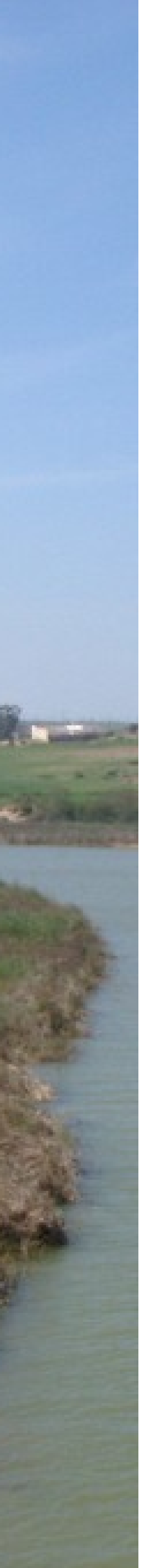

Assessment and Provision of Environmental Flows in Mediterranean Watercourses

- Basic Concepts, Methodologies and Emerging Practice

Mediterranean Case Study

ENVIRONMENT FLOW ASSESSMENT FOR THE EBRO DELTA IN SPAIN - IMPROVING LINKS BETWEEN WETLAND AND CATCHMENT MANAGEMENT

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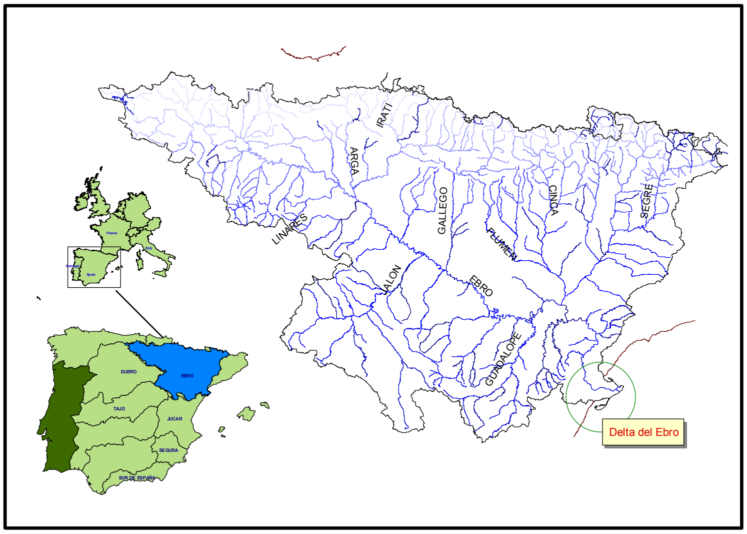
ENVIRONMENT FLOW ASSESSMENT FOR THE EBRO DELTA - IMPROVING LINKS BETWEEN WETLAND AND CATCHMENT MANAGEMENT

1. BACKGROUND

The Ebro River Watershed

The Ebro River situated in the North East quadrant of Spain is the largest river in the Iberian Peninsula. It has the most extensive watershed and network of tributary rivers in Spain and flows from the Cantabric Mountains (northern Spain) 910 km eastward into the Mediterranean Sea, midway between the cities of Barcelona and Valencia.



Climatologic variations within the basin, together with its geomorphology support a high level of biodiversity and ecosystem variability. While soil erosion is moderate, up to 12% of the land in the catchment has high to extreme rates of erosion associated with the loss, poor maintenance and lack of conservation of the vegetal cover.

Close to 3 million people live in the river basin. Almost 784,000 ha of land are irrigated with water drawn from the river, with a minimum volume of 6,310 Hm^3 per year. This is equivalent to the average flow of the Segre River, the most important tributary of the Ebro, which provides 35% of its average annual flow. About 340 dams (about half of them with large reservoirs) have been built on tributaries in the basin and on the main stem. Many of these dams are multi-purpose where hydropower production is combine with storage for irrigation and urban water supply. All reservoirs in the watershed tend to be used simultaneously for these three purposes, but as a main trend, reservoirs in the mid and lower basin tend to be operated primarily for irrigation, whereas hydropower tends to be the dominant function in the upper catchment.

The Ebro River system is heavily fragmented and thus presents many ecologically concerns typical for fragmented rivers, such as the downstream impacts on freshwater ecosystems associated with the alteration of the natural hydrologic regime (flow alteration in quantity and time), changes in river morphology and sediment fluxes and water quality alteration.

Existing dams in the Ebro River currently trap approximately 95% of the suspended sediment load as compared to measurements from the beginning of the 1900s. In the last forty years, low flows past the town of Tortosa, 40 km upstream of the mouth of the river, have decreased approximately 40% [1]. The Spanish National Hydrological Plan (SNHP) envisages the construction of more dams on the Ebro and its tributaries, as well as water transfer from the Ebro

BOX 1: Characteristics of the Ebro Basin.

- Area covered: 85,362 km^2, equivalent to 17.3% of Spain.
- It is the largest flow in the Iberian Peninsula with an average discharge of 18,217 Hm^3/year, and high variability (27,000 Hm^3/yr maximum, 8,000 Hm^3/yr minimum).
- 347 tributaries in a 12,000-km^2 network.

Source: Confederación Hidrográfica del Ebro to the southern basins.

El Delta de l'Ebre

One of the main issues in environment flow discussion is in relation to the delta. The delta of the Ebro River is a site of high economic and environmental importance. Almost 50,000 people live on the delta, and it has been estimated that economic activities associated with the ecosystems of the delta produce an annual turnover of 100 million Euros from fisheries, aquiculture, agriculture (rice farms) and tourism.

BOX 2 FORMATION OF THE DELTA

The main formation of the delta has its origin in the end of the last glacial period, but it is not until 2000 years ago that it started to take shape. The formation process was accelerated in the XIV-XV century with the deforestation of the mid and upper basins. The sedimentation rate until the 1960s was over 8 Tm/year. Since then, the creation of several dams and reservoirs (the most important being the Mequinenza-Ribarroja system) has reduced the sedimentation to 0.3 Tm/year, leading to coastal retreat and plain subsidence.

From the 33,000 ha of area covered by the delta plain, about 65% (21,000 ha) have been converted to paddy fields. Approximately 11,000 ha remain as natural wetlands within a designated Natural Park, of which about 8,000 ha were added to the list of RAMSAR sites of internationally significant wetlands in 1993. The area is the second most important SPA (Special Protection Area) in Spain after the Doñana National Park. It became part of the Natura2000 Network after the European Council declared it area of special interest for the conservation of its halophytic vegetation. It is an internationally significant site for birds and fish fauna, both marine and freshwater.

The delta de l'Ebre is, however, under a wide range of natural and anthropogenic pressures[2] (Box 3). These threats affect the socio-economic welfare of the local communities who depend on the riparian ecosystem, even though they are responsible for some of these threats.

BOX 3 MAIN THREATS AND PRESSURES OF THE EBRO DELTA

1. Decreased river discharge and virtual elimination of sediment discharge leading to coastal retreat - the mean annual flow has decreased approximately 40% in the last 40 years, although it has become significant from the 1980s with the increase in the reclamation of irrigated land.
2. Modification and homogenization of the extreme flows - the flood hydrographs have flattened and the minimum flows have increased in relation to the natural ones.
3. Deterioration of water quality in the river, estuary, lagoons and bays.
4. Loss of wetlands and other natural habitats, and constituent species.
5. Salt water intrusion.
6. Sinking of the delta plain and lack of accretion, leading to lowering of the delta plain below sea level.
7. Climate Change.
    a. Sea level rise.
    b. Drop in rainfall rate (4% reduction in the last 50 years).
8. Declining fisheries.
9. Eutrophication and pesticide release from agriculture.
10. Urbanization of the deltaic plain: population, roads
11. Anthropogenic activities either industrial (e.g. salt mines, fisheries) or traditional (e.g. fish, game).
12. Introduction of exotic species.

The decrease in river discharge at its mouth also leads to salt water intrusion within the river system. The salt wedge can penetrate 16 km inland when this flow is around 100 m^3/s and up to 35 km in summer months if the flows fall below 80 m^3/s. Although the intrusion of marine water within a river is common in estuarine systems and is usually regarded as important in the life cycle of many species, a long-term intrusion of salt water together with eutrophication affects the wetlands of the delta by causing anoxia.

The delta is also threatened by a subsidence of 2-5 mm/year. Roughly 45% of the deltaic plain is currently less that 50 cm above sea level. Because the sedimentation rate has been reduced from 3-15 mm/year to 0.1-4 mm/year, the lack of accretion is leading to coastal retreat and land subsidence. The predicted rise in the Mediterranean sea of between 0.4-1.0 m in this century due to climate change, as forecast by the UNFCCC, would aggravate the situation further.

With modern agriculture, the Delta faces the threats of pesticides release and eutrophication. The potential threats come either from excessive release of nutrients and pesticides (increase of agricultural pressure) or from the decrease in the filtration capacity of the wetlands when the flow regime is extremely reduced. Modern irrigation practices have also led to a decrease in the average salinity of the system.

In order to maintain all the ecological functions of the ecosystem, all the factors mentioned before (i.e., reduction in discharge, eutrophication, sedimentation rates) should be considered in the determination of an e-flow for the Delta del Ebro.

BOX 4: HUMAN ACTIVITIES IN THE EBRO DELTA

Until 1860, when the first irrigation canal was built, the delta presented a natural state combined with few spare rice farms, with a regime of natural flood events, high sedimentation rates and no eutrophication.

The development of traditional rice agriculture occurred between 1860 and 1960. Wetland reclamation during the first half of the 20th century was particularly encouraged by the 1879 water law, which considered wetlands to be insalubrious. During this period of time no large dams were built on the lower reach of the Ebro, which still maintained regular flood events and sedimentation rates.

The development of modern rice agriculture took place after the 1960s with the use of chemical fertilizers and pesticides. Large dams were built during this period such as the Mequinenza (1966) and Ribaroja (1969) as well as the Oliana, Santa Ana, Escales. The large river floods disappeared, accretion rates decreased drastically and eutrophication and pollution levels raised.

Concerned about these threats and pressures, the Ramsar Commission sent a mission to the Delta in 2002 to study the problems. The mission recommended a review of upstream flow regulations impacting the wetland, a programme of geomorphologic and hydrodynamic research for the delta zone, elaboration of a strategic management plan and greater public participation in planning and management decision-processes impacting on the deltas ecosystem functions and services.

2. THE POLICY AND INSTITUTIONAL CONTEXT

Spanish Water Regulation

Currently, the main watershed management bodies in Spain are the Confederaciones Hidrográficas (CH) which all report to the Ministry of Environment. This is consistent with the EU Water Framework Directive (2000) but it basin organizations also have a long history in Spain. The first Spanish water law (passed on 1879) identified the watershed as a management unit and provided the basis to create watershed organizations (Confederaciones Hidrográficas) to regulate “the collective uses of public waters”. In 1926, the CH Ebro became the first established Confederaciones Hidrográfica. Today the CHE is responsible to regulate river abstractions and protect the rights of all the users within the Ebro basin. Under Spanish legislation, the CHs have direct responsibility for environmental flows assessments.

At the beginning of the 20th century, instream river abstractions in the Ebro occurred basically for irrigation purposes. In subsequent decades, water abstraction and its uses expanded to include the construction of storage reservoirs, generation of hydroelectric power, urban and industrial water supply. As with water uses, water laws and regulations have also become more complex over time. The historic Water Law of 1879 was superseded in 1985. The 1985 law brought substantial modernization and changes and included regulatory aspects for hydroelectric companies and other water-abstraction users. The 1985 law was the first of its kind in Spain to recognize the importance of maintaining both water quality and the integrity of fluvial ecosystems. It also introduced the concept of environmental flows and recognized the ecological importance of wetlands, and therefore the associated hydrological and ecological services they provide. Previously, the 1879 Water Law had seen wetlands as unhealthy and therefore included provisions to reward those who converted wetlands into agricultural lands.

To understand the present Spanish scenario, it is important to mention the Spanish National Hydrological Plan (SNHP) and the EU Water Framework Directive (WFD).

The Spanish National Hydrological Plan

The SNHP approved by Congress in 2001 set out the government vision on how it intends to regulate, manage and plan the water resources and all their related uses within the Spanish geography. As one step leading to the approval of the SNHP, in 1999, the Water Law (1985) was modified to adapt it to the purposes and needs of the SNHP. The SNHP identifies an elaborate programme of infrastructure development and management to assure constant water supply all over Spain. These actions are in some cases the building of additional dams and, in others, the inter-basin transfer of water. In the case of the Ebro a principle aim is to transfer what is referred to as surplus flow in the Ebro watershed to the Júcar, Segura and other southern basins. The elements of the SNHP that include water transfers from the Ebro have caused great controversy, especially because of the different perspectives and uncertainty in defining surplus flows and the environmental and socio-economic impacts in the donor and receiving basins.

View of the “Canal Vell” Lagoon

The EU Water Framework Directive (WFD)

The WFD passed in 2000 by the European Parliament, establishes the common rules that the different EU state members must include in their own water legislation, aiming to protect or restore the “good status” to aquatic ecosystems, promote the sustainable use of water, reduce pollution and improve integrated water management and introduce economic pricing of water as a principle tool for dement management. The Directive places special emphasis on environmental objectives to protect all water environments and to reduce human impacts on them.

The Spanish National Water Council (CNA), a water-expert consultative organism created by the 1985 Water Law, revised the SNHP on January 2001, prior to its approval. In the recommendations, the CNA required the elaboration of an Environmental Strategic Plan for the Delta, the PIPDE (Integral Plan for the Protection of the Delta del Ebro). The PIPDE was to be finished one year after passing the SNHP Law, in summer 2002. It aims to guarantee the maintenance of special ecological conditions of the Delta, and following SNHP instructions, should also include "the definition of a hydrologic regime which allows the development of the ecological functions of the river, the delta and the adjacent marine ecosystem".

The Environmental Strategic Plan was elaborated by the CPIDE (Consortium for the Integral Protection of the Delta del Ebro). Besides the preparation of the Plan, the Consortium coordinates and directs the implementation of the PIPDE. The consortium is meant to represent the various water use interests. The 12 members executive board is appointed (6 appointed by the National Government, and 6 elected by the Generalitat de Catalunya, the regional government).

3. ENVIRONMENTAL FLOW METHODS AND TOOLS EMPLOYED

The SNHP (2000) sets a tentative environmental flow value for the lower Ebro at 100 m^3/s (equivalent to 3,150 Hm^3/year). The reference method[3] used was the "Caudal Básico de Mantenimiento" (Basic Maintenance Flow or QBM)[4].

The QBM methodology dates back to 1993, where the Generalitat de Catalunya (the regional government of Catalonia) started deliberations on the elaboration of a regulation on minimum flows for the Ebro, in the framework of the 1985 Water Law. The regulation had to be supported by scientific advice. Thus the Catalan government commissioned the preparation of a methodology adapted to the Ebro conditions, even though a regulation to prescribe an environmental flow never emerged at that time.

The QBM is a hydrological methodology that uses flow record statistics to determine the minimum flow aspect of an environmental flow regime. The main principle is to analyse the variation in the distribution of the minimum flows that have occurred for periods of time ranging between 1 and 100 consecutive days. The analysis aims to obtain a value called Basic Flow (Q_b) that represents the minimum threshold under which the biological habitability conditions can become threatened. This method was selected as a starting point because minimum flows was seen as the main driver of habitability alteration. Alternative approaches such as physical habitat modelling methods have limitations and were more expensive (data collection) and time consuming. The QBM is good for conducting rapid assessments. In this situation, it was important to provide timely input into the SNHP, and in the future, build more complex assessments.

The statistical methodology of the QBM is based on ecological principles. It is based on the principle that the living communities within the river have adapted to a specific flow regime and therefore their biological cycles and ecological requirements are adapted to seasonal variations of this regime. Likewise, they are adapted to tolerate minimum flows of a given magnitude over a given period of time (according to the local discharge regime). Riparian communities can tolerate extreme low flows only for very short periods of time (e.g., one or two days); in longer events the same flow will not be enough to ensure the survival of the communities. Therefore, the objective of the QBM is to determine the average length and magnitude of low flow periods. The value obtained is considered to be the minimum flow of the river in order to maintain the ecological functions of the stream.

Methodology

The method uses mean daily flows for 10 to 12 consecutive years, or a period considered long enough to obtain stable results based on past experience. It calculates the moving average from 1 to 100 consecutive values for each year. The beginning of the hydrological year is selected making sure there are no low flow periods on any extreme of the annual series; by doing so, all low flow periods within the annual hydro-biological cycle will be included entirely. For the determination of the Ebro QBM, the starting month for the hydrological year is April, which is also the month of highest biological activity[5].

The method gathers the minimum value for each mobile average, which corresponds to time periods ranging from 1 to 100 days, and then obtains for each year the value of Qb, deduced as the flow corresponding to the maximum relative increment within the minimum flows averaged series. The average of Qb values for each year – for the years considered for this study- is the flow defined as the minimum flow to maintain.

The biological significance of these values relates to the capacity of the inhabitants of the river to tolerate low flows for given periods of time. If, for example, the average value of columns 8 and 10 are 6 and 6.7, we have an ecosystem that will tolerate flows as low as 6 m^3/s for a maximum period of 8 consecutive days. Statistically, in order to maintain the ecological functions of the ecosystem intact for two additional days, the minimum average flow for the entire period needs to be raised to 6.7 m^3/s. As with any statistical result, these values should be taken with caution.

The QBM methodology was hydro-biologically validated in 2002, regarding the influence of QBM flows on parameters such as water quality, primary production, macrobenthos, fishes and fish habitat availability. It is necessary to ensure that the environmental flow has the necessary hydro biological functionality to preserve the habitability in the stream. According to the SNHP (in the case of the Ebro[6]), this is achieved by maintaining a minimum depth to allow fish mobility. Hydraulic assessment is then conducted to evaluate if the basic flow (Q_b) fulfils the criterion or not. If it does not, a supplementary flow named Adjustment Flow (Caudal de Acondicionamiento or Q_{ac}) is added to the first flow, enough to comply with the habitability requirements. The sum of the Q_b and the Q_{ac} is the Maintenance Flow (Q_{man}) and is the absolute minimum flow for the river.

The Q_{man} has no biological functionality *per se*. It needs to include seasonal variability to reproduce the natural flow regime and bankfull flows (maximum discharge conveyed in the water course without overtopping the banks) to simulate bankfull conditions. The seasonal variability is obtained using a seasonal variability factor (F), a ratio between the average flow for the month and the minimum average monthly flow for the year. This step is similar to BBM methodology. The QBM then obtains a flow regime for the entire year simulating natural conditions by multiplying the Q_{man} by the F ratio for every month. As a result, each month of the year has a different discharge value intended to respond to the different seasonal ecological needs. Apart from the ordinary temporal variability, the QBM establishes Flood Flow events that are defined in terms of magnitude, frequency, seasonality and duration.

Shortcomings and advantages of the QBM method

The QBM method aims to infer ecological functions of the river based on two parameters easily measurable from the hydrological series: flow availability and periodicity. It is suitable as a rapid assessment method and easy to apply on any type of stream, although it is designed for Mediterranean-like rivers, which present as a major limiting factor the "availability" of flows. Hence, the QBM method focuses on obtaining a minimum flow, initially leaving aside other factors such as flow regimes needed to maintain sediment transport rates, water quality (e.g. dilution and dispersion), and so forth, although they can also be considered as requirements of the Maintenance Flow.

The method is quite sensitive to the quality of the hydrological date series used. Therefore, if the series present errors or do not represent natural conditions (i.e., dam management controlling the flow regime) the e-flow determined will not possess the ecological quality the principles of the method mean to have. The construction of a new dam generates new hydrological conditions (modifying the ecological structure of the system) that may be considered as "natural" if maintained for a long period of time. Based on these premises, any hydro assessment will simply reduce the environmental flow regime (EFR) with each successive dam. Therefore, it becomes more and more relevant to restore previous and pristine values of an already regulated river before undertaking any EFR assessment.

Another aspect –mentioned in the current SNHP environmental flow proposal but not numerically defined- is the need for periodic flushing floods and their role in reproducing the natural flow regime of the river. The simulation of the bankfull flow is necessary to preserve the substrate composition, the bed morphology, a good state of the hyporrheic zone and to compensate the colonization pressure of the riparian vegetation. The bankfull flow for the area corresponds to a return period of 1.58 years. Nonetheless, since the bankfull flow will need to be scaled to the magnitude of the QBM annual flow regime, the SNHP document agrees that it will be necessary further and deeper analysis on the matter.

4. KEY MEASURES AND STAKEHOLDERS PERSPECTIVES

In July 2001, CEDEX[7] began a revision of the methods and the hydrological data series used to calculate environmental flow requirements. In this new assessment, CEDEX used the last 10 available years at Tortosa gauging station. There were still limitations. The series were not complete, so the flow values were not consecutive. Moreover, the flow series from Tortosa is affected by water abstraction and uses upstream and therefore do not fully represent the natural stream flows. The assessment yielded a minimum flow value of 121.5 m^3/s for the lower Ebro, as compared to the 100 m^3/s in the SNHP (2000).

- Regional Government Perspectives

The consideration of environmental flows is strongly linked to the ongoing debate on strategies for water allocation between basins. The Catalan government expressed concern regarding the low value (100 m^3/s) set in the SNHP as well as the water transfer proposal more generally. Converse to what is stated in the ASH (Analysis of the Hydraulic Systems) document of the SNHP, the Generalitat de Catalunya (GENCAT) take the position that the interior basins of Catalonia have a current water deficit of 100 Hm^3/year and a deficit of 300-350 hm^3/year is expected in future[8]. The Catalan government seeks an increase in the water transfer to the interior basins of Catalonia. The GENCAT also considers that an extraction of water of 1,050 Hm^3/year from the Ebro, as proposed by the SNHP, is not viable considering the pressure and water-related threats the delta is currently facing. This is to some extent due to the transfer being carried exclusively by the Ebro River. Hence GENCAT proposes options to assure water supply for the interior basins of Catalonia (principally the Barcelona metropolitan area) and measures to reduce the volume of water transferred outside its territory.

The Generalitat de Catalunya has proposed several alternatives to water transfer from the Ebro, such as implementing desalinization plants or (instead of transferring Ebro water to the south) transferring water from other basins like the Duero or the Tagus (although the Spanish Government is reluctant to adopt this alternative because it would imply transnational management issues with Portugal). By using different sources of water for the transfer, the Catalan government expects to use only 200 Hm^3/year out of the 1,200 Hm^3 of the labelled Ebro adjustable flow surplus[9]. The remainder would be used to increase the flow allocated as e-flow, thus going from 100 m^3/s to 132 m^3/s (that is 3,150 + 1,000 = 4,150 Hm^3/year). Yet it represents an increase in the environmental flow, this value is inductive rather than deductive; the increment in the allocation of water for the e-flow is done without detailed analysis of the environmental needs and ecological response thresholds.

- Scientific and Environmental Community

Members of the scientific community, together with many national and international environmental NGOs object to both the SNHP and GENCAT calculations of the minimum required flows. They point to recent scientific studies on the delta including the RAMSAR Mission findings. They advocate a more generous environmental flow to protect the delta, its ecological functions and living species. Scientists and NGOs consider that the SNHP should give more consideration to international obligations and recommendations such as in relation to the Convention on Biological Diversity (CBD) and RAMSAR. Among the threats they envisage are the decrease in sediment transport and the anoxia caused by salt wedge intrusion combined with higher eutrophication levels. Their proposals generally place emphasis on two factors: adequate maintenance of flood events, and the flow necessary to limit the effects of saltwater intrusion in the estuary, which increase with lower flows in the river.

Studies estimated that in order to compensate the sediment budget (to neutralize the deficits), moderate floods of 1,000 to 2,000 m^3/s[10] would be necessary[11], giving a total annual release of 5,000 Hm^3. On the other hand, to retreat the salt wedge or avoid long intrusion periods, a minimum flow of 150 m^3/s would be needed throughout the year with an increase to 400 m^3/s during the winter periods[12]. This corresponds to the time of the year that the SNHP plans to transfer the water from the Ebro to other basins. Therefore, the scientific community and NGOs have proposed a minimum flow requirement of 350 m^3/s[13], equivalent to a seasonally variable flow of 11,000 Hm^3/year.

The environmental community also argues there was limited public participation in the processes to determine the e-flow values for the lower Ebro. As this ongoing debate around e-flows may be only one of many factors delaying the implementation of the SNHP, several stakeholders and organizations have taken this opportunity to express their opinions regarding the economic and ecological viability of the Plan and alternative values for the e-flow proposed. It is anticipated that further opportunity for increased participation and dialogue will take place around the Strategic Environmental Assessment that looks at the proposed environmental flows, which must be included in the Watershed Plans.

- The CPIDE (Consortium for the Integral Protection of the Delta Ebro)

The Strategic Environmental Assessment, published as part of the PIPDE, will determine the e-flow for the lower Ebro and therefore the amount of transferable water. According to the SNHP law, water transfers from the Ebro will be permitted only once the environmental requirements of the Delta del Ebro are guaranteed (i.e. the environmental flow is determined). CPIDE was expected to endorse the PIPDE by July 2002; one year after the SNHP law was passed. However, the differences between members of the Consortium have delayed the approval process. The PIPDE establishes an average minimum flow value from 103 to 143 m^3/s, and two flood events, one in spring (with a maximum flow of 600 m^3/s during 36 hours) and another event in autumn (with two peaks of 1,200 and 1,000 m^3/s during 48 hours). The Plan was resubmitted to CPIDE in July 2003, but was not approved because –amongst other reasons, the proposed e-flow was considered not to be sufficient.

- Local Perspectives

Local stakeholders (e.g., rice producers, tourism, aquiculture and fisheries) are advocating outcomes that meet their needs, but are waiting for a final consensus on how the e-flow regime will be established and managed. The local concerns include the belief that the institution to manage the lower Ebro should be locally based, or at minimum, a strong mechanism for local participation in management decisions provided. This would serve to increase the input of people living in the Delta, who feel they should have greater weight in the decisions that so directly affect their local economy and environment.

Moreover, what initially was supposed an adaptive management process has become a protracted and politically driven debate. It is feared this will result in a fixed value for an environmental flow once tradeoffs are made. This will limit the scope for adaptive responses as conditions evolve over time and in response to monitoring and knowledge improvement. In addition, because the SNHP proposes water transfer from the basin, government as well as local stakeholders from the potential receiving basins eager to entered the dialogue informing the Ebro environmental flow decision. This increases the complexity of the negotiation and tradeoffs.

- European Commission Interests

Another aspect is the Spanish government anticipates EU financing support for the SNHP works. For this, the EU will require compliance with the body of European Environmental legislation to guarantee the conservation of the special environmental conditions of the Delta. In view of the recent stalemate in finalizing the e-flows and more generally in relation to the SNHP, recently the European Commission invited the Spanish Government and other organizations and institutions (e.g. CPIDE, European Environmental Agency, WWF, New Water Culture Foundation, Plataforma en defensa de l'Ebre) to a technical meeting in Brussels for dialogue on the SNHP and its environmental management implications. This has opened another avenue for wider input and expression of opinion by different water use and sectoral interests concerning the management of the Ebro and its watershed.

5. LESSONS LEARNED

The Spanish National Hydrological Plan is the main driver of decision-making for management of flows in the Ebro River, and within this, the strategic plan for the Delta (PIPDE) is the main instrument for assessing environmental flow regime to be provided in the lower reaches of the river when implementing the SNHP. The e-flows are otherwise essential to set boundary conditions for tradeoffs in the regulation of flows including abstractions, transfers out of the basin and reservoir operating policies. Although the PIPDE is still under negotiation, several lessons can be drawn from the dynamic situation at present.

The determination of an environmental flow regime for the Delta del Ebro needs a holistic approach. The complexity underlines a basic principle in e-flow estimation to select the right criteria to determine the e-flow. It also argues that the combined input of the scientific community, the local communities and professionals is needed early in the process, not only to establish the criteria, but also to build consensus around the approach used to decide the flow regime and adaptively manage the situation over time.

The scientific studies conducted in the Delta conclude that the environmental flow must not be a single value but a regime of flows. Although this is valid for all river ecosystems, it is crucial in the Delta del Ebro environment, which is highly dependent on seasonal flows. At present, despite what is published in the PIPDE, discussions by the institutions responsible for determining the e-flow appear heading to a single fixed value. The main reason for this is the parallel negotiation that aims to fix the level of water transfer from the basin. This will present a hurdle for adaptive management.

The management of the Delta is affected by external factors that will only be resolved if all key actors reach an agreement on the implementation of the SNHP. Since the Delta del Ebro system strongly depends on events occurring upstream the watershed (such as storage, releases and water abstractions), the capacity for local decision-making to manage resources in the lower delta is considerably constrained. Moreover, the scope of the SNHP has brought from the receiving basins new stakeholders eager for water, thereby increasing the pressure and the complexity of this process. In the views of many, the resolution of these complex issues has been weakened by the lack of sufficient mechanisms for open and transparent public participation and input to the processes that prepare recommendations.

The CPIDE, who is responsible for the elaboration and implementation of the PIPDE, is not seen by many stakeholders as fully representing all the different interests on the Ebro, or providing clear mechanisms for stakeholder dialogue to inform the analysis on which they deliberate. All members have been appointed either by the Central or the Regional Government. Most are politicians or officials working for government agencies (e.g., National Congress, Catalan Water Agency, etc.). Experience elsewhere suggests that to increase public confidence, the views of the economic, social and environmental sectors, as well as the scientific community should be adequately taken into account at each stage in the process.

Overall, the process for determination of an environmental flow regime for the lower Ebro has become more problematic than expected. This is because: (1) the e-flows assessment was not linked to other important issues within the basin that worsen the situation in the Delta; and, (2) it has been largely perceived as driven by the implementation of the SNHP, itself a subject of considerable controversy. The determination of the environmental flow in the Delta del Ebro should include a flow regime that ensures sufficient habitability for stream-dwelling organisms, as well as adequate transport of sediment and nutrients. Some of these issues may be left outside of the environmental flow equation by addressing the source of the problems upstream. The construction of the dams planned in the SNHP are said to have low impact on sediment and nutrient transport downstream because the existing dams (i.e. Mequinenza-Ribaroja) already trap over 95% of sediment. A more holistic approach in the management of dam releases may help overcome the difficulties of determining the e-flow regime for the lower Ebro.

The determination of an environmental flow for the Delta del Ebro depends not only on the ecological requirements of local ecosystems, but also on the management and planning of the entire watershed. Since practices upstream directly influence the flows downstream, and thus affect the wetland ecosystem of the Delta, environmental flows may be used as the linking tool between watershed management and wetland conservation in the Delta. Management goals then would encourage the development of an ecosystem management approach in the Ebro River and would provide a better opportunity to strike a balance between human and environmental needs.

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7. WEB SITES

Congreso Ibérico sobre Gestión y Planificación del Agua	http://www.us.es/ciberico/articulosint.html http://www.us.es/ciberico/annexe4_3ue.pdf http://www.us.es/ciberico/leyaguas.pdf
Ministerio de Medio Ambiente	http://www.mma.es/rec_hid/plan_hidro/index.htm
Confederación Hidrográfica del Ebro	http://www.oph.chebro.es/ http://www.chebro.es/
Agencia Catalana del Agua	http://mediambient.gencat.net/aca/ca/home/inici.jsp
EU European Environment Agency	http://themes.eea.eu.int/Specific_media/water/links

TIMELINE

1985 Water Law 29/1985 introduces the current planning framework.
1986 Official declaration of the Natural Park of the Delta del Ebro.
1989 Minimum historic annual flow of the Ebro (4,299 Hm^3).

1993

- (March) 7,736 ha of the Delta del Ebro are included in the list of wetlands of international importance (Ramsar site n. 593).
- (April) The Ministry of Public Works and Urban Planning presents the first National Hydrological Plan (SNHP) Draft.
- (June) Reply of the Spanish Water National Council on the 1993 SNHP pre-project. The 1993 SNHP did not progress.

1998

- Approval of the Watershed Hydrological Plans.
- The new Ministry of Environment published the "White Paper on Water in Spain" that reassessed the hydrological situation of the country.

1999

- (July) The Secretary of the Ramsar Convention communicates to the Dirección General de Conservación de la Naturaleza his concern on the conservation status of the delta
- (October) The General Director of Natural environment, Department of Agriculture and Fisheries of the Generalitat de Catalunya, replies to the Ramsar Secretary inviting him to visit the delta.
- (October) The Spanish National Commission for the Protection of Nature approved the "Spanish Strategic Plan for the conservation and rational use of wetlands".
- (December) Water Law 46/1999 modifies the 29/1985 Law.

2000

- (September). The Ministry of Environment presented the new SNHP Draft accompanied by five technical reports.
- (September) The MRA (Ramsar Advisory Mission) visits the Delta for 5 days.
- (October) Approval of the EU Water Framework Directive (Directive 2000/60/EC)

2001

- (January) Revision of the SNHP by the National Water Council.
- (July) Law 10/2001 of the SNHP passed. Article 26 indicates that the Watershed Organisms are responsible for determining the environmental flows. Additional Provision 10th asks for the elaboration of the PIPDE within a year of the publication of the law.

2002

- (January) The Ministry of Environment submits to the European Commission the *SNHP Strategic Environmental Assessment.*
- (September). The Ministry of Environment submits to public consultation a Memory-Resume of the Environmental Impact Study, thus starting the formal process for the Ebro transfer evaluation.

2003

- (April) The Generalitat de Catalunya proposes to the Ministry of Environment the establishment of the e-flow for the Ebro in 135 m^3/s. The Central Government refuses.
- (July) The PIPDE is presented to the CPIDE. The President of the CPIDE considers that the environmental flow presented does not fulfill the requirements and the PIPDE is not approved.
- (October) The European Commission invites all involved stakeholders to a technical meeting in Brussels to exchange points of view.

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[3] Ministerio de Medio Ambiente, 2000. PHN Volumen IV.
[4] Palau, 1996.
[5] Ministerio de Medio Ambiente, 2000. Plan Hidrológico Nacional. Vol. IV: Análisis Ambientales. Page 70.
[6] See endnote 5
[7] Centro de Estudios y Experimentación de Obras Públicas, research center part of the Ministry of Public Works.
[8] Document Reference: Alegaciones al Borrador del PHN. Agencia Catalana del Agua. GENCAT. On the web.
[9] Agencia Catalana de l'Aigua, 2000, quoting volume III of the PHN document.
[10]Other authors like Palau note that at this flow value some of the towns adjacent to the river become flooded.
[11] Prat, N., 2001.
[12] Prat, N., 2001.
[13] Part, N., 2001. *Afecciones al bajo Ebro derivadas del PHN, Alternativas y necesidades de un nuevo modelo de gestión del agua.* On the web.