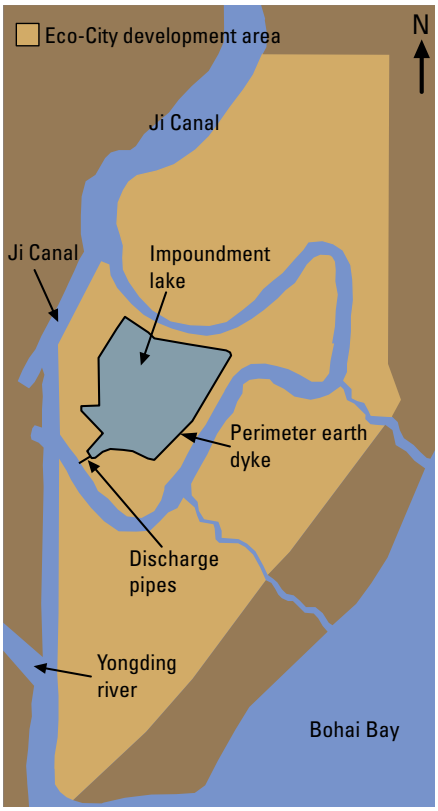
Lakes and impoundments: Wastewater impoundment lake remediation, Tianjin Eco-City, China

Tianjin Eco-City is a 30 km^2 modern city project currently under joint development by the governments of Singapore and China. Located 40 km from Tianjin and 150 km Southeast of Beijing the project is scheduled to house a population of 350,000 when it is completed around 2020. Tianjin Eco-City will use sustainable technologies, such as solar and wind power, plus innovative wastewater treatment and seawater desalination to reduce its carbon footprint. The new city is designed to be ecologically friendly with existing wetlands and biodiversity preserved or improved.

Located within the Eco-City development area is an existing 3.0 km^2 wastewater impoundment lake that has been receiving domestic and industrial wastewater from the local Hangu District since the mid 1970's. The wastewater impoundment lake is surrounded by a 3 m high perimeter earth dyke and has an impoundment capacity of 5.6 million m^3. At the Southern end of this lake are two pipe sluice gates which enable lake discharge via the 1,000 year old Ji Canal directly to the Bohai Sea. During the rainy season when the Ji Canal is prone to overflowing, the sluice gates are closed to prevent river water backflow into the wastewater impoundment lake.

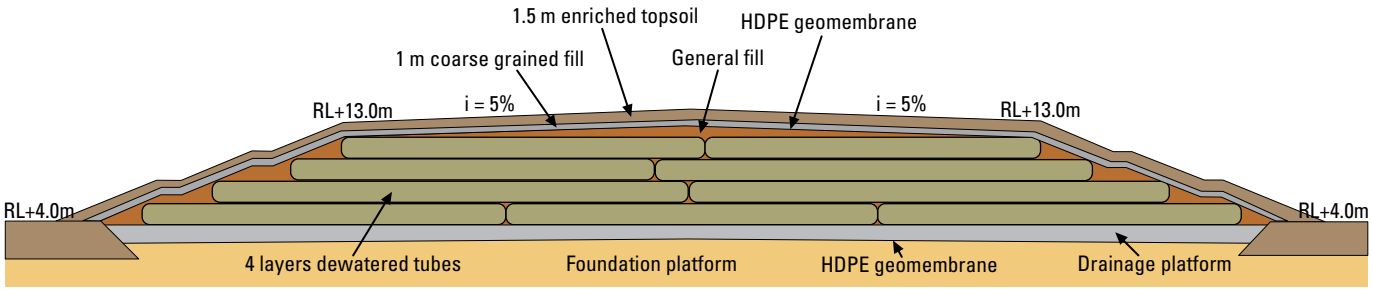
Central to the Eco-City development is the plan to remediate the wastewater impoundment lake that has become laden with contaminated sediments as a result of years of domestic and industrial waste runoff. The water and sediments within the impoundment are contaminated with high levels of heavy metals of mercury, arsenic, copper and cadmium, as well as hexachlorobenzene and DDT. According to the plan the wastewater impoundment was to be transformed into a wetland and recreational lake.



Eco-City development area showing location of impoundment lake

The remediation solution required the contaminated sediments to be dredged from the lake and dewatered to a consistency that allowed them to be used as the fill material for the construction of a landscaped mound along the Western shore of the transformed lake. Geotube® dewatering containers were used to contain the dredged contaminated sediments and dewater the material to a consistency similar to that of compacted borrow material. A total of 2,400,000 m^3 of contaminated sediments were dredged and dewatered in order to construct the landscaped mound.

To begin with, a Geotube® dewatering platform was constructed on a reclaimed platform extending from the Western side of the lake. The close proximity of the dewatering platform to the dredging operation minimised the piping and pumping energy required to move the contaminated sediment slurry to the dewatering facility. The dewatering facility was designed along the same concept as an on-site waste containment facility. Thus, when dewatered, the contaminated sediment solids do not need to be removed to an external landfill, but are capped insitu.



Capped mound containing the dewatered contaminated sediments

The contaminated sediment solids remain within the Geotube® container units which are in turn secured within a geomembrane lined facility with both lower and upper barrier systems.

Because of the large scale nature of the dewatering project it was decided to carry out a full scale prototype dewatering test in order to determine accurate dewatering parameters that could be used in the final detailed design. By maintaining a constant sediment slurry inflow rate during filling the dewatering rates both during Geotube® filling and drawdown were recorded over specific time increments. Also, the quality of the effluent water was tested at different time increments. This enabled a determination to be made of project dewatering rates and the volumes and numbers of Geotube® dewatering containers required. It also confirmed the dosing levels of the chemical dewatering accelerant that had been determined in prior small scale testing.

Following the full scale prototype test, detailed design, tender and construction followed.

Three dredges with a combined dredging capacity of 3,000 m^3/hr were used to deliver the contaminated sediment slurry to the dewatering platform. Prior to reaching the Geotube® containers the incoming slurry was dosed with the required concentration of chemical dewatering accelerant. Multiple valve controls were provided at regular intervals along the incoming slurry pipeline to allow convenient branching to fill the layout of the Geotube® containers with sediment slurry. Generally, at any time, 6 Geotube® containers were filled simultaneously.

When the Geotube® containers were filled to the control height of 3 m, the slurry control valves were shut with the sediment slurry being diverted to an adjacent battery of 6 tubes laid out ahead of time. The Geotube® containers were allowed to dewater for a few days before being filled again to the control height. This filling and dewatering was carried out over 6 or 7 cycles before a new layer of Geotube® containers was laid above.

The effluent discharged from the Geotube® dewatering containers was released back into the impoundment lake.

A new water treatment plant was constructed nearby to serve Tianjin Eco-City. Its first task was to treat the impoundment lake water. Following completion of the dredging of the impoundment lake it was pumped dry, re-profiled and impounded again with treated water from the nearby Ji Canal.

Almost 19 km of Geotube® containers of circumference ranging from 27.5 m to 30.5 m were used. These were stacked 4 layers high. The whole dewatering operation was carried out over a 6 month period. Finally, the dewatering platform was capped to form a 9 m high landscaped mound, with a plan footprint area of approximately 12 ha.

Client: Tianjin Eco-City Environmental Co., Ltd, Tianjin, China.

Consultant: Tianjin Municipal Engineering Design & Research Institute, Tianjin, China.

Contractor: CCCC Tianjin Dredging Co., Ltd, Tianjin, China.

Dredging contaminated sediments from the impoundment lake

Three layers of Geotube® containers on the dewatering platform

Geotube® dewatering platform

Part of the remediated lake following landscaping