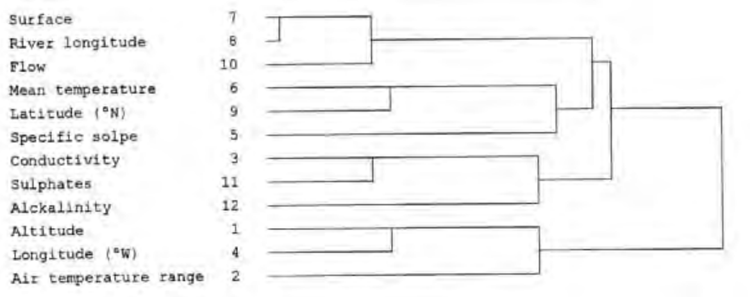


Table 10	Preliminary ecotypes for Júcar RBD

Ecotype	Description
1	Large river (Júcar)
2	Alicante rivers
3	Castellón and north Valencia rivers
4	Júcar lowland tributaries
5	Turia lowland
6	Small coastal rivers
7	Júcar and Cabriel mid-altitude
8	Júcar upper tributaries
10	Mancha rivers
11	Júcar mid-altitude tributaries
13	Mijares headwater and tributaries
14	Alfambra headwater
15	Turia and Alfambra mid-altitude
16	Júcar, Turia and Cabriel headwaters and tributaries

Source: Júcar RBA

ables selected were: altitude, air temperature range, conductivity, latitude, specific slope, mean annual temperature, surface, river longitude, longitude, conductivity, sulphates and alkalinity. These variables had been used to look for homogeneous groups or conglomerates of cases by means of a Hierarchical Cluster Analysis. As a measure of vicinity, the Euclidian distance was obtained and the dendrogram was made using average linkage between groups (figure 54).

Finally, the stations have been grouped taking into consideration these variables, and 14 ecotypes have been established (table 10 and figure 55).

In general terms, the typology developed in the Júcar RBD has similarities with the one developed by CEDEX. However, the Júcar RBD classification shows significant differences between the more humid northern areas, and the driest southern ones. A variation of gradient with the latitude, that explains the presence of different ecotypes, is present. The great influence of the lithology of the basin is also observed in this classification, since it shows the existence of waters with high conductivity and the importance of sulphates in specific areas.

2.1.1.2. Lakes

WFD defines *lake* as a body of standing inland surface water, and specifies a size typology based on a surface area with a lower limit of 0.5 km^2. In the approach presented here, the category of *lakes* includes not only what it is understood commonly as lakes, but also the marshes with a defined water surface.

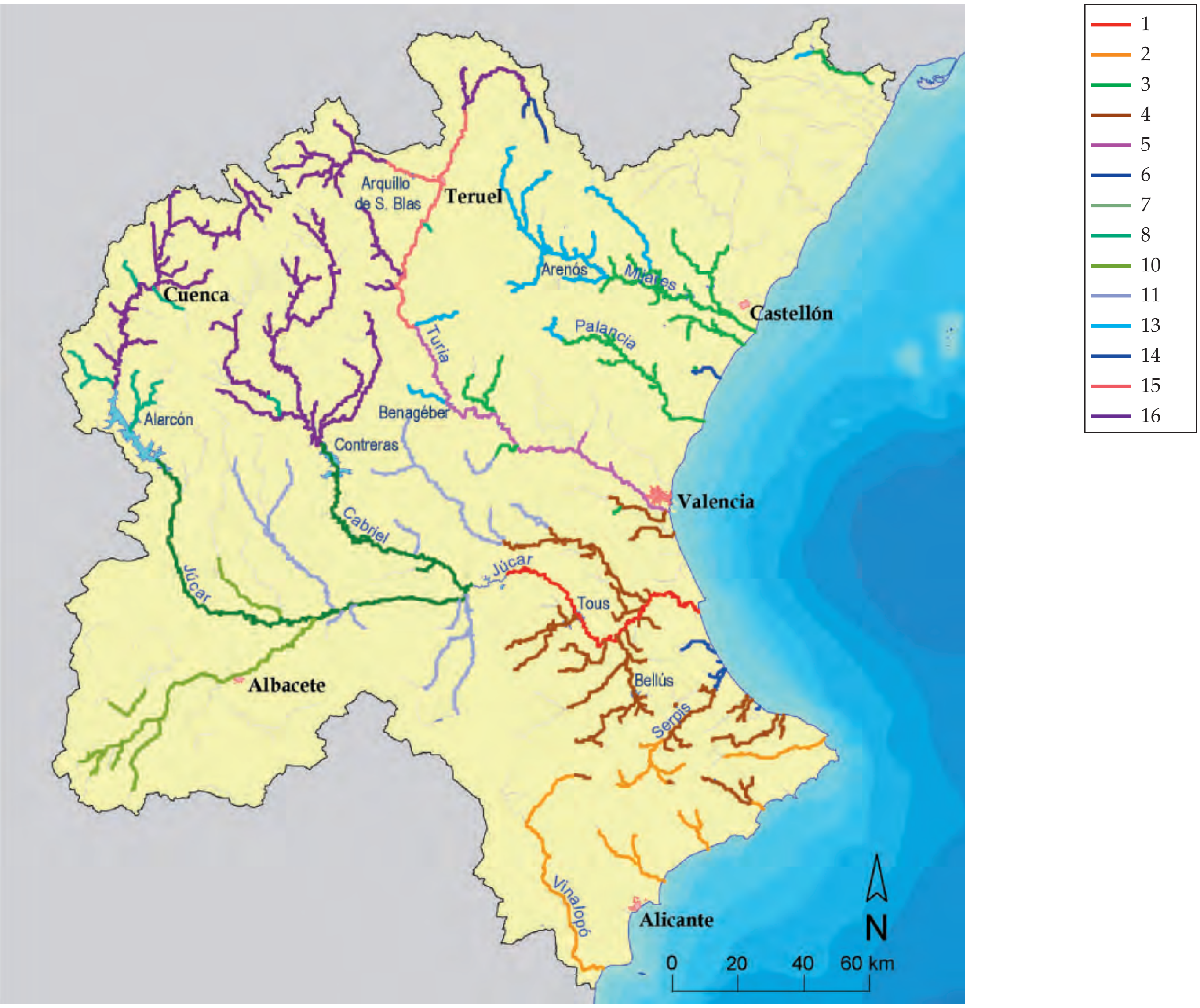
The preliminary criteria defined by CEDEX include a water body into the category *lake* if the water surface is greater than 50 ha (0.5 km^2), or if the water surface is greater than 8 ha and its maximum depth is greater than 3 m. In case that a water body is affected by infrastructures for irrigation or drainage or it is regulated by gates, or if it has been used as a salt pan and is still affected by the hydromorphological modifications, or if the water level fluctuates artificially, then the water body will be considered as a heavily modified water body (HMWB).

All water bodies within the preliminary defined lake category in the Júcar RBD have been considered HMWB (figure 57 and table 11). It is to note that in case of lakes included in wetlands, only the water surface has been represented, and not the area defining the associated natural ecosystem.

Marshes have been included in this category if they contain a water surface that meets the specified dimensions for lakes. Aerial photographs can be used to determine the surface that is occupied by water during the wet season as can be seen in figure 56. This figure shows the Pego-Oliva marsh, where the orange perimeter belongs to the protected area and the preliminary determination of the area that can be occupied by water has been drown in blue.

L'Albufera, near the city of Valencia, is a relevant example of a heavily modified lake. Al-

Preliminary ecotypes by Júcar RBA | Figure 55



though it is connected to the sea, the lake is fed by freshwater inflows (the average salinity is 2 g/l) and for that reason, it is proposed to be included within the category of lake. These inflows come from surface and groundwater runoff and from returns produced in urban, industrial and agricultural areas. L'Albufera must be considered as a HMWB due to the presence of hydromorphological alterations, as gates (*golas* in Spanish), that affect the natural flow of the lake and its interaction with the sea. In the wetlands and lake section, L'Albufera is characterised with further detail.

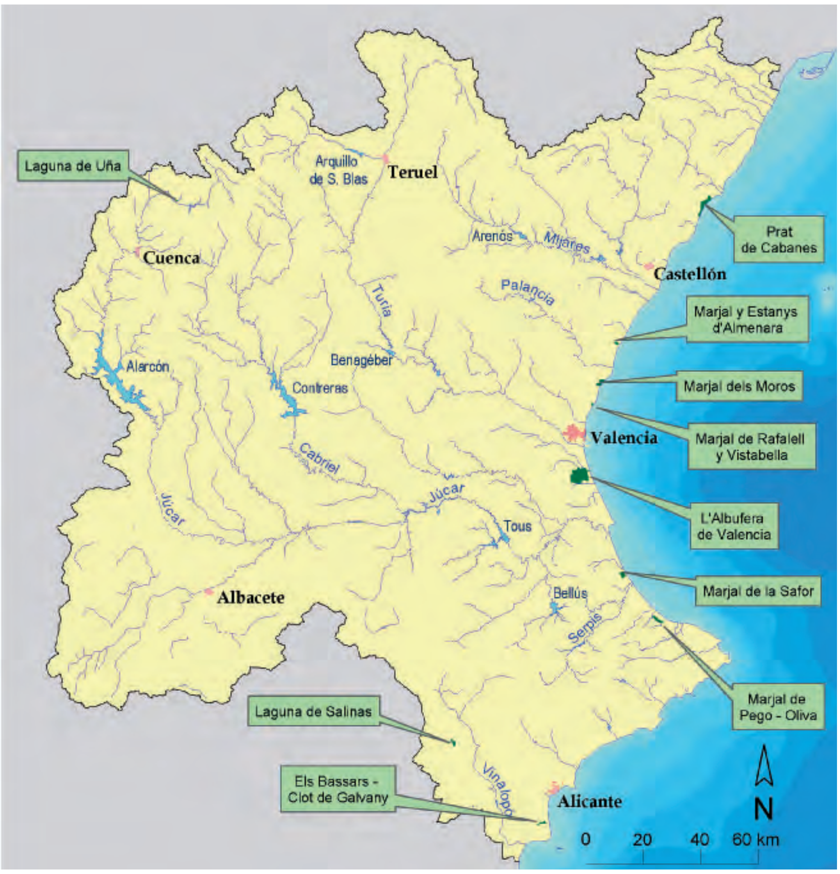
The appropriated analysis to develop a preliminary typology and to define the reference conditions for the Spanish lakes is now in course. The criteria for the establishment of ecotypes with System A of the WFD are: altitude, mean depth, surface area and geology. Also some optional factors are given with system B including: mean water depth, shape, residence time, mean air temperature, air temperature range, mixing characteristics, acid neutralising capacity, background nutrient status, mean substratum composition and water level fluctuation. CEDEX is now developing a nationwide study to define ecotypes for lakes.

Figure 56	Perimeter of the water surface in the Pego-Oliva marsh

Wetland perimeter
Water surface

Figure 57	Preliminary surface water bodies: Lakes (heavily modified)

Source: CEDEX and Júcar RBA



2.1.1.3. Wetlands

Wetlands are not considered water bodies according to the WFD. However, if they include a water surface that fulfils the requirements to be included in the category of lake, they will be considered as water bodies within this category, as it is the case of some marshes described in the previous section.

The Júcar Hydrological Plan (JHP) (CHJ, 1998) includes a list of 53 wetlands, which are shown in table 12 jointly with their location and estimated area. The total surface covered by wetlands is approximately 45 000 ha. This surface does not correspond just to the water surface, but also to the surface defined for the whole wetland, including the associated terrestrial ecosystem.

Preliminary surface water bodies: Heavily modified lakes — Table 11

Lake denomination
Laguna de Uña
Laguna de Salinas
Prat de Cabanes
Marjal y Estanys d'Almenara
Marjal dels Moros
Marjal Rafalell y Vistavella
L' Albufera Lake
Marjal de Pego Oliva
Marjal de la Safor
Els Bassar - Clot de Galvany

Channels connecting L'Albufera Lake to the sea — Figure 58

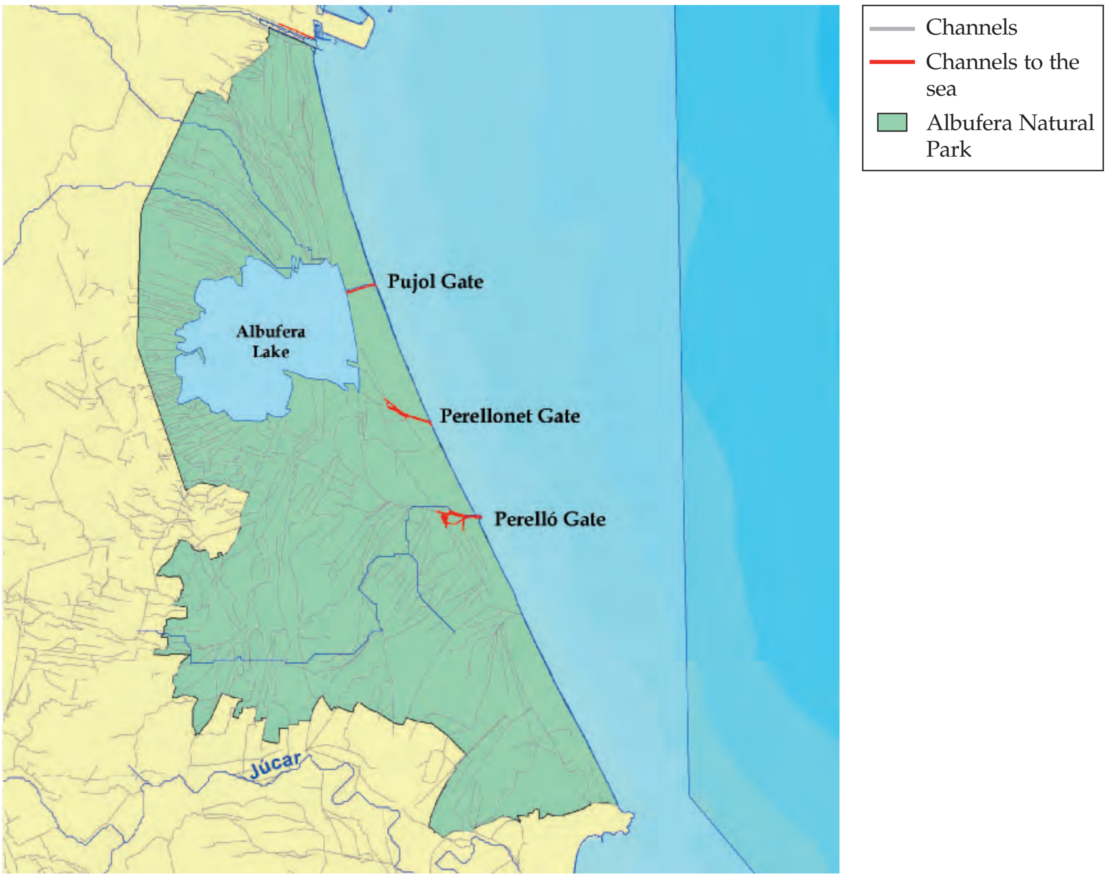
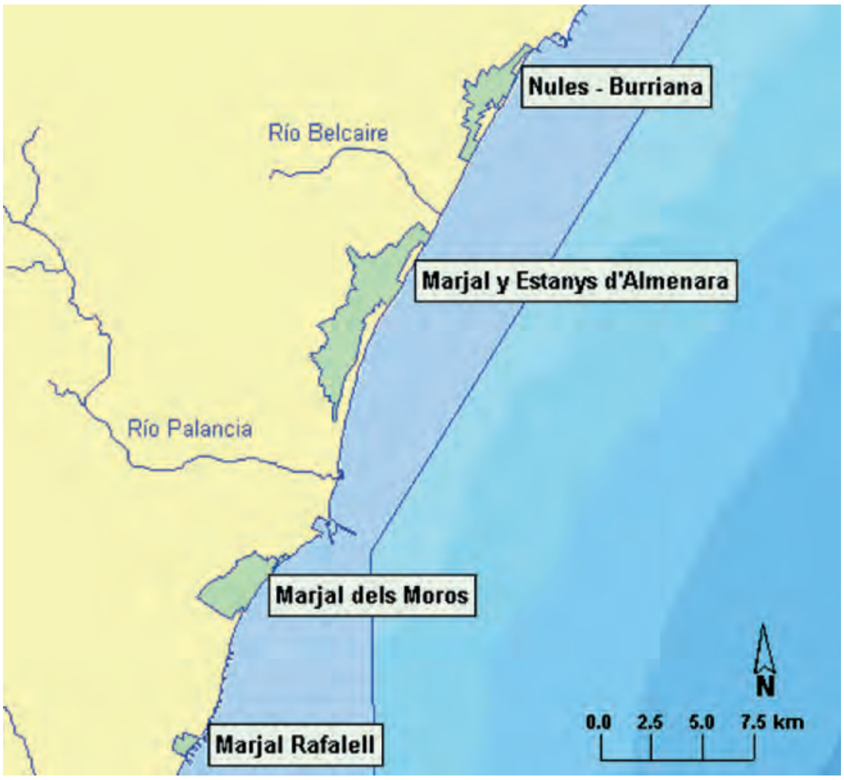


Table 12 **List of Wetlands included in the JHP (CHJ,1998)**

Wetland name	Autonomous Community	Area (ha)
Balsa del Pinar o de Rubiales	ARAGÓN	3.60
Laguna de Bezas	ARAGÓN	9.04
Laguna del Carpillo	ARAGÓN	0.31
Laguna del Tortajada	ARAGÓN	1.61
Salinas de Arcos de la Salinas	ARAGÓN	4.88
Laguna del Acequión	CASTILLA-LA MANCHA	24.76
Laguna del Arquillo	CASTILLA-LA MANCHA	522.34
Sistema El Bonillo-Lezuza-El Ballestero	CASTILLA-LA MANCHA	7 885.49
Pantano de Fuente Albilla	CASTILLA-LA MANCHA	7.03
Laguna de Ontalafia	CASTILLA-LA MANCHA	41.68
Laguna de Riachuelos	CASTILLA-LA MANCHA	2.32
Laguna Ojos de Villaverde	CASTILLA-LA MANCHA	339.74
Laguna de Sugel	CASTILLA-LA MANCHA	11.66
Laguna del Pozo Airón	CASTILLA-LA MANCHA	0.44
Lagunas de Cedazos	CASTILLA-LA MANCHA	84.35
Laguna del Marquesado	CASTILLA-LA MANCHA	5.06
Laguna de Uña	CASTILLA-LA MANCHA	21.42
Salinas de Monteagudo	CASTILLA-LA MANCHA	6.23
Complejo lagunar Torcas de Cañada Hoyo	CASTILLA-LA MANCHA	181.68
Complejo Lagunar de Arcas/Ballesteros	CASTILLA-LA MANCHA	275.03
Laguna de Navarramiro	CASTILLA-LA MANCHA	0.90
Torcas de Cuenca	CASTILLA-LA MANCHA	576.29
Complejo lagunar de Fuentes	CASTILLA-LA MANCHA	43.19
Laguna de las Zomas	CASTILLA-LA MANCHA	1.42
Torcas de la Maya del Chorro	CASTILLA-LA MANCHA	56.57
Surgencia del Río Ojos de Moya	CASTILLA-LA MANCHA	40.70
Cuevas del "Tío Manolo" y "El Boquerón"	CASTILLA-LA MANCHA	9.60
Parque Natural de L'Albufera	VALENCIA	21 120.02
Parque Natural de las Salinas de Santa Pola	VALENCIA	2 496.50
Parque Natural del marjal Pego-Oliva	VALENCIA	1 290.50
Parque Natural del Prat de Cabanes-Torreblanca	VALENCIA	811.79
Lagunas de Mata y Torrevieja	VALENCIA	3 700.00
Marjal de Almenara	VALENCIA	1 487.68
Marjal de La Safor	VALENCIA	1 228.83
Marjal del Sur del Júcar	VALENCIA	3 373.95
Marjal de Aigua Amarga	VALENCIA	207.87
Marjal de "El Moro"	VALENCIA	618.85
Prat de Peñíscola	VALENCIA	104.91
Balsares-Carabassí	VALENCIA	177.11
Salinas de Calpe	VALENCIA	40.86
Laguna y Salinas de Villena	VALENCIA	717.98
Laguna de Salinas	VALENCIA	284.07
Desembocadura del río Mijares	VALENCIA	321.95
Marjal de Rafalell y Vistabella	VALENCIA	103.08
Navajos de Sinarcas	VALENCIA	24.43
Salinas de Cofrentes	VALENCIA	2.67
Dehesa de Soneja	VALENCIA	2.48
Laguna de San Mateo	VALENCIA	11.15
Clot de la Mare de Deu	VALENCIA	7.50
Nacimiento del "Riu Verd"	VALENCIA	3.48
Estany de Nules	VALENCIA	531.18
Embalse de Embarcaderos	VALENCIA	393.34
Embalse de Elda	VALENCIA	24.17

Examples of marshes in the Júcar RBD — Figure 59



The most characteristic wetlands in number and extension are the marshes. Generally, they are large flooding surfaces fed by groundwater, and to a lesser extent, by surface water. Their delineation is a difficult task, and usually, only a protection perimeter much bigger than the water surface is available. The protected marshes of the District will be included in the Register of Protected Areas.

Presently, four wetlands are included in the Ramsar Convention List of Wetlands of International Importance (List first signed in Ramsar, Iran on 1971, currently with an overall of 1 328 sites worldwide). By being in this list, wetlands acquire a new status, not only at regional, but also at national and international levels. These wetlands become recognised by the 138 members of the Ramsar Agreement as being of significant value for the region or country in which they are located, and also for the international community as a whole. These four wetlands names and date of inclusion in the Ramsar list are shown in table 13.

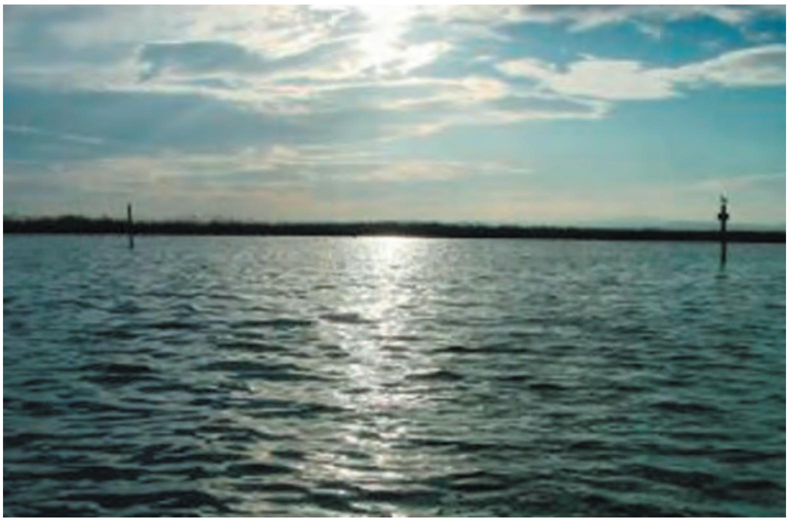
Among these wetlands, L'Albufera Lake stands out for its uniqueness. It is a lagoon within the limits of a Natural Park declared by means of the Environmental Regional Legislation (Decree 89/1986). The Reserve consists mainly on a wetland of 21 120 ha located 10 km South from the city of Valencia, and includes not only the lake but also its surroundings (figure 60). The area around the lake is comprised of large extensions of rice fields, and a protective coastal string of dunes next to the Mediterranean Sea. The most relevant feature of L'Albufera is a shallow la-

Ramsar Wetlands within the Júcar RBD — Table 13

Ramsar Wetland	Date of inclusion	Autonomous Community	Area (ha)
L'Albufera de Valencia	05/12/89	Valencia	21 120
Pego-Oliva	04/10/94	Valencia	1 290
Prat de Cabanes-Torreblanca	05/12/89	Valencia	812
Salinas de Santa Pola	05/12/89	Valencia	2 496

Figure 60 **The Metropolitan Area of Valencia and the Natural Park of L' Albufera**

Figure 61 **L' Albufera Lake**



goon of 2 433 ha of free surface covered by water with an average depth of 0.88 m.

The ecosystem has been considered so valuable for the region, that in 1989 it was designated by the Spanish Government for inclusion in the Ramsar List, and on 1991 was designated by the Valencian Autonomous Community as an space protected by the Directive 79/409/CEE, which promotes the conservation of birds, and the Directive 92/43/CEE that supports the protection of the EC natural heritage.

The role played by this wetland in the migration of birds between Europe and Africa has been greatly documented. More than 250 different species of birds make use of the Park in a regular year for resting, feeding and sheltering, and 90 more species used the area for breeding. Furthermore, its environment holds a great variety of habitats, which support an extensive biodiversity of additional fauna and flora. These significant data, led the Autonomous Government in 1995 to formulate a Protective Plan for its Natural Resources, passed by Decree 96/1995.

Moreover, as the environment of the Park is extremely fragile and self-dependant on water resources, it is crucial to know and understand its water needs and water balance, as well as the quality aspects and reference conditions featured by the lake. This is the reason why the Júcar RBD is presently conducting a thoroughly and comprehensive study that intends to give answer to all these questions.

2.1.1.4. Coastal waters

The "coastal waters" definition according to the WFD is *surface water on the landward side of a line every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters*.

Spanish Law 10/1977 of January 4 establishes in article 2 that the internal limit of the maritime territory is determined by the maximum low tide line and, in its case, by the base straight lines that are established by the Government. This Law specifies that straight base lines established by the Decree included in Law 20/1967 of April 8, will constitute the internal limit of the territorial sea.

The Royal Decree 2510/1977, of August 5, establishes straight base lines for the delimitation of Spanish jurisdictional waters. This Decree establishes, in article 1, geographic coordinates (referred to nautical charts corresponding to those editions from the 50's and 60's on a scale of 1:100 000/150 000) for those points that define the straight base lines.

The geometrical definition on a GIS system of the base lines for the whole Spanish territory has been carried out by CEDEX. For the Júcar RBD, the associated coastal strip has defined base straight lines that have been used to determine the external delimitation of coastal waters. The straight lines were obtained by connecting external coastal points, which were usually capes. The main problem for delimitating coastal waters lied on the low precision of the location of those points, which were initially calculated from a very small scale, and made necessary the correction of the coordinates in some of the points to locate the correct geographic positions.

The addition of 1 nautical mile to the straight base lines in the Júcar RBD defines the external limit of coastal waters as seen in figure 62.

The WFD does not clarify how the terrestrial limits of coastal waters must be determined. The GD developed by the COAST working group (EC, 2003e), indicates that, since the structure of the

Preliminary coastal waters — Figure 62

Note: Preliminary coastal waters in green
Source: CEDEX

"inter-tidal" zone is one of the elements of hydromorphological quality, it is recommended to include this area in the category considering maximum level tides.

The use of the coastal line coming from nautical charts is sufficiently representative of the terrestrial limit of coastal waters in the Júcar RBD, since in this area the effect of tides is considered negligible.

A special case included in the coastal waters category is the "coastal lake", possibility considered in the GD on coastal waters (EC, 2003e, section 2.6.1). These lakes are water bodies very close to the sea and highly influenced by it, and seawaters enter them frequently.

Water bodies preliminarily defined as "coastal lakes" have been considered as heavily modified water bodies in Júcar RBD and are showed in figure 63 and table 14.

An example of a coastal lake identified in the Júcar RBD is the Estany de Cullera. It is a brackish lagoon with a surface of about 21 ha and a maximum depth of 7 m. This Estany is a natural floodway of the Júcar River ending in the sea. It is connected to a wetland of 3 439 ha and a vast area of rice fields and orange tree crops (figure 64). This example of water body is quite unusual and unique, since no permanent surface flow is reaching the sea as it happens with rivers.

CEDEX is developing the classification of coastal waters by ecotypes for the General Directorate of Coasts. The criteria for the establishment of ecotypes in coastal waters with the WFD System A are just two, and are shown in table 15.

Table 14 **Preliminary surface water bodies: Heavily modified coastal lakes**

Coastal lake denomination
Estany de Cullera
Salinas de Santa Pola

Figure 63 **Preliminary surface water bodies: Heavily modified coastal lakes**

Source: CEDEX and Júcar RBA

The results of System A application to the coastal waters of the Júcar RBD are the following:

- The ecoregion assigned is the Mediterranean one.
- Coastal water average salinity fluctuates between 30 and 40 g/l.
- Most of Júcar's coastal waters are shallow (<30m), to a lesser extent intermediate (30 – 50 m), sometimes they are deeper than 50 m, but they never reach 100 m.

This is very much the case for the whole Mediterranean ecoregion, and following System A only two types of coastal water bodies are found: shallow and intermediate. Due to this simple categorization, it seems necessary to apply System B to obtain a more diversified classification.

According to System B mandatory factors, coastal waters in the Júcar RBD belong to one single type within the Mediterranean ecoregion with a tidal range below 1 m and salinity concentration from 30 to 40 g/l.

Optional factors are also given by System B that determine characteristics of coastal waters and hence, the biological population structure and composition: current velocity, wave exposure, mean water temperature, mixing characteristics, turbidity, retention time (of enclosed bays), mean substratum composition and water temperature range. As previously mentioned, it is necessary to apply the optional factors to define specific type characteristics. GD on coastal waters (EC, 2003e) suggests the following order when choosing these factors: wave exposure, deepness and other ecologically relevant factors.

For the Júcar case, it is appropriate to use wave exposure, deepness and substratum composition, but it is also possible to use the rest of the optional factors. Currently, the ongoing analysis is trying to establish the final factors to be used.

2.1.1.5. Transitional waters

The WFD defines "Transitional waters" as *bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows*.

In the ecological Mediterranean region, tides are not considered appreciable (<1 m) and in most cases, the sparse incursion of saline water reduces the extension of transitional waters. On the other hand, Mediterranean rivers do not usu-

Estany de Cullera (coastal lake) | **Figure 64**

Definition of ecotypes at coastal waters with the System A | **Table 15**

Type based on mean annual salinity	Type based on mean depth
<0.5‰: freshwater	shallow waters: <30 m
0.5 to <5‰: oligohaline	intermediate: 30 to 200 m
5 to <18‰: mesohaline	deep: >200 m
18 to <30‰: polyhaline	
30 to <40‰: euhaline	

ally present sufficient freshwater outflows to form plumes that extend into the sea, being this phenomenon very infrequent.

Different possibilities to establish transitional waters are being studied at present by the General Directorate of Water (GDW) and by the General Directorate of Coasts. As a general rule, the delineation of transitional waters will be defined by means of the limit between the hydraulic public domain and the public maritime terrestrial domain. This limit, according to the Coastal Law, extends upstream by the river shores until the tide effect is noticeable. This system agrees with the one proposed by GD on transitional and coastal waters (EC, 2003e). For the Júcar RBD case, the reduced extension and significance (less than 5 km) of these transitional waters may lead to the decision of not considering them as differentiated water bodies.

The criteria for the establishment of ecotypes with the WFD System A are just two, as shown in table 16:

Table 16 — **Definition of ecotypes at transitional waters with the System A**

Type based on mean annual salinity	Type based on mean tidal range
<0.5‰: freshwater	<2m: microtidal
0.5 to <5‰: oligohaline	2 to 4 m: mesotidal
5 to <18‰: mesohaline	>4m: macrotidal
18 to <30‰: polyhaline	
30 to <40‰: euhaline	

Optional factors are given once more with System B to determine the characteristics of the transitional water and hence the biological population structure and composition: depth, current velocity, wave exposure, residence time, mean water temperature, mixing characteristics, turbidity, mean substratum composition, shape and water temperature range. Similarly to the ecotypes for coastal waters, this kind of analyses are currently being carried out by CEDEX and the Júcar RBD.

2.1.1.6. Artificial and heavily modified water bodies

According to the GD elaborated by the Heavily Modified Water Bodies Working Group on *"Identification and designation of heavily modified and artificial water bodies"* (EC, 2003d), the overall goal of the WFD for surface waters is to achieve "good ecological and chemical status" in all surface water bodies by 2015. Some water bodies may not achieve this objective for different reasons. Under certain conditions, the WFD allows Member States to identify and designate artificial water bodies (AWB) and heavily modified water bodies (HMWB) according to Article 4(3) of the Directive. By making this designation, less rigorous objectives are applied to water bodies and an extension of the timing for achieving the objectives is given. These derogations are described in Articles 4(4) and 4(5) of the WFD.

HMWB are water bodies, which, as a result of physical alterations by human activity, are substantially changed in character and cannot meet a "good ecological status" (GES). AWB are water bodies created by human activity. Instead of a GES, the environmental objective for HMWB and AWB is achieving a "good ecological potential" (GEP), which has to be met by 2015.

The designation of HMWB and AWB is optional and must be carried out by each RBD. In those places where modified or artificial waters are not designated, the objective will consist on achieving a good ecological status. This optional designation is not an opportunity to avoid achieving ecological and chemical objectives, since GEP is an ecological objective, which may often, in itself, be challenging to achieve.

The designation may, in some instances, help to protect wider environmental interests; e.g. the removal of a human alteration may lead to the destruction of valuable environmental features.

The concept of HMWB was introduced into the WFD in recognition that many water bodies in Europe have been subject to major physical alterations to allow a wide range of water uses. Article 4(3)(a) lists the following types of activities, which were considered likely to result in a water body being designated as a HMWB:

- Navigation, including port facilities, or recreation;
- Activities for the purposes of which water is stored, such as drinking-water supply, power generation or irrigation;
- Water regulation, flood protection, land drainage;
- Other equally important sustainable human development activities.

These specified uses tend to cause considerable hydromorphological changes in water bodies of such scale, that restoration and the achievement of GES may not be possible even in the long-term, without preventing the continuation of that specific use. The concept of HMWB was thus created to allow for the continuation of these uses, which provide valuable social and economic benefits, while allowing mitigation measures to improve water quality.

The WFD takes a very similar approach for AWB and HMWB. AWB were created for the same specified uses listed in Article 4(3)(a). A key question, in order to differentiate between AWB and HMWB, is the meaning of the word "created" as used in Article 2(8). More specifically, the question is whether "created" refers to creating a new water body from previously dried land (e.g. a canal), or whether it could also denote a water body that has changed in category (e.g. river into a lake as a consequence of the construction of a

Preliminary HMWBs | Figure 65

Canalization
Reservoirs
Heavily modified lakes

Source: CEDEX

dam, or coastal water into a freshwater lake due to reclaiming). The criterion followed by CEDEX has been to define AWB as water bodies located where there was not a previous water surface.

In the case of Júcar RBD, HMWB and AWB are still not totally designated, and criteria for their identification are being developed by CEDEX as part of the characterisation that is being carried out at national scale.

Some of the proposed criteria by CEDEX to define the HMWB are:

- Reservoirs: They are considered as heavily modified rivers because water bodies change their category due to the construction of a dam (from river to lake). To be included in this category, the water body is required to be located inside a "significant river", according to the criteria previously defined and to have a water surface greater than 50 ha.
- Canalised rivers: They are considered heavily modified rivers when an alteration of a length greater than 5 km is produced in a river reach.
- Heavily modified lakes: Water bodies must be studied case by case in order to establish if they must be considered heavily modified lakes. For the Júcar RBD case, as mentioned, all lakes have been included in this category.
- Ports: Although the final criteria has not been decided, it is very probable that only the greatest ports are going to be considered HMWB. Other ports may be considered as pressures.

Figure 66 Reservoirs included in the category "Heavily modified rivers"

HMWB according to the above criteria are shown in figure 65 (coastal heavily modified water bodies are not represented).

All reservoirs included in this category are shown in figure 66.

CEDEX is developing those works necessary to typify reservoirs. To develop these works, 12 variables are being used. Among them, there are: geographic variables (altitude, longitude, and latitude), morphometric variables of reservoirs (depth, surface and volume), variables related to water geology and mineralisation (alkalinity and conductivity), variables related to the drainage basin of the reservoir (basin surface and time retention) and climatic variables (mean air temperature and variation of air temperature).

Procedures used for the calculations use GIS format variables and determine the variable accumulated value in the fluvial network point in which the reservoir is located. This process uses the same GIS coverages than the ones used for river typology, except for the morphometric variables in which databases from CEDEX have been used.

A statistic treatment has been developed for the data in different stages, and it includes: studies of factorial analysis of the main components and successive trials of classification that combine different options of the cluster analysis. For the analyses base, it was decided to reduce the number of variables to 8 in order to eliminate redundant information, being those variables the following: altitude, latitude, longitude, depth, surface, and alkalinity, as mandatory factors of System B, and drainage area and air mean temperature as optional factors.

Reservoirs are classified mainly depending on their mineralisation, drainage basin size (which distinguishes reservoirs of high river sections or small fluvial networks from reservoirs of lower river sections, or main flows), altitude and reservoir size. Currently, limits for these former variables are being looked for as well as characteristics, such as the thermo dynamic of the reservoir, and some other climatic factors, that allow differentiate among groups of reservoirs with different ecologic reference potential. The obtained results will be compared with the available biological information.

Other examples of HMWB are the harbours located in the coastal stretch. On the Júcar RBD coastline, three great ports are present, one for each capital of province: Valencia, Alicante and Castellón. These ports provide accommodation for large vessels and are vital nexus between terrestrial and marine transport of goods. Eight other ports of medium size are exploited for commercial, fishing and recreational activities. The Valencia port stands out among all these ports since 20% of the annual Spanish exports is directed through it, being currently the biggest cargo container port in Spain.

Regarding the definition of AWB, some of the criteria proposed by CEDEX are:

- Reservoirs: They are considered artificial water bodies when they are located off limits of the "significant river network" and they have a water surface greater than 50 ha.
- Canals: Only main canals with valuable ecological status should be considered. No decision has been taken yet on the inclusion of certain canals.

Cortes de Pallás-La Muela Reservoir | **Figure 67**

Only a reservoir is going to be considered as AWB in the Júcar RBD, and it is La Muela Reservoir (figure 67). This reservoir is part of an important hydraulic reversible complex, as described in section 4. It is located in the top of a mountainous massif and has a storage capacity of 22 hm^3 with a net jump of around 500 meters.

2.1.1.7. Surface water bodies

Surface water bodies include the categories described in preceding sections: rivers, lakes, transitional and coastal waters, and heavily modified and artificial water bodies.

A preliminary map of surface water categories is shown in figure 68. From this map, some important data are obtained. For example, the total length of surface water bodies is around 5 600 km, of which 5 095 km are rivers and 479 are HMWB. There are ten heavily modified lakes, two heavily modified coastal lakes and one reservoir designated as artificial water body (AWB); channels that could also be designated as AWB are under study. Transitional waters have not been defined yet, but it seems that there are not going to be significant water bodies included within this category in the Júcar RBD.

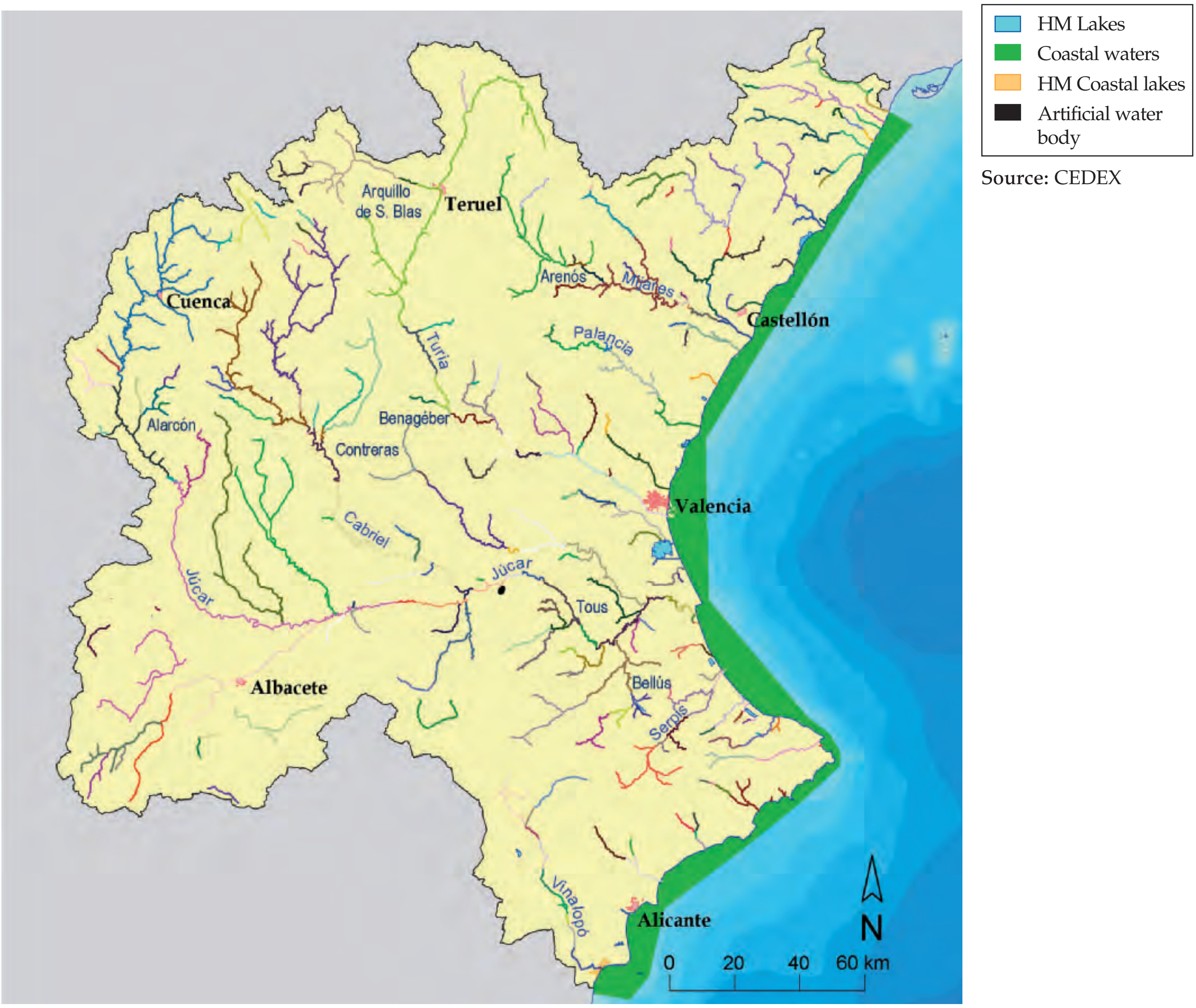
In addition, criteria established by the WFD and the GD (EC, 2003a) have been applied by CEDEX to obtain a preliminary classification of surface waters into water bodies.

The defined network of significant rivers has been fragmented in water bodies according to changes of categories, typologies and other aspects. By doing this fragmentation river reaches that are too short are often obtained. These river reaches are not identified as water bodies, since they are not considered significant. The criterion adopted to define a river reach as a water body consists of presenting a minimum length of 5 km, which is consistent with the one established

Figure 68 **Preliminary surface water categories**

Source: CEDEX

Preliminary surface water bodies — Figure 69



Source: CEDEX

by WFD for reservoirs (a reservoir of 0.5 km^2 is equivalent to 5 km-long and 100 m-wide). Figure 69 shows the surface water bodies that have been defined in the Júcar RBD. The number of preliminary surface water bodies is 268, of which 255 are rivers, 10 are heavily modified lakes, 2 are heavily modified coastal lakes and 1 is an artificial water body.

2.1.2. *Establishment of type-specific reference conditions for surface water bodies*

According to Annex II of WFD, for each surface water body type characterised, type-specific hydromorphological, physico-chemical and biological reference conditions must be established representing the values of the hydromorphological, physico-chemical and biological quality elements specified in Annex V for that surface water body type at high ecological status.

These type-specific conditions may be either spatially based or based on modelling, or may be derived using a combination of these methods. Whenever it is not possible to use these methods, MS may use expert judgement to establish such conditions.

2.1.2.1. Rivers

The determination of the reference conditions can be carried out through different methods, and the establishment of a reference network stands out among them. The reference network is obviously the most reliable method, but it will not be always possible to establish reference monitoring stations for all typologies, due to the conditions the reference water bodies must fulfil.

Therefore, the first step in the establishment of type-specific reference conditions has been the selection of river reaches under undisturbed or slightly disturbed conditions. These portions should be understood as reaches with no or very minor anthropogenic alterations over the values of the physico-chemical, hydromorphological and biological quality elements.

In order to identify the degree of alteration of the different water bodies in the Júcar RBD, an analysis has been developed with two consecutive and complementary phases. The first phase consists in fixing the pristine water bodies, which are water bodies in full natural conditions or with no anthropogenic alteration. This identification has been done following the criteria defined by CEDEX. As a second phase, and as part of a more detailed process, a preliminary analysis of pressures and impacts focusing on ecological and chemical aspects and considering effects, such as the auto-depuration of organic discharges, has been done in the Júcar RBD. The results of this analysis allowed a broader identification of water bodies with a small degree of alteration (slightly altered waters). Data coming from the monitoring network in these reaches were used to determine the preliminary reference conditions for the defined ecotypes.

The first phase has been developed following the criteria defined by CEDEX (2004a) in the draft document entitled *"Preliminary selection of possible river reaches of the reference network"*, and has consisted in the identification of pristine water bodies, or those that are currently preserved in their natural status. The methodology that was used aimed at identifying the main pressures acting on water bodies and defining those thresholds from which it can be determined that the natural conditions of water bodies are altered.

The identification of main pressures comes from the selection of a series of indirect pressure indicators estimated from homogeneous cartographic information of the whole District. These indicators are as follows:

- Naturalness basin indicator, based on land uses;
- Indicator of the most important human activities that may affect the physico-chemical characteristics of water bodies, based on urban, industrial and agricultural demands;
- Indicator of the consequence of water flow regulation, based on reservoirs storage capacity;
- Morphological alterations indicator, based on land uses.

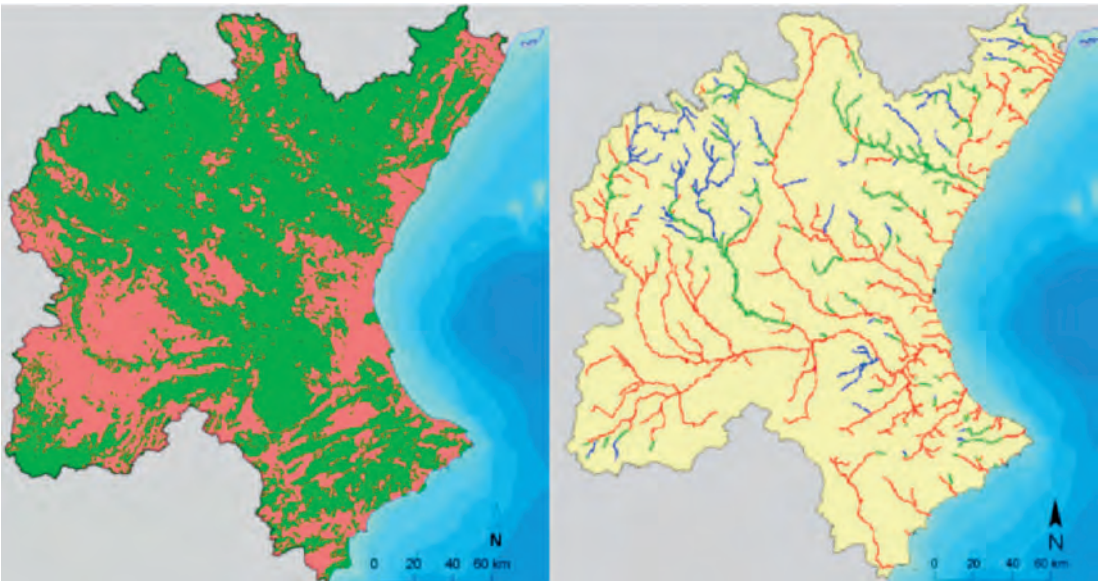
Although selected indicators are not as detailed as the ones used in the pressures and impacts analysis, they are sufficient to obtain a first estimate and they gather those main anthropogenic pressures identified by the WFD in Annex II (1.4).

The determination of thresholds that characterise the disturbance or alteration of natural conditions was done by CEDEX by contrasting different values of these thresholds with information gathered in the proposed reference stations network of project GUADALMED[1]. The results obtained through this process were fairly confident. Thresholds are described as follows:

1) Degree of alteration of the basin drainage surface (figure 70), based on the land use information of the map obtained through the CORINE LAND program. Alteration of the natural status is produced when the basin's surface that is preserved natural is lower than 70% of the draining basin and slight alteration is produced when this percentage is between 70% and 80%.

1 GUADALMED is a research project, which aims to study in detail a broad group of Spanish Mediterranean Rivers in order to solve difficulties that may arise when determining their ecological status. In this project, many entities participate including the Universities of Barcelona, Balears Islands, Vigo, Murcia, Almería and Granada, as well as other organisms and institutions as CEDEX, Ministry of Environment, The Regional Council of Barcelona, The Regional Board of Andalusia, and the Catalonian Water Agency. In its first phase (1999-2002), five reference places were chosen for each monitored basin, only considering each area's experts, which is a criterion described in the WFD. The outcome expected from this project is the establishment of general methodology bases that could be used for selecting and validating reference conditions in the project GUADALMED-2 (2002-2004).

Natural and artificial areas (left side) and percentage of naturalness in water bodies (right side) — Figure 70



Natural areas	0 - 70
Modificated areas	70 - 85
	85 - 100

Water bodies affected by abstractions and discharges — Figure 71

- Non Affected
- Affected

2) Alteration due to abstractions, discharges and water returns produced by the use of water (figure 71):

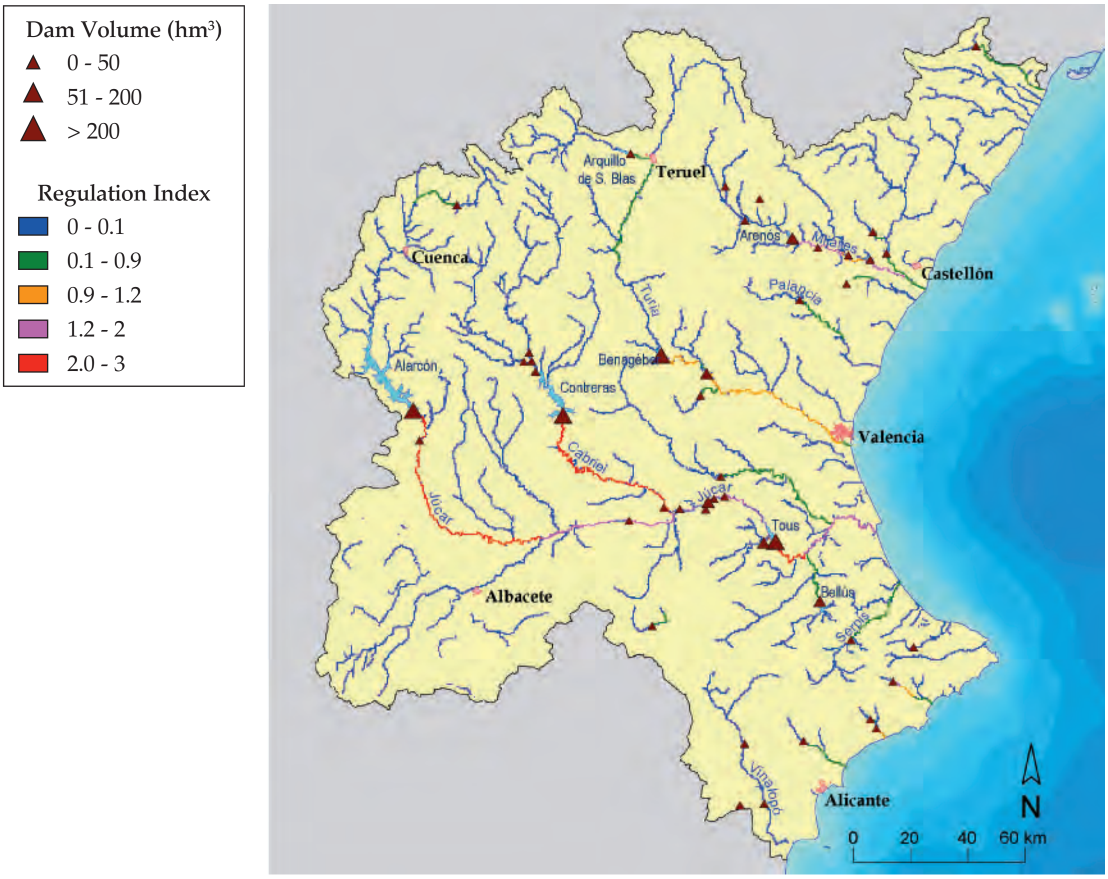
- Alteration due to domestic uses, the alteration threshold is fixed when urban demand is greater than the natural resource by 3%;
- Alteration due to agricultural uses, the alteration threshold is fixed when agricultural demand is greater than the natural resource by 10%;
- Alteration due to industrial uses, the alteration threshold is fixed when industrial demand is greater than the natural resource by 1.5%.

3) Morphological alteration due to water flow regulation (reservoirs). There is a morphological alteration when regulation capacity of existing upstream reservoirs exceeds natural resource by 25%.

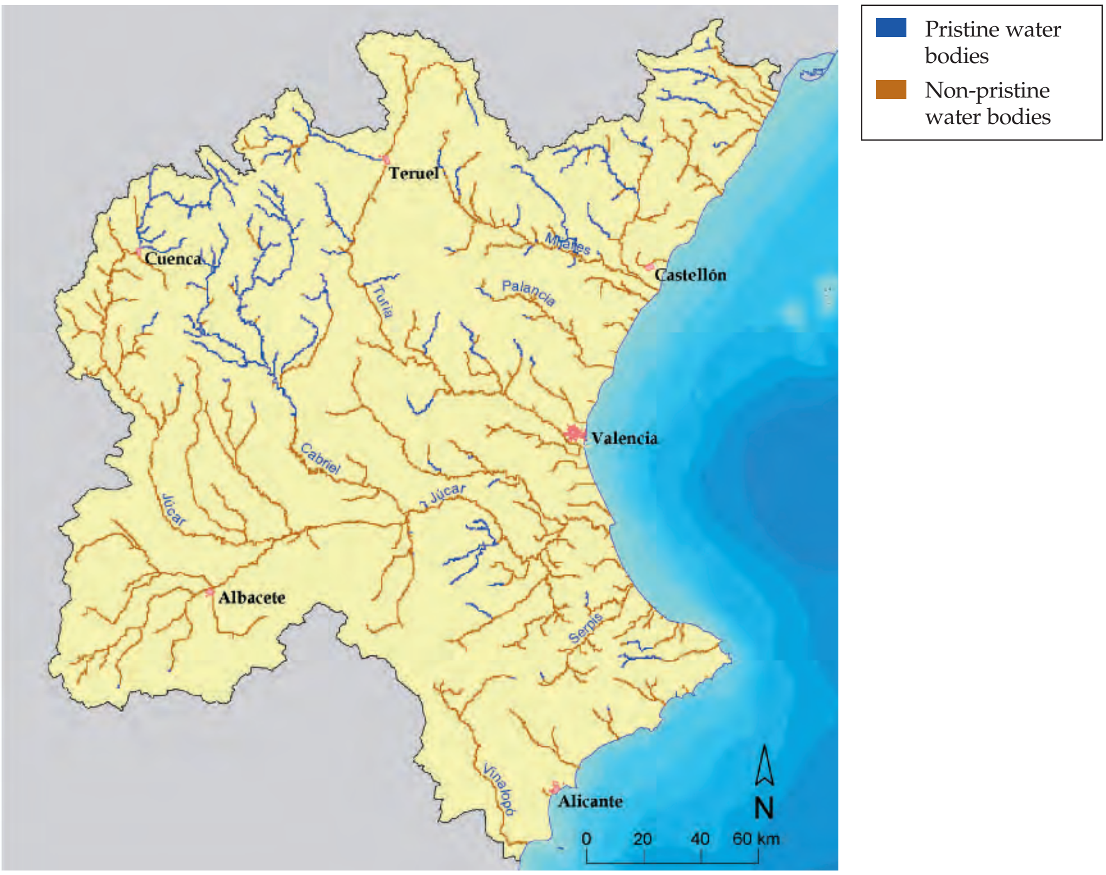
4) Morphological alterations of riverbeds, due to anthropogenic activity in the vicinities of water bodies, and mainly due to the existence of channelling. The definition of altered areas has been derived from superimposing agricultural activities or the population settlements on the water body.

This analysis and establishment of threshold, has allowed identifying pristine water bodies in the Júcar RBD (figure 73). The total length of pristine water reaches is about 1 500 km, which represents 27% of all water bodies. Those reaches are the most adequate to establish reference conditions for the ecotypes to which they belong.

Figure 72	Water bodies affected by regulation dams



Pristine and non-pristine water bodies — Figure 73

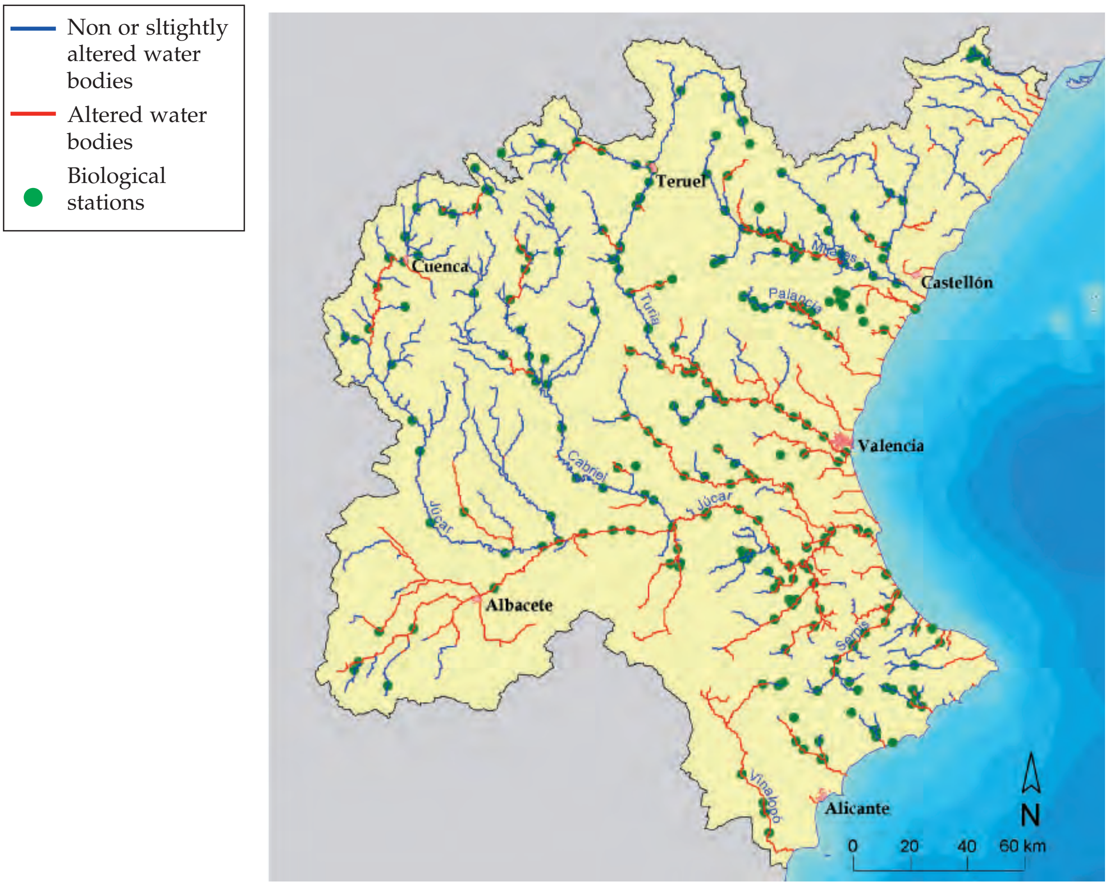


However, since the main objective of the prior analysis, is to identify all pristine waters, an important number of water bodies with slight anthropogenic alteration are left out of the natural condition areas. This is the reason why the second phase for the identification of water bodies with "no or slight anthropogenic alteration" has been developed taking into account the pressures analysis described later in this report. This action allows broadening the range of reference conditions to almost the total number of ecotypes identified in the Júcar RBD, agreeing with the information obtained through the chemical water quality and biological measuring networks existing in the Júcar RBD.

The combination of both types of results allows identifying not only pristine waters (Phase I of the analysis), but also water bodies with "no or slight anthropogenic alterations" (Phase II of the analysis).

As a result of the analysis of significant pressures described in section 4.1 of this document, figure 74 shows the reaches with "non or slightly altered water bodies" in blue, and the control points of the biological monitoring network. These reaches have been obtained by grouping the classes corresponding to "very low pressure" (in blue) and "low pressure" (green) shown in the map of figure 131. The total length of these reaches is about 3 600 km, representing 71% of the total length of rivers defined as water bodies.

Figure 74	Slightly altered water bodies and biological monitoring network



From a total of 247 measurement points of the biological monitoring network, a total of 116 are located on reaches with “no or slight alteration”, which means that there is abundant data to carry out this kind of analysis. By superimposing the “non or slightly altered” reaches map with the ecotypes map (figure 74, and 55) it is concluded that from those 14 ecotypes defined in Júcar RBD, 13 have representation in this type of waters. Altered conditions are found in ecotype 1 located in the last reach of the Júcar River, areas that are usually much more affected by anthropogenic alterations.

Table 17 shows the number of reaches belonging to each ecotype, those with “no or slight alteration”, the number of monitoring stations and those station located on reaches with “non or slightly altered” waters. In the reaches located on ecotype 1 it is not possible to find this kind of waters.

The calculation of a commonly used biological index, *the Iberian Macroinvertebrate Index (IBMWP)*, has been carried out to define, in a preliminary way, the reference conditions for each ecotype where “non or slightly altered” waters are represented and at least one monitoring station exists.

Conditions of reference should not be limited just to some values of classic indexes that suppose the maximum alteration that can be found, but they could be accompanied by a population pattern. In this same line, classic indexes could be modified in the near future to follow the WFD criteria. The IBMWP index was developed in a time when the main objective of indexes was to assess water quality, understood as a general concept to be applied equally to all water bodies. This index establishes a scale of species valorisation that may appear in the ecosystem, being its value the sum of all values assigned to each species. Under current circumstances, where the maximum quality is considered at natural conditions, species could at least be assigned a different value in different ecotypes and could even be valued negatively if present in some ecosystems. In any case, the following paragraphs describe the work developed with classic indicators.

Therefore, the values of the IBMWP index have been obtained in the “non or slightly altered” wa-

Characteristics of naturalness of the ecotypes defined by the Júcar RBD — Table 17

Ecotype	Number of reaches	Number of reaches with "non or slightly altered" waters	Number of biological monitoring stations	Number of biological monitoring stations on reaches with "non or slightly altered" waters
1	10	0	8	0
2	31	13	16	6
3	61	31	38	20
4	95	53	42	18
5	13	2	12	5
6	9	1	6	1
7	20	10	14	8
8	14	8	7	3
10	26	17	7	3
11	33	17	16	5
13	33	20	31	19
14	3	1	3	1
15	7	6	9	7
16	125	86	36	21

ter reaches with monitoring stations. This procedure allows obtaining values of that indicator for 13 of the 14 ecotypes defined in the Júcar RBD. Consequently, these values could be assumed equivalent to *high status*. For those ecotypes without monitoring station in "non or slightly altered" water, different analyses are currently in course.

Reference conditions have been established for each ecotype corresponding to "non or slightly altered" waters. Keeping in mind the values of the macroinvertebrate index in the reference stations, the ranges of quality can be calculated for each ecotype using mean values obtained as the thresholds of quality. Following the recommendations of the REFCON Guidance (EC, 2003f), the mean or median values from the reference site is considered the best starting point when establishing the classification schemes for ecological status. Table 19 shows for each ecotype the thresholds proposed.

Values of Macroinvertebrate (IBMWP) index for each ecotype — Table 18

Ecotypes	Number of stations in "non or slightly altered" waters	Mean value of macroinvertebrate index
1	0	-
2	6	42
3	20	81
4	18	59
5	5	59
6	1	20
7	8	68
8	3	61
10	3	117
11	5	65
13	19	106
14	1	138
15	7	44
16	21	120

Table 19 Values of IBMWP thresholds proposed for each ecotype

Ecotypes	IBMWP thresholds
1	42 (*)
2	42
3	81
4	59
5	59
6	42 (*)
7	68
8	61
10	117
11	65
13	106
14	138
15	44
16	120

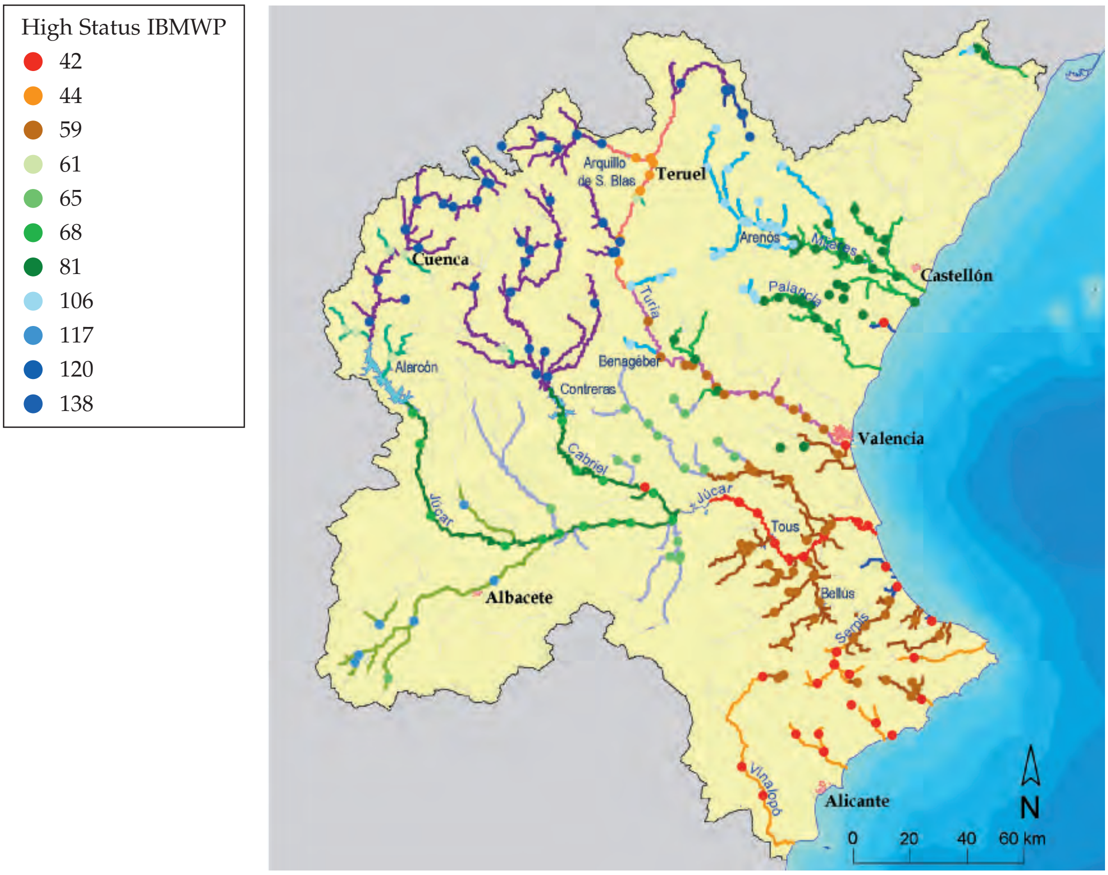
* expert judgement

The values corresponding to the high status limit for the IBMWP are shown in figure 75 superimposed on ecotypes. A strong consistence in the spatial behaviour pattern is observed.

Different biological indicators have been studied in the Júcar RBD, based on the analysis of diatoms, the identification of macrophytes (aquatic or semi-aquatic plants) and the analysis of the populations of fish species in selected points of the District. The use of these biological groups has been experimental and its methodologies are being improved. Nevertheless, the results obtained among the different indicators used can be compared to have a first approach to the ecological status of the Júcar RBD's rivers. Three indexes based on the three biological communities have been used: Diatoms index (DI), Macrophytes index (MI) and Ecotrophyc index (EI). The methods of calculation are described in the study of the design of the biological network for the Júcar RBD (CHJ, 2000a).

In order to establish a classification of ecological water quality using diatoms as water quality indicators, a specific index has been elaborated for Júcar RBD based on the indicative value of the

Figure 75 Values of high status limit for IBMWP superimposed on ecotypes



different species. The classification is the following one: ≥ 7 (Excellent); 6-7 (Good); 5-6 (Medium); 4-5 (Poor) and <4 (Bad). Table 20 shows for each ecotype the number of stations in "non or slightly altered" waters and the mean value of the DI.

The MI is based on the indicative value of the different macrophytes taxa present in the water, settling down five classes of quality: >30 (class I); 20-28 (class II); 12-18 (class III); 6-10 (class IV) and <4 (class V). Table 21 shows for each ecotype the number of stations in "non or slightly altered" waters and the mean value of MI.

The EI is based on the study of freshwater fish species and it is calculated as the ratio of the average biomass and the production obtained for each of the captured species. The average biomass is obtained through the biomass of each age class (fish weigh / surface unit of river reach) and its instantaneous rate of mortality, while the production is the mass generated by fishes that integrate the population of one year. The average biomass is calculated in those points where the existent populations in the moment of the sampling have a significant presence, or what is the same, in those ones where the populations have certain biological and numeric characteristics to consider them stabilised through time. The relationship between average biomass and production is delimited in three classes: ≥ 1 (high); 0.5-0.9 (medium); <0.5 (low). Table 22 shows for each ecotype the number of stations in "non or slightly altered" waters and the mean value of EI.

Values of DI for each ecotype — Table 20

Ecotypes	Number of stations in "non or slightly altered" waters	Mean value of Diatoms index
1	-	-
2	3	5.7
3	10	6.2
4	11	6.0
5	2	6.6
6	-	-
7	4	7.0
8	2	5.6
10	3	6.2
11	3	5.8
13	10	6.6
14	-	-
15	3	5.8
16	11	6.6

Values of MI for each ecotype — Table 21

Ecotypes	Number of stations in "non or slightly altered" waters	Mean value of Macrophytes index
1	0	-
2	3	12
3	7	12
4	6	18
5	1	18
6	1	8
7	3	17
8	1	26
10	3	23
11	3	22
13	8	26
14	0	-
15	1	20
16	7	23

Table 22	Values of EI for each ecotype	
Ecotypes	Number of stations in "non or slightly altered" waters	Mean value of Ecotrophyc index
1	0	-
2	0	-
3	2	0.49
4	0	-
5	0	-
6	0	-
7	1	1
8	0	-
10	0	-
11	0	-
13	2	0.71
14	0	-
15	0	-
16	1	0.61

2.1.2.2. Lakes

According to the WFD, the type-specific conditions may be either spatially based or based on modelling, and if it is not possible to use these methods, MS may use expert judgment to establish such conditions. This is the situation in most of the ecotypes corresponding to the category of "lake", where usually no systematic monitoring network exists.

A special case where the experts are defining the reference conditions is L'Albufera Lake, which was defined as a heavily modified water body (HMWB). This case is described in the following paragraphs.

L'Albufera has experienced an evolution from a brackish system, which is documented from at least the 12th century, to a fresh-water system, which started in the 17th century. The transition between both systems was accelerated by human factors such as the development of irrigation lands. The construction of the second section of the channel Acequia Real del Júcar in the 18th century introduced a change in the hydrological balance of the wetland, consolidating the fresh-water system. Large amounts of water were diverted each year to L'Albufera, from which only a small part was used for irrigation purposes. This action generated a huge volume of "excess" water that dramatically and definitely changed the nature of the former ecosystem. The brackish lake, with scarce water vegetation, was transformed into a shallow fresh-water system dominated by dense submerged zones of macrophytes and large areas covered with reeds.

This situation continued with small variations until recently. At the beginning of 1970 the system was still close to its ecological optimum stage: clean waters, large areas of water macrophytes, marshes, great biodiversity and scarce anthropisation.

The effects of wastewater inflows and of fertilisers and herbicides on the natural populations of the wetland became increasingly evident. In 1972, the macrophytes suddenly started disappearing from the lake, as well as most of the associated fauna, marking a point of inflection in a process of environmental degradation.

There are two main factors that explain water degradation and the subsequent loss of biodiversity within the wetland: the worsening quality of the resource as a consequence of serious structural deficiencies in the water treatment system (particularly in the Municipalities located at the South of Valencia) and the reduction of water inflow from the Júcar River through the Acequia Real del Júcar.

The wetland still receives water from different sources and with different characteristics. The central lake, or L'Albufera Lagoon, is a hypertrophic system result of the excessive nutrients coming from agricultural, urban and industrial water dumping (Soria et al., 1987). In addition, it is subject to hydric manipulation by means of the gates or sluices that permit the control of the water levels depending on the needs of rice crops surrounding the marshy area.

These sluices are installed in the sea-outlet channels (*golas*) and their influence on the water behaviour of the system is very important. Three of the channels, Pujol, Perellonet and Perelló are directly connected to the sea (as seen in previous figure 58). The other two, Mareny and Sant Llorenç, are connected to the channel system of the rice fields in the South of the park. The artificial nature of the *golas* is significant and all of them, except for the Perelló *gola*, are equipped with pumping systems.

In addition, the lake is undergoing an accelerated process of aggradation (Benet, 1983) mainly caused by the sediments from the flooding of the Poyo and Beniparrell "*barrancos*" (Mediterranean ravines).

In October 2003, the Ministry of Environment contracted a study on the sustainable development of L'Albufera of Valencia. This is being carried out under the direction of the Júcar River Basin Authority (RBA). The objectives of the study can be summarised in three main aspects: to characterise the pre-operational state of the environment, to develop a tool for the prediction and assessment of environmental impacts and to propose an action plan.

As the starting point for the study, a discussion meeting was held with different experts. Prior to the meeting, the experts were asked to send their personal comments on the sustainable development of L'Albufera, based on three main questions:

- What is the analysis of the state of L'Albufera as a consequence of its historical circumstances?
- What elements are relevant to characterise a sustainable and feasible scenario for L'Albufera?
- What measures and actions must be analysed in order to reach that scenario?

Concerning the characterisation of a sustainable and feasible scenario for L'Albufera, the conclusions of the experts meeting can be summarised as follows.

The ecological quality of the system in the 60's constitutes a model to be reached although it is not feasible to reproduce its boundary conditions. The sustainable scenario of L'Albufera will be a new scenario that, in the first place, it is necessary to define. Some aspects should be included in this definition:

- Clear water and oxygenated superficial sediment.
- Typical phytoplankton for coastal lagoons with diatoms and other algae species, but without cyanobacterian blooms. Chlorophyll concentrations corresponding to a mesotrophic lake (Chlorophyll maximum bellow 50 mg/l).
- Zooplankton integrated by big filtering species. Seasonal domination by cladocerans.
- Regeneration of the marshy and submerged vegetation (*Myriophyllum*, *Ceratophyllum*, *Potamogetum* and characea) with its associated fauna: shrimps or gambetes (*Atyaephyra desmaresti*, *Dugastella valentina* and *Palaemonetes zariqueiyi*); typical benthos for coastal lagoons, etc.
- Recovery of characteristic and endemic species of L'Albufera, as some cyprinids, crustaceans and molluscs.
- Improvement of the fishing resource in the lagoon: basses (*Dicentrarchus labrax*), eels (*Anguilla anguilla*), in reasonable and balanced proportions together with those of mullets (*Mugil cephalus*).
- Good state of the riparian formations in rivers and ravines. Reduction of altered riverbanks.
- Adequate flow and residence times. Good quality inflows in order to prevent both eutrophication and salinisation. Superficial inflows from the North and West to balance the dominance of inflows from the South.
- Maintenance of the biodiversity reservoirs such as the *ullals* or ponds.
- Sustainable sedimentation rates as a consequence of the control and reduction of contamination, erosion, transport and sedimentation processes.

2.1.2.3. Coastal and transitional waters

Within the Mediterranean ecoregion, where the Júcar RBD belongs, it is possible to establish reference conditions for coastal waters using the first of the suggested approaches in section 4.5.1. of Guidance on *Transitional and Coastal Waters* (EC, 2003e). According to this section, sites under minor alterations can be used to establish the reference conditions.

The Protocol concerning Mediterranean Specially Protected Areas (ZEPIM) is very useful to select these ecological important sites. (This Protocol was signed in Geneva on April 3, 1982, in agreement with the Barcelona Convention for the Protection of the Mediterranean against Pollution-1976). One of the main goals of listing areas under ZEPIM is to protect, preserve and manage in a sustainable way the areas of cultural and/or natural special interest, and the flora and fauna species in danger of extinction.

The following areas in the Spanish territorial waters are included in the ZEPIM list: Island of Alborán and nearby sea areas, the Gata-Nijar Cape, Marine Bottoms of the Almeria Levant, Maro-Cerro Gordo cliff (Málaga-Granada), Mar Menor and its surroundings, Columbretes Islands, Creus Cape, Cabrera Islands and the Medas Islands.

As these areas are distributed along a broad geographical extension, they enclose the vast majority of ecotypes and biological indices of the Span-

Figure 76 ZEPIM sites for establishing reference conditions for coastal waters at Júcar RBD

ish Mediterranean ecoregion. A further analysis on these sites will determine if they are suitable to establish the reference conditions and the corresponding biological indices for the different ecotypes.

Three ZEPIM highly representative sites of the Júcar coastline have been selected to develop the analysis: The National Park of the Archipelago of Cabrera, the Medas Islands and the Columbretes Islands. Their location is showed in figure 76.

2.2. Characterisation of groundwater

2.2.1. *Initial characterisation*

Member States (MS) must carry out an initial characterisation of all groundwater bodies to assess their uses and the degree to which each of them is at risk of failing to meet the environmental objectives established by the Directive.

The Directive establishes specific aspects to be considered for the characterisation of GW bodies in article 5 and annex II.2.1. These aspects are: location and boundaries, pressures (abstractions, diffuse and point source pollution, artificial recharge), the general character of the overlying strata in the catchment area from which the GW body receives its recharge, and finally the dependence of surface water ecosystems or terrestrial ecosystems.

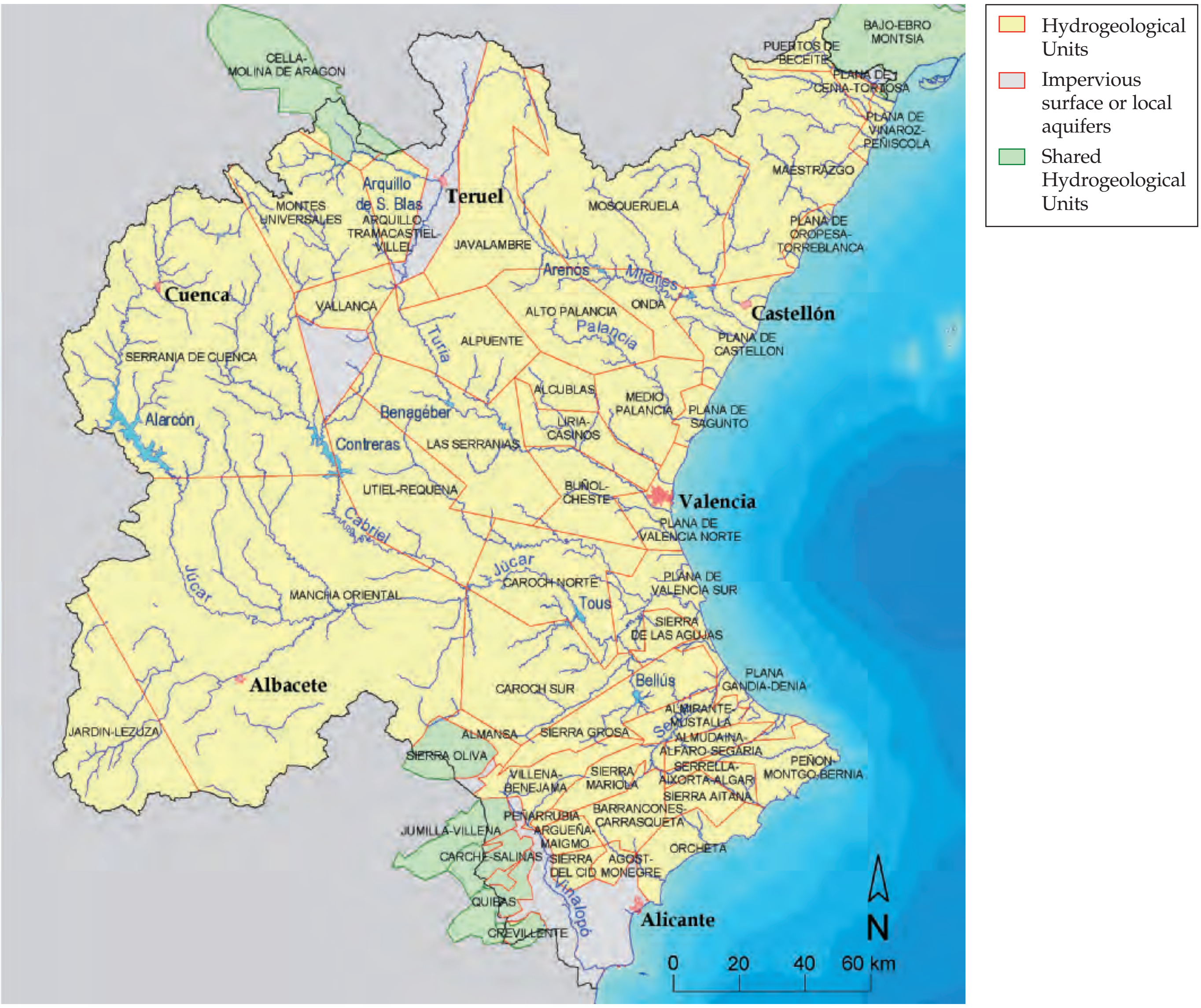
Following the WFD indications, groundwater bodies can be grouped for the purposes of the initial characterisation, the unit of analysis used in the Júcar RBD for GW bodies is the hydrogeological unit (HGU). In the Spanish legislation, this concept corresponds to one aquifer or a group of them suitable to be managed as a single administrative unit by means of a rational and efficient water use.

The adopted GW bodies are the 52 HGUs defined in the Júcar Hydrological Plan (JHP). These HGUs are based in the project carried out in 1989 by the Spanish Geological and Mining Institute (IGME) at national level. This study is the result of aggregating and interpreting a large number of previous hydrogeological analyses available at that time and new ones that were commissioned when needed.

The mapping of the HGUs was the result of considering different lithographic groups, as carbonated, detritic and alluvial aquifers. This process was followed by a thoroughly study for the determination and clustering accordingly to the aspects of lithology of pervious materials. The study also measured physical properties of the aquifers related to hydrodynamics (unconfined, partly confined or confined), composition (simple or multi layer), mean thickness and hydraulic parameters (e.g. hydraulic conductivity), and the storability of aquifers. All these characteristics were taken into account with the purpose of differentiating clearly all GW bodies. Finally, HGUs were represented by closed polygons defined by coordinates across the Spanish mainland and islands.

The location and boundaries of the 52 HGUs defined within the Júcar RBD are shown in figure

Hydrogeological Units (HGUs) | Figure 77



77. It is worth mentioning that 6 of them (dark coloured) are shared with other RBDs and managed jointly with them (Ebro, Guadiana and Tajo). The management criteria correspond to those defined in the Spanish Act 10/2001 by which the National Hydrologic Plan (NHP) was approved. The Act establishes the limits of shared aquifer and assigns water resources to each basin (MIMAM, 2000a).

The works carried out for the JHP and for the NHP make necessary the application of criteria established by the Guidance Document on *Identification of River Basin Districts in Member States. Overview, criteria and current state of play* (EC, 2002b), to assign each portion of the shared aquifer to one RBD. By applying this criterion, it follows that the external territory of the Júcar RBD would have to be taken out, and only the overlapping domain with the Júcar RBD should be considered for the purpose of this District management.

Main data corresponding to the initial characterisation of HGUs are shown in tables 23 and 24. Table 23 shows the disproportion of HGU sizes. For instance, the minimum and maximum GW body sizes correspond to the HGUs of Peñarrubia and Mancha Oriental (34 and 7 660 km^2 respectively). These tables also show that a high number of the GW bodies are of carbonated nature and unconfined. Many GW bodies present dependence from the aquatic ecosystems, which gives an idea of the limitation of water abstraction, and the associated environmental restrictions.

Table 23 Main physical data of HGUs within the Júcar RBD

Code	Name	Polygonal size (km²)	Pervious surface (km²)	Type	Lithology	Dependence with aquatic ecosystem
8.01	CELLA-MOLINA DE ARAGON	233.43	188.72	Multilayer	Carbonated	No
8.02	MONTES UNIVERSALES	1 350.37	1 072.69	Multilayer	Carbonated	Yes
8.03	ARQUILLO-TRAMACASTIEL-VILLEL	428.19	142.40	Unconfined	Carbonated	Yes
8.04	VALLANCA	397.06	214.92	Multilayer	Carbonated	Yes
8.05	JAVALAMBRE	1 578.55	818.00	Unconfined	Carbonated	Yes
8.06	MOSQUERUELA	2 395.21	1 797.85	Multilayer	Carbonated	Yes
8.07	MAESTRAZGO	1 934.43	1 201.47	Multilayer	Carbonated	Yes
8.08	PUERTOS DE BECEITE	189.69	145.18	Multilayer	Carbonated	Yes
8.09	PLANA DE CENIA-TORTOSA	95.63	77.21	Unconfined	Detritic	No
8.10	PLANA DE VINAROZ-PEÑISCOLA	126.13	125.34	Unconfined	Detritic	Yes
8.11	PLANA DE OROPESA-TORREBLANCA	106.37	105.42	Unconfined	Detritic	Yes
8.12	PLANA DE CASTELLON	585.25	554.40	Unconfined	Detritic	Yes
8.13	ONDA	456.10	377.86	Unconfined	Carbonated	No
8.14	ALTO PALANCIA	999.77	791.33	Mixed	Carbonated	Yes
8.15	ALPUENTE	1 098.57	633.26	Mixed	Carbonated	Yes
8.16	OLMEDA	92.34	54.96	Unconfined	Carbonated	No
8.17	SERRANIA DE CUENCA	5 137.58	2 712.86	Mixed	Carbonated	Yes
8.18	LAS SERRANIAS	1 529.27	1 050.55	Mixed	Carbonated	Yes
8.19	ALCUBLAS	299.27	204.38	Unconfined	Carbonated	No
8.20	MEDIO PALANCIA	690.24	520.60	Mixed	Carbonated	Yes
8.21	PLANA DE SAGUNTO	133.54	132.72	Multilayer	Detritic	Yes
8.22	LIRIA-CASINOS	493.67	445.86	Multilayer	Mixed	Yes
8.23	BUÑOL-CHESTE	634.11	343.68	Multilayer	Mixed	Yes
8.24	UTIEL-REQUENA	1 487.11	653.02	Unconfined	Mixed	Yes
8.25	PLANA DE VALENCIA NORTE	328.91	326.61	Unconfined	Detritic	Yes
8.26	PLANA DE VALENCIA SUR	561.94	537.20	Unconfined	Detritic	Yes
8.27	CAROCH NORTE	1 266.90	773.59	Unconfined	Carbonated	Yes
8.28	CAROCH SUR	1 406.79	862.57	Unconfined	Detritic	Yes

Main physical data of HGUs within the Júcar RBD — Table 23 (Cont.)

Code	Name	Polygonal size (km²)	Pervious surface (km²)	Type	Lithology	Dependence with aquatic ecosystem
8.29	MANCHA ORIENTAL	7 660.04	3 625.43	Multilayer	Carbonated	Yes
8.30	JARDIN-LEZUZA	1 453.57	376.41	Mixed	Carbonated	No
8.31	SIERRA DE LAS AGUJAS	188.74	188.35	Unconfined	Carbonated	No
8.32	SIERRA GROSA	790.05	476.98	Multilayer	Carbonated	Yes
8.33	ALMANSA	115.99	49.79	Unconfined	Detritic	No
8 34	SIERRA OLIVA	261.57	189.49	Mixed	Carbonated	No
8.35	JUMILLA-VILLENA	93.27	19.88	Unconfined	Carbonated	No
8.36	VILLENA-BENEJAMA	459.18	305.86	Multilayer	Mixed	No
8.37	ALMIRANTE-MUSTALLA	342.09	197.18	Multilayer	Carbonated	Yes
8.38	PLANA GANDIA-DENIA	227.11	222.62	Unconfined	Detritic	Yes
8.39	ALMUDAINA-ALFARO-SEGARIA	220.65	146.35	Multilayer	Carbonated	Yes
8.40	SIERRA MARIOLA	321.40	203.62	Multilayer	Carbonated	Yes
8.41	PEÑARRUBIA	33.53	15.88	Unconfined	Carbonated	No
8.42	CARCHE-SALINAS	133.62	22.41	Mixed	Carbonated	Yes
8.43	ARGUEÑA-MAIGMO	146.94	87.46	Multilayer	Carbonated	No
8.44	BARRANCONES-CARRASQUETA	409.76	158.67	Multilayer	Carbonated	No
8.45	SIERRA AITANA	238.35	84.61	Multilayer	Carbonated	Yes
8.46	SERRELLA-AIXORTA-ALGAR	184.62	66.15	Mixed	Carbonated	Yes
8.47	PEÑON-MONTGO-BERNIA	463.68	279.36	Unconfined	Mixed	No
8.48	ORCHETA	464.00	131.38	Unconfined	Mixed	No
8.49	AGOST-MONEGRE	103.53	33.38	Mixed	Carbonated	No
8.50	SIERRA DEL CID	138.04	43.74	Mixed	Carbonated	No
8.51	QUIBAS	122.04	47.74	Unconfined	Carbonated	No
8.52	CREVILLENTE	71.27	23.96	Unconfined	Carbonated	No

Data from table 24 have been extracted from the analysis of pressures described in section 4.3 *Impact on groundwater*. As seen in the data, diffuse pollution is affecting a relative low number of GW bodies, and those seriously impacted are also suffering a high pressure from the quantitative side. This combination of pressures occurs because the coastal plain in which these GW bodies are located, is subject to a high level of exploitation and returns from irrigation with high concentration of nitrates. The mean annual recharge, also shown in the table, is calculated by adding the following variables: infiltration due to rain, infiltration from rivers, irrigation returns and lateral recharge.

Table 24	Main pressures data of HGUs within the Júcar RBD

Note: n.d. means no data available

Code	Name	Mean annual recharge (hm³/year)	Total Abstraction (hm³/year)	Diffuse pollution	Artificial recharge
8.01	CELLA-MOLINA DE ARAGON	10.00	0.15	n.d.	No
8.02	MONTES UNIVERSALES	195.68	0.43	n.d.	No
8.03	ARQUILLO-TRAMACASTIEL-VILLEL	7.63	0.14	n.d.	No
8.04	VALLANCA	34.80	0.27	n.d.	No
8.05	JAVALAMBRE	79.93	0.41	n.d.	No
8.06	MOSQUERUELA	148.80	5.97	Low	No
8.07	MAESTRAZGO	215.58	35.65	Very low	No
8.08	PUERTOS DE BECEITE	20.15	0.79	n.d.	No
8.09	PLANA DE CENIA-TORTOSA	18.37	11.81	Very low	No
8.10	PLANA DE VINAROZ-PEÑISCOLA	73.55	49.14	High	No
8.11	PLANA DE OROPESA-TORREBLANCA	31.36	26.03	High	No
8.12	PLANA DE CASTELLON	141.77	134.23	High	No
8.13	ONDA	20.99	4.05	n.d.	No
8.14	ALTO PALANCIA	55.95	9.88	Very low	No
8.15	ALPUENTE	47.35	1.22	n.d.	No
8.16	OLMEDA	2.86	0.20	n.d.	No
8.17	SERRANIA DE CUENCA	511.10	9.16	Low	No
8.18	LAS SERRANIAS	69.04	5.22	Very low	No
8.19	ALCUBLAS	43.01	3.16	n.d.	No
8.20	MEDIO PALANCIA	88.50	63.25	High	No
8.21	PLANA DE SAGUNTO	48.05	45.54	High	No
8.22	LIRIA-CASINOS	100.59	75.47	High	No
8.23	BUÑOL-CHESTE	119.77	81.54	Low	No
8.24	UTIEL-REQUENA	45.63	16.31	Low	No
8.25	PLANA DE VALENCIA NORTE	136.28	58.71	High	No
8.26	PLANA DE VALENCIA SUR	252.63	65.86	High	No
8.27	CAROCH NORTE	122.46	61.08	Low	No
8.28	CAROCH SUR	112.92	40.52	Very low	No
8.29	MANCHA ORIENTAL	376.63	406.60	Low	No
8.30	JARDIN-LEZUZA	71.18	5.47	Low	No
8.31	SIERRA DE LAS AGUJAS	43.15	36.83	Low	No
8.32	SIERRA GROSA	98.19	42.21	Low	No
8.33	ALMANSA	5.51	4.73	n.d.	No
8.34	SIERRA OLIVA	3.91	6.39	n.d.	No
8.35	JUMILLA-VILLENA	1.31	36.12	n.d.	No