



River. Space. Design.

**Planning Strategies,
Methods and Projects
for Urban Rivers**

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River. Space. Design is a systematically organised reference book for the design and planning of river spaces. Urban river landscapes need to unite a broad range of requirements – most notably flood control, ecological considerations and open space design – often within tight space constraints. Taking a process-oriented approach, this book offers concrete guidelines for sustainable long-term interventions.

Arranged in two volumes, this book contains a comparative analysis of more than 50 successful projects alongside rivers and streams in Europe, and dissects them into their individual design elements. The result is a catalogue of effective design strategies and tools that provides readers with an attractive and inspiring overview of the broad and varied spectrum of design possibilities for river spaces.

Each project is illustrated with photographs taken especially for the book and each principle is illustrated with explanatory diagrams. The book's interdisciplinary structure is of interest to landscape architects, architects, engineers, urban planners and hydrologists alike.

Adding bed load ↗ Agriculture ↗ Art objects and furniture ↗ Attachable protection elements
↗ Backwaters ↗ Balconies ↗ Bank reinforcement as needed ↗ Bioengineered groynes ↗ Boulders
and stepping stones ↗ Branches ↗ Broad riverbank steps ↗ Building over the existing reinforcement
↗ Buildings on piles ↗ Cableways ↗ Camping and caravan sites ↗ Closable access ↗ Creating
meanders ↗ Creating multiple channels ↗ Creating scour holes ↗ Dead wood ↗ Dike parks ↗ Dike
steps and promenades ↗ Dikes as path networks ↗ Electronic warning systems ↗ Escape routes
↗ Events grounds ↗ Extending the flow length ↗ Extensive natural areas ↗ Fish passes ↗ Floating
and amphibious houses ↗ Floating islands ↗ Floating jetties ↗ Flood channels ↗ Flood-tolerant
buildings ↗ Fold-out protection elements ↗ Foreshores ↗ Glass walls ↗ High water marks
↗ Incorporating a straightened channel ↗ Influencing perceptions of the wall height ↗ Integrating flood
protection walls ↗ Intermediate levels ↗ Introducing disruptive elements ↗ Invisible stabilisation
↗ Laid stone groynes ↗ Large single rocks ↗ Living revetment ↗ Marinas ↗ Masonry riverbank
revetment ↗ Moored ships ↗ Mound principle with buildings ↗ Mounds ↗ New embankment walls
↗ Overhangs ↗ Parks within the flood plain ↗ Partially naturalising the riverbank ↗ Paths within the
flood plain ↗ Piled stone groynes ↗ Polder systems ↗ Portable protection elements ↗ Ramps and
slides ↗ Regulating water extraction ↗ Removing riverbank and riverbed reinforcement ↗ Reprofilling
the channel cross-section ↗ Reprofilling the dike section ↗ Reprofilling the flood plain ↗ Retaining
sightlines ↗ Retention basins ↗ River access parallel to the bank ↗ River access perpendicular to the
bank ↗ Riverbed sills ↗ Sand and gravel beaches in bays ↗ Sand and gravel beaches on inner bends
↗ Selective bank reinforcement ↗ Semi-natural riparian management ↗ Setting back the dike
↗ 'Sleeping' riverbank reinforcement ↗ Sports facilities and playgrounds ↗ Stone revetment
↗ Submerged groynes ↗ Submergible boardwalks ↗ Submergible furniture ↗ Submergible planting
↗ Submergible riverside paths ↗ Superdikes ↗ Surmounting the embankment wall ↗ Suspended
pathways ↗ Terraced stone revetment ↗ Terraces ↗ Trees on dikes ↗ Underwater steps ↗ Using the
historical city wall ↗ Varying the riverbed and transverse structures ↗ Warning signs and barriers
↗ Watertight facades ↗ Widening the channel

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Herbert Dreiseitl

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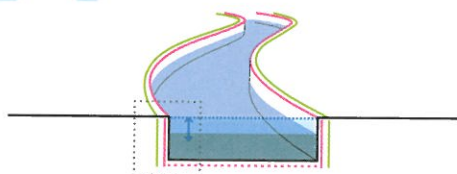
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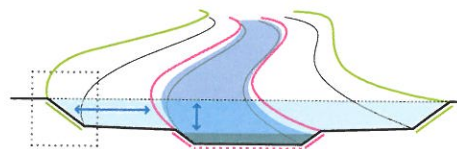
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A Embankment Walls and Promenades



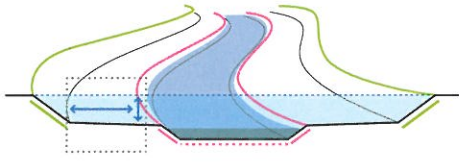
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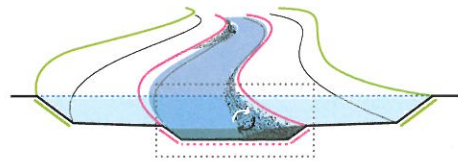
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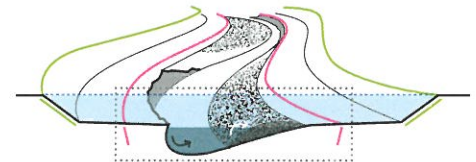
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Flood Areas

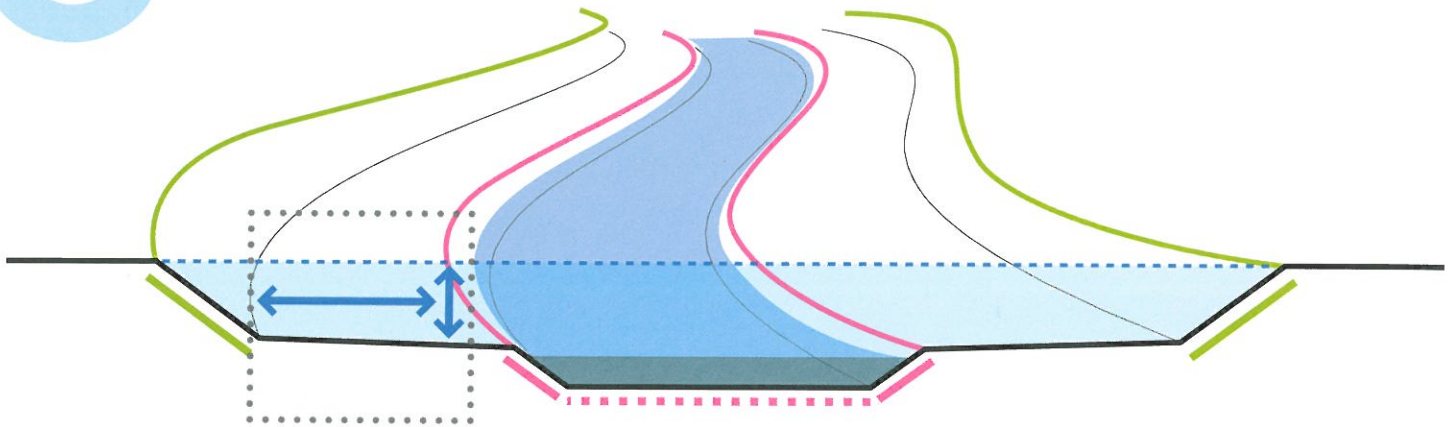


Ebro, Zaragoza

From monofunctional flood plains to submersible landscapes with multiple uses. The area between the flood limit and the river is so designed that, despite naturally occurring periodic flooding, it can be used as open space for recreation while serving as a natural habitat for many riparian species at the same time.

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Flood Areas

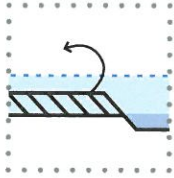


Spatial situation Through the industrial uses, settlement and intensification of agriculture that went with dike construction and artificial land elevation in preceding centuries, many natural flood plains have been lost. Retaining and creating new zones along rivers that can be flooded in the event of high water is today an important contribution to flood protection. These retention areas create space into which the river can expand as the water level rises. Along with flood protection, flood plains in urban spaces mainly serve recreational purposes; for many towns and cities, amenities along watercourses with direct access to the water offer the principal local recreational area. A system of cycleways and footpaths along the flood plain also represents a connection between urban and rural spaces outside the city. Process Space C may also be described as the submersible space between the reinforced, i.e. fixed limits of the river (red line), which also constitutes the limits of the self-dynamic river channel development, and the flood limit (green line): this is the river plain, which is flooded when the water level is high.

Operative processes This Process Space is flooded at irregular intervals. The water level can, according to the river's size, vary by several metres. It is possible to extend the flood area by shifting the flood protection line back into the hinterland. Another possibility is to excavate the flood plain. The extent of this space influences the water level reached during high water events; if the flood area of a river is extended the water level in this stretch of the river sinks. Furthermore, the flood surge is slowed and weakened where the water can spread out; the area serves as a retention space.

Water levels commonly rise following long periods of rain during the winter months and after the snowmelt in spring, but also after heavy sudden rain in summer, and the flood plain can be under water for anything between a few days and several weeks. Away from the main current the flow rate decreases, sediment can settle and, especially in lowland watercourses, lead to slow but continuous raising of the flood plain area. After each flood the higher areas dry out, while in the lower-lying places ponds and marshy areas remain that store water for longer periods. If they have contact with the groundwater they survive as isolated patches of water all year round.

Design approaches The challenge for design is to find the best possible combination of the various functions – water retention, nature and recreation – of these spaces. Setting back the dikes and lowering the dike foreland enlarges the retention space and creates new retention areas for water, but at the same time also affects the ecological



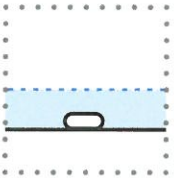
C1 Extending the space

- C1.1 Setting back the dike
- C1.2 Branches
- C1.3 Flood channels
- C1.4 Reprofilng the flood plain
- C1.5 Backwaters
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- C1.7 Retention basins



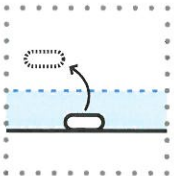
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- C2.1 Mounds
- C2.2 Mound principle with buildings
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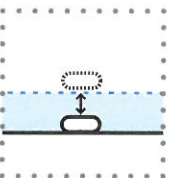
C3 Tolerating

- C3.1 Paths within the flood plain
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- C3.4 Parks within the flood plain
- C3.5 Extensive natural areas
- C3.6 Agriculture
- C3.7 Camping and caravan sites
- C3.8 Events grounds



C4 Evading

- C4.1 Warning signs and barriers
- C4.2 Electronic warning systems



C5 Adapting

- C5.1 Floating and amphibious houses
- C5.2 Marinas

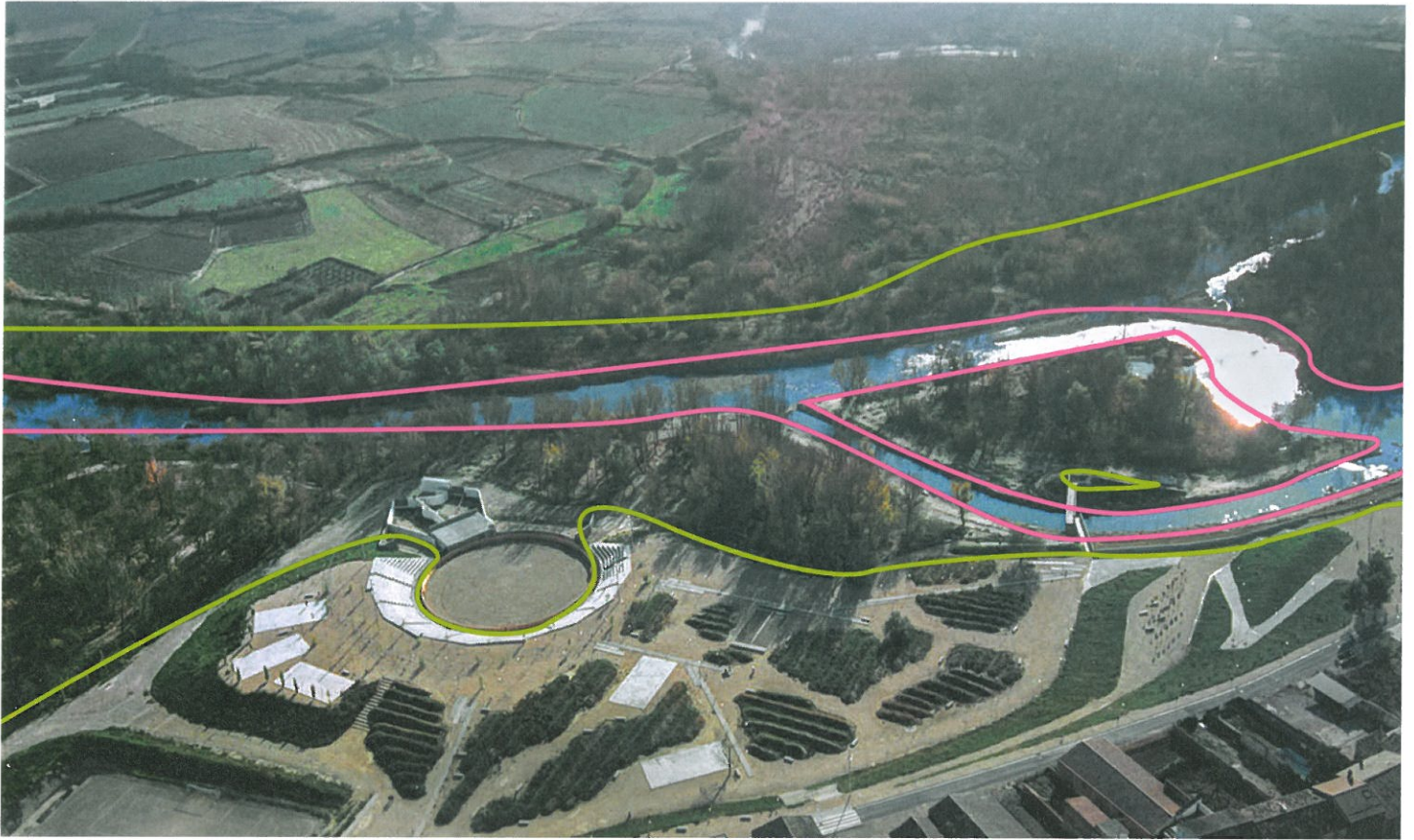
potential and usability of the riverside spaces that are thus created. The basic prerequisite for designing these spaces is adjusting the planned use to the frequency and duration of high water events and the different degree and depth of flooding according to various probabilities (from annual high water events through to a one-in-a-100-year flood, HQ100). Along with this, flood-resistant access which is also to some extent usable during flooding is necessary; alternatively, evacuation via elevated escape routes triggered by various warning and information systems can be devised. Although the river plains offer themselves primarily for recreational uses, more and more flood-tolerant constructions such as raised or floating structures or buildings on mounds are being built in flood plains. This can be understood as the first indications of increasing interest in integrating flood hazard areas in the townscape – and conversely regarding part of the townscape as a flood area. Extensive spaces that carry no water at mean water level but are flooded at high water can be enhanced with flood-adapted uses. The design tools and measures shown illustrate the possibilities of extending, accessing or using the Process Space intelligently and practicably. The interventions and uses adapt to fluctuations of the river in various ways. The design strategy can consist of allowing flooding more space, tolerating temporary flooding, or evading it. Floating elements, for example, can adapt to fluctuations in water level within the flood plain.

For the measures in Process Space C, it is mostly the objectives of flood protection or nature conservation that dominate. Above all, in large-scale projects with an eye on care and maintenance costs, a combination of expanding retention spaces and developing natural flood plain landscapes is most attractive, while in city centres recreational uses dominate.

Amenity The spaciousness and closeness to water of flood plain areas means that attractive open spaces can evolve that are easily accessible and offer a good variety of possible uses. These flood plains offer space for events, sports and leisure facilities, sunbathing meadows, barbecue areas and playgrounds. These uses are temporary as they are restricted to flood-free periods. Rivers that are enhanced as nature conservation areas or extensive cultural landscapes can provide high quality leisure and recreation environments if they are appropriately accessible in densely populated urban spaces. They constitute durable open space structures, as they are on the one hand indispensable for flood protection and on the other hand exclude the possibility, with a few exceptions, of permanent uses such as housing or commerce and industry. For these reasons flood-sensitive areas represent a chance for the long-term securing of recreational space for city dwellers, and their development can signify a positive impetus for urban development. Good zoning to avert conflicts between nature conservation and leisure seekers is important. The linearity of these spaces means that they can be a structurally important part of a city's greenspace system.

Flood protection River flood plains make an important contribution to flood protection. Extending the flood plain can be an economical alternative to raising the height of dikes; as the water level rises the river can spread out over the retention space, thus reducing the flow rate and high water surge, and relieving the burden on downstream areas. There are various possibilities for enhancing this relief effect: measures such as shifting the flood protection line towards the hinterland or expanding the flood plain volume by excavation increases its retention capacity. Polder systems can use the available space more effectively.

The shaping of the flood space influences the hydraulic roughness and thus also the interplay of currents during high water periods. High roughness causes the water to back up, thus raising the water level and delaying discharge. If the flood plain is restricted, for the purposes of flood protection all elements that could further delay discharge need to be removed, and tree planting or development of riparian woodland cannot be permitted. When such areas are redesigned this can lead to conflicts of interest with the aims of nature conservation, urban development or recreational uses. One solution can be to oversize the retention space to compensate for higher roughness.



Ecology Natural river spaces that develop without human restraint are particularly precious because of their rarity and high structural diversity. With the variety of biotope types in variably moist areas these riparian woodlands, marshy areas and water meadows are home to an enormous diversity of flora and fauna. The areas are therefore particularly suitable for nature enhancement, especially because intensive agriculture or construction of new residential or commercial estates in flood plains is possible in only a few exceptional cases. Creation of more flood spaces can also happen on a large scale; the Dutch flood protection programme 'Ruimte voor Rivieren' (Room for the Rivers), for example, pursues the idea of creating an interlinked system of quasi-natural ever-changing landscapes along the major rivers wherever new flood containment areas are needed, complemented by flood-adapted urban development in the towns and cities they pass through. Implementing and marketing riverside building projects at selected sites can also make a contribution to financing more extensive river development measures elsewhere. The areas developed this way have become valuable nature conservation areas and charming urban and recreational landscapes.

In Zuera on the Gallego a new branch of the river was dug to bring the water closer to the town. The flood limit (green line) was also defined in such a way that the new bullring is flooded in high water periods – the water remains in the arena for a few days afterwards and creates a lake.

Project Catalogue



Introduction

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Project Catalogue
Introduction

A

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D

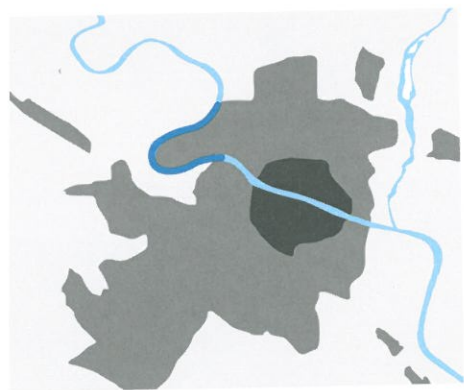
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E

Process Space E: Dynamic River Landscapes

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Ebro

Parque del Agua, 2008
Zaragoza, Spain

River data for project area

Catchment area: 40 400 km²

Mean discharge (MQ): 267 m³/s

One-in-100-year flood discharge (HQ 100): 4300 m³/s

Width of riverbed: 90–120 m; Width of flood plain: 150 m

Location: 41° 40' 07" N – 00° 54' 45" W

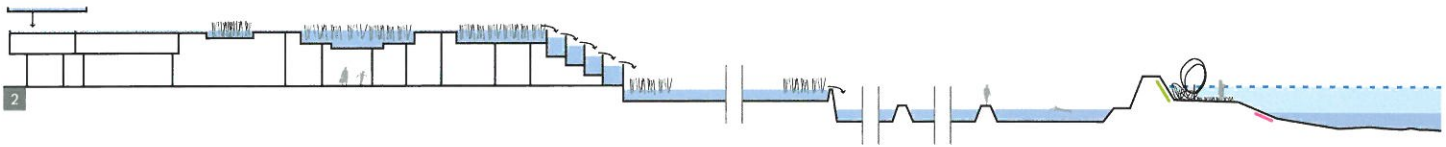
A Water Park for Expo 2008 The responsible use of water resources was the theme of the 2008 Expo in Zaragoza. The Ebro is Spain's largest river in terms of discharge, and flows through an agricultural landscape in northern Spain characterised by irrigation structures. In terms of urban-development goals, the Expo site was intended to enhance links between the area of a large loop in a river some 2 km from the city centre, dominated by agricultural use, and the adjoining fringes of Zaragoza and the city centre. This was mainly achieved by means of several new bridges, including the Bridge Pavilion designed by Zaha Hadid, a structure enclosed in a 'shark-scale skin' pattern which rapidly became the symbol of the Expo.

As the planning area, the Meandro de Ranillas (meaning 'meander of the frogs'), was frequently flooded, it was always largely kept free of development. At the edge of the exhibition grounds themselves, a 'Water Park', 125 ha in size, was created within the loop of the Ebro. A network of channels and several large pools were excavated. The most intensively modified parts of the park are protected from flooding by the surrounding dike – a riverside 'Nature Park' and the riparian vegetation planted there are, however, allowed to flood on a frequent basis. Both portions of the park are devoted to the theme of water and, in both form and conception, demonstrate a different way of using water and rivers which represents an exciting juxtaposition of process and control.

A park as a filter The inner park protected by the dike is a controlled but generally open system. Water from the river is allowed to flow through it on a controlled basis although, if flooding occurs and the water backs up as a result, this system is sealed off to prevent contaminated river water from entering the park. The pools are

Design tools

- B1.4 Dikes as path networks
- C1.5 Backwaters
- C3.1 Paths within the flood plain
- C3.4 Parks within the flood plain
- C3.5 Extensive natural areas



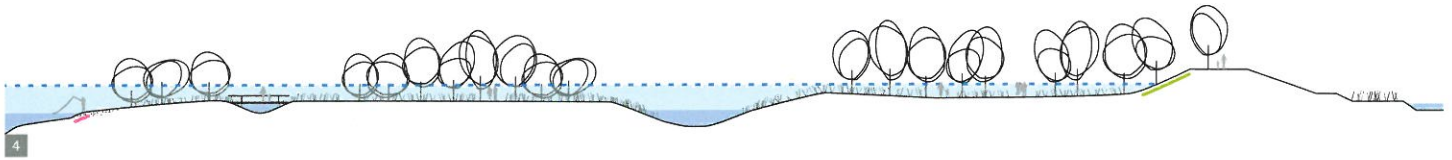
sealed at their bases so that no groundwater can infiltrate. This part of the park acts as a purification system. The water for the park comes from the Ebro, specifically from the Rabal irrigation ditch near the park, and is partly fed by groundwater. This water is channelled through the entire park via an aqueduct that naturally purifies it over several levels, and through large vegetation filters, until it is finally collected in large, sealed pools and then used for boating and even bathing, after which it is returned to the Ebro. This transport and water treatment system forms a kind of backbone for the activities in the park over a distance of 2.5 km, which separates, connects and defines areas of different use.

- 1 The 2008 floods highlighted the dual character of the park: behind the dike, the protected part with canals and pools; in front of the dike, the inundated, tree-covered flood plain [C3.5].
- 2 This schematic section of the park shows the various water pools and the purification system.
- 3 Artificial watercourses and paths run through the inner park at different levels. The plantings here are geometrically laid out.

The original natural flood plain of the Ebro meander is now structurally separated from the river system by the dike, but water treatment takes place in the park via the artificial purification facility, much as occurs with a natural flood plain. The complex system of water ditches, water expanses and paths behind the dike, some of which run on the dams, is derived from the ditches, protective walls and field structures of the previous agricultural use. The geometric plantings, in which different vegetation types on the Ebro are represented – from plant communities in wet sites to extremely dry locations – highlight the artificial nature of the park’s landscape. In the case of smaller (annual, for example) flood events, the dike – which has a wide path on its crest – protects the inner park. The dikes offer the park protection from floods up to a one-in-50-year flood event. At higher water levels, the entire park is flooded, apart from a few important buildings set on elevated foundations.

Riparian woodland with microrelief The natural-looking portion of the park located outside the dike is in constant contact with the river. Here, the dynamic river landscape that is inundated during flooding is emphasized by the design to the point of appearing specifically ‘staged’. As this riverside park is situated on the inside of the river loop, sedimentation processes take place here. The state of the banks reflects the strong, natural dynamic of the river. Gravel beaches developed that were deliberately made accessible to the public by the architects.



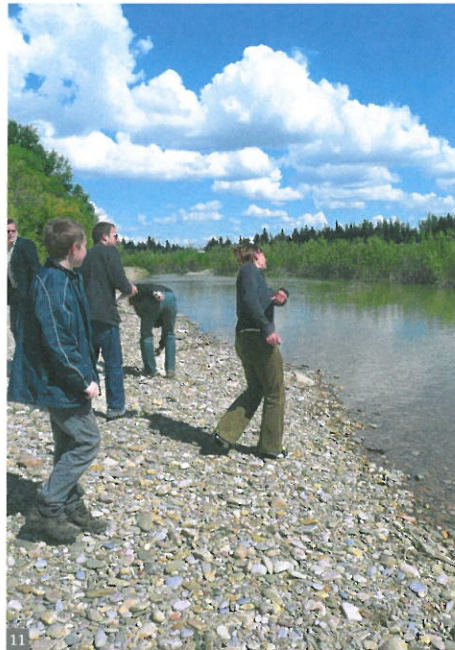


Here, the remnants of the former riparian forest with tamarisk and poplar trees was taken as the base for the site enhancement work. The planners planted willows, poplars and tamarisks on a grid system to create a new riparian woodland. The new stands of trees are clearly distinguishable from the existing ones. In this way, 'nature' as shaped by human hands will, gradually but visibly, show continuous development into a riparian forest influenced by the river. The regeneration of the riverside landscape of the Meandro de Ranillas was also inspired by artificial microtopography. In the past, gravel was extracted from the banks of the Ebro and the gravel pits were later filled with building rubble. This rubble was removed and the hollows planted with wetland vegetation. Today, they play an important ecological role as biotopes and form an eye-catching feature in the riparian landscape. The purified water entering from the park also seeps into these hollows and, in turn, is fed into the Ebro. In this way, an extremely diverse aquatic landscape has developed in front of the dikes, which is – despite its periodic flooding – made accessible via paths, bridges and outdoor furniture. Christophe Girot describes the enhancement as having a 'laissez faire' aesthetic that 'has an natural and alluvial feel, although the scenography of the entire riparian zone is very strongly regulated and remains very much of a piece with the large-scale urban setting of the Expo.' [Girot, 2010, p. 32]

The juxtaposition of the two water systems, the canals and expanses of water which are used for leisure activities and the dynamic water landscape with the riparian woodland, have their own fundamentally different starting points in the agricultural and river landscape of the Ebro. Within the Water Park, the architects combine the different aesthetics of the two zones into a complex and multifaceted arrangement.



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- 4 This schematic section of the Nature Park in front of the dike shows the riparian biotopes in the flood plain and the shallow gravel bank by the river.
- 5 A purification pond with aquatic plants; in the background, the slope up to the aqueduct can be seen.
- 6 Bridges provide access to the flood plain area in front of the dike [C3.4].
- 7 The path on the winding dike separates the two parts of the park [B1.4]. On the banks, a new riparian woodland was planted in a strict grid formation.
- 8 The backwaters in the flood plain [C1.5] were cleared of building rubble and replanted with wetland vegetation.
- 9 In the south there is a large outdoor swimming area with a beach into which the purified water flows.
- 10 The existing poplar woodland was the starting point in planning the Ebro riverbank.
- 11 A natural pebble beach on the riverbank was made accessible and forms part of the park.



Gallego

Parque Fluvial, 2000–2001
Zuera, Spain

River data for project area

Catchment area: 3276 km²

Mean discharge (MQ): ~ 30 m³/s

One-in-100-year flood discharge (HQ 100): ~ 650 m³/s

Width of riverbed: 30 m; Width of flood plain: 300 m

Location: 41° 51' 59" N – 00° 47' 07" E

Design tools

C1.2 Branches

C3.1 Paths within the flood plain

C3.2 Sports facilities and playgrounds

C3.4 Parks within the flood plain

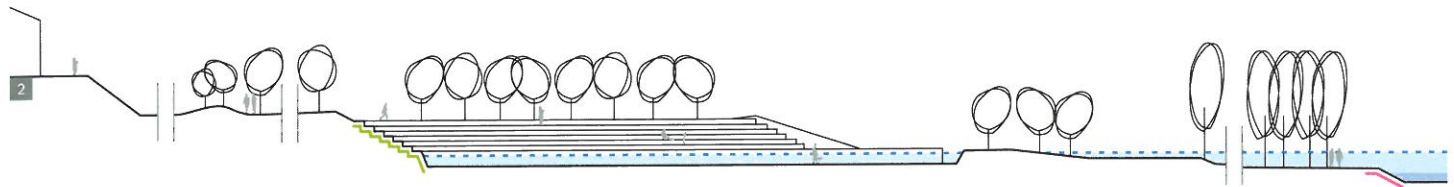
D4.3 Stone revetment

A new riverside front for the town For a long time, Zuera had turned its back on the Gallego River. The space between this watercourse and the old town situated on the embankment some 15 m above river level had, over the years, become a dumping ground for building waste and a hilly landscape of earth banks had accumulated. The area between the town and the river did not exist as an urban space. The planners' main task was, therefore, to reconnect the townscape with the river and to design ways of bridging the large difference in height between the old town and the Gallego such that access to the river was possible once more. Moreover, the southern bank of the river was so badly eroded that it had to be renewed. This was also to include the renaturation of the riverbanks. Furthermore, a canal that had been clogged by debris and rubble was to be cleared. What prompted all this enhancement work, however, was the town's desire to build its own bullfighting arena for an annual festival.

A park on three levels In order to reconnect the town with its river, the planners developed a park consisting of three levels. These three terraces have steps leading down to the river and serve different purposes. The first level is that of the riverbank. Excavation works cause it to be periodically and very frequently flooded. This area now has a very low-level bank that extends far into the river basin and is only a little above the Gallego's mean water level. The flood plain is inundated even when the river is only slightly above normal level. The contours of the park are constantly changing, even where water fluctuations are only minor: first, specially created ditches fill with water, then the trees and shrubs higher up are also inundated. The alternating impact of the water has resulted in an ecologically diverse riverbank.

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Project Catalogue
Flood Areas



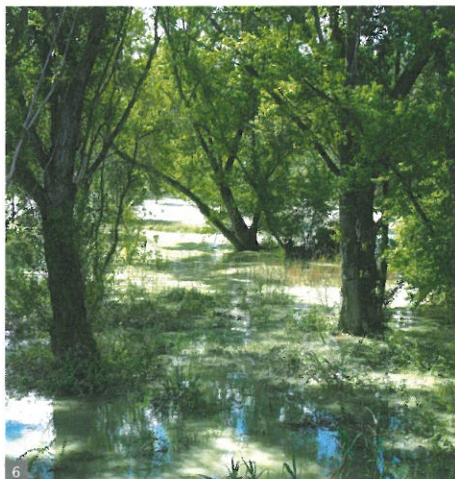
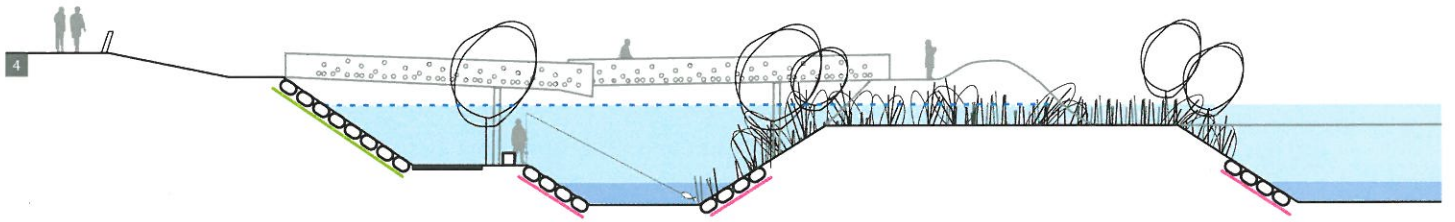
The second level is an intermediate terrace. This is where the park itself is located, with different trees and shrubs planted on the hills, which reflect the structure of the former banks formed of debris. Seats and boules courts are laid out here. The third level is at the elevation of the old town, with a promenade-like path along the edge of the site and a view of the river over the park.

- 1 Bullfighting arena spanning the middle and bank levels [C3.2]
- 2 Schematic section of the three levels of the park
- 3 Oblique aerial view of the park with revitalised canal and resulting island [C1.2]

The bullfighting arena The newly constructed bullfighting arena forms the linking element between the level of the park and the riverbank. As it is built to fill this vertical gap, this construction does not form a barrier between the river and the town. The venue is integrated into the park's landscape such that arena-goers can very conveniently enter its stands from park level. The bullfighters or artists enter the arena from the level of the river. The arena, which seats 6000, is so constructed and laid out that, in the event of flooding, it is inundated up to the first level of seating. When the water recedes, it leaves a circular expanse of water in the arena. In this way it not only bridges the vertical distance to the river, but also becomes a stage that dramatises a flood event as a spectacle and enables the townspeople to observe the flooding processes.

New island and riverbank A former canal was cleared in front of the water park and separates off an island that is accessible from the park level via a bridge. The river thus verges close to the town again at this point. The riverbank, along which there is access for cars, is popular with anglers. The banks of the canal are reinforced with large granite slabs; the joints between them have been colonised by plants. The bridge is so constructed that, during heavy rain events, it acts as a surface drain in the river, not unlike a gargyle. Extreme floods inundate the island, which is a conservation area today. Right on the bank, at the lowest level, a riparian woodland has grown up which was made accessible and thus integrated within the park. For the low-lying areas, the architect designed a heavy, submergible concrete bench. Both with and without backrests, these are to be found throughout the park, and a furniture manufacturer has included them in its catalogue. What started with a bullfighting arena has had a radical influence on the overall structure of the town: the new park connects the town with the flood plains, and what used to be the 'back end' of the town has become an attractive riverfront location.



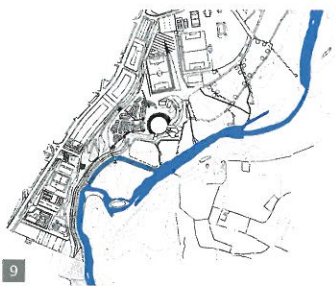
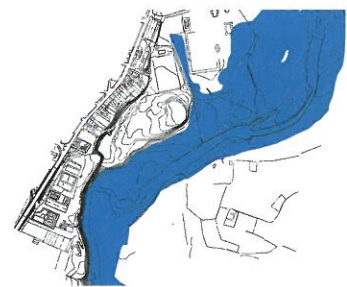
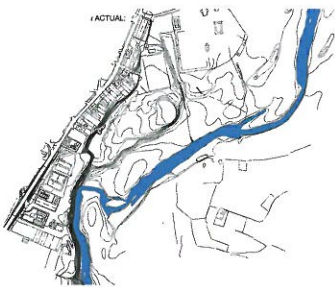


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- 4 Schematic section of the new canal and island. The banks of the branch channel were reinforced by an attractive natural stone revetment [D4.3]. The path is popular with anglers.
- 5 Bridge at high water
- 6 Inundated riverbank level upon flooding
- 7 Flood-proof bench called 'Zuera'
- 8 Middle level of the park
- 9 Different extents of the area covered by water before (top row) and after (bottom row) the park's construction: normal water level, medium flood and severe flood



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