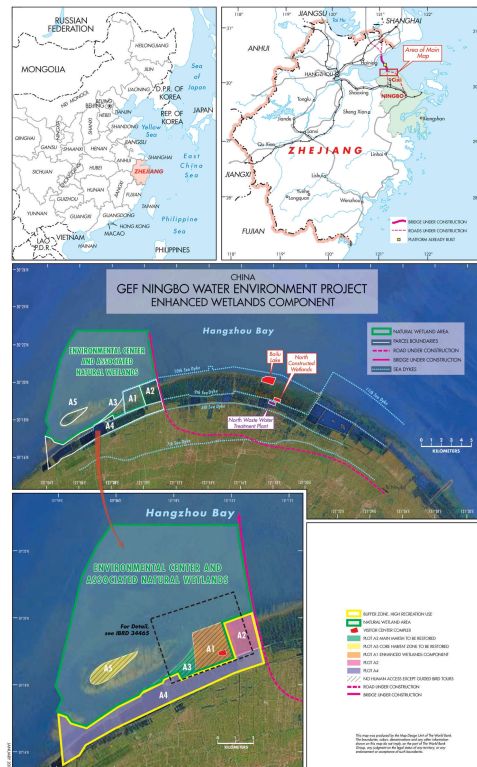


## Designing Constructed Wetlands for Multiple Uses



**Abstract:** The Ningbo Water and Environment Project is being implemented in the Ningbo Municipality of Zhejiang Province in China, south of the Hangzhou Bay. This project aims to reduce land-based pollution along the Cixi coast and the East China Sea, promote innovative low cost wastewater treatment techniques and encourage coastal zone conservation through: a) the construction of a wetland for tertiary treatment of one Cixi city wastewater treatment plant, b) the development of a wetland center with multiple purposes (including wetland restoration, non-point source pollution reduction, bird watching and environmental education) and; c) the dissemination of trainings and workshops to promote various project experiences. This project represents current good practice for multipurpose design for constructed wetland design and wetland restoration.

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# Designing Constructed Wetlands for Multiple Uses

Experience of the GEF - sponsored

## GEF/WB: GEF Ningbo Water and Environment Project

GEFID: 2750, World Bank Project ID: P086505

### PROJECT DESCRIPTION

The Ningbo Water and Environment Project (NWEF) is the first project financed under the Strategic Partnership Investment Fund for Pollution Reduction in the Large Marine Ecosystems (LMEs) of East Asia established by the GEF and World Bank.

In line with the Fund's objective, the overall project development objective is to reduce land-based pollution along the Cixi coast and the East China Sea, promote the replication of innovative low cost wastewater treatment techniques, and encourage coastal zone conservation.

Under a baseline (non-GEF) NWEF, Cixi City Government will invest \$128 million in the provision of waste water collection and treatment services in the city, including for the construction of two waste water treatment plants using a WB loan. The incremental GEF-NWEF (Components 1 – 3 below) forms an integral part of Cixi's wastewater project as it provides improved wastewater treatment through a constructed wetland and the preservation of enhanced wetlands for non-point source pollution treatment.

The Project has three components:

1. **Constructed Wetland** for Tertiary Treatment of the 100,000 m<sup>3</sup>/d Cixi Wastewater Treatment Plant (US\$7.1 million);
2. **Development of a Wetland Center** that consists of two activities: i) enhancement and restoration of degraded wetland and tidal mudflats and ii) construction of a Visitor Center Building and associated facilities for wetland education and research (US\$8.0 million). The Cixi City Government has designated an existing area in the vicinity of the Ningbo-Shanghai Bridge as the Wetland Center.

The Wetland Center covers an area of approximately 43.5 km<sup>2</sup> and includes various

multipurpose plots: i) a recently reclaimed, non-tidal land within the existing sea dike (**Plot A1** with 4.3 km<sup>2</sup>); ii) a tidal marshland to the west of Plot A1 (**Plot A3** with 1.4 km<sup>2</sup>); iii) a low lying island to the north of Plot A3 (**Plot A5** with 1.8 km<sup>2</sup>); and iv) the tidal mudflat/bay section adjacent to Plots A1, A3, and A5, and covering approximately 36 km<sup>2</sup>. **Plots A2** and **A4** would remain agricultural or low-density buffer areas.

As of 2005, all the proposed Wetland Center is owned and managed by the Cixi City Government. In particular, Plot A1 was used as a wetland conservation area, Plots A3 and A5 were contracted to local farmers for crab farming, and the beach and bay areas were contracted to local farmers for shellfish harvest and for fishing.

It is proposed that about 300 ha, or 90% of the land area, of Plot A1 could be ecologically enhanced to establish fluctuating level freshwater wildlife bird ponds and surroundings, or high and low tide habitat for migratory birds. All together, Plots A1, A3 A5, and the tidal mudflats will form an integrated ecological system with birds flying to and from the sites at high and low tides and the removal of human competition from the enhanced natural wetland will provide a better feeding ground and support more birds, fish and other marine life.

3. **Design and Management support** (US\$2.0 million), including: i) a Wetland Center Management Assistance Contract with a NGO/University Consortium; ii) Engineering Design; and iii) Training and Dissemination of Project Experience.

### THE EXPERIENCE

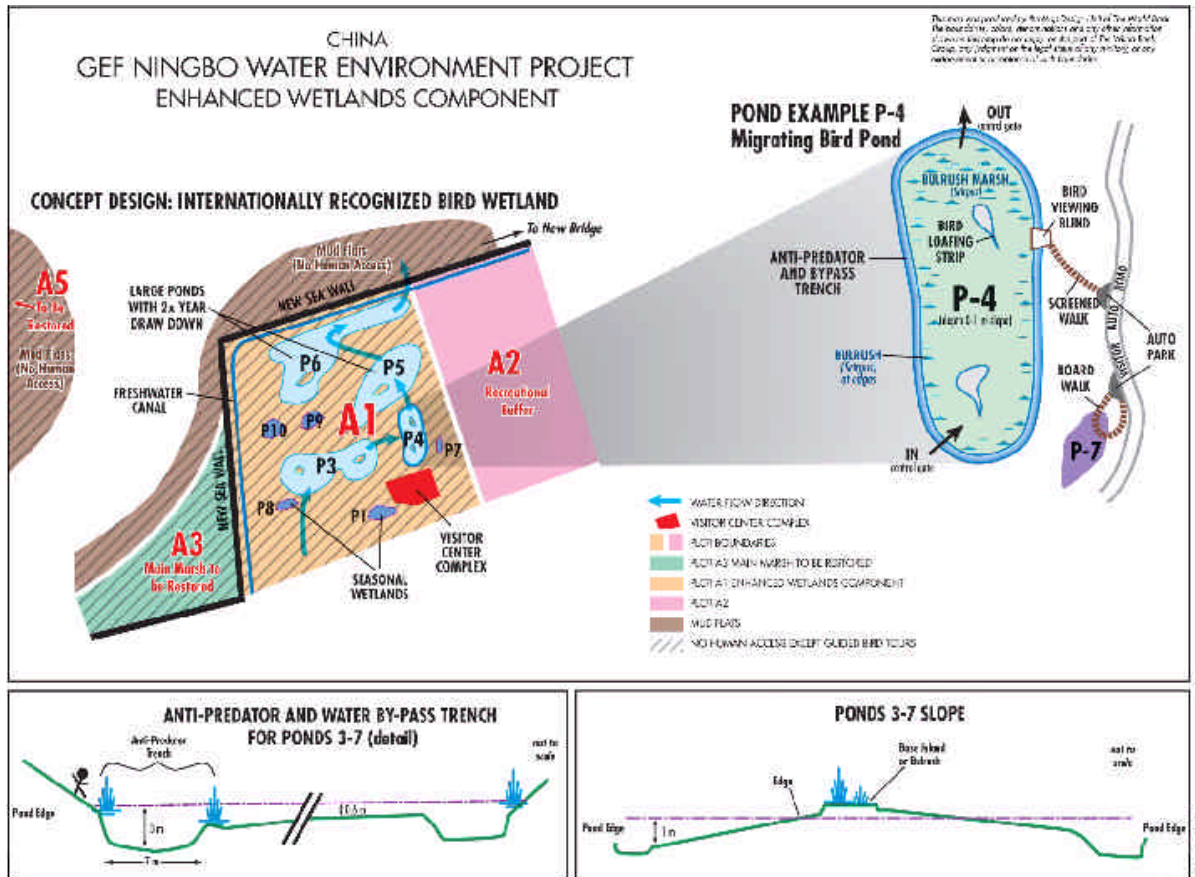
#### TWM ISSUE

East Asia's rapid economic growth has been accompanied by significant environmental degradation. Land-based pollution of the region's seas, coasts, estuaries and rivers is one of its most severe environmental problems and

is degrading the region's large marine ecosystems (LMEs).

Unprecedented economic growth in East Asia has resulted in rapid urbanization, especially in coastal cities. The urban population concentration in coastal regions has caused the

pollution. Coastal wetlands provide natural purification for the run-off before it flows into the sea, as well as an important habitat for migratory birds and marine life. Knowledge of the important eco-system functions provided by wetlands is lacking throughout East Asia. There is a clear need to increase awareness and



seas of East Asia to largely bear the brunt of the environmental impact of this development. The result is that land-based pollution of East Asia's seas, coasts, estuaries and rivers is a severe problem that is well-recognized by the countries in the region, particularly China.

The rapid population growth in coastal cities such as Ningbo is making planning and financing for utility services such as water and wastewater very challenging. Advanced technologies for water and wastewater treatment are often applied in China without considering the financial or operational implications, and then subsequently not utilized.

Non-point source pollution from urban and agricultural run-off is a large and growing problem, and a significant contributor to marine

mobilize public opinion to preserve coastal habitats and reduce land-based sources of pollution.

To help the littoral states address this problem, the GEF and World Bank, in collaboration with other partners such as the GEF/UNDP/IMO Partnership for Environmental Management of the Seas of East Asia (PEMSEA), have established a Strategic partnership for Pollution Reduction Fund for the Large Marine Ecosystems of East Asia.

The NWEF will be the first project implemented under this Fund, and it will be implemented by the Ningbo Municipality, which is located 175 km south of Shanghai, borders Hangzhou Bay, and is China's second-largest port. Investments in water supply and pollution control in the

municipality have lagged far behind its rapid economic development, so its coastline is severely polluted. Its local governments have now declared pollution reduction a priority and adopted a progressive, sub-regional and multi-sector approach to it.

Cixi City, located north of Ningbo Municipality on the shore of Hangzhou Bay, covers an area of 1,100 km<sup>2</sup> and has a population of around one million people. The newly started construction of Cixi-Shanghai Bridge across the Hangzhou Bay (the Hangzhou Bay Bridge) is seen by Cixi as a new opportunity to integrate Cixi into Shanghai and Yangtze Delta Region and therefore will further strengthen Cixi's economy. Millions of visitors are expected to visit Cixi and Ningbo via the new Bridge. In the meantime, new city area is being planned along the Bay on both sides of the Bridge, conservation for wetlands in the Hangzhou Bay area is being initiated, and control of water pollution is expected through the implementation of the newly approved NWEF.

#### *ADDRESSING THE ISSUE*

The NWEF would implement the above approach, and demonstrate a cost-effective and innovative solution, including a constructed wetland for municipal wastewater treatment and a natural wetland conservation area for non-point source pollution control, biodiversity protection, and environmental education. It would also produce multi-focal area benefits and have high replication potential.

This multipurpose approach includes 3 components:

**(i) Wetland Restoration and Conservation:** the high suspended solids concentration in Hangzhou Bay, combined with hydrological and tidal currents, results in overall **sediment accretion** along the northern Ningbo coastline in Cixi City, Ningbo Municipality, with accretion rates on the order of 50-100 meters per year. Consequently, in contrast to most situations, wetland areas are actually being created in Cixi due to the sediment accretion along the coastline. Therefore, the city has the unique opportunity to develop new tracts of land while at the same time preserving its wetland area.

**(ii) Wastewater Treatment** will be addressed by i) two wastewater treatment plants, one in the north of Cixi City (100,000 m<sup>3</sup>/day) and one in the east (50,000 m<sup>3</sup>/d); ii) the north wastewater treatment plant will have a constructed wetland for tertiary treatment (86 ha in total); iii) an associated collection system of mains and link sewers (230 km of pipe and 58 pump stations); and iv) a natural wetland conservation area (43.4 km<sup>2</sup>) that will reduce non-point source pollution, conserve biodiversity, and promote environmental education.

**(iii) Environmental Awareness:** this project shows the growing interest in environmental issues where different points will be used to promote biodiversity protection through various environmental education activities.

#### **RESULTS AND LEARNING**

What can be learnt from this experience is the effectiveness of innovative project design. This allows for 4 lessons worth of highlighting:

1) **Simplify Wastewater Treatment:** China has severe effluent standards for treatment plants discharging into environmentally sensitive receiving water bodies, such as Hangzhou Bay. In an effort to meet these standards, wastewater companies often select technologically sophisticated treatment processes which are complex and expensive to operate. Consequently, many wastewater treatment plants in China do not perform as originally intended due to lack of operating funds and expertise. The GEF project will take advantage of the abundant reclaimed land in Cixi to develop a constructed wetland for tertiary treatment for the North Cixi plant. Even though the constructed wetland has higher initial capital costs than conventional tertiary treatment (chemical coagulation followed by filtration) it has lower operational costs and it is a simpler method.

2) **Consider Ecological Dimensions of Urban Development:** Chinese cities are growing rapidly and transforming agricultural or undeveloped land into industrial, residential, and commercial areas. In the course of this transformation, it is also important to consider environmental and ecological amenities to enhance the quality of life and support the ecosystem. The Cixi City Government has taken



the bold move under the project of reserving significant amounts of land for both the constructed wetland (86 ha) and the Wetland Center (43.5 km<sup>2</sup>) to help preserve coastal resources and provide environmental amenities to its citizens and visitors.

**3) Take into Account Non-Point Source Water Pollution:** Run-off from urban areas and agricultural land can contain large quantities of pollution, particularly nutrients which are contributing to massive red tides in the East Asia Sea. In addition to controlling municipal and industrial dischargers, it is important for Chinese cities to begin to tackle non-point sources of pollution in order to achieve ambient water quality objectives. This project intends to demonstrate an innovative and ecologically friendly approach to non-point source control by filtering water from nearby canals through an enhanced wetland system in the Wetland Center to improve water quality.

**4) Full involvement of local stakeholders.** The development of this project has involved a wide group of local stakeholders in government as well as NGOs, and key research institutes and universities which have been working on pollution and conservation issues in Hangzhou Bay. Stakeholder workshops have been organized with representatives from Ningbo and Cixi agencies, various NGOs and wetland researchers, who were invited first to develop a sustainable vision for the project and then to review the conceptual design of the project prepared by consultants. Engaging these stakeholders in the project development process, has helped reach consensus on key activities of the project (size and functions of wetland center and constructed wetland, etc). It is foreseeable that such consensus will facilitate the implementation of the project.

## REPLICATION

This project starts implementation in September 1, 2006 and therefore not much can be said about implementation activities or challenges specific to replication. However, various replication strategies can be drawn from project design, including: a) the **replication of innovative low cost waste water treatment techniques** and b) **promotion of coastal zone conservation**.

As part of the Strategic Partnership Investment Fund for Pollution Reduction in the Large Marine Ecosystems of East Asia, this project will fund various trainings and workshops domestically and internationally (US\$200,000). These trainings and workshops will support dissemination both of innovative wastewater treatment techniques as well as wetland conservation in China and in East Asia.

In the case of wetland conservation, the Wetland Center will be a key replication mechanism for the project as the idea behind it is that it will serve as a source of information for people throughout China and East Asia who can visit the center and can learn more about wetland conservation and wastewater treatments.

Once implementation starts, various monitoring indicators will be used to measure project progress. Monitoring the number of visitors to the Wetland Center could then be a proxy for measuring future replication.

Two specific conditions worth to highlight about the project design are: i) **local government support**, where the mayor of the Cixi city was very supportive of the project even when the techniques were new and unproven, he was also willing to allocate a very large amount of coastal land for environmental purposes. The challenge would then be to get other majors so far-sighted; ii) **Wetland extension**, initially the wetland set aside was much lower and only after calculations of water retention were done, it was determined that a greater area was required (Source STAP study).

## SIGNIFICANCE

This project is one of the first constructed wetland conservation projects in China. Its significance has been finding innovative, simplified and effective methods for wastewater treatment (i.e., multipurpose wetland) while at the same time building public support (i.e., through creation of a visitor center) for pollution control and environmental conservation in the region, with the potential to be expanded in the country and be also an example for other Asian countries.

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## KEYWORDS

- ◆ Waste Water Treatment
- ◆ Innovative Project Design
- ◆ Constructed Multipurpose Wetland
- ◆ Wetland Restoration
- ◆ Nutrient reduction

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