European Commission

NWRM

Natural Water Retention Measures

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Service contract n°07.0330/2013/659147/SER/ENV.C1

Case Study

Restoration of Oroklini Lake (Wetland)

Environment

This report was prepared by the NWRM project, led by Office International de l'Eau (OIEau), in consortium with Actéon Environment (France), AMEC Foster Wheeler (United Kingdom), BEF (Baltic States), ENVECO (Sweden), IACO (Cyprus/Greece), IMDEA Water (Spain), REC (Hungary/Central & Eastern Europe), REKK inc. (Hungary), SLU (Sweden) and SRUC (UK) under contract 07.0330/2013/659147/SER/ENV.C1 for the Directorate-General for Environment of the European Commission. The information and views set out in this report represent NWRM project's views on the subject matter and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this report. Neither the Commission nor any person acting on the Commission's behalf may be held Key words: Biophysical impact, runoff, water retention, effectiveness - Please consult the NWRM glossary for more information.

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I. Basic Information

Application ID *(Country_Numeric, e.g.: Greece_01)*	*Cyprus_03*			
Application Name *(provide a short name)*	Restoration of Oroklini Lake (Wetland)			
Application Location	Country: *(select from list in Annex 1)*	Cyprus	Country 2: *In case of transboundary applications*	
	NUTS2 Code *(select from list in Annex 1)*	*CY00*		
	River Basin District Code *(select from list in Annex 1)*	*CY001*		
	WFD Water Body Code *(select from list in Annex 1)*			
	Description *(free text, short description of the location)*	*Oroklini lake is a small shallow brackish lake located close to the coast of Larnaca, within the Oroklini municipality premises.*		
Application Site Coordinates *(in ETRS89 or WGS84 the coordinate system)*	Latitude: 34,967222 *(WGS84)*		Longitude: 33,650833 *(WGS84)*	
Target Sector(s)	Primary:	Hydromorphology		
	Secondary:	Urban		
Implemented NWRM(s)	Measure #1:	*N2*		
Application short description	Several water management measures were applied in order to retain water within the lake basin and fit the needs of target species found in the wetland. In order to restore Oroklini lake, several water management and habitat management measures were applied. These measures aimed to secure water presence in the lake, mainly in order to fit the needs of two nesting species; the Black-winged Stilt *Himantopus himantopus* and the Spur-winged Lapwing *Vanellus (Hoplopterus) spinosus.* These measures included: 1. **Water Management** measures for the retention of water within the lake all year round and mainly in the upper basin. These included investigation of the hydrological features of the lake, restoration of an overflow sluice, flow control measures and re-connection of the different lake areas in the lower basin and removal of earth material that has been used to fill in part of the site. 2. **Habitats management** measures for the restoration of lake habitats. These included the removal of alien species and planting of native species, reed beds management, fencing and creation of suitable nesting grounds for the two target species.			

II. Policy context and design targets

Brief description of the problem to be tackled	Several hydraulic measures were applied in the mid 40's in order to desiccate the Oroklini lake due to health concerns such as malaria, as well as other mosquito-borne diseases. These measures included the creation of drainage canals, plantation of *Eucalyptus* sp. and *Acacia* sp. trees in the area, the earth fill in parts of the lake for cultivations expansion and the creation of an earth embankment of 292m long in order to restrain water in the upper lake basin. The above led to ecosystem degradation and therefore management measures were considered urgent, in order to retain water quantities and restore the wetland. As part of the wetland restoration, water retention measures were aiming at secure water availability in the upper basin of the lake and maintain high water level in order to facilitate the needs of avifauna, instead of flowing and spreading in the lower, larger basin, thus creating small ponds that would dry up in a short time.*Several hydraulic measures were applied in the past in order to desiccate the Oroklini lake due to health concerns. This has led to ecosystem degradation and therefore management measures were considered urgent, in order to retain water quantities and restore the wetland.*		
What were the primary & secondary targets when designing this application? *Select from the drop-down menu.* *The possibility for more than one target is provided. Additional info can be given in the "remark" field to address e.g. other targets not included in the list, and give some details*	Primary target #1:	Other (please describe in the "remarks" below)	
	Primary target #2:	Regulation of hydrological cycle and water flow	
	Secondary target #1:	Regulation of the chemical status of freshwater	
	Secondary target #2:	Natural assimilation (purification) of effluents through dilution, dispersion, and physic-chemical processes	
	Remarks	Restore ecosystem habitats, functions and support biodiversity.	
Which specific types of pressures did you aim at mitigating? *Select the relevant Directive (EU, non-EU) from the drop-down menu and type-in the related pressures. Different types of pressures as identified by EU-Directives (WFD, FD, etc.) are listed in the Annex 2*	Pressure #1:	WFD identified pressure	Degradation of physicochemical and ecological status of the water body.
	Pressure #2:	Other EU-Directive's identified pressure (specify)	Habitats directive : Important habitats degradation
	Pressure #3:	Other EU-Directive's identified pressure (specify)	Birds Directive: Species and their habitats degradation.
	Remarks		
Which specific types of adverse impacts did you aim at mitigating? *Select the relevant Directive (EU, non-EU) from the drop-down menu and type-in the related impacts. Different types of adverse impacts as identified by*	Impact #1:	WFD identified impact	Alteration of ecological and physicochemical status
	Impact #2:	WFD identified impact	Altered habitats due to morphological changes
	Impact #3:	Other EU-Directive's identified impact	Habitats directive : degradation of

EU-Directives (WFD, FD, etc.) are listed in the Annex 2		(specify)	important habitats
	Impact #4:	Other EU-Directive's identified impact (specify)	Birds' directive: degradation of bird species populations and their habitats.
	Remarks		
Which EU requirements and EU Directives were aimed at being addressed? *Select from the drop-down menu the different types of requirements as identified by EU-Directives (WFD, FD, etc.), and provide additional specification.*	Requirement #1:	WFD-achievement of good ecological status	*Specify*
	Requirement #2:	WFD-achieving objectives for Protected areas	*Enforce the community mandates for protected areas.*
	Requirement #3:	Other EU-Directive requirements (Specify)	*Habitats directive : Preservation of important habitats*
	Requirement #4:	Other EU-Directive requirements (Specify)	*Birds directive: Preservation of important bird species and their habitats*
	Remarks		
Which national and/or regional policy challenges and/or requirements aimed to be addressed?	The "Cyprus's Biodiversity Strategy Action Plan" is in line with the "EU Biodiversity Strategy" and the "Global Biodiversity Strategy". It aims at "halting the loss of biodiversity and the degradation of ecosystem services by 2020, and restoring them in so far as feasible, and in parallel strengthen Cyprus' contribution to averting global biodiversity loss". The current project aimed at restoring Oroklini lake in order to provide the appropriate habitats for two target species, in order to sustain their populations.		

III. Site characteristics

Dominant Land Use type(s) *Select from the drop-down menu with the CORINE LU types and codes. Space of additional comments/remarks is provided*	Dominant land use	*411 Inland marshes*
	Secondary land use	*Type in the relevant Code Level3*
	Other important land use	*Type in the relevant Code Level3*
	Remarks	
Climate zone *Select from the drop-down menu*	warm temperate dry	
Soil type *Select from the list with the FAO classes in Annex 3*	Solonchalks	
Average Slope *Select from the drop-down menu*	gentle (2-5%)	
Mean Annual Rainfall *Select from the drop-down menu. Values are in mm,*	300 - 600 mm	
Mean Annual Runoff *Select from the drop-down menu. Values are in mm.*	0 - 150 mm	
Average Runoff coefficient (or % imperviousness on site) *Select from the drop-down menu. Space of additional comments/remarks is provided*	0.3 - 0.5	
	Remarks	
Characterization of water quality status (prior to the implementation of the NWRMs)	Data not available. The lake has not been designated as a water body, although it is assumed that it will be included in the next Article 5 update of the Cyprus river basin. Therefore no monitoring has been implemented in Oroklini lake by today for the purposes of WFD.	
Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	*Positive way: The restoration of the wetland is expected to improve the biological functions of the ecosystem and therefore improve the water quality of the lake.* The construction of an earth embankment in the area since the 40's provided a retention structure that would prove to be a valuable element in the progress of the project. Its presence and the actions for the restoration of the sluice, enabled the retention of water in the upper basin of the lake.	
	Negative way: The low water permeability of the lake sediments does not allow for groundwater recharge and therefore water retention can only by achieved only within the surface water body.	

IV. Design & implementation parameters

Project scale	Small (e.g. farm, plot, building complex, block)	*Small wetland*
Time frame *NWRM(s) Installation date and*	Date of installation/construction (MM.YYYY)	*2012*

lifespan	Expected average lifespan (life expectancy) of the application in years	*>20*
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*
	1. BirdLife Cyprus	Determination of design details of the measure
	2. Game Fund Department	Monitoring
	3. Oroklini Community Board	Implementation
	4. Department of Environment	Monitoring
	5.	
The application was initiated and financed by	The application of measures were funded with EU funds and co-funded by the above authorities through the Life+ project.	
What were specific principles that were followed in the design of this application?	The measures were designed bearing in mind the ecosystem functions and species needs, the achievement of good water quality, the implementation of time-resilient measures and the creation of wetland conditions highly acceptable by the public.	
Area (ha)	Number of hectares treated by the NWRM(s). *e.g. It could be the upstream drainage area in case of retention ponds*	*295*
		The catchment area of the lake is 295 hectares. This can be divided to: - 6 hectares of the upper basin were water is retained - 31.5 hectares of the lower basin - 257.5 hectares the catchment basin of the lake
Design capacity	The calculations indicate that a maximum of 23 428m^3 of water can be retain according the design of the restored weir. Besides this, other benefits such as the biodiversity enhancement and the water pollutants removal cannot be calculated.	
Reference to existing engineering standards, guidelines and manuals that have been used during the design phase	*Reference*	*URL*
	1.	
	2.	
	3.	
	4.	
	5.	
Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?	The presence of a sluice even if it had been previously breached and was not functional, was a determining factor for the restoration works. It was preferred and deemed appropriate to restore the present structure instead of designing and constructing a new weir. The restoration of vegetation was limited to species already present in the lake due to the brackish character of the lake.	

	Finally, in the lower basin, the presence of blocked canals imposed the need of reconnecting them in order to allow water to spread in the whole lower basin area.

V. Biophysical impacts

Impact category (short name) Select from the **drop-down menu** below:	**Impact description** (Text, approx. 200 words)	**Impact quantification** (specifying units)	
		Parameter value; units	% change in parameter value as compared to the state prior to the implementation of the NWRM(s)
Runoff attenuation / control	*Describe the impact on runoff reduction and/or control*		
Peak flow rate reduction	*The measures have minor impact in flow reduction due to the high capacity of the lake.*		
Impact on groundwater	*It is expected that the ground water level will be slightly increased due to the low permeability of the lake sediments.*	*Infiltration rate: >3mm/h*	*NA*
Impact on soil moisture and soil storage capacity	*Describe the impact on the soil moisture and soil retention capacity*		
Restoring hydraulic connection	*The measures will decrease the outflow of water towards the sea and therefore improve the hydro morphological characteristics of the lake.*	Although a temporal lake, water was present in the lake until September; i.e. 1-2 month more than previous years.	
Water quality Improvements	*Such an investigation has not been commenced but the retention of water quantities in the lake basin is assumed to have improved wetland habitats and biodiversity.*	Increased water residence was observed in 2014. The lake was flooded during summer despite the low precipitation. Increased numbers of water birds were observed in 2013	

		-2014	
WFD Ecological Status and objectives	*The wetland has not been monitored for the purposes of WFD but the retention of large water quantities is thought to somehow restore biotic functions and therefore increase biodiversity and the overall status of the lake.*		
Reducing flood risks (Floods Directive)			
Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)	*The accumulation of water upstream the retention dam has improved habits of wading birds and especially for species belonging to the Annex I of the Bird Directive.*	Increased biodiversity was verified by observations such as: Nesting Spur-winged Lapwing and Stone-curlew were recorded on the restored field. First record of Little Egret nesting. Kentish Plover nests. The last breeding record was in 2007. Cattle Egrets nested for the first time. On nesting islets created Spur-winged Lapwings nested. Eels were observed in the lake for the first time.	
Soil Quality Improvements			
Other			

VI. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application?	Elevated amounts of water and for a greater period have resulted in increased biodiversity in the area and especially increased numbers of wading birds. This has raised the public interest for the wetland and mild tourist activity has been observed.

	The restoration of the lake through the retention of water seems to be changing the attitude of locals towards the wetland.		
Financial costs	***Total:***	*1 050 000 €*	*Once the Measures are in place, it is estimated that the operation and maintenance cost is insignificant*
	Capital:	*1 000 000 €*	*The initial works (embankment, channels, etc) were established 7 decades ago so the capital cost can only be assumed and brought to Net Present Value*
	Land acquisition and value:	*0 €*	*Affected Land is Governmental*
	Operational:	*25 000 €*	*This refers to the actions of the LIFE+ project related to NWRMs i.e. wetland restoration.*
	Maintenance:	*25 000 €*	
	Other:	*0 €*	*Text / Specify*
Were financial compensations required? What amount?	*Was financial compensation required: No*		
	Total amount of money paid (in €): No		
	Compensation schema:		
	Comments / Remarks:		
Economic costs	*Actual income loss: Not applied*		
	Additional costs: No		
	Other opportunity costs: None		
	Comments / Remarks:		
Which link can be made to the ecosystem services approach? *Hint: The actual benefits of improving nature's water storage capacity are essentially linked to an improved provision of some of the following ecosystem goods and services:* - *Freshwater for drinking.* - *Water provision to deliver water services to the economy both for drinking and non-drinking purposes.* - *Water security (reliability of supply and resilience to drought).*	The measures provides several ecological services such as increased biodiversity, Habitat for species/ Maintenance of genetic diversity, slight reduction of peak flows, Moderation of extreme events, nutrient uptake, natural areas for recreational activities, better water quality, increased water infiltration and increased riparian cover.		

- *Health security (control of waterborne diseases).* - *Flood security and protection.* - *Storm surge protection.* - *Biomass production.* - *Amenities (associated to habitat protection): fish and plants, tourism, recreation, and others.* - *Benefits of improved coastal water quality and ecological status for a sustainable commercial production of shellfish with human health and welfare values.*	

VII. Monitoring & maintenance requirements

Monitoring requirements	No specific monitoring needs. Monitoring can be commenced for water level, water quality, species and habitats in order to better understand ecosystem processes and apply better management practices.
Maintenance requirements	Reed beds management in order to avoid abstraction of the inflow streams and the wetland encroachment by reed beds.
What are the administrative costs?	Expenses for reed bed management and inflow streams.

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts?	Comparison of pre- and post- measures application.
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	Info N/A
How cost-effective are NWRM's compared to "traditional / structural" measures?	Info N/A
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	The urban expansion in the drainage basin of the lake, increases point and diffuse pollution sources and other pressures. This can have adverse effects on the wetland quality and therefore affect the measures effectiveness on biodiversity and water purification. Additionally it is expected to increase the inflow into the lake.
What is the standard time delay for measuring the effects of the measures?	1 - 4 years

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	Attitude of landowners within and in the periphery of the lake. The surrounding area is used for agriculture purposes and the lake restoration included the reclamation of public

	land from agriculture. In addition a flea market in the area was active and had to be closed, thus creating reactions from the organizers.
What were the main enabling and success factors?	Attitude of decision makers which were very decisive in implementing the measures for the wetland restoration despite the reactions. In addition the attitude of the local Council and authorities which participated in the project and supported the actions implemented. Finally local naturalists and experts which also supported the implementation of the project in order to restore the wetlands functions.
Financing	National and EU funds.
Flexibility & Adaptability	Yes. The baseline conditions present in this case study were the dry conditions and desiccation of the lake due to water management measures taken in the past, the presence of alien species and the wetland encroachment by locals. Therefore targeted measures were taken in order to deal with these conditions. These measures can be adapted to different conditions depending on these conditions nature. For instance increased flows can be tackled by the current works.
Transferability	This application can be selected in lake ecosystems which have been degraded due to bad water management practices and/or have been degraded by decreased water inflow. Additionally the creation of retention ponds can be serve with similar measures such as the creation of embankments and weirs. The restoration of riparian buffers can be realized also by removing alien species and planting native plants. Reclamation of floodplain is another associated measure that can be used in other occasions.

X. Lessons learned

Key lessons	Proper water management with small-scale measures can restore wetlands within urban areas for furthering nature conservation objectives such as wet grassland conditions for rare breeding birds. This at the same time may offer minor flood protection.

XI. References

Source Type	*Project Report*

Source Author(s)	I.A.CO Environmental & Water Consultants Ltd		
Source Title	Determination of important hydrological features for Oroklini Lake" Project LIFE10 NAT/CY/716 for Bird Life Cyprus as Beneficiary.		
Year of publication	2012		
Editor/Publisher	LIFE10 NAT/CY/716 Deliverable		
Source Weblink	http://admin.brainserver.net/uploads/oroklini/Deliverables/Determination_of_important_hydrological_features_for_Oroklini_Lake.pdf		
Key People		*Name / affiliation*	*Contact details*
	1.	*Ayis Iacovides*	*a.iacovides@iaco.com.cy*
	2.	*Iacovos Iacovides*	*iac.iacovides@iaco.com.cy*
	3.		
	4.		

Source Type	*Project Report*		
Source Author(s)	NERCO – N. HLYKAS & Associates		
Source Title	Preparation of a Management Plan for the Oroklini Lake (in Greek)		
Year of publication	2011		
Editor/Publisher	Dept. of Environment MANRE, Cyprus		
Source Weblink			
Key People		*Name / affiliation*	*Contact details*
	1.	*Elena Stylianopoulou*	*estylianopoulou @ environment.moa.gov.cy*
	2.		
	3.		
	4.		

Source Type	*Project Report*		
Source Author(s)	Lefkios Sergides		
Source Title	Oroklini wetland restoration		
Year of publication	2006		
Editor/Publisher	BirdLife Cyprus		
Source Weblink			
Key People		*Name / affiliation*	*Contact details*
	1.	Lefkios Sergides	
	2.		
	3.		
	4.		

XII. Photos Gallery

Figure 1: A small earth-fill retention dam (shown with red) and an overflow sluice (shown with blue) were constructed in 1940, in order to retain water in the upper basin of the lake and prevent its desiccation. These were constructed in order to prevent water from spreading in the lower basin, create conditions favouring mosquitos. Photo: Google earth

Figure 2 : The sluice was abandoned and partly destroyed, and therefore water was released in the lower parts of the wetland. In 2012, the sluice was repaired in the framework of a Life+ project and the retention capacity of the upper basin was increased. Photo: IACO Ltd (2013)

Figure 3 : The earth embankment is about 292m long and has been covered with dense vegetation. Photo:IACO Ltd (2013).

Figure 4: As a result of the NWRMs, the upper basin of the lake retains sufficient amounts of water for sustaining aquatic habitats and species, even in dry years. Photo: IACO Ltd (2013).

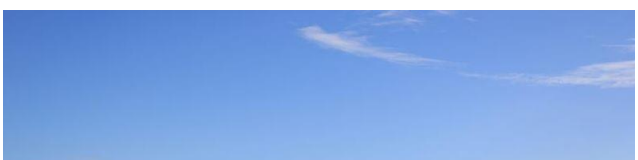

Figure 5: Part of the wetland basin area was reclaimed and restored after its modification to serve a local flee market. Photo: Oroklini Life Project http://www.orokliniproject.org/en/web-pages/2 (2013)