



1. Introduction

1.1 In Hong Kong, some 7 000 hectares of land representing around 6% of total land area (or 25% of developed area) was formed by land reclamation. However, a majority of reclaimed land was formed prior to 2000 and only about 700 hectares were created in the recent two decades or so. In order to increase long-term land supply, the Government has recently put forward the Lantau Tomorrow Vision ("Lantau Tomorrow") with proposed reclamation of artificial islands in central waters covering 1 000 hectares of land near Kau Yi Chau ("KYC") in the first phase. However, in light of a number of cost overruns and delays in mega projects in recent years, there are concerns over the cost management of large-scale reclamation. Among others, there are also concerns over the impact of land reclamation on its surrounding environment and ecology.

1.2 Across the globe, many places have implemented measures to strengthen cost management of large public projects. In particular, Norway is renowned for its effective cost management of major government infrastructure projects through its quality assurance scheme ("QA scheme"). This scheme is applied to different large infrastructure projects and since its implementation, many of these projects have registered more reliable cost estimates and reduced project overruns. The scheme has been referenced by other overseas places such as Denmark and Sweden.

1.3 On the other hand, the Netherlands is a land-scarce albeit advanced economy with a long history in land reclamation. More than 17% of its total land area is formed by reclamation. It has recently completed the first phase of the expansion of the Port of Rotterdam (known as "Maasvlakte 2") by reclaiming 700 hectares of land from the European Union's ("EU") protected areas. In order to minimize the environmental impact of reclamation, a suite of sustainable design, environmental mitigation and monitoring measures were adopted.

1.4 At the request of Hon Kenneth LAU Ip-keung, the Research Office has conducted a research study on cost management and environmental mitigation measures in land reclamation. This information note begins with an overview of land reclamation in Hong Kong, followed by a discussion on global trends in cost management and environmental mitigation. It will then examine Norway's experiences in cost management of large infrastructure projects and the Netherland's experiences in environmental mitigation with reference to the Maasvlakte 2 project.

2. Land reclamation in Hong Kong

2.1 As a hilly terrain with little flat land, Hong Kong's coastline has undergone land reclamation since the 19th century to accommodate the city's burgeoning population. In the early days, reclamation projects were mainly developed along the Victoria Harbour.¹ Since the 1970s, the Government has launched the New Town Development Programme, with six new towns² being built on reclaimed land. For instance, the development of Tseung Kwan O New Town³ began in 1983 for an initial population of some 175 000 and has since expanded to provide for a planned population of 450 000.⁴ As a result of economic slump in the late 1990s and early 2000s, land development through reclamation slowed down (**Figure 1**) and reclamation projects carried out thereafter were mainly for infrastructure and commercial development, such as the reclamation of Penny's Bay for the Hong Kong Disneyland and the artificial island of the Hong Kong-Zhuhai-Macao Bridge ("HZMB"). As at 2016, a total of about 7 000 hectares of land was reclaimed (**Figure 2**), housing around 27% of the population and 70% of commercial activities.

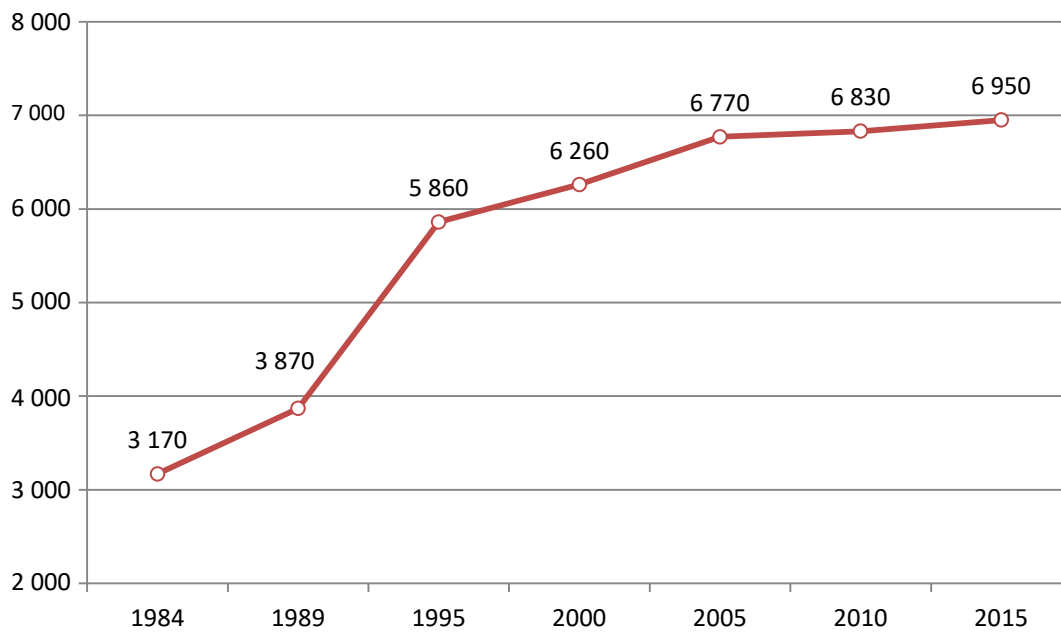
¹ In 1997, the Protection of the Harbour Ordinance was enacted to put in place a presumption against reclamation along the Victoria Harbour. See Housing, Planning and Lands Bureau (2004).

² These include Tsuen Wan, Sha Tin, Tuen Mun, Tai Po, Tseung Kwan O and Tung Chung. See Civil Engineering and Development Department (Undated).

³ The Tseung Kwan O New Town was developed mainly by reclaiming Tseung Kwan O Bay and formation of platforms on both sides of a long narrow inlet. See Civil Engineering and Development Department (2019).

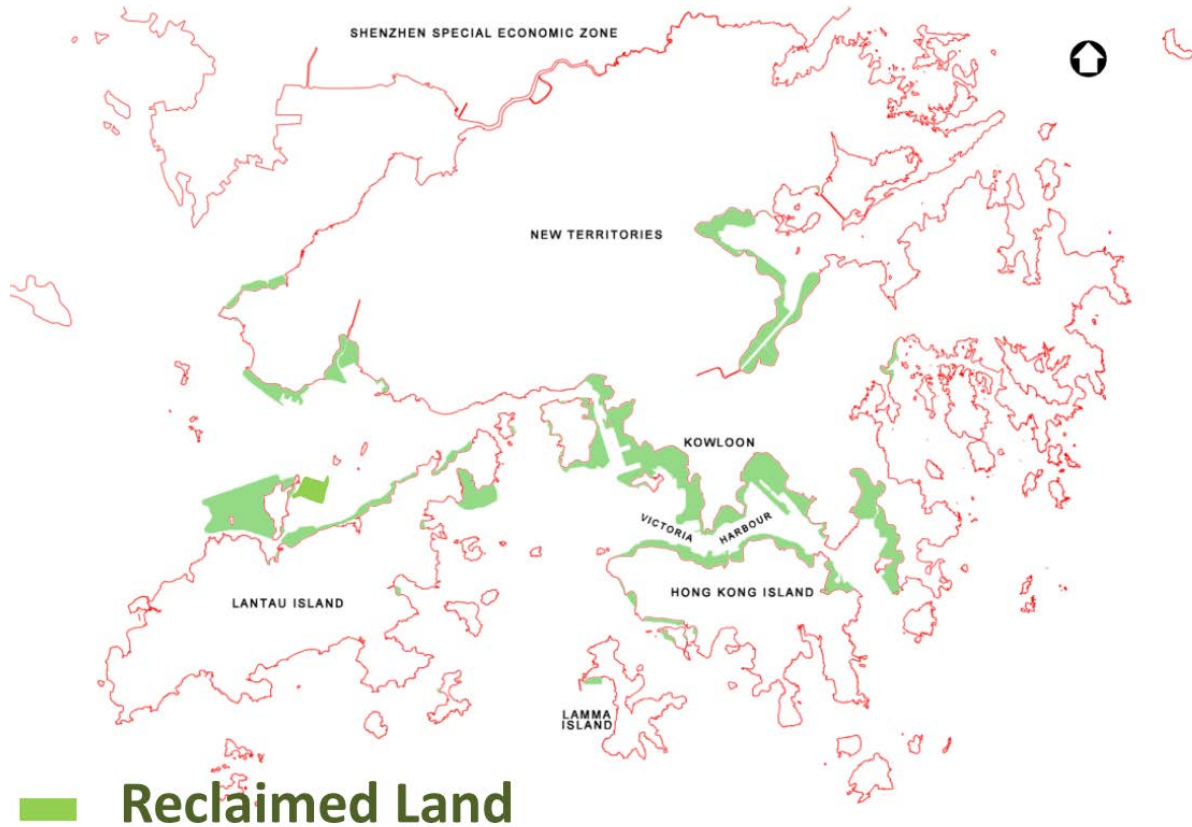
⁴ As at 2016, the population in Tseung Kwan O was 398 479. See 2016 Population By-census (2018).

Figure 1 — Cumulative land reclamation area (in hectares), 1984 to 2015



Source: Development Bureau (2017b).

Figure 2 — Area of reclaimed land in Hong Kong as at 2016



Source: Civil Engineering and Development Department (Undated).

2.2 At present, the two on-going major reclamation projects are the Three-Runway System ("3RS") Project and Tung Chung New Town Extension⁵. The 3RS Project is overseen by the Airport Authority ("AAHK") and involves reclaiming some 650 hectares of land north of Chek Lap Kok at a cost of HK\$56.2 billion in money-of-the-day ("MOD") prices⁶. Construction began in August 2016 with a schedule for commissioning the Third Runway by 2022 and the entire 3RS Project by 2024. However, AAHK has recently encountered a shortage in the supply of marine sand from the Mainland, which resulted in a slippage of 18 weeks in the schedule of reclamation filling for land formation.⁷ This has raised concerns over whether the 3RS Project could be completed on time and within budget.

Proposed reclamation of artificial islands in the central waters

2.3 In 2011, to assess the feasibility of enhancing land supply, the Government commenced a study on "Enhancing Land Supply Strategy: Reclamation Outside Victoria Harbour and Rock Cavern Development". The study was concluded in 2014 and identified development potential for artificial islands in the central waters between Hong Kong Island and Lantau.⁸ Subsequently in 2016, the Hong Kong 2030+ strategic study set out the preliminary development parameters for the artificial islands. According to the strategic study, the artificial islands in central waters will form part of the East Lantau Metropolis, providing an estimated 1 000 hectares of land to support the long-term development of Hong Kong.

2.4 More recently, the Chief Executive has announced the initiative of Lantau Tomorrow in her 2018 Policy Address. Spanning two to three decades, Lantau Tomorrow includes the phased reclamation of 1 700 hectares of artificial islands near KYC and Hei Ling Chau in

⁵ The Tung Chung New Town Extension involves reclaiming around 130 hectares of land at a cost of HK\$20.6 billion in MOD prices to provide around 40 800 subsidized and private housing flats.

⁶ The cost estimates of capital works projects are converted from constant prices into MOD prices by referring to the Government's assumptions on the trend rate of change in the prices of public sector building and construction output for the relevant contract periods. See Development Bureau (2013).

⁷ In order to mitigate this delay, AAHK has sought to diversify the source of fill materials and increase the use of Deep Cement Mixing to reduce fill demand. See AAHK (2019).

⁸ A proposal to upgrade "768CL – Strategic studies for artificial islands in the central waters" was submitted in May 2014 for the Public Works Subcommittee's deliberation. However, following a large number of motions proposed by Members and in view of other capital work projects that needed deliberation, the Administration withdrew the item on 26 November 2014. See *Minutes of the 4th Meeting of the Public Works Subcommittee of the Legislative Council* (2015).

Central Waters (**Appendix I**). According to the Government, the first phase will focus on developing the KYC artificial islands of 1 000 hectares with a target to commence reclamation works in 2025. At present, the Government is seeking funding approval from the Finance Committee of the Legislative Council to initiate the feasibility study costing HK\$550.4 million in MOD prices. There is currently no concrete implementation timetable for the remaining artificial islands of 700 hectares near Hei Ling Chau. Since the announcement of the initiative, there have been grave concerns over a number of issues, particularly cost management and environmental impact, in view of the inadequacies seen in previous large infrastructure projects.

Cost management concerns

2.5 In March 2019, the Government released a ballpark estimate for the construction of Lantau Tomorrow at HK\$624 billion in September 2018 prices.⁹ Yet some anticipate that if MOD prices are adopted, the cost of Lantau Tomorrow would be much higher or even exceed HK\$1,000 billion.¹⁰ There are worries that the reclamation project may experience **cost overruns** or **unexpectedly high costs** as previous mega projects,¹¹ such as the Hong Kong Section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link ("XRL") and the HZMB development (**Figure 3**).¹² According to the Government, cost overruns or higher-than-estimated costs were mainly attributable to increases in (a) **project contingencies** such as higher-than-expected tender prices and worse-than-expected ground conditions; and (b) **price adjustments** such as escalations in labour and material costs.¹³ This is especially the case for mega projects as they usually involve higher risk premium and longer time uncertainty.¹⁴ For the proposed KYC artificial island, there has been an added concern of shortage of fill material¹⁵ which may cause project delay and resultant cost increases.

⁹ Based on the ballpark estimate, construction of KYC artificial islands will cost some HK\$256 billion, including HK\$140 billion for reclamation and HK\$116 billion for supporting infrastructure.

¹⁰ Based on various news reports, this calculation is made on the assumption that construction of the KYC artificial islands begins in 2025 and ends in 2035, with a price adjustment factor of 5% per annum. See 香港 01(2019) and 星島日報(2019).

¹¹ According to the Government, mega projects refer to construction projects with contract sum over HK\$1 billion. See Works Bureau (2002).

¹² See Legislative Council Secretariat (2018).

¹³ Ibid.

¹⁴ See Development Bureau (2014).

¹⁵ According to the Government, it is estimated that about half of the fill materials will be public fill while the remaining will mostly be manufactured sand. See Development Bureau (2019a).

Figure 3 — Selected mega projects with increased approved project estimates ("APE")⁽¹⁾

Mega project	Original APE (HK\$)	Revised APE (HK\$)	% increase in APE	Actual expenditure up to 31 March 2018 (HK\$) ⁽²⁾	Major reasons for increase
Hong Kong-Zhuhai-Macao Bridge	55.7 billion	70.0 billion	25.7%	57.8 billion	(a) Higher-than-expected tender prices; and (b) delay caused by judicial review.
Hong Kong Section of Guangzhou-Shenzhen-Hong Kong Express Rail Link	66.8 billion	86.4 billion	29.3%	78.9 billion	(a) Unfavourable ground conditions; (b) knock-on delay in interfacing contracts; and (c) changes in design and price escalations etc.
Central-Wan Chai Bypass and Island Eastern Corridor Link	28.1 billion	36.0 billion	28.2%	25.5 billion	(a) High-than-expected cost for tunnel construction; (b) increase in provision for price adjustment; and (c) changes in work items.
Liantang/Heung Yuen Wai Boundary Control Point	16.3 billion	25.0 billion	53.7%	14.2 billion	(a) Higher-than-expected tender prices due to surge in construction costs and poor ground conditions.
Central Reclamation Phase 3	3.6 billion	5.8 billion	61.8%	5.7 billion	(a) Delay caused by judicial review; and (b) higher-than-expected price fluctuation.

Notes: (1) Thus far, the Government has provided information on completed projects up to the 2017-2018 financial year. The final outturn costs for the listed projects are not available.

(2) This column reflects the actual expenditure of relevant projects up to 31 March 2018 but does not represent the final outturn cost.

Sources: Estimates of expenditure (various years) and relevant papers from the Public Works Subcommittee.

2.6 Indeed, to address the issue of cost overruns in capital works, in recent years, the Government has sought to improve the accuracy of cost

estimates by making use of reference class forecasting¹⁶ and refining procurement models through risk-sharing mechanisms.¹⁷ The Government also requires systematic risk management¹⁸ to be carried out by relevant project teams at regular intervals for public works with cost estimates exceeding HK\$200 million.¹⁹ In 2016, the Government established the Project Cost Management Office ("PCMO") under the Development Bureau to carry out cost management of infrastructure projects, including project scrutiny, review of works requirements, and enhancement of project management performance.²⁰ However, since most of the projects vetted by PCMO have yet to reach completion, the effectiveness of these measures remain to be seen.

2.7 Nevertheless, to strengthen existing gateway process for cost management, the Government has planned to upgrade PCMO into a dedicated **Project Strategy and Governance Office** under the Development Bureau. Reporting to the Financial Secretary and comprising some 13 multi-disciplinary in-house professionals, the soon-to-be-established Office will implement new initiatives with enhanced monitoring during project lifecycle. While the effectiveness of this Office remains to be seen, there are views that the Government should **enhance external scrutiny of project costs** through **engaging independent cost management consultants** to improve transparency and promote better accountability in project cost control.^{21, 22} There are also

¹⁶ This method predicts future project costs based on the actual cost outturn in a reference class of similar projects. As opposed to an agency's own prediction of costs, it adopts an "outside view" based on data from previous completed projects. In 2012, the Development Bureau commissioned a study on the feasibility of using reference class forecasting in Hong Kong, with the major roadworks projects of the Highways Department as a pilot reference class. The studies have since been expanded to cover drainage, sewerage, waterworks and building projects. See Flyvbjerg et al. (2016) and Development Bureau (2017a).

¹⁷ In Hong Kong, the risk-sharing mechanism through a family of contracts known as New Engineering Contracts ("NEC") has been adopted for suitable mega projects over HK\$1 billion. In particular, NEC includes target cost options for pain/gain sharing for under and/or overspent costs. See Development Bureau (2017c).

¹⁸ Systematic risk management is a qualitative tool which comprises various risk planning, identification, analysis, evaluation and treatment processes.

¹⁹ See Environment, Transport and Works Bureau (2005).

²⁰ See Development Bureau (2018).

²¹ Under current practice, cost management alongside project design and monitoring of works are usually undertaken by the same contractor. See 香港測量師學會 (2016 & 2019).

²² External scrutiny helps improve quality of work as it can guard against "group think" and errors. Following the XRL project, the Government appointed an Independent Expert Panel to examine issues in cost overrun. It was recommended that creation of a small independent advisory group comprising experienced professionals may provide strategic review on the Government's portfolio of infrastructure projects. See Independent Expert Panel (2014) and Institution of Civil Engineers (2017).

views that a **tiered approach to contingency management** should be adopted, where contingency reserves are divided into portions managed by different relevant entities/authorities²³ which incentivize project entities to exercise better cost control and ensure smoother project delivery.²⁴

Environmental related concerns

2.8 Apart from cost issues, land reclamation and its associated activities may adversely affect the marine environment. In recent decades, non-dredge reclamation methods have been recognized as more sustainable and environmentally-friendly because they minimize the release of sediments and/or suspended particles into the surrounding waters. Such methods have indeed been adopted in the 3RS and HZMB projects.²⁵ However, even though more sustainable solutions are available, there remain concerns that reclamation works would impact on the surrounding marine and terrestrial ecology, leading to permanent loss of seabed and benthic species and damage of on-shore habitats.²⁶

2.9 According to the Government, the central waters in KYC are "ecologically less sensitive" compared to the eastern, western and southern waters of Hong Kong.²⁷ However, certain environmental concern groups such as World Wide Fund and the Conservancy Association dispute that since the central waters is not covered by existing regular ecological monitoring, there is a **lack of ecological data** to assess whether the area is suitable for reclamation.²⁸ Some concern groups have conducted surveys to gauge the ecological value of the central waters. Preliminary findings indicate the

²³ On 29 April 2014, the MTR Corporation set up the Independent Board Committee to review the managerial approach of the XRL project. A group of independent experts were appointed by the Committee to assist with its review, which includes recommending enhancement measures to budget control and reporting systems within the project management of the XRL project. See Legislative Council Secretariat (2015).

²⁴ See MTR Corporation Limited (2014).

²⁵ See Transport and Housing Bureau (2015) and Highways Department (2015).

²⁶ See The World Association of Waterborne Transport Infrastructure (2010).

²⁷ See Civil Engineering and Development department (2014) and Development Bureau (2019c).

²⁸ These include, for instance, the Hong Kong Reef Check by the Agriculture, Fisheries and Conservation Department. See 香港海豚保育學會 (2019).

presence of **sea pen corals** in the central waters, as well as **protected and/or endemic species** in the neighbouring Sunshine Island.²⁹

2.10 Furthermore, some concern groups have questioned whether existing environmental impact assessment ("EIA") ensures adequate mitigation of impact. With reference to previous reclamation projects, they were particularly concerned that (a) **key mitigation measures were only in place after completion of construction**; and (b) **ecological values were understated** by baseline surveys.

2.11 The HZMB and 3RS projects have both been criticized for adopting a "develop first, conserve later" approach in implementing mitigation measures.³⁰ Designation of new marine parks was adopted in both projects as a mitigation measure for the loss of Chinese White Dolphin ("CWD") habitats. However, the Environmental Permits ("EP") granted by the Environmental Protection Department only required marine parks to be designated after completion of construction work. According to some concern groups, this approach was inadequate because **loss of CWD habitat already occurred during construction**.³¹ Indeed, dolphin abundance in the waters of Lantau dropped by over 45% between 2011 and 2017, when the construction of HZMB was underway. While the Brothers Marine Park was designated in 2016 as a compensation measure, it has recorded zero dolphin density as at 2017.³²

2.12 Some concern groups have also **questioned the reliability of marine ecological assessments** in EIA. In 2014, EIA for the 3RS project reported a low coverage (i.e. 1%-5%) of gorgonian corals at the project sites. However, following issuance of EP, a subsequent coral survey in 2016 found significantly higher coverage (i.e. up to 20%) of gorgonian corals at the project sites.³³

²⁹ According to the surveys, sea pen corals are found in the central waters, and an active nest of the nationally Class II protected White-bellied Sea Eagle and the Bogadek's Burrowing Lizard which is endemic to Hong Kong are found on Sunshine Island. An earlier study carried out by the Government in 2016, namely "Hong Kong 2030+: Preliminary Concepts for the East Lantau Metropolis", has reported similar findings. See Development Bureau (2016) and Hong Kong Bird Watching Society (2019).

³⁰ See World Wide Fund (2014) and 香港 01(2016).

³¹ See Hong Kong Bird Watching Society (2019).

³² For the 3RS project, a 2 400-hectare marine park will be set up in 2023 to tie in with the full operation of the 3RS. The Government explained that early establishment of marine park is infeasible because the designated area coincides with construction work. See AAHK (2016b).

³³ The coral survey was conducted as part of AAHK's Coral Translocation Plan as required by the EP for the 3RS project. However, EP did not specify the amount of corals that should be translocated. See AAHK (2016a).

Despite this finding, AAHK identified that only 6% of coral colonies were suitable for translocation,³⁴ and some coral sites with the highest density and number were excluded.³⁵ AAHK was therefore criticized for **underestimating the coverage of coral colonies** and **adopting insufficient mitigation measures**. Although AAHK subsequently agreed to carry out an additional coral transplantation exercise³⁶ upon the request of the Advisory Council on the Environment, this measure did not form part of the EIA/EP requirement.

3. Global practices in cost management and environmental mitigation

Cost management of major projects

3.1 Across the globe, **management of major infrastructure projects** including land reclamation is seen as a challenge because of the large scale, long duration, high societal and environmental impacts, contractual and technical complexity, and high number of stakeholders involved. According to various studies, cost overruns are not uncommon in major infrastructure projects across the world. For example, a study of 1 603 major projects across 104 countries recorded an average cost escalation of 40%;³⁷ and in an evaluation of 56 major infrastructure projects funded by the European Commission ("EC"), it was found that cost overruns were registered on 91% of projects at an average extra cost of 21%.³⁸ Similar to Hong Kong, cost overruns in overseas places are widely considered to be attributable to market volatility factors, inaccurate cost estimation, poor implementation and unforeseen conditions.

3.2 To deal with the challenges, **strengthening project scrutiny in the front-end phase**³⁹ is seen as an important success factor in cost management because there is more room for modifications and cost-saving measures up front. **Singapore** is a case in point adopting this approach. Apart from

³⁴ Corals with less than 10% partial mortality and size of 5 cm or greater, and attached on boulders of less than 50 cm in diameter, were deemed suitable for translocation. See AAHK (2016a).

³⁵ For instance, none of the corals at Sha Chau, which recorded 3 300 colonies and a coverage of 20%, were included in the translocation plan. See AAHK (2016a).

³⁶ Coral transplantation involves collection of coral fragments from the donor site and attaching them to appropriate substrate at the recipient site. The additional coral transplantation by AAHK is not a requirement under the Environmental Permit. See AAHK (2017).

³⁷ See Flyvbjerg (2016).

³⁸ See RGL Forensics, Faber Maunsell/Aecom and Frontier Economics (2009).

³⁹ In general, the front-end phase spans from initial project conception up to the point where a final decision to finance the project is made.

setting up the Centre for Public project Management⁴⁰ under the Ministry of Finance to review projects above S\$100 million (HK\$581 million), major projects over SG\$500 million (HK\$2.9 billion) are, before submission for budget approval, subject to a rigorous two-stage gateway process by a dedicated **Development Projects Advisory Panel** comprising senior public officials, academics and industry practitioners.⁴¹ The first stage involves evaluating the strategic business case of the project, whereas the second stage involves optimising overall project design including construction method and procurement approach. The Singapore government considers that this gateway process helps ensure **external scrutiny and early-project involvement by a panel of experts** from both public and private sectors, and enables responsible agencies to come up with cost-saving solutions over the project lifecycle. In recent years, reclamation projects such as Changi Terminal 5 and Tuas Port development have been subject to this gateway process.

3.3 In the **United Kingdom** ("UK"), complex and strategically significant projects are subject to third-party scrutiny which aims to **provide an objective opinion on the effectiveness of project governance and risk management**.⁴² The Infrastructure and Projects Authority ("IPA"), reporting to the Cabinet Office and the Treasury, conducts assurance reviews throughout the project lifecycle to assess a project's likelihood of achieving its objectives on time and within budget. The reviews are normally conducted by civil servant reviewers.⁴³ For **high-risk major projects** with whole life costs over £1 billion (HK\$10.5 billion), they may be subject to a separate **project assessment review by a Major Projects Review Group** ("MPRG") consisting of senior government and private sector experts, to scrutinise the deliverability, affordability and value for money. The review notably takes place at **three stages** where approval from the Treasury is required, namely (a) prior to project case approval; (b) before the project goes to tender; and (c) following receipt of bids and prior to award of contract. Additional points of review may be initiated when challenges and/or poor delivery confidence arise. MPRG may

⁴⁰ Similar to Hong Kong's PCMO under the Development Bureau, the Centre for Public Project Management, established under the Ministry of Finance in 2011, is a multi-disciplinary team of architects, engineers and surveyors tasked with reviewing the scope, design and cost reasonableness of project proposals. See Ministry of Finance (2017).

⁴¹ In Singapore, the ministerial Development Planning Committee, comprising three Cabinet Ministers, is responsible for approving all capital expenditures in excess of SG\$50 million (HK\$290 million). See Blöndal (2006).

⁴² See IPA (2018).

⁴³ The civil servant reviewers are accredited for their skills and experience in tackling delivery issues of major projects. If there is no relevant experience and availability in the reviewer pool, the review team may include an accredited external contractor. See IPA (2016).

put forth recommendations which include imposing conditions on project continuation, re-scoping and/or halting the project.⁴⁴

Environmental mitigation measures of land reclamation

3.4 Avoidance, minimization and mitigation measures are important tools to reduce the environmental impact arising from reclamation. A notable example is the construction of a road and rail link (known as Øresund Link) alongside a 160-hectare artificial island in Øresund Strait to connect **Denmark** and **Sweden** in the 1990s. To address the grave environmental concern over change in water and salt flow resulting from construction activities, an international panel of experts was appointed to design minimization measures. The expert panel advised that EIA should provide statistically rigorous and testable predictions on the potential effects of construction activities.⁴⁵ Based on the analysis of the expert panel, a "**zero impact solution**" was come up to ensure sustainable design of Øresund Link, limited sediment spillage during construction, and active environmental monitoring. Modifications were also made at the design stage to avoid the development affecting the neighbouring Saltholm Island, a natural reserve. Three years after completion of the Link, environmental surveys indicate that the ecosystem in Øresund has fully recovered.

3.5 In **Singapore**, EIA was conducted in 2012 to evaluate the effects of the port development at Tuas due to begin in 2015⁴⁶, and the result indicated that coral colonies near south of Tuas would be affected by the reclamation activities. EIA therefore recommended **relocating most of the corals to neighbouring sites** to help preserve coral diversity. Following this, the Maritime and Port Authority initiated a conservation programme in 2013 prior to the commencement of development at Tuas. Under the programme, over 80% of 2 800 coral colonies were translocated to three sites with similar conditions.⁴⁷ Coral nurseries were also set up to grow, transplant and eventually reattach coral fragments to the reef substrate. The conservation programme was deemed a success with a 92% survival rate for corals reared in nurseries.⁴⁸ The programme for both translocation and transplantation

⁴⁴ See IPA (2016).

⁴⁵ See Gray (2006).

⁴⁶ The Tuas Port development will be conducted in four phases over a span of three decades. The Phase 1 development, which began in 2015, costs SG\$2.42 billion (HK\$ 13.6 billion) and involves reclaiming some 294 hectares of land. See Business Times (2015).

⁴⁷ See Maritime and Port Authority (2015).

⁴⁸ See Maritime and Port Authority (Undated).

reportedly costs around SG\$6 million (HK\$33.7 million) and monitoring of coral health is set to continue until 2019.⁴⁹

3.6 In **Dubai**, it has likewise put in place measures to minimize the impact of infrastructure projects on coral habitats. Its responsible authority has promulgated a regulation⁵⁰ requiring application of Coral Translocation Permits in areas with identified coral patches before dredging and/or reclamation may occur. A translocation plan should be submitted detailing schedule of work and adoption of best practices. As part of the procedure, applicants are required to undertake **third-party baseline surveys**, conduct studies of proposed receiving sites, and **employ acceptable practices to assure survival of corals**. Furthermore, applicants are required to engage qualified marine ecologists to **conduct regular survival monitoring** including observations on the health and survival of transplanted corals **for four years after project completion**.⁵¹

4. **Norway's experiences in cost management of infrastructure projects**

4.1 During the 1990s, the Norwegian government experienced cost overruns in major infrastructure projects, which typically cost 20% to 40% more than the original budgeted cost, with some even costing few times more than the original estimates.⁵² Subsequently, the Norwegian government appointed an inter-ministerial committee in 1997 to review the delivery and cost control of major projects. It was found that cost overruns were mainly attributable to deficiencies in the **front-end phase** of major projects, including (a) lack of oversight before projects are presented to the Parliament; (b) inadequate attention to cost uncertainty and cost benefit; and (c) lack of alternatives for consideration. Based on these findings, the committee recommended introducing an external quality assurance scheme to enhance scrutiny of major projects.

⁴⁹ See Chou et al. (2017) and Strait Times (2016).

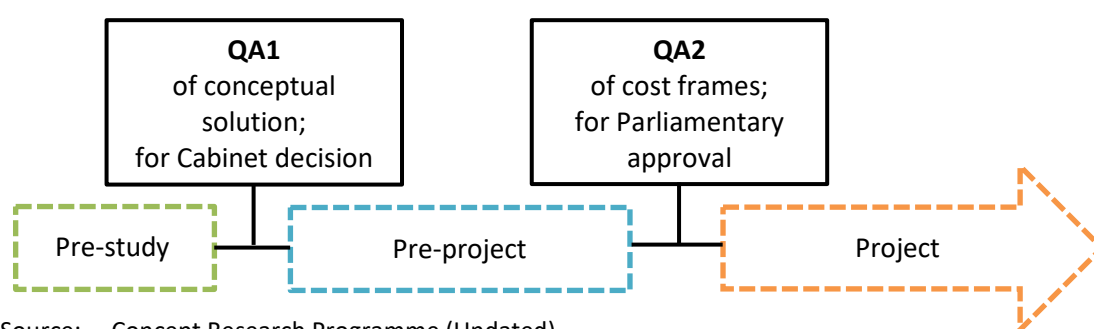
⁵⁰ See Government of Dubai (2010).

⁵¹ Ibid.

⁵² See Samset and Volden (2013) and Samset et al. (2016).

4.2 The Norwegian QA Scheme was formally introduced in 2000 to strengthen cost control on major projects with an estimated cost above Nkr750 million (HK\$723 million).⁵³ These projects are required to undergo **external quality assessment** on their concept, cost estimate and management regime. The Scheme features two stages, namely (a) quality assurance of **conceptual solution** ("QA1") before Cabinet decision on whether to proceed with the project;⁵⁴ and (b) quality assurance of **cost frames** ("QA2") prior to appropriation by the Parliament (**Figure 4**).

Figure 4 — The Norwegian QA Scheme



Source: Concept Research Programme (Undated).

Cost control under the QA Scheme

4.3 An **external quality assurer** comprises a consortium of consultancy firms with expertise in, among others, design and engineering, project management, contracting and procurement, and economic consulting. The Ministry of Finance pre-qualifies the consortia once every five years through a framework agreement, and has a set of guidelines defining the scope and requirements of the QA Scheme. At present, there are six pre-qualified consortia and award of contract is through competitive bidding. In 2016, the Ministry commissioned a survey on the time and cost of the QA Scheme based on a sample of projects completed since 2000. It has been estimated that the average cost for external quality assurance (both QA1 and QA2) was around Nkr4.6 million (HK\$4.2 million) per project, which amounted to about 0.2% of

⁵³ The requirement for external quality assurance is formally laid down in the Regulations on Financial Management in central government. The cost threshold for major projects has been increased from Nkr500 million (HK\$482 million) to Nkr750 million (HK\$723 million) since 2015. Offshore oil and gas investments, however, are exempted from the Scheme. See Royal Norwegian Ministry of Finance (2010).

⁵⁴ The QA Scheme was expanded in scope in 2005 to include QA1. See Samset et al. (2016).

total project estimate excluding contingency reserves. On average, QA1 and QA2 took about 9.7 months and 6.5 months respectively.⁵⁵

4.4 Under **QA1**, the quality assurer provides independent analysis of the costs, benefits, and uncertainty of the "zero-option" (i.e. status-quo) and at least two conceptually different alternatives. This ensures that **due consideration is given to the cost-effectiveness of the proposed project option**. On the other hand, **QA2** aims to ensure **operational success and a realistic budget**. The quality assurer reviews relevant project documents and provides external scrutiny on overall cost management, including cost frame, project risks, choice of contract strategy, and management of contingency reserves.⁵⁶

4.5 As part of the QA Scheme, the quality assurer provides a **third-party analysis of project risks and uncertainties** at different phases from project investment, operation, to maintenance.⁵⁷ The uncertainty analysis involves identifying and ranking conditions that contribute most to project uncertainty, and recommending measures to reduce project risk. Most of the risk reduction measures are related to project management and organization, and contracting and procurement.⁵⁸

4.6 As a means to maintain effective management of project cost and contingencies, the quality assurer establishes a **tiered cost frame** specifying funding thresholds for the project (**Figure 5**). Instead of a full funding model, the tiered cost frames set out the amounts for baseline control and contingency reserves. It helps incentivize project entities to adopt stricter monitoring and control of project costs, since spending of contingency reserves will require consent at the ministry level. Furthermore, a list of **cost-saving measures** may be put into effect if the project exceeds the cost frame set by the Parliament. The cost-saving measures, which typically amount to some 5% of the project cost frame, include modifications which would not compromise project functionality but may affect visual impression and/or project flexibility.⁵⁹

⁵⁵ Based on unofficial translation of the survey report, this finding is based on an analysis of 23 investment projects which have undergone the QA Scheme. The above cost figure includes both QA1 and QA2 process, but excludes internal costs incurred on government ministries and/or departments. See EY (2016).

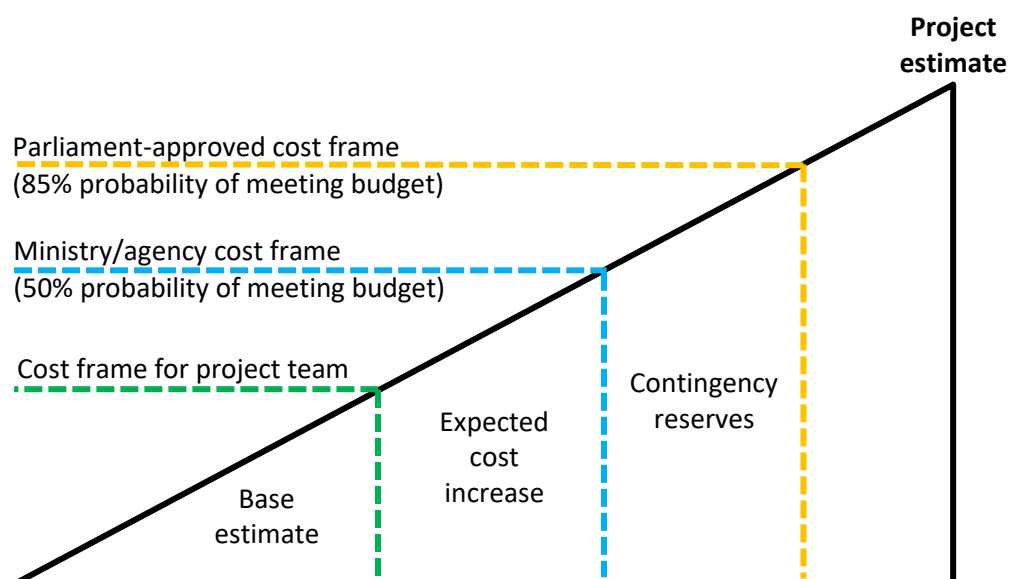
⁵⁶ See Concept Research Programme (Undated).

⁵⁷ See Finansdepartementet (2008).

⁵⁸ See Torp et al. (2006).

⁵⁹ Ibid.

Figure 5 — Cost frame management for Norwegian major projects



Source: Concept Research Programme (Undated).

Effectiveness and implementation issues

4.7 Based on the implementation experiences, the process to conduct conceptual appraisal and QA1 review before the Cabinet decision generally took two to four years, while stage two from pre-project phase, QA2 review, to Parliament's approval, followed by engineering and construction phase generally took about two to five years.⁶⁰ According to various evaluation studies,⁶¹ the implementation of **QA2** has resulted in **more frequent cost underruns** and **more effective cost control** for Norway's portfolio of major infrastructure projects. Based on cost data from 78 projects, it is observed that **close to 80% of the projects have stayed within the approved cost frame**, yielding an **average cost saving of around 6%**. The results also suggest reduced frequency and magnitude of cost overruns compared to the period prior to the QA Scheme.

4.8 Notwithstanding the above positive findings, there are concerns that, when preparing the initial base estimates, line agencies may tend to overestimate costs to reduce risk of overruns⁶² although the cost estimates will later undergo quality assurer's review. Reliance on external consultants may also render a concern over the adequacy of expertise in the market. Moreover, the QA Scheme is focused on the project front-end phase and does

⁶⁰ See Volden and Samset (2017).

⁶¹ See Odeck et al. (2015), Samset et al. (2016), and Welde (2017).

⁶² See Odeck et al. (2015).

not require further quality assurance during project implementation and/or construction. This is essentially based on the assumption that Norwegian ministries have in place well-established practices and guidelines to ensure smooth project delivery.⁶³ Nevertheless, the experiences indicate that the Norwegian QA Scheme has been successful in reducing cost overruns. According to the Norwegian government, other places such as Denmark, Sweden and Cyprus have followed a similar cost management scheme for their infrastructure projects.

5. The Netherlands' experiences in environmental mitigation for land reclamation

5.1 In the Netherlands, the Port of Rotterdam is the largest port in Europe. In order to expand its capacity, the Port of Rotterdam Authority commenced the project of Maasvlakte 2 in 2008 (**Appendix II**). With a cost of €2.9 billion (HK\$31 billion), the first phase of Maasvlakte 2 extension involved reclaiming 700 hectares of land from the North Sea.⁶⁴ The reclaimed area consists of seawalls, shipping quays, rail and roads, and other usable sites. The first-phase Maasvlakte 2 extension was completed on schedule and has been in operation since 2013.

5.2 However, Maasvlakte 2 involved reclamation in Voordelta, a marine environment of high natural value protected by EU's Natura 2000 network.⁶⁵ It was found that the construction and operation activities would incur loss of seabed and habitats, decline in plant and bird species, and increase in emission levels.⁶⁶ Under the EU regulations, developments within Natura 2000 must be offset by adequate compensation, either by establishing a new habitat, or by recreating and/or improving an affected habitat.⁶⁷ In 2002, the Dutch government issued a formal notification with proposed compensation measures to EC. Subsequently, EC approved the Maasvlakte 2 project on the condition that (a) compensation measures are executed in a timely manner;

⁶³ See Odeck et al. (2015).

⁶⁴ The Maasvlakte 2 extension will be carried out in phases with further port sites rolled out between 2013 and 2030. The entire project is expected to cover 2 000 hectares of land. See Port of Rotterdam Authority (Undated).

⁶⁵ Natura 2000 is a network of specially protected areas in the EU member states as stipulated by the Habitat Directive. Under the EU regulations, only projects with an "overriding public interest" may be carried out in Natura 2000 sites. See European Commission (2019).

⁶⁶ See European Commission (2003) and Meulen (2016).

⁶⁷ See European Council (1992) and van Gent (2014).

and (b) management plans and monitoring programmes are in place to ensure their long-term effectiveness.⁶⁸

5.3 The Maasvlakte 2 project had involved extensive public consultations. Besides collecting public views at the stage of EIA and spatial planning, the Port of Rotterdam Authority also set up a stakeholder's forum to gauge the concerns of environmental groups. Taking into account compensation requirements and public feedback, the Dutch government drafted the key development plan ("Key Plan") delineating the scale of reclamation, constraints and preconditions for design, construction and operations. After further public consultation and refinements, the Key Plan was approved by the Dutch Parliament in October 2006. The Key Plan notably laid down two reference designs as a baseline (**Appendix III**), affirming that **negative environmental impacts of the final design would not exceed** those of the **reference designs**; and that **additional measures would be adopted** if environmental monitoring programmes indicate **existing compensation measures are inadequate**.⁶⁹

5.4 Based on the Key Plan, the government developed the final package of measures to minimize its impact on the environment upon completion of another round of EIA on construction and zoning. These included sustainable design and construction features, new protection areas for marine and land ecosystems, and an extensive environmental monitoring programme. The following sections discuss these features in more detail.

Sustainable design and construction

5.5 Maasvlakte 2 adopted some sustainable design features to further reduce its environmental impact as compared to the reference designs set out in the Key Plan.⁷⁰ This included implementing a **"cut-through" design**⁷¹ **with less reclamation required** to obtain the same amount of usable land (Appendix III). **Soft seawalls** featuring less sand use and more space for nature development were also implemented to **mitigate the loss of natural coastline**.⁷²

⁶⁸ See European Commission (2003).

⁶⁹ See Project Mainportontwikkeling Rotterdam (2006).

⁷⁰ See Port of Rotterdam Authority (2007).

⁷¹ The cut-through design involves modifying the existing water channel in Maasvlakte to serve as access to Maasvlakte 2. Instead of a dedicated entrance, incoming ships reach the port via a short detour. The design resulted in a 20% reduction in the amount of reclaimed land. See Port of Rotterdam Authority (Undated).

⁷² See Peeters (2013) and Port of Rotterdam Authority (2007).

5.6 During construction stage, dredging contractors were required to comply with **sustainable building guidelines** developed by the Ministry of Infrastructure and Water Management, and to **use clean and energy-efficient vessels** and **reuse construction materials** such as concrete blocks and quarry stones. **Seabed landscaping**⁷³ was also adopted to create artificial sand ridges and troughs in sand extraction areas to **provide a favourable habitat for recovering marine species**.

Environmental compensation and monitoring

5.7 In addition to the design features, ecological compensation measures were implemented to mitigate the impact on terrestrial and marine habitats as well as a number of bird and plant species.⁷⁴ This included the institution of a 25 000-hectare **seabed protection area** to reduce human disturbance and improve ecological gain.⁷⁵ In accordance with EC's advice, the **protection area was instituted prior to the construction of Maasvlakte 2**. Within the area, trawling activities are prohibited and certain recreational activities such as speedboats are regulated. To compensate for the loss of habitat, **resting and foraging zones were created for sensitive seabird species**.⁷⁶ Furthermore, a 35-hectare **artificial dune area** was created to offset increased emissions from shipping activities which may impoverish the nearby sand dunes ecosystem.⁷⁷ The dune area was **formed in parallel to the construction** of Maasvlakte 2, and **continuous site management**⁷⁸ was provided to ensure desired compensation targets are met.

5.8 As required by the Key Plan, environmental monitoring programmes were put in place before, during and after the construction of Maasvlakte 2. **The environmental monitoring programmes are expected to run through the**

⁷³ Seabed landscaping involves the creation of artificial sand ridges and troughs which mimic natural seabed habitats. See EcoShape (Undated).

⁷⁴ See European Commission (2003).

⁷⁵ The entire Maasvlakte 2 project is expected to result in the loss of some 2 500 hectares of seabed. According to the Key Plan, the seabed protection area of 25 000 hectares is expected to achieve an ecological gain of 10%, i.e. roughly equivalent to the loss of 2 500 hectares of seabed area. See Project Mainportontwikkeling Rotterdam (2006).

⁷⁶ See Meulen (2016).

⁷⁷ According to the environmental impact assessment, the construction of Maasvlakte 2 could lead to a reduction of up to 3.8 hectares of dune areas. See Port of Rotterdam Authority (2007).

⁷⁸ Site management includes fine tuning measures in case the dune development deviates from compensation targets. See Meulen (2016) and Government of the Netherlands (2018).

project's lifetime⁷⁹ and comprise surveys on the ecosystem covering silt concentration, benthic species, fish and bird activities, abiotic conditions, etc.⁸⁰

5.9 Furthermore, a **Quality Control Round Table** comprising the Port of Rotterdam Authority, government bodies and environmental concern groups was set up to monitor the progress of compensation measures.⁸¹ The Round Table meets biannually to discuss and, where necessary, recommend additional compensation measures. For instance, the **resting areas for bird species have been extended** following surveys which suggested that the original areas were suboptimal. There is also an on-going review on additional regulations for leisure activities in protected areas because of their disturbance on protected species.

6. Observations

6.1 The Government has recently announced the Lantau Tomorrow initiative. Like other major infrastructure projects, land reclamations raise concerns over cost and environmental impact because of their complexity, large scale and long duration. In Hong Kong, in view of the instances of cost overruns or higher-than-estimated costs in mega projects, the Government has in recent years rolled out some cost management measures for public works, including establishing PCMO for project management and cost control. Nevertheless, it has been suggested that the Government should also draw upon external expertise to enhance scrutiny of project costs.

6.2 Among the overseas places studied, various cost management measures have been implemented for infrastructure projects. Specifically, Norway, the UK and Singapore attach great importance to external scrutiny of mega projects. For example, the Norwegian QA scheme relies on independent external assurers to recommend a realistic budget through the process of cost estimation and risk analysis, and identification of cost-saving and risk-reduction measures at the front-end stage. Tiered cost frames are also instituted, where spending over the target cost will require consent at the ministry level to avoid overspending of project contingencies. This host of measures have resulted in better cost control.

⁷⁹ The monitoring programmes for seabed protection area and dune area are in place until at least 2021. See Government of the Netherlands (2018).

⁸⁰ See Port of Rotterdam Authority (Undated) and Hendriksen et al. (2017).

⁸¹ See Ravesteijn et al. (2015).

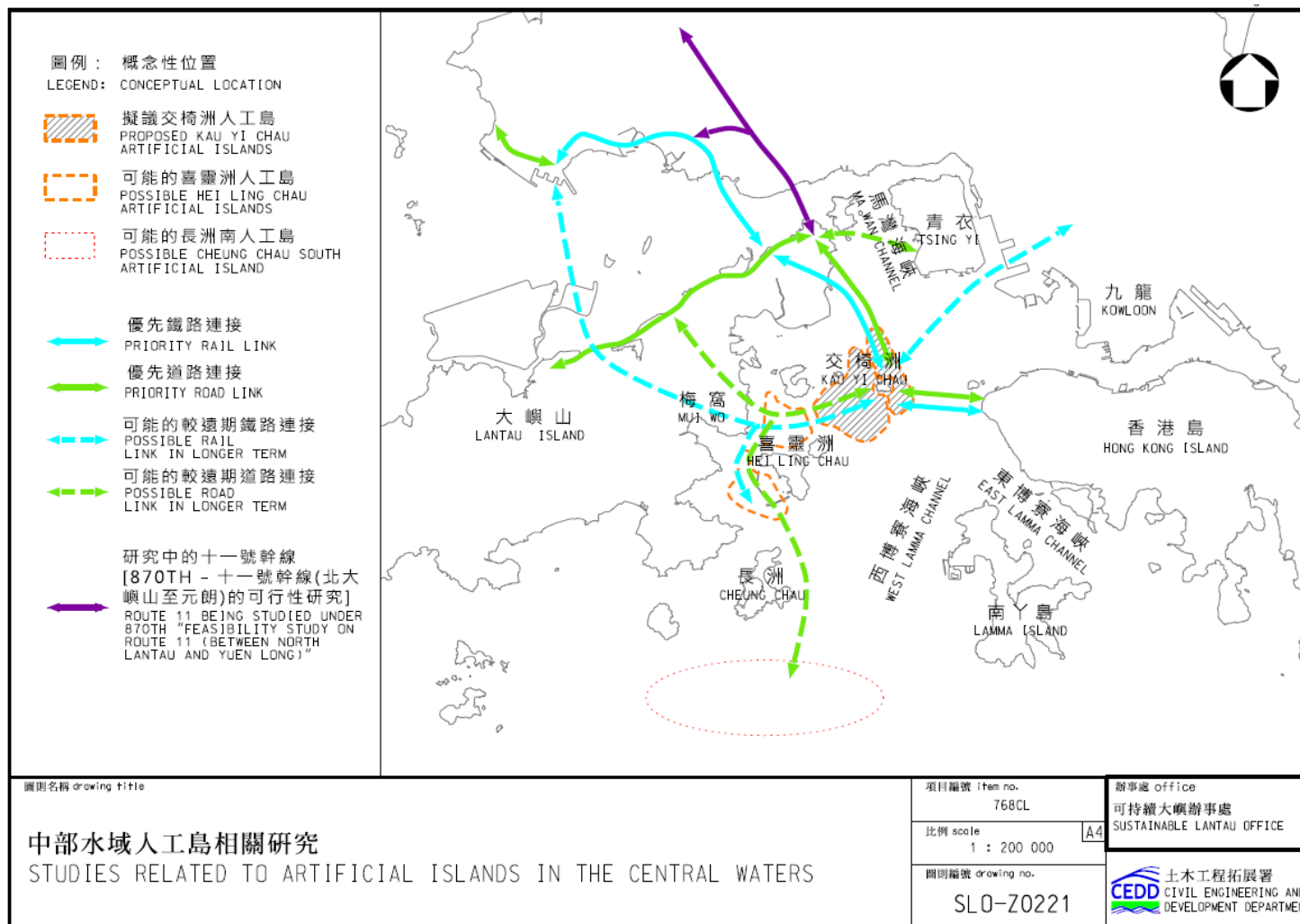
6.3 As regards the environmental impact of reclamation, there were concerns over the effectiveness and adequacy of mitigation measures adopted in previous reclamation projects in Hong Kong. For instance, compensation for the loss of habitat under the HZMB project only took place after construction was completed; and the coral translocation efforts in the 3RS project were criticized as unreliable and insufficient. For the proposed KYC artificial islands, while the Government has characterized the central waters as "ecologically less sensitive", some concern groups have highlighted the presence of sea pen corals as well as protected and/or endemic species in the area, giving rise to concerns whether there will be adequate and timely mitigation/compensation measures in place.

6.4 In the project of Maasvlakte 2 reclamation, the Netherlands government has devised a comprehensive plan to meet the EIA requirements and address environmental concerns of the public. Compensation measures such as formation of protection areas were implemented prior to construction. Furthermore, the effectiveness of mitigation measures are monitored by a Quality Control Round Table comprising both public officials and environmental concern groups with the ambit to suggest additional measures if required. As regards coral translocation, it has been carried out in Singapore and Dubai with continued survival monitoring for some years after project completion. These experiences may be of relevance when considering reclamation projects in the future.

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Proposed location of artificial islands in the central waters



Source: Development Bureau (2019c).

The project of Maasvlakte 2



Source: Rijkswaterstaat (2014).

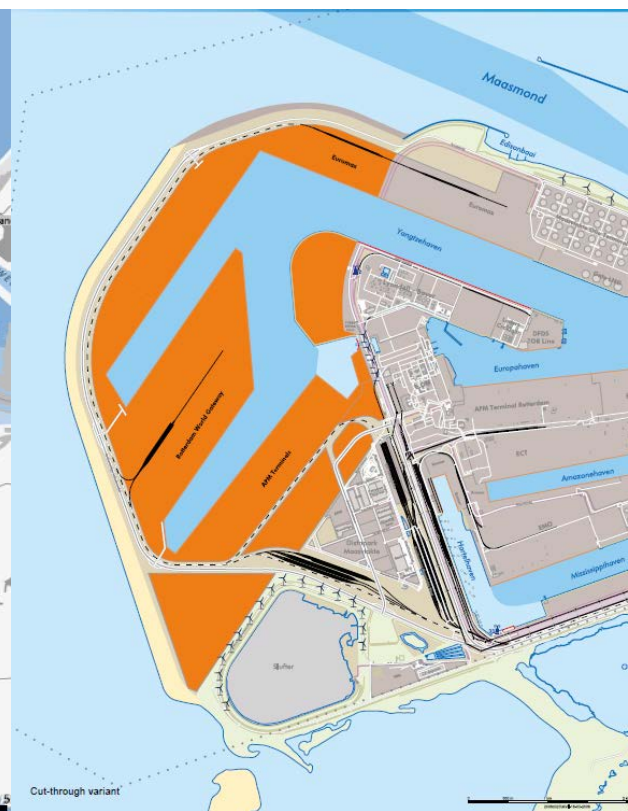
The three designs of Maasvlakte 2⁽¹⁾



Reference design 1, with extended pier



Reference design 2, with immediate access to the sea



Final design, the "cut-through" design

Note: (1) The orange area denotes the proposed Maasvlakte 2 reclamation area.

Source: Port of Rotterdam Authority (2008).

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