



European  
Commission



# Natural Water Retention Measures

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## *Individual NWRM* *Lake restoration*



Environment

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## I. NWRM Description

A Lake is a water retention facility. It can store water (for flood control) and provide water for many purposes such as water supply, irrigation, fisheries, tourism, etc. In addition, it serves as a sink for carbon storage and provides important habitats for numerous species of plants and animals, including waders. In the past, lakes have sometimes been drained to free the land for agriculture purposes, or have simply not been maintained and have silted up. Restoring lakes consists in enhancing their structure and functioning where they have been drained in former times.

## II. Illustration



Perch lake, (USA)

Source: <http://giizis13.wordpress.com/page/3/>

## III. Geographic Applicability

| Land Use                       | Applicability | Evidence                                                                                                                                                              |
|--------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Artificial Surfaces            | No            | The restoration of lakes and surroundings, wetlands, bogs, fens, mires, as well as forests and agricultural lands if they are in the vicinity of the lake to restore. |
| Agricultural Areas             | Possible      |                                                                                                                                                                       |
| Forests and Semi-Natural Areas | Possible      |                                                                                                                                                                       |
| Wetlands                       | Yes           |                                                                                                                                                                       |

| Region         | Applicability | Evidence                                                                                                          |
|----------------|---------------|-------------------------------------------------------------------------------------------------------------------|
| Western Europe | Yes           | The restoration of lakes and surroundings can take place anywhere as long as there is a (current or former) lake. |
| Mediterranean  | Yes           |                                                                                                                   |
| Baltic Sea     | Yes           |                                                                                                                   |

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|                           |     |  |
|---------------------------|-----|--|
| Eastern Europe and Danube | Yes |  |
|---------------------------|-----|--|

### IV. Scale

|                                       | 0-0.1km <sup>2</sup>                                                                                                                                                               | 0.1-1.0km <sup>2</sup> | 1-10km <sup>2</sup> | 10-100km <sup>2</sup> | 100-1000km <sup>2</sup> | >1000km <sup>2</sup> |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------------|-----------------------|-------------------------|----------------------|
| Upstream Drainage Area/Catchment Area | No                                                                                                                                                                                 | No                     | Possible            | Yes                   | Yes                     | Yes                  |
| Evidence                              | Lakes, by their size, could drain large catchment areas. Under 1 km <sup>2</sup> , the temperatures of water, stream and dynamic evolution are more phenomena of ponds than lakes. |                        |                     |                       |                         |                      |

### V. Biophysical Impacts

| Biophysical Impacts      |                                                   | Rating | Evidence                                                                                                                                                                                                                                                                            |
|--------------------------|---------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Slowing & Storing Runoff | Store Runoff                                      | High   | This measure, by enhancing the lake structure (size) and functioning, in particular by cleaning out the accumulated sediment, can increase its capacity for storing runoff. The runoff storage is equal to the total volume of the lake minus the volume already occupied by water. |
|                          | Slow Runoff                                       | Medium | This measure, by enhancing the lake structure (size) and functioning, can slow down the runoff                                                                                                                                                                                      |
|                          | Store River Water                                 | High   | This measure, by enhancing the lake structure (size) and functioning, can increase its capacity for storing river water                                                                                                                                                             |
|                          | Slow River Water                                  | Medium | This measure, by enhancing the lake structure (size) and functioning, can slow down the river water                                                                                                                                                                                 |
| Reducing Runoff          | Increase Evapotranspiration                       | Low    | Evapotranspiration might change according to the surface area and/or extent of riparian habitat.                                                                                                                                                                                    |
|                          | Increase Infiltration and/or groundwater recharge | Low    | A lakes has more a storage function than an infiltration function. The impact of its restoration will be limited to the restoration of the associated alluvial groundwater.                                                                                                         |
|                          | Increase soil water retention                     | Low    | Soil water retention might change according to the surface area and/or extent of the lake and its riparian habitat.                                                                                                                                                                 |
| Reducing Pollution       | Reduce pollutant sources                          | None   |                                                                                                                                                                                                                                                                                     |
|                          | Intercept pollution pathways                      | Low    | As the river runoff and water are slowed down, pollutants can deposit easier in the lake                                                                                                                                                                                            |

|                    |                                         |      |                                                                                                                                                                                                                                                                                                                                                  |
|--------------------|-----------------------------------------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Soil Conservation  | Reduce erosion and/or sediment delivery | High | As the river runoff and water are slowed down, sediment can deposit easier in the lake, therefore reducing sediment delivery on the river. At the opposite, this can accelerate erosion processes in the river, if the deposition and therefore reduction of coarse sediment in the lake is too important.                                       |
|                    | Improve soils                           | Low  | Soil quality might change according to the surface area and/or extent of the lake and its riparian habitat.                                                                                                                                                                                                                                      |
| Creating Habitat   | Create aquatic habitat                  | High | Lake restoration increases the preservation of aquatic species and habitats (in the lake and not in the rivers).                                                                                                                                                                                                                                 |
|                    | Create riparian habitat                 | High | Lake and surrounding restoration could have an impact on the riparian vegetation by rebuilding or creating natural environment for riparian species. The creation of riparian habitat could be made directly by artificial facilities or indirectly by favouring the riparian vegetation development and conservation or rehabilitation of banks |
|                    | Create terrestrial habitat              | None |                                                                                                                                                                                                                                                                                                                                                  |
| Climate Alteration | Enhance precipitation                   | None |                                                                                                                                                                                                                                                                                                                                                  |
|                    | Reduce peak temperature                 | None |                                                                                                                                                                                                                                                                                                                                                  |
|                    | Absorb and/or retain CO <sub>2</sub>    | None |                                                                                                                                                                                                                                                                                                                                                  |

## VI. Ecosystem Services Benefits

| Ecosystem Services         |                                          | Rating | Evidence                                                                                                                                                                                               |
|----------------------------|------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Provisioning               | Water Storage                            | High   | The lake constitutes a natural or artificial reservoir.                                                                                                                                                |
|                            | Fish stocks and recruiting               | High   | The lake constitutes a natural biological reservoir. Fish stocks could be increased by improving habitat, temperature and water quality.                                                               |
|                            | Natural biomass production               | High   | Since it creates new habitats (aquatic, riparian and terrestrial), this measure increases the biomass production.                                                                                      |
| Regulatory and Maintenance | Biodiversity preservation                | High   | Lake restoration allows the restoration of the food chain by improving the production of phytoplankton and zooplankton, creating optimum conditions for the aquatic and terrestrial linked ecosystems. |
|                            | Climate change adaptation and mitigation | None   |                                                                                                                                                                                                        |

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|          |                                |        |                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------|--------------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | Groundwater / aquifer recharge | Low    | Lakes can have an infiltration function.                                                                                                                                                                                                                                                                                                                                                                        |
|          | Flood risk reduction           | Medium | As lakes have a storage function, their better capacity for storage due to restoration actions can allow reducing the flood risk                                                                                                                                                                                                                                                                                |
|          | Erosion / sediment control     | High   | The impact dealing with sediment is mostly linked to the storage function of the lake, creating more erosive conditions by increasing the outfall water erosive power. Cleaning out the sediment accumulated in the lake could improve sediment transit by reducing sediment storage and the lake filling speed.                                                                                                |
|          | Filtration of pollutants       | Low    | Closely linked to sediment storage, filtration of pollutants will be dependent on sediment management practices, mainly cleaning out the sediment accumulated in the lake, as well as pollutants controlled release practices around the lake.                                                                                                                                                                  |
| Cultural | Recreational opportunities     | High   | Lake restoration can be synonymous of biodiversity development and so of an increasing fauna and flora attraction.<br><br>The development of tourism is supported by aquatic activities and infrastructures that should be integrated to the environment. Lake can become a “lived” and living recreational and natural area for the population, legitimizing the financial resources used for its restoration. |
|          | Aesthetic / cultural value     | High   |                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Abiotic  | Navigation                     | None   |                                                                                                                                                                                                                                                                                                                                                                                                                 |
|          | Geological resources           | None   |                                                                                                                                                                                                                                                                                                                                                                                                                 |
|          | Energy production              | None   |                                                                                                                                                                                                                                                                                                                                                                                                                 |

## VII. Policy Objectives

| Policy Objective                                              |                                                         | Rating                                                                                                                                                                                                          | Evidence                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Water Framework Directive</b>                              |                                                         |                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                        |
| Achieve Good Surface Water Status                             | Improving status of biological quality elements         | High                                                                                                                                                                                                            | Lake restoration is a key point to reach a good water ecological status. Improving water circulation, habitat for aquatic species, growing of the riparian vegetation, limitation of invasive species... are all dedicated to foster an autonomous dynamic of the lake.                                                                                                                                |
|                                                               | Improving status of physico-chemical quality elements   | Medium                                                                                                                                                                                                          | Potential to improve water quality in receiving water bodies through reduction in sediment loading and addressing urban diffuse pollution. Potential to reduce chemical pollution and improve the chemical status of surface water downstream as it can control pollution related to pesticides and others, adsorbing it in soil particles that are eroded and end up in surface aquatic environments. |
|                                                               | Improving status of hydromorphological quality elements | Medium                                                                                                                                                                                                          | Reduction in river peak runoff rates may reduce channel erosion during storm events.<br>On the other hand, lakes decrease sediment transport downstream, which might lead to erosion                                                                                                                                                                                                                   |
|                                                               | Improving chemical status and priority substances       | Low                                                                                                                                                                                                             | Lake role regarding the chemical status and the priority substances could be thought through a management plan of sediment, especially by cleaning out the sediment accumulated in the lake. Sediment concentrate pollutants and so priority substances. If it's not possible to act on releases upstream, a special management plan should be drafted in the same time of the restoration plan.       |
| Achieve Good GW Status                                        | Improved quantitative status                            | Low                                                                                                                                                                                                             | Lake restoration can allow increasing infiltration and groundwater recharge.                                                                                                                                                                                                                                                                                                                           |
|                                                               | Improved chemical status                                | Low                                                                                                                                                                                                             | As lake restoration can have a role in pollutant deposition, they can have a role in improving the chemical status of groundwater                                                                                                                                                                                                                                                                      |
| Prevent Deterioration                                         | Prevent surface water status deterioration              | Medium                                                                                                                                                                                                          | As lake restoration can play a role in improving biological, physical and chemical status of water surface, they can prevent surface water status deterioration                                                                                                                                                                                                                                        |
|                                                               | Prevent groundwater status deterioration                | Low                                                                                                                                                                                                             | As lake restoration can have a role in pollutant deposition, they can prevent groundwater status deterioration                                                                                                                                                                                                                                                                                         |
| <b>Floods Directive</b>                                       |                                                         |                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                        |
| Take adequate and co-ordinated measures to reduce flood risks | Medium                                                  | Reduction and storage of surface runoff will contribute to reduced peak flows in receiving watercourses, effectively maintaining the natural flood risk capacity of a catchment and its natural water features. |                                                                                                                                                                                                                                                                                                                                                                                                        |

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| <b>Habitats and Birds Directives</b>                                  |      |                                                                                                                                                                |
|-----------------------------------------------------------------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Protection of Important Habitats                                      | High | As lake restoration is a key point to reach a good water ecological status, it can allow protecting important habitats                                         |
| <b>2020 Biodiversity Strategy</b>                                     |      |                                                                                                                                                                |
| Better protection for ecosystems and more use of Green Infrastructure | High | As lake restoration is a key point to reach a good water ecological status, it can allow better protection for ecosystems and more use of Green Infrastructure |
| More sustainable agriculture and forestry                             | None |                                                                                                                                                                |
| Better management of fish stocks                                      | High | As lake restoration is a key point to reach a good water ecological status, it can allow better management of fish stocks                                      |
| Prevention of biodiversity loss                                       | High | As lake restoration is a key point to reach a good water ecological status, it can allow preventing biodiversity loss                                          |

## VIII. Design Guidance

| <b>Design Parameters</b>      | <b>Evidence</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dimensions                    | <p>Very variable. Typical area: 10 ha (&gt;4ha); Typical depth: &gt;5m. But these numbers are only indicative as the definition of a lake is vague and based on non-quantifiable criteria such as the fact that sun light does not penetrate until the bottom of the lake, or the fact that surface waves prevent the formation of vegetation on the shore of the lake.</p> <p>For high impact on water river storage, hydraulic infrastructures should be built or modified to increase the total volume lake capacity storage.</p> <p>Another way to improve the water storage is to build a water management plan able at taking into account all uses and their variability.</p> |
| Space required                | The space required is highly variable depending on the size of the lake, the topography, the contributing rivers and streams.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Location                      | It would be sensible to take into account the natural design in order to minimize artificial landscaping.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Site and slope stability      | n/a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Soils and groundwater         | n/a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Pre-treatment requirements    | n/a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Synergies with Other Measures | n/a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |



## **IX. Cost**

| Cost Category            | Cost Range | Evidence                                                                                      |
|--------------------------|------------|-----------------------------------------------------------------------------------------------|
| Land Acquisition         | /          | No information                                                                                |
| Investigations & Studies | /          | No information                                                                                |
| Capital Costs            | 4 000€/ha  | Habitat restoration at Croxall Lakes Nature Reserve                                           |
| Maintenance Costs        | Minimal    | Since these lakes have long lifespan, once in operation only minimal maintenance costs arise. |
| Additional Costs         | /          | Infrastructures for green tourism development                                                 |

## **X. Governance and Implementation**

| Requirement                        | Evidence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Definition of the responsibilities | The effective restoration and maintenance of lakes may include local planning authorities, environmental regulators, private landowners and land managers, farmers and other bodies with responsibilities water management (e.g. irrigation bodies, drainage boards, etc).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Monitoring                         | <p>The water storage should be managed in order to satisfy the different uses (recreative, agriculture, ecosystems, irrigation...). The impact will depend of existing uses, priorities and elaboration of guidance documents for management.</p> <p>In water scarce areas or areas in which agriculture is practiced, there may be some direct reuse of water from the lakes without monitoring water quality. But in the vast majority of situations, monitoring is recommended in order to provide confidence in the effectiveness of the measure.</p> <p>Concerning protection against floods, rehabilitation of dykes appears as the main measure of improving it, as this restores the lake storage capacity. Lake restoration implies most of the time a change in management practices. Protection against floods could be improved by a better management of water levels. Efficient management of flood risk should be seen as an integrated strategy taking into account all uses.</p> |

## **XI. Incentives supporting the financing of the NWRM**

| Type | Evidence                                                                                           |
|------|----------------------------------------------------------------------------------------------------|
| CAP  | The GAEC standards include retention of landscape features and establishment/retention of habitats |

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|--------------|-----------------------------------------------------------------------------------------------------------|
| LIFE Program | Restoration of lakes supports the creation and conservation of natural habitats and improves biodiversity |
|--------------|-----------------------------------------------------------------------------------------------------------|

## **XII. References**

| Reference                                                                                                                                              | Comment                                                                                                                                                                       |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| “Costs, benefits and climate proofing of natural water retention measures”                                                                             | Stella Consulting, NWRM Final Report - May 2012                                                                                                                               |
| Role of flood storage ability of lakes in the Changjiang River catchment, T. Nakayama, M. Watanabe, Global and Planetary Change 63 (2008) 9–22         |                                                                                                                                                                               |
| Design, implementation and cost elements of Green Infrastructure projects, Naumann, S., McKenna, D., Kaphengst, T., Pieterse, M. and Rayment, M., 2011 | <a href="http://ec.europa.eu/environment/enveco/biodiversity/pdf/GI_DICE_FinalReport.pdf">http://ec.europa.eu/environment/enveco/biodiversity/pdf/GI_DICE_FinalReport.pdf</a> |