

My WaterWay@Punggol

A Living Laboratory for Urban Living Solutions

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Honeycomb-inspired Design

In designing the floating wetlands system, HDB engineers took inspiration from the organic form of honeycomb, an architectural form made out of hexagonal cells that are conjoined, creating a light-weight structure of high strength and rigidity. By assembling these “cells” or modules, durable “floating platforms” on water bodies are formed with three distinct features:

- The system enables the cultivation of wetland plants, transforming the plain water surface into pockets of greenery that beautifies the environment, cleanses the water and improves biodiversity by attracting a variety of birds, butterflies and dragonflies etc.
- It allows for flexible configuration in any size and shape, through the use of hexagonally-shaped modules, which can be easily assembled and sited anywhere, according to site conditions such as contours of the water surface area.
- HDB also invented and patented a unique interlocking solution to enhance the rigidity and stability of the assembled modules, as well as to allow easy assembly, movement and dismantling. This interlocking system comprised protrusions and depressions on all sides of each hexagonal floating module for secure linkage. Reinforcements with stainless steel connector pins were then used to lock the modules in place.

Ease of maintenance was a crucial factor in the design. The system had to support both the weight of plants and workers carrying out maintenance, while remaining buoyant and stable, especially when they are exposed to waves caused by passing boats. Through extensive modelling and simulation conducted in partnership with the National University of Singapore, studies on the elastic deformation and stress distributions in the system under various combinations of loading were done. The study enabled HDB to determine the minimum module configuration required to achieve optimal buoyancy on the waterway – a platform of 4 by 3 modules, which could support a total of 360kg of plant load and human load of up to 600kg (about seven humans weighing 80kg each).



Meandering through the heart of Singapore’s first Eco-town, My Waterway@Punggol has become an icon that is synonymous with Punggol. At 4.2km long, Singapore’s longest man-made waterway was designed from the outset to be environmentally sustainable, and to promote biodiversity. Beyond a picturesque landmark for residents to enjoy recreational activities, the waterway was envisioned to be a habitat where flora and fauna thrive and residents could come close to nature.

With a surface area of approximately 130,000m², My Waterway@Punggol presents a vast canvas for HDB to intensify the greenery along the waterway and enhance the water quality. In 2015, HDB developed two green engineering innovations – the Floating Wetlands System and Freshwater-Tolerant Mangroves – after test-bedding them in its master laboratory at the Centre of Building Research.

1. Freshwater-tolerant mangroves line the banks of My Waterway@Punggol and play a key role in stabilising the riverbank, cleansing the water and enriching its biodiversity. Image by Housing & Development Board



To intensify urban greenery, 15 wetland species¹ cultivated in environmentally-friendly plant media (coconut fibre and woven mat) were planted into the floating modules, covering an area of 550m² (about the size of five units of 5-room HDB flats). Currently, the largest single floating wetland at My Waterway@Punggol is made up of 130 modules, spanning an area of 84.5m² (close to the size of a 4-room HDB flat), and is able to bear a weight of 10,400kg (equivalent to the weight of 130 men who weigh 80 kg each).

Freshwater-tolerant Mangroves – Singapore’s First Man-made “Arboretum of Native Mangroves”

In the past, mangroves used to line the banks of rivers, especially those around Punggol. With increasing urban development, mangrove coverage in Singapore was reduced from about 13% in 1819² to about 1% in 2011.³ As a living laboratory, the waterway offered HDB a unique opportunity to bring mangroves back to the waters, especially rare and endangered native species, thereby expanding the mangrove coverage in Singapore.

In selecting the mangrove species, HDB had two key considerations – mangroves typically thrive under saline conditions, and the freshwater waterway would not be suitable for all mangroves. Hence, HDB specifically shortlisted species that

were able to thrive in freshwater conditions, and first test-bedded them at its Centre of Building Research. A total of 35 mangroves and freshwater swamp species⁴ were found to be resilient and sustainable. These species were then cultivated along the banks of a 3km stretch of My Waterway@Punggol.

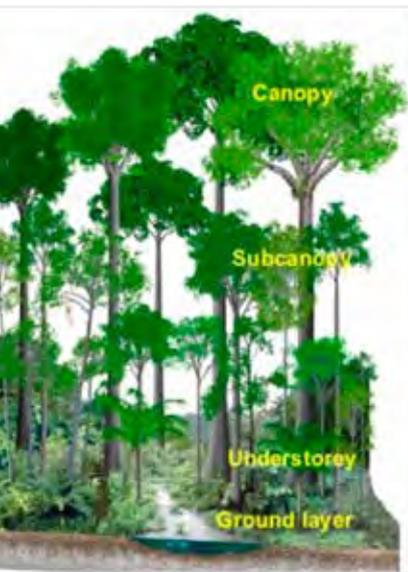
Beyond the selection of suitable mangrove species, research and innovation was also carried out to devise a methodology to cultivate them in a sustainable manner. Working with the Nanyang Technological University, HDB applied a new slope modelling technique to optimise the placement of mangroves, which strengthens the riverbank. This technique harnessed the ability of the mangrove roots to bind soil effectively, thus stabilising the riverbanks and helping to prevent erosion.

HDB’s engineers and landscape architects also jointly designed the freshwater-tolerant mangroves to create conducive habitats for wildlife, through varied layers of vegetation. For instance, mangrove species that were shorter would attract butterflies and dragonflies, while taller species would attract birds such as the Sunbird and Kingfisher.

Lusher Greenery, Cleaner Water and Greater Biodiversity

Besides beautifying the waterway, the mangroves and floating wetlands also double up as natural water cleansers, improving water quality by up to 30%. With a network of extensive and fibrous roots, they are able to remove excess nutrients in the water and slow down the rate of surface runoff into the water. Hence, from the outset, HDB had selected mangrove species with the natural ability to yield good water quality, such as the *Acrostichum speciosum*, *Phragmites karka*, and *Cyperus alternifolius*.

2, 3. Extensive modelling and simulation studies allowed HDB to determine the most effective module configuration that could carry both plants and humans, in both static and moving water conditions. Images by Housing & Development Board



Strata 4 (>15m)	 Common Kingfisher	 Brown-capped Woodpecker
Strata 3 (5-15m)	 Olive-Backed Sunbird	 Long-tailed shrike
Strata 2 (1m-5m)	 Grass yellow	 Tawny coster
Strata 1 (<1m)	 Common scarlet	 Common Amberwing

The impact of the floating wetlands and freshwater-tolerant mangroves on biodiversity is evident. Surveys showed that they had helped to attract a spectrum of flora and fauna, including some endangered bird species. Between 2011 and 2013, over 80 bird species, nine butterfly species and 11 dragonfly species were observed. In another study in 2015, 15 more bird species, two butterfly species and nine odonate species were observed along the waterway. Among these, migrant bird species from as far as Siberia make their stopover in Singapore en route to Australia, and include the Common Greenshank, Little Egret and Yellow Bittern. Also often seen fluttering along the waterway, butterfly species like the Common Grass Yellow, Great Eggfly and Blue Pansy are a welcome sight in an urbanised environment.

Growing the Potential

Today, My Waterway@Punggol is the first and only man-made site in Singapore with such an extensive variety of freshwater-tolerant mangroves and floating wetlands in one place. They have brought the appreciation of flora and fauna closer to home, where residents can enjoy the sights and sounds of nature at their doorstep. At the same time, they help soften the hardscape of the built structures, providing visual relief for all along the waterway.

Beyond Punggol, HDB will also explore the possibility of applying these innovative solutions to more towns and estates. One possibility is to bring the freshwater-tolerant mangroves to water bodies in new housing areas, such as the Alkaff Lake in Bidadari and the quarry pond in Tampines North Quarry Park. To further tap on the potential of the floating wetland system, HDB is also studying the feasibility of adopting it beyond greening, such as floating solar panels on water bodies, to intensify the harnessing of solar energy. 

Some plants such as the *Cyperus alternifolius*, also tend to develop long roots that can filter the waters in their immediate vicinity, allowing more sunlight to reach and support the growth of phyto-organisms, which form rich food sources for small marine life. This sets off a natural food chain cycle, which enables the ecosystem to flourish, as small organisms are consumed by larger fish and insects, which then attract other forms of wildlife like birds and crustaceans.

On top of cleansing the water, mangroves can also help to remove carbon from the environment through sequestration, a process whereby carbon dioxide is taken in during photosynthesis; and phytoremediation, a process by which plants remove contaminants from the soil, water, sediments, air, and also help to minimise algae growth.

4. HDB has successfully cultivated 35 mangrove and swamp species under freshwater conditions at the waterway. Three of which are endangered native species, namely *Lumnitzera littorea* (left), *Kandelia candel* (centre), and *Lumnitzera racemosa* (right). Images by Ria Tan of www.wildsingapore.com

5. A wide variety of fauna is attracted by the different layers of the freshwater-tolerant mangroves. Image by Housing & Development Board



References

¹ Some of these species include *Crinum menhune*, *Heliconia*, *Cyperus haspen*, *Acrostichum speciosum*, *Phragmites karka* *Cyperus alternifolius* and *Pandanus amaryllifolius*.

² Source: <http://mangrove.nus.edu.sg/guidebooks/text/1003.htm>

³ Source: <https://www.nss.org.sg/documents/Pages%2099-120.%20Yang%20et%20al.,%202013.%20Singapore%20Mangroves.pdf>, page 100

⁴ The 35 species of mangroves and freshwater swamp species comprise different mangroves families such as *Rhizophoria*, *Bruguiera*, *Avicennia*, *Xylocarpus*, *Lumnitzera*, *Sonneratia*, *Ceriops*, *Nipah*, *Kandelia*.

6. The innovative Floating Wetlands System and Freshwater-Tolerant Mangroves bring the appreciation of flora and fauna closer to home. Image by Housing & Development Board

Awards garnered by HDB's innovative freshwater-tolerant mangroves and floating wetlands system:

- The American Environmental Sustainability Honor Award for Excellence in Environmental Engineering and Science™ Competition 2017
- National Energy Globe Award Winner 2017
- ASEAN Outstanding Engineering Achievement Award 2016
- The Institution of Engineers, Singapore (IES) Prestigious Engineering Award 2016
- The Institution of Structural Engineers (IStructE) Singapore Award for Sustainability 2016