Synthesis of a collective book led by ASTEE under the coordination of Bernard Chocat and supported by ONEMA.

Ecological engineering in aquatic environments:

WHY AND HOW?

March 2015

astee
association scientifique et technique pour l'eau et l'environnement

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RÉPUBLIQUE FRANÇAISE
Ministère de l'Écologie, du Développement durable et de l'Énergie

ONEMA
The French national agency for water and aquatic environments

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A BRIEF HISTORY OF ECOLOGICAL ENGINEERING IN FRANCE

Over the past 50 years, the situation of aquatic environment management in France has changed profoundly, with the development of European legislation and the major water laws of 1964, 1992 and 2006. It has gradually progressed from the preservation of a resource, in a purely anthropogenic sense, to the management of a natural environment.

This evolution has actually been in two main directions:

- The goal is no longer to develop aquatic environments solely for the benefit of man, but to preserve or rehabilitate their ecological functioning as best possible, including humans as one component among the others in aquatic ecosystems.
- The strategy to implement must no longer aim for full artificial management of ecosystems but instead rely on nature itself as the agent and/or driver of action.

This is not to favor nature over human, but to preserve nature in order to ensure the sustainability of uses relying on it.

The central idea is that not only does the preservation of ecosystems and their respective natural functions not oppose anthropogenic uses, but it is vital to ensure continuity, even if sometimes conflict may exist.

Ecological engineering is one of the tools supporting this development. It is a highly topical concept in the scientific community but is also a popular subject of interest amongst managers of aquatic environments and practitioners. The French Ministry for Ecology has specially set up a national action plan and encouraged the organization of economic professionals through the French Union for Professionals in Ecological Engineering (abbreviated to UPGE in French). It then developed its activities by encouraging the creation of an even larger organization within the French Federal Association of Ecological Engineering Stakeholders (abbreviated to A-IGEco in French). At the end of 2012, the Ecological Engineering - Project Management Methodology Applied to the Preservation and Development of Natural Habitats - Wetlands and Watercourses NF X10-900 AFNOR standard was published.

> The central idea is that not only does the preservation of ecosystems and their respective natural functions not oppose anthropogenic uses, but it is vital to ensure continuity, even if sometimes conflict may exist.

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ECOLOGICAL ENGINEERING: WHAT ARE WE TALKING ABOUT?

1 Many definitions exist

Professionals in the ecological engineering industry are still having difficulty finding a single, accepted definition, as it is often the case with emerging concepts.

Scientifically, one of the most advanced and comprehensive definitions in France is that proposed by the Manifeste de la recherche pour l'ingénierie écologique (Research Manifesto for Ecological Engineering) [1]:

"Ecological engineering refers to scientific knowledge and practices, including empirical knowledge and practices, which can be mobilized for the management of environments and resources, and the design, implementation and monitoring of facilities or equipment inspired by or based on mechanisms that govern ecological systems. It involves the manipulation, usually in situ and sometimes under controlled conditions, of populations, communities or ecosystems, the management of natural dynamics and the evaluation of their desirable and undesirable effects. It is engineering centered on living beings that is considered as an action objective or means."

2 The need to supplement this definition with concrete requirements

The formal definition is, however, insufficient for practical use and a survey conducted in 2011 by a working group from the French Scientific and Technical Association for Water and the Environment (known as ASTEE in French) with French representatives from State services, authorities, operators and businesses, etc. supplemented this scientific definition with several additional requirements [2] related to its implementation:

- Recognition of the diverse fields of application, which cover all phases of the project (stages of design, implementation, management and monitoring).
- The need to be part of a sustainable territorial policy, meaning a political project built in space and time, which integrates ecological management and which is in balance with social fabric and related activities as well as socio-economic development and environmental uses.
- The need to rely on a systemic vision which includes:
    - o The need to take into account the different dimensions: temporal (How will the ecosystem and uses evolve over time?) and spatial (What is the relevant study territory? How to manage ecological continua and scales [3]?)
    - o The need to consider as many ecological and socio-economic factors as possible and analyze their interactions.
- The need to implement an approach which respects the principles of engineering, namely a rigorous technical approach to the design, implementation and evaluation of projects, based on shared practices and sound science.

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[1] *See: http://www.set-revue.fr/sites/default/files/archives/Manifeste_ingenierie_ecologique.pdf*

[2] *Some of which incorporate elements of the definition.*

[3] *For example, in the case of a river, one must consider the four ecosystem dimensions to be addressed:*
• Longitudinal dimension: upstream-downstream relationships, continuity, etc.;
• Transversal dimension: relationships between the main channel, riverbanks and floodplain;
• Depth dimension: relationships between the river, substrate and accompanying water table;
• Temporal dimension: daily and annual cycles, trend developments and crisis situations (rise in water level, low water levels).

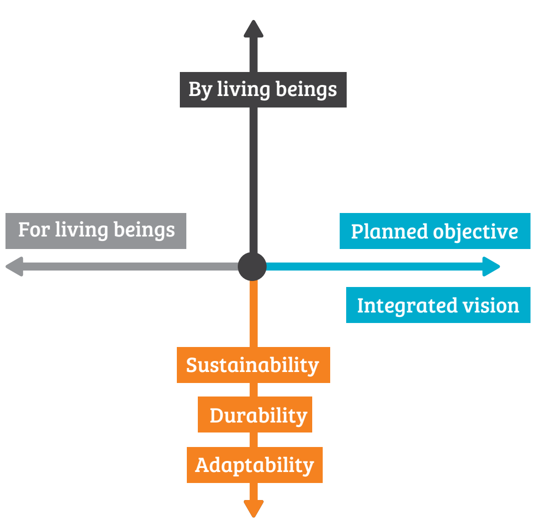
• The need to work in multidisciplinary teams, meaning mixing academic and multi sectorial skills, and also involving various public and private stakeholders.
• The need to allow time for the ecosystem to adjust and therefore incorporate human intervention in its own time. In terms of practicality, the system must be able to evolve over time with minimal human intervention. This does not mean that maintenance is unnecessary, but implies that thinking on maintenance operations and environmental management must be an integral part of the engineering project.
• The need to accept some uncertainty in the result, especially due to variability of ecological and social responses. The dynamics of living beings, the integration of a project in a territory, how it is accepted by populations, etc., are in fact not completely controllable. These constraints require monitoring. This monitoring must be integrated from the beginning of the operation and, in order to be meaningful, it is essential that the project can be adjusted and adapted if required. As the ecological development of a site can take several years, intermediate steps should be taken over long evaluation periods to monitor any deviation from the intended development path. This approach must also allow for adjustment through intervention. This is especially important because global climate change may alter the functioning of ecosystems in coming decades in ways that are difficult to predict. A necessary condition for success is to have anticipated funding for these stages from the start of the project.

3 The choice to offer criteria rather than a new definition

Rather than proposing a new definition, we decided in the end to offer criteria that may help determine what a "good" ecological engineering project is.
With regard to the aforementioned analysis, we selected the following four criteria, to which we have tried to link keywords:

• **The project should contribute to maintaining and/or restoring the proper functioning of aquatic environments** and associated ecosystemic services: "For living beings"
• **The project must be based on management and/or planning design practices** based on, or inspired by, mechanisms that naturally govern ecological systems: "By living beings"
• **The project must adhere to a sustainable territorial policy,** meaning it must be part of a political project that integrates an ecological vision consistent with social fabric and related activities as well as socio-economic development and environmental uses: "Planned objectives and an integrated vision"
• **The project must aim to ensure ecosystem resilience** in order to achieve the project objectives over time, which may mean developing them: "Sustainability, durability and adaptability"

QUALITY ASSESSMENT DIMENSIONS OF AN ECOLOGICAL ENGINEERING PROJECT



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ECOLOGICAL ENGINEERING: HOW DOES IT WORK?

1 Ecosystems serving humans

The central idea supporting ecological engineering is that ecosystems perform natural functions that can be directly or indirectly useful to society through the services they offer.

Human uses relying on water systems are indeed numerous. Let us cite, for example, the supply of drinking water and water to industries, irrigation, fishing, aggregate extraction, hydroelectric power generation, the ability to collect urban or industrial discharge, navigation, etc., as well as many recreational uses related to the landscape or ecological quality of water systems.
These uses are often heavily dependent on functions that the ecosystem provides virtually for free: self-purification of surface water, refilling of the groundwater with good quality water, flow regulation (limiting extreme values), sediment transport and maintenance of the substrate and habitat quality, sustainability of ecosystems and natural landscapes, etc.

2 Aquatic ecosystem functions can be restrictive for human activities

While they serve man, aquatic ecosystems are still natural objects. They do not obey morals and do not care about any inconvenience they may cause. Our society has often been required to manage these ecosystems, generally in order to control excesses or facilitate uses.

3 The uses that man makes of water systems and the developments we impose on them may impair their functioning

Most of these developments and uses have an impact on ecosystems which varies in its degree and duration. This impact may be due to the uses themselves (extraction of water or aggregate, pollutant emissions, etc.) or the technical devices built to perform or help them (dykes, dams, riverbank developments, etc.).
The result in all cases is an alteration, sometimes significant, to some of the natural functions. This alteration may even threaten uses themselves.
Effectively, if we are not careful, we risk chopping off the branch we're sitting on!

4 The goal of ecological engineering is to better reconcile uses and ecological functions

These complex interactions between ecological functions, developments and uses are at the heart of the issue of sustainable and balanced management of water systems.

The objective of ecological engineering is to better understand these interactions, to better control them, and to seek solutions which better reconcile the uses and natural functioning of ecosystems.

Despite all application singularities associated with the wide range of objectives and environments, a new balance still needs to be found between human and nature, by offering developments that are based on natural mechanisms and by attempting to positively mobilize instead of opposing them.

To achieve this, a systemic approach is necessary, since all the functions of aquatic ecosystems are interconnected and condition how these ecosystems serve humans. Understanding of these relationships, combined with a sound study of the whole system, is therefore a pre-requisite for effective implementation of any intervention. Otherwise a local improvement to a function is likely to damage another function, sometimes in an entirely different area of the water system.

Purifying waste water from a small municipality through an extensive plant

• THE SITE :
Nègrepelisse is a municipality of around 5,200 inhabitants located in the Tarn-et-Garonne county. The waste water is collected in a combined sewage system. The natural outlet for this water is the Montrosies stream, a tributary of Courounets, itself a tributary of the Aveyron river.

• THE PROBLEM WHICH LED TO THE PROJECT:
The treatment of waste water relied on an old natural lagoon, the capacity of which became insufficient with population increase. The elected representatives wished to establish an inexpensive, effective channel which was well integrated into the rural landscape and able to incorporate the existing lagoons so as to preserve the heritage.

AN AERIAL VIEW OF THE PLANT: TOP, THE 2 LAGOONS, BOTTOM LEFT, THE 2 FILTER STAGES

• THE SOLUTION IMPLEMENTED:
The existing lakes had reed bed filters added to them. In 2009, at the time of implementation, it was the most extensive plant in France, with a surface area of 8,000 m· covered with reeds. The nominal treatment capacity of the plant was 4,000 inhabitants, which could be expanded to 6,000.

• SOLUTION BENEFITS: The cost of implementation was similar to that of a conventional plant. However, operating costs have halved, mainly due to the very small amount of sludge produced. Furthermore, energy consumption has been divided by 10. The concentrations of output pollutants are well below discharge standards for key parameters (COD, BOD5, TSS). In the summer, when the host environment is most sensitive to anthropogenic releases, treatment of nitrogen and phosphorus is improved by the interconnecting lagoons between the two stages of planted filters. The lagoons also safeguard the treatment facility. In the event of automatic or electromechanical equipment malfunction of the planted filters, raw sewage is directed towards the lagoons for treatment before release into the environment...

• THE REASONS FOR SUCCESS:
Political will combined with research by technical partners with expertise in the area.

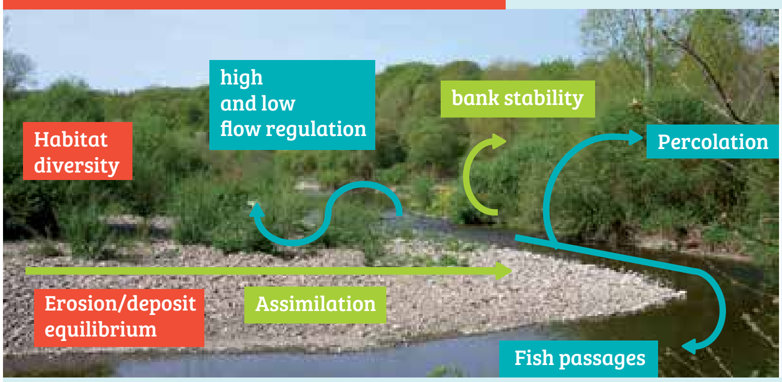
• TO FIND OUT MORE: The Communauté de Terrasses et Vallées de l'Aveyron (CCTVA)

Implementation of a departmental plan for the restoration of watercourses to meet good ecological status objectives

• THE SITE :
All the watercourses in the Haut-Rhin county.

• THE PROBLEM WHICH LED TO THE PROJECT:
The Water Framework Directive (WFD) requires various aquatic environments to be returned to their optimal ecological status in 2015. To achieve this goal it is necessary to implement a comprehensive approach covering both ecological functioning, biodiversity of the bed and banks and the impact of hydraulic developments.

AREAS OF WORK FOR THE PROJECT



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• THE SOLUTION IMPLEMENTED:
The Haut-Rhin General Council decided to implement, in partnership with the water agency and in conjunction with the 15 river associations, a comprehensive restoration programme for the main watercourses in the county. The goal was to return the watercourses to their full capacity for performing their various functions. Each programme had three areas of work: a "hydromorphology" focus, a "continuity" focus and an "ecology" focus. A detailed inventory of rivers and works was first performed, then a programme of concrete operations was proposed. A consultation was held between the various stakeholders relating to SAGEs (in progress), which in particular included a non-technical summary that was sent to each stakeholder in the drainage basin.

EXAMPLES OF TYPES OF ACTIONS PROPOSED

CONTINUITY
- partial or total removal of weirs
- improvement to existing fish passes
- creation of fish passes
- weirs modification

HYDROMORPHOLOGY
- diversification of watercourses
- preservation of functional mobility areas
- side channel reconnection
- rebuilding of degraded mobility areas

ECOLOGY
- specific management of riparian forest
- knotweed control
- acacia control
- wetlands preservation
- wetlands restoration
- riparian forest management plan

• SOLUTION BENEFITS: The programme's comprehensive coverage, taking into account all the natural and anthropogenic issues present likely to be impacted, and combining three areas of work for a coherent result; the formal and structured nature of the programme allowing experiences to be compared and mutually enriched; the establishment of a common methodology, tested and validated in studies and pilot projects.

• THE REASONS FOR SUCCESS: The ability to mobilize various sources of funding (General Council, Water Agency); the establishment of a technical committee to monitor the progress of the programme; the possibility to rely on existing river associations and consultation with all stakeholders.

• TO FIND OUT MORE : Haut-Rhin General Council.

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ECOLOGICAL ENGINEERING: WHAT CAN IT BE USED FOR?

Ecological engineering covers a broad scope of applications in terms of aquatic environments, and the reasons that prompt an ecological engineering project on a water system are diverse.
They can be strictly related to the development or preservation of an anthropogenic use (preservation of a drinking water resource, for example), they can be only related to the improvement of the ecological state of the environment (restoration of a wetland for example) or targeted both at ecological objectives and use objectives.
They may be associated with preventive action (avoiding environmental degradation and/or inconvenience to use) or remedial action (helping to decrease pollution, for example).
They may relate to managing an aquatic ecosystem or urban development operation.
From the perspective of the policy maker, a large number of reasons can therefore be identified when considering the use of ecological engineering. While not exhaustive, we selected seven that seem representative of the various potential fields of application.
These seven points of entry, which are not in any order of importance, either economic or in terms of their ecological or social issues, are:

- To protect the quality of water resources by controlling diffuse pollution in particular;
- To improve the treatment of point-source discharges and reduce their impact on aquatic environments;

Ecological engineering can be used both to achieve environmental goals (restoration of an aquatic environment) than to achieve usage objectives (stormwater management)

- To control rises in water levels and floods;
- To control evolutions in the riverbed (siltation, incisions, etc.);
- To better manage urban storm water by reducing its negative effects and exploiting it;
- To enhance landscapes and water-related uses;
- To restore aquatic environments and develop biodiversity.

The boxes illustrate some of these issues and show how ecological engineering can actually be implemented in real cases.

Fighting against lake eutrophication through wetland rehabilitation

• THE SITE :

Lake Aydat, with an area of 60 hectares, is the largest natural lake in Auvergne. Located 837 m above sea level in the upstream part of the Veyre basin, it was formed by a lava flow. It is home to many recreational and tourism activities: fishing, swimming, hiking, water sports (canoeing, pedal boats, kayaking), mountain biking.

• THE PROBLEM WHICH LED TO THE PROJECT:

Lake eutrophication due to excess phosphorus was causing algal blooms that were liable to threaten tourism.

LAKE AYDAT

1910'S

OLD POST CARD © EDITION LL

FROM 2012

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• THE SOLUTION IMPLEMENTED:

This consisted in creating a natural biological filter at the lake entrance, to fix some of the nutrients and allow settling of suspended solids. For that, the former wetland located on the Veyre was restored. This wetland of 1.6 ha had been filled in under 1m of backfill by the Aydat municipality in the 1970s in order to create urban developments there (a football field, a car park, a playground and a waste collection site).

• SOLUTION BENEFITS:

In addition to improving the water quality of the Veyre river which feeds the lake, this solution helped some ecological functions to develop (the wetland is a refuge and breeding ground for fish, amphibians, birds etc.) and offers an educational role (wooden decks and observatories were created for the public to explore the site, building public awareness of the wetland's different roles).

• THE REASONS FOR SUCCESS:

The project was carried out on the right territorial scale as part of a river contract supported by a joint association ('syndicat mixte'). In addition to the wetland restoration, further actions were taken upstream: remeandering the Veyre's and renaturing its banks, improvement to collective sewage systems, changes of agricultural practices. The joint association also ensured land control of part of the land to allow development of the site and its subsequent management under good conditions.

• TO FIND OUT MORE: Joint association of the Veyre and Auzon valleys (Syndicat Mixte des Vallées de la Veyre et de l'Auzon (SMVVA))

THE RESTORED WETLAND

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SOME IDEAS FOR THE DEVELOPMENT OF ECOLOGICAL ENGINEERING

Ecological engineering is a rapidly emerging field and its structuring is still being created.
To try to anticipate future changes, it would be interesting to list perspectives seeking to analyse the challenges we must face and the approaches we can adopt to promote development.
The central hypothesis is that it is how public works are managed which will determine the evolution in the field over the coming years. This assumption is, of course, questionable because other factors may also play a major role, for example the development of skills and knowledge, a significant change in societal demand or even a series of climatic or environmental events. However, it is realistic because, with the financing it provides, public works management is the main driver of the activity. The main areas identified are as follows.

1 Improve project governance

1. CLARIFY GOVERNANCE IN THE WATER INDUSTRY

In 2014 in France, it is still very rare that a clearly identified stakeholder is responsible both for global, planned management of water resources and the aquatic environment. Skills are often divided between many stakeholders whose areas of expertise (catchment protection, diffuse pollution control, introduction of "blue infrastructure", protection and restoration of wetlands and watercourses, to name a few) often partly overlap. Their administrative scopes also often prove to be ill-adapted to water management issues (for example, a community of municipalities' administrative border in terms of managing run-offs from a catchment basin). Therefore, there are now often real difficulties with ecological engineering project management.

The French law of 27 January 2014 on the modernization of territorial public action and metropolitan claim should improve this situation. It grants a compulsory new authority known as GEMAPI in French (Management of Aquatic Environments and Flood Prevention) to local authorities. Although this jurisdiction may be applied directly by municipalities, they are encouraged to transfer it to a group of authorities (unions, public development and water management establishments, public territorial basin establishments, etc.) capable of managing facilities to a consistent hydrologically scale, the watershed.
However, it will take some time before the structures are effectively in place.

2. MOBILIZE ALL STAKEHOLDERS TO BETTER LEGITIMIZE THEIR ACTION

Another requirement is for the project manager to have the legitimacy to act. This legitimacy may be institutional and come from the exercise of either a conventional regulatory function by an elected representative (for example, ensuring the continuity and safety of drinking water supply) or a new one (implementation of GEMAPI authorities). It can also be based on a significant event (for example, in response to a flood) or an action decided collectively (implementing a SAGE[4]).
However, even if the support structure has administrative and technical skills, it rarely has both territorial recognition - for example, local political standing - and sectorial recognition (legitimacy in the agricultural world, amongst land stakeholders, etc.).
It is therefore necessary to mobilize all stakeholders involved in the various sectors or with expertise in the field. To be truly effective, this mobilization must also be made at the beginning of study.

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[4] Water Development and Management Plan

2 Better manage financial constraints

1. REASSURE FOR PROJECT COSTS AND DIFFICULTIES

Ecological engineering still involves a study cost which is higher than that of a traditional project. What is even more unfortunate is that studies are often perceived by project managers as a waste of time and money.
In addition, the cost of acquisition or control of land may also contribute to pushing up the price of ecological engineering solutions. Finally, the need for monitoring over the duration of operations and the obligation to change organization systems responsible for maintenance and operation are likely to increase operating and maintenance costs.
This economic argument, however, can be reversed. In fact, the cost of works required for an ecological engineering project is very often lower than that of a traditional project.
The preventative approach, which aims to develop ecosystem resilience and is at the heart of the ecological engineering approach principles, often saves subsequent expenditure (better cost-benefit ratios).

2. CONVINCE LOCAL AUTHORITIES OF THE INTEREST OF PARTIAL SELF-FINANCING

In the French context, the difficulty which local authorities have to finance parts of projects themselves (an issue which is not specific to this field) seems to be one of the major obstacles to the emergence and development of ecological engineering projects. Indeed, even if project managers may benefit from various subsidies (water agencies, regional councils, European funds, etc.), there are still some parts they must finance themselves.
Until recently, and except in the case of dedicated structures, such as an intermunicipal union with clearly identified jurisdiction in the field of management of aquatic environments, local authorities had no specific budget for this type of expenditure. In addition, the French regulatory environment did not require mayors to act on the management of aquatic environments beyond their obligations to protect their citizens or to ensure water policy.
The aforementioned French law of 27 January 2014 also allows municipalities or EPCIs with their own taxation to levy a specific tax to fund activities. The proceeds from this tax may be combined with grants.
Nevertheless, in the current context where the environment is not necessarily seen as a priority issue, new taxes are not well received by population. The decision to act therefore remains dependent on strong political decisions and financial incentives such as subsidies.

3. DEVELOP TECHNICAL AND FINANCIAL SUPPORT SYSTEMS IN THE AQUATIC ENVIRONMENTS SECTOR

Financial aid in France can come from different structures: Regions, Europe, etc. However, in the field of management of aquatic environments, the main financial support encouraging public works project managers to use ecological engineering is granted by water agencies (Agences de l'eau in French).
It is also important to note that the role of these water agencies is not just financial:

- On the one hand they help to carry out aquatic environment improvement projects by contributing significantly to their funding;
- On the other hand, they often contribute to reformulating or supplementing the objectives of public works project managers, which can encourage them to use ecological engineering.

The fact that water agencies preferentially provide their subsidies towards preservation or restoration methods for aquatic environments based on ecological engineering may contribute heavily to developing this type of approach.

3 Develop training and information for stakeholders

1. DEVELOP INFORMATION AND AWARENESS OF CITIZENS, PROJECT MANAGERS AND THEIR ADVISERS

Awareness of the issues and principles of ecological engineering is also a key point. The current awareness and information deficit concerns citizens as well as the project managers who represent them. The development of information available to elected representatives, citizens and technicians thus appears to be a lever to promote the development of ecological engineering. One possible solution is to rely on supporting evidence. Successful feedback, showing that an aquatic environment in good condition can also be a nice aquatic environment to live in and with, while serving its residents, is a powerful asset.

2. BETTER PROMOTE SOFT TECHNIQUES TO URBAN PLANNING PROFESSIONALS

For many professionals in French urban planning, trained in Civil Engineering skills, ecological engineering techniques are considered sub-techniques. Moreover, they often present competency issues. This is a real problem that undeniably harms the image and the development of ecological engineering.

Controlling high water levels by returning a river to its original bed

• THE SITE :
La Fontenelle is a small river in the Seine Maritime county that crosses the municipality of St Wandrille-Rançon. This river was diverted from its bed over almost 1,200 m in 1792, just downstream from the abbey, in order to power a mill.

• THE PROBLEM WHICH LED TO THE PROJECT:
Since 1995 the river has experienced several major floods. There was a particularly remarkable episode on 26 December 1999 which caused widespread damages, including on historic buildings. The main factor that triggered the flood was identified as the fact that the artificial bed was "perched", meaning it was set higher than the bottom of the valley.

BEFORE THE WORKS

8 MONTHS AFTER THE WORKS

• THE SOLUTION IMPLEMENTED:
Various studies run after these floods led to the proposal to return the river to its original bed, still visible in the landscape.

• SOLUTION BENEFITS:
This was a mixed solution that ensured both the safety of property and people and the ecological functioning of the watercourse. Beyond the historical aspect (returning to the original location), the solution adopted offered hydraulic benefits (ability to size the average bed, restoration of the flood plain, limitation of stresses on the banks in the urbanized area), both in terms of landscape (valley bottom landscaping) and ecology (re-establishment of ecological, fish and sedimentary continuity, restoration of natural habitats).

• THE REASONS FOR SUCCESS:

• The existence of a competent and wilful structure led by an experienced facilitator. Having monitored the project almost from the beginning until today, four years after the works, he has a real technical and ecological expertise, particularly relating to this watercourse, as well as a good relationship with residents and elected representatives that have been cemented over the duration.

• The extensive bilateral and group consultations, which had their ups and downs, despite having been established with the 25 riverbank owners involved since early on in the study. Opposition to the project abated in writing (public inquiry) in relation to oral meetings and was alleviated by listening to the inconveniences experienced by each stakeholder and by undertaking relevant measures by the local authority (water agency funding). The project partners were quick to recognize errors (oversizing) and to draw lessons from them which were subsequently discussed.

• TO FIND OUT MORE: Joint association for the Caux Seine drainage basins (Syndicat Mixte des Bassins Versants Caux Seine).

Urban storm water management through wetland restoration

• THE SITE :
The Jonchets' wetland is located in the town of Grand-Charmont, a municipality in the Montbéliard urban area. In the second half of the 20th century, this wetland faced gradual urbanization, which led to its gradual drying up.

• THE PROJECT CREATION:
Drying up of the wetland, waterproofing and the development of sewage networks had diverse consequences in the 1990s: aquatic environment eutrophication, fish mortality during rainy seasons, floods, etc. The municipality then undertook an alternative rainwater management policy. Moreover, in the years following 2000, the municipality began a new urbanization programme in order to renew the quality of its habitat. The layout of the Jonchet mixed development zone (ZAC in French) was then initiated.

• THE SOLUTION IMPLEMENTED:
The choice was made to manage storm water in the new district by restoring the buffer role of the wetland in particular, via water replenishment. Related objectives were then to put in place an alternative storm water management policy when performing urban development in the periphery of the wetland and to create a balanced, educational environment which is accessible to residents. The wetland was thus integrated into a 7-hectare park, linked to surrounding neighborhoods by soft transportation modes. The habitats were also diversified: pond, pools, ditches.

• SOLUTION BENEFITS:
The main added value of this operation was to transform what appeared to be a threat to nature (an urbanization project) into an opportunity to restore a natural

AFTER WORKS

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area. The second benefit was to ensure this restoration plays a positive role in terms of quality of life (reduced risk of downstream flooding, landscape diversification, creation of a biodiversity reservoir, etc.).

• THE REASONS FOR SUCCESS:
The political will and experience of the Montbéliard urban area community in terms of alternative storm water management techniques; the organization of visits to similar projects in other towns to convince the mixed development zone project stakeholders; the integration of the project into a global policy on the sustainable management of urban storm water.

• TO FIND OUT MORE: Montbéliard urban area community (Communauté d'agglomération de Montbéliard); Municipality of Grand-Charmont (Commune de Grand-Charmont)

Another difficulty closely concerns the design and execution of works. More accustomed to Civil Engineering works, both design offices and construction companies struggle to adapt their approaches to softer solutions, which are more respectful of nature, and in particular mobilise much more diverse skills. The first edition of the Ecological Engineering company Directory, published by the Ministry for Ecology in October 201,4 may be helpful in overcoming this difficulty.
Finally, maintenance of works also often poses problems. For example, the maintenance of alternative techniques for storm water drainage must generally be carried out by services other than the sanitation department (roadside, cleaning and green space services).
Overall, a great deal of effort in initial training and continuous professional development must be made to break down the barriers between trades and skills.
A significant progression by design offices and businesses towards multidisciplinarity is in progress and this development will be strengthened if decision-makers favor companies that are making efforts in this direction.

3. BETTER FORMULATE THE SPECIFICATIONS

One consequence of the two previous points is that project managers, as well as the technicians who advise them, are not always aware of the specificities of ecological engineering projects. This lack of training can lead to difficulties in the development of precise or relevant study specifications. Thus, some specifications may sometimes either represent a real barrier to the entry of ecological engineering companies into public contracts, or, conversely, enable any company, even without specific expertise in ecological engineering, to respond and be selected.
The Ecological Engineering - Project Management Methodology Applied to the Preservation and Development of Natural Habitats - Wetlands and Watercourses NF X10-900 AFNOR standard[5], which was approved in the autumn of 2012, is likely to provide an initial response to the specifications development problem. Initial feedback on its implementation will help to adapt it if necessary.

4. WORK WITH THE DEMAND FOR NATURE AND ENCOURAGE THE COMMITMENT AND DETERMINATION OF INDIVIDUAL STAKEHOLDERS

The commitment to and knowledge of the concerns of one or a more motivated stakeholders appears to be a key element in the development of ecological engineering projects. Analysis of successful projects shows that this success often depends on the existence of a partnership between a technician and an elected representative.
As the demand for nature now constitutes a key determining factor in the choice of living environment for a large number of citizens, we can use this aspect. Although there is often confusion between "nature" and "garden", this can be used effectively to promote ecological engineering, particularly in urban or suburban areas. This is often an effective motivation for both elected representatives and technicians.
Its mobilization, however, requires project objectives to be clarified and an optimal balance to be established between the objectives aiming to develop uses, landscapes and urban amenities, and those aiming to restore "natural" functioning of the aquatic environment.

4 Improve and better use the regulatory environment

1. BETTER USE THE REGULATORY ENVIRONMENT

In France, regulatory aspects are often seen as obstacles to the use of ecological engineering. In particular, in the status of this framework, which lie somewhere between structures built and natural environments, often presents difficulties in terms of access security or rules of use.
The lessons gained from past experiences, however, show that fears are often exaggerated and that good design of developments is sufficient to prevent any risk of dispute or accident.
However, clarification on the status of certain structures (for example, those involved in rainwater storage) would be desirable.

[5] This AFNOR standard is a document, issued in October 2012, the main goal of which is to standardise best practices to adopt in terms of methodology/governance in an ecological engineering operation applied to wetlands and waterways.

In contrast, current developments in French legislation, particularly in implementing the Grenelle de l'environnement proposals, can play a very positive role in promoting ecological engineering.

2. RECONCILING PUBLIC PROCUREMENT AND INNOVATION

Another often cited obstacle directly affects public procurement operation in France.
Remuneration of Project Management Assistance missions (known as AMO in French) is proportional to the cost of the works. However, ecological engineering methods for developing natural environments are often less expensive than more conventional Civil Engineering methods. With the work being less expensive, remuneration of the AMO mission is less great, even if the need for study and follow-up is much greater.
This mode of operation is therefore likely to lead to the favouring of technical solutions which are costly in terms of work but simple in terms of studies, over solutions which are costly in terms of studies but much cheaper in terms of implementation.
The development of public AMO at the time of preliminary studies or the development of the specifications, benefiting from specific funding, possibly subsidised by the water agencies or regions could quite easily overcome this obstacle.

3. FIND TOOLS TO CONTROL LAND

Another problem is the difficulty concerning acquisition (or control) of land in order to undertake the restoration work on an aquatic environment.
In France, most watercourses are not government property and their bed and banks belong to waterfront land owners. It is estimated that 90% of watercourses are on private property.
The local authority wishing to carry out watercourse management work must, in most cases, acquire the land, or at least ensure control by entering into contracts with local residents. This requirement poses many problems in terms of procedures, finance, interpersonal relationships, socio-professional fabric in rural areas, and finally, long-term use.
The need to control the land may therefore be an obstacle to the emergence of an ecological engineering project.
There are, however, other ways to restore or manage an aquatic environment beyond acquiring the land. For example, the project manager may negotiate a management agreement with owners. Development of these procedures could be an important step in the journey to overcoming this limitation.

5 Better define project objectives and agree to develop them

1.CLEARLY DEFINE PROJECT OBJECTIVES

The fact that projects are struggling to emerge is often due to poorly defined objectives.
Most elected representatives take action on aquatic environments following problems that have directly impacted the local population (floods, pollution leading to, for example, fish mortality or bathing bans, etc.).
They are often forced, whether by personal environmental convictions, by legislation (European Water Framework Directive), or because they wish to obtain grants, to expand their objectives and aim to "restore good ecological status". However, formulated that way, this goal is often insufficiently precise and the expected outcomes lack visibility and are not motivating either for the citizens or their elected representatives.
To overcome this difficulty, it is recommended that objectives are broken down into concrete sub-goals which are, if possible, quantifiable, even if only roughly: increased fish populations, obtaining a quality label, increased site attendance, etc. This will be all the more effective if carried out as part of an analysis shared by all local stakeholders.
However, one must be attentive to the choice of these sub-objectives as ecologically, cause-effect relationships are not always obvious, and the consequences of an action can be difficult to predict.

2. ACCEPT UNCERTAINTIES REGARDING THE EVOLUTION OF PROJECTS

Due to the above-mentioned difficulty, many elected representatives are afraid to use ecological engineering which appears to them to be more of an art than a rational technical approach. They fear, for example, having to accept (and justify to their citizens) an ecological path of environment evolution different to that which they envisaged at the outset. However, although the path is different, the interest will not necessarily be smaller. We must simply accept some uncertainty in the result.
Moreover, this is not always true. For example, with regard to the physical restoration of aquatic environments (reconstruction of meanders, returning the watercourse to its original bed, removal of riverbank protections, opening up a watercourse) or alternative techniques for storm water drainage, ecological engineering techniques have been used and mastered for many years. Much well-documented feedback exists on the subject, such as the "Collection of Experiences on Hydromorphological Restoration of Watercourses" by ONEMA (downloadable http://www.onema.fr/Le -recueil-d-experiences-sur-la).
While uncertainty exists, it is at least partly under control.

THIS SUMMARY IS TAKEN FROM

"ECOLOGICAL ENGINEERING IN AQUATIC ENVIRONMENTS: WHY AND HOW?"

Download for free, but only in French, from the ASTEE website: www.astee.org

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The human being has always built the natural environment to suit their needs.

Over the last two centuries this development has often been against nature, considered as inconsistent and sometimes dangerous.

This mode of action, even if it was effective at first, has now resulted in a large number of environmental issues: ecosystems deregulation, pollution of the natural environment, difficulties in mobilizing the resources...

Ecological engineering is to consider nature as a partner rather than an adversary, and that a healthy environment can provide more services as a damaged one.

This text is a summary of a more detailed book illustrated with examples. For decision-makers, the aim of this document is to demonstrate that acting by and for nature can meet the various society demands, from the preservation of the water quality to the valuation of river banks through the protection against flooding.
