Past, present and future of flood management in the *Ebro River Basin*

In order to minimize flood hazard it is essential to have basin-wide scale real-time information systems in place as well as trustworthy forecasts allowing for an effective decision-taking in flooding events. This article describes the time evolution of flooding events monitoring and control in the Ebro River Basin (NE Spain) and how the current Automatic Hydrological Information System and Decision-Making Assistance System allow for reservoir manoeuvres reducing flood risk significantly.

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1. Introduction

A river basin is the territory which drains the water of a single river, that is, a percentage of a drop of water that falls on that territory will end up flowing to the sea through the principal river which gives its name to the basin.

Figure 1. Map of the river basins in Spain.

The management of water in Spain is entrusted to the River Basin Districts in the inter-Community basins (their geographical scope comprises more than one Autonomous Community), which are autonomous bodies dependent on the Ministry of Agriculture, Food and the Environment, while in the intra-Community basins, the management is performed by the regional governments through entities such as the water resources agencies.

Royal Decree 125/2007, of 2 February, established the territorial scope of the river basin districts, while the Water Framework Directive of the year 2000 was the provision that created the concept of river basin district, understanding as such the land and sea area made up by one or several neighbouring river basins and the transitional, underground and coastal waters associated with such basins.

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The *Confederación Sindical del Ebro*(1), created on 5 March 1926, was the first River Basin organisation in the world. Its model was supported on three pillars: **the unity of the basin, democratic participation**(2) **and hydrological planning** (3). We should highlight the fact that Spain has been a pioneer in the development of water resources plans, and the Water Framework Directive has extended such plans to all of the countries of Europe.

In the ninety years of operation of the Ebro River Basin Authority, known in water management circles as the "CHE" -*Confederación Hidrográfica del Ebro*- which is how we will refer to it in the course of this article, *flood events have occurred at any time of the year and we can say that they will continue to occur*.

An examination of the historical data of the Ebro River station in Zaragoza (EA 9011), published by the General Directorate for Water (MAGRAMA) in the Official Yearbook of Hydrometric Stations (ROEA)(4), suffices for us to see how in the last seventy years, annual maximum flows in excess of the MAXIMUM NORMAL HIGH WATER FLOW (Qmco) have occurred in twenty-six of them.

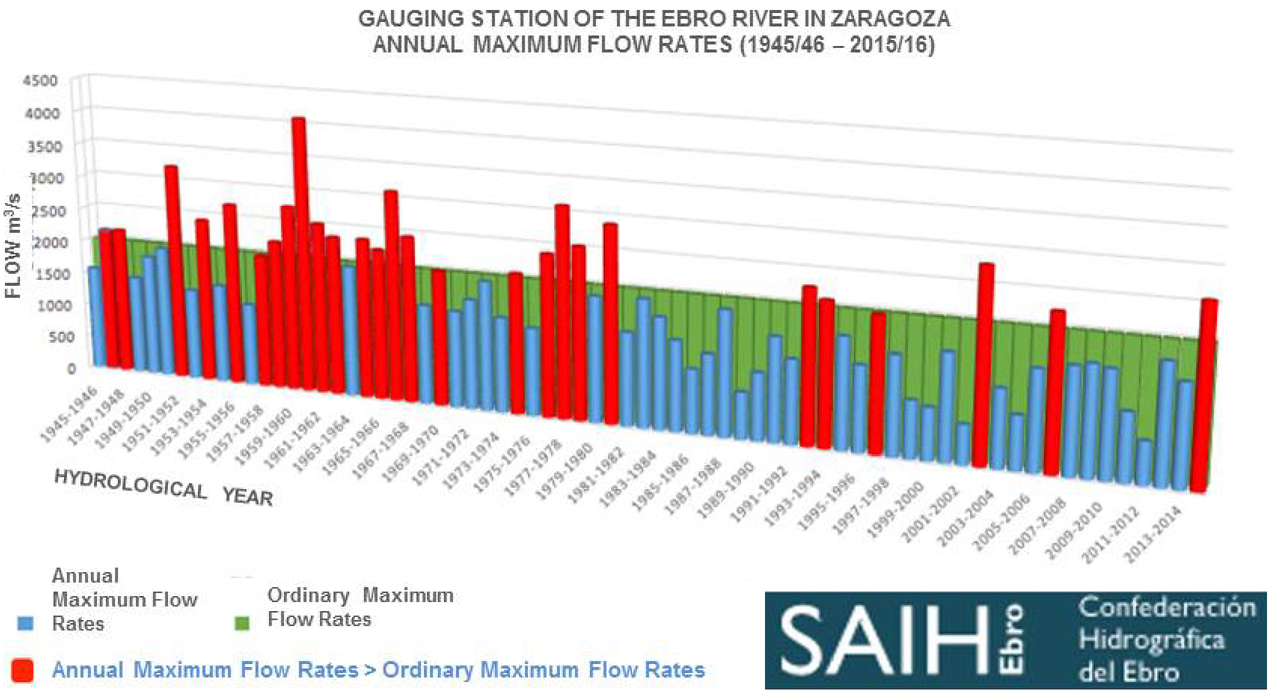


Figure 2. Annual maximum flows at the EA 9011 Ebro station in Zaragoza.

(1) http://chebro.es/contenido.visualizar.do?idContenido=2509&idMenu=2081

(2) http://chebro.es/contenido.visualizar.do?idContenido=2517&idMenu=2084

(3) http://chebro.es/contenido.visualizar.do?idContenido=42695&idMenu=4780

(4) http://sig.magrama.es/aforos/visor.html

The table set out below shows a reduction in the percentage of extraordinary flood events starting from 1962. More than likely, there are several reasons that could explain this reduction, but one very evident reason is that in 1958 and 1960, a number of reservoirs began to operate, including the Yesa on the Aragón River and the Ullíbarri and Urrúnaga Reservoirs in the Zadorra River basin, all of which are located upstream from Zaragoza.

Period	Number of years	Number of events where Q annual max > Q ordinary max	Remarks
1945 - 1961	16	10	No reservoirs
1962 - 1996	34	13	In 1961, the Zadorra River reservoirs and the Yesa reservoir began to function
1997 - 2002	5	1	In 1997, the SAIH network began to operate
2003 - 2016	13	2	In 2003, the SAD began to operate

We can conclude that reservoir management has provided us with a tool which, in addition to storing water for irrigation purposes, hydroelectric uses and supplies to cities and towns, serves for flood abatement (by making the flows entering a reservoir higher than those leaving it, whereby we reduce the flows moving downstream from the reservoir and, consequently, the damage which the flood waters could cause). It is also important to note that, **at times, these manoeuvres can create an impression of false security** since the reduction of the number of flood events as a result of good management of the reservoirs leads the downstream cities and towns to feel that parts of the river no longer belong to the public water domain.

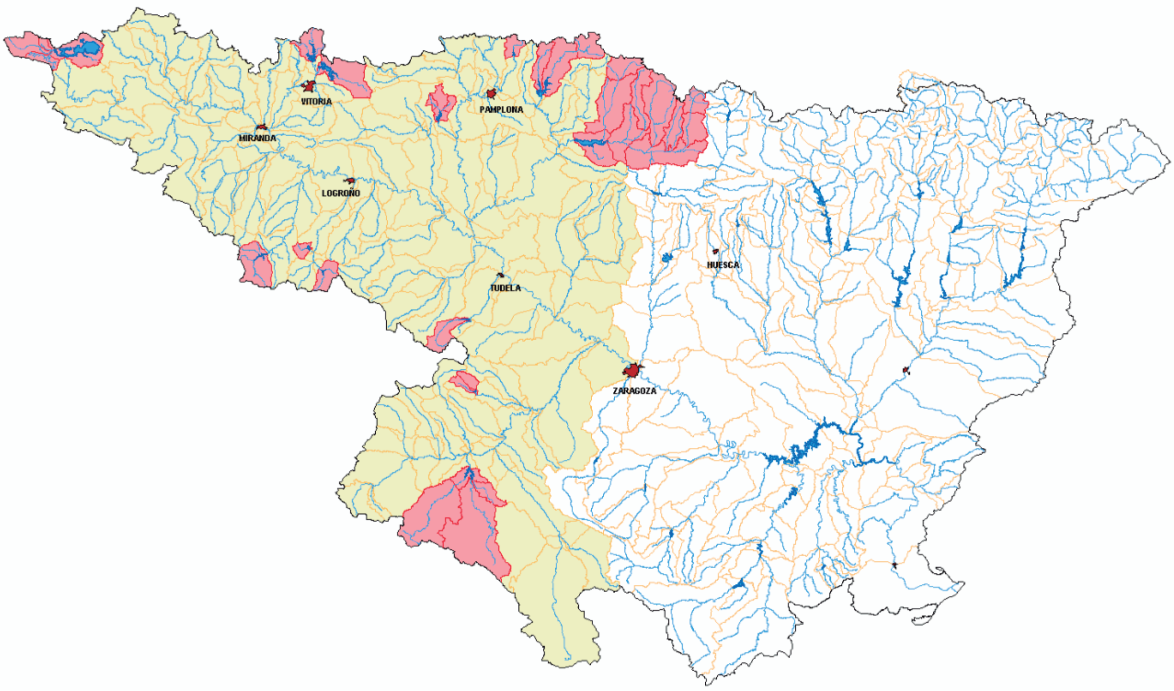


Figure 3. Catchment area up to HS9011, Ebro river in Zaragoza, 18.1 % regulated at the present time.

Even with the capacity of the reservoirs for abating flood waters, this effect is limited by the river basin surface regulated up to a particular populated area. If we take the example of Zaragoza, the basin up to the 9011 hydrometric station (Ebro River in Zaragoza) has only 18.1% of its catchment area regulated, and therefore the effects of the abatement are not sufficient, **making it necessary to have other tools available such as early warning and proper land planning**.

2. Flood management in the past (1926-1983 and 1983-2000)

We will define the "past" as from the creation of the CHE up to the end of the twentieth century, divided into two stages: 1926-1983 and 1983-2000, and we are going to make an "archaeological" study of what resources were available for managing a flood episode at that time.

The official network of hydrometric stations (ROEA), which in the Ebro River Basin has series of historical data since the beginning of the past century, was made up by hydrometric stations where there was a visual scale and a "scale watcher" (a voluntary observer living near the station) who recorded the heights observed on the scale in a log. When in the decade between 1960-1970, water level recorders or limnimeters began to be installed(5), in addition to making a record in the log, the scale watcher was responsible for changing the sheet on which the variations in the water level during the past week had been continuously recorded. This sheet was then sent by ordinary post to the CHE central headquarters, for making a planimetric diagram(6) of the data to be included as part of the historical series.

Figure 4. Data sheet for manual recording of the observations of the scale.

Figure 5. Scale of the HS 9096 Segre hydrometric station in Balaguer.

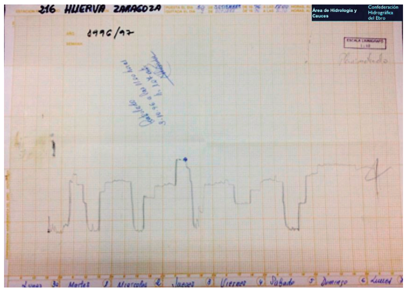


Figure 6. Water level recording made at the EA 9216 Huerva hydrometric station in Zaragoza.

In case of floods, the telegraphic service was formerly used for transmitting the observations of the water level as urgently as possible to the CHE headquarters. The information on the figures received was collected here on sheets of graph paper which were progressively attached, forming the flood hydrograph, and technical assessments were made on the progression and sent to the Governor of the Province.

The people in cities or towns affected by floods were only aware of what was happening there by in situ observation and, with the arrival of telephone lines, there was a possibility that someone living upstream might keep them informed of how the situation was developing. **During those years, it can be said that the HAZARD LEVEL was very high, since the warning times for taking preventive measures were very short.**

In terms of flood events, 1982 and 1983 were especially violent years with significant episodes on:

- 20 October 1982, failure of the Tous (Valencia) dam and major floods in the area of Alicante.
- 6, 7 and 8 November 1982, serious flooding in a large part of Spain with cities affected such as Lleida, Fraga (Huesca), Barcelona free-trade zone, Girona, Arán Valley.

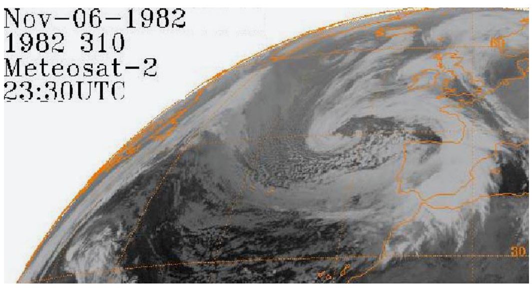


Figure 7. Meteosat image 6/11/1982 "Cut -off low" that caused Tous dam failure

(5) Device that continuously records the height of the water at a hydrometric station on a river. The recording is called a limnograph.

(6) The planimetric diagram, in this case, makes it possible to determine the maximum daily level and the daily average. The relevant flow rates and volumes in movement are calculated on the basis of these figures.

- 20 August 1983, floods in the Basque Country affecting Gipuzkoa and, especially Bizkaia, the towns on the Nervión River and with serious damage in downtown Bilbao.

Figure 8. Estuary of Bilbao in august 1983 and now in 2016 at the point of the La Ribera Market.

These events led the then Ministry of Public Works and Town Planning (MOPU), through the General Directorate for Hydraulic Works, to implement a National Dam Safety and Surveillance Programme which established the following key milestones:

- The engaging of 42 technicians to reinforce the human resources of the River Basin Authorities devoted to the safety of the dams.

- Equip the dams with safety systems, such as generating sets and radio communications systems (radiotelephones).

- Implement information systems in real time at all of the river basins, which today is known as the Automatic Hydrological Information System (SAIH), providing the River Basin Authority managers with hydrometeorological information for minimising the damage caused by floods.

If we take ourselves back to 1983, **just 33 years ago**, and think that we had to AUTOMATICALLY make the data on the volumes flowing in the rivers, the water entering the reservoirs and all of the rain falling on a river basin, such as the Ebro with a surface area of 85,000 km², arrive at a control room at the central office in Zaragoza, we need to know what communications technologies existed and on what level computers were operating at the time (in terms of both hardware as well as software), in order to realise that what today would be very easy to do, at that time was a major challenge. Let's see why:

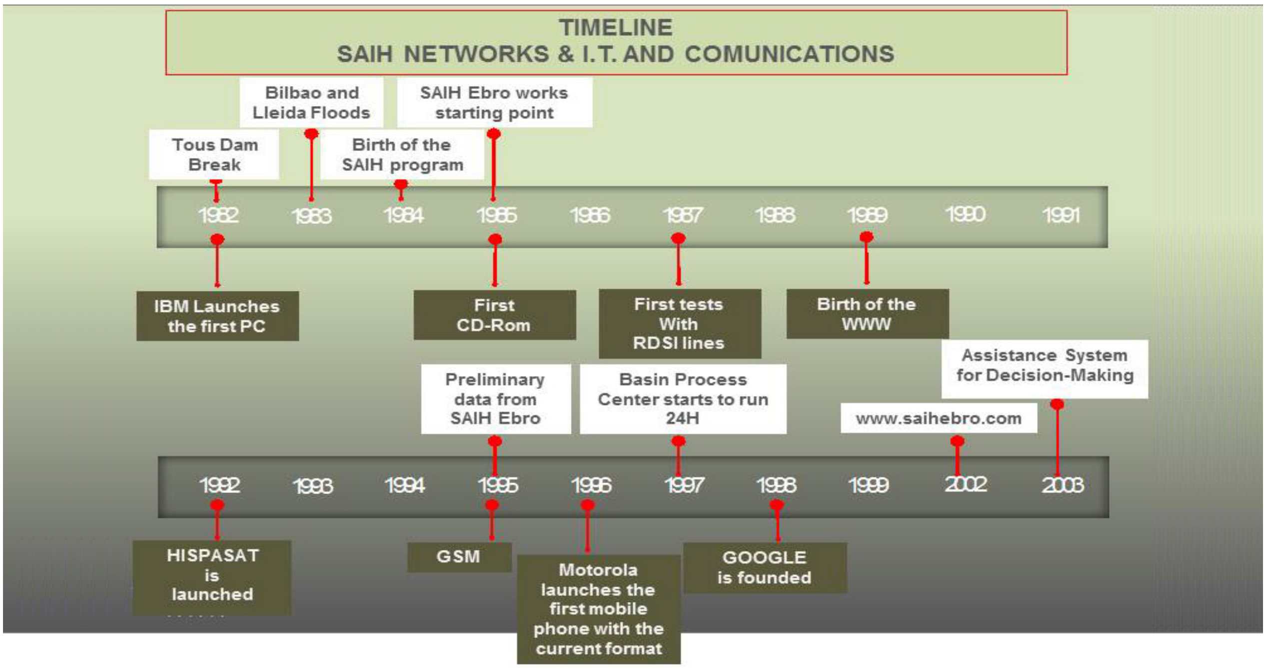


Figure 9. Time line of the evolution of telecommunications and the implementation of the SAIHs.

The first installation works for setting up SAIH networks commenced in the Júcar, Sur, Segura and Ebro River basins and, due to the status of the communications systems at that time, the authorities found it necessary to build communication networks of their own based on a secondary network of terrestrial repeaters in the UHF band and a primary or transmission network, in the microwave band, making it possible to connect the stations to the control centre, located at the central headquarters of the respective basin authorities. Starting in 1992, with the launch of the HISPASAT satellite, the SAIHs of the Guadalquivir, Tagus and Cantábrico which commenced operations as from that year, were designed and installed with communications by satellite.

The current communications network of the SAIHEbro(7) operates through a communications system of its own, consisting of a transmission network (Primary Microwave Network) with 125 links that reach the principal reservoirs and offices, together with an access network (Tetra Network) which covers practically the entire river basin, through 69 base stations, coexisting with other satellite, Wimax and GPRS communications systems.

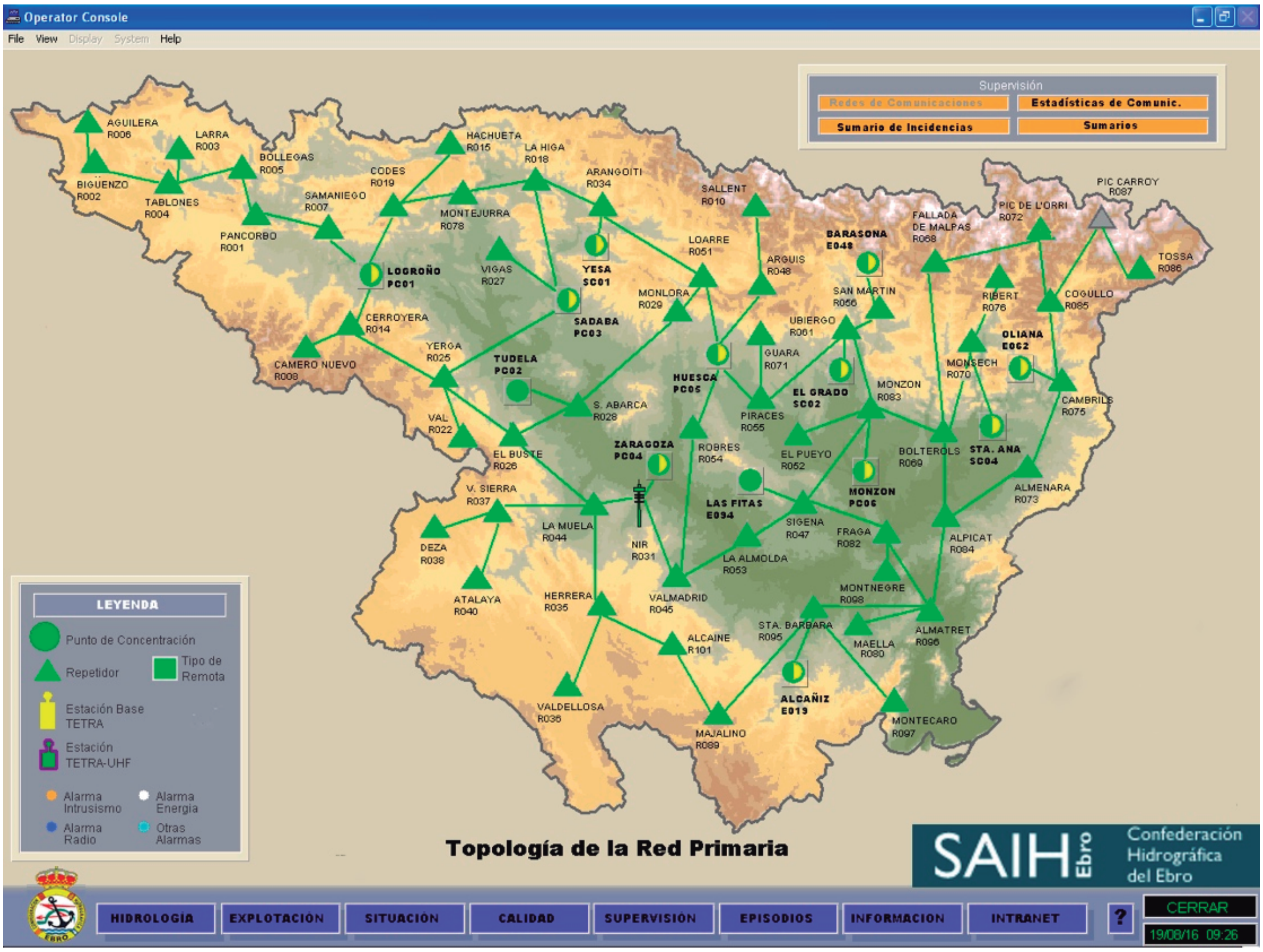


Figure 10. Outline of the primary communications network.

(7) http://195.55.247.237/saihebro/index.php?url=/presentacion/comunicaciones

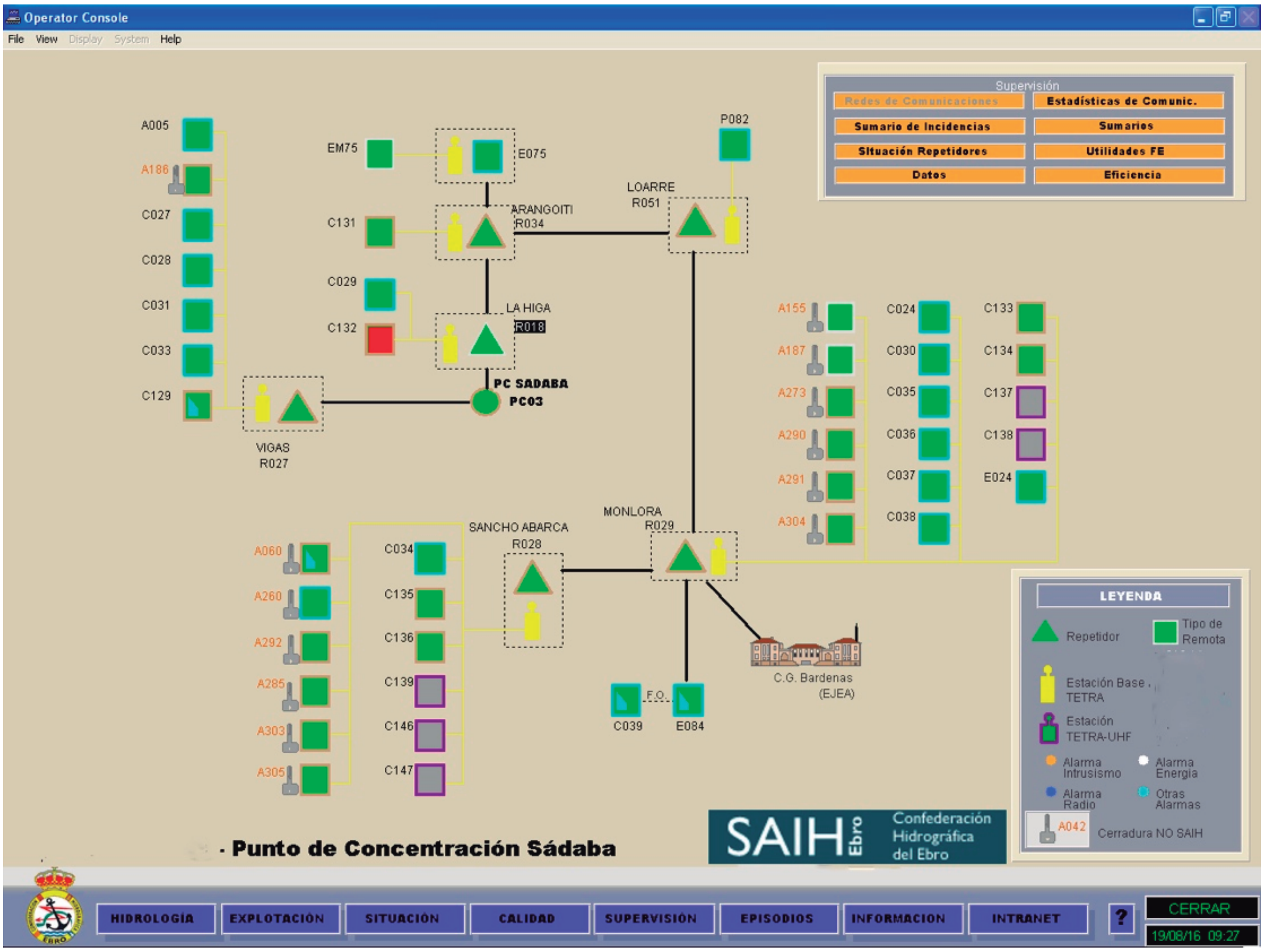


Figure 11. Outline of the secondary communication network in the area around Sádaba.

If we take a look at the data acquisition hardware in the control stations and in the control centre, we find that, at the time, the staff had to work with the technology available in 1985-1995. As an example of the characteristics of the equipment of that time, we are setting out below the features of the first computer installed in the River Basin Processing Centre:

Operating System HPPA HP-UX 9.4
RAM: 96 MB
CPU: 50 MHz and 70 MIPS
4 Disks: 300 MB

Another significant aspect of the project for the implementation of the SAIHEbro is the fact that the work took almost ten years to complete, partly due to the difficulties for successfully installing the close to 100 radio repeaters in mountainous terrain, together with the difficulties in obtaining permits for the land use, making the electricity connections and building the access roads. Finally, we began to receive data from the full network at the end of 1996, and our "debut" came with the January 1997 flood, which served to convince the management of the CHE that the service provided by the SAIH should be 24h/365 days (at the present time, this is the only River Basin Authority that has this service around the clock).

The 24h service is fully justified, because floods can occur at any time and do not conform to normal working hours, requiring the effort of all of the technical teams involved in the management of the event.

At this stage of the past, we must note that the floods in December 1996 and October 2000 served for gaining "experience" in the operation of the system and made the departments of the CHE themselves, as the external agents involved in flood episodes (managers of hydroelectric reservoirs, civil defence authorities), realise that tools of this nature are extremely useful in the global management of the basin.

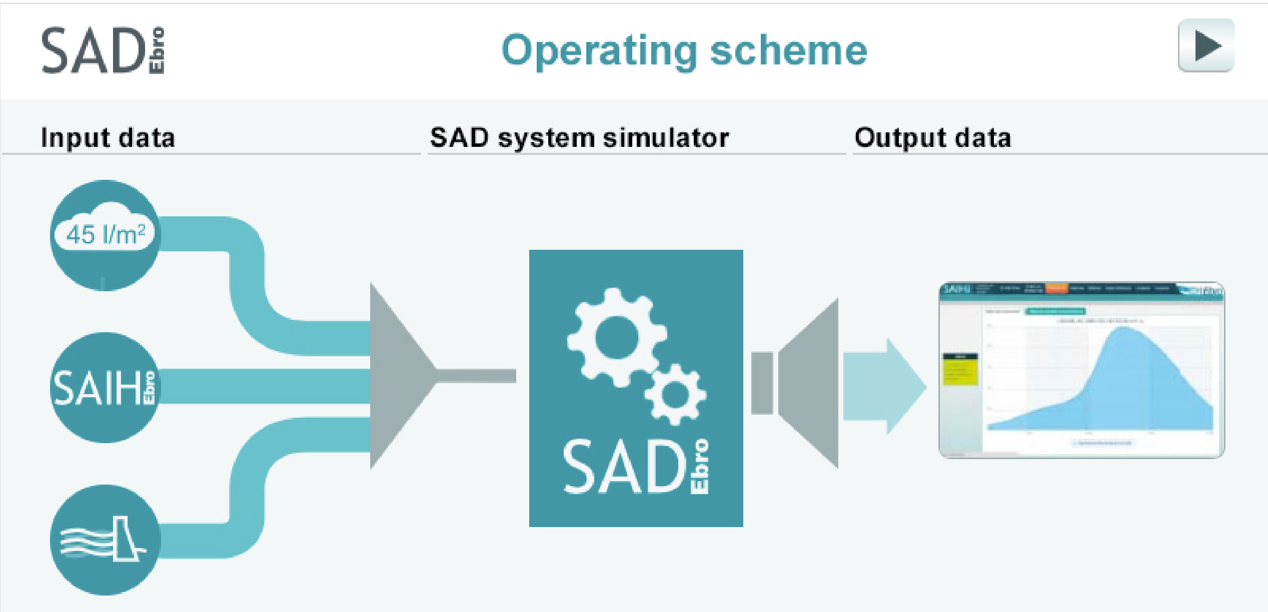
We have discussed how floods were managed up to 1997, prior to the SAIH, let us now see how they were managed with the SAIH up to the year 2000. The monitoring of the rivers no longer depended on the information sent regularly by the "scale watchers". With the data captured by the SAIH network, the Hydrology Service **was then able to monitor, at fifteen-minute intervals**, the first 110 hydrometer stations and to be aware of the rainfall situation at 223 stations distributed throughout the basin.

The reservoirs, which up to that time were managed almost on an individual basis, changed the way they were managed when the information provided by the SAIH network became available, as **the River Basin Processing Centre, with the information from the entire basin, made it possible to begin deciding what manoeuvres needed to be initiated from the perspective of how they were going to influence the outcome, when the reservoir waters joined the flows of the unregulated rivers**. During this stage, the reaction times were increased, both in terms of the abatement actions at the reservoirs as well as the warning time for alerting the civil defence authorities, which began their deployment in the Autonomous Communities starting from the Basic Civil Defence Regulation published in 1992.

3. Flood management today (2000-2016)

We can mark as the borderline between the past and the present the time when in the year 2000, the management of the River Basin Authority decided to develop a tool that would take advantage of the meteorology products available at that time, providing forecasts of precipitation and temperatures for the next seventy-two hours with a spatial resolution of 0.16° land surface (approximately between 13 and 14 Km) updated every 8 hours, obtained through the HIRLAM model of the State Meteorological Agency(8) (AEMET).

We have called this tool the Decision- Making Assistance System(9) (SADEbro), and it functions on the basis of the following module:



(8) http://www.aemet.es/es/eltiempo/prediccion/modelosnumericos/hirlam

The inputs into the system are: weather forecasts of rainfall and temperatures for the next 72 hours, the data observed by the SAIH network with respect to flows, reservoir volumes, rainfall, ambient temperature and the manoeuvres planned in the next 72 hours by the reservoir managers.

The **SAD simulator** collects all of this information and, using the **hydrological models**, converts the rainfall forecast into runoff, taking into account that, depending on the temperature forecast, part of that precipitation will remain as snow while the other part, depending on the moisture status of the soil, will flow on to the groundwater. The runoff will be propagated by the **hydraulic models** throughout the basins forming the network of the Ebro River Basin. Given that some waterways are interrupted by reservoirs, the SAD has a **reservoir management module** which makes it possible to simulate how the possible manoeuvres planned there, on the basis of the incoming flows predicted by the SAD are going affect the situation downstream and the volumes of the reservoir itself.

With all of this, since 2003, the SAD has been preparing the data on the flows predicted for the next 72 hours at the hydrometric stations of the river basin, as well as the flows entering the reservoirs. This information, together with the information captured by the SAIHEbro network, is available on the website www.saihebro.com

An example of the results of the forecasts prepared by the SAD can be found in the management of the Mequinenza, Ribarroja and Flix reservoirs, located along the lower stretch of the Ebro (mouth) during the flood episodes from the end of January to mid-March 2015.

If we look at the management of the flood as a mathematical problem, we need to be aware of the following initial data:

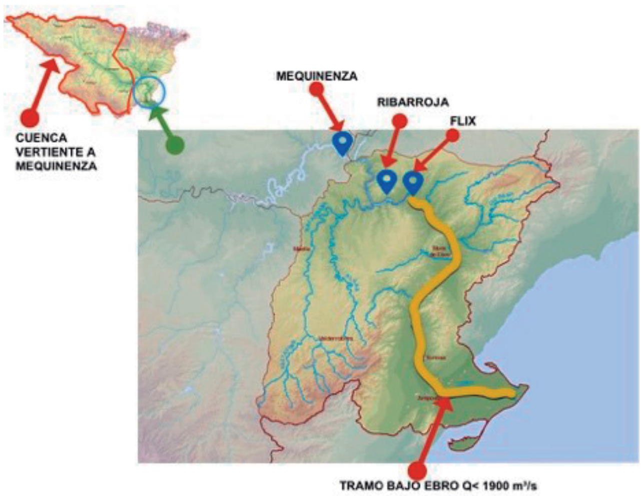


Figure 12. Location map of the MEQUINENZA-RIBARROJA-FLIX system.

- The floods occurring in the upper and middle basin of the Ebro River take from 3 to 5 days to reach the reservoirs of the mouth, which means that we have that time for planning the outflows on the basis of the volumes predicted by the SAD.

- The capacity of the Mequinenza Reservoir is 1,500 hm³.

- The objective is to try not to release flows in excess of 1,900 m³/s since higher flows will begin to cause damage in the lower stretch of the Ebro where the largest populated area is the city of Tortosa (Tarragona). These maximum flows are, of course, conditioned to the safety of the dam and, if it were to become necessary to release more than 1,900 m³/s to prevent the failure of the dam, they would be released.

With the information provided by the SAD, the Mequinenza Reservoir began to increase the outflows on 29 February 2015, eight days before the arrival at the reservoir of the peak of the high water which generated flooding at the head-waters of the Ebro (area of the Merindades de Burgos and in the Miranda de Ebro area). The maximum inflows of the reservoir were 1,800 m³/s while the outflow was 800 m³/s.

(9) http://www.saihebro.com/saihebro/index.php?url=/presentacion/previsiones

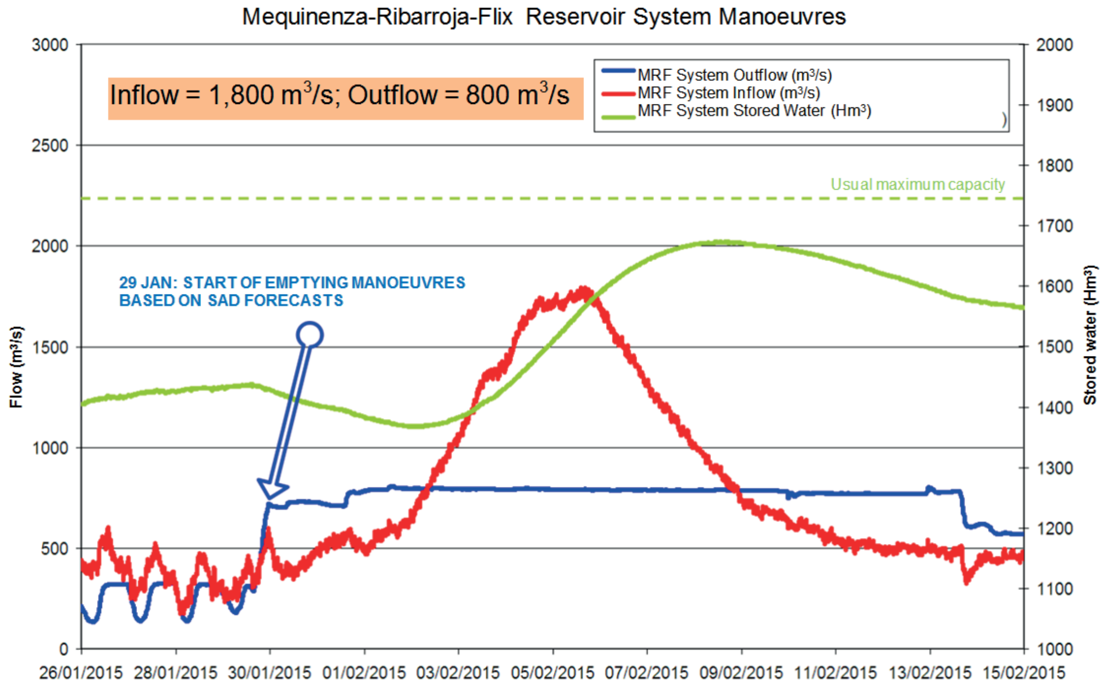


Figure 13. Preventive manoeuvre at the Mequinenza re- servoir from 29/01/2015 to 15/02/2015.

Given that the flooding continued during the months of February and March, the Mequinenza Reservoir exceeded its **normal maximum level** from the 4th to the 9th of March, reaching 104 % of its capacity, which did not create a hazardous situation since dams are designed to withstand design flooding calculated for a return period of 1,000 years. With this decision, flooding was prevented during those days in the area of the mouth of the river, since the maximum flow discharged was 1,850 m³/s, at the limit for the onset of damage, while the maximum inflow was 2,500 m³/s.

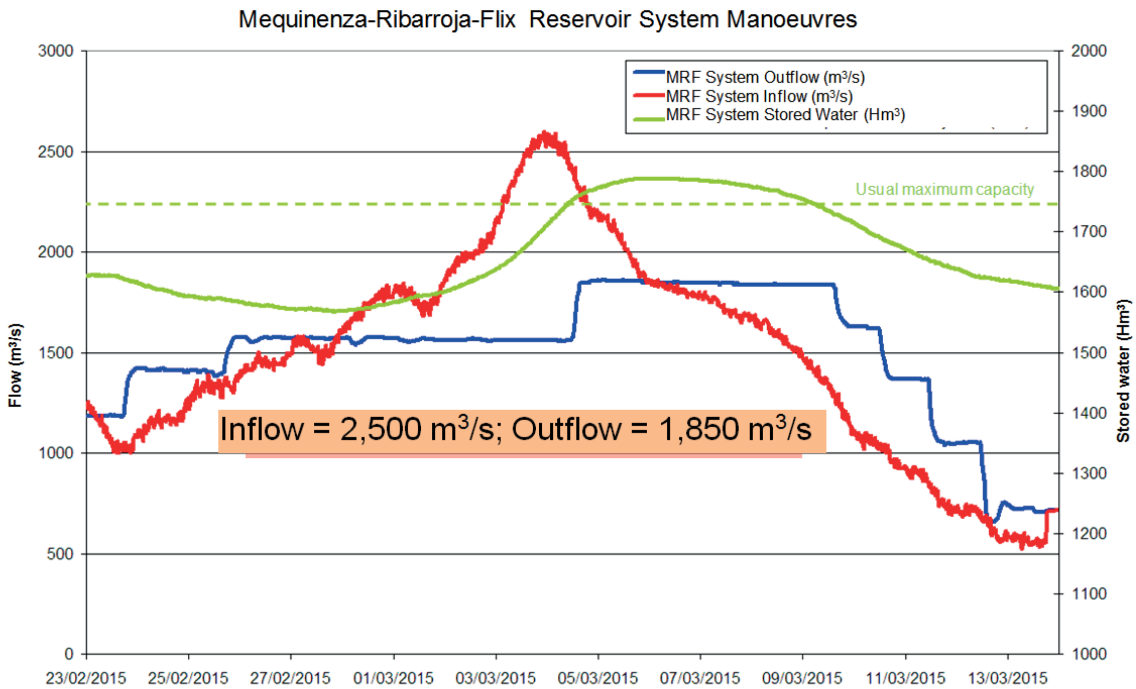


Figure 14. Mequinenza manoeuvres march 2015.

Another example, also on the same dates, could be the management of the Ullíbarri and Urrúnaga Reservoirs on the Zadorra River, with respect to the flows through Vitoria-Gasteiz:

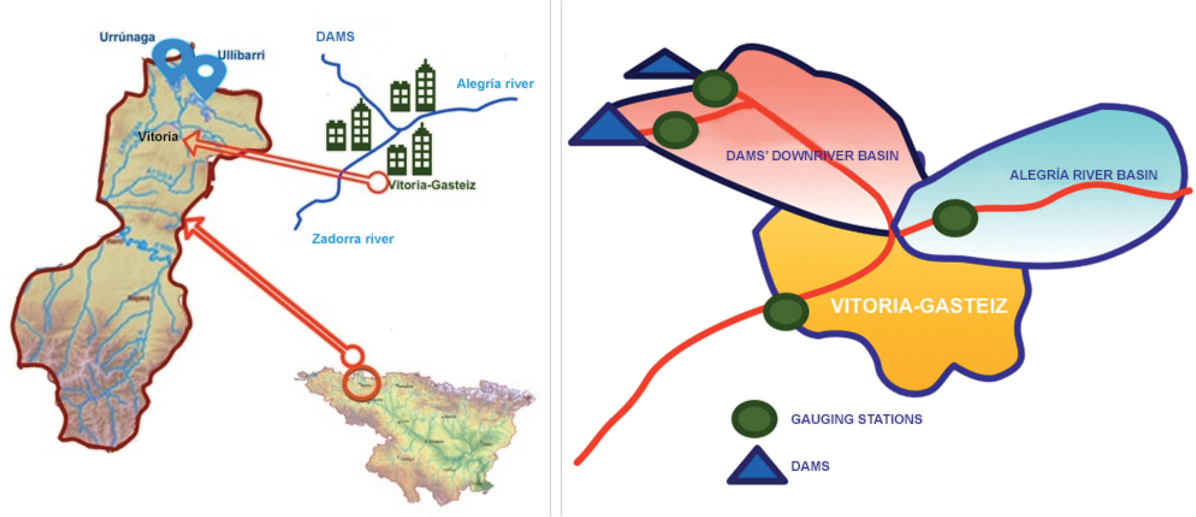


Figure 15. Location of Vitoria-Gasteiz with respect to the reservoirs and hydrometric stations.

Here, the data to be taken into account when managing a flood event are:

Flows in excess of 130 m³/s should be prevented from moving through the Zadorra station in Vitoria-Abetxuko, taking into account the fact that the volume flowing through this station is the sum of the outflow from the reservoir plus the flow from the catchment area between the reservoir and the hydrometric station and, above all, the flows from the Alegría River basin.

In addition, the volume should be kept below the normal maximum level of the Ullíbarri Reservoir and the flow discharged by the reservoir must not exceed 70 m³/s, to prevent damage in the area between the reservoir and Vitoria-Gasteiz.

The following graph shows how the Ullíbarri Reservoir was managed from 26 February to 4 March 2016.

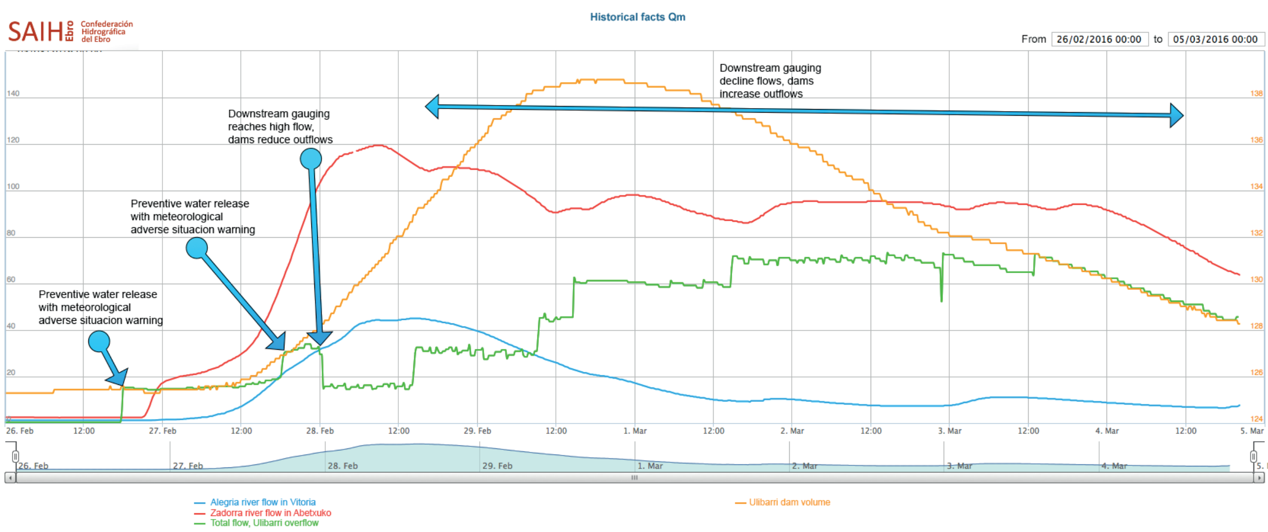


Figure 16. Management of Ullíbarri february 2015.

The Ullíbarri Reservoir had experienced inflows of 130 m³/s and, at that time, was releasing 30 m³/s, and when the maximum flow of 119 m³/s was moving through Vitoria-Abetxuko, there was an outflow of 15 m³/s from the reservoir.

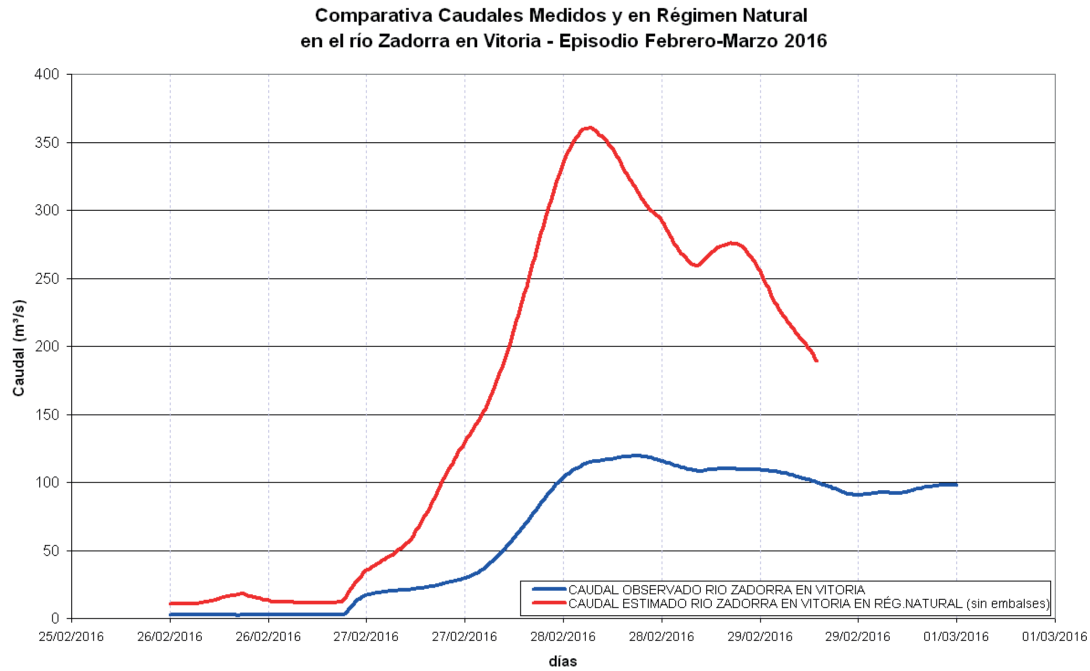


Figure 17. Comparing the flows in Zadorra river: without dams and with dam management.

If we assume that the volumes flowing through Vitoria-Gasteiz are affected by the management of the two Zadorra system reservoirs (Ullíbarri and Urrúnaga), the abatement achieved by both leaves us with the following hydrograph (18) comparing the flow that passed **through the Abetxuko station (maximum 119 m³/s) with the flow which would have passed under natural conditions without reservoirs (maximum 360 m³/s) in this last episode.**

The information in real time provided by the hydrometric stations and the rainfall data by the SAIH network located upstream and downstream have made it possible in the last few years to dispel the myth that the manoeuvres of the reservoirs are responsible for flooding the cities and towns downstream, since it has been verified that the **inflows generated by unregulated basins are sufficient for causing floods prior to the time when the reservoirs begin to discharge water**. As an example, in Vitoria-Gasteiz, the Alegría River basin and the basin of the Zadorra downstream from the reservoirs tend to contribute sufficient flow for causing floods on their own. A similar situation occurs with Pamplona-Iruña and the Ulzama River plus the Arga River basin between the Eugui reservoir and the city.

The **reservoirs** not only **do not add but rather reduce**, if they are managed with information from forecasts and data on the flows occurring upstream, enabling them to adjust the preventive releases in order to increase drawdowns before the regulated rivers grow and limit the flows released when these increase in volume, achieving the abatement effect which is one of the purposes of reservoirs.

A Standing Committee has been set up at the CHE for making all of the decisions on outflows and the warnings to be given to the civil defence bodies. The Committee is made up by the CHE President, Technical Director and Head of Operations, whose functions are described in Royal Decree 927/1988, of 29 July, approving the Public Administration of Water and Hydrological Planning Regulation. Article 49 determines how the Standing Committee, which must come together automatically in cases of floods or other exceptional circumstances, is to function. The Committee may take the measures it deems appropriate, without prejudice to reporting subsequently to other bodies and to the regulations existing in the context of civil defence. This Committee is also the body responsible for informing and providing consultancy to the competent authorities in terms of civil defence in flood emergencies.

It is important to note that organisations such as the National Meteorology Agency (AEMET) or the River Basin Authorities are responsible for **NOTIFYING** events assessed as unfavourable in aspects such as the weather or hydrology, while the civil defence bodies (local, regional or national) are those which activate the relevant **WARNINGS** and take the measures they consider appropriate in the face of a flood risk, pursuant to the Basic Civil Defence Planning Guidelines, approved by the Council of Ministers on 9 December 1994, establishing the framework for the development of special civil defence plans for flood risks.

4. The future of flood management (2016-)

With the experience gained in the last sixteen years and looking in the direction where the advances in meteorology products are heading, the new developments in hydrological models and, particularly hydraulic models, together with the evolution of new communication technologies, enable us to predict that the management of floods will increasingly succeed in reducing the damages they cause, however, **THIS DOES NOT MEAN THAT THEY ARE GOING TO GO AWAY and, for this reason, it is essential to know how to live with them**.

Meteorology, at the present time, is already working with probabilistic meteorological models, and there is a need for decision-making assistance systems to also work with them, to be able to offer a product that reflects the degree of uncertainty, not only with respect to the quantity of rainfall but also in terms of the final situation of where the rainfall has occurred. **It is also important to make citizens understand what is meant by an event with a 90% likelihood of occurrence, so that they will be aware that the decisions they make will have to take into account the fact that there is a 10% chance that the expected event will not take place**.

In events of convective rainfall, the response times are very short, and the network of rain gauges does not suffice. Progress needs to be made in relating the reflectivity information(10) provided by the weather radars with their correspondence in rainfall, in a way that will enable us to make combinations of real rainfall and radar-inferred rainfall.

The hydraulic models of wave propagation downstream used at the present time are 1D hydraulic models(11) with high flows that do not represent the flow of the water well but, on the contrary, do have an advantage in terms of the calculation time they need. Up to now, the 2D hydraulic models required calculation times of almost one day for the entire Ebro River basin (the 1D model takes less than half an hour); at the present time there are already developments in place which can make simulations almost in real time, taking around one hour. An example of this are the studies being carried out at the University of Zaragoza by the Computational Hydraulics Group(12).

(10) The meteorological radars provide echoes (reflectivity) of the drops of water in the clouds that are of a size sufficient for turning into rain. By correlating the reflectivity of the radars with the rainfall actually recorded, these estimates of precipitation can be improved.

(11) - 1D hydraulic models: models adequate for calculating the flow and the depth in regular cross-section channels and without overflow of the principal channel. These simplify the problem with the hypothesis that the flow only occurs in the longitudinal direction of the channel.
- 2D hydraulic models: models adequate for calculating the flow and the depth in natural cross-section channels and with overflow of the principal channel. These show the flow occurring in any direction, both within the channel, as well as on the flood plain.

(12) http://ghc.unizar.es/

The new technologies will help to meet the targets set in the recently approved FLOOD RISK MANAGEMENT PLANS (PGRI). One of the key elements of the plans is **COORDINATION**, for which the **INTEROPERABILITY of the information** handled by the various players in a flood episode is essential. Another is **SELF-PROTECTION**, for which it is essential for those likely to be affected to have access to the forecasts of the volumes flowing in the rivers and what risks are associated with them.

With the new technologies we will be able to build "web portals" where we can put together all of the information and also develop "app"-type applications, which will enable the notifications or warnings to reach users in simple and clear terms.

In the case of the Ebro River basin, software has been developed that will enable us to learn what level of risk (high, medium or low) is affecting a land parcel or town by consulting the Ebro Flood Risk Management Plan website(13).

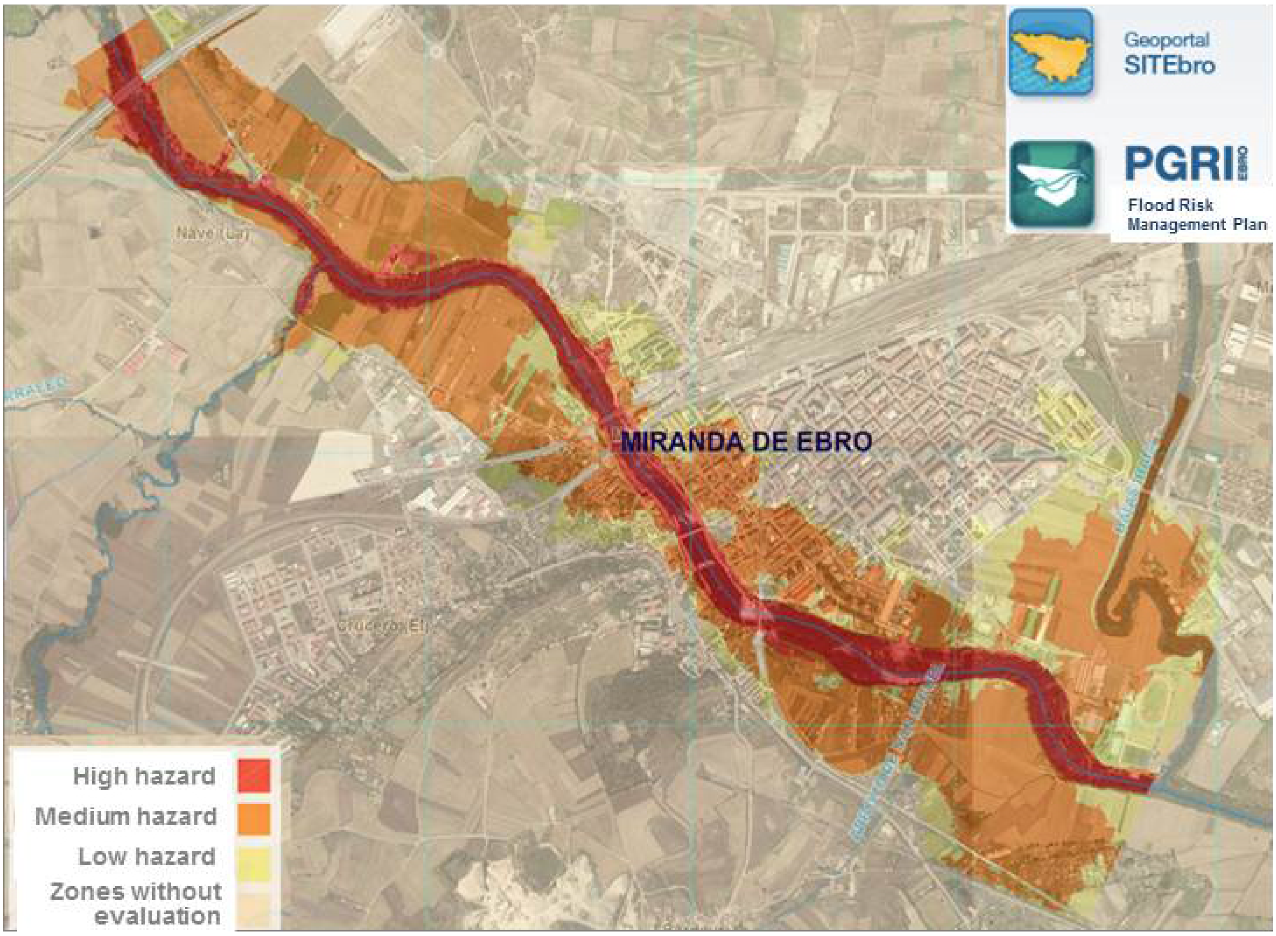


Figure 18. Result of the "LEARN YOUR RISK" query for the city of Miranda de Ebro (Burgos)

We can mention a few examples of how this is getting underway with ground-breaking projects that apply one or more aspects from among those indicated previously. A specific case is an initiative of the Town Council of Pamplona with an SMS(14) warning system for the risk of flooding by the Arga River. The Town Council of Pamplona-Iruña cooperates in this initiative with the Ebro River Basin Authority, which supplies the Town Council with the information on the expected flows observed upstream from the town. This can be considered as a self-protection tool because the Town Council has assessed what it needs to do for each level of risk associated with a real or predicted flow.

(13) http://www.chebro.es/PGRI/

(14) http://www.pamplona.es/VerPagina.asp?IdPag=192920VA&Idioma=1

Conclusions

LET US CONTINUE TO FOCUS ON THE NEW TECHNOLOGIES IN FLOOD MANAGEMENT

- What looked like “madness” in 1984 has become a necessary tool for the management of the water resources at the Ebro River Basin Authority.
- It is essential for the maintenance of these early warning tools for the management of hydrological events to be seen as an investment and not as an expense by all levels of society affected by the damage caused by floods, by promoting investment for furthering the continuous improvement which will take us to the point where each new event will cause less damage than the previous event, even though we will never be able to arrive at “zero” damage.
- We should take advantage of the new communication technologies in order to reach as soon as possible the potential aggrieved parties to attempt to reduce the exposure of elements that can be moved.
- We should put COORDINATION tools into place among the various organisations involved (AEMET, River Basin Authorities, Civil Defence, hydropower companies, etc.) for achieving the reduction of the flows and consequently of the damage caused.

RISING OF THE AWARENESS OF THE AGENTS INVOLVED IN A FLOOD

- We need to learn to COEXIST WITH THE RIVER, to be aware of the risk involved in activities carried out in areas close to the channel and to define SELF-PROTECTION plans which will enable us to minimise the damage caused by floods.
- We should further LAND PLANNING as one of the tools delivering the greatest benefits in the reduction of damage.
- We should introduce in our messages to society the positive aspects of these management tools and publish not only the damage caused but also how much damage has been prevented.
- LET US PROMOTE the use of insurance against floods, including crop insurance, in those areas and activities with a high risk of flooding.

Links of interest

The governance of water in Spain
http://www.magrama.gob.es/es/agua/temas/sistema-espaniol-gestion-agua/0_Catalogo_gobernanza_del_agua_tcm7-361391.pdf

News reports on historic floods
http://www.zaragoza.es/contenidos/medioambiente/materialesdidacticos/otros/catalogo-ebro.pdf
http://foro.tiempo.com/67-de-noviembre-de-1982-un-temporal-olvidado-t83554.0.html

Information on the SAIH programme
http://www.magrama.gob.es/es/agua/temas/evaluacion-de-los-recursos-hidricos/SAIH_WEB_MMA_V301109_tcm7-28827.pdf

Information on tools of the future
https://www.youtube.com/watch?v=UkRd9puQRvU
http://www.tesicnor.com/wp-content/uploads/2016/05/DavidGonzalez-TESICNOR.pdf
http://www.kisters.es/agua/software/calamar-gestion-de-datos-de-radares.html