

RIVER ENGINEERING



Compagnie Nationale du Rhône
L'ÉNERGIE À L'ÉTAT PUR

Engineering Division
2, rue André Bonin - 69316 Lyon Cedex 04 - France
Tél. 33 (0)4 72 00 68 15 - Fax 33 (0)4 72 00 67 74

ingenierie@cnr.tm.fr
www.cnr.tm.fr

GRAPHISTAR 05/2005

NAVIGABLE WATERWAYS
HYDROPOWER DEVELOPMENT SCHEMES
RIVER DEVELOPMENT
HYDRAULIC STUDIES
HYDROLOGICAL STUDIES
ENVIRONMENT



CNR'S EXPERIENCE AS DESIGNER AND OPERATOR OF THE RHONE'S DEVELOPMENT SCHEMES

RIVER ENGINEERING

In 1934, the government entrusted the concession for developing and operating the Rhône to the Compagnie Nationale du Rhône (CNR), giving it three main missions: electricity production, navigation and irrigation and other agricultural uses. Partner with Electrabel, which belongs to the Suez Groupe, CNR is the second largest French electricity producer and the only one to have been awarded a certificate for producing 100% renewable energy. Alpengie is the name given to its innovative and modular "Green" electricity supply available to its customers.

Since 2003, CNR has been implementing a long-term plan of missions in the general interest aimed at optimising hydropower production, developing river transport, protecting the environment and developing regional economic and tourist resources. As designer and operator of hydropower plants, barrages and locks on the Rhône, it has developed industrial and port sites, marinas, mooring points and leisure areas. It also provides river engineering services in France and over twenty countries around the world.



COMPETENCIES

CNR's competencies and expertise in river engineering are recognised in France and throughout the world and rely on over 70 year experience of developing and operating the Rhône and its partnerships with universities and scientific research centres.

Our proven multidisciplinary teams carry out large scale projects, calling on innovative solutions and technological expertise.

CNR'S DEVELOPMENT SCHEMES

CNR has constructed and currently operates and maintains 18 development schemes on the Rhône:

- ◆ 18 barrages and 1 dam
- ◆ 14 wide gauge locks
- ◆ 19 hydropower plants
- ◆ 400 km of dikes
- ◆ 32 pumping stations
- ◆ 300 km of navigable wide-gauge waterways
- ◆ 500 ha of port sites

CNR'S ENGINEERING OFFICE

CNR's engineering office acts as design engineer for all the technical projects on the Rhône and carries out all the necessary studies, analysis, tests, measurements and inspections. Acting in close collaboration with owners and promoters, our technicians are trained to listen to your needs and satisfy your expectations.

CUSTOMERS

Our customers are owners, promoters and statutory operators either public or private.



CNR'S RIVER ENGINEERING SERVICES

RIVER ENGINEERING



AREAS OF EXPERTISE

- ◆ **Navigable waterways:**
locks, canals, rivers, industrial ports and marinas.
- ◆ **Hydropower schemes:**
low and medium head hydropower plants, mini-hydropower plants, barrages, automated and remote controlled operating systems, regulation, pumping stations.
- ◆ **River development:**
dikes, weirs, fish ladders, white water stadiums.
- ◆ **Hydraulics studies:**
hydrometrics, flow rate prediction.
- ◆ **Environment:**
hydrobiology, restoration of natural sites, phytoremediation, impact studies.

OUR SERVICES

Consulting and expertise

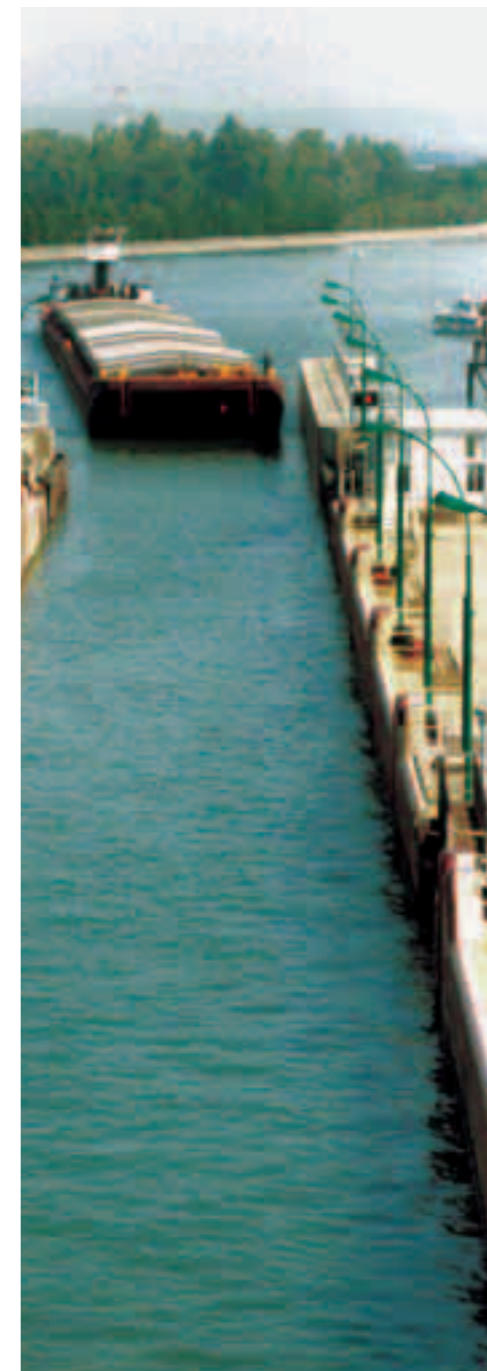
- ◆ Expertise
- ◆ Diagnosis
- ◆ Impact studies
- ◆ Master plans
- ◆ Technical and socio-economic feasibility studies

Design engineering missions

- ◆ Preliminary designs
- ◆ Tender designs
- ◆ Basic designs
- ◆ Assistance to the promoter
- ◆ Site management

OUR ADVANTAGES

- ◆ **Biological engineering:**
CNR is expert in techniques designed to protect river banks by revegetating navigable stretches in order to maintain their ecology and landscape.
- ◆ **Physical model laboratory:**
physical models are essential tools for dealing with complex hydraulics problems (3D flows, sediment dynamics, etc.) in synergy with mathematical models.
- ◆ **Material laboratory:**
in addition to classical materials testing, CNR has developed original tests to assess the resistance of concretes and mortars to abrasion and hydraulic shocks.
- ◆ **Hydromet software:**
developed in partnership with IRD (Institut de Recherche pour le Développement), this software permits the remote acquisition, storage, automatic processing and dissemination of hydro-meteorological data.
- ◆ **Diagnosis, maintenance and renovation:**
the diversity of the hydraulic structures operated by CNR gives it unrivalled experience in diagnostics, maintenance and renovation.
- ◆ **Hydraulic automation and regulation:**
to overcome the severe constraints of running the Rhône's run-of-the-river hydropower plants, CNR has designed and implemented extremely precise regulation regimes for flow rates and reservoir levels, based on the principle of predictive regulation.





THE RHONE AND ITS TRIBUTARIES

CNR, A CHOICE PARTNER

RIVER ENGINEERING



CNR'S DEVELOPMENT SCHEMES

- 18 barrages and 1 dam
- 14 wide-gauge locks
- 19 hydropower plants
- 400 km of dikes
- 300 km of wide gauge navigable waterways



A MAJOR PLAYER IN SUSTAINABLE DEVELOPMENT IN THE RHONE WATERSHED

Committed to respecting the environment, CNR is continuing its policy in favour of sustainable development with general interest missions in 4 areas:

- ◆ **navigation:** improving the quality of the navigation service and developing the waterway;
- ◆ **hydropower production:** optimisation of existing structures and building small hydropower plants;
- ◆ **environment:** hydraulic and ecological restoration of the Rhône;
- ◆ **stronger local presence:** supporting and assisting local and regional initiatives to boost economic and tourist development relating to the river.

THE RIVER ENGINEERING SPECIALIST

CNR offers you reliability and security.

Our experts carry out complex studies and designs, implementing proven solutions in the following fields:

- ◆ civil engineering, automatic control and electricity, hydromechanics, geotechnics, hydraulics, hydrology, environment, biological engineering.

AN INTERNATIONAL REPUTATION

Thanks to our unique experience as designer and operator, we export our know-how to:

- ◆ Argentina, Bangladesh, Bolivia, Brazil, Burkina Faso, China, Columbia, Korea, Egypt, Italy, Macedonia, Mali, Mauritania, Niger, Pakistan, Panama, Paraguay, Peru, Senegal, Switzerland, Thailand, Tunisia, Uruguay, Venezuela, Vietnam.



NAVIGABLE WATERWAYS

NAVIGABLE WATERWAYS



CNR, THE REFERENCE IN THE FIELD

Promoter, design engineer and operator of infrastructures on the Rhône since 1933, CNR's reputation is known in France and throughout the world in the field of regulation of rivers for navigation.

A GLOBAL APPROACH

CNR offers a global and realistic approach by integrating environmental concerns, whether the aim is to modernise existing infrastructures or to create new waterways.

OPTIMISED MAINTENANCE

Navigable waterway infrastructures are designed with the aim of optimising their future maintenance, since CNR is also an expert in operating rivers.

A VECTOR OF DEVELOPMENT

Working with our teams means participating in the development of river transport and promoting sustainable development.

AREAS OF ACTION

- ◆ Locks, bridges and crossings
- ◆ Master plans for developing navigable waterways
- ◆ Development of navigable canals and rivers
- ◆ Development of industrial ports and marinas
- ◆ Bathymetry of navigable channels

SERVICES

- ◆ Feasibility studies, expertises
- ◆ Technical-economic studies
- ◆ Full design engineering
- ◆ Delegated owner
- ◆ Technical assistance
- ◆ Assistance to the operator

A FEW REFERENCES

MASTER PLANS

Italy:

- formulation of a master plan for the development of navigable waterways in Lombardy.

Uruguay:

- study for the regional development and improvement of navigability on the river Uruguay.

DEVELOPMENT OF NAVIGABLE WATERWAYS

France:

- preliminary designs for the layout of the wide-gauge Seine-Nord canal that will link the basin of the Seine and Oise with the north European canal and river network (length: 105 km);

- tender design for making the upper Rhône navigable for pleasure craft;

- widening of the navigable waterway linking the "grand canal" of Alsace with the port of Mulhouse.

DEVELOPMENT OF INDUSTRIAL PORTS AND MARINAS

France:

- development of the new container port of Lyon-Edouard Herriot.

South America:

- study on developing ports on the Parana and Paraguay rivers.

LOCKS AND BRIDGES

Panama:

- design of a third complex of locks (428 m long, 55 m wide, 18 m draught) with saving basins on the Panama Canal.

Italy:

- wide gauge lock for the port of Cremona on the River Po: basic and working designs, construction of a physical model and supervision of works.

France:

- study and supervision of crossing works of the Lunel barrage on the River Lot (lock, access channel, bridge, etc.);

Construction of a mooring point
(Sainte Colombe - Rhône)



Locks at Gatun on the Panama Canal





HYDROPOWER

DEVELOPMENT SCHEMES

HYDROPOWER DEVELOPMENT SCHEMES



AREAS OF ACTION

- ◆ Low and medium head hydropower plants
- ◆ Small hydropower plants
- ◆ Barrages, ponds and pumping stations
- ◆ Automation and regulation systems for hydropower developments
- ◆ Control points, networks and electric systems

SERVICES

- ◆ Development plans and feasibility studies
- ◆ Technical-economic studies
- ◆ Design engineering
- ◆ Delegated owner
- ◆ Technical assistance
- ◆ Assistance to the operator
- ◆ Expertise

A FEW REFERENCES

LOW AND MEDIUM HEAD HYDROPOWER PLANTS

Switzerland:

- renovation of the Chancy-Pougny plant comprising the replacement of 5 turbine units by machines equipped with Kaplan turbines, renovation of the electric, control and monitoring equipment. The replacement of units 1 and 2 will increase output from 7 to 12 MW per unit.

Pakistan:

- construction of a low head plant next to the Chasma dam on the River Indus (8 x 23 MW units).

SMALL HYDROPOWER PLANTS

France:

- design and construction of several small hydropower plants next to the dams or barrages on the upper Rhône (between Switzerland and Lyon). They permit turbinning the compensation water for the old branch of the Rhône river.

BARRAGES

France:

- study of the safety of dam and barrages on the Rhône (risks of landslides, dam stability, hydraulic studies, monitoring systems, warning systems, etc.).

France-Switzerland:

- operation and monitoring of dam outlets during sluicing on the Rhône with the aim of ensuring permanent water quality control (suspended matter, water temperature, oxygenation, etc.)

AUTOMATION AND REGULATION SYSTEMS

France:

- design and construction in partnership with EDF of the Rhône 2000 system ensuring the automated control of the 12 hydropower plants downstream of Lyon.

Switzerland:

- automation studies and development of software for the hydropower plants of Verbois, Seujet and Chancy-Pougny



The development scheme at Brégnier-Cordon (Ain)

A GREEN ENERGY PRODUCER

The 19 hydropower plants on the Rhône built by CNR produce 25% of France's hydroelectricity.

A TECHNICAL LEAD

CNR has acquired unrivalled experience in harnessing low and medium head hydropower plants, in particular by using bulb turbine generators.

OPTIMISED OPERATION

The remote control system used to manage the development schemes and produced internally permits real-time data acquisition and control of production by implementing prediction and planning tools.

ENVIRONMENTAL INTEGRATION

CNR designs specific developments to improve their integration in the environment: landscaping, respect for flora and fauna, and ensuring water quality.



RIVER DEVELOPMENTS

RIVER DEVELOPMENTS



AMBITIOUS PROJECTS

Our engineers rely on their knowledge and understanding of streams and rivers to carry out your projects, taking into account all their technical and socio-economic dimensions.

A SPECIALIST IN DIKES

We have designed and built over 400 km of earth dikes along the Rhône subject to permanent maintenance and monitoring. We place our expertise at your service.

A VERY WIDE RANGE OF STRUCTURES

Weirs, bridges, fish passes, siphons, bank protection, etc. CNR assists you from design to construction and then the maintenance of these structures.

ECOLOGICAL ENHANCEMENT

Our multidisciplinary teams have pioneered revegetation and biological engineering techniques to preserve and enhance sites.

AREAS OF ACTION

- ◆ Expertise, design, construction and reinforcement of dikes
- ◆ Bank protection and restoration
- ◆ Development of flood protection structures
- ◆ Development of nautical sports centres
- ◆ River structures: crossings, weirs, siphons, fish ladders

SERVICES

- ◆ Expertise
- ◆ Impact studies
- ◆ Design engineering
- ◆ Assistance to the owner
- ◆ Technical assistance
- ◆ Assistance to the operator

A FEW REFERENCES

STUDIES AND DESIGN ENGINEERING OF DIKES

France:

- design, construction, monitoring and maintenance of over 400 km of dikes along the Rhône to ensure the longevity and safety of the developments.

BANK PROTECTION AND RESTORATION

France:

- bank protection with rip-rap on the bends of the Rhône to resist currents: studies using mathematical and scale models.

- formulation of a management plan for the concession's natural sites and conversion of the results on GIS (Geographic Information System).

FLOOD PROTECTION STRUCTURES

France:

- protection against flooding of the Oignin (Ain) by constructing a deviation channel to lower water levels upstream and reduce inundations in habited areas.

Island of Reunion:

- study of development of the land behind the embankment of the Galets river exposed to a residual risk of breach.

RIVER STRUCTURES: CROSSINGS, WEIRS, SIPHONS AND FISH PASSES

France:

- design engineer of the reconstruction of the fish pass at the Pues weir (Drôme) made of rip-rap, 109 m long and protected by a sheet pile curtain.

- construction of a fish pass for the siphon on the Seran: fish population study, sizing of structures, construction and monitoring after commissioning (traps, electric fishing, etc.)

Reinforcement of the dike at Fer à Cheval (Gard)



Construction of a fish ladder on the upper Rhône



HYDRAULIC STUDIES

HYDRAULIC STUDIES



HYDRAULIC MODEL OF THE RHONE

CNR has formulated proven mathematical models of the Rhône river whose input data and results are regularly updated and matched against reality.

FLOOD RISK STUDIES

Our expertise in operating a river in flood (inflows from tributaries, flows and solid transport) allows us to define flood hazards and evaluate risk reduction strategies.

THE CONTRIBUTION MADE BY SCALE MODELS

The most complex hydraulics studies are carried out on physical scale models in our test, measurement and control laboratory.

DECISION MAKING TOOLS

Using Geographic Information Systems - GIS - (plans, video animations) facilitates diffusing and understanding the results of our hydraulics studies.

AREAS OF ACTION

- ◆ Watershed development master plans
- ◆ Definition and mapping of flood areas
- ◆ Expertise and sizing of hydraulic structures
- ◆ Hydraulics studies on scale and 1D and 2D mathematical models

SERVICES

- ◆ Expertises
- ◆ Impact studies
- ◆ Design engineering
- ◆ Assistance to the owner
- ◆ Technical assistance
- ◆ Assistance to the operator

A FEW REFERENCES

MASTER PLANS

Bolivia and Peru:

- formulation of a regional master plan to limit flooding and improve use of resources in the watershed.

Bangladesh:

- study of an integrated development project aimed principally at controlling water flows during major hydrological and meteorological events (rivers floods, cyclones).

DEFINITION AND MAPPING OF FLOOD AREAS

France:

- operation of 20 mathematical models on the Rhône river to simulate flood routing and map the results to provide dynamic visualisation of flood plains.

- study of flood risks for the Lyon urban area using a detailed mathematical model and creating hazard maps.

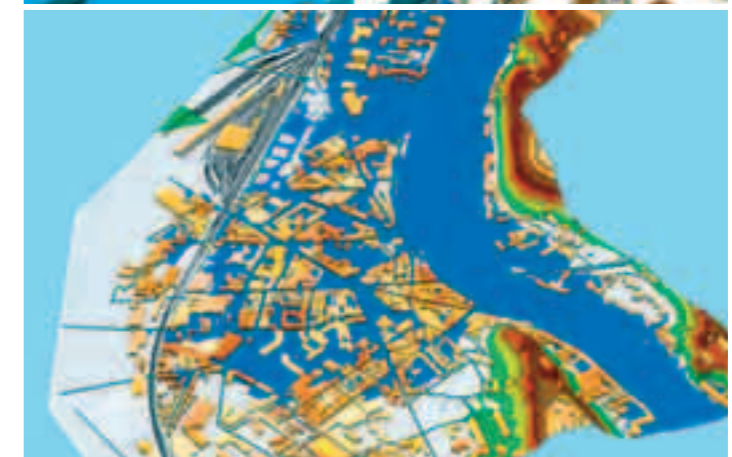
EXPERTISE AND SIZING OF STRUCTURES

France:

- physical modelling of structures designed to protect against torrential flooding of the Riuferrer (Pyrenees Orientales).

- study using a physical model of the Grenouillère watershed (Bordeaux), an underground structure of 63,000 m³ principally intended for combating floods and cleaning up run-off water during rain.

GIS map of the flood hazard for Lyon urban area





HYDROLOGICAL STUDIES



AREAS OF ACTION

- ◆ Hydrological studies of watersheds
- ◆ Management of hydrometeorological data (Hydromet software)
- ◆ Studies and advice related to installing and operating measurement networks
- ◆ Flow prediction and flood warning

PRESTATIONS

- ◆ Consulting and expertises
- ◆ Design engineering
- ◆ Assistance to the owner
- ◆ Development and sale of software

A FEW REFERENCES

HYDROLOGICAL STUDIES OF WATERSHEDS

Switzerland:
- definition and installation of a system for predicting inflows to the Geneva Lake and the progression of flow rates in the Arve at Geneva.

Upper Paraguay:
- installation of an observatory of the water resources of the Upper Paraguay watershed and construction of an integrated information system.

MANAGEMENT OF HYDROMETEOROLOGICAL DATA (HYDROMET SOFTWARE)

France:
- installation and operation of a network of about 120 measurement points on the Rhône river and its main tributaries. The measurements of these stations are transmitted automatically and permit real-time monitoring of the hydrological phenomena in the watershed.

Paraguay:
- supply and installation of a satellite transmission system for hydrological and agro-meteorological data (36 measurement stations).

FLOOD PREDICTION AND WARNING SYSTEM

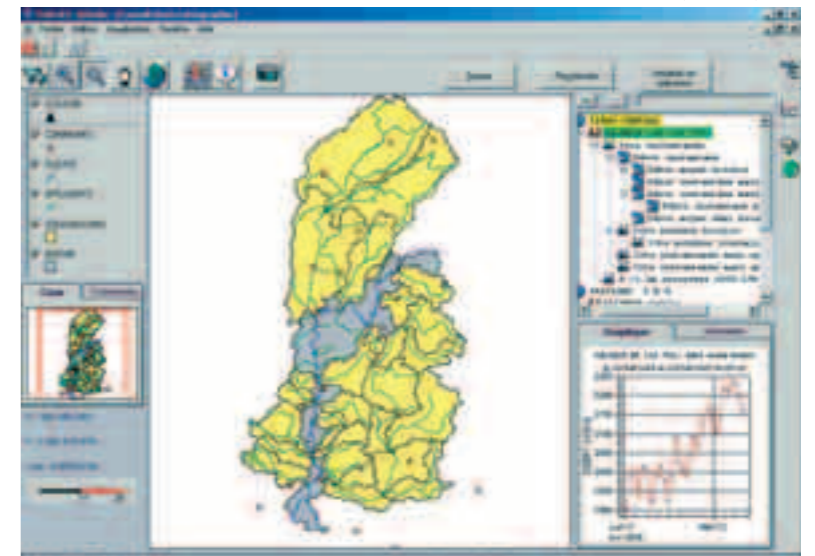
Senegal:
- study and installation of a flood warning plan in the case of exceptional and catastrophic floods of the Senegal river.

China:
- study and installation of a flood warning system for the Beijiang watershed.

Internet site providing information for navigation on the Rhône



Hydromet software



THE EXPERIENCE OF A MEASUREMENT EXPERT
As river developer and hydropower producer, CNR manages an impressive network of level, flow rate and speed measurement stations.

DAILY FLOW RATE PREDICTION
In order to optimise its hydropower production, CNR has developed tools for predicting the flow rates of the Rhône's tributaries on the basis of meteorological forecasts and rainfall - runoff models.

HYDROMET, AN EFFICIENT TOOL
In partnership with IRD (Institut de Recherche pour le Développement), CNR has developed an efficient software to collect and process hydrometeorological data.

FLOOD PREDICTION
CNR makes use of its long experience in the fields of processing hydrometeorological data, modelling flows and flow prediction to study and improve flood warning systems.



THE ENVIRONMENT



OUR SPECIALITY: WATER AND RIVERS

CNR is active in all natural environments relating to water and rivers: wetlands, spawning grounds, streams, oxbows and secondary branches, lakes, reservoirs and borrow pits.

AN IN-THE-FIELD APPROACH

Performing ecological surveys (surface and underground waters, sediments, fauna and flora) is an essential task in all projects comprising an environmental approach.

MASTERING ECOLOGICAL AND PLANT ENGINEERING

A pioneer in this field, CNR now masters ecological and plant engineering techniques to restore, rehabilitate and create natural environments.

RESEARCH AND DEVELOPMENT

Our ongoing R&D activity allows us to offer you alternative techniques that are both socially and environmentally friendly, such as phytoremediation for treating polluted soils.

AREAS OF ACTION

- ◆ Hydro-ecological diagnosis
- ◆ Enhancement and restoration of natural environments
- ◆ Management of natural sites
- ◆ Contaminated sites, sediments and soils
- ◆ Regulatory documents and impact studies

SERVICES

- ◆ Technical Expertise
- ◆ Environmental diagnosis and monitoring
- ◆ Preliminary studies, feasibility studies
- ◆ Full design engineering
- ◆ Consulting and work supervision

A FEW REFERENCES

HYDRO-ECOLOGICAL DIAGNOSTICS

France:
- monitoring the hydrobiological quality of the Rhône by determining benthic invertebrates according to an experimental protocol.

Columbia:
- ecological diagnosis in the framework of a project to improve navigation on the River Magdalena.

ENHANCEMENT AND RESTORATION OF NATURAL SITES

France:
- ecological study of the riparian zone of the Bourget Lake (water quality, sediments, erosion) and design of a project to protect reed beds (breakwaters and islands).
- restoration of the oxbows of the Rhône river : increase of compensation water, ecological restoration, revegetation.

MANAGEMENT OF NATURAL SITES

France:
- study of methods and resources for combating the proliferation of an invasive species, *Amorpha fruticosa*.
- study of integrating 6 hydropower plants in the landscape of the Rhône.

CONTAMINATED SITES, SOILS AND SEDIMENTS

France:
- diagnosis of polluted sites and soils in the 29 industrial and port areas belonging to CNR's concession and the formulation of a ten year plan.
- feasibility study of phytoremediation treatment of a site contaminated by heavy metals.

REGULATIONS AND IMPACT STUDIES

France:
- Public enquiry and impact study in the framework of making the upper-Rhône navigable for pleasure craft.
Uruguay:
- impact study in the framework of a regional project to develop and improve navigability on the River Uruguay.

Studies for combating invasive species (*Amorpha fruticosa*)



Ecological restoration and revegetation of oxbows