Prevention, protection, preparation and repair: measures to reduce flood risk along the axis of the Ebro

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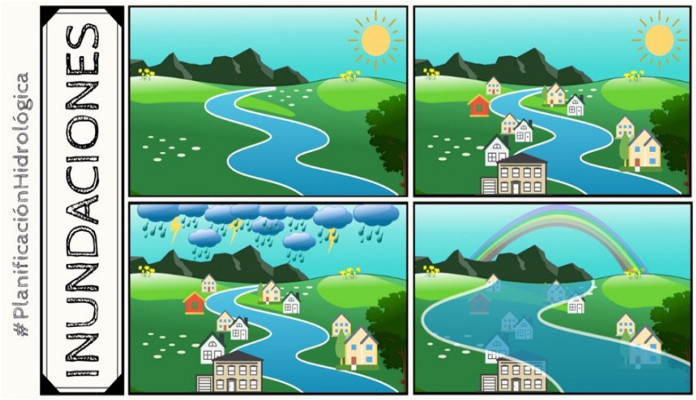
Society as a whole (victims, the authorities, associations, etc.) shares the same goal as regards floods: Keeping down the loss and harm to property and, above all, to people. On the middle stretch of the Ebro, the recurrence of the flooding phenomenon and the economic and social impact of water level rises set the river basin authority to work in its quest for innovative action to curb the adverse effect of flooding a long time ago.

There are two pillars here: The first one is coordination. This entails joint work that has prompted definition of the Ebro Resilience Strategy and has brought together the Ministry for the Ecological Transition and the Demographic Challenge, the Ebro Basin Authority and the regional governments of La Rioja, Navarre and Aragon, while including the direct participation of local institutions in the search for a consensus among affected, associations and academia.

The second one is the pursuit of new approaches to what is a complex problem and an inevitable natural phenomenon. This calls for combined efforts to diminish its negative effects. There is no single or definitive solution and everything done in the past has led towards seeking a necessary change of model to achieve different results.



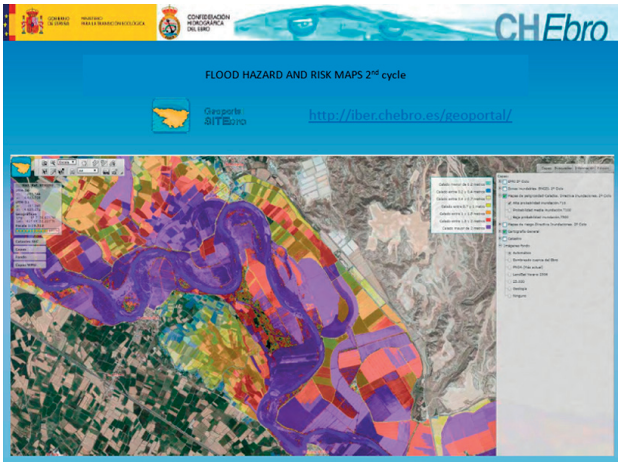
On the other hand, Ebro Resilience means implementing the Flood Risk Management Plan (FRMP) for the Ebro Area (PGRIEbro for the Spanish) on the middle section of the river, and consequently also the lines marked out by the European Union via its Floods Directive, where the PGRIEbro represents the third and final phase of its implementation.

The previous phases of implementation of Directive 2007/60 initially consist of performing the preliminary flood risk assessment (the PFRA) for each hydrographic basin and pinpointing the *Areas with a Potentially Significant Risk of Flooding (APSRF)*, and then secondly, acquiring knowledge of the extent of floods under various different probability scenarios by producing Flood Hazard and Risk Maps.

For its part, the FRMP for the Ebro Area (PGRIEbro), the third phase of the Directive, is intended to raise awareness of flood risk and promote self-protection among the population and both social and economic actors; make territorial planning adequate; improve predictive capacity; strengthen coordination among public administrations; reduce the vulnerability of exposed elements; lessen the hazardousness of flooding, and upgrade the condition of water bodies.

We are currently at the second phase of the second cycle (each cycle comprises the three phases referred to, which are reviewed every six years) of flood risk planning in which the new hazard and risk mapping has been submitted to public consultation. We shall soon move on to the third phase of the second cycle, which entails a review of the FRMP from the first cycle.

Within the Ebro river basin some 1,721 km of rivers have been defined as APSFRs, which were identified in the PFRA as those stretches of river where the flood risk is greatest, i.e. where the loss from flooding may be highest. The entire mid-section of the Ebro is an APSFR.



Hazard and risk maps have been made for over 4,000 km of rivers and they examine three separate return periods or possible scenarios: high, medium or low flood frequencies. These are respectively associated with a statistical likelihood of occurrence every 10, 100 or 500 years. These maps will be fed into the National

Flood Zone Mapping System (SNCZI for the Spanish) and are accessible for all government bodies and individuals using our "SITEbro" map viewer, representing a publicly available tool for decision-making.

In this second cycle, the Ebro Basin Authority has decided to give greater prominence to the data from the gauging stations, given that this provides a better knowledge and a data series that is six years longer than in the initial cycle, where it had already been indirectly taken into account, since the CAUMAX application was used to find the flows studied (CAUMAX being the map of maximum flow volumes in Spain which was charted by "CEDEX", the Centre for Studies and Experimentation of Public Works, in 2011 when they were calculated using a natural system and measured using gauging stations).

Calculating the flow volumes along the line of the Ebro using kinematic studies (based on gauging station data) and a regulated system is particularly important. The flows which the CAUMAX application provides always relate to the natural system for rivers, meaning that, in those cases where the watershed is regulated to a significant degree, flows have been taken from the data series logged by gauging stations to reflect how the contributing basin actually functions. At any rate, the values which CAUMAX provides for each river section always serve as a reference, especially in those cases where no alternative hydrological calculation procedure is used.

According to the scheduling in the Directive, the new FRMP for the Ebro Area is due to have been approved by December 2021 and within it the programme of measures will have been reviewed that also applies over the middle stretch of the Ebro. These are offered grouped into seven different topic areas that encompass:

1. **River and hydrological / forestry restoration,** which we will go on to examine and is covered in the types of intervention that are carried out along the mid-section of the Ebro.

2. The **draining of linear infrastructure,** with examples that we will also cite as illustration.

3. **Flood forecast.** This is a commitment to improving our ability to forecast, which in the Ebro basin is represented by the Decision Assistance System, the SADEbro. This allows improved management of flooding with optimised intervention of the basin's regulation infrastructure.

4. The **civil protection measures** used to safeguard people and property before, during and after a flood, which are fleshed out in the municipal, district, regional and national civil protection plans to guard against flood risk.

5. **Territorial planning and urban development.** This part addresses the need to make the uses to which the land is put in flood zones compatible with flooding as a phenomenon. The answer to this is should be found in the regulatory framework and planning by government bodies.

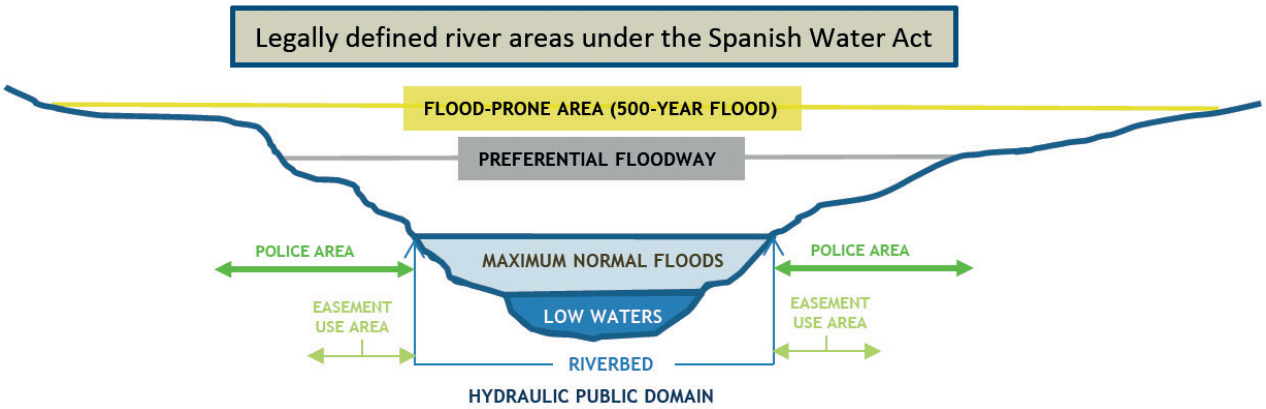
6. **Promoting insurance,** to curtail economic vulnerability to flooding and intended to involve private individuals, as well as those who own property and engage in business activities that are exposed to floods. Here, the Consorcio de Compensación de Seguros has an extremely important role to play in the recovery process.

7. **Structural measures.** Associated with a cost/benefit analysis and which represent the civil engineering solution wherever people and property have to be protected and which, in combination with improved forecasting in preparation for flood events, serves to offset their adverse effects.

This configuration of measures reflects arrangements based on shared responsibility among all the social stakeholders, government bodies (from the European Union down to local level), various different entities, associations, universities and individuals, etc.

The regulatory framework and self-protection

We have mentioned that territorial planning is one of the sets of measures that is included in the Flood Risk Management Plan. The latest amendment to the Hydraulic Public Domain Regulations of December 2016 identified the uses and activities that are vulnerable to flood risk.



The more specific nature of current regulations allows determination of adequate and proportional measures for uses in Preferential Floodway Areas (within the flood zone and associated with surges having a 100-year return period), which are allocated to reducing exposure and vulnerability to flood risk, as well as the avoidance of further set-ups of vulnerable activities in the Preferential Floodway Area.

Land-use limitations applicable at National level

Land Use	Preferential floodway			Flood-prone area	
	Rural land	Urbanized land	Special regime for municipalities with high likelihood of flood	Rural land	Urbanized land
School or health centres, retirement homes, disability care homes, sports centres, penitentiary facilities, fire stations, Civil Protection facilities	No	No	Only if there is no alternative location and if it is designed with security conditions	To be avoided, unless there is no alternative location and if it is designed with security conditions	Can be permitted if security conditions are considered to the possible extent
Large commercial areas where crowds of people could gather	No	No	No		
Buildings, repair works, rehabilitation or change of use, underground garages, basements and surface car parks, and other underground constructions	No	Yes, with security conditions	Yes, with security conditions	Yes, with security conditions	Yes, if security conditions are considered to the possible extent
Facilities where products likely to be hazardous to human health and the environment are handled such as gas stations, industrial treatment plants, waste stores or electrical facilities for high and medium tension	No	No	No	Yes, with security conditions	Can be permitted if security conditions are considered to the possible extent
Campsites, accommodations areas and buildings associated with campsites	No	These activities do not usually occur in urbanized land. If they happen to exist, at least the corresponding security conditions must be guaranteed	Yes, with security conditions and outside the police area	To be avoided, unless there is no alternative location and if it is designed with security conditions	
Urban waste water treatment plants	Only if there is no alternative location or if systems are compatible with floods		Only if there is no alternative location or if systems are compatible with floods		
Greenhouses, non-permeable enclosures and fences, material or waste storage	No		No	Yes	Yes
Changes in land morphology that could alter the capacity of discharge	No		Yes	Yes	Yes
Livestock breeding farms	No		Yes, with security conditions and outside the police area	Yes	Yes
Linear infrastructures in parallel to the riverbed	Only if there is no feasible alternative to these infrastructures and if the latter have been designed minimising risk		Only if there is no feasible alternative to these infrastructures and if the latter have been designed minimising risk	Yes	Yes
Sanitation and water supply infrastructures and other underground pipes; works for maintenance, enhance and protection of existing infrastructures	Yes	Yes	Yes	Yes	Yes
Buildings for agricultural use with a maximum of 40 m² and works associated with water uses allowed by Spanish Water Act	Yes, with security conditions	Yes, with security conditions	Yes, with security conditions	Yes	Yes

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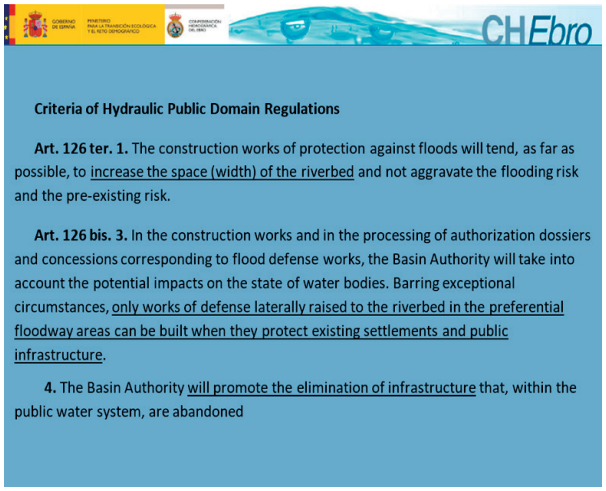
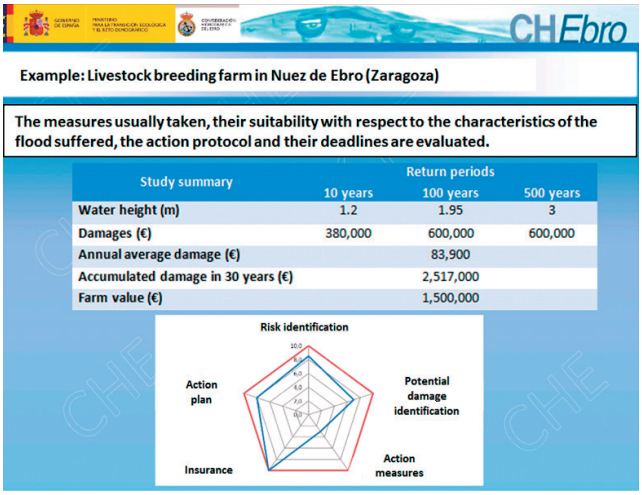
The latest amendment of the Hydraulic Public Domain Regulations (RDPH for the Spanish "Reglamento del Dominio Público Hidráulico") of December 2016 proposes that, to the extent that it is possible, the tendency should be to "widen the breadth of the channel and not aggravate floodability and the pre-existing risk". It also suggests only building defensive construction work raised above the sides of the watercourse in the Preferential Floodway Area "when these protect existing population centres and public infrastructure".

Yet, these measures are not merely directed at laying down how we should approach our relationship with the flood zone from now onwards, as efforts have also been made to mould life as it already is to flood risk by taking protective or adaptive action to reduce the vulnerability of pre-existing elements, or else by removing them if we cannot manage to do this.

In this respect, the Ministry for the Ecological Transition and the Demographic Challenge has published a series of guides including some on reducing the vulnerability of buildings to flood risk, adapting farming and livestock concerns to the risk, recommendations about refitting buildings in flood zones and one on good practices in action to preserve, maintain and improve watercourses.

Following these criteria and within the scope of the Ebro Resilience Strategy, the Ebro Basin Authority (CHE for the Spanish) is conducting a pioneering campaign in Spain featuring a hundred specific studies of adaptation work on farms and/or livestock concerns at no cost to those wishing to benefit from it. The studies are being carried out among volunteer owners and they conclude with a presentation of alternative solutions plus a cost/benefit analysis for each of them.





On top of this, there are plans for ordinary management of the CHE which also boost resilience to flooding.

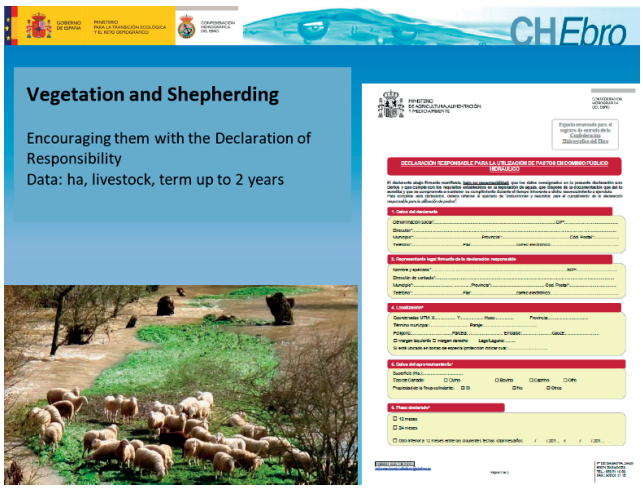
Within the context of the Ebro Area's Hydrological Plan, in 2016 a standard **Declaration of Responsibility was defined for processing minor activities to preserve the Hydraulic Public Domain (HPD).**

The declaration means speeding up and cutting down on processing for interventions of little consequence which third parties apply for who have to have authorisation from the basin authority when the actions satisfy two preconditions:

1. They are outside protected areas (subject to specific environmental rules).
2. They do not affect other parties.

To be precise, the **following are held to be minor maintenance activities:**

- Removing dead trees and pruning those that hamper access to the watercourse or its right of way, provided that these do not involve any loss of the bank's arboreal substrate.
- Removing dead trees and pruning those that diminish the watercourse's drainage capacity.
- Removing items carried along by the current and which block the watercourse, especially crossings or work that represents an element that degrades or pollutes the Hydraulic Public Domain.
- Maintenance on gauging sections in official networks of gauging stations.



The CHE has recently passed another measure that is intended to foment a commitment to flood-resistant crops in the Ebro basin.

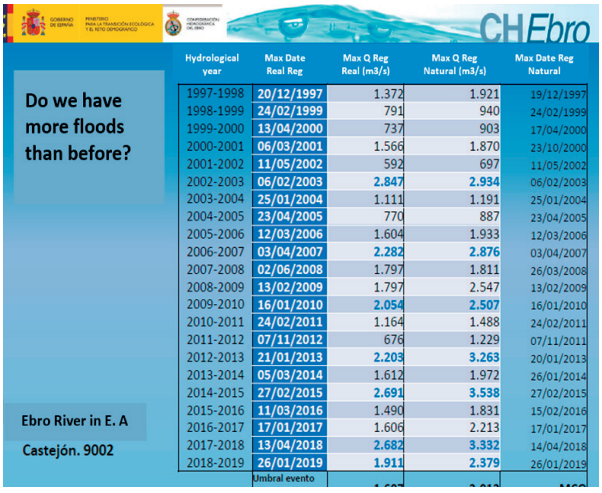
This has been brought in by regularisation of the charges on occupying public land with farming. This has changed from an across-the-board levy to one which takes into account two factors: the zoning according to the flood period and the rateable value of the adjacent property adapted to the Ebro basin.

There is moreover a discount on the charge for agricultural crops where there is HPD occupation and the intention is to replace them with forest crops that are compatible with flood risk. The charging of fees for occupation and farming activity is established in Heading VI of the recast text of the Waters Act and implemented in the Hydraulic Public Domain Regulations which set out the formal procedures for concession and authorisation in using the HPD.

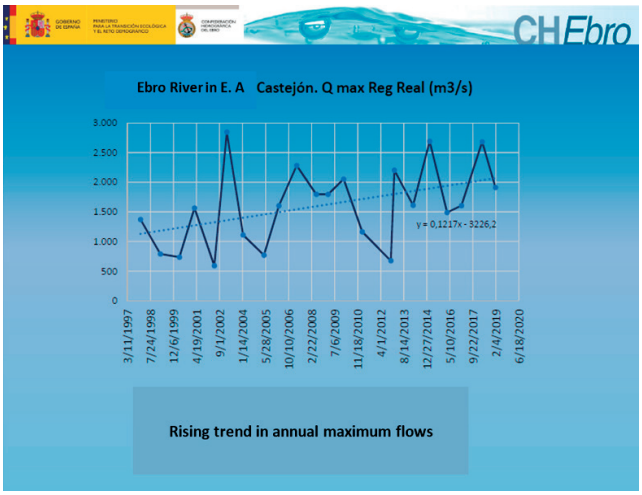
A better understanding of the mid-section of the Ebro

Increasing our knowledge is one of the keys to managing the future and one of our lines of work. Technology tools allow us to obtain data that provides an increasingly accurate reflection of the real situation and therefore to take decisions about taking on measures in the most affected areas.

The kinematic data logged speaks to us of a rising trend in annual maximum flows and a higher recurrence of extreme phenomena over recent years (comparison is made between the actual system of flows, lamination on account of reservoir management and the natural system, which means the maximum flows that might have occurred without dams):



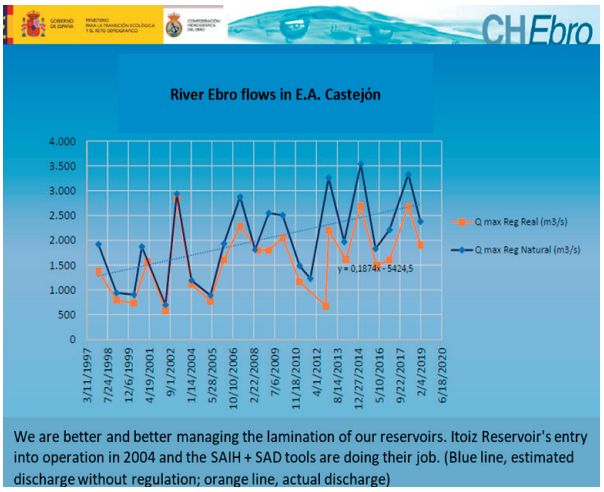
Hydrological year	Max Date Real Reg	Max Q Reg Real (m3/s)	Max Q Reg Natural (m3/s)	Max Date Reg Natural
1997-1998	20/12/1997	1.372	1.921	19/12/1997
1998-1999	24/02/1999	791	940	24/02/1999
1999-2000	13/04/2000	737	903	17/04/2000
2000-2001	06/03/2001	1.566	1.870	23/10/2000
2001-2002	11/05/2002	592	697	11/05/2002
2002-2003	06/02/2003	2.847	2.934	06/02/2003
2003-2004	25/01/2004	1.111	1.191	25/01/2004
2004-2005	23/04/2005	770	887	23/04/2005
2005-2006	12/03/2006	1.604	1.933	12/03/2006
2006-2007	03/04/2007	2.282	2.876	03/04/2007
2007-2008	02/06/2008	1.797	1.811	26/03/2008
2008-2009	13/02/2009	1.797	2.547	13/02/2009
2009-2010	16/01/2010	2.054	2.507	16/01/2010
2010-2011	24/02/2011	1.164	1.488	24/02/2011
2011-2012	07/11/2012	676	1.229	07/11/2011
2012-2013	21/01/2013	2.203	3.263	20/01/2013
2013-2014	05/03/2014	1.612	1.972	26/01/2014
2014-2015	27/02/2015	2.691	3.538	27/02/2015
2015-2016	11/03/2016	1.490	1.831	15/02/2016
2016-2017	17/01/2017	1.606	2.213	17/01/2017
2017-2018	13/04/2018	2.682	3.332	14/04/2018
2018-2019	26/01/2019	1.911	2.379	26/01/2019
	Umbral evento			



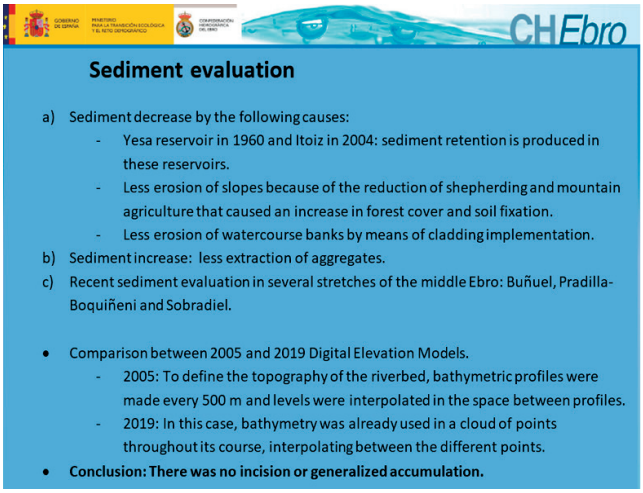
The development of forecasting tools has enabled optimisation of regulation infrastructure management in flood events, which could lead us to the false notion that the full weight of damage limitation should fall on such management, which is not possible: firstly because there are not dams on all water courses, and secondly because, as has been shown, they cannot avoid just any event, especially in high return periods (major river floods).

Knowledge is also helping us to debunk another of the myths about the actual situation regarding the Ebro waterway and which was leading us astray in efforts to hit on the necessary definition of the right measures. This concerns the widespread belief that there has been a build-up of sediment, which translates into the public calling for a "clean-up". This would in actual fact imply wholesale dredging activity as the core solution.

In 2019, new bathymetry of the watercourse was conducted along the middle stretch of the Ebro (the previous exercise having been in 2005), which allows us to conclude that no incision nor generalised accumulation has occurred with respect to the riverbed.



We are better and better managing the lamination of our reservoirs. Itoiz Reservoir's entry into operation in 2004 and the SAIH + SAD tools are doing their job. (Blue line, estimated discharge without regulation; orange line, actual discharge)



Types of action to improve safety in flooding

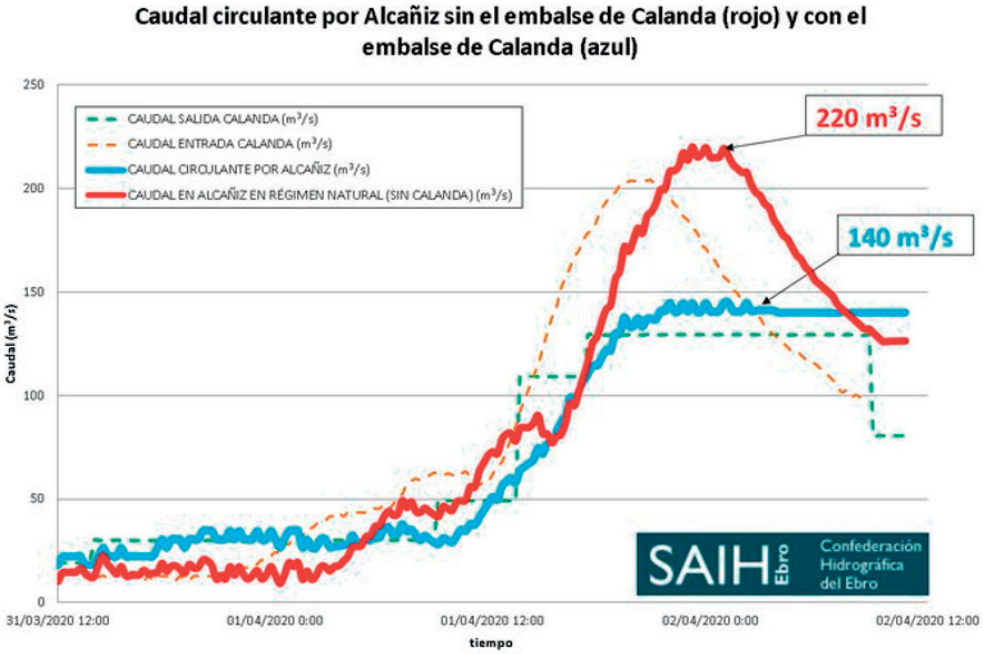
It is calculated that, over 2003-2018, the investment made in water-channel action and emergencies in the Ebro basin amounted to more than 151.5 million euros, which works out at an annual average of 9.5 million. The turnaround in interventions and the lines marked out by planning are intended to ensure that what is invested now reduces the fallout and damage, and therefore the economic impact of each bout of flooding.

All the issues which we have thus far discussed are now being implemented in the Ebro basin, particularly along its mid-section. Being able to draw on an increasingly sound knowledge thanks to the studies referred to, having experienced several extraordinary events within only a short space of time, together with both the administrative and technical involvement of this organisation, have allowed us to advocate actions that satisfy the criteria set out for curbing flood risk at EU level, first in the form of pilot proposed solutions and then generally.

In executing the emergency action following the extraordinary flood events in 2015, and particularly in 2018, the Ebro Basin Authority began to implement a programme of measures aimed at, not only recovery, but also building up resilience via action that also kept to the lines in the EU Floods Directive and consequently the Flood Risk Management Plan. These interventions are chiefly intended to protect population centres.

We have grouped these actions into **five categories** and they have both proved effective and show us the path to follow which, as we have already outlined, involves establishing varied blends of measures. All of this is within a regulatory framework that is increasingly illuminating as regards action on the watercourse and while bringing in interventions away from the waterway that enhance self-protection.

We now move on to examination of these categories. In addition to direct interventions, we have one sort known as **Type T0,** which also falls within the direct remit of this organisation and consists of **managing regulation infrastructure** and reservoirs thanks to the development of forecasting systems such as our Decision Assistance System (SADEbro) and our telematic control networks, the internationally recognised Automatic Hydrological Information System (SAIHEbro), which, where possible, allow moving flows to be reduced and surge points on certain tributaries not to run into each other.



Beneficial and reducing effect (lamination) for the municipality of Alcañiz from managing the Calanda reservoir (Teruel) during a flood event in April 2020. The blue line is the actual circulating flow whereas the red one is the hypothetical one, should not have the flood being laminated by the Calanda reservoir.

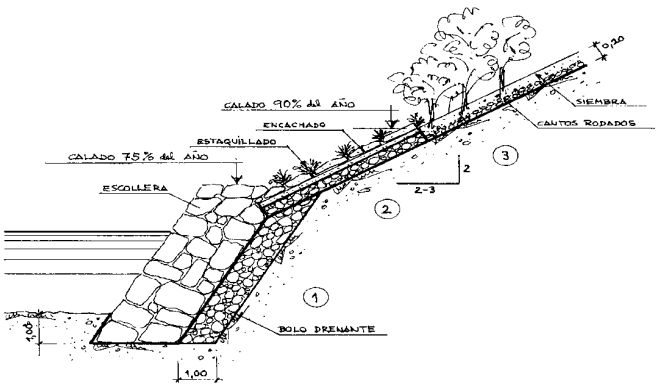
Type T1: improving structural defences

Action aimed at repairing "motas" (longitudinal earthen dykes) that channel the mid-section of the course of the Ebro, especially the dykes or walls that protect urban population centres, using reinforcement and structural solutions that improve their shielding ability.

The various different flood events subject these structures to progressive wearing over time. Furthermore, during extraordinary events featuring major river surges faults and breakage are caused which have to be repaired. In such cases, the repairs use selected materials which, together with careful management of how they are performed, achieve the goal of improving the structure to face future events of a similar nature, thus providing a sounder defence (more waterproof and resistant) which heightens safety. Both for earthworks and concrete structures, repairs of raised defences can be extended to their foundations in certain cases. With slopes, if necessary they are reinforced at the base and replanting is carried out up to the top.

- **Construction of new infrastructure**
  In 2nd line> of 7 km
- **Modification of existing infrastructure: repair, levelling or reinforcement**
  >150 km in 2015
  >110 km in 2018

Repair and refurbishment of a dyke in Osera de Ebro (Zaragoza).



Section type. Characteristic depths.

Type T2: improving the draining capacity of the watercourse

This involves efforts to restore the hydraulic part of the drainage system.

In some cases action is taken within the channelled area between dykes as a result of an over-accumulation in certain zones of sediment (this is removed or redistributed) or vegetation (this is cut back and removed).

Here, "curage" techniques are used and intervention takes place on large isles, eyots and thickets, by opening up offshoots among the vegetation and then carving out their beds to encourage the sediment to be shifted by normal flows.

Using "curage" to make large masses of sediment densely populated with vegetation (isles and eyots) passable is yielding visibly good results in the Ebro basin. The offshoots have to be plotted out by taking advantage of old water distributaries that have ceased to be of hydraulic use over time and restoring their connection to the main watercourse. Similarly the width of these newly opened-up offshoots should be properly scaled so as to achieve a speed of water throughput that makes sedimentation unlikely and works in favour of self-maintenance of their useful section. Efforts begin by opening up pathways through the vegetation then comes the dredging (deep furrowing) of the bed of the offshoot, which enables the breaking up of the crust and deep stirring of sediment, which requires less energy for ordinary rises in the water-level to move.

Work has currently taken place in several areas which together cover over 80 hectares. These remain ongoing.

In several other cases, more space is given to the river (i.e. width) by removing, setting back or lowering dykes. Setting dykes back restores space for the water channel on stretches where gaining breadth has proved very positive in encouraging expansion of the river and offsetting the erosional effects of the current as the flow running through it loses speed.

T2-1 Vegetation treatments and removal of obstructive elements
> 10 ha

T2-2. Lowering/setting back/ removing of dykes
Actions in more than 14 km:

- Setting back >11,000 m
- Lowering >2,000 m
- Removing >1,600 m

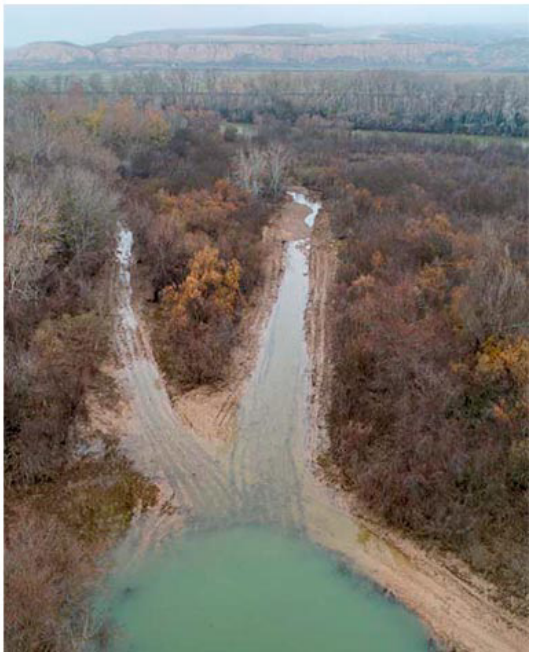
A. Setting back a dyke in Alfaro (LR) 710 m. River Ebro.
B. Dyke removal at Cabañas de Ebro (Z).
C. Novillas (Zaragoza). Work on vegetation and obstructive elements. River Ebro.

T2-3. Permeabilization of large masses of vegetated sediments by opening up offshoots of free circulation applying the "CURAGE" technique
27 Actions carried out:

- Alfaro
- San Adrián (2)
- Calahorra (2)
- Buñuel
- Viana
- Novillas (3)
- Boquiñeni
- Alagón (2)
- Torres de Berrellén
- Sobradiel (3)
- Utebo (2)
- Monzalbarba
- Alfocea (2)
- Alcala de Ebro
- Villafranca de Ebro (2)
- Pina de Ebro (2)

>19 ha in Natura Network
> 64 ha out of Natura Network

"Curage" in Utebo (Zaragoza). Above: plan. Bottom: during flooding of the Ebro.



River Ebro, “Mejana del Tormo” in Alagón (Zaragoza).

Curage in Alfaro (La Rioja) after the action of a flood on the River Ebro.

Type T3: permeabilization involving infrastructure. Relief channels

Permeabilization means taking action to improve the passability of flows (by increasing the drainage section) as they move under infrastructure crossing the watercourse (bridges). Action is also taken with respect to infrastructure away from the channelled watercourse (embankments of roads, railways or other civil engineering work) that holds in water and creates large dammed areas when the waterway has overflowed onto the floodplain.

Permeabilization can be permanent or temporary (integrable frames). The former kind is performed on bridges within the watercourse. The second sort is normally used away from it and allows a certain degree of control over the bursting of riverbanks.

Relief channels are new distributaries additional to the main course and dug out with a bottom level higher than the latter. They allow the river to divert a substantial part of the flows in circulation along them when there are high water levels (i.e. in floods). Sometimes they are dug in the area between dykes and at others alongside.

Besides bringing down the surface level in the section next to the main watercourse, which improves its safety in any overflow (vital in stretches besides population centres), this benefits how defensive structures perform by sapping the energy striking against them and consequently works in favour of a lower risk of structural breakage, both from erosion of the materials of which they are built and from hydraulic thrust.

T3-1. Infrastructure permeabilization
4 Permeabilizations:

- Novillas
- Frías
- Pradilla de Ebro
- Pina de Ebro

Pradilla de Ebro, increasing the permeability of the bridge over the river Ebro.

Frames on the river Ebro next to the CV-04 bridge in Novillas (Zaragoza) and integrable frames on the A-1107 road. Pina de Ebro (Zaragoza).

T3-2. Construction of relief channels

6 Relief channels:

- Alfaro
- Novillas
- Alcalá de Ebro
- Cabañas de Ebro
- Pina de Ebro
- Tauste

River Ebro relief channel at Alcalá de Ebro (Zaragoza).

Type T4: Overflow safety cordon

These are actions to defend population centres in situations where the river (upstream or downstream) flows outside the channelled course as a result of either breaking or flowing over the defensive structure (dyke).

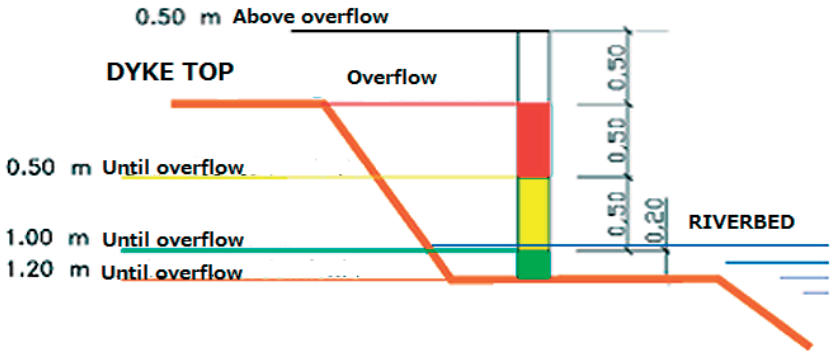
Existing infrastructure is used (paths, roads, walls...) which is levelled or built up to construct a cordon that surrounds the town or city centre to either delay or avoid it being flooded by water that has burst its banks. Sealing elements have to be applied to structures along the perimeter (livestock crossings, irrigation ditches...) that prevent or hinder water from coming into the urban centre.

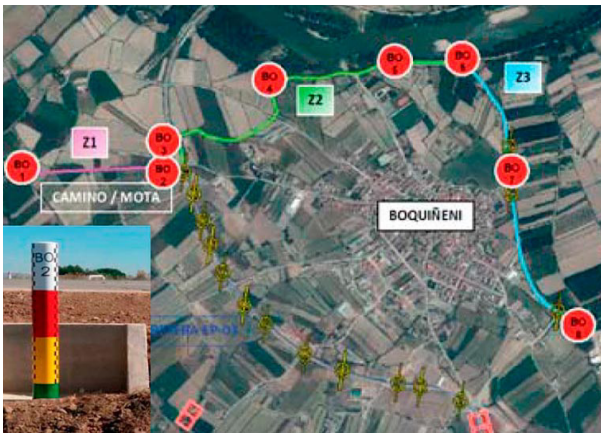
Boundary posts are also installed along the cordon, which are intended to enable monitoring of the progress of water-levels in situ and at any given time to find Height/time correlations to assist in decision-making, such as in the event of any evacuation.

To date, these have been formed at 12 urban centres along the Ebro and they continue to be made.

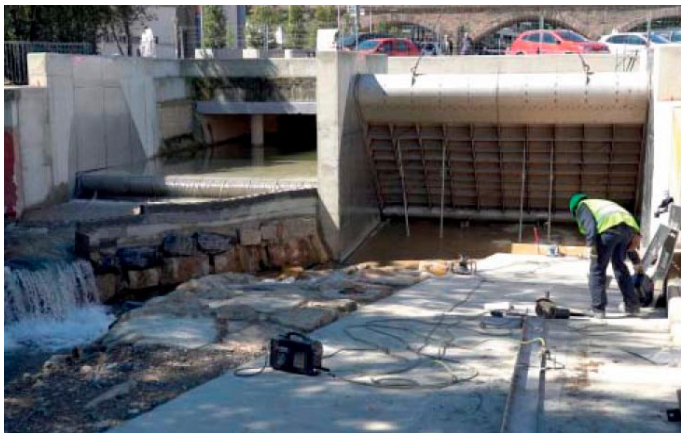
12 Urban centers:

- Novillas
- Sobradiel
- Alcalá de Ebro
- Alfocea (Z)
- Pradilla de Ebro
- Boquiñeni
- Cabañas de Ebro
- Pina de Ebro
- Torres de Berrellen
- Remolinos
- Monzalbarba (Z)
- Quinto





Lay-out of the safety cordon at Boquiñeni (Z). River Ebro.



Setting up caissons at the confluence of the rivers Queiles and Ebro. Tudela (NA).

Type T5: Temporary flood areas

These are mainly farming areas away from the zone between dykes and adjacent to the watercourse, which enable part of the flow along the channel to be diverted and temporarily stored safely and without significant damage in the

event of a river surge. They can be controlled (using a floodgate) which allows action to be taken by opening or closing it, or free (without a floodgate). All of those currently being created are free.

By drawing away significant volumes of water from the river and diverting them laterally, the presence of a temporary flood-prone area does not just bring benefits along the stretch of river located downstream (as one might think at first). The fields that become flooded within the area also reap benefits in several respects.

Thus, if a dyke bursts or there is overflowing (even from upstream along the bank), the impact on the fields and their infrastructure turns out to be greatly diminished or even non-existent, as the dammed water acts with a cushioning effect. The damage to the dyke itself is reduced, since the drop is reduced from it having been overrun. There is also a reduction in the differential between the hydrostatic pressures on the inner and outer slopes of the dyke. Finally the emptying out of the area occurs in a far shorter time as it is equipped with additional relief devices that allow the pent up water back into the waterway at the time when the river level falls below that of the flooded area.

At the moment, the 11 areas constructed (all in Aragon) allow temporary diversion and storage of over 11 hm3, taking up slightly more than 80 ha. It should be pointed out that a higher number of areas benefit proportionally, given that we would be letting the river use "extra" areas at precisely the time when this is most needed and not before; in other words in flood events when the corridor between dykes is often not enough to cope.

11 Areas with> 11 hm³ of storage:

- Novillas
- Pradilla
- Pina de Ebro (2)
- Alagón
- Boquiñeni
- Remolinos
- Torres de Berrellén
- Sobradiel
- Utebo
- Alfocea

A. Controlled flood-prone area in Novillas (Z). River Ebro.
B. Free temporary flood-prone area at Mejana de la Cruz in Alagón (Z). River Ebro.

Ebro Resilience

This experience of several different types of action has helped us define and draw up the Ebro Resilience strategy. The scope: a total of 324 km of waterway over the mid-section of the Ebro and lower stretches of tributaries from the mouth of the river Iregua in Logroño (La Rioja) to La Zaida (Zaragoza), which represents a catchment area that takes in 1,033,000 inhabitants.

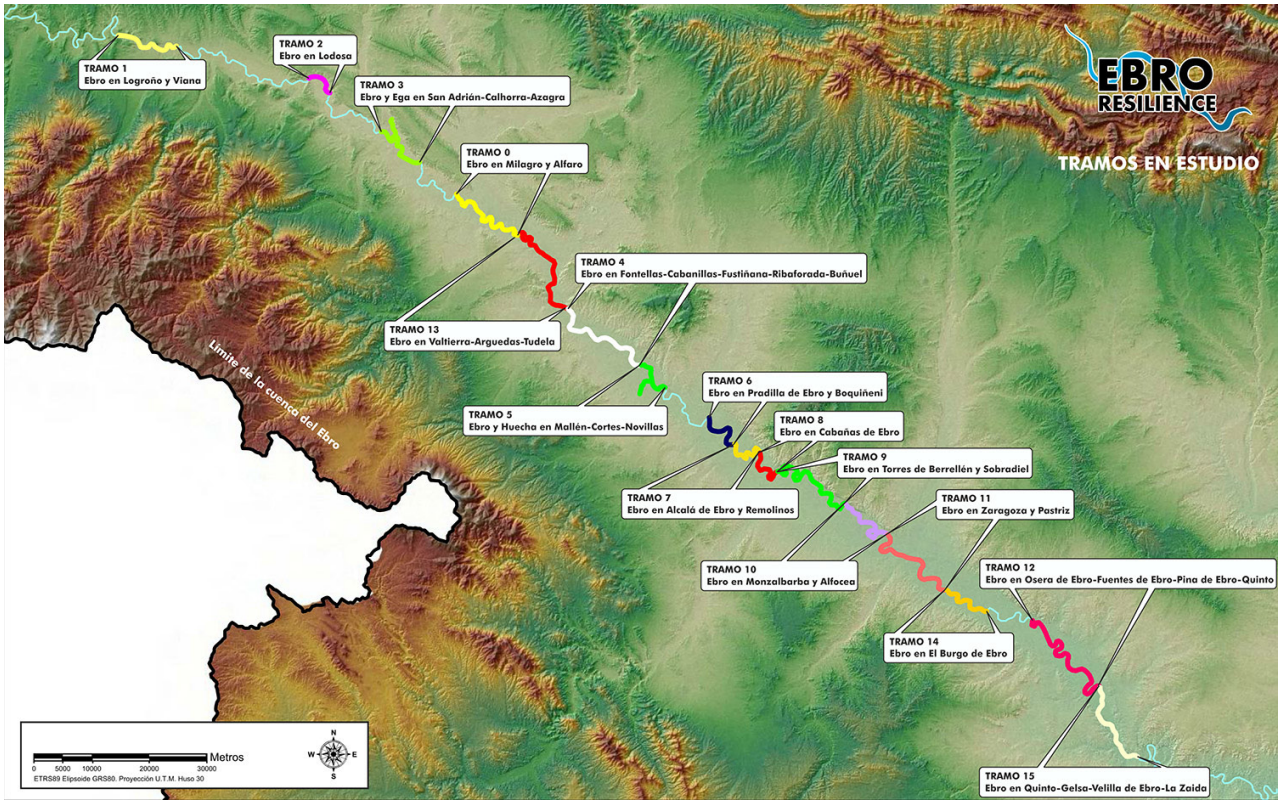
The strategy is a partnership mechanism for implementing flood risk management measures along the mid-section of the Ebro. It is the fruit of coordination among government bodies: The Ministry for the Ecological Transition and the Demographic Challenge, the Ebro Basin Authority and the regions of La Rioja, Navarre and Aragon, while also striving for collaboration with local councils and consensus with stakeholders in the territory.

Ebro Resilience divides its proposed river model into two separate zones: urban and non-urban environments.

The design for urban zones is to protect localities against river surges with a 25-year return period and for non-urban zones it is to ensure the draining away of the maximum normal water level rise and a reduction of effects for river surges for a return period of up to 10 years.

Within the Ebro Resilience Strategy detailed studies are being made of the flood risk on the 15 stretches with the biggest detected problems in surge events. The studies will define the actions to be taken to meet the objectives outlined in the previous paragraph. The sections being studied are:

1. The river Ebro in Logroño and Viana.
2. The river Ebro in Lodosa.
3. The rivers Ebro and Ega in San Adrián, Calahorra and Azagra.
4. The river Ebro from Alfaro to Tudela.
5. The river Ebro from Fontellas to Buñuel.
6. The rivers Ebro and Huecha in Mallén, Cortes and Novillas.
7. The river Ebro in Pradilla de Ebro and Boquiñeni.
8. The river Ebro in Alcalá de Ebro and Remolinos.
9. The river Ebro in Cabañas de Ebro.
10. The river Ebro in Torres de Berrellén and Sobradiel.
11. The river Ebro from Utebo to Zaragoza.
12. The river Ebro from Zaragoza to Pastriz.
13. The river Ebro in El Burgo de Ebro.
14. The river Ebro between Osera de Ebro and Quinto.
15. The river Ebro between Quinto and La Zaida.



And no less important is the informative, participative and inclusive campaign being carried out among those affected, social partners, users and, naturally, government bodies. Thus the actions to be analysed in the studies will incorporate suggestions provided during the participative sessions in the three regions concerned.

Together with these studies over the mid-section of the Ebro, the Ebro Basin Authority is currently undertaking two interventions to serve as benchmarks for river restoration that are intended to reduce the impact of flooding: the hydrological connection and the recovery of habitats on meanders in the lower section of the Arga in Funes, Navarre, and the morphological adaptation and environmental recuperation of the river Ebro at the Paraje de La Nava in Alfaro, La Rioja.

Hydrological connection on the lower section of the Arga in Funes (Navarre)

The project in Funes has become a pilot intervention for what the Ebro Resilience Strategy will mean on the mid-section of the Ebro. The starting point is to achieve coordination between all the administrations concerned to reduce the effects of flooding, though doing so via interventions that seek to restore the natural environment in the area where possible by reviving habitats.

> Restoring the natural environment at the confluence of the rivers Arga and Aragón is included within the Environmental Advancement Plan for Adaptation to Climate Change in Spain (PIMA-Adapta) and the FRMP for the Ebro basin (PGRIEbro).

The tasks included in the engineering work are aimed at moderating flood risk in the town of Funes. To this end, action is being taken to recover the river Arga flood plains, improve the drainage at the confluence of the rivers Arga and Aragón, enhance the quality of waters and restore riparian habitats characteristic of the zone's natural protected areas.

The funding for the project is being met by the Directorate General for Water at the Ministry for the Ecological Transition and the Demographic Challenge, while the Navarre regional government is covering compensation for loss of profits on poplar tree cultivation and the Funes council has made communal land available for the work.

Intervention on the River Ebro at the Paraje de La Nava (La Rioja).

The tasks of morphological adaptation and environmental restoration on the river Ebro as it passes through the Paraje de La Nava in Alfaro (La Rioja) are the first large-scale project in implementing the Ebro Resilience Strategy on the mid-section.

The intervention began in December 2019. The work mainly consists of removing 1,806 metres of the existing defences which runs parallel to the watercourse to be rebuilt in a position where it has been set back at a distance of between 100 and 300 metres along some 1,376 metres.

These tasks will be undertaken during the summer of 2020 in the low-water period. With the setting back of the defensive system some 30 hectares of irrigated plain will be reclaimed, where river restoration will take place featuring the planting of indigenous fertile plain species (7,000 assorted poplars, 1,600 ash trees and 1,800 bushes and shrubs such as willow, tamarisk, dogwood, hawthorn, blackberry and rose-bushes). There are also plans to create a zone of habitats suitable for the European mink by building a mosaic of wetland environments in the reclaimed plain area with over 1,300 aquatic plants.

MORPHOLOGICAL ADAPTATION AND ENVIRONMENTAL RESTORATION OF THE EBRO RIVER AT THE "PARAJE DE LA NAVA" IN ALFARO (LA RIOJA). SITUATION AFTER CONSTRUCTION WORKS.

Conclusion

The upkeep of public waterways is the competency of the Water Commissioners of the Basin Authorities (R.D. 984/1989 of 28 July) and it is important to appreciate what this means. Public waterways are the land covered by waters at the maximum level of normal rise, which, on the Ebro's mid-section, is that which takes place every two or three years. It is therefore the duty of the basin authorities to protect the banks and adjacent plains and to ensure that the watercourse is able to evacuate a normal river flood, but not those classed as extraordinary, which, by definition, run along the river banks(i.e. across the flood-prone zone, its flood plain).

This is reasonable, given that ordinary flooding runs along the hydraulic public domain but extraordinary floods affect privately-owned land located in the bordering areas or policed zones where the basin authorities do not have full competency.

The role of preserving waterways that is commended to basin authorities has a restriction on it that is set out in Law 10/2001 of the National Hydrological Plan (article 28.4), which stipulates that actions involving public waterways located in urban settings shall be the responsibility of the competent authorities regarding territorial planning and urban development (regions and, mainly, councils).

Nonetheless, the mid-section of the Ebro presents a high risk of flooding, with extraordinary floods that cause substantial damage and endanger the lives of the inhabitants on the plain, the frequency of floods having increased in recent decades.

From the flood in 2003 onwards, the Ebro Basin Authority began to implement original measures aimed at achieving integrated flood management. On one hand, actions started to be undertaken that were designed to reclaim river space. On the other hand, also beginning in that year, the Decision Assistance System started in operation, which incorporates a set of hydro-meteorological forecasting models and enables improved management of reservoir control in flooding situations. In addition to this, the reservoir at Itoiz (Navarre) was commissioned in 2004, which has considerable capacity for laminating flooding on the mid-section of the Ebro.

The coming into effect of the 2007 Floods Directive represented a change of model, when the basin organisation drafted the first **Ebro Flood Risk Management Plan (December 2015),** which is the framework instrument that covers a whole range of measures for the government bodies to implement which have competency for several issues, such as urban development, territorial planning, the natural environment, forest management, insurance, hydrology, hydraulics, etc.

In 2010, **Royal Decree 903 on assessing and managing flood risks** was published, which transposes the earlier directive and establishes that the Ministry for the Ecological Transition and the Demographic Challenge, the Ministry of the Interior, the regional and local governments shall, within the scope of their respective competencies, draw up the programmes of measures and perform the actions to manage flood risk. This means that managing the risk of flooding (extraordinary river floods) is the responsibility of all the arms of government involved.

Extraordinary river floods are inevitable, but we can make them less frequent, relieve the harm they cause and improve the recovery of people and property that are affected. Experience has taught us that we cannot resolve the problem by clearing and cleaning up rivers.

With these goals in mind the Ebro Resilience Strategy was came into being in 2017, which is framed within the National River Restoration Strategy. A new management model for the river Ebro with the philosophy of reclaiming river space, giving it more room to laminate (to begin to store water at its edges and slacken its flow as it moves forward) and for the water to both slow down and drop in depth, such that this reduces damage.

This strategy embraces both non-structural measures: development-related, adaptation of vulnerable (urban, agricultural and livestock) elements, restoration and safeguarding of ecosystems, and acquiring land; and structural measures: setting back dykes, controlled flood areas, permeabilization of infrastructure, occasional dredging, relief distributaries, "curage", etc.

The scope of this project is a 324 km length of the river Ebro at its middle section, from Logroño to La Zaida, with over a million affected inhabitants on the land neighbouring the river.

It is a strategy which is being implemented by the regional governments of La Rioja, Navarre and Aragon in conjunction with the Ministry for the Ecological Transition and the Demographic Challenge, as well as the Ebro Basin Authority. It is also one which could not be successfully brought to fruition without the determined and vital participation of councils, affected parties, those performing irrigation, environmental groups and universities.