

EXECUTIVE SUMMARY

Strategic Flood Risk Assessment New Yangon City Phase 1

Client: New Yangon City Development Company Limited

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Introduction

As the population of Yangon City is expected to grow rapidly in the coming decades, there is an urgent need to supply adequate housing, jobs, infrastructure, potable water and electricity. New Yangon City aims to create economic growth, jobs and homes. The development is characterised by two phases of which Phase 1 is currently being initiated (see Figure 1). This first phase of New Yangon City is approximately 90 km² and is situated west of Yangon River.

The aspiration for New Yangon City is that it is green, smart and liveable, improves Yangon's overall economic competitiveness and is well-integrated with the existing infrastructure of Yangon. New Yangon should serve as an example of efficiency, integrity and accountability and should be able to function as a stand-alone satellite city.

NEW YANGON CITY PROJECT

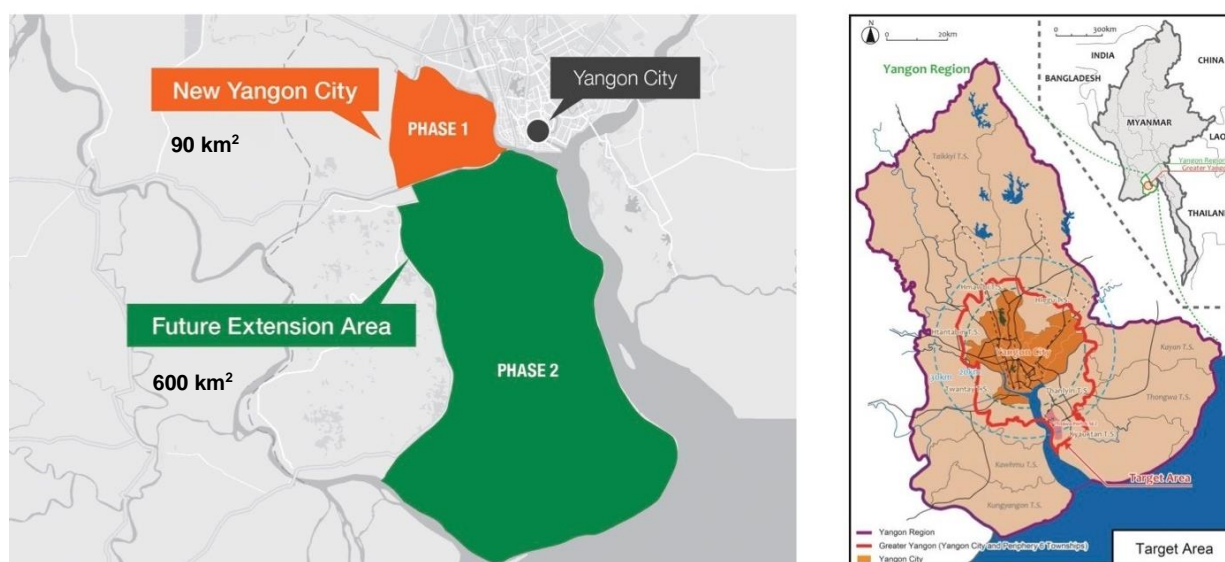


Figure 1: New Yangon City Phase 1 and Phase 2 (future expansion area).

As part of Phase 1, the New Yangon Development Company Ltd. (NYDC) has initiated a Strategic Flood Risk Assessment (SFRA) to ensure that the proposed development takes account of flood risk. Royal HaskoningDHV (RHDHV) was selected as the consultant to provide the SFRA and the scope of works included data collection, a flood hazard assessment, a flood risk assessment and identification of flood risk reduction measures.

Preparations

To understand what drives flooding in New Yangon, a baseline assessment was conducted at the start of the SFRA. It described the topographically low-lying areas in New Yangon City and distinguished two types of water systems that could cause flooding:

Fluvial-Coastal System

This consists of the Hlaing River, Pan Hlaing River and Twante Canal. A map of the system is provided in Figure 2. High water levels in this system are caused by the strong tide and storm surges originating from the Gulf of Martaban, as well as sea level rise expected in the future.

Assuming a 100-year design life of New Yangon City, a sea level rise of 90cm should be accounted for. During the monsoon period, water levels also increase in the system as the Ayeyarwady river discharges into the fluvial-coastal system surrounding New Yangon City.

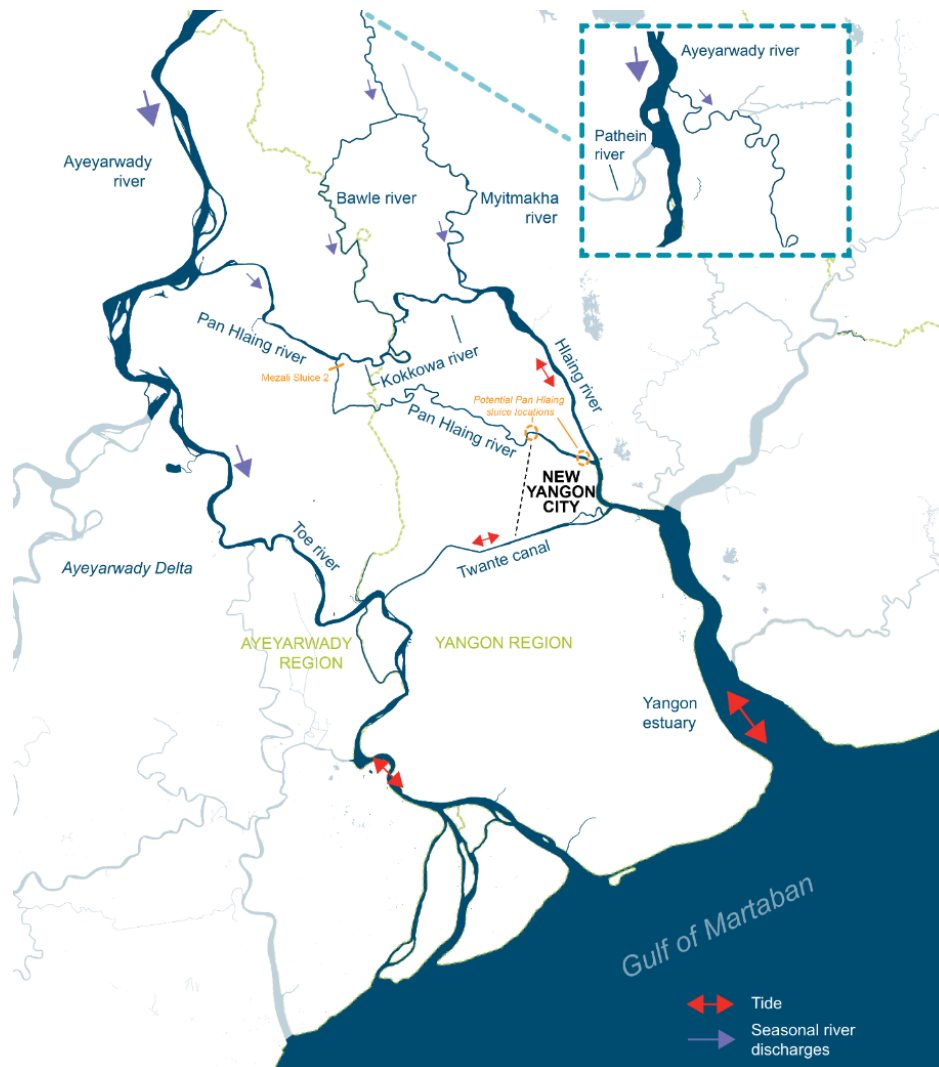


Figure 2: Overview of the hydraulic system around New Yangon City, displaying the tide and river influencing the water system surrounding New Yangon City Phase 1.

Pluvial System

New Yangon City will receive large amounts of rainfall with high intensities during the monsoon periods, which need to be managed appropriately to drain sufficiently to avoid pluvial flooding in a developing urban setting.

Extreme situations for New Yangon City will be a combination of the above fluvial-coastal-pluvial systems, which would introduce a significant flood risk to the urban development.

Data Gaps

In preparation of the flood hazard assessment and flood risk assessment, data requirements were requested and partially collected from numerous Myanmar government parties.

This Strategic Flood Risk Assessment has been undertaken with assumptions made, to help fill any data gaps (data gaps included historic high-water levels, discharge recordings, high frequency rainfall records in the project area at, e.g., at 5-minute intervals).

Flood Hazard Assessment

The Flood Hazard Assessment quantified the severity of potential floods in New Yangon City, and was conducted for the three different flood sources identified in the baseline assessment: tide and storm surge (coastal), river discharge (fluvial) and rainfall (pluvial).

Four different flood return periods were analysed (10-year, 50-year, 100-year and 200-year return period). As an example, the 10-year flood hazard map is displayed in Figure 3.

It was concluded that New Yangon City is prone to all three sources of flooding. A significant flood hazard is currently present at the project area, mainly due to the low-lying ground elevations, and the fact that the central part of the project area is lower than its perimeter.

Natural drainage of flood waters to the adjacent rivers and canals is therefore limited, so sufficient storage and drainage capacity is required to prevent any pluvial flooding.

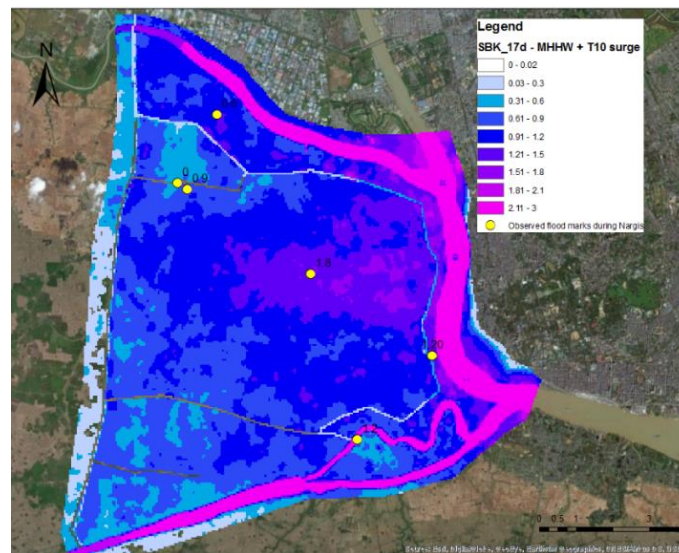
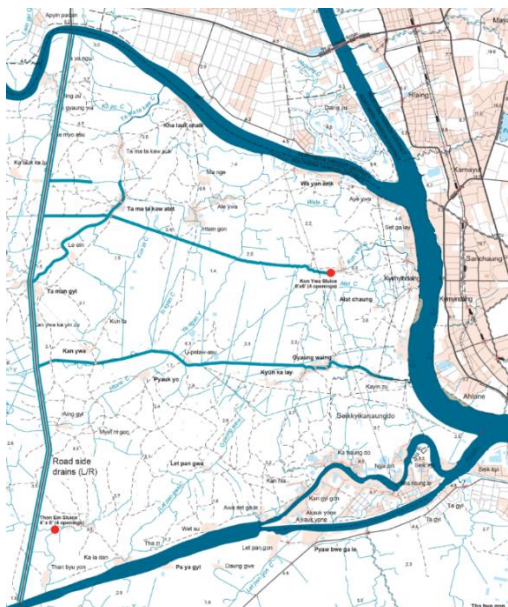


Figure 3: Example of a flood hazard map presenting the computed flood inundations (m) for a coastal surge event with a return period of 10 years. The observed flood marks during Nargis are given on the flood map as yellow dots for comparison.

Of the three flood sources, the coastal flood hazard is normative for future flood design levels, as it is expected to cause the largest flood depths in the area. Drainage to adjacent rivers and canals is impacted by the semi-diurnal tides that prevent gravity flow twice a day. Also, the storage depth may be limited due to the low ground elevation, flat project area and relatively high ground water tables. Large retention volumes would therefore need large surface area. A detailed drainage study is recommended to identify the most appropriate drainage infrastructure, to define its dimensions (of e.g. flood gates, water control structures, canals and pumps) and the most effective balance between discharge pumping capacity and retention volume.



Flood Risk Assessment

- The Economic Risk in the existing and future situation, both without flood protection, is respectively 1.2 billion USD and 2.1 billion USD per year. Investment costs of primary flood risk reduction measures, such as a primary ring-dyke system, are approximately 0.1 billion USD. The investment would be more than 300 times smaller than the long-term risk reduction it would create, leading to the conclusion that investing in flood protection upfront is cost-effective and justifiable.
- The average Personal Risk in the existing and future situation is respectively $0.7 \cdot 10^{-3}$ and $1.6 \cdot 10^{-3}$ (without flood protection), which are considered as relatively high.
- The estimated Fatality Risk for the existing and future situation is respectively 476 and 1,369 fatalities per year, both without flood protection. The effect of sea level rise in 2100 is expected to cause an increase in fatality risk of almost 900 fatalities which is an increase of 188%.

It was concluded that the optimum protection level for New Yangon City, from a risk management point of view, a protection level of 100-years is required at minimum.

Recommendations towards Flood Mitigation Measures for Flood Risk Reduction

The SFRA was completed by presenting recommendations that would reduce the flood risk in New Yangon City:

- (i) Protection of the project area from fluvial and coastal floods;

- (ii) Consideration of pluvial floods including improvement of the storage and discharge capacity of the drainage system; and
- (iii) Non-structural measures to reduce the vulnerability to flooding.

These measures are delivered through a Multi-Layer Safety Approach which incorporates Water Sensitive Urban Design.

Multi-Layer Safety Approach

“Avoid hazards and mitigate their potential impacts by reducing vulnerabilities and exposure and enhancing capabilities of communities”

Level 1 – Prevention

River and Coastal Flood Protection will be achieved via a Ring Dyke System (Figure 5). This includes a single ring dyke along the riverfronts surrounding the entire plot of New Yangon City. Additional internal ring dykes which are elevated main arterial roads, also function as an evacuation route during flood events.

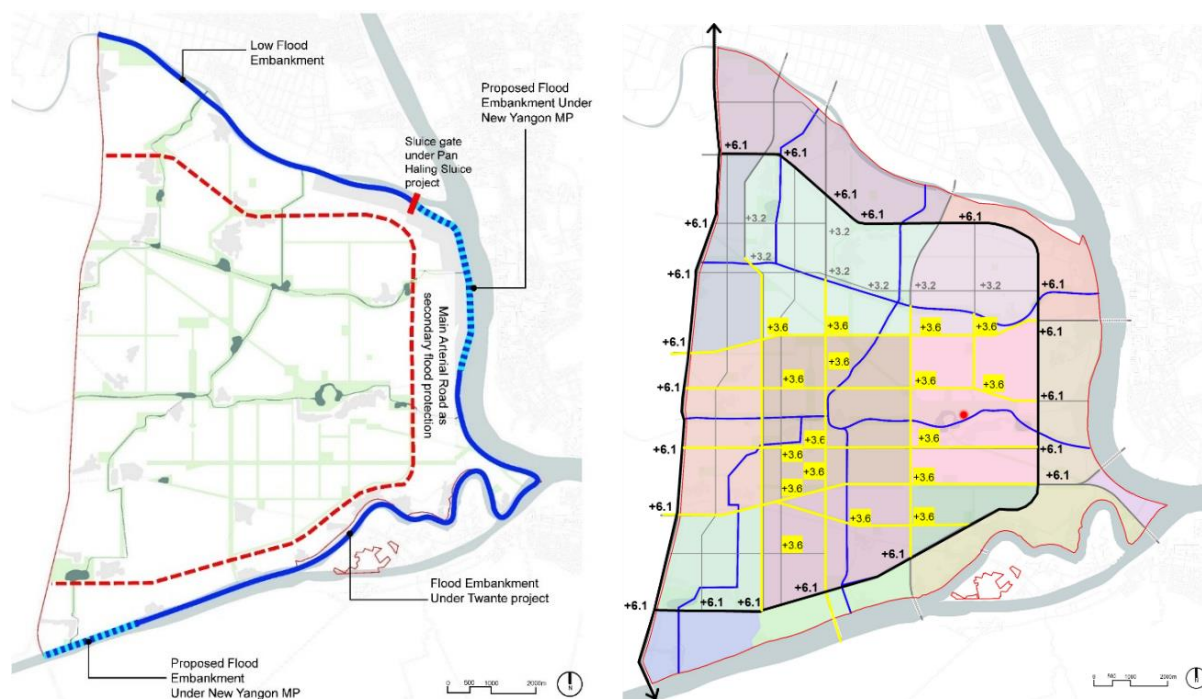


Figure 5: Conceptual strategy from the Master Plan (images by NYDC and AECOM) visualising the outer ring dyke surrounding New Yangon City Phase 1 and an elevated main arterial road functioning as an inner ring dyke (left) and the proposed internal ring dyke and road levels (right). These numbers are preliminary and subject to change.

Level 2: Spatial Planning and Zoning

a. Sub-catchments

Proposed Platform and Building Levels (Figure 6) in the Masterplan will form sub-catchments within New Yangon City, which will help control fluvial runoff and drainage.

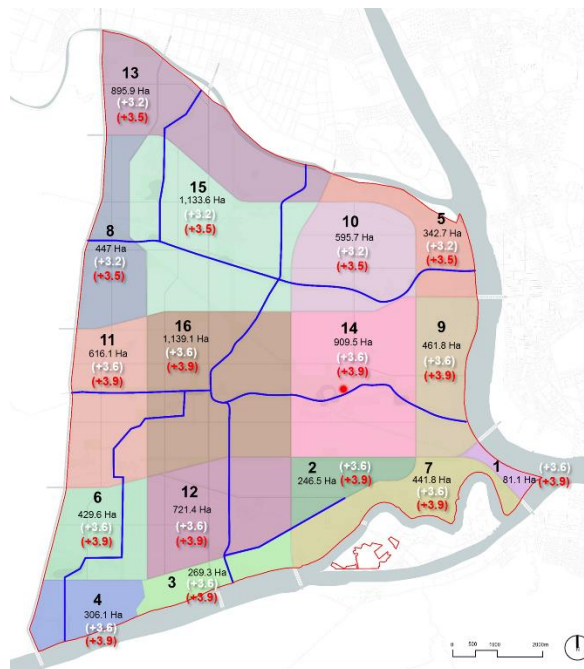


Figure 6: Conceptual strategy from the Master Plan (image by NYDC and AECOM) visualising the sub-catchments (bold black number is ID and small black text is catchment area size) and proposed platform (white text) and building levels (red text). Presented levels are preliminary and subject to change.

The layout and phasing of the flood compartmentation will need iterations and optimisation with the master planning and financial investment strategy.

b. Water Sensitive Urban Design

Water Sensitive Urban Design integrates the entire water cycle, i.e. management of storm water, groundwater, wastewater and water supply, into the urban design. This enables developers to create more liveable, healthier and eco-friendlier cities. Ideas were brought into the conceptual masterplan such as reducing the paved surface area by bringing in more green areas and assigning recreational spaces as temporal retention areas (Figure 7).

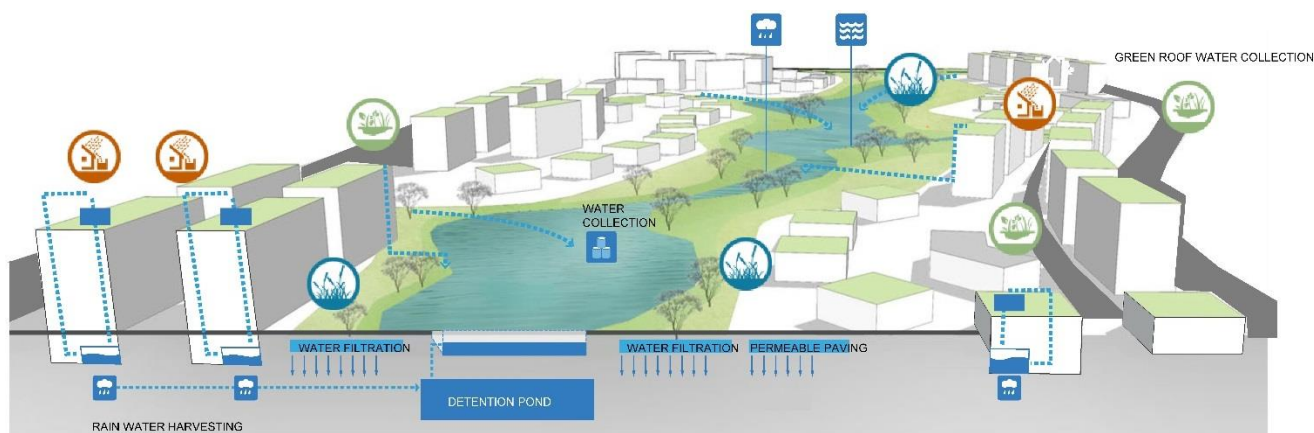


Figure 7: Visualisation of the Water Sensitive Urban Design in New Yangon City from the Master Plan by NYDC and AECOM, combining open spaces and retention areas.

The concept of “delay” “store” “drain” will help reduce flood risk from pluvial hazards, as illustrated in Figure 8.

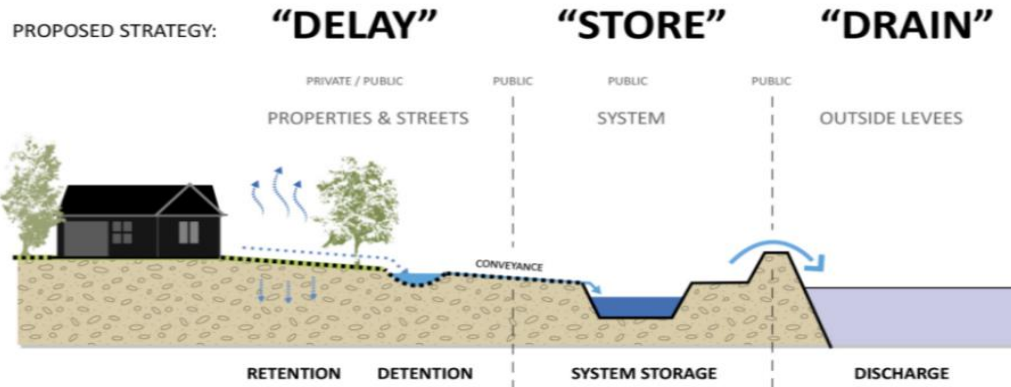


Figure 8: Water Sensitive Urban Design principles on storm water management.

The concept Masterplan proposes water control structures (control gates), drainage design criteria (streams and drainage channels), and space for temporal storage of drainage water (retention ponds). These are shown in Figure 9 and 10 on the next page.

For plot-level drainage measures, Urban Design Guidelines should be developed for slowing down urban runoff (buffer strips, pit traps, porous paving etc.). The concept Masterplan takes account of existing creeks and sluice gates, and will be developed further using detailed water engineering at the next design stage.

Level 3: Emergency Response & Resilience

For residual risk, non-structural measures are recommended, such as:

- Evacuation Routes – including elevated roads
- Flood Early Warning System – using technology and community awareness
- Integrated Flood Risk Management – close inter-governmental relationships
- Community Awareness – campaigns, evacuation centres



Figure 9: Water Sensitive Urban Design principles for storm water management across New Yangon City (by NYDC and AECOM).

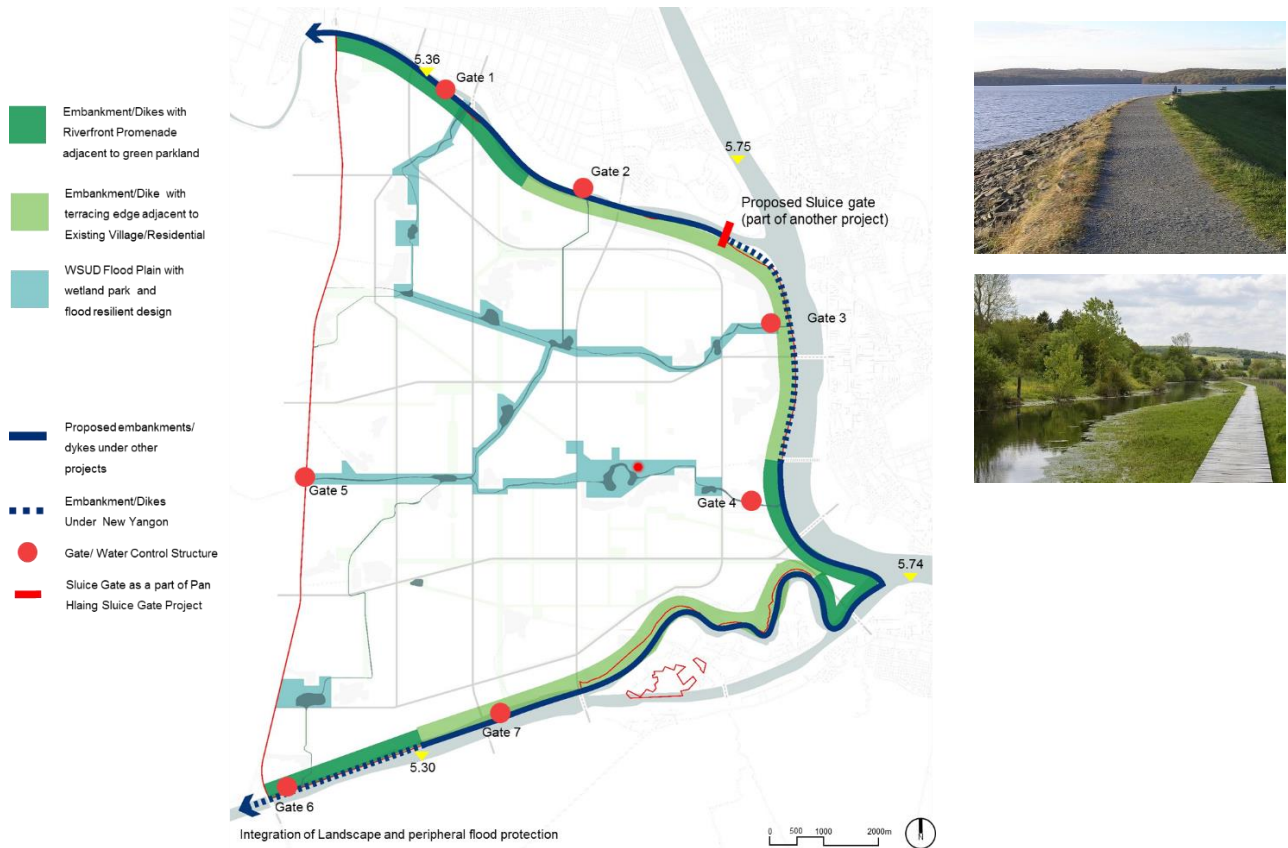


Figure 10: Channels, Gates and Dykes proposed across New Yangon City – channels and gates (by NYDC and AECOM).

Conclusions

New Yangon City is prone to all three sources of flood – tide and storm surge (coastal), river discharge (fluvial) and rainfall (pluvial). This can be mitigated via a multilayer approach of prevention, spatial planning & zoning, and emergency response & resilience.

Alterations and optimisations should be made for the flood protection measures (namely detailed drainage infrastructure and the phasing of the ring dyke system) in the next design phase of the New Yangon City development. New flood hazard maps and flood risk maps should be created by including the proposed measures in the hydraulic model. This would give insight in the actual flood risk reduction that is created by the measures and could then be compared to the investment costs to assess which Flood Risk Reduction measures are most cost-effective.

The development of New Yangon City forms part of Yangon Regional Government vision for development of Yangon Region to 2040. Therefore, an integrated approach to regional flood management and flood risk study is recommended for regional context.