Working Group on the Protection of the Harbour Ordinance

For discussion on 24 February 2017 | WGPHO/02/2017

Compliance with the Protection of the Harbour Ordinance

PURPOSE

At the meeting of the Task Force on Harbourfront Developments in Kowloon, Tsuen Wan and Kwai Tsing in March 2016, there were comments that various harbourfront enhancement initiatives had faced difficulties in implementation in face of the Protection of the Harbour Ordinance (PHO) (Cap. 531). The issue was then raised to the Harbourfront Commission (HC) for discussion and at its meeting in December 2016, it was decided that a Working Group would be set up to examine matters arising from PHO. This paper aims to look into past attempts to take forward harbourfront-related projects and the efforts made in complying with the PHO.

BACKGROUND

2. PHO first came into force on 30 June 1997. The Chairman of the Bills Committee for the Protection of Harbour Bill 1997 described in his report to the Legislative Council on 27 June 1997 that the purpose of PHO was –

> "…to ensure that Victoria Harbour will be protected against excessive reclamation. It establishes a presumption against reclamation in the harbour…"

3. When it was enacted in June 1997, the application of PHO was limited to the central part of Victoria Harbour. Subsequently, further legislative amendments were made in December 1999 to expand its scope to cover the whole of Victoria Harbour[1]. The amended PHO has

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[1] The boundaries of the Harbour are set out in Schedule 3 of the Interpretative and General Clauses Ordinance (Cap. 1) as – "On the east - A straight line drawn from the westernmost extremity of Siu Chau Wan Point to the westernmost extremity of Ah Kung Ngam Point (sometimes known as Kung Am); On the west - A straight line drawn from the westernmost point of Island of Hong Kong to the westernmost point of Green Island, thence a straight line drawn from the westernmost point of Green Island to the southeasternmost point of Tsing Yi, thence along the eastern and northern coast lines of Tsing Yi to the westernmost extremity of Tsing Yi and thence a straight line drawn true north therefrom to the mainland." A map showing the extent of the Victoria Harbour as defined is shown in **Annex A** for ease of reference. The same is

continued to remain in force since then. A copy of PHO is at **Annex B**.

4. Subsequently, in the judgment of *Town Planning Board v Society for the Protection of the Harbour Limited* (FACV No 14/2003) laid down by the Court of Final Appeal (CFA), CFA set out that there should be a presumption against reclamation and the presumption could only be rebutted by establishing an overriding public need for reclamation. A public need would only be regarded as overriding if it is compelling and present, and if there is no reasonable alternative to reclamation. Even if any, the extent of reclamation should not go beyond the minimum which is required by the overriding public need. The decision that there is an overriding public need for reclamation must be based on cogent and convincing materials (CCM).

5. For a detailed overview of the PHO and related issues, Members may wish to refer to HC paper 08/2016 (at **Annex C**), which was presented in the HC meeting on 21 June 2016.

COMPLIANCE WITH PHO

6. The Government is committed to protecting and preserving the harbour and enhancing it for public enjoyment. To ensure compliance with PHO in light of the CFA's judgment, the Government issued a Technical Circular (at **Annex D**) in August 2004 setting out the requirements of PHO and providing guidance for public officers and public bodies in considering and approving reclamation proposals within the Victoria Harbour. In September 2004, the Government also made a public statement that there would be no new reclamation plan in the Victoria Harbour (apart from the Central Reclamation Phase III (CRIII) and Wan Chai Development Phase II (WDII)).

7. The guidelines set out in the Circular apply to all reclamation proposals, regardless of scale, initiated by the Government or the private sector within the boundaries of the harbour. Based on the CFA judgment, the Circular provides a flow chart that highlights the major considerations that should be taken into account by public officers and public bodies in the decision-making process on reclamation proposals. It applies to all stages of the process covering planning and engineering investigations, preparation of plan and reclamation/road schemes for gazetting, consideration of objections, approval/authorization under relevant ordinances, funding approval and detailed design of a reclamation project.

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reproduced as Annex A to the Technical Circular.

8. According to the Circular, three basic questions will need to be answered for each area of reclamation - whether there is a compelling and present public need, whether there is any reasonable alternative, and whether the proposed reclamation extent is the minimum. Answers to these questions must be clearly documented and substantiated by cogent and convincing materials. It is the responsibility of the proponents of individual facilities (i.e. the client bureaux/departments) to prove, with engineering input from the relevant works departments, that the proposals they put forward will meet "the overriding public need test".

PROJECTS IMPLEMENTED UNDER THE PROCEDURES SET OUT IN THE TECHNICAL CIRCULAR

9. Since the promulgation of the Circular, the following large-scale projects were taken forward in accordance to stipulated procedures in order to comply with the PHO.

CRIII

10. The need for CRIII arose from a number of planning studies commissioned by the Government since early 1980s. Its aim is to provide land for essential transport infrastructure including the Central – Wan Chai Bypass. The land would also provide for part of a vibrant waterfront promenade on the northern shore of Hong Kong Island.

11. The Civil Engineering and Development Department (CEDD) conducted two reviews in respect of reclamation for CRIII to ensure its compliance with PHO. The first review was conducted in November 2003 by applying the "three tests" (i.e. "compelling, overriding and present need"; "no viable alternative"; and "minimum impairment") as laid down in the High Court judgment of 8 July 2003. The review concluded that the CRIII reclamation meets the "three tests".

12. Following CFA's subsequent judgment in January 2004 which laid down the single test of "overriding public need" to replace the "three tests", CEDD conducted a further review of CRIII in 2004, which resulted in the "Review of CRIII by applying the CFA's 'Overriding Public Need Test'" (Review Report). The Review Report applied the CFA's overriding public need test and its formulations to ensure that CRIII met the test based on social, economic and environmental needs; that there was no reasonable alternative to reclamation and that the extent of reclamation was minimum for the purpose. The Review Report set out justifications by looking into the structural design of each major element under CRIII. It contained detailed elaborations on the need for

the Central – Wan Chai Bypass and related road infrastructure. Other possible alternatives were also thoroughly examined and eliminated with sufficient reasoning. In addition, independent experts from various disciplines and third-party endorses provided supporting affirmations for CRIII as an optimal and necessary solution. The Review Report with a total of 116 pages excluding its Enclosures and Annexes is at **Annex E**.

WDII

13. The main purpose of the WDII project is to provide land within the project area for the construction of a Trunk Road (comprising the Central - Wan Chai Bypass and Island Eastern Corridor Link) and other key transport infrastructure including the necessary ground level roads for connection to the Trunk Road and to cater for through traffic from Central to Wan Chai and Causeway Bay. The land formed under the project would provide opportunities for the development of a waterfront promenade joining that at the new Central waterfront for public enjoyment.

14. CEDD completed a CCM report for the WDII project in 2007. The report first looked into whether there was an overriding public need for the Trunk Road. By drawing references to various traffic and transport studies, as well as the recommendations of an Expert Panel Forum, the report demonstrated that there was a compelling and present need for the Trunk Road. The report identified all possible alignments and concluded that there was no feasible "no-reclamation" alignment for the Trunk Road. It further examined different Trunk Road options in details, and the option with the least amount of reclamation was selected. The report also summarised public views collected and suggested a preferred scheme for the Trunk Road. The report also conducted a detailed examination on the engineering requirements of the preferred scheme to ascertain that it would fulfil all PHO requirements. The CCM report for the WDII project with a total of 100 pages excluding its Annexes is at **Annex F**.

Shatin to Central Link (SCL)

15. The SCL is a major infrastructure project developed in accordance with the Government's transportation policy and as part of the-then Railway Development Strategy. It comprises a railway line that would connect several existing railway lines and creates two distinct east-west and north-south railway corridors. The SCL project would involve temporary reclamation that would be removed after construction and replacement of the fender piles. Temporary reclamation would equally be subjected to the PHO.

16. Similarly, the Mass Transit Railway Corporation Limited (MTR) completed a CCM report in 2010. The CCM report demonstrated SCL's compliance with the overriding public need test by providing extensive evidence (e.g. improved accessibility in quantitative terms) and detailed accounts of the social, economic and environmental benefits to be brought about by SCL (e.g. estimation of the employment opportunities created as well as benefits in monetary terms). A number of "no-reclamation options" were investigated and found not viable or reasonable with the support of technical evidence. To ensure that the extent of reclamation was minimum, the exact areas of reclamation were identified and their respective engineering purposes were accounted for. The report also set out public consultation activities undertaken and general public views collected. The CCM report for the SCL project with a total of 26 pages excluding its Annexes is at **Annex G**.

Central Kowloon Route (CKR)

17. The CKR project comprises a trunk road across central Kowloon linking West Kowloon at Yau Ma Tei Interchange with the Kai Tak Development and road network at Kowloon Bay in East Kowloon. A section of the CKR tunnel between the Kowloon City Ferry Pier to the Kai Tak Development Area will pass through the seabed of Kowloon Bay. Due to site constraints, the construction would involve temporary reclamation.

18. Alike above-mentioned projects, the Highways Department completed a CCM report in 2013. The report covered detailed traffic justifications by analysing traffic situations in the concerned areas. It gave assessments on the estimates of economic returns and reduction in annual emissions to provide support to the community benefits of the project. The report then looked into various construction methods and engineering perspectives in proving that there was no viable or reasonable no-reclamation alternative and that the extent of temporary reclamation involved in the recommended scheme was the minimum. Public views collected were set out in the report and findings from two independent experts review were also included. The CCM report for the CKR project with a total of 23 pages excluding its Annexes is at **Annex H**.

PHO IMPLICATIONS OF SMALLER SCALE PROJECTS

19. The Circular made clear that small-scale reclamations required for the construction of piers, landing steps, etc. would also need to comply with the stipulated guidelines. Over the years, unlike major projects as outlined above, there did not appear to be any case of

small-scale reclamations that went through the procedures as required in the Circular. Some of these projects were brought to the discussion of the HC and its Tasks Forces but none has come into fruition yet.

Pontoons

20. Generally speaking, pontoons comprise floating unit(s) in the form of a floating platform and are usually located near the shore and would float on sea water. They can serve as landing facilities thereby facilitating embarkation and de-embarkation of vessels for water transport. They may also serve as facilities to allow for the transfer or launch of light vessels to and from the sea water, which would be an important facility to allow participation of different water sports in the harbour. Its use was discussed in various occasions, including the employment of floating pontoons as barrier-free access (BFA) facilities.

21. Due to the constantly varying tide levels, as well as carrying sizes of vessels making use of public landing facilities, there is at present no provision of BFA facilities thereon. Employment of a floating pontoon adjacent to these landing steps was once identified as a possible means to provide BFA for wheel chair users. According to legal advice, whether such pontoons are regarded as land and whether reclamation is involved would depend on the actual size of the pontoon, the duration and interval of use and its actual operation. However, it should be noted that Section 3(1) of the PHO establishes a statutory principle recognizing the harbour as a special public asset and a natural heritage of Hong Kong people and prescribing it to be protected and preserved. Before establishing if the use of any pontoon, even if for the provision of BFA, is permissible under PHO, many more facts and circumstances would have to be looked into, including whether such part of the harbour would then be deprived of its normal function after the employment of the floating pontoon.

22. The Chief Executive promulgated the promotion of a “water-friendly culture” in his 2013 and 2015 Policy Address. It is foreseeable that in the future development of water sports, the use of pontoons to facilitate safe transfer of lighter rowing boats and canoes, for instance, to and from the water would be necessary and their PHO implications would have to be suitably addressed.

Breakwaters

23. Back in 2011, there was a proposal of incorporating a yacht centre at the Yau Tong Bay “Comprehensive Development Area” that was discussed at the Task Force on Harbourfront Developments in Kowloon, Tsuen Wan and Kwai Tsing. The project proponent later

reported that in order to provide protected waters, they would need to build a breakwater. The construction of a breakwater within the Victoria Harbour would be considered as reclamation and hence be subjected to PHO. The project proponent later decided not to pursue with the proposal and one of the quoted reasons was that its private legal advice concluded that there could be difficulty in satisfying the overriding public need test in compliance with PHO with the construction of the breakwater.

Marinas

24. The Task Force on Water-land Interface conducted a general overview of marina development in Hong Kong in 2013. At the meeting, it was noted that if any marina is to be built, it would encompass key water-side structures including breakwaters, finger piers and guide piles. All these, if to be built within the Victoria Harbour, would have PHO implications.

Enhancement of Waterfront Promenades

25. In 2012, a District councillor of Central and Western District Council proposed a minor works project to construct a cantilever slab supported by bored piles on the landward side to enhance the waterfront promenade of Kennedy Town. While the District Council supported the proposal, legal advice considered that the cantilever slab erected over the sea would remove enjoyment of the sea of the area under the cantilever slab and would likely constitute reclamation even though there would be some space between the slab and the surface of the harbour. The project was then put on hold and no further discussion has been made since then.

Seawalls

26. There was no concrete discussion of the issue in past meetings, but Members have envisioned that if existing vertical seawalls would have to be replaced (either by sloping or vertical but wave-absorbing seawall), the need for reclamation would be likely, given that there is usually current usage immediately behind the seawalls and it would be difficult to retreat the seawalls landward.

Piers and Landing Steps

27. While there was no concrete discussion of particular plans to construct new piers, the Task Force on Water-land Interface has looked into an overview of future public landing facilities in West Kowloon Cultural District in 2013. Members envisioned that there might be PHO implications regarding provision and design of permanent piers,

and remarked that the possible implications should not compromise the need for piers. Similarly, it is envisaged that landing steps, if not built by retreating the seawalls landward, would also be subject to PHO.

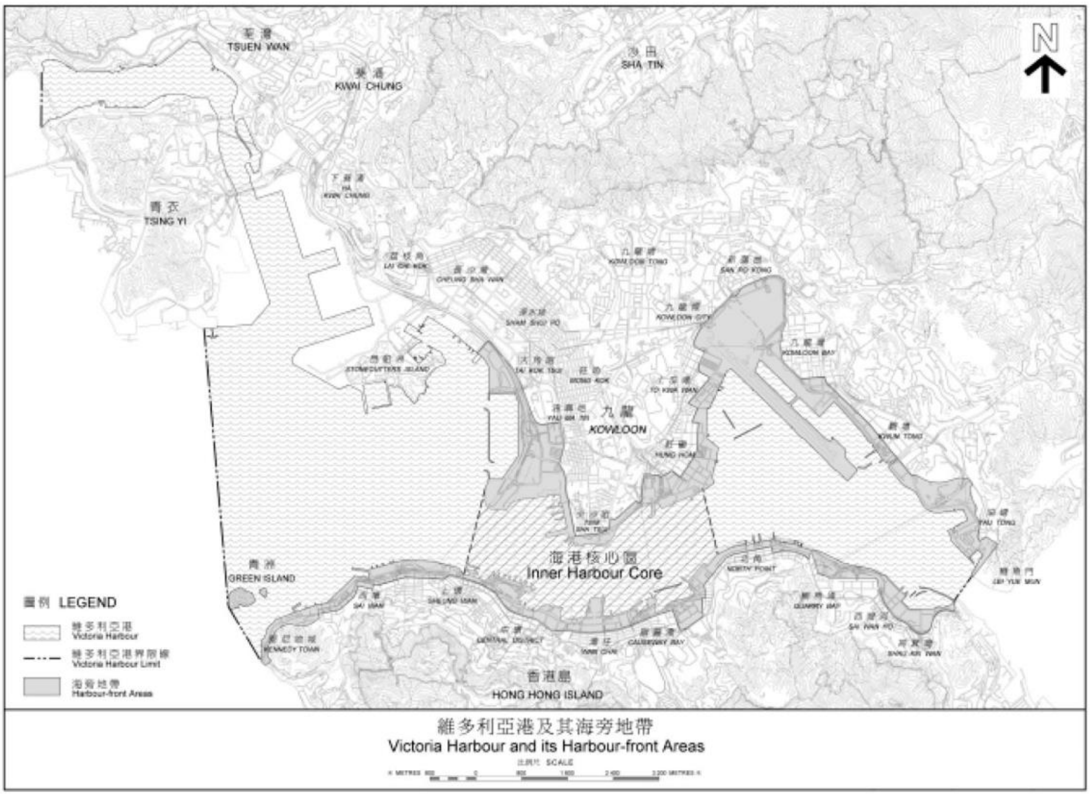
ADVICE SOUGHT

28. Members are invited to note the above harbourfront projects with different scale and nature and discuss possible ways to facilitate the implementation of harbourfornt enhancement projects, in particular those which include small-scale reclamations, with compliance with PHO in mind.

Secretariat
Working Group on the Protection of the Harbour Ordinance
Harbourfront Commission
February 2017

Annex A

A map showing the extent of the Victoria Harbour as defined in Schedule 3 of the Interpretative and General Clauses Ordinance (Cap. 1)



Chapter:	531	**PROTECTION OF THE HARBOUR ORDINANCE**	Gazette Number	Version Date

		Long title	75 of 1999	03/12/1999

An Ordinance to protect and preserve the harbour by establishing a presumption against reclamation in the harbour.
(Replaced 9 of 1998 s. 2. Amended 75 of 1999 s. 2)

[30 June 1997]

(Originally 106 of 1997)

Section:	1	**Short title**		30/06/1997

This Ordinance may be cited as the Protection of the Harbour Ordinance.

Section:	2	**Interpretation**	75 of 1999	03/12/1999

In this Ordinance, unless the context otherwise requires-

"reclamation" (填海) means any works carried out or intended to be carried out for the purpose of forming land from the sea-bed or foreshore; (Replaced 9 of 1998 s. 3)

"relevant Ordinance" (有關條例) means-

(a) the Foreshore and Sea-bed (Reclamations) Ordinance (Cap 127);
(b) the Cross-Harbour Tunnel Ordinance (Cap 203);*
(c) the Eastern Harbour Crossing Ordinance (Cap 215);
(d) the Mass Transit Railway (Land Resumption and Related Provisions) Ordinance (Cap 276);
(e) the Roads (Works, Use and Compensation) Ordinance (Cap 370);
(f) the Western Harbour Crossing Ordinance (Cap 436); or
(g) any other Ordinance under which reclamation is authorized or which otherwise provides for reclamation.

(Amended 9 of 1998 s. 3; 75 of 1999 s. 3)

Note:
* **Repealed — see 44 of 1999 s. 45.**

Section:	3	**Presumption against reclamation in the harbour**	75 of 1999	03/12/1999

(1) The harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people, and for that purpose there shall be a presumption against reclamation in the harbour. (Amended 75 of 1999 s. 4)

(2) All public officers and public bodies shall have regard to the principle stated in subsection (1) for guidance in the exercise of any powers vested in them.

Section:	4	**Transitional**	75 of 1999	03/12/1999

(1) This Ordinance does not apply to any reclamation authorized under a relevant Ordinance before the commencement of this Ordinance. (Amended 75 of 1999 s. 5)

(2) The Protection of the Harbour (Amendment) Ordinance 1999 (75 of 1999) ("the Amendment Ordinance") does not apply to any reclamation authorized under a relevant Ordinance before the commencement of the Amendment Ordinance. (Added 75 of 1999 s. 5)

Schedule:	1	**(Repealed 75 of 1999 s. 6)**	75 of 1999	03/12/1999

Harbourfront Commission

For discussion
On 21 June 2016

HC/08/2016

Background Information Note on Protection of the Harbour Ordinance

PURPOSE

At the meeting of the Task Force on Harbourfront Developments in Kowloon, Tsuen Wan and Kwai Tsing on 9 March 2016, a member commented that the Protection of the Harbour Ordinance (PHO) (Cap. 531) had not been facilitating the implementation of various harbourfront enhancement initiatives. The Task Force considered that the issue should be raised at the Commission for discussion and deliberation on possible way forward. This paper sets out background information on PHO to facilitate discussion by the Commission.

BACKGROUND OF PHO

2. PHO first came into force on 30 June 1997. It originated as a private member's bill introduced in 1996 by a Legislative Council Member who was the Deputy Chairperson of the Society for Protection of the Harbour (SPH) then. The Chairman of the Bills Committee for the Protection of Harbour Bill 1997 described in his report to the Legislative Council on 27 June 1997 that the purpose of PHO was –

> "…to ensure that Victoria Harbour will be protected against excessive reclamation. It establishes a presumption against reclamation in the harbour…"

3. The application of PHO, when it was enacted in June 1997, was limited to the central part of Victoria Harbour. Subsequently, PHO was further amended in December 1999 by expanding its scope to cover the whole of Victoria Harbour[1]. The 1999 amendment also originated from a private member's bill proposed by the same Legislative Council Member but the bill was eventually taken over by the Government. The amended

[1] The boundaries of the Harbour are set out in Schedule 3 of the Interpretative and General Clauses Ordinance (Cap. 1) as – "On the east - A straight line drawn from the westernmost extremity of Siu Chau Wan Point to the westernmost extremity of Ah Kung Ngam Point (sometimes known as Kung Am); On the west - A straight line drawn from the westernmost point of Island of Hong Kong to the westernmost point of Green Island, thence a straight line drawn from the westernmost point of Green Island to the south-easternmost point of Tsing Yi, thence along the eastern and northern coast lines of Tsing Yi to the westernmost extremity of Tsing Yi and thence a straight line drawn true north therefrom to the mainland." A map showing the extent of the Victoria Harbour as defined is shown in **Annex A** for ease of reference.

PHO has continued to remain in force since. A copy of the PHO in force is at **Annex B**.

THE PROVISIONS OF PHO

4. The long title of PHO provided that the Ordinance is -

> "(t)o protect and preserve the harbour by establishing a presumption against reclamation in the harbour…"

5. PHO consisted of 4 sections and one schedule (the schedule was repealed in the 1999 amendment exercise). Section 1 is the short title. Section 2 is interpretation, which provides for the definition of various terms. In particular, "reclamation" is defined to mean –

> "any works carried out or intended to be carried out for the purpose of forming land from the sea-bed or foreshore"

which refers to all reclamations regardless of their scale, nature or purpose, temporary or permanent.

6. Section 3 of PHO sets out the presumption against reclamation in the harbour and the duty of public officers and public bodies –

> "(1) The harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people, and for that purpose there shall be a presumption against reclamation in the harbour.
>
> (2) All public officers and public bodies shall have regard to the principle stated in subsection (1) for guidance in the exercise of any powers vested in them."

7. Section 4 deals with transitional matters, i.e. PHO does not apply to reclamation authorized before the commencement of PHO.

JUDICIAL REVIEW IN RELATION TO PHO

8. Under the proposed Central Reclamation Phase III, reclamation would need to be carried out within the Victoria Harbour. The land to be formed by the proposed reclamation would serve the following purposes, including –

(a) the provision of roads, namely a trunk road (Central-Wan Chai Bypass) and a road complex (Road P2, providing road connections between the trunk road and the existing road network in Wan Chai);

(b) the provision of a waterfront promenade;

(c) the elimination of "dead corners" in the harbour and the provision of an intercepting box culvert to enable stormwater to be discharged outside the typhoon shelter;

(d) the provision of a harbour park; and

(e) the reprovisioning of various facilities.

9. In connection with the proposed Central Reclamation Phase III, the Town Planning Board (TPB) exhibited the Draft Wan Chai North Outline Zoning Plan No. S/H25/1 (the draft plan) on 19 April 2002 for public inspection. The draft plan covered an area of about 76.54 hectares in Wan Chai North and designated uses for various parts of the area. Many written representations and comments on the draft plan objecting to the proposed reclamation were received by TPB.

10. After hearing the representations and comments (including those from SPH) on 6 December 2002 and 14 February 2003, TPB decided (a) to make limited amendments to the draft plan to meet some objections; (b) not to amend the draft plan to meet other objections; and (c) to submit the draft plan as amended to the Chief Executive in Council for approval.

11. On 27 February 2003, SPH initiated a Judicial Review (JR) against the decision of TPB in respect of the draft plan, in particular TPB's decisions not to modify the proposed reclamation. The JR went all the way to the Court of Final Appeal (CFA) (see *Town Planning Board V Society for the Protection of Harbour Limited* (FACV No 14/2003)). CFA handed down its judgment on 9 January 2004.

CFA'S RULING ON PHO

12. In its judgment, CFA set out the legal principles behind PHO, the presumption against reclamation and the test that can rebut it were clarified. CFA considered that the Victoria Harbour was a special public asset and natural heritage that belonged to Hong Kong people, and that the purpose of PHO was –

> "30. .... "to protect and preserve the harbour by

establishing a presumption against reclamation in the harbour". As succinctly and powerfully stated in the explanatory memorandum to the bill, the legislative purpose is "to *ensure* that [the harbour] *will* be protected against *excessive* reclamation". (emphasis added). The purpose is to make sure that the harbour will be so protected."

13. CFA further considered that –

> "42 ... The legislative intent was to confer a unique legal status on the harbour by enacting a strong and vigorous principle that it is to be protected and preserved as a special asset and a natural heritage of Hong Kong people, a principle that all public officers and public bodies must have regard to in exercising their powers."

14. Having regard to the purpose and intent, CFA considered that the Harbour must be kept from harm and to be defended and guarded, and there must not merely be protection, but also preservation –

> "*The statutory principle of protection and preservation of the harbour*
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> 32. Section 3(1) establishes a statutory principle recognising the harbour as a special public asset and a natural heritage of Hong Kong people and prescribing that it is to be protected and preserved as such an asset and such a heritage. This principle was enacted in general terms.
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> 33. As was observed at the outset, the harbour is undoubtedly a central part of Hong Kong's identity. It is at the heart of the metropolis both physically and metaphorically. The statute characterises this in the most distinctive terms. It is recognised not merely as a public asset but as a "special" one. It is something extraordinary. The recognition does not stop there. It is further acknowledged to be a natural heritage. "Natural" in that it was not created artificially by man but is part of nature. A "heritage" in that it is inherited as a legacy from previous generations and is to be transmitted from generation to generation. The harbour as a special public asset and natural heritage is declared to belong to Hong Kong people. This reinforces its character as a "public" asset. It is a community asset and as such, is to be enjoyed by the people of Hong Kong. By representing the harbour in such special terms in the statute, the legislature was giving legal recognition to its unique character.

> 34. It is because of its unique character that the harbour must be protected and preserved. The meaning of these words in the statutory principle is plain. There must be protection, that is, it must be kept from harm, defended and guarded. And there must be not merely protection. There must also be preservation. Preservation connotes maintenance and conservation in its present state. What must be emphasised is that under the principle, what is to be protected and preserved is the harbour as a special public asset and a natural heritage of Hong Kong people.
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> 35. It is manifest that in enacting the statutory principle, the legislature was giving legal recognition to the great public need to protect and preserve the harbour having regard to its unique character. The principle is expressed in clear and unequivocal language. The legislative intent so expressed is to establish the principle as a strong and vigorous one. By prescribing such a principle, the legislature has accorded to the harbour a unique legal status."

15. CFA considered that reclamation would result in permanent destruction and irreversible loss of what should be protected and preserved under the statutory principle. The legal effect of the statutory presumption against reclamation was not to impose an absolute bar against reclamation, but a presumption that could be rebutted –

> "*The statutory presumption against reclamation*
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> 36. …
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> 37. Reclamation would result in permanent destruction and irreversible loss of what should be protected and preserved under the statutory principle. The statutory presumption was therefore enacted to implement the principle of protection and preservation. It is a legal concept and is a means or method for achieving protection and preservation. Its legal effect is not to impose an absolute bar against any reclamation. It does not prohibit reclamation altogether. As a presumption, it is capable of being rebutted.
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> ….
>
> *Rebutting the statutory presumption*

> 40. The presumption is against reclamation. It is however rebuttable. It can be displaced. The critical question is: as a matter of statutory interpretation, what should be regarded as sufficient to rebut it?"

16. On rebutting the statutory presumption, CFA propounded a single and demanding test. The presumption against reclamation can only be rebutted by establishing an overriding public need for reclamation, i.e. "overriding public need test". To implement reclamation within the limit of the Victoria Harbour, the overriding public need test must be satisfied. Under the test, public needs are community needs, which include economic, environmental and social needs. A need should only be regarded as overriding if it is compelling and present and if there is no reasonable alternative to reclamation. In other words, even if any, the extent of reclamation should not go beyond the minimum which is required by the overriding public need -

> "*Overriding public need*
>
> 44. In order to implement the strong and vigorous statutory principle of protection and preservation, the presumption must be interpreted in such a way that it can only be rebutted by establishing an overriding public need for reclamation. This can conveniently be referred to as "the overriding public need test". The statute, in conferring on the harbour a unique legal status, recognises the strong public need to protect and preserve it. The statute envisages that irreversible loss to the extent of the reclamation would only be justified where there is a much stronger public need to override the statutory principle of protection and preservation.
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> 45. Public needs would of course be community needs. They would include the economic, environmental and social needs of the community.
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> 46. A need should only be regarded as overriding if it is a compelling and present need. The need has to be compelling so that it has the requisite force to prevail over the strong public need for protection and preservation. And it has to be a present need in the sense that taking into account the time scale of planning exercises, the need would arise within a definite and reasonable time frame. If the need would not arise over such a time frame, it would not have the strength to displace the presumption.

> 47. A compelling and present need goes far beyond something which is "nice to have", desirable, preferable or beneficial. But on the other hand, it would be going much too far to describe it as something in the nature of the last resort, or something which the public cannot do without.
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> 48. Where there is a reasonable alternative to reclamation, an overriding need for reclamation would not be made out. There would be no such overriding need since the need could be met by the alternative means. In considering what is a reasonable alternative, all circumstances should be considered. These would include the economic, environmental and social implications of each alternative. The cost as well as the time and delay involved would be relevant. The extent of the proposed reclamation should not go beyond the minimum of that which is required by the overriding need. If it does, the overriding need for the proposed reclamation could not be established, since there would be no need for the reclamation to the extent proposed. It is necessary that each area proposed to be reclaimed must be justified.
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> 49. What the legislation contemplates is the imperative that there shall not be any reclamation unless the overriding public need test is satisfied. The test as explained above should be regarded as a single test. It is by its nature a demanding one."

17. In addition, the decision that there is an overriding public need for reclamation must be based on cogent and convincing materials -

> *"Cogent and convincing materials*
>
> 50. In considering the exercise of any power in relation to any reclamation proposal, a public officer or a public body must apply the overriding public need test and decide whether it is satisfied. It would obviously not be sufficient for the decision-maker to incant the test and assert that the test has been met. This would only be paying lip service to the test. There must be materials before the decision-maker to satisfy him that there is an overriding public need for reclamation so as to rebut the presumption against it.
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> 51. To enable him to be so satisfied, the materials in the case in question must be cogent and convincing. If they do not have this quality, they would not be of sufficient weight to enable the decision-maker to be satisfied that the test is

> fulfilled. The requirement that the materials must be cogent and convincing flows from the demanding nature of the test.
>
> *The burden*
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> 52. Having regard to the demanding nature of the overriding public need test and the requirement that there must be cogent and convincing materials to satisfy the test, the burden on those seeking to rebut the presumption is a heavy one. That this is so is entirely commensurate with what is at stake: the irreversible loss to the extent of the reclamation of a special asset and a natural heritage belonging to the people of Hong Kong."

APPLICATION OF PHO

18. Subsequent to CFA's judgment, the Government set up the former Harbour-front Enhancement Committee (HEC) in May 2004 to advise the Government on, among others, planning, land uses and developments along the existing and new harbourfront of the Victoria Harbour, with a view to protecting the Harbour. One of its focuses was to provide feedback to and monitor the reviews on the remaining proposed reclamation within the harbour, namely the Wan Chai North and Southeast Kowloon reclamation proposals. In September 2004, the Government also made a public statement that there would be no new reclamation plan in the Victoria Harbour (apart from the CRIII and Wan Chai Development Phase II (WDII)).

19. To ensure compliance with PHO in the light of CFA's judgment, the Government issued a Technical Circular in August 2004 setting out the requirements of PHO and providing guidance for public officers and public bodies in considering and approving reclamation proposals in the Victoria Harbour. In particular, the Technical Circular provided guidelines for consideration of reclamation proposals, e.g. the relevant questions to be considered in the decision making process, the need for public consultation, the invitation of independent expert advice when necessary; flow chart in decision making process and examples of materials to justify the overriding public need in different scenarios. A copy of the Technical Circular which remains in force is at **Annex C**.

PREVIOUS DISCUSSIONS RELEVANT TO PHO

20. After the establishment of the Harbourfront Commission, the subject of PHO and projects involving reclamation in the Harbour had

been raised under the aegis of various projects or discussion items. Based on a quick desktop research by the secretariat, which may not be exhaustive given the time constraint of the research, the subject of PHO and projects involving reclamation within the Harbour had been raised on the following occasions -

(a) proposed bridge for linkage between Kwun Tong and the tip of the Kai Tak Runway – 1st and 5th Meeting of Task Force on Kai Tak Harbourfront Development (Kai Tak TF) on 7 September 2010 and 1 June 2011;

(b) proposed water sports centre at Kai Tak – 6th meeting of Kai Tak TF on 3 August 2011;

(c) Proportionality Principle[2] - 7th HC Meeting on 7 September 2011;

(d) the proposed boardwalk underneath the Island Eastern Corridor – 8th, 11th, 13th, 14th, 18th, 19th, 22nd and 23rd Meeting of the Task Force on Harbourfront Developments on Hong Kong Island (HKTF) on 12 January 2012, 30 October 2012, 7 June 2013 and 24 October 2013, 10 February 2015, 5 May 2015, 29 February 2016 and 25 May 2016;

(e) proposal from the Royal Hong Kong Yacht Club on activating the Wan Chai Waterfront - HC meeting on 15 October 2012;

(f) proposed yacht centre at Yau Tong Bay - 11th Meeting of Task Force on Harbourfront Developments in Kowloon, Tsuen Wan and Kwai Tsing (Kowloon TF) on 20 November 2012;

(g) Central Kowloon Route – Phase 2 Public Engagement Exercise – 12th HC Meeting on 7 January 2013;

(h) proposal to widen the promenade and the proposed harbour terrace in the area fronting the New World Centre – 12th Meeting of Kowloon TF on 22 January 2013;

[2] SPH presented the Proportionality Principle at the meeting of the Harbourfront Commission on 7 September 2011. According to SPH, the proposed principle aims to ensure that *"(t)he greater the adverse impact of the proposed reclamation on the harbour, the greater must be the justification; accordingly having established a public need, in deciding if such need overrides the importance of the harbour, the prime consideration is whether any enrichment of the public enjoyment of the harbour and any enhancement of the environmental, social and economic value of the harbour as a result of the reclamation would justify the loss and damage consequentially caused to the harbour."* In response, the Government has pointed out that on the basis of legal advice it received, the Proportionality Principle proposed by SPH is inconsistent with the current provisions of the PHO, which do not differentiate reclamations by their scale.

(i) an overview of marina development in Hong Kong – 5th Meeting of Task Force on Water-land Interface (Water-land Interface TF) on 19 March 2013;

(j) an overview of public landing facilities in West Kowloon Cultural District - 5th Meeting of Water-land Interface TF on 19 March 2013;

(k) briefing on the Protection of the Harbour Ordinance – 6th Meeting Task Force on Water-land Interface on 13 December 2013;

(l) discussion of public seawall within the Victoria Harbour – 10th Meeting of Water-land Interface TF on 19 May 2015;

(m) enhancing the Tsim Sha Tsui waterfront – 22nd Meeting of Kowloon Task Force on 9 March 2016.

21. Since the CFA judgment in 2004, we are only aware of the following three projects that have fulfilled the overriding public need test in accordance with the Technical Circular –

(a) CRIII and WDII (which involved permanent reclamation);

(b) Shatin-Central Link (which involved temporary reclamation); and

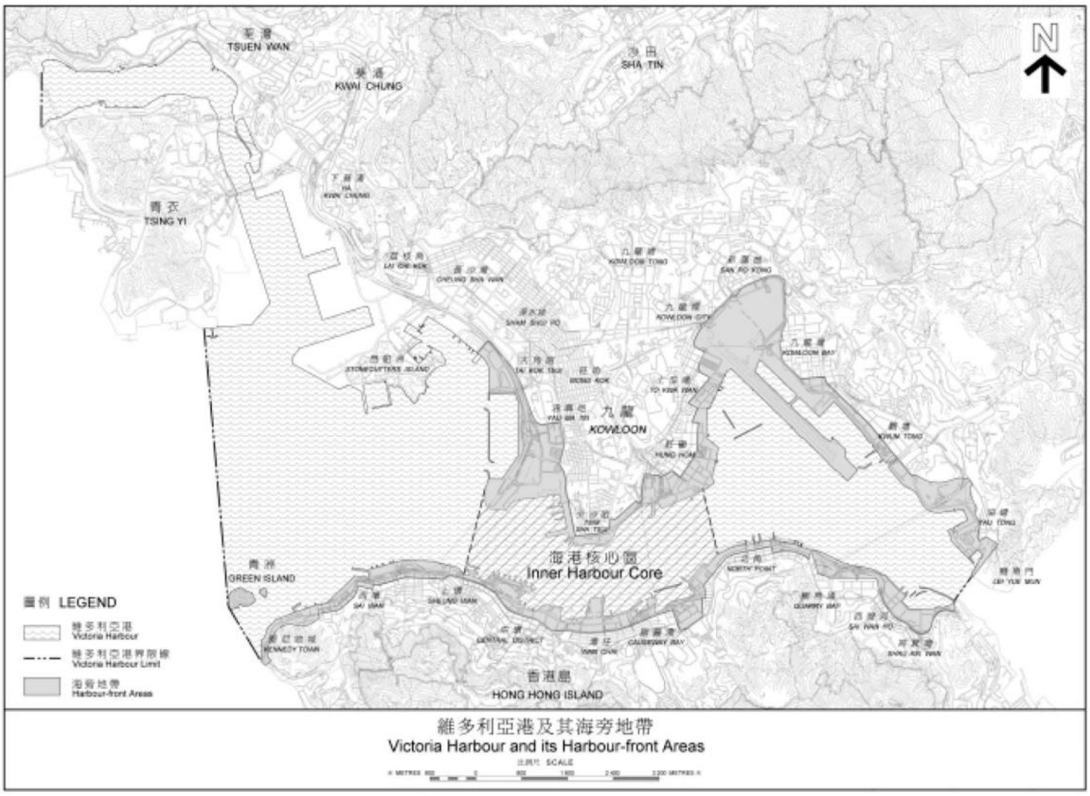
(c) Central Kowloon Route (which involved temporary reclamation).

22. Looking ahead, the proposed Boardwalk under the Island Eastern Corridor under planning would also involve reclamation. The Civil Engineering and Development Department commissioned an investigation study in March 2015 with the aim to, among others, review the feasibility of the proposed boardwalk and demonstrate its compliance with the PHO. CEDD is now assessing the views collected from stage one of the community engagement exercise as part of the process in preparing cogent and convincing materials with a view to deciding whether the project could satisfy the overriding public need test.

Secretariat
Harbourfront Commission
June 2016

<u>Annex A</u>

A map showing the extent of the Victoria Harbour as defined in Schedule 3 of the Interpretative and General Clauses Ordinance (Cap. 1)



Chapter:	531	**PROTECTION OF THE HARBOUR ORDINANCE**	Gazette Number	Version Date

		Long title	75 of 1999	03/12/1999

An Ordinance to protect and preserve the harbour by establishing a presumption against reclamation in the harbour.
(Replaced 9 of 1998 s. 2. Amended 75 of 1999 s. 2)

[30 June 1997]

(Originally 106 of 1997)

Section:	1	**Short title**		30/06/1997

This Ordinance may be cited as the Protection of the Harbour Ordinance.

Section:	2	**Interpretation**	75 of 1999	03/12/1999

In this Ordinance, unless the context otherwise requires-

"reclamation" (填海) means any works carried out or intended to be carried out for the purpose of forming land from the sea-bed or foreshore; (Replaced 9 of 1998 s. 3)

"relevant Ordinance" (有關條例) means-

(a) the Foreshore and Sea-bed (Reclamations) Ordinance (Cap 127);
(b) the Cross-Harbour Tunnel Ordinance (Cap 203);*
(c) the Eastern Harbour Crossing Ordinance (Cap 215);
(d) the Mass Transit Railway (Land Resumption and Related Provisions) Ordinance (Cap 276);
(e) the Roads (Works, Use and Compensation) Ordinance (Cap 370);
(f) the Western Harbour Crossing Ordinance (Cap 436); or
(g) any other Ordinance under which reclamation is authorized or which otherwise provides for reclamation.

(Amended 9 of 1998 s. 3; 75 of 1999 s. 3)

Note:
*** Repealed — see 44 of 1999 s. 45.**

Section:	3	**Presumption against reclamation in the harbour**	75 of 1999	03/12/1999

(1) The harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people, and for that purpose there shall be a presumption against reclamation in the harbour. (Amended 75 of 1999 s. 4)

(2) All public officers and public bodies shall have regard to the principle stated in subsection (1) for guidance in the exercise of any powers vested in them.

Section:	4	**Transitional**	75 of 1999	03/12/1999

(1) This Ordinance does not apply to any reclamation authorized under a relevant Ordinance before the commencement of this Ordinance. (Amended 75 of 1999 s. 5)

(2) The Protection of the Harbour (Amendment) Ordinance 1999 (75 of 1999) ("the Amendment Ordinance") does not apply to any reclamation authorized under a relevant Ordinance before the commencement of the Amendment Ordinance. (Added 75 of 1999 s. 5)

Schedule:	1	**(Repealed 75 of 1999 s. 6)**	75 of 1999	03/12/1999

19 August 2004

Housing, Planning and Lands Bureau
Technical Circular No. 1/04

Environment, Transport and Works Bureau
Technical Circular No. 1/04

Protection of the Harbour Ordinance

Purpose

This technical circular sets out the requirements of the Protection of the Harbour Ordinance (PHO) (Cap. 531) and provides guidance for public officers and public bodies to follow in considering and approving reclamation proposals.

Effective Date

2. This Circular takes immediate effect.

Effect on Existing Circulars

3. This Circular supersedes PELB Technical Circular No. 4/98 on Protection of the Harbour Ordinance and ETWB Technical Circular (Works) No. 32/2003 on Protection of the Harbour. However, the revised administrative arrangements for reclamation works as promulgated under PELB Technical Circular No. 3/97, Works Bureau Technical Circular No. 13/97 and 9/2001 shall remain in force.

Definition of Reclamation

4. The guidelines set out in this Circular apply to all reclamation proposals, regardless of scale, initiated by the Government or the private sector within the boundaries of the harbour as defined under section 3 of the Interpretation and General Clause Ordinance (Cap. 1) (see Annex A). According to section 2 of the PHO, reclamation means any works carried out or intended to be carried out for the purposes of forming land from the sea-bed or foreshore. In case of doubt on whether certain works would constitute reclamation, advice of the Department of

Justice should be sought.

Government's Position on Harbour Reclamation

5. The Government is committed to protecting and preserving the harbour and enhancing it for public enjoyment. Apart from the Central Reclamation Phase III and the reclamation proposals for Wan Chai North and South East Kowloon, the Government will not undertake any further reclamation in the harbour. These guidelines are therefore of particular relevance to the two proposed development projects of Wan Chai Development Phase II and South East Kowloon Development. Small-scale reclamations required for the construction of piers, landing steps, etc. not subject to the revised administrative arrangements promulgated in 1997 should also comply with these guidelines.

Protection of the Harbour Ordinance

6.1 Section 3 of the PHO provides that:

(a) "The harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people, and for that purpose there shall be a presumption against reclamation in the harbour." [*section 3(1)*]

(b) "All public officers and public bodies shall have regard to the principle stated in subsection (1) for guidance in the exercise of any powers vested in them." [*section 3(2)*]

6.2 Section 3(1) of the PHO establishes a statutory principle recognizing the harbour as a special public asset and a natural heritage of Hong Kong people and prescribing it to be protected and preserved.

6.3 Section 3(2) imposes a specific legal duty on public officers and public bodies to abide by the legal principle stated in section 3(1) in the exercise of any powers vested in them. The legal burden to rebut the presumption is a heavy one. To overcome the presumption, all public officers and public bodies must follow the principles prescribed in the PHO and the CFA judgment conscientiously and decide whether it is complied with before coming to a decision.

Court of Final Appeal's Judgment

7.1 On 9.1.2004, the Court of Final Appeal (CFA) handed down its judgment on the Town Planning Board (TPB)'s appeal against the High Court's ruling in respect of the draft Wan Chai North Outline Zoning Plan, clarifying the interpretation of the legal principles behind the PHO. The CFA judgment and its Summary (FACV 14/2003) is viewable at the website of the Judiciary at www.judiciary.gov.hk.

7.2 According to the CFA, the harbour is a special public asset and natural heritage is declared to belong to Hong Kong people. It is a community asset and is to be enjoyed by the people of Hong Kong. It must be kept from harm, defended and guarded. There must be not merely protection. There must also be preservation.

7.3 Reclamation would result in permanent destruction and irreversible loss of what should be protected and preserved under the statutory principle. The statutory presumption against reclamation was therefore enacted to implement the principle of protection and preservation. It is a legal concept and is a means or method for achieving protection and preservation. Its legal effect is not to impose an absolute bar against reclamation. It does not prohibit reclamation altogether. As a presumption, it is capable of being rebutted.

7.4 The CFA propounded a single and demanding test. The presumption against reclamation can only be rebutted by establishing an overriding public need for reclamation, i.e. "the overriding public need test".

7.5 ***Public needs*** are community needs and include the economic, environmental and social needs of the community.

7.6 A need should only be regarded as ***overriding*** if it is compelling and present and if there is no reasonable alternative to reclamation, as follows:

(a) a compelling need must have the requisite force to prevail over the strong public need for protection and preservation of the harbour;

(b) the meaning of present need is that taking into account the time scale of planning exercises, the need would arise within a definite and reasonable time frame;

(c) all circumstances should be considered in considering whether there is a reasonable alternative to reclamation, including the economic, environmental and social implications of each alternative, the cost as well as the time and delay involved.

7.7 The extent of reclamation should not go beyond the minimum of that which is required by the overriding need. It is necessary that each area proposed to be reclaimed must be justified.

7.8 The decision that there is an overriding public need for reclamation must be based on cogent and convincing materials.

Guidelines for Consideration of Reclamation Proposals

8.1 Considerations in the Decision-making Process

8.1.1 Based on the CFA judgment, a flow chart highlighting the major considerations that should be taken into account by public officers and public bodies in the decision-making process on reclamation proposals is at Annex B. It applies to all stages of the process covering planning and engineering investigations, preparation of plan and reclamation/road schemes for gazetting, consideration of objections, approval/authorization under relevant ordinances, funding approval and detailed design of a reclamation project. However, it does not apply to the works implementation stage which is basically to implement the project already approved by all relevant authorities.

8.1.2 All public officers and public bodies that are involved from initial project inception to the planning and design stage are required to critically examine the need for the proposed reclamation project. The considerations and any decision on the reclamation project should be recorded fully in writing.

8.1.3 For each area of reclamation, three basic questions will need to be answered. The whole process including the decisions as to whether there is a compelling and present public need, whether there is any reasonable alternative, and whether the proposed reclamation extent is the minimum must be clearly documented and substantiated by cogent and convincing materials. It is the responsibility of the proponents of individual facilities (i.e. the client bureaux/departments) to prove, with engineering input from the relevant works departments, that the proposals they put forward will meet "the overriding public need test".

8.1.4 There is no hard-and-fast rule on what materials could be considered as cogent and convincing. It depends on the merit of each case. Provided that one takes account of all relevant matters and does not consider irrelevant matters, one's decision could not be challenged as perverse, irrational or unreasonable.

Question 1 – Is there a compelling and present public need?

8.1.5 In assessing whether there is an overriding public need for providing certain infrastructure or facility which may involve reclamation, it will be necessary to establish that the need is a public need, and is compelling and present.

8.1.6 Public needs are community needs and include the economic, environmental and social needs of the community. The following are some examples of public needs:

Economic Needs

- sustain economic growth and prosperity of the economy (e.g. by providing or improving essential infrastructure such as roads, railways, drainage and sewerage facilities, or facilities which require a waterfront location such as cruise terminal);

Environmental Needs

- needs which are most substantial/formal (e.g. reclamation for constructing environmental infrastructures like sewage treatment plants);
- needs which are confirmed through proper environmental studies such that they are indeed environmental "needs" rather than ad hoc justifications for reclamation; and
- needs which are backed up by broad community consensus, instead of just some "wants" by the few to justify reclamation. The concepts of "needs" and "wants" are different and should not be mixed up.
- It will be up to the project proponent to carry out studies to justify the environmental needs. When considering the environmental needs for the proposed reclamation, the project proponent may also need to

examine the "net result" after taking into account the possible adverse environmental implications arising from the project or at least the reclamation itself.

Social Needs

- Improve quality of life of the community (e.g by providing more public amenities and promoting public accessibility to the harbour-front).

8.1.7 An overriding need must be compelling and justified by cogent and convincing materials. The exact type and extent of supporting materials depend on the nature and purpose of the project/facility. Annex C gives some examples of the materials that may be required for justifying certain projects.

8.1.8 An overriding need must also be present. To satisfy this requirement, there must be a sufficiently concrete programme of implementation and firm commitment from the concerned department and bureau, with endorsement by relevant authorities, where applicable. Annex D is a proforma for confirming the present need for a proposed facility involving reclamation.

8.1.9 In providing cogent and convincing materials to justify the urgent public need for reclamation, it is necessary to set out any adverse consequences of not meeting the public need in time, which may cover various aspects including the economic, environmental and social implications, as well as the time, cost and delay involved.

Question 2 – Is there any reasonable alternative to reclamation?

8.1.10 Alternatives to reclamation can be in various forms such as changing the policy choices, siting/reprovisioning a use/facility at an alternative location or adopting an alternative road/rail alignment, and employing different design and construction methods. Annex E gives some sample questions that need to be answered in considering whether there are alternatives to reclamation.

8.1.11 All alternatives, including those put forward by the public, should be clearly set out and carefully examined to assess whether they are reasonable alternatives. A "no reclamation" scenario must be taken as the starting point in considering alternatives. It is imperative to examine if an overriding public need can be met without any reclamation.

8.1.12 All circumstances should be considered in determining whether there is a reasonable alternative to reclamation, including the economic, social and environmental implications, cost and time incurred, and other relevant considerations.[1] The assessments should be properly documented, and where appropriate, subject to public scrutiny. If any reasonable alternative is available, the reclamation proposal should not be considered further. An alternative may be considered as "unreasonable" if it (the following is not exhaustive) –

(a) could not achieve or substantially achieve the set objectives;

(b) would have significantly adverse economic, social and environmental implications;

(c) would cause unacceptable delay to achieving the objectives;

(d) would result in prohibitively high cost; and/or

(e) would involve employment of untested technology.

8.1.13 As a general rule, reprovisioning of affected facilities on reclaimed land should be justified on individual basis and should not be taken for granted. All reprovisioning requirements must be justified individually on their own by the concerned departments and bureaux. It is necessary to demonstrate that there is no reasonable alternative but to reprovision an affected facility on reclamation.

Question 3 – Is the proposed reclamation extent minimum?

8.1.14 If it can be established that there is no reasonable alternative to reclamation in meeting the overriding public need, the next step is to ensure that

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[1] The range of indicators and criteria may include but not necessarily limit to the following:

- Economic Implications – economic growth and prosperity, overall cost of doing business, and employment opportunity;
- Social Implications – community need and aspiration, community support/consensus, healthy living, heritage preservation, social cohesion, and community identity;
- Environmental Implications – air quality, noise, water quality, waste disposal, energy efficiency, natural resources, landscape and visual impacts, and nature conservation;
- Cost – financial viability, return on investment/economic return, capital cost, and recurrent cost;
- Time – lead time of implementation, and time required to achieve the objectives; and
- Others – effectiveness of achieving the objectives, technical feasibility, and safety consideration.

2

reclamation must be restricted to only the amount strictly necessary to meet the overriding public need.

8.1.15 The extent of reclamation for each and every component must be fully justified on its own and minimized. Reclamation for a particular element/objective (e.g. reprovisioning of waterfront facilities affected by reclamation) cannot be justified by its association with the reclamation scheme, or individual components in the scheme, proposed for meeting certain overriding public needs (e.g. provision of essential road and railway infrastructure). The extent of reclamation may be considered as minimum if further reduction in reclamation would, for example –

(a) significantly compromise the effectiveness and efficiency of a particular facility;

(b) substantially increase the capital and running costs; and/or

(c) unduly lengthen the construction time and result in unacceptable delay in provision of the required facilities and services.

8.1.16 The consideration leading to the decision of not selecting an alternative that may minimize the extent of reclamation because it does not pass the test of reasonableness should be documented as part of the cogent and convincing materials.

8.2 Public Consultation

8.2.1 It is of paramount importance to gauge the views of the public on the need identified by the Government as an overriding public need. Public consultation should therefore be conducted on any reclamation proposal in the harbour. A proactive approach should be adopted to encourage public involvement in the process to instill a sense of partnership between the Government, stakeholder groups and the community. All relevant parties, including the Legislative Council, Town Planning Board, Harbour-front Enhancement Committee, relevant District Councils, professional institutes, interest groups, relevant advisory committees and the general public, should be consulted as appropriate. The extent of public consultation should be determined with reference to the scale of the reclamation proposal.

8.2.2 To be effective and useful, the public consultation exercise should be well structured and a consultation strategy including the following major aspects should be formulated:

(a) the scope and timing of consultation;

(b) the target audience to be consulted;

(c) the methods of consultation (e.g. informal sounding out; opinion polling/market research/questionnaire survey; exhibition; press conference/briefing/release; publication of consultation materials; presentation to relevant committees/bodies; public consultation forum, etc.);

(d) the types of consultation and presentation materials to cater for different types of audience and events; and

(e) the level of representation at various consultation events.

8.2.3 The public should be involved early in the planning process. For any reclamation proposal that requires the carrying out of a comprehensive planning and engineering feasibility study, the public should be consulted at various key stages of the feasibility study, for example, when the inception report is prepared, preliminary findings of the study are available, alternative conceptual schemes are formulated and the preferred scheme recommended under the study, before a final decision is made by the Government. In particular, it is useful to collect public views on whether the facilities proposed on reclamation are generally accepted as meeting “the overriding public need test”, and whether there are any alternatives to reclamation that need to be examined.

8.2.4 Public views gathered from consultation should be carefully analyzed and incorporated, where appropriate. All public views addressed to the Government should be suitably responded to, for example, by way of correspondence or a consolidated consultation report.

8.3 Independent Expert Advice

Where necessary, independent experts from outside the Government should be invited to ascertain if “the overriding public need test” has been satisfied, if the reclamation are cogent and convincing.

Annexes

Annex A	The Boundaries of the Harbour
Annex B	Flow Chart on Major Considerations in Decision-making Process on Reclamation Proposals
Annex C	Examples of Materials to Justify the Overriding Public Need
Annex D	Proforma for Confirming the Present Need for Facility Involving Reclamation
Annex E	Examples of Questions that Need to be Answered on Alternatives to Reclamation

(Michael M.Y. Suen)

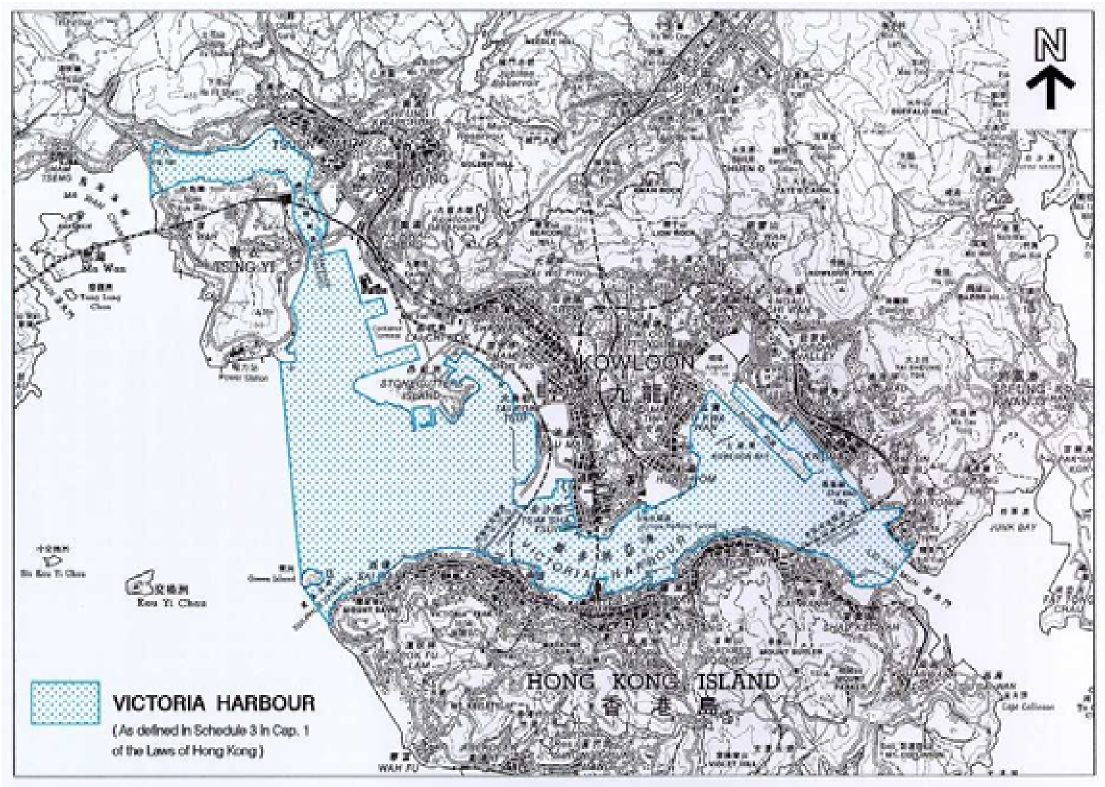
Secretary for Housing,
Planning and Lands

(Dr. Sarah Liao)

Secretary for the Environment,
Transport and Works

Annex A

The Boundaries of the Harbour



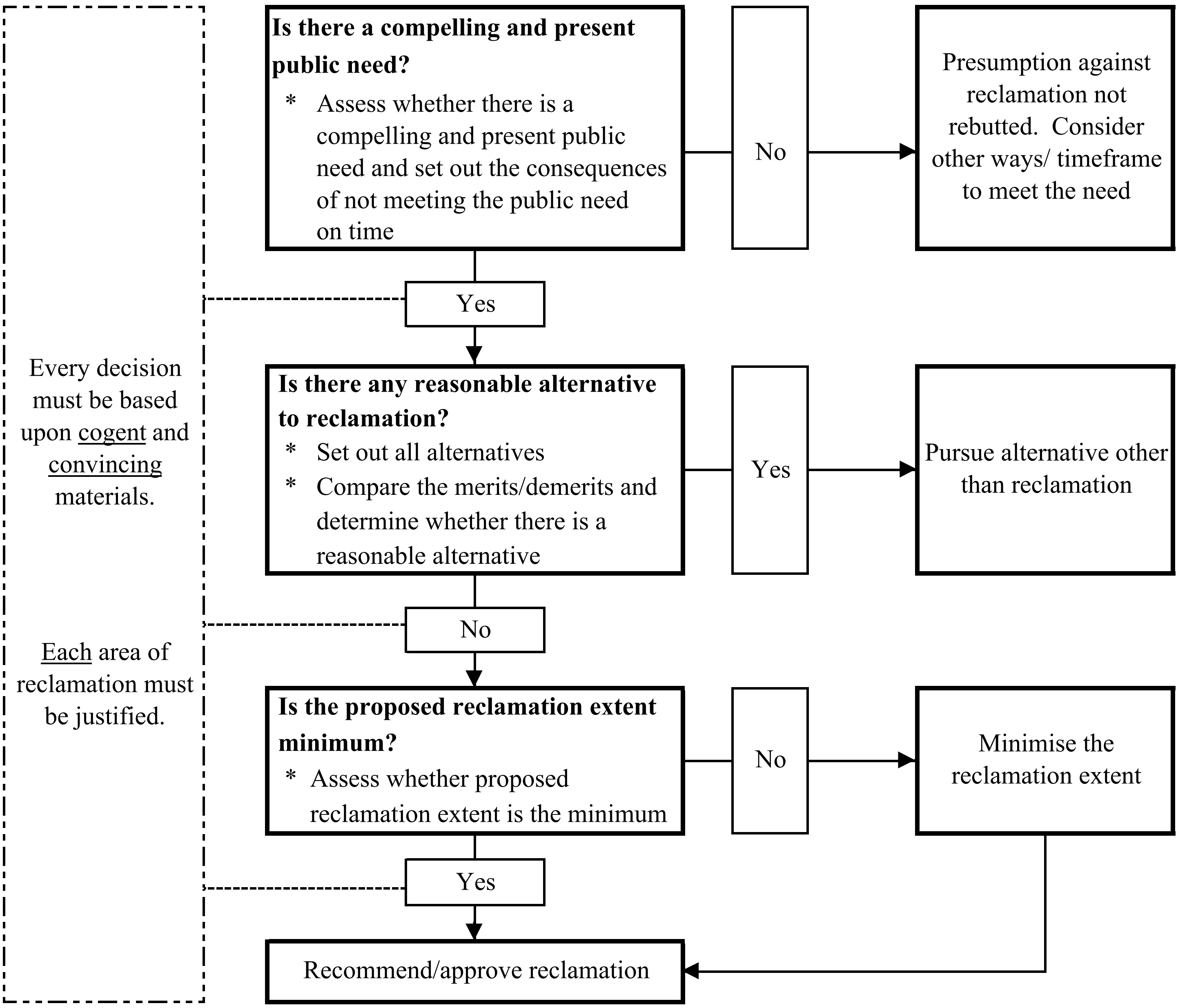
According to the Interpretation and General Clauses Ordinance, the "Boundaries of Harbour" means the waters of Hong Kong between:

(a) *the eastern limit – a straight line drawn from the westernmost extremity of Siu Chau Wan Point to the westernmost extremity of Ah Kung Ngam Point; and*

(b) *the western limit – a straight line drawn from the westernmost point of Island of Hong Kong to the westernmost point of Green Island, thence a straight line drawn from the westernmost point of Green Island to the south-easternmost point of Tsing Yi, thence along the eastern and northern coast lines of Tsing Yi to the westernmost extremity of Tsing Yi, and thence a straight line drawn true north therefrom to the mainland.*

Annex B

Flow Chart on Major Considerations in Decision-making Process on Reclamation Proposals



Footnote : The public will be consulted as necessary at various stages.

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Annex C

Examples of Materials to Justify the Overriding Public Need

Case 1: Trunk Road and Railway

Economic Aspect

- Findings and recommendations of updated transport studies
- Role of trunk road and railway in strategic transport network
- Road traffic forecasts in specific timeframe (e.g. volume/capacity ratios, speed of vehicular traffic)
- Congestion relief to adjacent roads
- Daily boardings, rail ridership, percentage of trips by rail
- Overloading of rail system and critical peak hour loadings
- Journey time
- Cost and benefit analysis
- Economic returns
- Economic loss due to congestion
- Effect on competitiveness of Hong Kong

Environmental Aspect

- Improvement in air quality
- Reduction in noise sensitive receivers exposed to excessive road traffic noise
- Reduction in energy consumption
- Improvements along other roads (by the relief in traffic provided by the new project)

Social Aspect

- Increase in mobility of passengers
- Improvement in living and working environment (may include qualitative assessment)
- Public support (may be established through public consultation)
- Improvement in living and working environment

Case 2: Drainage and Sewerage Facilities

Economic Aspect

- Resident/working population and domestic/non-domestic units to be served by the facilities
- Reduction in flooding risk inland
- Reduction in economic loss due to flooding

Environmental Aspect

- Improvement in water quality
- Reduction in expedient connections to stormwater drains

Social Aspect

- Improvement in healthy living and working environment (may include qualitative assessment)
- Public support (may be established through public consultation)

Case 3: Promenade

Economic Aspect

- Enhancing the image of Hong Kong as an international city and its competitiveness (may include qualitative assessment)
- Number of tourists visiting the promenade
- Number of major events using the promenade as venue

Environmental Aspect

- Improvement in visual quality and landscape character of the waterfront

Social Aspect

- Public support and aspiration for a high-quality waterfront promenade and supporting facilities (may be established through surveys and public consultation)
- Improvement in healthy living and working environment (may include qualitative assessment)

<u>**Annex D**</u>

<u>**Proforma for Confirming the Present Need for Facility Involving Reclamation**</u>
(One proforma should be used for <u>each</u> proposed facility)

Facility:	*(Specify the name of facility - e.g. sewage pumping station)*
1. **Date Required:**	*(Specify the timing when the facility is required)*
2. **Justifications:**	*(Explain why the facility must be provided at the above time)*
3. **Authority and Decision Date:**	*(Specify the authority giving the endorsement to the provision of the facility and the date of decision)*
4. **Public Works/ Building Programme:**	*(Specify the category of Public Works/Building Programme in which the facility falls, and relevant dates of inclusion/upgrading in the progamme)*
5. **Public Views/ Support:**	*(Give an account of the public views/support on the provision of the facility, including the dates when the consultations were undertaken)*

Examples of Questions that Need to be Answered on Alternatives to Reclamation

Alternative Ways to Meet the Public Need (including policy choices)

- Should demand management measures be used instead of reclaiming the harbour to provide land for developing new facility?
- Can a change in policy effectively resolve the problem?
- Is there an alternative mode of operation/system that can achieve or substantially achieve the same objectives of the proposed reclamation?
- Can the existing facilities be improved or better utilized to reduce or postpone the need to provide the new facility on reclamation?
- Can cash compensation be paid in lieu of reprovisioning of affected facilities?
- Can pollution problem be controlled at source?

Alternative Locations of Use/Facility or Alternative Alignments

- Can a particular use or facility be located outside the proposed reclamation?
- Can an alternative road/railway alignment be adopted to obviate the need for or minimize reclamation?

Alternative Design and Construction Methods (more related to minimizing extent of reclamation)

- Can road tunnels be built instead of surface roads?
- Can the size and land requirement of a particular facility be further reduced to minimize reclamation?
- Can staging and work sequence of construction be varied to reduce the reclamation extent?
- Are there alternative construction/foundation methods for waterfront structures to minimize reclamation?

19 August 2004

Housing, Planning and Lands Bureau
Technical Circular No. 1/04

Environment, Transport and Works Bureau
Technical Circular No. 1/04

Protection of the Harbour Ordinance

Purpose

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Protection of the Harbour Ordinance

6.1 Section 3 of the PHO provides that:

(a) "The harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people, and for that purpose there shall be a presumption against reclamation in the harbour." [*section 3(1)*]

(b) "All public officers and public bodies shall have regard to the principle stated in subsection (1) for guidance in the exercise of any powers vested in them." [*section 3(2)*]

6.2 Section 3(1) of the PHO establishes a statutory principle recognizing the harbour as a special public asset and a natural heritage of Hong Kong people and prescribing it to be protected and preserved.

6.3 Section 3(2) imposes a specific legal duty on public officers and public bodies to abide by the legal principle stated in section 3(1) in the exercise of any powers vested in them. The legal burden to rebut the presumption is a heavy one. To overcome the presumption, all public officers and public bodies must follow the principles prescribed in the PHO and the CFA judgment conscientiously and decide whether it is complied with before coming to a decision.

Court of Final Appeal's Judgment

7.1 On 9.1.2004, the Court of Final Appeal (CFA) handed down its judgment on the Town Planning Board (TPB)'s appeal against the High Court's ruling in respect of the draft Wan Chai North Outline Zoning Plan, clarifying the interpretation of the legal principles behind the PHO. The CFA judgment and its Summary (FACV 14/2003) is viewable at the website of the Judiciary at www.judiciary.gov.hk.

7.2 According to the CFA, the harbour is a special public asset and natural heritage is declared to belong to Hong Kong people. It is a community asset and is to be enjoyed by the people of Hong Kong. It must be kept from harm, defended and guarded. There must be not merely protection. There must also be preservation.

7.3 Reclamation would result in permanent destruction and irreversible loss of what should be protected and preserved under the statutory principle. The statutory presumption against reclamation was therefore enacted to implement the principle of protection and preservation. It is a legal concept and is a means or method for achieving protection and preservation. Its legal effect is not to impose an absolute bar against reclamation. It does not prohibit reclamation altogether. As a presumption, it is capable of being rebutted.

7.4 The CFA propounded a single and demanding test. The presumption against reclamation can only be rebutted by establishing an overriding public need for reclamation, i.e. "the overriding public need test".

7.5 ***Public needs*** are community needs and include the economic, environmental and social needs of the community.

7.6 A need should only be regarded as ***overriding*** if it is compelling and present and if there is no reasonable alternative to reclamation, as follows:

(a) a compelling need must have the requisite force to prevail over the strong public need for protection and preservation of the harbour;

(b) the meaning of present need is that taking into account the time scale of planning exercises, the need would arise within a definite and reasonable time frame;

(c) all circumstances should be considered in considering whether there is a reasonable alternative to reclamation, including the economic, environmental and social implications of each alternative, the cost as well as the time and delay involved.

7.7 The extent of reclamation should not go beyond the minimum of that which is required by the overriding need. It is necessary that each area proposed to be reclaimed must be justified.

7.8 The decision that there is an overriding public need for reclamation must be based on cogent and convincing materials.

Guidelines for Consideration of Reclamation Proposals

8.1 Considerations in the Decision-making Process

8.1.1 Based on the CFA judgment, a flow chart highlighting the major considerations that should be taken into account by public officers and public bodies in the decision-making process on reclamation proposals is at Annex B. It applies to all stages of the process covering planning and engineering investigations, preparation of plan and reclamation/road schemes for gazetting, consideration of objections, approval/authorization under relevant ordinances, funding approval and detailed design of a reclamation project. However, it does not apply to the works implementation stage which is basically to implement the project already approved by all relevant authorities.

8.1.2 All public officers and public bodies that are involved from initial project inception to the planning and design stage are required to critically examine the need for the proposed reclamation project. The considerations and any decision on the reclamation project should be recorded fully in writing.

8.1.3 For each area of reclamation, three basic questions will need to be answered. The whole process including the decisions as to whether there is a compelling and present public need, whether there is any reasonable alternative, and whether the proposed reclamation extent is the minimum must be clearly documented and substantiated by cogent and convincing materials. It is the responsibility of the proponents of individual facilities (i.e. the client bureaux/departments) to prove, with engineering input from the relevant works departments, that the proposals they put forward will meet "the overriding public need test".

8.1.4 There is no hard-and-fast rule on what materials could be considered as cogent and convincing. It depends on the merit of each case. Provided that one takes account of all relevant matters and does not consider irrelevant matters, one's decision could not be challenged as perverse, irrational or unreasonable.

Question 1 – Is there a compelling and present public need?

8.1.5 In assessing whether there is an overriding public need for providing certain infrastructure or facility which may involve reclamation, it will be necessary to establish that the need is a public need, and is compelling and present.

8.1.6 Public needs are community needs and include the economic, environmental and social needs of the community. The following are some examples of public needs:

Economic Needs

- sustain economic growth and prosperity of the economy (e.g. by providing or improving essential infrastructure such as roads, railways, drainage and sewerage facilities, or facilities which require a waterfront location such as cruise terminal);

Environmental Needs

- needs which are most substantial/formal (e.g. reclamation for constructing environmental infrastructures like sewage treatment plants);
- needs which are confirmed through proper environmental studies such that they are indeed environmental "needs" rather than ad hoc justifications for reclamation; and
- needs which are backed up by broad community consensus, instead of just some "wants" by the few to justify reclamation. The concepts of "needs" and "wants" are different and should not be mixed up.
- It will be up to the project proponent to carry out studies to justify the environmental needs. When considering the environmental needs for the proposed reclamation, the project proponent may also need to

examine the "net result" after taking into account the possible adverse environmental implications arising from the project or at least the reclamation itself.

Social Needs

- Improve quality of life of the community (e.g by providing more public amenities and promoting public accessibility to the harbour-front).

8.1.7 An overriding need must be compelling and justified by cogent and convincing materials. The exact type and extent of supporting materials depend on the nature and purpose of the project/facility. Annex C gives some examples of the materials that may be required for justifying certain projects.

8.1.8 An overriding need must also be present. To satisfy this requirement, there must be a sufficiently concrete programme of implementation and firm commitment from the concerned department and bureau, with endorsement by relevant authorities, where applicable. Annex D is a proforma for confirming the present need for a proposed facility involving reclamation.

8.1.9 In providing cogent and convincing materials to justify the urgent public need for reclamation, it is necessary to set out any adverse consequences of not meeting the public need in time, which may cover various aspects including the economic, environmental and social implications, as well as the time, cost and delay involved.

Question 2 – Is there any reasonable alternative to reclamation?

8.1.10 Alternatives to reclamation can be in various forms such as changing the policy choices, siting/reprovisioning a use/facility at an alternative location or adopting an alternative road/rail alignment, and employing different design and construction methods. Annex E gives some sample questions that need to be answered in considering whether there are alternatives to reclamation.

8.1.11 All alternatives, including those put forward by the public, should be clearly set out and carefully examined to assess whether they are reasonable alternatives. A "no reclamation" scenario must be taken as the starting point in considering alternatives. It is imperative to examine if an overriding public need can be met without any reclamation.

8.1.12 All circumstances should be considered in determining whether there is a reasonable alternative to reclamation, including the economic, social and environmental implications, cost and time incurred, and other relevant considerations.[1] The assessments should be properly documented, and where appropriate, subject to public scrutiny. If any reasonable alternative is available, the reclamation proposal should not be considered further. An alternative may be considered as "unreasonable" if it (the following is not exhaustive) –

(a) could not achieve or substantially achieve the set objectives;

(b) would have significantly adverse economic, social and environmental implications;

(c) would cause unacceptable delay to achieving the objectives;

(d) would result in prohibitively high cost; and/or

(e) would involve employment of untested technology.

8.1.13 As a general rule, reprovisioning of affected facilities on reclaimed land should be justified on individual basis and should not be taken for granted. All reprovisioning requirements must be justified individually on their own by the concerned departments and bureaux. It is necessary to demonstrate that there is no reasonable alternative but to reprovision an affected facility on reclamation.

Question 3 – Is the proposed reclamation extent minimum?

8.1.14 If it can be established that there is no reasonable alternative to reclamation in meeting the overriding public need, the next step is to ensure that

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[1] The range of indicators and criteria may include but not necessarily limit to the following:

- Economic Implications – economic growth and prosperity, overall cost of doing business, and employment opportunity;
- Social Implications – community need and aspiration, community support/consensus, healthy living, heritage preservation, social cohesion, and community identity;
- Environmental Implications – air quality, noise, water quality, waste disposal, energy efficiency, natural resources, landscape and visual impacts, and nature conservation;
- Cost – financial viability, return on investment/economic return, capital cost, and recurrent cost;
- Time – lead time of implementation, and time required to achieve the objectives; and
- Others – effectiveness of achieving the objectives, technical feasibility, and safety consideration.

2

reclamation must be restricted to only the amount strictly necessary to meet the overriding public need.

8.1.15 The extent of reclamation for each and every component must be fully justified on its own and minimized. Reclamation for a particular element/objective (e.g. reprovisioning of waterfront facilities affected by reclamation) cannot be justified by its association with the reclamation scheme, or individual components in the scheme, proposed for meeting certain overriding public needs (e.g. provision of essential road and railway infrastructure). The extent of reclamation may be considered as minimum if further reduction in reclamation would, for example –

(a) significantly compromise the effectiveness and efficiency of a particular facility;

(b) substantially increase the capital and running costs; and/or

(c) unduly lengthen the construction time and result in unacceptable delay in provision of the required facilities and services.

8.1.16 The consideration leading to the decision of not selecting an alternative that may minimize the extent of reclamation because it does not pass the test of reasonableness should be documented as part of the cogent and convincing materials.

8.2 Public Consultation

8.2.1 It is of paramount importance to gauge the views of the public on the need identified by the Government as an overriding public need. Public consultation should therefore be conducted on any reclamation proposal in the harbour. A proactive approach should be adopted to encourage public involvement in the process to instill a sense of partnership between the Government, stakeholder groups and the community. All relevant parties, including the Legislative Council, Town Planning Board, Harbour-front Enhancement Committee, relevant District Councils, professional institutes, interest groups, relevant advisory committees and the general public, should be consulted as appropriate. The extent of public consultation should be determined with reference to the scale of the reclamation proposal.

8.2.2 To be effective and useful, the public consultation exercise should be well structured and a consultation strategy including the following major aspects should be formulated:

(a) the scope and timing of consultation;

(b) the target audience to be consulted;

(c) the methods of consultation (e.g. informal sounding out; opinion polling/market research/questionnaire survey; exhibition; press conference/briefing/release; publication of consultation materials; presentation to relevant committees/bodies; public consultation forum, etc.);

(d) the types of consultation and presentation materials to cater for different types of audience and events; and

(e) the level of representation at various consultation events.

8.2.3 The public should be involved early in the planning process. For any reclamation proposal that requires the carrying out of a comprehensive planning and engineering feasibility study, the public should be consulted at various key stages of the feasibility study, for example, when the inception report is prepared, preliminary findings of the study are available, alternative conceptual schemes are formulated and the preferred scheme recommended under the study, before a final decision is made by the Government. In particular, it is useful to collect public views on whether the facilities proposed on reclamation are generally accepted as meeting "the overriding public need test", and whether there are any alternatives to reclamation that need to be examined.

8.2.4 Public views gathered from consultation should be carefully analyzed and incorporated, where appropriate. All public views addressed to the Government should be suitably responded to, for example, by way of correspondence or a consolidated consultation report.

8.3 Independent Expert Advice

Where necessary, independent experts from outside the Government should be invited to ascertain if "the overriding public need test" has been satisfied, if the reclamation are cogent and convincing.

<u>Annexes</u>

Annex A	The Boundaries of the Harbour
Annex B	Flow Chart on Major Considerations in Decision-making Process on Reclamation Proposals
Annex C	Examples of Materials to Justify the Overriding Public Need
Annex D	Proforma for Confirming the Present Need for Facility Involving Reclamation
Annex E	Examples of Questions that Need to be Answered on Alternatives to Reclamation

(Michael M.Y. Suen)

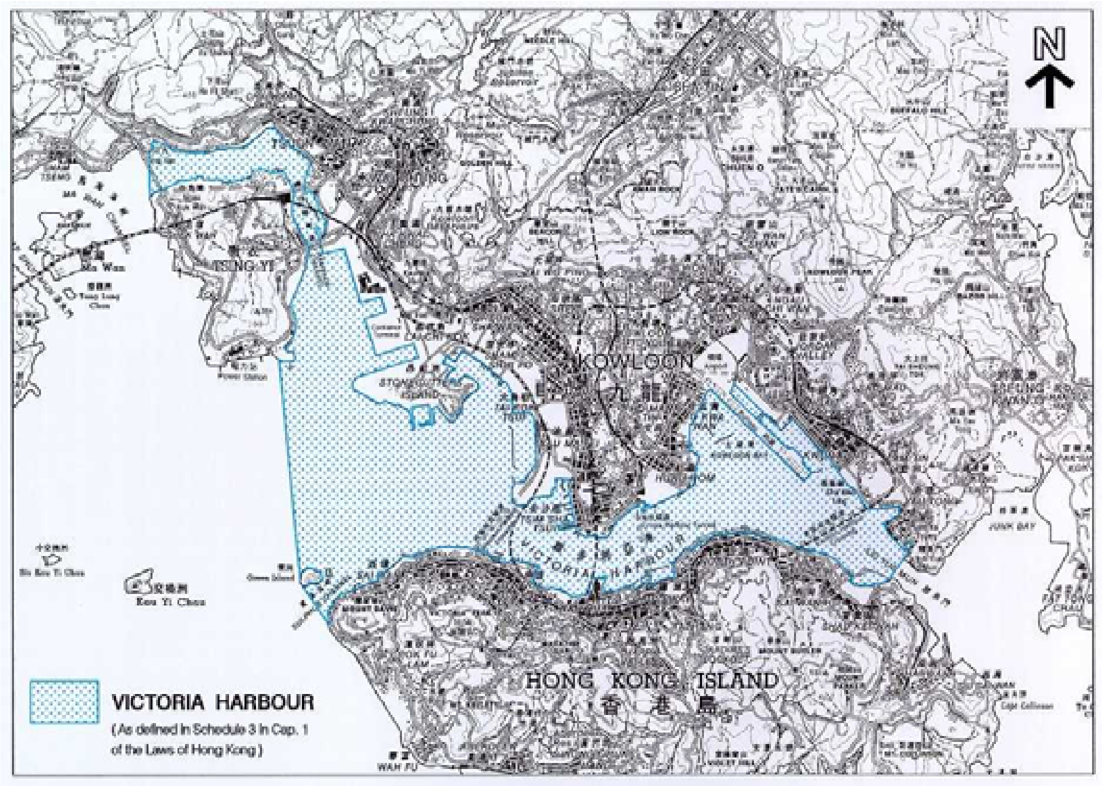
Secretary for Housing,
Planning and Lands

(Dr. Sarah Liao)

Secretary for the Environment,
Transport and Works

Annex A

The Boundaries of the Harbour



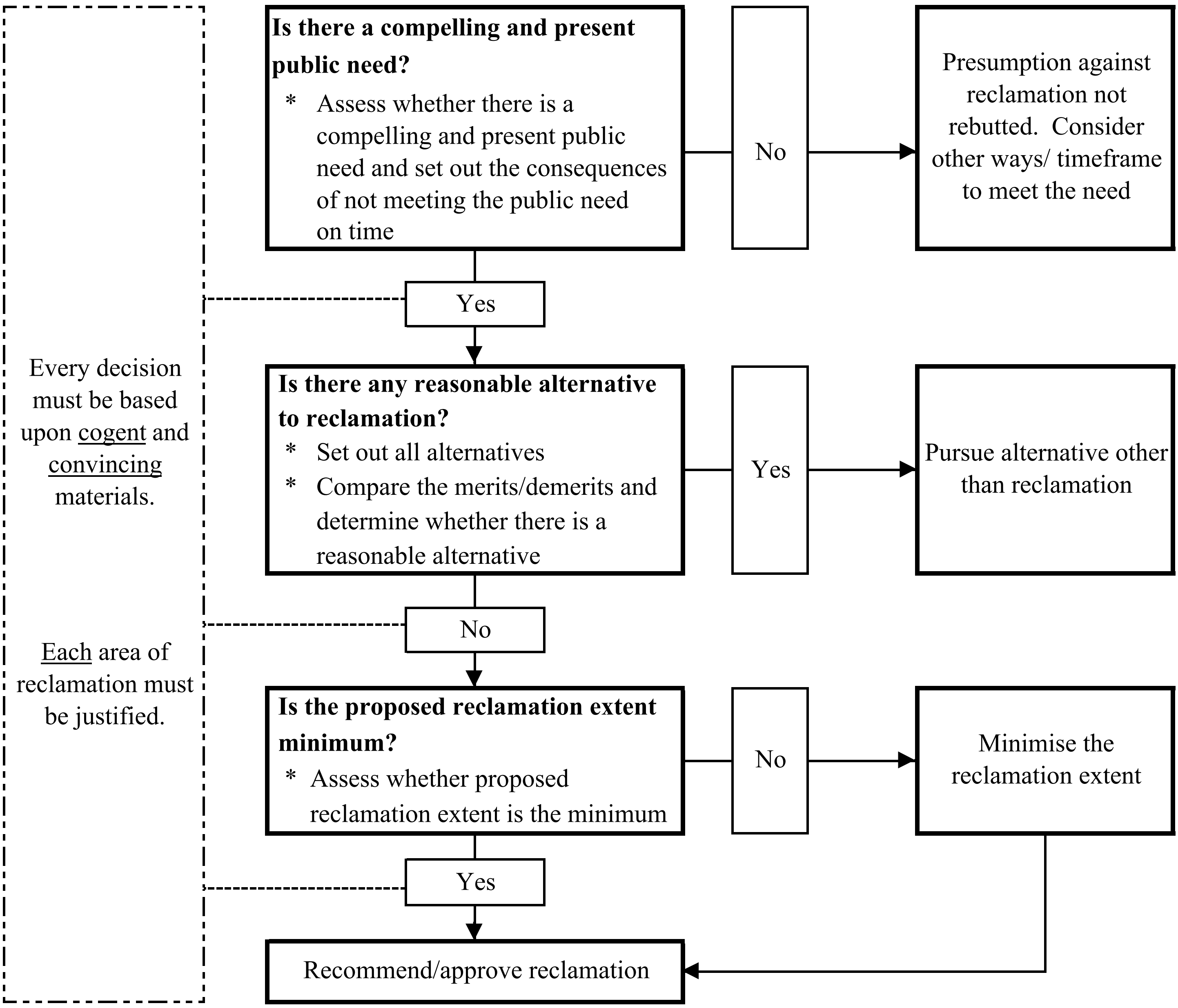
According to the Interpretation and General Clauses Ordinance, the "Boundaries of Harbour" means the waters of Hong Kong between:

(a) *the eastern limit – a straight line drawn from the westernmost extremity of Siu Chau Wan Point to the westernmost extremity of Ah Kung Ngam Point; and*

(b) *the western limit – a straight line drawn from the westernmost point of Island of Hong Kong to the westernmost point of Green Island, thence a straight line drawn from the westernmost point of Green Island to the south-easternmost point of Tsing Yi, thence along the eastern and northern coast lines of Tsing Yi to the westernmost extremity of Tsing Yi, and thence a straight line drawn true north therefrom to the mainland.*

Annex B

Flow Chart on Major Considerations in Decision-making Process on Reclamation Proposals



Footnote : The public will be consulted as necessary at various stages.

Annex C

Examples of Materials to Justify the Overriding Public Need

Case 1: Trunk Road and Railway

Economic Aspect

- Findings and recommendations of updated transport studies
- Role of trunk road and railway in strategic transport network
- Road traffic forecasts in specific timeframe (e.g. volume/capacity ratios, speed of vehicular traffic)
- Congestion relief to adjacent roads
- Daily boardings, rail ridership, percentage of trips by rail
- Overloading of rail system and critical peak hour loadings
- Journey time
- Cost and benefit analysis
- Economic returns
- Economic loss due to congestion
- Effect on competitiveness of Hong Kong

Environmental Aspect

- Improvement in air quality
- Reduction in noise sensitive receivers exposed to excessive road traffic noise
- Reduction in energy consumption
- Improvements along other roads (by the relief in traffic provided by the new project)

Social Aspect

- Increase in mobility of passengers
- Improvement in living and working environment (may include qualitative assessment)
- Public support (may be established through public consultation)
- Improvement in living and working environment

Case 2: Drainage and Sewerage Facilities

Economic Aspect

- Resident/working population and domestic/non-domestic units to be served by the facilities
- Reduction in flooding risk inland
- Reduction in economic loss due to flooding

Environmental Aspect

- Improvement in water quality
- Reduction in expedient connections to stormwater drains

Social Aspect

- Improvement in healthy living and working environment (may include qualitative assessment)
- Public support (may be established through public consultation)

Case 3: Promenade

Economic Aspect

- Enhancing the image of Hong Kong as an international city and its competitiveness (may include qualitative assessment)
- Number of tourists visiting the promenade
- Number of major events using the promenade as venue

Environmental Aspect

- Improvement in visual quality and landscape character of the waterfront

Social Aspect

- Public support and aspiration for a high-quality waterfront promenade and supporting facilities (may be established through surveys and public consultation)
- Improvement in healthy living and working environment (may include qualitative assessment)

Annex D

Proforma for Confirming the Present Need for Facility Involving Reclamation

(One proforma should be used for each proposed facility)

Facility:	*(Specify the name of facility - e.g. sewage pumping station)*
1. **Date Required:**	*(Specify the timing when the facility is required)*
2. **Justifications:**	*(Explain why the facility must be provided at the above time)*
3. **Authority and Decision Date:**	*(Specify the authority giving the endorsement to the provision of the facility and the date of decision)*
4. **Public Works/ Building Programme:**	*(Specify the category of Public Works/Building Programme in which the facility falls, and relevant dates of inclusion/upgrading in the progamme)*
5. **Public Views/ Support:**	*(Give an account of the public views/support on the provision of the facility, including the dates when the consultations were undertaken)*

Annex E

Examples of Questions that Need to be Answered on Alternatives to Reclamation

Alternative Ways to Meet the Public Need (including policy choices)

- Should demand management measures be used instead of reclaiming the harbour to provide land for developing new facility?
- Can a change in policy effectively resolve the problem?
- Is there an alternative mode of operation/system that can achieve or substantially achieve the same objectives of the proposed reclamation?
- Can the existing facilities be improved or better utilized to reduce or postpone the need to provide the new facility on reclamation?
- Can cash compensation be paid in lieu of reprovisioning of affected facilities?
- Can pollution problem be controlled at source?

Alternative Locations of Use/Facility or Alternative Alignments

- Can a particular use or facility be located outside the proposed reclamation?
- Can an alternative road/railway alignment be adopted to obviate the need for or minimize reclamation?

Alternative Design and Construction Methods (more related to minimizing extent of reclamation)

- Can road tunnels be built instead of surface roads?
- Can the size and land requirement of a particular facility be further reduced to minimize reclamation?
- Can staging and work sequence of construction be varied to reduce the reclamation extent?
- Are there alternative construction/foundation methods for waterfront structures to minimize reclamation?

A Review of Central Reclamation Phase III by applying the Court of Final Appeal's "Overriding Public Need Test"

April 2004

A Review of Central Reclamation Phase III
by applying the Court of Final Appeal's
"Overriding Public Need Test"

Table of Contents

PART ONE

Glossary

Atrium Link	An elevated enclosed pedestrian deck connecting the Hong Kong Convention and Exhibition Centre and its Extension across the Convention Avenue and the water channel at Wan Chai North.
Bentonite slurry	A thin mixture of a liquid, especially water, with the absorbent aluminum silicate clay which is formed from volcanic ash.
Central Reclamation Phase III (CRIII) project	Reclamation of about 18 ha of land of the seabed in front of the Star Ferry Pier from Central reclamation phase I to Lung King Street which is part of the 23 ha of reclaimed land under the approved OZP No. S/H24/6 for Central District (Extension). The scope also includes construction of seawalls; roadworks; culvert extensions; drainage; sewer and service systems; cooling water pumping stations for future developments; reprovisioning of ferry piers, landing steps, cooling water pumping systems, public cargo working area and Government helipad; hinterland drainage improvement works and landscaping works at roadside amenity.
Cope line	A cope line is a reference vertical line along the outermost top corner of the coping of a seawall. The coping is the uppermost in-situ concrete portion of a vertical seawall.
Diaphragm wall (D-wall)	Diaphragm wall is a widely employed technique whereby reinforced concrete retaining walls are cast in-situ from existing ground down to the required depth. A trench or panel is excavated using special equipment and remains open in a stable condition due to the fact that it is kept full

	of bentonite slurry. Reinforcement cages are lowered into the trench, after which concrete is introduced at the base by a tremie tube and the bentonite slurry is progressively displaced and drawn off. By constructing a series of panels, a continuous wall is achieved.
Dual-2 carriageway	A dual carriageway road with 2 traffic lanes on each side of the carriageway.
Dual-3 carriageway	A dual carriageway road with 3 traffic lanes on each side of the carriageway.
Environmental Impact Assessment (EIA)	The EIA refers to the Environmental Impact Assessment process under the Environmental Impact Assessment Ordinance, Cap.499 (EIAO). The purpose of the EIAO is to avoid and if total avoidance is not practical, to minimize and control the adverse impact on the environment of designated projects to acceptable levels through the EIA mechanism. The EIAO came into operation on 1 April 1998. Designated projects specified under Schedule 2 of the EIAO, unless exempted, must follow the statutory EIA process and require environmental permits for their construction and operation (if applicable, and decommissioning). Designated projects specified under Schedule 3 of the EIAO that mainly cover feasibility studies require approved EIA reports but not environmental permit.
MPD	Metre above Principal Datum. Principal Datum is the reference datum generally used throughout Hong Kong and is 1.23 metres below the Mean Sea Level.
Volume to capacity (v/c) ratio	A v/c ratio is an indicator which reflects the performance of a road. A v/c ratio equal to or less

than 1.0 means that a road has sufficient capacity to cope with the volume of vehicular traffic under consideration and the resultant traffic will flow smoothly. A v/c ratio above 1.0 indicates the onset of congestion. A v/c ratio above 1.2 indicates more serious congestion with traffic speeds deteriorating progressively with further increase in traffic.

Abbreviation

AEL	MTRCL Airport Express Line
AREOT	Overrun tunnel for the Airport Railway and Tung Chung Line
CBD	Central Business District
CFA	Court of Final Appeal
CRI	Central Reclamation Phase I
CRII	Central Reclamation Phase II
CRIII	Central Reclamation Phase III
CRC	Connaught Road Central
CTS	Comprehensive Transport Study
CTS-3	The Third Comprehensive Transport Study
CWB	Central – Wanchai Bypass
CWPS	Cooling water pumping station
EMSD	Electrical and Mechanical Services Department
GR	Gloucester Road
HKCEC	Hong Kong Convention and Exhibition Centre
HR	Harcourt Road
HyD	Highways Department
IECL	Island Eastern Corridor Link
IRAE	Initial Reclamation Area East in the construction sequence of CRIII
IRAW	Initial Reclamation Area West in the construction sequence of CRIII
ISL	MTRCL Island Line

JR	Judicial Review
LegCo	Legislative Council
MD	Marine Department
NIL	North Hong Kong Island Line
OZP	Outline Zoning Plan
PLA	People's Liberation Army
RDS-2	Second Railway Development Study
RDS-2000	Railway Development Strategy 2000
SPH	Society for Protection of the Harbour Limited
TCL	MTRCL Tung Chung Line
TD	Transport Department
TDD	Territory Development Department
TWL	MTRCL Tsuen Wan Line
v/c ratio	volume to capacity ratio
WDII	Wan Chai Development Phase II

Chapter 1 – Introduction and Background

1.1 Introduction

1.1.1 Central Reclamation Phase III (CRIII) arises from a number of planning studies commissioned by the Government first dated back to the early 1980s. The CRIII has gone through a due process of statutory town planning procedures and public consultation, in which there had been thorough public discussion on matters including the scale of reclamation and the usage of the land to be made available by the project.

1.1.2 The need for the Central and Wan Chai Reclamation was first identified in the strategic study on "Harbour Reclamations and Urban Growth" undertaken between March 1982 and October 1983. The need was further confirmed in various planning studies, including the Territorial Development Strategy of 1984, the Port and Airport Development Strategy 1989, Metroplan 1991, and the Territorial Development Strategy Review of 1996. The whole Central and Wan Chai Reclamation project forms land for the construction of, among other things, strategic transport links, associated surface road networks, the Airport Railway and its Hong Kong Station and the Hong Kong Convention and Exhibition Centre Extension. The Central Reclamation Phases I, II and the Wan Chai Reclamation Phase I were completed in 1997 to 1998. CRIII is the fourth of the five phases of the Central and Wan Chai Reclamation. A plan showing the five phases of the Central and Wan Chai Reclamation is shown at **Appendix 1.1**.

1.1.3 CRIII is needed to provide land for essential transport infrastructure including the Central – Wan Chai Bypass (CWB) and Road P2 network. The need for the CWB was reconfirmed in the Comprehensive Transport Study (CTS-3) completed in 1999. In a recent rerun of the CTS-3 transport model, the results indicated that the demand for CWB remained firm. The CRIII is also needed to re-provision existing waterfront facilities (e.g. pumping stations providing cooling water for buildings in Central, Star Ferry piers and Queen's Pier), which will be affected by the reclamation to provide the above-mentioned essential transport infrastructure.

1.1.4 Also accommodated in the CRIII will be –

- a military berth for the People's Liberation Army (PLA) as agreed under the 1994 Sino-British Defence Land Agreement;
- an overrun tunnel for the Airport Railway and Tung Chung Line (AREOT) to allow them to operate at their full capacity; and
- the future North Hong Kong Island Line (NIL).

All these essential infrastructure are shown in **Appendix 1.2**.

1.1.5 The land made available for the above items will provide an exceptional and unique opportunity for a vibrant waterfront promenade on the northern shore of Hong Kong Island extending from the Central Business District (CBD) to Wan Chai for the access and enjoyment by the community. About 5.1 ha of reclaimed land on CRIII is reserved for commercial uses. However, such uses are consequential to the reclamation extent determined by the need for the provision of essential transport infrastructure and reprovisioning of affected waterfront facilities. Stringent height restrictions are stipulated on the Central District (Extension) OZP so that mainly low-rise developments will be allowed. The commercial sites along the promenade are meant for waterfront related commercial and leisure uses such as low rise retail shops and cafes/restaurants to complement the function of the promenade for the enjoyment of citizens and tourists.

1.1.6 The Legislative Council, relevant District Councils (including Central & Western and Wan Chai District Councils), professional bodies (including Hong Kong Institution of Engineers, Hong Kong Institute of Planners, Hong Kong Institute of Architects, Hong Kong Institute of Surveyors, Hong Kong Institute of Landscape Architects and the Real Estates Developers Association of Hong Kong) and the general public have all been consulted on CRIII. There is a general support for the Central District (Extension) OZP and the CRIII project.

1.2 History of CRIII

1.2.1 Plan-making process

1.2.1.1 On 27 April 1998, the then Secretary for Planning, Environment and Lands under the delegated power of the Chief Executive directed the Town Planning Board (TPB) to prepare a new OZP for the Central Reclamation Phase III and its adjoining areas. Subsequently, the draft Central District (Extension) OZP was exhibited for public inspection on 29 May 1998 in accordance with section 5 of the Town Planning Ordinance (TPO). At that time, the draft OZP covered a proposed reclamation area of 38 hectares.

1.2.1.2 At the end of the two-month exhibition period, 70 valid objections were received, the majority of which were against the proposed scale of reclamation. After considering the objections, the TPB requested the Government to undertake a study to make recommendations to reduce the scale of reclamation. As a result, the area of reclamation was reduced to 23 hectares (i.e. the "minimum reclamation option"). The minimum reclamation option was presented to the objectors at the TPB hearing on 30 March 1999 and was considered generally acceptable by them as a suitable basis for the planning of the reclamation. After giving due consideration to the objections and the revised reclamation extent proposed by the Government, TPB agreed to adopt the minimum reclamation option as the basis for preparing amendments to the draft OZP.

1.2.1.3 On 10 June 1999, the Government presented the minimum reclamation option to the Panel on Planning, Lands and Works and the scheme was generally accepted. On 16 July 1999, the proposed amendments to the draft OZP (with the reclamation extent reduced from 38 ha to 23 ha) were gazetted under section 6(7) of the TPO.

1.2.1.4 In mid-1999, the Government presented the amended draft OZP to the then Central and Western District Board and various professional bodies including the Hong Kong Institution of Engineers, Hong Kong Institute of Planners, Hong Kong Institute of Architects, Hong Kong Institute of Surveyors, Hong Kong Institute of Landscape Architects and the Real Estate Developers' Association of Hong Kong. They generally supported the minimum reclamation option. On 22 February 2000, the amended draft OZP incorporating this option was approved by the Chief Executive in Council and gazetted as Central District (Extension) OZP No. S/H24/2 on 3 March 2000. The Plan went through several changes in the subsequent years with the current approved Plan being Central District (Extension) OZP No. S/H24/6. However, apart from the incorporation of four piers, the extent of reclamation remains unchanged.

1.2.2 Authorization and funding approvals

1.2.2.1 Pursuant to the above plan-making process, the Government duly proceeded with the authorization of the reclamation and surface road networks within CRIII under the Foreshore and Sea-bed (Reclamations) Ordinance and Roads (Works, Use and Compensation) Ordinance respectively in December 2001. Relevant bodies including the Central & Western, Wan Chai and Eastern District Councils were consulted in March 2000 regarding the proposed CRIII works, and expressed no adverse comments. As a designated project under Schedule 2 to the Environmental Impact Assessment Ordinance, CRIII's environmental impact assessment report was endorsed by the Advisory Council on the Environment and approved by the Director of Environmental Protection (DEP) in August 2001. An Environmental Permit for the CRIII works was issued by the DEP in March 2002. The Finance Committee of the Legislative Council approved funding for CRIII's detailed design and construction on 28 April 2000 and 21 June 2002 respectively.

1.2.2.2 Details of discussion at the District Councils, and the Panels and Finance Committee of the Legislative Council are at **Enclosure 1.1.**

1.2.3 CRIII works

1.2.3.1 The CRIII works contract as shown in **Appendices 1.3** and **1.4** was awarded to Leighton-China State-Van Oord Joint Venture (the Contractor) on 10 February 2003. The contract period is 55 months and is due for completion in September 2007.

1.2.3.2 The site was handed over to the Contractor on 28 February 2003. Thereafter, works commenced in various areas of the site and the Contractor commenced surveying, erection of hoarding, preparatory works, site establishment and mobilization. On 24 May 2003, the Contractor commenced marine site investigation at Initial Reclamation Area West and over the following months continued with the contract works including dredging, rockfilling and piling.

1.2.4 Chronology of events

1.2.4.1 The chronological events related to CRIII are set out at **Enclosure 1.2**.

1.3 The High Court Judgment on the draft Wan Chai North OZP and the Engineering Review of CRIII based on the "three tests"

1.3.1 According to the Protection of the Harbour Ordinance (PHO), "the harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people, and for that purpose there shall be a presumption against reclamation in the harbour". Furthermore, the Ordinance stipulates that all public officers and public bodies shall have regard to the above principle for guidance in the exercise of any powers vested in them. On 27 February 2003 the Society for Protection of the Harbour Limited (SPH) commenced legal proceedings and applied for judicial review of the decisions of the TPB made in connection with the draft Wan Chai North OZP – the challenge concerned WDII and did not include the CRIII works.

1.3.2 The High Court delivered the judgment on 8 July 2003 in respect of the judicial review. In the judgment, with regard to the presumption against reclamation under section 3 of the PHO, the following three tests were laid down –

"…the purpose and extent of each proposed reclamation ought to be individually assessed by reference to the three tests of –

- compelling, overriding and present need;
- no viable alternative; and
- minimum impairment."

1.3.3 This interpretation of the PHO would apply to all future planning of harbour front areas which included reclamation. Because of the great general or public importance of the case, the TPB appealed to the Court of Final Appeal (CFA).

1.3.4 On 31 October 2003, after reassessing the purpose and extent of each individual component of the proposed reclamation based on the three tests laid down by the High Court, the TPB requested the Government to conduct a comprehensive planning and engineering review on WDII and to draw up a minimum reclamation option that would comply with the law. The TPB will reconsider the draft Wan Chai North OZP and the objections according to the provisions of the Town Planning Ordinance upon completion of the review. The review is scheduled to commence soon with a view to drawing up a conceptual scheme for public consultation by end 2004.

1.3.5 In respect of the CRIII works and the Central District (Extension) OZP, unless set aside by the Court, the Central District (Extension)

OZP remains lawful and valid. The Government has to discharge contractual obligations under the CRIII works contract.

1.3.6 Following the High Court judgment, the Administration publicly announced that it would review all reclamation proposals inside the Harbour against the High Court's three tests. Accordingly, the Administration completed in November 2003 a review of the reclamation extent of CRIII with the essential infrastructure therein by applying the three tests (hereafter referred to as "the November 2003 Review"). That Review has examined each component in CRIII individually and concludes that they meet the three tests. It has been endorsed by Professor Y S Li, Chair Professor of Coastal and Environmental Engineering & Head of Department of Civil and Structural Engineering of the Hong Kong Polytechnic University. Professor Li has confirmed in writing that in his view, the analysis as presented in the November 2003 Review Report has convincingly demonstrated that the CRIII reclamation can comply with the three tests laid down in the High Court's judgment. Professor Li also confirms that CRIII is an integral part of and a necessary continuation of the early and completed phases of the Central and Wan Chai Reclamations, and that apart from the proposed construction of the key infrastructure in Central, namely the CWB, Airport Railway Extended Overrun Tunnel and Road P2 network, the CRIII reclamation can enhance the tidal flow and water quality in the Victoria Harbour by eliminating a zone of rather stagnant water. A copy of Professor Li's letter is at **Enclosure 1.3**. The November 2003 Review Report has been released to Members of the Legislative Council Panel on Planning, Lands and Works and Panel on Environmental Affairs as well as representatives of deputations attending the Legislative Council (LegCo) joint Panel meetings on the subject and members of the public upon request. It has also been posted on the CRIII website for public scrutiny.

1.4 The Court of Final Appeal's Judgment

1.4.1 The CFA handed down its judgment on 9 January 2004 in respect of the draft Wan Chai North OZP. The CFA held that the statutory principle of protection and preservation of the Harbour is a strong and vigorous one. The statutory presumption against reclamation in the Harbour is to implement the principle of protection and preservation. It does not prohibit reclamation altogether. As a presumption, it is capable of being rebutted.

1.4.2 The CFA dismissed the TPB's appeal and substituted the three tests laid down by the High Court with a single test of "**overriding public need**", which by its nature is a "demanding" test. A copy of the CFA judgment is at **Enclosure 1.4**. The presumption against reclamation can only be rebutted by establishing **an overriding public need for reclamation**. Such a need means a community need and would include "**the economic, environmental and social needs of the community**".

1.4.3 As stated in the CFA judgment, a need should only be regarded as overriding if it is a compelling and present need. The compelling need is far beyond "something nice to have, desirable, preferable or beneficial" but does not go as far as the "last resort" or something that the public "cannot do without". The present need is "taking into account the timescale of planning exercises, the need would arise within a definite and reasonable time frame". In addition, where there is a reasonable alternative to reclamation, there is no overriding need for reclamation. All circumstances should be considered as to whether there is any reasonable alternative and they would include the economic, environmental and social implications of each alternative. It is also relevant to take into account the cost, time and delay involved in respect of each alternative.

1.4.4 In order to satisfy the overriding public need test, there must be **cogent and convincing materials** before the decision-maker to establish an overriding public need for reclamation and rebut the presumption against reclamation. The burden to rebut such presumption is a heavy one and it falls on a public officer or public body in considering the exercise of any power in relation to any reclamation proposal.

1.4.5 Finally, as regards the extent of the proposed reclamation, the CFA also stated that it should not go beyond the minimum of that which is required by the overriding need. Each area proposed to be reclaimed must be justified.

1.4.6 Following the CFA judgment, the Administration has stated that it would review CRIII by applying the CFA's overriding public need test. The conclusion reached in the following chapters is that the extent of the CRIII reclamation is required to meet an overriding public need, in the form of essential transport infrastructure, including the CWB, and the reprovisioning of the existing facilities along the waterfront affected by the reclamation, including the Star Ferry piers, the Queen's Pier, public landing steps and cooling water pumping stations. We also need to build a PLA berthing space. Both the Road P2 network and NIL are located to the south of the CWB. So they will not push the reclamation extent further into the Harbour. As regards the waterfront promenade, it will be built on land formed for the CWB and reprovisioned facilities.

Chapter 2 – The Review

2.1 Scope of the Review

2.1.1 A revisit of the history and sequence of the development of CRIII will clearly demonstrate that CRIII is part and parcel (being the fourth of the five phases) of the Central and Wan Chai Reclamation planned in the 1980s and implemented since the early 1990s. CRIII aims at providing essential transport infrastructure to meet public needs that will arise within a definite time frame, notably the CWB, the Road P2 network and the AREOT. The limits of reclamation under CRIII are determined by the alignment of the CWB and the reprovisioning of existing facilities affected by the proposed reclamation. Allegations that the CRIII has sought to reclaim more land than is needed for the essential transport infrastructure are unfounded. Even the oft-quoted waterfront promenade is not a cause for reclamation. It will only be developed on land formed for the CWB which will be constructed within the CRIII area in the form of a tunnel and the reprovisioning of cooling water pumping stations affected by the CWB.

2.1.2 Other land use proposals are planned consequential to the reclamation limit determined. Hence, the Review focuses on examining individual areas of the proposed reclamation area to confirm whether they can meet the overriding public need test. Land use zoning on the reclaimed land is not a subject matter to be reviewed for justifying the compliance of the overriding public need test.

2.1.3 The Central District (Extension) OZP includes the CRIII reclamation of about 18 hectares and a proposed reclamation area of about 5 hectares to the north of Lung King Street. It has always been the Administration's intention, justified on grounds of works sequencing and environmental consideration, to implement the 5 hectares reclamation as part of the Wan Chai Development Phase II (WDII) works. In light of the review to be undertaken on WDII pursuant to the CFA judgment, this Review, as in the case of the November 2003 Review, covers only the CRIII, while the 5 hectares proposed reclamation area will be reviewed under the WDII. Upon completion of the WDII review, the Chief Executive in Council will be requested to consider whether the Central District (Extension) OZP should be referred to the TPB for amendment under section 12 of the TPO insofar as the 5 hectares of proposed reclamation are concerned. Such a procedure is not uncommon in the plan-making process.

2.2 Approach of the Review

2.2.1 To satisfy the requirement of "no reasonable alternative" specified in the CFA judgment, we have in this Review examined all suggested alternatives in respect of the individual components of reclamation put forward or brought to our attention by concerned parties, professionals or other members of the public in recent months. They can be categorized into two groups – the alternatives and comments we received in the two Legislative Council joint Panel meetings held on 27 November and 8 December 2003, and alternatives contained in SPH's Affirmations it submitted to the High Court in early February 2004 in the judicial review proceedings in relation to CRIII. It should be noted that the Judge hearing the CRIII JR only allowed the SPH to refer to the contents of those Affirmations for the limited purpose of supporting its contention that alternatives did exist; the Judge did not decide whether such alternatives were reasonable or viable, nor did he consider it within his purview to go into the merits of the reclamation.

2.2.2 In the following paragraphs, we will present the CRIII components and our review in accordance with the CFA's "overriding public need test" one by one, followed by the suggested alternatives referred to in paragraph 2.2.1 above, and our responses to those suggested alternatives. With particular reference to the engineering alternatives put forth in respect of the alignment of the CWB, the form and construction of seawalls and the size, configuration and operation of water cooling pumping stations, it should be pointed out that these are complex and inter-related physical infrastructural works the feasibility of which could only be assessed and confirmed through comprehensive studies. Likewise, the environmental acceptability of such alternatives could only be confirmed through environmental impact studies. Moreover, where affected parties are involved, such as in the case of the reprovisioning of pumping stations, these parties would have to be extensively consulted and their agreement obtained. Most of the suggested alternatives addressed in this Review are short of the necessary details. If the Administration were to assess the feasibility of each of these, it would give rise to significant implications in terms of time, delay and cost of the project which, according to the CFA judgment are valid considerations to be taken into account in deciding whether there exists a reasonable alternative. Nonetheless, despite the inherent limitations in assessing these alternatives, we have sought the opinion of independent experts and their views are reflected as appropriate in this Review Report with their expressed consent. A list of the experts who have provided comments and their respective areas of expertise is at **Enclosure 2.1**.

2.3 Central – Wan Chai Bypass

2.3.1 The CWB is a strategic route connecting the Rumsey Street flyover at the west via the Island Eastern Corridor Link with the Island Eastern Corridor at the east as shown in **Appendix 2.1**. The ***compelling and present need for CWB*** is supported by various transport studies. Transport Department (TD) conducted periodic Comprehensive Transport Studies (CTS)[1]. The CTS-2 completed in 1989 confirmed the need to provide the CWB and the Island Eastern Corridor Link by the mid to late 1990s. After

[1] According to Mr Tim Man, transport planning specialist, with the multi-modal modeling capability and its ability to assess policy options, the application of the CTS model to assess infrastructural needs is scientific. The CTS model is one of the most sophisticated ones which can cope with the complicated fabric of urban transport in Hong Kong's context **[Enclosure 2.2]**.

completion of the CTS-3[2] Study in 1999, the CTS-3 traffic forecasts have been regularly updated taking into account the latest available traffic survey data as well as the latest circumstances like land use planning data including employment and population growth, inflation/deflation rates, economic growth, cross boundary traffic projections, port and airport throughputs, and other socio-economic data and forecasts. In a recent re-run of the CTS-3[3] in the fourth quarter of 2003, the results re-affirmed the need for the CWB despite changes in land use planning assumption and a decrease in population projection of the territory (including the deletion of the Western District Development project). The study model predicted that the traffic volume during the peak hours in 2011 on critical sections of the Connaught Road Central/Harcourt Road/Gloucester Road (CRC/HC/GR) Corridor would exceed their capacities by 30% if the CWB could not be built in time. It should also be noted that the existing CRC/HR/GR Corridor has been so heavily used for many years, major repair / reconstruction works would likely be

[2] The CTS-3 transport model is a suite of conventional 4-stage transport model developed and further enhanced by the consultants in the series of comprehensive transport planning studies undertaken by the Hong Kong Government in the past few decades, with the latest version being developed and used in the CTS-3 Study completed in 1999. It was developed to evaluate at a territorial level the strategic transport infrastructure requirements for the short, medium and long term for Hong Kong. The model is capable of testing and evaluating a wide range of transport policies like demand management measures and other traffic management measures. For instance, vehicle restraint measures like raising the First Registration Tax (FRT), Annual Licence Fees (ALF), fuel taxes, etc. which would impede the ownership and usage of private vehicles, management measures like better coordination of public transport, fare integration, park-and-ride initiatives, etc. have been evaluated in the CTS-3 Study. The model is also capable of simulating the effect of congestion on trip distribution (i.e. to avoid going to the congested area) and change of mode (i.e. to change to non-road based public transport). Such simulation capability is adequately checked and confirmed when the model is calibrated and validated using the most up-to-date observed data on the traffic volume on major roads and usage of various modes of transport. With further adaptations and refinement, the model is capable of and was used in testing specific transport policy options and district traffic solutions, such as in the case of evaluating the ERP options and addressing district and local traffic issues.

[3] According to Professor Lo Hong Kam, transport expert and Associate Professor of the Department of Civil Engineering at the Hong Kong University of Science and Technology, the CTS-3 model is used to study the traffic impacts of demand management and transportation improvement schemes and represents the state-of-the-art in practice. As a 4-step transportation planning model with feedback between steps, it is among the most sophisticated of its kind. The CTS-3 model is calibrated by two data collection schemes that are among the most comprehensive in the world **[Enclosure 2.3]**.

required in the next 15 to 20 years' time. If the CWB was not completed by then, the east-west traffic would be severely disrupted when part of the CRC/HR/GR Corridor has to be closed for carrying out the necessary repair / reconstruction works. Mr Tim Man, transport planning specialist, has pointed out that there is an apparent and pressing need for the CWB to relieve the prevailing traffic congestion experienced along the Corridor traversing through the CBD. With the additional traffic generated by committed developments in CRI, congestion can be expected to exacerbate to an intolerable level **[Enclosure 2.2]**. Professor Lo Hong Kam, transport expert and Associate Professor of the Department of Civil Engineering at the Hong Kong University of Science and Technology, has noticed that severe congestion now occurs on the roadway segment covering Connaught Road Central-Harcourt Road-Gloucester Road on a regular basis. According to Professor Lo, the traffic congestion "will only get worse with the opening of the International Finance Centre, urban re-development of Central and Western District, and future development of south-western part of Hong Kong Island. There will also be future traffic demands arising from further developments in Western Kowloon and North West New Territories. The CTS-3 result that the Corridor is overloaded to be beyond its capacity is, without a doubt, credible" **[Enclosure 2.3]**. Besides looking at the operational requirements like traffic projections and forecasts, the project evaluations conducted in the CTS-3 Study and subsequent updating reviews have taken into consideration various relevant factors like economic evaluation on the cost-benefit effectiveness of proposed projects, developmental considerations, environmental considerations, public acceptability, budgetary constraints, etc. Therefore, scoring systems with sensitivity tests using different weightings have been adopted to test the optimal solutions to be recommended. In addition, various other forms of alternatives like supply side and demand side management measures have been examined and recommended in the Study. The CTS-3 model is a tool that helps the Government to formulate a solution to cope with the anticipated traffic demand. The traffic studies confirmed and its subsequent updating reviews re-confirmed the compelling and present need to build the CWB.

2.3.2 CWB is needed to meet the transport needs of the community within ***a reasonable and definite planning time frame***. As pointed out above and illustrated in the Traffic Forecast in Central Business District, if CWB is not available by 2011, traffic conditions along the CRC/HR/GR Corridor will deteriorate and considerable traffic congestion will occur. At present, CRC, HR and GR are already operating beyond their capacities with the volume/capacity (v/c) ratio above 1.0. Congestion is not limited to the normal a.m. and p.m. peak hours. Without the CWB, traffic congestion will deteriorate to a v/c ratio of 1.3. Other east-west secondary corridor, such as Hennessy Road and Queensway would also be heavily congested by that time as the capacity of these roads would be constrained by the traffic signals and kerbside loading / unloading activities of buses, taxis and goods vehicles. The traffic on the CRC/HR/GR Corridor will in turn cause congestion in the neighboring roads in Central and Wan Chai creating gridlocks. CWB is therefore critically needed to provide a relief route to the existing road network to ease the traffic burden on the CRC/HR/GR Corridor on Hong Kong Island. This view is supported by Dr Cheng Hon-kwan, former Chairman of Transport Advisory Committee, who opines that the CWB is urgently needed to resolve the traffic congestion problem in Central and Wan Chai **[Enclosure 2.4]**.

2.3.3 If CWB is not available by 2011, it is estimated that traffic conditions will worsen to a speed of 5 km/hr and it would take about 45 minutes for drivers to travel from Rumsey Street to Causeway Bay for the 4 km long CRC/HR/GR Corridor. According to Mr Fred Neal Brown, who is a transport expert, there will be substantial increase in travel by all modes to the north foreshore of the Hong Kong Island and the CBD. With the already protracted delay to the CWB, the travel and environmental prospects for CBD will worsen in terms of –

- Worsening traffic congestion;
- Increasing risk of gridlock;
- Substandard air quality, noise and physical environment;
- Deteriorating operating conditions for public transport; and
- Poor access to the waterfront and degraded environment for pedestrians.

Mr Brown further opines that the CWB is an essential component for the land use/transport/environmental revitalization and development of the CBD and the north foreshore of Hong Kong Island as a whole. The original planning for the CWB envisaged completion in the 1990s. The protracted delay in implementation is already causing degradation of the environment and accessibility in the CBD **[Enclosure 2.5]**. According to the Chartered Institute of Logistics and Transport in Hong Kong, the CWB will relieve the serious traffic congestion on the main roads along the north shore of the Hong Kong Island to an acceptable level **[Enclosure 2.6]**.

2.3.4 Because of the unique position of the CBD, the social and economic costs of serious traffic congestion and gridlock are high. In measuring the cost effectiveness of a project, Government looks at the overall benefit brought to the community by the project. For transport infrastructure, the bulk of such benefit refers to the saving in travelling time for the public and congestion relief to adjacent roads. In assessing the cost-effectiveness of CWB, TD has estimated that on the first year of operation of CWB, about 365,000 road users will benefit from using the new road each day and the average time saved by each user will be 20 minutes and the cost of user time is $60 per hour. These input assumptions will result in the cost of time saved amounting to $2,193 million in the first year. Using the Internal Rate of Return equation, we evaluate that the investment on the CWB will generate an Economic Internal Rate of Return of about 28% over its estimated project life of 40 years. Using the CFA formulations, the CWB is clearly meeting the ***social and economic needs*** of the community.

2.3.5 The compelling need for CWB could also be appreciated by viewing its significance in Hong Kong's strategic road network. As illustrated in **Appendix 2.2**, the CWB is the final and most vital road link that is currently missing on the northern shore of Hong Kong Island. This conduit is needed to divert through traffic away from the CBD, to cater for anticipated traffic growth beyond 2006 and to alleviate congestion on existing road networks (already operating at capacity) that feed into Central from the east to the west, and vice versa. Without CRIII, the CWB cannot be built and there will be a "missing link" between Kennedy Town and Causeway Bay along the northern shore of the Hong Kong Island, as well as in the territory-wide strategic road network. Professor Lo Hong Kam supports the argument that the CWB constitutes a missing link in the Hong Kong transportation network. Without the CWB, the CRC/HR/GR Corridor becomes the only linkage with insufficient capacity to serve the heavy demands between the Western Harbour Crossing, Cross Harbour Tunnel and Central, as well as the through traffic eastbound and westbound on Hong Kong Island, and northbound traffic from the mid-levels **[Enclosure 2.3]**. Professor C O Tong, Associate Professor of the Department of Civil Engineering at the University of Hong Kong, echoes Professor Lo's view by saying that "the CWB is needed to ensure the provision of a functional and balanced road network" **[Enclosure 2.7]**. In a letter to the Administration, the Hong Kong Institute of Planners "supports the early completion of the road network to resolve the increasing traffic congestion problems" **[Enclosure 2.8]**.

2.3.6 The community need for the CWB has been well recognized throughout the planning stage of the project. At the 6th In-house Meeting of Central and Western District Council held on 23 July 1998, members passed a motion requesting the Government to build CWB close to the Central waterfront immediately. Highways Department consulted the Eastern District Council on 6 September 2001, the Central and Western District Council on 13 September 2001, and the Wan Chai District Council on 18 September and 20 November 2001 on the CWB works. Members expressed support for the project. At the Public Works Subcommittee of the Finance

Committee of the Legislative Council meeting on 5 June 2002 during which funding application for the CRIII project was discussed, Members expressed support for the CRIII on account of the need to provide land for construction of the CWB to ease the traffic congestion problem in Central. It is relevant to note that amongst those who had lodged objections to the Central District (Extension) OZP during the plan making process, only one objector said that there was no need for more roads. All the other objectors did not raise objection to the CWB. Some objectors actually indicated their support for the CWB during the objection hearings. At the joint meeting of the Panel on Planning, Lands and Works and the Panel on Environmental Affairs on 27 November 2003, the Chairman of GMB Maxicab Operators General Association Ltd (GMB) supported reclamation for the provision of essential road infrastructure, including CWB, to relieve traffic congestion in Central as this would facilitate the operation of the GMB Maxicab lines running between Central and Wan Chai. At the same meeting, the spokesman of the Hong Kong and Kowloon Taxi Merchants' Joint Committee supported the construction of the CWB to resolve the traffic congestion problem in Central.

2.3.7 In her judgment, Madam Justice Chu said that "the applicant is prepared to accept that as a matter of principle at least, reclamation for the CWB and the IEC Link may be able to satisfy the three tests propounded by the applicant". In the CFA judgment, it was likewise pointed out that the position of SPH is that it accepts the proposed roads, being essential infrastructure, may satisfy the overriding public need test for rebutting the presumption. However, the Society appears to have changed its stance later in the CRIII judicial review hearing.

2.3.8 In the November 2003 Review, we have already analyzed the horizontal and vertical alignment options of CWB and concluded that the ***extent of reclamation for the CWB under the CRIII is the minimum that is required***. The horizontal alignment of the CWB is fixed by the control points at both connecting ends, namely the

Rumsey Street Flyover to the west and the Island Eastern Corridor to the east. In addition, the Central District is already fully packed on the road surface as well as in the underground which makes it difficult to build the CWB on existing land. The Final Study Report for Central -- Wan Chai Bypass Tunnel Review under the Comprehensive Feasibility Study for CRIII Minimum Option in 1999 has identified the following constraints on the alignment of the CWB. These include –

- The Rumsey Street Flyover (the western end of the CWB) where provision has already been built for the future extension;
- The existing developments and on-going developments including Harbour Building, Exchange Square, One and Two International Finance Centre, Four Seasons Hotel, Hong Kong Convention and Exhibition Centre, its Extension and the Atrium Link between them, Wan Chai Towers and Central Plaza;
- Existing Roads including Connaught Road Central, Harcourt Road, Gloucester Road, Man Cheung Street;
- Existing underground structures including the existing MTR Tsuen Wan Line and Airport Railway;
- The existing MTR Cross Harbour Tunnel (Tsuen Wan Line) including the joints of the tunnel tube;
- The Cross Harbour Tunnel in Causeway Bay; and
- Existing Island Eastern Corridor (the eastern end of the CWB).

2.3.9 Apart from the above control point constraints, the curvature of the CWB alignment has been examined in order to bring the CWB as close as possible to the existing shoreline and thus reduce the extent of reclamation. However, since the CWB within the CRIII is in the form of a tunnel, it is important to avoid sharp curves and maintain the minimum sight distance for driving safety considerations. As a result, the horizontal alignment of the CWB cannot be shifted further southward/landward. We have also examined the alternatives of elevated or at-grade options of the

CWB within the CRIII but these are confirmed to be non-feasible, from the technical, environmental or visual impact angles. Details on this are contained in the November 2003 Review Report, a relevant extract is at **Appendix 2.3**.

2.3.10 The most reasonable, practical and optimal option that is environmentally acceptable is therefore to construct the CWB within CRIII area in the form of a tunnel through CRIII reclamation along the alignment as shown on the figure in **Appendix 1.3**. According to the Chartered Institute of Logistics and Transport in Hong Kong, alternative alignments for the CWB as proposed by various groups opposing reclamation are impractical **[Enclosure 2.6]**. From the engineering perspective, Mr Koo Yuk Chan, who is a civil and geotechnical engineer, comments that "extensive engineering studies have been carried out to investigate the feasibility of different alignment options for the CWB within the CRIII. The one presently adopted by the Government is the most practical, reasonable and environmentally acceptable option, requiring minimum reclamation and satisfying various constraints" **[Enclosure 2.9]**.

Suggested Alternatives considered

2.3.11 Despite extensive support for the CWB when the project was conceived and progressed between 1998 and 2003, the SPH and some community groups have in recent months proposed other "alternatives" to solve the traffic problems. At the LegCo joint Panel meeting on 27 November 2003, the following bodies voiced their comments and alternatives on the CWB –

- Conservancy Association **[Enclosure 2.10]**
- Urban Watch **[Enclosure 2.10]**
- 中重型貨車關注組 **[Enclosure 2.10]**
- Rights of Taxi Owners and Driver Association **[Enclosure 2.10]**

2.3.12 Their inputs can be classified into the following categories –

- To fully utilize the Western Harbour Crossing
- Extension of the MTR to Kennedy Town
- Provision of hillside escalators from Central to Mid-levels
- Provision of bus-bus interchanges at the fringe areas of Central
- Restricting loading and unloading times in Central
- Adoption of Electronic Road Pricing

2.3.13 TD has indeed considered the feasibility of these alternatives in relieving traffic congestion in the Central and Wan Chai areas and concluded that the CWB is needed to relieve the congestion problem. The considerations in respect of these alternatives are set out below.

2.3.13.1 *Full utilization of the Western Harbour Crossing (WHC)*

2.3.13.1.1 The suggestion of adopting an equal toll for WHC and Cross Harbour Tunnel (CHT) so as to increase utilization of the former is not expected to relieve significantly congestion in the Central and Wan Chai areas as most of the traffic would still need to go through Central, except for the small percentage of traffic from and to the western part of the Hong Kong Island[4]. For the testing of different possibilities of toll levels among the three cross harbour tunnels, we have evaluated the case in which the CHT charged a higher level of toll than that charged by the WHC. Under such a tolling regime, WHC would experience a great surge in traffic volume, a substantial proportion of which is diverted from CHT. This would strain further the already heavily congested Connaught Road Central (CRC) and the road network in the Central Business District

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[4] The actual average traffic throughput of WHC, CHT and EHC in response to the toll increase at CHT from $10 to $20 for private cars which took effect on 1 September 1999 were 37,800, 119,000 and 67,000 daily vehicles respectively for the 12-month period before the toll increase while the three tunnels recorded 42,300, 118,100 and 71,900 vehicles daily respectively for the 12-month period after the increase. Therefore, the effect of doubling the CHT toll on reducing traffic using CHT was only 900 vehicles daily or less than 1% of its original volume.

(CBD) if the CWB and related roads are not built to relieve these roads. Therefore, this suggestion would only further exacerbate the already serious congestion of the road network in Central. According to Mr Tim Man, "past experience suggested that even when the toll level was doubled at CHT, the shift of traffic to use the other two cross harbour tunnels was not significant. The under-usage of the WHC continues owing to the enduring traffic congestion along Connaught Road Rumsey Street Flyover with queues very often extending beyond Shun Tak Centre in the E/B direction in the morning peak period. In the W/B direction, traffic congestion is also experienced along the Gloucester Road/Connaught Road Central corridor. The capacity constraints at the western and eastern ends of the corridor result in an increase in travel time which offsets the benefits of using the WHC. This further supports the necessity of building the CWB to relieve the existing traffic congestion along the Gloucester Road/Connaught Road before better utilization of the WHC can be realized."**[Enclosure 2.2]**.

2.3.13.1.2 We have also assessed the scenario where CHT and WHC adopt similar toll levels. Our assessment indicates that there would be a very minor (of about 2% only) reduction of traffic to a section of Gloucester Road (GR) near Immigration Tower. However, the traffic condition along CRC and the road network in the CBD would be further aggravated due to the increase in traffic that needs to access WHC. According to the result of TD's traffic model, it is predicted that the possible relieving effect of an equal toll on GR would be less than 2%.[5] This is

[5] It is estimated that equalizing the toll will reduce the total traffic volume on Cross Harbour Tunnel (CHT) and Eastern Harbour Crossing (EHC) by about 14,000 vehicles per day while the traffic volume of WHC will increase by 24,000 vehicles per day when compared to the present daily traffic volumes on the three tunnels of 123,000, 74,000 and 40,000 vehicles respectively. The reduction of CHT and EHC traffic will cause a drop in this type of cross harbour traffic on Gloucester Road (GR) by 9,000 vehicles per day while this is partly offset by the increase in the GR traffic by 6,000 vehicles per day due to the increase in WHC traffic traveling via GR so that the net effect is a reduction of 3,000 vehicles per day on GR. This when compared to the

because the diversion of traffic from CHT to WHC is likely to result in a corresponding increase in traffic volume along CRC, adding to the traffic congestion thereat. Therefore, the overall traffic condition of the CRC/HR/GR Corridor is not expected to improve under such a hypothetical toll regime. Hence, the equal toll proposals would not be effective in solving the traffic congestion on the existing roads.

2.3.13.1.3 This could be attributable to the fact that some additional traffic in the east would be attracted to use WHC via the Corridor. Similarly for cross-harbour traffic from the Southern District via the Aberdeen Tunnel, they would have to travel along the Corridor before they can use WHC to take advantage of the lower toll. On the other hand, traffic from the Central District originally destined to use CHT would be removed from the GR/HR but part of it would be added back to the CRC if they are diverted to use WHC under a cheaper toll. For the cross-harbour traffic from Wan Chai diverted from CHT to WHC, the reduction in traffic in the eastern part of GR will result in increase in traffic in the western part of the Corridor. There would hence be a balancing out effect overall. Furthermore, the amount of cross harbour traffic on the Corridor, estimated to be about 20%,[6] is relatively minor when compared to the bulk of the non-cross harbour traffic using the Corridor, the volume of which is not at all affected by the toll levels of the cross harbour tunnels.

2.3.13.1.4 When the toll levels of WHC and CHT become the same, some CHT traffic would shift to use WHC while some Eastern Harbour Crossing (EHC) traffic would shift to use CHT to take advantage of the relief of traffic congestion of CHT. The latter

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present daily traffic on GR west of CHT of 176,000 vehicles per day constitutes a net reduction of about 2%.

[6] According to the traffic proportions on GR as based on Base District Traffic Model run, 20% of the morning peak hours eastbound traffic is heading for CHT, 65% to Eastern District, and 15% to Canal Road Flyover.

will result in a slight increase of about 2% in traffic demand on the section of GR east of CHT (near Excelsior) aggravating the congestion thereat.

2.3.13.1.5 Therefore, the "equal toll" option does not provide an effective solution to congestion along the Corridor. Moreover, such arrangement would also be subject to a commercial agreement with the tunnel operators which will take time to negotiate but with no certainty over the outcome.

2.3.13.2 *Extension of the MTR to Kennedy Town*

2.3.13.2.1 The extension of the West Hong Kong Island Line to Belcher by 2011 was adopted as an assumption in a rerun of the traffic model in 2003 by TD. The results show that extending the MTR to Kennedy Town will not help relieve congestion in the Corridor. This is because most bus routes run along the inner roads including Des Voeux Road and Queen's Road. Any reduction in bus service as a result of diversion of passengers to the MTR will be limited and will at most provide slight relief to the already congested inner roads.

2.3.13.3 *Provision of hillside escalators from Central to Mid-levels*

2.3.13.3.1 Providing additional escalator links will help relieve the traffic burden along the roads in the Mid-levels but will not help relieve congestion in the Central and Wan Chai areas. Experience of the existing Central – Mid-levels Escalator Link is that the Link helped to relieve pressure on public transport demand in the Mid-levels, but there was no drop in traffic volume after the Link was opened.

2.3.13.4 *Provision of bus-bus interchanges (BBIs) at the fringe areas of Central*

2.3.13.4.1 TD has taken active steps in rationalizing and restructuring bus routes in the past five years. The number of bus trips going through Central has been reduced by more than 10% as a result. The Department is now examining a proposal on several potential BBIs in the Central Business District. The scope of further reduction in bus trips going through Central is unlikely to be of a significant scale.

2.3.13.5 *Restricting loading and unloading times in Central*

2.3.13.5.1 Confining the loading/unloading activities to night time could adversely affect the commercial activities in Central. We need to balance the interest of businesses and other trades. Currently, the loading/unloading facilities are already provided on a restrictive basis taking into account the need to minimize any adverse impact on traffic.

2.3.13.5.2 As a responsible government, we have to balance the interests of different parties, including the trucking industry, the business operators and other road users. TD has regularly received requests from the Associations of the truck operators demanding the opening up of restricted zones and reducing the restriction hours to help their business. In fact, we have already imposed severe restrictions on loading/unloading (L/UL) activities along majority sections of the CRC/HR/GR Corridor. Imposing further restrictions on L/UL activities along the internal roads of the CBD cannot help relieve the congestion along the CRC/HR/GR Corridor and will have serious impact on the business activities in the CBD.

2.3.13.5.3 Roads are built to serve different needs of the public. Reasonable loading/unloading activities will have to be allowed along the roads. In order to achieve the highest capacity of the trunk road corridor, we have imposed severe restriction on loading/unloading along CRC/HR/GR. As such, loading/ unloading activities have to be allowed in the internal roads, such as Hennessey Road and Des Voeux Road Central. In cases where capacities of the internal roads are constrained, they are due primarily to the signalized junctions rather than the loading/unloading activities.

2.3.13.6 *Adoption of Electronic Road Pricing (ERP)*

2.3.13.6.1 A Feasibility Study on ERP (the Study) was completed in April 2001 to examine the practicability of implementing an ERP system in Hong Kong and the need for such a system to meet transport objectives. While the Study concluded that the implementation of an ERP system in Hong Kong is feasible from the technical point of view, it also considered that given that peak hour travel speed in urban areas is forecast to remain above 20 km/hour, drastic restraint measures such as ERP were not warranted on traffic management grounds before 2006 for Hong Kong Island and 2011 for Kowloon at the earliest if the growth of the private vehicle fleet is no more than 3% per year. The Study also pointed out that ERP could only be implemented where there was a high level of consensus in the community. After considering all the relevant factors with reference to the above conclusions, the Administration decided that ERP should not be pursued at that time. The decision was then presented to and agreed by the LegCo in early 2001. Professor Lo Hong Kam agrees that the acceptability of the ERP by the community must be duly considered **[Enclosure 2.3]**.

2.3.13.6.2 In one of the Affirmations submitted by SPH, Professor William Francis Barron accuses that the Government has never released the full report on ERP. This accusation is factually wrong. We have advised that the Final Report of the Feasibility Study on ERP was released in April 2001. The "Executive Summary" quoted by Professor Barron is the full Final Report setting out the process, major findings and key recommendations of the Study. The road pricing concept, technological options, alternative traffic management measures, need for ERP, possible system for Hong Kong, integration with other Intelligent Transport Systems, benefits and public consultation were examined in detail during the Study.

2.3.13.6.3 Professor Barron also alleges that no supporting evidence was given to the Government's assertion that various traffic management measures were not adequate to replace the CWB and the Road P2 network. Mr Hardy Lok Kung Chin, a Chartered Engineer authorized by SPH, raises a similar point, saying that a more comprehensive study needs to be undertaken with a view that the CBD can impose toll charges, which has proved to work well in other cities/countries in curbing the growth of traffic volume. We do not agree with these views. Hong Kong has been imposing one of the world's highest levels of First Registration Tax (FRT) on private car and fuel taxes as a form of managing the demand of private car ownership and usage. We also have a very good public transport system. In combination, they result in probably the highest usage of public transport (about 90% of all persons trips) amongst world-class cities with similar or higher level of developments. The scope and potential effect for further demand management to provide even higher usage of public transport could be limited and might not be acceptable to the public.

2.3.13.6.4 To unduly restrain traffic demand in the CBD could also have a significant impact on economic activities in this important financial center of Hong Kong. In the case of London, the London Chamber of Commerce had looked at how the congestion charge was affecting business within the charging zone. The results found that it had a negative effect particularly on smaller retailers and that a significant number were thinking of relocating. Moreover, the figures illustrate that the objective of such schemes is mainly to regulate the traffic to and from the charging zone. In the case of London, the charge applies only to vehicles traveling inside, not on, the boundary. The ring road around the charging zone provides an alternative route for the through traffic not entering central London. Similarly, the Electronic Road Pricing System in Singapore also charges only those vehicles passing through the gantries installed at entry points into the CBD. In Hong Kong, because of the geographical constraints around the CBD, such an alternative route does not exist.

2.3.13.6.5 Another view expressed by Professor Barron in one of SPH's Affirmation is that the supply expansion option (i.e. construction of new road works) was assumed because the Government has rejected ERP. In fact, ERP is only a traffic management measure for regulating traffic demand in a designated area. While the Administration will continue to review the need for and effectiveness of ERP to manage local traffic, the CWB would still be necessary to provide an alternative route for the through traffic.

2.3.13.6.6 The availability of a reasonable alternative route is key to obtaining community support for the implementation of any such scheme. The magnitude of the forecast growth in traffic moreover demands infrastructure improvement in addition to traffic management measures. The provision of an alternative east-west corridor in the form of CWB is hence crucial in any proposal to address the congestion of the CBD. The completion of the CWB will provide a more efficient transport network to sustain the long term growth of Hong Kong. As pointed out earlier, ERP is a traffic management measure for the management of traffic demand in a specific area and cannot serve as a replacement of the CWB. The CWB would still be necessary to provide an alternative route for the through traffic. Mr Tim Man has expressed his support to this point. According to him, "with all the traffic management measures exhausted, it has been proved inadequate to resolve the persistent traffic congestion in the CBD area. While it is not disputed that traffic management measures or demand management measures in the CBD would be needed subject to other considerations, it is considered that CWB would still be required regardless. There will still be a compelling need for CWB to address the traffic demand passing through the CBD" **[Enclosure 2.2]**. Likewise, the Chartered Institute of Logistics and Transport in Hong Kong has voiced its view that there is a need for the CWB **[Enclosure 2.6]**. Also, Professor Andrew Leung, Head and Professor of the Department of Building and Construction at the City University of Hong Kong, pointed out that "traffic management is an option but it would be unfair to ask those who just want to go by-pass Central to pay. Any traffic system must provide an escape route and that is not possible without more road works" **[Enclosure 2.11]**.

2.3.13.6.7 The implementation of ERP would only affect the trips destined for the CBD area and is not designed to curb cross-district movements catered for by the CWB. Only a dual-3 CWB could have the capacity to receive the diversion of trips if ERP were to be applied to the CRC/HR/GR Corridor.

2.3.13.6.8 The Government has thoroughly assessed the ERP and has released the full report. The Government is not rejecting ERP but its implementation is not yet mature in the current circumstances. ERP is still one of the possible forms of traffic management measures providing that (a) there will be an alternative route bypassing the charging zone; and (b) there is community consensus on its implementation.

2.3.14 In sum, given that the predicted traffic volume during the peak hours in 2011 on critical sections of the Corridor will exceed their capacities by 30% and the alternative measures will not be able to achieve a reduction in traffic volume on the Corridor to within capacity level, constructing the CWB within the CRIII is the ultimate solution to the traffic congestion problem in the Central and Wan Chai areas. There is ***no reasonable alternative to reclamation for the purpose of providing for Hong Kong's***

economic and social needs by way of relieving existing and projected traffic congestion along the CRC/HR/GR Corridor. That congestion will be relieved by CWB.

2.3.15 At the LegCo joint Panel meeting on 27 November 2003, the SPH presented two alternatives as illustrated in a conceptual sketch supported by some brief notes, namely a no-CWB option and a reduced reclamation option **[Appendix 2.4]**. It should first of all be acknowledged that the planning and engineering feasibility of a works project, let alone a major transport infrastructural project like the CWB, can only be confirmed through a series of preliminary and detailed feasibility studies, followed by detailed design and impact assessments. The SPH's proposals are short of details and are no more than a piece of conceptual work. Nonetheless, we have considered these alternatives for what they are worth.

2.3.16 The SPH's *no-reclamation option* apparently relies on traffic management measures to reduce traffic flows into the area and a new surface road cutting through the open space strip between the existing Star Ferry and Queen's Piers and City Hall. The proposed surface road will not only degrade the concourse in front of the Star Ferry and the environment of the City Hall, it also does not address the main problem of taking traffic out of the CBD. It cannot be a substitute for the CWB. Besides, drastic traffic flow reduction options would adversely affect the commercial activities in the CBD. The inadequacy of traffic management measures to meet growing traffic demand is discussed in detail in the preceding paragraphs.

2.3.17 The SPH's *reduced reclamation option* which requires reclamation of 15.1 ha (as compared to the Government's 18 ha under CRIII or a total of 23 ha if the 5 ha to be reclaimed under the Wan Chai Development Phase II are to be included) portrays only the CWB alignment with no provision or regard for essential support such as the seawall; the reprovisioning of cooling water pumping stations affected by the reclamation; the impact on marine traffic; the construction staging and work sequence to ensure all existing facilities could continue to function properly during the construction. When the seawall structure for the CWB and the affected facilities to be reprovisioned to the waterfront are added back to the reclamation, any reduction in the extent of reclamation under the SPH's alternative is more apparent than real.

2.3.18 Professor Wong Wah-sang of Urban Watch had proposed an alternative of building a road from Connaught Place to Lung Wui Road via the Star Ferry public car park (to be demolished) and Edinburgh Place and to build a podium on top of the new road to compensate for the loss of Edinburgh Place. We consider this proposed link road at Edinburgh Place not an acceptable alternative because of the following reasons –

- The section of CRC fronting the City Hall is only one of the bottlenecks along the main east-west trunk road corridor causing traffic congestion. In fact, both eastbound and westbound and many other sections of roads along the CRC/HR/GR Corridor are suffering from heavy congestion during most of the day. This is the reason why we need to build the CWB to provide an ultimate solution to the traffic problem along this Corridor.
- Other than not being able to adequately address the existing traffic problem along HR and GR and other sections of CRC, the proposed road from Connaught Road to Lung Wui Road cannot help relieve the eastbound traffic of CRC as the western end of the proposed new road is not directly connected with the CRC. The CRC traffic would have to route through the already overloaded CRC/Pedder Street junction before entering into the new road. The CRC/Pedder Street junction would not be able to cope with further additional traffic. On the other hand, the eastern end of the proposed new road would join Lung Wui Road. From this point, the traffic can turn right to re-join CRC/HR. However, traffic weaving would be a problem as the traffic along CRC/HR will remain heavy. The traffic can also turn left and join Lung Wui Road - Fenwick Pier Street heading

to Wan Chai North. However, the capacities of both Convention Avenue and Harbour Road in Wan Chai North are constrained at their junctions with Fleming Road. The spare capacities from these two junctions, if any, are quite limited and will not be able to provide real relief to the congestion problem along the main CRC/HR/GR Corridor. Moreover, it is observed that the traffic condition in Wan Chai North during evening peak hours has worsened since early 2003, mainly due to congestion along GR eastbound that leads to redistribution of through traffic into the local roads in Wan Chai North such as Convention Avenue, Harbour Road and Hung Hing Road.

- The new road will only serve at a district level to alleviate congestion at a few critical junctions on CRC in Central in the short term. The traffic leaving Central heading east will still be stuck in Wan Chai. In order to solve the regional traffic problem, a bypass between Central and the Eastern District is pertinent.
- Other than the above mentioned inadequacies, the proposed link road will give rise to considerable public concerns including physical and operational impacts on Jardine House, Star Ferry, City Hall and the ex-UC Headquarters Building and pedestrian access to Star Ferry, Queen's Pier and the promenade to the north of Lung Wui Road. None of these would be easy to resolve.

2.3.19 In one of the Affirmations submitted by SPH, Professor William Francis Barron accuses the Government of not having considered the combined effect of implementing more than one traffic management measure at a time. Even if all these measures were implemented together, the minor benefits from each will not be able to provide notable relief to the congestion along the trunk road corridor or in the CBD because these measures will only have short term or local effects. The need for CWB and Road P2 network is unquestionable.

2.3.20 Professor Barron has also presumed that urban planning and transport planning are separated. This presumption is incorrect. The Government has all along taken a holistic approach in our planning work whereby transport planning, environmental and engineering considerations are all integrated into urban planning. Examples of such integrated planning studies completed include "Study on Harbour Reclamation and Urban Growth"; "Territorial Development Strategy"; "Territorial Development Strategy Review" and "Central and Wan Chai Reclamation Feasibility Study". Regarding the CWB and the Road P2 network, they form an integral part of the 5-phase Central and Wan Chai Reclamation which provides land for, amongst others, resolving the existing traffic congestion problem in Central and Wan Chai Districts as well as supporting the developments in the completed phases of the reclamation. The planning of the road works went through a rigorous and integrated planning and public consultation process.

2.3.21 In another of SPH's Affirmation, Mr Richard Francis Di Bona alleges that the net impact of constructing new roads may often be worsening congestion, rather than congestion relief. We would submit that this is contrary to the tested experience in Hong Kong. As evident from the construction of Island Eastern Corridor, the completion of the project in the 1980s has brought about substantial relief to the then seriously congested King's Road running inland in parallel along the eastern part of Hong Kong Island.

2.3.22 Mr Di Bona's comparison between the need for building the CWB and road building to facilitate continuing growth in road traffic is misleading. The CWB and P2 are not proposed to facilitate growth in road traffic. They are required to solve existing traffic congestion problem and the growing demand due to committed developments.

2.3.23 Mr Di Bona has also proposed the idea of imposing a peak hour levy on CHT. The imposition of peak hour levy would cause the spreading of the peak hour congestion to a wider range thus either prolonging or shifting the peak congestions to longer periods. It is important to note that the traffic volume of the CHT has been consistently high throughout the daytime and up to until at least 8pm. There is negligible or virtually no scope for redistributing the demand in the daytime traffic to the night. Such a proposal is similar in effect to raising the tolls of CHT.

2.3.24 Environmental consideration is one of the major objectives that should be given due regard in all new proposals including highway projects. In fact, the presence of serious traffic congestion would also cause an adverse effect on the environment by producing additional emissions and noise impacts during prolonged congestions. The CWB and related roads have been assessed by HyD and TDD in their feasibility assessments and comprehensive EIA studies have been undertaken which demonstrated that these projects are acceptable from the environmental point of view.

2.3.25 In Hong Kong, many transport infrastructure projects have provided the much-needed relief to the existing parallel corridors i.e. WHC in relieving CHT and Route 3 (Country Park Section) in relieving Tuen Mun Road. The Lantau Link provides the vital and sole road access to the Hong Kong International Airport. In the case of CWB and P2, apart from the traffic forecasts which confirm their need, the already serious congestions along the existing roads clearly demonstrate their need.

2.3.26 Mr Hardy Lok, authorized by SPH, alleges that the Government has not produced sufficient data and evidence to discard other options for the CWB, such as immersed tubes or partially immersed tubes, that may be superior in terms of reduction or elimination of reclamation. This is indeed not true. Both the immersed tubes and partially immersed tube options have been considered by the Government's consultants and found to be not feasible. The findings are summarized in the following.

2.3.26.1 *Immersed Tube Tunnel Option*

2.3.26.1.1 There are two potential options that could be considered in replacing the present cut and cover tunnel with an immersed tube tunnel. In the first option, the CWB is constructed as a conventional immersed tube tunnel. In this case there is in general no reclamation associated with the tunnel. The tunnel would run along the shoreline, off the existing seawall, embedded in the seabed (in much the same manner as the existing cross harbour tunnels). In the second option, the immersed tube tunnel is viewed as an alternative method of tunnel construction, to replace the cut-and-cover method of construction. Reclamation would still be formed over the CWB tunnel and other aspects of the project such as reprovisioning of cooling water facilities, ferry piers, ground level roads, etc, remain much as currently proposed.

2.3.26.1.2 In considering these immersed tube tunnel options, it has to be recognized that the current horizontal alignment of the CWB, i.e. along the Central and Wan Chai shoreline (passing through the water channel between the Hong Kong Convention and Exhibition Centre (HKCEC) and its Extension) and rising up to the Island Eastern Corridor Link (IECL) through the eastern portal located at the Wan Chai Public Cargo Working Area (PCWA) basin, is a major constraint. As explained in paragraph 2.3.8 above, no alternative horizontal alignment options exist.

2.3.26.2 *Immersed Tube Tunnel Constraints*

2.3.26.2.1 There are a number of physical and engineering constraints which make immersed tube tunnel construction impractical or even not possible.

2.3.26.2.2 At the western end of the CWB, a 250m section of the tunnel at the western portal cannot be constructed as an immersed tube tunnel, where the precast tunnel units are floated into place, since the tunnel straddles the existing seawall. If an immersed tube tunnel technique is to be adopted, it would be necessary to remove the seawall to below the depth of the tunnel, and the land behind would need to be retained. It would not be practical to support a 20m deep excavation without lateral support. In order to retain the land behind the excavation, large diameter contiguous bored piles will need to be installed with ground anchors. Construction within a temporary cofferdam would also require support of a 20m deep excavation with anchors. A practical approach would be to carry out a cut-and-cover tunnel construction after reclaiming this area. Some reclamation in this area would be required in any event for the ventilation building at the portal and for the initial section of the approach tunnels to the western portal. Therefore, immersed tube tunnel method could not be implemented for the first 250m section of the CWB at the western portal.

2.3.26.2.3 The HKCEC water channel also presents a physical constraint to immersed tube tunnel construction. It would not be feasible to float in the precast tunnel units within this strip of water since a deep excavation with adequate lateral support cannot be achieved at the seawalls of the HKCEC and its Extension. Ground anchors are not an option due to the proximity of the existing buildings and their foundations. Struts cannot be used since they will interfere with the floating in of the immersed tube units. Also it would be extremely difficult to manoeuvre the tunnel units into this tight space. The access bridges to the HKCEC Extension would need to be demolished before replacement access can be provided over the CWB tunnel. Hence the CWB tunnel will need to be cast-in-place within a cofferdam or built as a cut-and-cover tunnel from reclaimed ground. As the cofferdam will require extra cost and time to build, the most practical engineering solution would be to construct the tunnel as a cut-and-cover tunnel after reclaiming the water body between the two seawalls of the Convention Centres. This would have the minimum impact on the foundations of the two buildings and traffic access can be maintained at all times to the HKCEC Extension.

2.3.26.2.4 Supporting the argument for cut-and-cover construction at the HKCEC is the presence of two slip roads for entry to and exit from the tunnel between the Convention Centre buildings. These cannot be constructed without prior reclamation. Some reclamation will also be required to the west of the HKCEC Extension to accommodate the slip road from the east-bound CWB tunnel leading traffic on to Expo Drive at the HKCEC Extension.

2.3.26.2.5 The MTR Tsuen Wan Line crossing, to the west of the HKCEC, is another constraint to immersed tube tunnel construction. The CWB tunnel will pass over the existing MTR Tsuen Wan Line, which is an immersed tube tunnel. The CWB tunnel must not impose any loads on, or cause any significant movement of the existing immersed tube tunnel. The proposed scheme for this tunnel crossing, developed and agreed in consultation with MTRC, involves construction of a row of bored piles along either side of the Tsuen Wan Line tunnel with precast tunnel sections supported by these piles for the CWB tunnel which spans over the MTR tunnel. The CWB tunnel would rise out of the seabed at this crossing point.

2.3.26.2.6 The foundation of the CWB tunnel causes further constraint to immersed tube tunnel construction. Conventionally, an immersed tube tunnel would be founded on a firm soil stratum with the soft marine sediments dredged away to form a trench in which a foundation base is prepared for the tunnel units. The CWB tunnel level varies around -10mPD. However, the alluvial clay layers along the alignment of the CWB are found at levels down to around -20mPD. Typically, the thickness of the material to be dredged would therefore be around 10m, with the trench then backfilled with suitable foundation material. As an associated issue, dredging of an immersed tube tunnel trench to -20mPD alongside the existing gravity structure seawalls, the bases of which are at around -5mPD, would undermine the seawalls.

2.3.26.2.7 It would be feasible to found the tunnel units on underwater piles (though their construction would be difficult) instead. This solution would avoid the need for excessive dredging for foundations and the adjacent seawalls would not be adversely affected. Piled foundations would also solve the problem of differential settlement at the interfaces with the sections of the tunnel that must be piled in any event, e.g. the MTR Tsuen Wan Line crossing and the cut-and-cover section through the HKCEC water channel. In overcoming the foundation constraints, therefore, immersed tube tunnel construction would require piled foundations.

2.3.26.2.8 In view of the above constraints, consideration of the immersed tube tunnel options (with and without reclamation) must assume cut-and-cover tunnel through the HKCEC water channel and for the last 250m length at the western tunnel portal, with reclamation required at the western tunnel portal area, in the HKCEC water channel and to the west of the HKCEC Extension (up to the MTR Tsuen Wan Line crossing). Immersed tube tunnels over the remaining lengths of the CWB would be piled.

2.3.26.3 *Immersed Tube Tunnel without Reclamation*

2.3.26.3.1 Constructing the CWB as an immersed tube tunnel, without reclamation over the top of it, will result in problems associated mainly with the fact that the tunnel structure will be above seabed level (it is assumed that this is what Mr. Lok refers to as "partially submerged tubes"). The top of the tunnel structure will be at levels ranging from -2.5mPD to +2.9mPD (over the

MTR Tsuen Wan Line). Over most of the tunnel length, the top of the tunnel will, therefore, lie immediately below the water surface or even completely above water level. A number of issues arise from this situation.

2.3.26.3.2 The tunnel structure itself would be an eyesore, especially with debris being deposited on the roof, creating an unsightly waterfront. The tunnel would be visible through the water and, of course, there are sections where it rises above water level.

2.3.26.3.3 The concrete of the tunnel structure will be exposed to an extremely aggressive marine environment, in particular where the tunnel lies in the intertidal zone, and prevention of rapid deterioration of the concrete structure will be of great concern. In addition, the tunnel will be exposed to wave action, and protective measures will be required.

2.3.26.3.4 The tunnel structure would also need to be protected against ship impact. A physical barrier would need to be constructed along the seaward side of the tunnel to prevent entry of all marine traffic; in effect, a breakwater or a seawall abutting the seaward side of the tunnel, stretching along the entire length of the waterfront. This breakwater would cause negative visual impacts, significantly affecting the aesthetics of the Harbour at an important location such as next to the HKCEC. Access to the shoreline by marine craft would not be possible, including ferries to the Wan Chai ferry pier and the Star Ferry piers and the crafts using Queen's Pier.

2.3.26.3.5 In view of these constraints and adverse impacts, the option of constructing the CWB as an immersed tube tunnel, without reclamation over the top of it, is not considered feasible.

2.3.26.4 *Immersed Tube Tunnel with Reclamation*

2.3.26.4.1 It would be technically feasible to reclaim over the immersed tube tunnels, after the tunnel units have been placed in position, assuming the tunnels are piled. Unlike the case above, the tunnel will then be adequately protected, affected shoreline facilities (ferry piers, etc) can be reprovisioned, the necessary ground level roads can be built and the shoreline can be improved in line with the original planning intentions of this project.

2.3.26.4.2 The arguments against this form of construction are principally those relating to greater construction complexity, cost and, not least, practicality.

2.3.26.4.3 A staged construction (similar to that currently proposed for the implementation of the project) will be required, even for the immersed tube tunnel option. Advance reclamation areas are needed for reprovisioning of affected facilities, such as the Wan Chai ferry pier, the Star Ferry pier and Queen's Pier, before the existing facility can be taken out of service to facilitate the construction of the CWB tunnel and reclamation. This means that it will not be possible to construct the immersed tube tunnel by placing the tunnel units in sequence from one end to the other. Instead, the sequence in which immersed tunnel units are floated in and placed in position will have to follow the sequence of the reclamation staging. This staggered construction sequence, as well as the fact that the immersed tube tunnel sections need to be connected to cut-and-cover tunnel sections at several locations along the overall length of the CWB tunnel, will result in a large number of in-site construction joints between tunnel units. The construction of these joints requires underwater construction works and these are one of the most difficult aspects of immersed tube construction.

2.3.26.4.4 The tunnel units would be founded on submerged piles. This would also involve complex construction, especially since underwater construction techniques would be involved, particularly for the connections of the tunnel units to the piles. Cost would be a major factor to be considered; the cost of the CWB tunnel construction would increase by some 50% as a result of the piled foundations.

2.3.26.4.5 From a practical point of view, the use of immersed tube tunnel construction in between sections of cut-and-cover tunnel construction, will result in a piecemeal approach to construction.

2.3.26.4.6 Taking into account practical aspects as well as the greater construction difficulties and the substantially increased costs, the option of constructing the CWB as an immersed tube tunnel, with reclamation over the top of it, is not considered feasible.

2.3.26.4.7 Instead, the most sensible, practical and cost effective approach will be to construct the CWB as a cut-and-cover tunnel over the entire length, after carrying out the least amount of reclamation, which would enable and facilitate the construction of the tunnel and all other project works with the least amount of difficulty and disruption.

2.3.27 On the CWB, the Hong Kong Institute of Architects has the following views. "HKIA accepts that the most reasonable, practical, environmental sensitive and optimal solution to resolve the predictable traffic congestion problem in the Central and Wan Chai areas is to construct the CWB within CRIII area in the form of a tunnel through CRIII reclamation to the minimum extent. We do not see any acceptable alternative but to conform to this criteria" **[Enclosure 2.12]**.

2.3.28 The Real Estate Developers Association of Hong Kong (REDA) "acknowledges the need for a 3+3 lane Central/Wan Chai bypass and acknowledges that reclamation is needed to construct and protect this submerged road" **[Enclosure 2.13]**.

2.3.29 *Conclusion*

2.3.29.1 Based on the above re-examination, the CWB within the CRIII goes far beyond “something which is just nice to have, desirable, preferable or beneficial”. Given its many social and economic justifications supported by cogent and convincing materials and the broad community support as revealed in the comprehensive statutory consultation process, the CWB certainly satisfies the “overriding public need test”. In order to build the CWB, land must be reclaimed, and there is no reasonable alternative to reclamation. The Government has considered a whole package of traffic management measures. The Government has adopted and will adopt <u>both</u> demand side traffic management <u>and</u> supply side traffic management measures in resolving traffic congestion problems. Even with the practicable demand side traffic management measures in place, there is still a compelling and present need to provide the CWB.

2.3.29.2 The Government has been active in pursuing other traffic management alternatives to provide relief in the short term. In the long term, CWB offers the only viable solution. Traffic management measures will complement CWB but cannot replace it. There are no reasonable alternatives to CWB.

2.4 Road P2 network

2.4.1 While the limits of the reclamation under CRIII are determined by alignment of the CWB, the timing of CRIII is dictated by two other important pieces of transport infrastructure, namely the Road P2 Network which is needed by 2006 to relieve growing traffic demand within Central and the AREOT which is needed to ensure safe operation of the Airport Express Line and the Tung Chung Line.

2.4.2 The Road P2 Network consists of surface roads to be built on land formed for the CWB. With the exception of areas between the existing shoreline and the CWB alignment which have to be reclaimed anyway for environmental reasons as they are no longer connected with the Harbour, these surface roads will be built on land so formed and will not push the reclamation extent further into the Harbour. This road network will provide much needed relief to the existing roads.

2.4.3 At present, traffic generated from the completed Central Reclamation area north of Exchange Square (CRI) has to route through some already congested roads and junctions in Central such as Man Po Street, Man Yiu Street and Man Cheung Street/Man Yiu Street junction. Traffic along the Connaught Place east-bound outlet has to wait for several traffic light cycles before it can join CRC. There is high potential of a gridlock in the CRI area as traffic is unable to exit onto CRC, seriously affecting the operation of the Exchange Square, Airport Railway Station, One and Two International Finance Centre, the hotel development, the ferry piers and other commercial developments in the same area. The gridlock will in turn cause traffic to pile up along routes carrying incoming traffic to CRI including CRC, Pedder Street and Queen's Road Central.

2.4.4 The forecast transport need will arise within a definite and more imminent time frame – by 2006 upon full occupation of the IFC II and commissioning of the new hotel on CRI. According to findings of the Strategic Traffic Review for the Business District completed by TD in 2003, by the year 2006, traffic along this main east-bound outlet is forecast to double its current volume.[7] Critical junctions in the CBD, such as CRC/Connaught Place, CRC/Pedder Street, Connaught Place/Harbour View Street and Man Yiu Street/Man Cheung Street will be seriously overloaded. Without the Road P2 Network, traffic will queue up to about 850 meters along the full carriageway width of Connaught Place/Man Yiu

[7] The estimate was based on the results of the Strategic Traffic Review Study traffic model run which showed that traffic along Connaught Place will increase from about 700 vehicles per hour in 2002 to about 1,400 vehicles per hour in 2006 during the morning peak period.

Street/Man Cheung Street around the Airport Railway Station and International Finance Centre throughout the day. If tourists and travelers using the Airport Express Line from and to the Airport were caught in this traffic jam, the appeal of the Airport Railway would be reduced. Traffic congestion in the vicinity will also adversely affect thousands of island residents using the ferry piers daily for commuting to and from work. TD has estimated that if the Road P2 Network was not built by 2007, each day some 26,000 road users would have to tolerate a 20-minute delay at the junction of Connaught Place and CRC, incurring an economic cost of $156 million annually.[8] Dr Cheng Hon-kwan, Chairman of Transport Advisory Committee, agreed that the Road P2 network is urgently needed to resolve the traffic congestion problem in Central and Wan Chai **[Enclosure 2.4]**. Mr Koo Yuk Chan has also pointed out that a delay in the construction of the Road P2 network "will adversely affect the operation of the Airport Railway Station, the IFC and the facilities in the CRI area, resulting in considerable economic loss and public inconvenience" **[Enclosure 2.9]**. To Professor C O Tong, the Road P2 network, together with the CWB, is needed to ensure the provision of a functional and balanced road network. There is no reasonable alternative but to build the planned roads in order to increase the capacity of the existing crowded road network". Professor Tong has given his support for the building of the CWB and Road P2 network **[Enclosure 2.7]**.

2.4.5 There are ***no reasonable alternatives*** to the Road P2 Network. Restricting traffic into the area will result in considerable economic loss and adversely affect the operation of the Airport Railway Station, the IFC, the ferry piers, etc. Various traffic management measures in lieu of building the Road P2 Network have been

[8] The economic cost refers to the cost to road users due to additional traveling time. In deriving the cost, TD has taken into account the delay in time that road users will suffer from congestion in the CRI area, namely along Connaught Place, Man Yiu Street and Man Cheung Street, for not having the CWB and Road P2 in place by 2011. The daily congestion period is expected to span over 12 hours and 25,920 road users will be affected with average additional 20 minutes spent in the traffic congestion. This comes to about 2.6 million man-hour per year, or approximately $156 million per year.

considered. These include restricting loading/unloading times in Central, reducing bus trips in Central, implementation of ERP, etc. Many of these measures are controversial. Even with all the traffic management measures, traffic in CRI will be paralyzed by 2011 if Road P2 network is not built, because continuous traffic queues will be found along CRC (without CWB), and vehicles from Connaught Place will not be able to exit onto CRC even when the traffic lights are in their favour.

2.4.6 TD has explored practical traffic management measures such as road and junction improvement schemes and bus rationalization measures. These measures can however only maximize the capacity of the existing road network and ease existing congestion, but are not capable of addressing the further growth in traffic flows in the CBD.

2.4.7 To conclude, there is an overriding public need for the Road P2 Network. This need will arise within a more imminent time frame, by 2006. There are no reasonable alternatives as restricting traffic into the area will result in considerable economic loss and adversely affect the operation of the Airport Railway Station, the IFC, the ferry piers, etc. The traffic condition in the area will continue to deteriorate before completion of the Road P2 Network.

2.5 Airport Railway Extended Overrun Tunnel

2.5.1 During the feasibility study and design stages of the Airport Railway (AR), it was identified that an overrun tunnel was required east of Hong Kong Station (requiring demolition of the Star Ferry piers) to ensure trains failing to stop at the design position do not collide with the tunnel end (the safety requirement) and to allow trains to be turned back on the east side of the station without hindering trains approaching from the west, thereby enabling the AR to operate to its design capacity and allow the use of separate platforms for Airport Express Line (AEL) arrivals and departures (the full design capacity requirement). Due to phasing problems with the Central Reclamation, the Government and the MTRCL have agreed during negotiations on the AR project in 1991 that the overrun tunnel will be constructed in two stages. Under stage one, a short overrun tunnel of approximately 84m was completed and put into operation when the AR opened in mid-1998. The overrun tunnel was to be extended to its full extent for both safety and design capacity requirements under the scheduled CRIII works.

2.5.2 For safety reasons, an overrun tunnel of sufficient length is required at all terminal stations to ensure trains failing to stop at the design position, as a result of human error or defective equipment, would not collide with the tunnel end. These train overruns occur infrequently and pose no safety risk provided adequate overrun tunnel is available. As it is not possible to eliminate overruns, overrun tunnel is a compelling need. Mr R J Black, Project Director of MTRCL, has pointed out that "the provision of an adequate length of overrun tunnel is a safety issue". As far as the extended portion to meet safety requirement is concerned, approximately another 40m is needed as early as possible as the existing short overrun tunnel of 84m is only marginally tolerable. Annual reports on risks assessment submitted by the MTRCL to the Hong Kong Railway Inspectorate confirm the urgent need for the extended overrun tunnel. According to Mr Black, "the current overrun tunnel arrangement will only remain acceptable until 2006 based on recent trends in railway patronage growth". He concludes that "MTRCL's firmly held view is that the overrun tunnel extension is required as soon as practically possible" **[Enclosure 2.14]**.[9]

[9] The line capacity of the AR can be enhanced by having longer trains (maximum 8-car for TCL and 10-car for AEL) running at shorter headways (shortest at 2.25 minutes for TCL and 4.5 minutes for AEL) to meet the increase in demand. Alternatively, the safety of the AR can be improved by an appropriate signaling system imposing speed restriction and having shorter trains (currently at 8-car trains for TCL and 7-car trains for AEL) at longer headways (currently at 5 minutes for TCL and 10 minutes for AEL). Capacity and safety are therefore conflicting attributes. While safety must not be compromised, without the 40m overrun tunnel to be constructed as early as possible within CRIII, MTRC will have to sacrifice capacity for safety. Bearing in mind the anticipated demand for the AEL and TCLs' capacities will increase, and the

2.5.3 As regards the further extended portion (approximately another 460m) to meet the full design capacity requirement,[10] although a review by the MTRCL in 2002 based on the latest projections for growth in demand indicates that the AEL and TCL will only be required to operate at their full design capacity by 2014 the earliest, the necessary railway route protection measures have to be incorporated in the CRIII project.

2.5.4 The AREOT will accommodate two scissor-type crossovers and stabling facilities for both the AEL and TCL. The full overrun tunnel for the TCL will also give opportunities for extensions into the eastern part of Hong Kong Island as part of the NIL proposed by RDS-2000.

2.5.5 Current alignment of the AREOT has no reasonable alternative in engineering terms. Like the CWB, its alignment is constrained by existing control points. At the western end, the extended overrun tunnel has to link up with the existing 84m overrun tunnel. At the other end, the extended overrun tunnel has to join up with the protected route for the NIL which is in turn constrained by the water channel of the Hong Kong Convention and Exhibition Centre. The purpose of overrun tunnel is to provide additional braking distance beyond the station platform in case trains overshoot. Relatively straight tracks are highly desirable for overrun tunnels. The

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fact that the planning and building of the overrun tunnel will take several years, this work should commence at the earliest opportunity. Otherwise, MTRCL will not be able to meet the increasing passenger demand on those two lines.

[10] In order to operate AEL and TCL to full design capacity, the existing crossovers west of Hong Kong Station have to be removed and re-provisioned east of Hong Kong Station and an overrun tunnel of sufficient length (approximately 500m) for trains to reverse is required. This modification will bring about four features. Firstly, it provides approaching trains with a clear path free of trains leaving the TCL platform. Secondly, it enables MTRCL to lift the speed restrictions on approaching trains due to enhanced geometry/track arrangement. Thirdly, maximum 10-car AEL trains can be operated. Fourthly, approaching AEL trains does not have to wait until the single platform is cleared.

extended overrun tunnel alignment is already tucked as close to the existing shoreline as possible.

2.5.6 To conclude, it is clear that the existing short overrun tunnel east of Hong Kong Station was a compromise solution to reclamation phasing problems and is not adequate to meet safety and operational requirements at improved service levels. Reclamation to provide the AREOT can satisfy the overriding public need test and that need is an integral part of the Airport Railway at the time when the project was conceived. An extended overrun tunnel to meet safety requirement is very much a current need and its non-availability could not be tolerated for long. There is no reasonable alternative and the extent of reclamation is the minimum that is required based on an acceptable alignment.

2.6 Cooling water pumping stations (CWPS)

2.6.1 The limits of the CRIII reclamation, as illustrated in cross section diagrams in the November 2003 Review Report and the CRIII Booklet, are determined by the CWB alignment, the essential facilities along the existing shoreline that need to be reprovisioned to the future waterfront and the new seawall. There is a present and compelling need for these facilities and reprovisioning them elsewhere so as to avoid or reduce reclamation within the CRIII is not an acceptable alternative as explained below..

2.6.2 The CWPSs affected by reclamation for the CWB are serving a large number of important buildings in Central and Queensway, including the LegCo Building, City Hall, HSBC Main Building, Central Government Offices, Murray Building, Queensway Government Offices, High Court, Police Headquarters, Pacific Place, Prince's Building Group[11], Admiralty Centre, etc. All these buildings are

[11] The Prince's Building Group is made up of Chater House, Prince's Building, Alexandra House, Standard Chartered Bank Building, Nine Queen's Road Central, Gloucester Tower, Edinburgh Tower and the Landmark.

designed for seawater cooling system only. These CWPSs have to be reprovisioned to initial areas of reclamation before the existing ones could be rendered inoperative by reclamation to ensure continued operation of the buildings as shown in **Appendix 2.5**. The owners of these buildings strongly opined that even a short duration of disruption in serviceability of their buildings is unacceptable, from the economic and social angles. We have considered other systems of providing cooling to the buildings which may avoid or reduce the extent of reclamation in consultation with the affected owners and conclude that there is ***no reasonable alternative*** taking account of all relevant circumstances.

2.6.3 Switching to *fresh water cooling towers* from the existing seawater systems serving the buildings affected by the CRIII project is technically problematic. Professor Andrew Leung pointed out that "to switch to fresh water cooling towers, extra floor space and structural loads in the affected buildings are required **[Enclosure 2.11]**. Moreover, as the fresh water cooling towers are less energy-efficient than sea water systems, additional plants may need to be installed to provide the same amount of cooling. The additional floor space for plants and equipment may not be available in the affected buildings. Certain major components of the existing seawater cooling systems would need to be replaced to suit the new fresh water cooling tower systems. With these technical constraints, the alternative of using fresh water for water-cooled air-conditioning in the affected buildings is considered not feasible. Mr Albert Cheng Wai-shing, a chartered engineer from Black & Veatch Hong Kong Limited, remarks that "the continued adoption of seawater cooling is a logical technical solution for the end users as there will be minimum interruption to the formal operation of existing pumping stations during the reprovisioning works **[Enclosure 2.15]**.

2.6.4 An *air-cooled system* option is not viable as it requires additional floor space in the buildings to install the air-cooled plants as well as additional switch rooms to cater for the greater electricity demand. Loading constraints in existing buildings are difficult if not impossible to overcome. Air-cooled system is also less energy efficient than water-cooled systems.

2.6.5 The option of *individual evaporative cooling towers* requires additional floor space in the buildings to install the evaporative cooling tower. Similar to air-cooled systems, loading constraints are very difficult to overcome. Also, it would require the supply of mains fresh water which subject to further study may not be catered for by the present water supply network in the district. Again, this option is less energy efficient than sea water-cooled systems.

2.6.6 The option of *district cooling system* requires a centralized sea water pumping station as well as a District Cooling Plant site. Although the footprint of the sea water pumping station will be smaller, the Government will need to identify additional land to accommodate the District Cooling Plant. A service provider is also required to operate the plant for serving all buildings connected to the plant and that will require a redesign of the pipe route and a tender for the service provider, not to say the need to resolve the legal, land and institutional issues.

2.6.7 The option of *centralized sea water system* requires a centralized sea water pumping station which will have a smaller footprint than the District Cooling System. Similar to the District Cooling System, this option requires a service provider to operate the plant for serving all buildings connected to the plant and that will also require a redesign of the pipe route and a tender for the service provider. There are the same legal, land and institutional issues to be resolved. Furthermore, the development of a centralized cooling water system is very complicated. A large number of varying equipment is available in the market but each owner has his own favourite. Complex issues on apportionment of installation and operation costs, future operational requirements and peak demand of individual building owners, maintenance liabilities, equipment backup, property right and so on are difficult to reach a compromise. A much longer time in negotiations, with possible Government intervention, is necessary for the centralized system to materialize. The continual running of the system to the satisfaction of all owners is also problematic. Any centralized system will resemble a mini-public utility service that would preferably require a designated company and a proper legal framework. To achieve a satisfactory outcome on all these complex issues in the CRIII project given the time constraints is simply unrealistic.

2.6.8 Some comments and suggested alternatives on the CWPS and the associated issue of seawall design have come to our attention and they can be categorized into the following groups –

- Size of the CWPS
- Number of the pump-cells
- Location of the CWPS
- Seawall foundation options / seawall structure position / other seawall design options
- Lagoons and reservoirs
- Alternative cooling systems
- Other general comments

TDD's response in respect of these suggestions is set out below.[12]

2.6.8.1 *Size of the CWPS*

2.6.8.1.1 The current size of the pumping stations are designed to take into account affected owners' requests to provide a safe working environment for future maintenance and routine cleaning and aims to overcome complaints about disturbance by members of the public as evidenced in the pumping stations constructed within CRI. On this aspect, TDD points out that "under the design of the CRIII pumping stations, closing off

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[12] TDD's response to the "alternatives" put forth has been formulated with expert input from Atkins China, Maunsell Consultants Asia Limited, and Black & Veatch Hong Kong Limited. Maunsell is at present TDD's consultant for the WDII Design and Construction Consultancy. The firm is therefore the expert in commenting on the difference between the sizes of the WDII and CRIII pumping stations and the impracticability of constructing the CWB in the form of an immersed tube tunnel in such a capacity.

part of the public promenade to gain access to the pumping station is not necessary".

2.6.8.1.2 Mr Robert Chu Ka Yun, a retired Mechanical Engineer providing views in one of SPH's Affirmations, alleges that the proposed promenade of 60m in width is justified on the basis of providing some 26 pump-cells. According to him, the Government did not explain what efforts, if any, had been made to reduce the size and number of the pump-cells or the extent of this "massive" reclamation.

2.6.8.1.3 The size of the pump cells are determined from the technical requirements of the respective pump house owners and by the shortcomings in pump cell size and arrangements experienced from CRI. The size of the CWPS in CRI has been heavily criticized. Swire Properties Ltd. representing also other private enterprises, had submitted an enhancement proposal to the CWPS. They complained about the operational difficulties and maintenance drawbacks inside the small pump house compartment in CRI and highlighted the obstruction and nuisance to the public resulting from the frequent cleaning and maintenance of pumping equipment on the promenade which is a place for enjoyment by the public at large. In the current CRIII case, the CWPS which is larger than that in CRI, has been designed to overcome the shortcomings in the CRI experience and is based on practical and safety requirements necessary for routine maintenance and cleaning to be carried out inside the pump house compartment. The present design would hence provide a safe working environment to the maintenance personnel and will eliminate inconvenience to the public. The 5m wide base heel at the base of the CWPS is required to attain sufficient soil dead load to achieve the adequate factors of safety against flotation, sliding and overturning. The current size of the CWPS is therefore essential. Furthermore in CRIII, the enlarged pump house has been delicately designed to blend in with the two-level promenade. Steps are included to connect the two levels so that people can enjoy the harbour without the disturbance due to the existence of CWPS.

2.6.8.1.4 Moreover, the arrangement of the CWPS is determined by the relationship of the distance between CWPS and CWB. The rubble mound foundation of the CWPS will have to be set at a distance of about 2m from the CWB tunnel Diaphragm wall (D wall). If the rubble mound is in contact with the D wall, the following problems will likely occur –

- overbreak in the D wall construction;
- leaking of bentonite slurry through the rubble layer of the foundation (as the particle size of the rubble is large) and contaminating the underground water and the harbour;
- collapse of the D wall trench due to undermining or decrease of stability;
- increase in construction cost; and
- increase in construction time.

2.6.8.1.5 Mr Robert Chu has further suggested that the reclamation extent can be reduced by reducing the size and number of pumping stations as per those adopted in the proposed WDII. TDD however pointed out that the rationale for the arrangement and size of WDII's CWPS preliminary design is different from that of CRIII which had undergone a detailed design stage. It is thus premature to argue on the basis of those preliminary designs in WDII that reasonable alternatives exist for CWPSs under CRIII. In practice, the actual arrangement and size of CWPSs in WDII could only be ascertained at the detailed design stage of WDII taking account of the reprovisioning needs and construction sequencing of the reclamation and the CWB tunnel, in order to ensure that the operation of these cooling systems is maintained at all times during construction. Nonetheless, the claim that the design of CWPS in WDII could be adopted for CRIII in order to minimize the amount of reclamation is refuted below.

2.6.8.1.6 As shown in Drawing No. SK66 **[Appendix 2.6]**, the pumping station under WDII is integrated with the wave energy absorbing seawall for more efficient construction and to minimize the extent of reclamation required for its installation. The cooling water intake feeds into a wet well immediately behind the seawall. Seawater is then drawn into the pumping system which is located in a dry well, behind which is a service chamber. The overall dimension of the pumping station is 20.4m, comprising 3.5m for the seawall and intake structure, and 16.9m for the pumping chamber. The pumping station is designed to be below the promenade level, with maintenance access provided from above through access covers. A 5m wide utility zone is allowed behind the pumping station.

2.6.8.1.7 The dimensions of the pumping chamber have been designed in a manner such that sufficient room will be available to accommodate all the necessary pumps, valves, fittings, etc, on the basis of the existing pumping system that will be reprovided. Operational and maintenance provision is similar to the existing cooling water system, and appropriate to the scale of the pumping station facilities.

2.6.8.1.8 The pumping stations proposed under the CRIII project are also located immediately behind the new seawalls, with similar rationale in respect of minimizing the extent of reclamation as the WDII proposal. Dimensions of the CRIII pumping station do differ slightly from those of the WDII pumping station. The seawall and intake structure is approximately 10m wide, mainly due to the pumping chamber being set back further from the edge of the seawall to cater for different access needs than those in WDII. The pumping chamber itself (wet wells, dry well and service chamber) is approximately 20m wide; a cross-over well is incorporated in the CRIII design, which accounts for the approximate 3m difference in dimension from that of the WDII pumping chamber. Other than the cross-over well, pumping chamber dimensions are quite similar between the WDII and CRIII designs, with the overall dimensions of the main elements almost identical. Differences are mainly in respect of the detailed arrangements of the pumping facilities.

2.6.8.1.9 The incorporation of a cross-over well in the CRIII design arises out of the requirements of the operators of the affected buildings in Central, and is mainly a function of the more onerous maintenance requirements and constraints of the cooling facilities in CRIII than those of the Wan Chai pumping station. In the Wan Chai Development Phase II Comprehensive Feasibility Study (WDIICFS), no requirement for a cross-over well was raised by the building operators, nor was an essential need for one identified in the study. In addition, no specific requirements for access arrangements were raised by the operators in the WDIICFS, nor was any special need for access other than that which is conventionally provided and identified in the study.

2.6.8.1.10 The remaining difference in dimensions between the two pumping station designs is a 5m wide 'heel' at the base of the CRIII pumping station, which performs a structural function in resisting flotation, sliding and overturning. The WDII pumping station is not as deep as the CRIII pumping station, and the preliminary design undertaken in the WDIICFS indicates that this 'heel' is not required. Nevertheless, the 5m wide utility zone behind the WDII pumping station provides flexibility to accommodate the foundation requirements of the pumping station that may arise during the detailed design of the structure in the later detailed design stage.

2.6.8.1.11 In sum, the differences in dimensions between the WDII and CRIII pumping stations lie essentially in the greater set back of the CRIII pumping chamber from the edge of the seawall and the incorporation of a 3m wide cross-over well in the CRIII design. Both of these differences arise from the need to take into account building operators' specified operational and maintenance requirements and the much larger scale of the cooling facilities in CRIII, which requires a design tailored to meet site specific constraints. Discounting these factors, the dimensional differences between the CRIII and WDII pumping stations are not substantial.

2.6.8.1.12 Another major difference between the CRIII and WDII cases is the scale of the cooling water supply systems. In Wan Chai, for example, the design is based on a two cell pumping chamber which will supply the Sun Hung Kai Centre with cooling water through 450dia intake pipelines, while in CRIII, Pacific Place for example will be supplied by a four cell pumping station (which has an operational capacity of 3,000 litres per second) through a 1200dia pipeline. Furthermore, the pumping stations in CRIII for different owners are grouped together to ensure the maintenance and operation activities are confined to as small an area as possible. This grouping of pumping stations further increases the scale and complexity of the pumping station facilities and their operational and maintenance activities. This difference in scale of the pumping station facilities leads to special requirements in CRIII, in particular for access to the pumping stations. In CRIII, to facilitate the much higher level of usage by the operators' personnel and so as not to cause unnecessary obstruction to the public, a side door entrance is provided off a widened promenade area. Closing off part of the public promenade to gain access to the pumping station is not necessary in this case. In WDII, the smaller scale of the pumping facilities and fewer number of building operators using the pumping station means that a more conventional below ground structure, with access from above, can be implemented without undue disruption to the public or inconvenience to the operator. The site specific requirements that determine the design of these CWPSs are illustrated in another case. The pumping station in Causeway Bay is slightly larger than that at the Wan Chai shoreline, as it is located in a specially widened promenade area and accessibility has not been identified as cause for concern. There are good reasons for differences in the design of the cooling water pumping stations for WDII and CRIII.

2.6.8.1.13 The use of the WDII pumping station design in CRIII is not appropriate. Each project must incorporate designs specific to its own needs and constraints. In this respect, both the CRIII and WDII designs are fit for purpose within their separate contexts. The replacement of one design by the other would result in a product which is not fit for purpose and would not meet the end users' needs.

2.6.8.1.14 To conclude, the CRIII pumping stations are designed in a way such that a balance is struck between the need to limit the floor plan area and make adequate provision for operation and maintenance requirements. The interests of the private and public sector end users in grouping, maintenance access and safety issues have been considered and reflected in the general arrangement of the design.

2.6.8.1.15 Assuming that the locations of the new CWPS are acceptable to the various landlords/users, Mr Hardy Lok on behalf of SPH argues that the present foundation design for the CWPS should be re-examined and scrutinized. According to Mr Lok, the CRIII review completed in November 2003 by TDD has acknowledged that the adoption of driven pile, bored pile or mat foundation methods can at least reduce approximately 6m of reclamation extent. On this, TDD has the following response.

2.6.8.1.16 The extent of the rubble mound foundation is only one of the factors governing the distance between the CWPS and the CWB tunnel. The critical factor is the space required to accommodate the supply pipelines from the CWPS. Using piled foundation or mat foundation for the CWPS cannot reduce the overall width if the space required for the cooling water pipelines and their thrust block cannot be reduced. The proposed distance between the pipelines and the tunnel wall construction is already less than 5m, which is considered minimal. Any reduction of this distance will significantly increase the risk of ground movements and damage to the pipes, which would be unacceptable.

2.6.8.1.17 If a piled foundation was employed, it would involve significant construction challenges and risks as it requires a significant amount of working in deep water. Deep foundations would also have a major adverse impact on the overall reprovisioning costs. Professor Andrew Leung pointed out that "employing techniques such as driven pile, bored pile and mat foundations would result in negligible saving in reclamation (about 1%) and such saving can only be achieved at longer construction time, at more than ten times of the initial construction cost and at many times more of the life long maintenance cost when compared to the proposed design **[Enclosure 2.11]**. The current rockfill foundation design is a reasonable and most cost effective solution.

2.6.8.2 *Number of the pump-cells*

2.6.8.2.1 Mr Robert Chu on behalf of SPH also alleges that among the 29 pump-cells along the new waterfront, only 17 pump cells are required to serve the existing buildings and 12 are needed for new developments. He suggests that the former restriction in the use of fresh water for cooling systems imposed by the Government has in the past few years been lifted and sea water cooling is no longer needed for new buildings. Therefore a maximum of only 17 pump cells will be needed and even these can be further reduced.

2.6.8.2.2. According to TDD, the numbers of pumping stations and layouts of the current arrangement were determined from years of extensive consultations with the relevant Government departments and respective private owners during the design phase. The Government has examined other alternatives than the seawater cooling to the existing buildings and considers that such alternatives are not reasonable. Moreover, the area within CRIII project is not within the Pilot Scheme area for fresh water cooling. The provision of pumping station for the future developments in the area alongside the reprovisioned CWPS is a compelling and present need.

2.6.8.2.3 In regard to the reduction of the number of pump cells, the number of pumping stations was reduced wherever possible, for example, the opportunity was taken to delete the pumping station belonging to the Furama Hotel when its site was redeveloped. Also, the Government pumping stations were combined wherever possible to reduce the overall numbers, for instance, the pumping stations for LegCo Building, City Hall, Central Government Offices, Murray Building, Queensway Government Offices, High Court, Police Headquarters are grouped together to form a new pumping station.

2.6.8.2.4 Furthermore, TDD has pointed out that additional pumping station cells at the new pumping stations at the Wan Chai shoreline and in the Causeway Bay typhoon shelter are also provided for new development sites which may require their own cooling water supply.

2.6.8.3 *Location of the CWPS*

2.6.8.3.1 Some commentators have suggested the option of relocating the pumping stations elsewhere in order to avoid reclamation and introducing suction culverts around the CWB. Mr Albert Cheng Wai-shing, a Chartered Engineer, however, points out that such an option will impose hydraulic constraints in the long supply culvert and deep chamber downstream to the penstock, which will subsequently cause solids settlement and hence maintenance problems **[Enclosure 2.15]**.

2.6.8.3.2 Mr Nigel John Easterbrook, a Chartered Civil Engineer, has suggested in one of SPH's affirmations that the CWPSs proposed by TDD should be removed. He is of the view that the CWPSs are not needed and, in any event, can be relocated elsewhere. Such a view is however unsubstantiated. Site selection at the seafront is a logical engineering solution for satisfying the hydraulic requirements for the cooling water pumping systems.

2.6.8.3.3 Mr Robert Chu, in a separate affirmation filed by SPH, on the other hand, has suggested that the reclamation extent can be reduced by adopting the option of relocating the pumping stations to the two sides of the new waterfront. On this alternative, TDD commented that the proposal fails to look at the construction sequence, and conflicts with existing ferry and pumping station operations. This alternative has ignored the severe constraints associated with the construction phasing and the essential requirement to maintain the existing CWPS/marine facilities in continuous operation until the reprovisioned facilities are commissioned.

2.6.8.3.4 If the pumping stations were to be provided on the two ends, accommodating the western group of pumping stations (PS-1) will require construction of a large portion of reclamation; this will block safe marine access to the existing Edinburgh Place piers (which are used by the "Star Ferry Co. Ltd. and Discovery Bay Transportation Services Ltd.) and Queen's Pier. Furthermore, there is insufficient existing land space to accommodate the large number of new cooling water mains that would be required. The only way to overcome this would be to construct an area of reclamation to the north of the General Post Office but this is not feasible as it would block the existing pumping station intake and discharge pipelines. Similar problems would occur for the proposed eastern group of pumping stations (PS-2) as they require a portion of reclamation immediately to the north of the existing pumping stations which will block the existing discharge pipelines of Pacific Place, Police Headquarters Phase I, II and III, Queensway Government Offices and High Court. On the contrary, the current scheme with most of the pumping stations located in the central portion of the new seawall, was developed specially to ensure that safe marine access can be maintained to the existing piers during construction so that the existing pumping stations can operate without interruption. The grouping of the pumping stations in the current scheme also enables the supply pipelines to be laid close together thereby making access for maintenance better and limiting the extent of the wayleaves required.

2.6.8.3.5 Mr Hardy Lok on behalf of SPH does not agree that the CWB will act as an imperishable barrier so as to necessitate the pumping stations to be on the north harbour side of the CWB. From the engineering point of view, he argues that it is quite possible and without any great expense to relocate the pumping stations to the south side. Mr Michael Chu Ka Sein, a Chartered Engineer, in his letter to the Administration, has also suggested that the pumping chambers can be located on the landward side of the CWB. On this, TDD has the following comments.

2.6.8.3.6 There are substantial technical, construction risk and long term maintenance problems with the proposed conceptual scheme. It has not addressed the method and risks associated with the construction of the deep shafts, the culvert under the tunnel or the breaking through of the diaphragm wall. The large groundwater pressures at this depth will have to be firmly controlled. From an engineering perspective, the proposed scheme is not a reasonable alternative because of its inherent technical problems and maintenance burden and would almost certainly be completely unacceptable to the system owners.

2.6.8.3.7 In suggesting relocation of the CWPS to the south of the CWB, Mr Hardy Lok has not proposed a feasible alternative location. Based on the two conceptual sketches, A and B, provided by Mr Lok in one of SPH's affirmations **[Appendix 2.7]**, TDD has the following response.

2.6.8.3.8 It is presumed that sketch A suggests that the pumping station would be adjacent to the south side of the CWB Tunnel, with isolating penstocks at the inlet of the CWPS. A multi-compartment supply culvert is proposed. The means of isolation and the distribution method to the individual pumping stations cannot be determined from sketch A. Looking at the hydraulics of the supply culvert arrangement, the water level in the sea will be identical to the water level inside the chamber downstream of the penstock. Therefore, a self cleansing velocity cannot be achieved, and there will be possible settlement of solids in the section of the supply culvert under the CWB Tunnel. In addition, it is possible that solids/debris will settle in the chamber downstream of the penstock and create additional maintenance problems for the end users. Furthermore, there is no horizontal access to the pumping stations. Access to the pumping stations will be from the road surface south of the CWB.

2.6.8.3.9 Sketch B suggests an inverted siphon design for the section of the return culvert around CWB Tunnel. The maintenance responsibility and ownership of the multi-compartment return culvert would need to be resolved. The proposed manhole does not satisfy its primary purpose of providing adequate access to undertake routine maintenance and repair in such a massive and deep underground structure. A bigger size desilting opening at both ends of the return culvert, preferably accessible by public road, is required for loading/unloading of plant and equipment for servicing this culvert. An additional above-ground ventilation building/structure should be provided if man entry is required for maintenance and repair of the return culvert. Also, lighting and fire services equipment need to be considered.

2.6.8.3.10 For such a single multi-compartment structure, maintenance or repair for one part of the compartment would interrupt the pumping operation of the whole multi-compartment. It is not generally acceptable from the perspective of operation and maintenance of the pumping system to have such a deep underground structure for the water cooling system. Furthermore, leakage or damage to the return culvert would have the potential to cause settlement of the CWB due to loss of filling material surrounding the structure.

2.6.8.3.11 It is noted that the existing seawater cooling system for HSBC required the excavation of a 7m diameter tunnel from the harbour to the location of the heat exchanger system. Provision of a similar arrangement would be a major addition to the current scheme which implies that more reclamation of land is needed.

2.6.8.4 *Seawall foundation options / seawall structure position / other seawall design options*

2.6.8.4.1 Some commentators have also queried the selected foundation option for constructing the pumping stations, namely the rubble mound foundation. TDD points out that the seawall and pumphouse resting on a rubble mound (with marine mud removed) is a proven safe design worldwide. There are other structural forms for the CWPS foundation such as driven pile, bored pile and mat foundation. However, these alternatives could cost as much as a hundred-fold and are not reasonable alternatives in view of the costs involved. Typical cross-sections of the three alternatives and the respective cost estimates and reduction in reclamation limit (by approximately 6 metres) are included in **Appendix 2.8 (a) – (d)**. Moreover, the driven pile, bored pile and mat foundation all require maintenance. On the other hand, the rubble mound foundation is virtually maintenance-free.

2.6.8.4.2 Mr Edwin Chung Kwok Fai, a Chartered Engineer, from Black & Veatch Hong Kong Limited, has studied some pumping station design alternatives other than the one proposed by the Government. His comments are that the other designs are either impractical, or do not follow the common practice, or will impose severe constraints to the design of the pipe and the CWB structure as well as its method of construction. He is of the view that the other designs would not be adopted in normal practice **[Enclosure 2.16]**. Thus, taking account of the economic and cost factors, the current design of the pumping stations represents the most optimal solution. Any allegations that we are over-reclaiming for these pumping stations are unfounded. Moreover, the use of land reclaimed for reprovisioning these pumping stations is for community and leisure purposes. To further re-assure the public, the Administration has undertaken to find means within the plan making system to make sure that land reclaimed will only be used for the purpose for which reclamation was originally justified.

2.6.8.4.3 Mr Nigel John Easterbrook on behalf of SPH has suggested re-aligning the CRIII foreshore with a refined seawall structure position adjoining the CWB and enabling 35 m (TDD's 60 m - 25 m = 35m) of the promenade zone to be saved over about a 700m length, i.e. 24,500 sq.m (700m by 35 m = 24,500 sq.m or 2.45 ha) of reduced reclamation. According to TDD, such a reduction of reclamation area is not achievable. The relocation of the CWPS elsewhere is not a reasonable alternative. In the Government's scheme, the spacing between the CWPS and the CWB is considered to be the minimum required looking at the amount of seawater discharge pipework, electric cables and other utilities required for the operation and maintenance of the pumping stations and the pipelines, cables and utilities therein.

2.6.8.4.4 Mr Easterbrook has also proposed a refined seawall structure in the promenade zone, without the CWPS, which would reduce the TDD structural set-out of 60m to only a total of 25m. This proposal assumes that the pumping station will be removed from its current position. Moreover, this cross-section indicates that the refined seawall is of 15m. In comparison with the Government's wave absorption seawall without the pumping station as its back, this refined seawall does not result in any reduction of width. The alternative refined seawall design simply has not taken into account the requirements for the seawater intake pipe or culvert. It is thus not a reasonable alternative as such.

2.6.8.4.5 The refinement of the seawall structure and the claimed reduction in the reclamation area in Mr. Easterbrook's alternative is based on baselines different from those in the Government's design, the most significant difference being the assumption that the CWPS will be relocated or not needed. Mr Easterbrook has not gone further to address problems associated with relocation of the CWPSs away from the seawall. There are obvious hydraulic, maintenance and operational deficiencies which render such a proposal unreasonable.

2.6.8.4.6 On the technical side, it is considered that there are major aspects in his scheme that are impractical or do not follow the common practice. For example, Mr Easterbrook's alternative requires construction of a temporary seawall. The construction of a temporary seawall may require a larger amount of dredging, and a large area of temporary reclamation to accommodate the sloping seawall, than the current scheme proposed by the Government. The temporary seawall construction and removal activities will have an increased environmental adverse impact, as the temporary seawall filling and removal will create pollution. The additional construction phases involved will also substantially extend the works programme and increase the construction costs. Furthermore, the method requires a temporary seawall filling on both sides of the CWB so that the structure will not become unbalanced and overloaded – this will expose the tunnel structure to an unnecessary risk of damage. In summary, the proposed design and its construction are not a reasonable alternative.

2.6.8.4.7 The current design adopted in the Government's scheme, i.e., a rubble foundation for the seawall, is the most commonly adopted solution. It represents the most cost-effective form of seawall design. The proposed CWPS will rest on the seawall rubble foundation which is an appropriate foundation material without the need of piles or other form of foundation. The design is therefore considered as cost-effective and low construction risk.

2.6.8.4.8 The Government's scheme is considered a minimum option in view of the following –

- As shown on Drawing No. HK I-Z624A by TDD **[Appendix 1.4]**, the tip of the rubble foundation at the inside of the seawall would be about 2m from the proposed diaphragm wall for the future CWB Tunnel. This is considered appropriate from an engineering point of view for diaphragm wall construction and will avoid potential difficulties of the rubble mound being in contact with the diaphragm wall as mentioned in paragraph 2.6.8.1.4 above.
- In addition, without the needed distance, disturbance of the rubble seawall by the diaphragm wall construction could cause undesirable movement of the seawall. The situation would be particularly unacceptable if the pumping station founding on the seawall rubble is disturbed.
- From the same TDD Drawing No. HK I-Z624A **[Appendix 1.4]**, it is noted that the clearance between the cooling water pipes and thrust blocks from the pumping station and the future CWB Tunnel is only about 7m. This space is required for diaphragm wall construction to avoid

disturbing the pipes. The risk of disturbing the pipes will increase as this clearance distance reduces. The risk of disturbance must be kept to an acceptable level as disturbance to the pipes causing malfunctioning of the cooling systems of the CBD buildings could have tremendous effect on their operation. The space allowed in the design of the reclamation layout is considered to be the minimum.

- A robust temporary support system is essential to ensure stability of the adjoining ground. Diaphragm walls have been allowed for the construction of the future CWB Tunnel. This scheme is much more reliable in minimizing any ground movement outside the excavation which is not acceptable in consideration of the essential cooling pipes connecting the pumping station.
- It must be realized that the distance between the cope line of the seawall and the northern edge of the CWB is determined by various design features, i.e., the wave absorbing seawall, pump house chambers, emergency vehicular access, cooling water mains, utilities and other services and their construction, maintenance and operation. Further reduction of that distance would not be a reasonable alternative.
- The results of the recent site investigation (SI) by the CRIII contractor to confirm the design assumptions indicate that the dredge level in the vicinity of the CWPS to the east of the PLA Berth is -19.5mPD and the seabed level is -12.0mPD. The distance from the cope line to the tip of the rubble mound foundation at such dredged level (-19.5mPD) is 58.7m according to the current design and the updated SI results. It tallies approximately with the planned distance between the cope line and the northern diaphragm wall of the CWB, i.e. 60m.

2.6.8.4.9 The positioning of the CWPS is governed by a number of factors. The inlet pipe must be positioned between the sea level

(0mPD) and the existing seabed (-12mPD). It must be located a few metres below sea level so that there is sufficient water head to convey seawater to feed the pumps. This requirement is to prevent the burning out of the pumps. The temperature of the intake water is also important to the effective performance of the cooling water system. If there is adjacent heated water discharge, the separation between the discharge and the intake pipe becomes a crucial factor. Previous water quality sampling and mathematical modeling had shown that a plume of heated water quickly spreads along the line of the seawall under the influence of tidal currents. During summer the heated water stays within a relatively shallow surface layer of less than 2m thick. Vertical separation is therefore much more important than horizontal separation. Therefore, the current layout for the CWPS is the minimum extent of reclamation required.

2.6.8.5 *Lagoons and reservoirs*

2.6.8.5.1 Mr Robert Chu has in one of SPH's affirmations further suggested that the reclamation extent can be reduced by adopting the alternative of providing either lagoons or reservoirs as a source of water.

2.6.8.5.2 On this alternative, TDD considers that the two identified locations for lagoon would pose major barriers to roads, utilities, culverts and other infrastructure. Both of the lagoons proposed would be located above MTRC NIL tunnel, which would not be acceptable at the very least from maintenance point of view. The lagoons also present serious technical challenges, such as the size and arrangement of the supply pipelines required to ensure the water in them is adequately replenished. The suggested scheme also has not demonstrated how the existing pumping stations would be kept in operation during construction of reclamation – the very reclamation required to construct the lagoons will block the existing pumping station intake and outfall pipes. It is an important criterion for continuity of supply of cooling water throughout the reclamation works, the construction phasing has to be designed such that the reprovisioning system will be fully commissioned prior to any works commencing directly in front of the existing intakes. This major shortcoming would make the alternative technically not feasible.

2.6.8.5.3 The intention of the lagoon scheme appears to be to retain the existing pumping stations. However, it could not be true as there is greater head loss associated with the increased in length of intake pipe from each lagoon to the respective pumping stations and this leads to the size of intake pipe increasing so as to reduce the flow velocity and preventing the occurrence of cavitation in the intake pipe. Any extra bends in the intake pipe routings also increase the head loss. The existing pumping systems need to be upgraded to suit this requirement. Moreover, without the necessary technical details, the feasibility of the scheme is questionable. If this alternative were to be pursued, the net positive suction head requirements of the existing pumps would have to be reviewed by the individual pumping station owners to assess whether the increase in suction distance would cause cavitation problems or affect the normal operation of the existing pumping equipment. Any such evaluation would come to a conclusion similar to the above that the existing pumping systems require upgrading. However, there would not be sufficient space in the existing pumping station to accommodate the new pumping system with increased capacity. It is also not feasible to increase the size of the pumping stations at their present location. The idea of retaining the existing pumping stations at their present location cannot stand.

2.6.8.5.4 The new suction culvert from the Harbour to the proposed lagoons would have to pass around the CWB Tunnel and the hydraulics must be reviewed critically to make it a feasible option. As mentioned above, supplementary pumping facilities at the new seafront would be required and as a result, the objective of this option – "to reduce reclamation" – would not be fulfilled. Moreover, the provision of the new pipe suction culvert under the CWB Tunnel will impose construction difficulties and maintenance problems. Mr Albert Cheng Wai-shing, a Chartered Engineer, also points out that such an option will impose hydraulic constraints in the long supply culvert and deep chamber downstream to the penstock, which will subsequently cause solids settlement and hence maintenance problems **[Enclosure 2.15]**.

2.6.8.5.5 The viability of this alternative also hinges on the feasibility of constructing pipes or culvert underneath the CWB tunnel. From a general engineering perspective, this scheme will impose severe constraints to the design of the pipe and CWB structure, as well as the method of construction of the CWB, and would not be adopted in normal practice. Since two locations are identified in this alternative, two sets of pipes may be needed and would run underneath the CWB tunnel. These sections of pipe cannot be inspected or maintained underneath the CWB. One of the drawbacks for deeply embedded pipes is that it is extremely difficult if not impossible to remove siltation inside the pipe as it is fully submerged under water. In addition, there would be high risk of damaging the pipes by settlement/movement during and after the construction of the CWB. These concerns will impose severe and stringent constraints to the design of the pipe and CWB structure, as well as the method of construction of the CWB. Special provisions and mediation measures would need to be incorporated to resolve the concerns. All these provisions would not just increase the construction cost but also increase the cost in the operation and maintenance side. The large quantities of harbour water required in the lagoon could present environmental and health risks. If the water is not adequately circulated and used then it would result in an increase in level of pollutants. Mediation measures would have to be included to ensure the water quality would be up to an acceptable standard. This would certainly increase the cost. Such a scheme would not be cost-effective. A Chartered Engineer, Mr Edwin Chung Kwok Fai from Black & Veatch Hong Kong Limited, has studied such alternatives and that proposed by the Government. His comments are that the alternative designs are either impractical, or do not follow the common practice, or will impose severe constraints to the design of the pipes and the CWB structure as well as the method of construction. He is of the view that the alternative designs would not be adopted in normal practice **[Enclosure 2.16]**.

2.6.8.5.6 In summary, the proposal to have lagoons or reservoirs would not be a reasonable alternative scheme for CRIII because of its incompatibility with the congested infrastructure in the area, shortcoming to meet the criterion to provide continuous water supply throughout the reclamation works and wrong assumption of retaining existing pumping system. The increase of cost during construction, operation and maintenance would also be of concern. Connection of these lagoons/ reservoirs to the Harbour may be more complex than envisaged and difficulties in delineating maintenance responsibilities would arise. Moreover, if "mechanical aid" which effectively means pumping were required to feed these lagoons/reservoirs, then the benefits offered by this proposal in terms of minimizing reclamation would be negated. Finally, this scheme purposely dismisses the environmental concerns associated with the lagoon/reservoirs. This is a potential for serious problems and should not be overlooked in any reasonable alternative worth considering.

2.6.8.5.7 Mr Hardy Lok in one of SPH's affirmations has on the other hand suggested that a central cooling water well can be built within the project site, with a simple intake structure along the waterfront towards the Convention Centre area and sea-water can be pumped across to an intermediary station (location to be identified) distributed to the various buildings concerned. The main benefit of such a proposal is the potential elimination of the numerous pumping stations from the foreshore, thus allowing for a reduction in the overall width of the reclamation.

2.6.8.5.8 According to TDD, the suggestion of a central cooling water well for distribution to the various buildings without supporting details is not a reasonable alternative. Connection of this well to the Harbour may be more complex than envisaged and maintenance responsibilities would have to be resolved. If "mechanical aid", which effectively means pumping, is required to feed this well, then the benefits offered by this proposal in terms of minimizing reclamation would be negated. Thus, this is not a reasonable alternative. Environmental concerns and operational problems of such a facility have not been addressed at all.

2.6.8.6 *Alternative cooling systems*

2.6.8.6.1 Alternative air conditioning systems using different cooling methods such as ponds or lakes acting as heat sinks or fresh water supply systems or evaporative cooling towers have been suggested by Mr Nigel John Easterbrook on behalf of SPH. As discussed in paragraphs 2.6.3 to 2.6.7, these are not reasonable options.

2.6.8.6.2 It was not Government's policy at the time of the design to utilize fresh water supply as cooling water for air conditioning systems. Even now, the fresh water system in Central has inadequate capacity to provide water for the air conditioning systems of new large developments. The area within CRIII project is not within the Pilot Scheme area for fresh water cooling. The current pumping station provision for future developments is, therefore, a reasonable and justifiable solution.

2.6.8.6.3 As discussed in paragraph 2.6.3, air-conditioning alternative by fresh water cooling towers is technically problematic. In practice, the change to fresh water supply would also require the agreement of the respective owners because of the additional financial implications and the time and delay thus caused would render such an alternative not a reasonable alternative for CRIII.

2.6.8.6.4 Mr Robert Chu has in one of SPH's affirmations suggested using Centralized Piped Supply System for Cooling Tower (CPSSCT) for new buildings. On this alternative, TDD's view is the CPSSCT is only in preliminary study stage. Under the CPSSCT system, a centralized sea water pumping station and a service provider is required to operate the plant for serving all buildings connected to the plant. There are legal, land and institutional issues to be resolved. Furthermore, the development of a centralized cooling water system would involve complex issues such as apportionment of installation and operation costs, future operational requirements and peak demand of individual building owners, maintenance liabilities, equipment backup, property right, etc. These would have to be addressed and resolved before a CPSSCT system is developed. In addition, CPSSCT system will normally require cooling towers located on the roof of each building and hence will impose a restriction to the floor usage of the new building. Therefore, it is not considered as an alternative to seawater pumping station for new building which will impose any floor usage restriction to new buildings.

2.6.8.6.5 Mr Hardy Lok has suggested the HSBC Tunnel Solution as an alternative. According to him, the present sea water supply to the Headquarters of the HSBC at No. 1 Queen's Road Central makes use of two vertical shafts; one located (on the waterfront) at Edinburgh Place and the other at the basement of the Hong Kong Bank. The shafts are connected by a large diameter service tunnel bored through bed-rock estimated to be in excess of 300m long, and in fact the sea water pipes are housed in the service tunnel. The advantage of this is the ease of maintenance for both the pipes and the pumps. The new proposed relocated scheme does not provide a continual tunnel feature connection to the existing Hong Kong Bank pipework within a tunnel, and indeed it will be a much inferior setup than what they enjoy at present. On this, TDD has the following comments.

2.6.8.6.6 The existing cooling water system for HSBC comprises a relatively shallow intake pipe at the seawall that is connected to a large diameter vertical shaft, which is approximately 70m deep. The existing pumps are located within the shaft and these pump the seawater through pipes that run vertically down the shaft. At the base of the shaft the pipes run inside a tunnel to the location of the HSBC main building. Under the current reprovisioning scheme the existing pipe and pump system will not be altered. The new pumping station, at the new seawall, and its connecting pipework will simply form an extension of the existing shallow intake pipe back to the existing pumps in the shaft. The suggested extension of the existing deep tunnel to the new seawall pumping station would, therefore, not be a reasonable scheme as the intake pipes would be far too deep to connect to the existing pumps. This would require a completely new deep pumping station at the new seawall which would probably occupy more space than the current pumping station design. In summary, the proposal for a deep tunnel to take the seawater intake pipes back to the existing HSBC pumping station is not a reasonable alternative as it is technically inappropriate, expensive and unlikely to result in a reduction in the reclamation.

2.6.8.6.7 Mr Hardy Lok has further contended that the centralized pipe supply system with intermediary pumping stations, as an alternative scheme, should prove technically feasible. However, no details have been provided on the layout or size of the system. TDD opines that the system is likely to require two sets of pumps for each user, which would be both less efficient and less reliable than the current scheme. The central pump required would be huge but there is no indication by the proponent of its likely size or location. TDD envisaged that the intermediary pumping station at the seawall would be very large, probably larger than the current pumping stations, resulting in the distance between the seawall and the CWB tunnel actually being increased rather than reduced. The proposal is therefore not a reasonable alternative scheme.

2.6.8.7 *Other general comments*

2.6.8.7.1 Mr Ian Thomas Brownlee, a Town Planner, in one of SPH's affirmations, has argued that some 9 ha (approximately 1 million square feet) of reclamation to the north of the CWB is justified by the need for some 29 pumping stations. To him, this area could be significantly reduced by reducing the number of pumping stations, exploring alternative cooling systems, adopting a centralized cooling water system, etc. He further contended that there is no legal obligation for the Government to reprovision the pumping stations and that these pumping stations are not for public use and therefore the need for these pumping stations is not a public need. There is a public need in that the pumping stations are required to maintain the economic and social viability of Central by providing an essential uninterrupted utility to the buildings. These pumping stations are located on the existing waterfront and are affected by the reclamation for essential infrastructure. In commenting on the public need justifying reclamation, Professor Andrew Leung [**Enclosure 2.11**] commented that "similar pumping services to the existing buildings must be provided continuously during the development because a civilized society has to respect those facilities people had paid for and are entitled to enjoy. I consider the claim that the pumping stations are not needed as uncivilized".

2.6.8.7.2 On the public need test, we should point out that the reclamation works under CRIII will affect several groups of CWPS serving both Government and private buildings in the vicinity, including Central Government Offices, Queensway Government Offices, High Court, Murray Building, LegCo Building, City Hall, Police Headquarters, Hongkong and Shanghai Bank Main Building, Pacific Place, Admiralty Centre, and Prince's Building Group. All these Government offices and private buildings cannot properly function and operate without reprovisioning of their seawater intakes and discharge outlets for central air-conditioning systems. The continued operation of the pumping stations is vital to the smooth and efficient operation of the CBD. Any disruption to the continued operation of these buildings will create adverse social and economic impact.

2.6.8.7.3 The CFA judgment has pointed to the need to take into account factors like cost, time and delay in assessing reasonable alternatives. This is particularly relevant in considering alternatives to the CWPSs under the CRIII. For private buildings with affected CWPSs, the respective private owners are required to pay for the reprovisioning costs in accordance with existing Government agreements. As such, they have to be consulted on the detailed design of their CWPS.[13] After extensive discussion and consultation with Electrical and Mechanical Services Department (EMSD) and the respective owners (including Hongkong and Shanghai Banking Corporation Ltd, Hongkong Land Ltd, Swire Properties Management Ltd and MTRCL), the consultants came up with the current design of the CWPS that is acceptable to all parties concerned. The locations of the CWPSs have also been

[13] TDD first met the private owners formally in June 2000 for the CRIII reprovisioning arrangement. From June 2000 to February 2003 when the CRIII main contract commenced, there is a period of 33 months of active negotiations.

agreed by the affected private owners. Re-opening such negotiations with affected private owners on alternative systems would render it impossible to complete CRIII within the needed timeframe.

2.6.8.8 We have in this Review addressed at length the reclamation for the CWPS, covering the need for reprovisioning, the size and number of the pumping stations, their configuration and foundation, with a view to dispelling any misconception or allegation that more land than needed is to be reclaimed under CRIII for reprovisioning these essential facilities. The current design and work sequencing represents the solution for which there is no reasonable alternative, taking into account time, delay and costs implications and involves minimum reclamation.

2.7 Ferry piers

2.7.1 The "Central – Tsim Sha Tsui" ferry services have been in operation since 1888. The Tsim Sha Tsui (East) and Hung Hom ferry services are existing passenger services that have been in operation since 1986 and 1965 respectively. The reprovisioning of ferry piers meets ***the compelling and present need*** of the community. During the course of extensive public consultations on the CRIII project, none have expressed the slightest indication that these ferry services could be dispensed with. On the contrary, both the Star Ferry operator as well as some LegCo Members have expressed a strong wish to reprovision the Star Ferry piers to preserve and restore its iconic value to Hong Kong and enhance its attraction to tourists.

2.7.2 There is ***no reasonable alternative*** to a permanent reprovisioning of the Star Ferry piers. At present, the existing Pier No. 1 is used by Government vessels and fireboats. It is not feasible for the pier to accommodate additional services. TD has reviewed the utilization of the Piers No. 2 to 7, the locations of which are shown in **Appendix 2.9**. The findings are set out in the following paragraphs.

2.7.3 Pier No. 2 - At present, the western berth of Pier No. 2 is used for the “Central – Ma Wan” service and is fully utilized. The eastern berth, now vacant, is earmarked for possible ferry service to Penny’s Bay when Disneyland starts to operate by late 2005. The berth, in theory, can be released for temporary use for ferry service for about 1.5 years until mid 2005. From the marine safety perspective, however, it is potentially dangerous to allow the “Central – Hung Hom” and “Central – Tsim Sha Tsui East” services to use the eastern berth of Pier No. 2 even on a temporary or transitional basis because the eastbound sailings to Hung Hom and Tsim Sha Tsui East will create heavy cross marine traffic with the westbound sailings to outlying islands. This will also cause delays to the ferry services which will likely be objected by the ferry operators. Marine Department has the same observation.

2.7.4 Pier No. 3 - At present, Pier No. 3 is used for the “Central – Discovery Bay” service. The pier is fully utilized and cannot accommodate additional services.

2.7.5 Pier No. 4 - At present, Pier No. 4 is used for the “Central – Sok Kwu Wan” and “Central – Yung Shue Wan” services and it is fully utilized during peak periods. It cannot accommodate additional services.

2.7.6 Piers No. 5 and 6 - At present, these 2 piers are used for the “Central – Cheung Chau”, “Central – Peng Chau” and “Central – Mui Wo” services. A detailed survey was conducted on 7 October 2003 to ascertain the berthing utilization. The survey examined the feasibility of using only 3 berths of the two piers for the above 3 services but it is found out that such a proposal is not feasible because –

- any slight delay of one sailing will affect the timetable of services of all three routes;
- any delay due to high wind or bad weather will have a

knock-on effect due to its extremely tight utilization and may easily affect the service level; and

- no allowance has been made for vessels to berth at the piers for purposes other than loading and unloading. Hence, vessels have to frequently move in and out of the piers to make way for vessels engaging in active loading and unloading causing operational inefficiency. Furthermore, idle berthing needs to be arranged elsewhere or has to stay in the fairway which may cause congestion to the marine traffic.

2.7.7 It is concluded from the above that 4 berths are needed for the 3 outlying ferry services mentioned above.

2.7.8 Pier No. 7 - This pier is earmarked for the permanent reprovisioning of Star Ferry's "Central – Tsim Sha Tsui" service after refurbishment in 2005. Its 2 berths will be fully utilized.

2.7.9 Since only Pier No. 7 can be spared for the permanent reprovisioning of Star Ferry's "Central – Tsim Sha Tsui" service, the reprovisioning of the remaining existing services viz "Central-Hung Hom" and "Central-Tsim Sha Tsui East" services would require a new pier, i.e. Pier No. 8.

2.7.10 Pontoons – Marine Department has commented that it may be possible to moor a pontoon at the tip of Pier No. 7 to create an extra berth for temporary reprovisioning of Star Ferry's "Central – Hung Hom" service. However, judging from experience in Central Reclamation Phase I where the ferries using a pontoon for temporary berthing were small hovercrafts which were small and highly maneuverable as compared with the Star Ferry, it is doubtful that Star Ferry will accept that such a proposal is practical to suit its operation in terms of the safety of its passengers as well as the smooth running of its schedules and the maintenance of the Star Ferry icon.

2.7.11 In order to ensure that the Star Ferry services will not be interrupted during the implementation stage of CRIII, a small piece of land called Initial Reclamation Area West ("IRAW") will have to be constructed at the beginning to provide land for the construction of Pier No. 8 and associated passenger and traffic circulation facilities as shown in **Appendix 2.5**. The temporary shorelines on the south and south east of IRAW have been designed to maintain a maximum width of navigation channel to ensure that the construction activities for IRAW will not affect the operation of the existing Star Ferry services. After the construction of IRAW and Pier No. 8 and the refurbishment of Pier No. 7, the existing ferry services will be moved to Piers No. 7 and 8.

2.7.12 The proposed location of Pier No. 8 is aligned with the existing Piers No. 1 to 7. This integral pier arrangement will provide convenient interchange facilities with other modes of transport. The drop-off facilities and public transport interchange will be fully utilized as these facilities can be shared by all passengers (including passengers from the future public landing steps, i.e. Piers No. 9 and 10). The design and location of Pier No. 8 is intended to avoid serious interruption to the existing ferry services at Edinburgh Place during the construction of Pier No. 8. Moreover, the following points have been taken into consideration –

- Minimum requirements for land and sea frontage;
- Convenient and short walk access under cover, with no conflict with other transport modes;
- Integration of ferries with other transport modes;
- Good uncongested interchange with bus, taxi and other nearby modes of transport with reasonable walking distances to the interchange;
- Sufficient waiting and circulation areas with minimum conflict with non-passengers waiting for other services;
- Smooth ferry operation to minimize delays;
- Efficient ferry operation to reduce operation costs;
- Attractive and convenient facilities to retain patronage; and
- Minimization of conflicts with existing land uses.

2.7.13 The current arrangements to reprovision the ferry piers as embodied in the CRIII works are the outcome of a prolonged negotiation with the "Star" Ferry Co. Ltd. which has made strong objections during the statutory plan making process. The "Star" Ferry Co. Ltd.'s objection, being the only unwithdrawn further objection to the amended OZP with the minimum reclamation option incorporated, was mainly against the proposed relocation of its piers to Pier No. 7. It had subsequently taken the "Star" Ferry Co. Ltd. and the relevant Government Departments another two years to sort out the details relating to the reprovisioning. This prolonged and thorough examination would have met the CFA formulation of no reasonable alternative taking all circumstances into consideration. Any re-opening of negotiations on Star Ferry piers reprovisioning would inevitably lead to significant delays and abortive costs. No alternatives to reprovisioning the Star Ferry piers have been put forward by commentators or deputations attending the LegCo joint Panel meetings. There is no reasonable alternative to reprovisioning the ferry piers as planned.

2.8 Public landing steps

2.8.1 CRIII will change the current shoreline and thus the existing 15 sets of public landing steps at Queen's Pier and the original Central waterfront area will be affected as shown in **Appendix 2.10**. Queen's Pier is the most popular and busiest public pier in Central. There is a heavy demand from vessels engaged in port operations, harbour tours and other recreational activities. Marine Department's record shows that more than 50 vessels use the pier per hour during the peak period. Reprovisioning is necessary to ensure their continued operation. A total of 12 sets of landing steps will be reprovisioned within CRIII through Piers No. 9 and 10 adjacent to the pier cluster in the Central Waterfront so that users may benefit from the transport infrastructure in the vicinity.

2.8.2 Queen's Pier cannot be closed during the implementation stage of

CRIII. The public pier at Tsim Sha Tsui is fully utilized during Saturday, Sunday and Public Holidays and has no reserve capacity. Besides, its location cannot substitute the Queen's Pier and other public landing steps located in Central.

2.8.3 The two public piers No. 9 and 10, which have a total of 12 sets of landing steps, are required to replace the existing 15 sets of landing steps at the Queen's Pier and the Central Waterfront. The location of Piers No. 9 and 10 has been chosen after taking the following factors into consideration –

- The landing facilities should be located to the east of ferry piers. This is because Central Piers No. 1 to 8 have occupied the main Central waterfront. Landing steps located within this strip is not possible due to over-congestion. To the west of these piers, the Hong Kong-Macau Ferry Terminal is the constraint that prohibit further addition of landing steps;
- Site should be located in an embayment of water away from fairways to provide buffer for layby and waiting vessels;
- Adequate road transport infrastructure including public transport interchange, layby for cars and car parks etc. should be available near the landing facilities; and
- The acceptability of the community and users.

2.8.4 At the southeast corner of Pier No. 8, CRIII shoreline will turn clockwise by 45° and connect to the shoreline which is offset at an average of 60m northwards from the edge of CWB. Piers No. 9 and 10 are located on this section of shoreline. By turning the direction of the shoreline 45° clockwise, the layout of Piers No. 9 and 10 has been designed such that on one hand there is a sheltered berthing area from the waves generated from the ferry vessels, and on the other hand, vessels using these piers will not interfere with the operation of the PLA berth on the east.

2.8.5 The orientation of this section of shoreline will also avoid the creation of a dead corner and a zone of stagnant water which is likely to result in localized adverse water quality if the shoreline is turned 90° clockwise forming a sharp corner.

2.8.6 To conclude, there is an overriding public need to reprovision the public landing steps affected by the CRIII works to the new waterfront. There is no reasonable alternative and the extent of reclamation is the minimum that is required for the purpose.

2.9 PLA berth

2.9.1 The 1994 Sino-British Defence Land Agreement provides, inter alia, that “the Hong Kong Government will leave free 150 meters of the eventual permanent waterfront in the plans for the Central and Wan Chai Reclamation at a place close to the Prince of Wales Barracks for the construction of a military dock after 1997.”

2.9.2 Discussion with PLA indicated that the PLA berth must be located in front of the Central Barracks. Apart from the 150m long berth, two 75m long and straight approaches must also be reserved at both ends of the berth for the safe maneuvering of the necessary warships during berthing. The agreed PLA berth layout is based on a planning intention to visually integrate the proposed military dock with the promenade along the waterfront of Central and Wan Chai Reclamation, and that the dock area would be open to public access when it is not in military use.

2.9.3 Since the CRIII is the final phase of Central Reclamation through which the permanent shoreline will be provided, the Government is obliged to fulfill the above requirement. There is no other alternative. The shoreline in front of the Central Barracks is constrained by Piers No. 9 and 10 on the west and the cooling water pumping stations on the east as shown in **Appendix 2.11**. It cannot be shifted further southward or landward, otherwise, the berthing requirements stated above cannot be met. The reclamation is no more than what is required for the length of the berth as stipulated in the Agreement.

2.10 North Hong Kong Island Line

2.10.1 The CRIII has given due consideration to a future North Hong Kong Island Line (NIL) and has sought to protect its alignment. Although the NIL will not be needed before 2016, the alignment for this strategic rail link which is supported by numerous transport modeling studies conducted by the Government and the MTRCL should be protected administratively to ensure its future construction would not be jeopardized. According to MTRCL's Mr R J Black, "if the proposed NIL is to remain an achievable element of Hong Kong's future railway network, the physical alignment requires planning route protection from the encroachment of other infrastructure" **[Enclosure 2.14]**.

2.10.2 The Railway Development Strategy 2000 (RDS-2000) published in May 2000 provides the planning framework for the expansion of Hong Kong's railway network up to 2016. The RDS-2000 recommends the implementation of the NIL to relieve the existing Island Line (ISL) and Tsuen Wan Line (TWL) Nathan Road corridor. The NIL is an extension of the existing MTR TCL along the north shore of Hong Kong Island to run from Hong Kong Station through onto the eastern half of the existing MTR ISL at Fortress Hill. The RDS-2000 recommends that the target completion window for the NIL would be between 2008-2012. In late 2002, Government, in view of the reduction in forecast employment and changes in land use assumptions since the Second Railway Development Study (RDS-2), reviewed the need for the NIL. The assessment is that there is no strong need to implement the NIL, within the window of 2008 to 2012 as set out in the RDS-2000. The completion of the NIL is to be deferred to beyond 2016, but the alignment for the NIL should be protected administratively to ensure the future construction of the NIL would not be jeopardized.

2.10.3 As far as the limits of reclamation are concerned, the NIL alignment is in fact fixed by various control points. It has to join the Airport

Railway Extended Overrun Tunnel to the west, run along the water channel of the HKCEC as the columns and foundation of the HKCEC at this water channel were specifically designed for this purpose and at the eastern end, connect up with the existing station at Fortress Hill. The alignment of NIL is already tucked as close to the existing shoreline as possible and is on the landward side of the CWB. Any shifting of the NIL alignment outside and inland of this water channel will affect the foundation of the HKCEC.

2.11 Conclusion

2.11.1 To conclude, we have applied the CFA's "overriding public need test" and its formulations to each area proposed to be reclaimed under the CRIII. The CRIII meets the test based on social, economic and environmental needs within our planning horizon, with some needs more imminent than others. There is no reasonable alternative to reclamation. The extent of reclamation is the minimum that is required for the purpose. Dr the Hon. Raymond Ho has written to the Administration expressing his support for the CRIII. To quote from him, "I do not think that the reclamation extent in CRIII is excessive. The 18 ha required for reclamation under CRIII is already minimum" **[Enclosure 2.17]**. Dr Ho's view is echoed by Mr Maurice Lee Wing Woo, a civil, environmental, geotechnical and structural engineer, who points out that "the extent of reclamation in CRIII is the optimal solution to the needs. Any delay in CRIII will delay such required works and induce negative social and economic impacts". On the future coastline of CRIII, Mr Lee adds that "the new coastline after CRIII will enhance the existing coastline with respect to continuation of land use and infrastructure, aesthetic performance of the coastline, and water current" **[Enclosure 2.18]**. Professor Bernard V Lim of the Department of Architecture at the Chinese University of Hong Kong comments that "reclamation, limited yet not massive, needs to be viewed in a positive light, in the context of promoting the importance of urban design as a means to deliver better and more sustainable environment, and enhancing the public realm of Hong

Kong to elevate its status as a world city" **[Enclosure 2.19]**.

2.11.2 Some engineers have further pointed out that CRIII can enhance the tidal flow and water quality of the Victoria Harbour. Professor Y S Li, Professor Andrew Leung and Dr the Hon. Raymond Ho have all made this point. According to Professor Y S Li, Chair Professor of Coastal and Environmental Engineering and Head of Department of Civil and Structural Engineering, "the CRIII reclamation will enhance the tidal flow and water quality in the Victoria Harbour by eliminating a zone of rather stagnant water" **[Enclosure 1.3]**. Professor Andrew Leung **[Enclosure 2.11]** and Dr the Hon Raymond Ho have made very similar remarks **[Enclosure 2.17]**.

Chapter 3 – Publicity and Public Consultations

In view of the public concern over the issue of reclamation in the Harbour, the Government has stepped up efforts to reach out to the community to explain the justifications and scope of CRIII. In the following we have summarized the publicity and public consultation measures related to the CRIII project.

3.1 The CRIII Website

3.1.1 The Housing, Planning and Lands Bureau (HPLB) has set up a website at www.hplb.gov.hk/cr3 in order to enable the public to have a better understanding of CRIII so that they can discuss the issues concerned in an informed and rational manner. The website came into being on 25 October 2003 and comprises the basic facts, maps, plans, feature articles, court judgments and relevant LegCo papers on CRIII. The website also gives a full account of the Government's position on the issue of Harbour reclamation through the press releases, statements and open letters published in the past several months. The website has received 37,818 visits as of end March 2004. At **Enclosure 3.1** we have printed out the main contents of the CRIII website.

3.2 Leaflet on "*Our Harbour – Past, Present and Future*"

3.2.1 The HPLB has produced a leaflet (in separate bilingual versions) summarizing the Government's stance and commitment to protect and preserve the Harbour. Contained in the leaflet are the key messages that looking ahead –

- The Government wants the Harbour to be a harbour for the people and a harbour of life;
- The Government has abandoned the proposals of reclamation at Kowloon Point and Tsim Sha Tsui;
- The Government will amend relevant OZPs to eliminate the reclamation plans for Tsuen Wan and the Western District;
- The CRIII project was approved after extensive public

consultation and it enables the essential road networks to relieve traffic congestions in Central; and

- The Government will continue to listen to views of the public and hold discussions with different sectors of the community on the task of protecting and preserving the Harbour.

3.2.2 We have distributed a total of 107,600 Chinese copies and 37,700 English copies of the leaflet to the public since late November 2003. The leaflet has been distributed to DCs, secondary and primary schools, youth centres, libraries, professional bodies, green groups, LegCo, port groups, and counters of relevant bureaux and departments. Bilingual copies of the leaflet can be found at **Enclosure 3.2**.

3.3 Booklet on "*All About Central Reclamation Phase III*"

3.3.1 The Government has produced a combined bilingual booklet on CRIII to provide a comprehensive factual account of CRIII. Contained in the booklet are the history, scope, and justifications as well as the due diligence and scrutiny that CRIII has gone through. We have distributed a total of 134,000 copies of the booklet to the public since 18 December 2003. The booklets were sent to all concerned professional institutes, green groups, public organizations and schools, etc. To reach out to the community, we arranged an on-the-street distribution to passers-by in Central and Admiralty on 19 December 2003 and more than 20,000 copies of the booklets were distributed. The booklet has been sent to DCs, secondary and primary schools, youth centres, libraries, professional bodies, green groups, LegCo, port groups, and counters of relevant bureaux and departments. A copy of the booklet is attached at **Enclosure 3.3**.

3.4 Public Statements on the Harbour

3.4.1 To reiterate the Government's commitment to protect and preserve the Harbour, numerous public statements have been made over the past few months. The more prominent ones are described in the following.

3.4.2 *2030 Study consultative documents*

3.4.2.1 The Government wishes to develop a land use, transport and environment strategy under the Hong Kong 2030 Study to guide the long-term development of Hong Kong. The views of the public on a number of planning options and alternatives have been sought during the public consultation. Based on public views expressed in the first two stages of consultation, the Stage 3 consultation has adopted as one of its broad directions for development the provision of a quality living environment through better design of the harbourfront and public space and better protection of the natural and cultural heritage. In connection with this, the Government has reiterated its commitment to preserve and protect the Victoria Harbour. Specifically, the consultative document contains the statement that the Government will not undertake any further reclamation in the Harbour apart from the works in Central, Wan Chai North and South East Kowloon to meet essential needs.

3.4.2.2 An extract of *Hong Kong 2030 Planning Vision and Strategy, Stage 3 Public Consultation – Consultation Booklet* is attached at **Enclosure 3.4**.

3.4.3 *2004 Policy Commitments of the Secretary for Housing, Planning and Lands*

3.4.3.1 Issued on 7 January 2004, the 2004 Policy Agenda lists the Government's new and ongoing initiatives over the next three and a half years. The one relating to Harbour development under SHPL's purview read as follows – "Ensuring that our planning and land use objectives are geared towards our mission to protect the Victoria Harbour and enhance it for the enjoyment of our residents and visitors alike. Apart from Central, Wan Chai North and South East Kowloon, the Government will not undertake any further reclamation in the Harbour. Our policy will be reflected in relevant town plans." Such a statement is reproduced in a paper entitled "Briefing on the work of the Housing, Planning and Lands Bureau (Planning and Lands Branch) and Public Consultations underway" which is submitted to all the 18 District Councils (DC) as a basis for consultation of DCs by representatives of HPLB. Between January and March 2004, HPLB officials attended all 18 DC meetings and the subject matter of harbour reclamation was discussed at length at several of these meetings.

3.5 Other Public Consultations

3.5.1 Since mid 2003, SHPL and his colleagues have been reaching out to the community, green groups, professional institutes, advisory bodies, political groups, and business organizations to explain CRIII. Relevant officials participated in public forums and activities organized by the Citizen Envisioning @ Harbour and attended radio and TV programmes to explain the Government's position and articles in Chinese and English newspapers and letters to editor were written to explain the Government's position. Copies of the latter are at **Enclosure 3.5**.

3.5.2 The Government has also actively engaged SPH. SHPL and his colleagues have met with SPH on five occasions in the month of November 2003 under its new chair-lady, including two technical sessions to discuss CRIII and to listen to their "alternatives" of lesser reclamation and no reclamation.

3.6 Legislative Council Joint Panel Meetings

3.6.1 SHPL led a team of officials to attend a joint meeting of the Panels of Environmental Affairs and the Planning, Lands and Works on 13 October 2003, in which CRIII was explained in detail. The LegCo

Brief prepared by the Housing, Planning and Lands Bureau has presented the background, latest development and the Government's position regarding CRIII. A copy of the paper is at **Enclosure 3.6**.

3.6.2 To help gauge public views, the Joint Panels held two meetings on 27 November and 8 December 2003. Representatives from 20 deputations attended the meeting, including the SPH. A list of the deputations is at **Enclosure 3.7**.

3.6.3 The 20 deputations presented their views, mainly on CRIII, in the first joint Panel meeting of 27 November 2003. The main concerns expressed by the deputations are summarized in the following –

- Engaging the public in proposed Harbour reclamations
- Traffic and transport justifications for the CWB
- The impact of the High Court judgment regarding the draft Wan Chai North OZP on CRIII and future reclamations
- CRIII's reclamation extent
- Environmental impact of CRIII
- Public participation in the use of reclaimed land and design of the waterfront

3.6.4 Most deputations did not dispute the need for the CWB but expressed the wish for the Government to listen to the views of the community and carefully examine whether the present proposed scale of reclamation at CRIII is the "real" minimum. Some other deputations, in particular the Conservancy Association, requested the Government at the meeting to provide more robust transport justifications for the CRIII project, and to consider other traffic management measures as a long-term measure to tackle the traffic problems in Central and Wan Chai.

3.6.5 The papers submitted by the Administration at the above joint Panel meeting and the minutes of the meeting are attached at **Enclosures 3.8 and 3.9** respectively.

3.6.6 At the second joint Panel meeting of 8 December 2003, the

Government responded to the views presented by the 20 deputations in the previous meeting. The Secretary for the Environment, Transport and Works presented the transport justifications for the key traffic infrastructure to be constructed under CRIII. SHPL said that the Government would continue to listen to views of the public and hold discussions with different sectors of the community on the matter. He reiterated that the Government was committed to protecting and preserving the Harbour and shared the vision of the TPB of providing an easily accessible and lively waterfront for enjoyment of the public.

3.6.7 The papers submitted by the Administration at the above joint Panel meeting and the minutes of the meeting are attached at **Enclosures 3.10 and 3.11** respectively.

3.7 Aspirations for the Harbour

3.7.1 In the course of the above-mentioned public consultation, the Government's stated position to provide more accessibility and more public amenities on the harbour-front is generally welcome and supported by the public. This view is illustrated in the Report of the Citizen Envisioning @ Harbour, a copy of which is at **Enclosure 3.12**.

3.7.2 The Government's vision is to make the Victoria Harbour a harbour for the people and a harbour of life, easily accessible for the enjoyment of all.

3.7.3 As mentioned before, the land required for the essential infrastructure items will provide an exceptional and unique opportunity for a vibrant waterfront promenade on the northern shore of Hong Kong Island extending from the CBD to Wan Chai for the access and enjoyment by the community. Stringent height restrictions are stipulated on the relevant OZP such that only low rise developments will be allowed on the waterfront. The commercial sites along the promenade are meant for waterfront related commercial and leisure uses such as low rise retail shops and cafes/restaurants to complement the function of the promenade for the enjoyment of citizens and tourists.

3.7.4 With the CWB built underground, the greenfield site formed by the CRIII will provide an excellent opportunity to create a vibrant waterfront fully equipped with leisure, tourism and related retail facilities. From the Waterfront Promenade, residents and visitors alike will be able to enjoy the spectacular view of Victoria Harbour and Hong Kong's stunning skyline.

3.7.5 Apart from the Waterfront Promenade, the Central District (Extension) OZP envisages a Statue Square Open Space Corridor. This corridor will extend from Statute Square and Hong Kong Bank Building towards the waterfront. Pedestrians will be able to stroll along this corridor to access the waterfront. It will end at the reprovisioned Star Ferry Pier and public piers. There is a plan to recreate the 1912 Star Ferry terminal which will become a new landmark in Central and a major tourist attraction. This will enhance enjoyment of the waterfront by residents and tourists.

3.7.6 The creation of a vibrant waterfront is supported by the Hong Kong Institute of Architects (HKIA). In its letter to the Administration endorsing the CRIII, HKIA comments that, "the harbour is a valuable amenity and it is not sufficient to only demonstrate that there is a need for reclamation. Justification must be also on works that will enhance the overall environment of the waterfront, i.e. a continuous pedestrian environment that can be used by the people and which allows easy access to and from surrounding districts and supported by a range of leisure, recreational, well designed and integrated commercially operated attractions such as outdoor cafes, festival markets, kiosks, shaded sitting areas, cultural facilities including a maritime museum, and other water-related uses and features" **[Enclosure 2.12]**.

3.7.7 HKIA supports minimum reclamation with minimal amount of the reclaimed land reserved for commercial use. It also supports that such limited commercial use along the promenade be designated for waterfront related commercial and leisure uses such as low rise retail shops and cafes/restaurants to serve as attractions.

Chapter 4 – Implications on the Programme and Cost of CRIII

4.1 In its judgment, the CFA has emphasized that "there must not be any undue delay in applying for judicial review. With any reclamation proposal, substantial public funds and third parties rights would be involved. It is of obvious importance and in the interests of good public administration that all concerned should know where they stand as soon as possible so that the earliest opportunity for any challenge should be promptly taken. If not, the courts have the discretion to refuse relief." [Para. 70 of the CFA judgment refers] Dr the Hon Raymond Ho fully agrees with "the CFA judgment which has emphasized that there must not be any undue delay in applying for judicial review" **[Enclosure 2.17]**. We consider this guidance by the CFA a relevant consideration in this Review. In the following paragraphs, we will demonstrate that substantial public funds are involved and third parties rights have been created under CRIII to the extent that the consequences of aborting the CRIII now would be costly.

4.2 From initial proposal to start of work, CRIII has been under detailed study and consideration for five years, including extensive public consultations. In his letter to the Administration, Dr the Hon. Raymond Ho agreed that the "CRIII has undergone a process of due diligence and scrutiny" **[Enclosure 2.17]**. According to Mr Koo, "the proposed CRIII is based on a series of professional engineering studies conducted over the years and a long process of consultations with the general public and professional bodies" **[Enclosure 2.9]**. In its letter to the Administration, the Hong Kong Institute of Planners (HKIP) stated that the Central District (Extension) OZP had gone through a "very transparent plan making process and many professional institutes and members of the public were involved". HKIP also considered that the OZP "should be implemented as soon as possible to help relieve traffic congestion in Central and to provide a waterfront promenade worthy of Hong Kong's status as an international business and tourist centre" **[Enclosure 4.1]**. The major milestones in CRIII and lists of statutory and advisory bodies, professional bodies and affected parties consulted on CRIII as well as the main ordinances involved are contained in the Section "A Process of Due Diligence and Scrutiny" in the Booklet *All About Central Reclamation Phase III.*

4.3 The approved Central District (Extension) OZP remains lawful unless the court rules otherwise and the Government has to discharge contractual obligations under the CRIII works contract. The SPH has publicly demanded that all current works under the CRIII should be stopped and the Central District (Extension) OZP should be referred by the CE in C to the TPB for reconsideration. This will have grave consequences.

4.4 Unlike the Wan Chai Development Phase II where the extent of reclamation is the subject of a draft Plan, the CRIII is based on the Central District (Extension) OZP approved by the CE in C in February 2000. If SPH's request that the Central District (Extension) OZP be referred to TPB for reconsideration is acceded to, the Planning Department estimates that the preparation of a new plan and the statutory process involving gazettal of the plan under section 5, processing of objections, and submission of the draft plan to the CE in C for approval under section 8 will take at least 14 months.[14] This has not allowed for the time required for preparing the engineering and planning review, the needed public consultations with LegCo, relevant District Councils and interested groups, re-opening negotiations with stakeholders whose existing facilities will be affected by any proposed reclamation, etc. Once a

[14] The 14-month period is made up of 3 months of administrative processing (including preparing and circulating the draft plan for departmental comments, consolidating departmental comments and preparing documents for TPB consideration, and preparing gazetting of the new plan under s.5 of the TPO). We have compressed the administrative processing as much as possible. The remaining 11 months are statutory provisions in the TPO, which is made up of 2 months of exhibiting the new plan for public inspection and 9 months for considering objections and submitting the draft OZP to CE in C for approval.

preferred and acceptable option is available, funding approval for the detailed design and construction, preparation of tender documents, detailed design and tendering of the works will have to be carried out. From start to finish, the entire process (including the 14 months for the plan-making process as mentioned above) may take 39 months to complete, assuming a fast-track approach (including an expedited funding application and approval process, and that the detailed design is conducted in parallel with the gazettal and authorization of the OZP, reclamation scheme and road works) and that the review and the redesign are not extensive. Otherwise, the entire process may take as long as 59 months to complete.

4.5 The consequences of such delays should be obvious. Without the 40m extension in the Airport Railway Extended Overrun Tunnel to be constructed as early as possible within the CRIII, the Airport Express Line and Tung Chung Line cannot operate at their full, design capacity due to safety concerns. The non-availability of the Road P2 Network in 2007 at the earliest would give rise to unacceptable traffic congestion within Central. If the CWB is not available by 2011, traffic conditions along the CRC/HR/GR Corridor will deteriorate and unacceptable traffic congestion will occur. Also, the northern shore of the Hong Kong Island would continue to be deprived of the "missing link" critically needed to improve the traffic flow between the western and eastern parts of the Hong Kong Island. As estimated above, the deteriorating traffic conditions and the traffic congestion would lead to very significant social and economic costs.

4.6 CRIII is subject to a $3,790 million contract awarded in February 2003. The contract is expected to last 55 months and works have commenced on site in February 2003. If the Central District (Extension) OZP were to be returned to the drawing board and has to go through the planning, authorization, design and tendering process again likely to last for 39 months to 59 months as discussed above, the current CRIII contract could not be preserved. If the CRIII works contract were to be terminated, there would be immediate loss of about 400 direct jobs. More job opportunities of up to 1,100 additional jobs that could have been created as the project progressed over the next four years would not be available. Based on the limited information available as at 31 January 2004, the possible losses are estimated to be over $600M, which is subject to substantiation by the Contractor and Consultant.

4.7 Mr James Bruce Humphrey, a Chartered Quantity Surveyor, has in one of SPH's affirmations made an assessment of the likely cost consequences based on the several possible positions under the CRIII contract that may arise as a result of the SPH's application for an Order by the Court to remit the Central District (Extension) OZP to the TPB for reconsideration. Mr Humphrey's main points are summarized as follows –

- Mr Humphrey has dealt with the likely costs (to the Employer) that might arise on a project like CRIII in the event of frustration, termination or abandonment, and suspension.
- According to Mr Humphrey, if the CRIII contract came to an end by frustration, the estimate of the likely real loss to the Government is in the order of HK$30 to HK$40 million. That is the likely cost of stopping operations and re-starting.
- Mr Humphrey does not agree with TDD that, if the Government orders a suspension which lasts 90 days (plus a further 28 days within which the Engineer must decide whether to give permission to resume work), the contractor will treat the contract as abandoned or terminated.
- Mr Humphrey adds that TDD's estimate of $403.3 million for "loss of profit" is based on what the Engineer has told TDD the contractor says his claim would be.
- Mr Humphrey argues that the most natural, and sensible, way forward is for the Engineer to order a suspension for a sufficient time for the requested review to be undertaken.
- Mr Humphrey has also examined the likely re-tender price level if for any reason CRIII comes to an end. He does not envisage any significant increase as a result of inflation in

the light of the foreseeable industry workload in projects of comparable scale. Nor does he see much scope for a lowered tender due to further deflation.

4.8 TDD's response to the above points is summed up in the following.

4.9 The estimates of Mr Bruce Humphrey at HK$30 to 40 million for "likely real loss" have been based on the assumption of a "frustration" situation for which GCC Clause 85 will apply, and the contractor would then not be entitled to payment for loss of profit according to GCC Clause 84. There is however doubt with this "frustration" assumption, and the applicability of GCC Clauses 84 and 85 has yet to be established. It is noted that the present situation of CRIII is not similar in nature to the various types of "special risks" as listed in Clause 84 or "war" as quoted in Clause 85. If the assumption of "frustration" could not sustain, we would be faced with a situation of "breach of contract" under which any "loss of profit" claim would become valid.

4.10 Mr Humphrey has assumed that all the works done and services carried out so far need not be scrapped and would not be wasted and that quite a lot of them could proceed as originally planned despite the OZP were to be referred to the TPB for review. This is an unrealistic assumption tantamount to implying that the TPB review would come up with the same scheme and shoreline configuration such that the precast seawalls could be re-used. It would be imprudent for the Government to estimate possible financial loss to Government based on a minimal impact scenario.

4.11 Whether or not the existing partial suspension of the Works would lead to an abandonment/termination pursuant to Clause 55 by the contractor is a matter to be examined taking account of the extent of works suspended, the programmed inter-relationship of the suspended works and the numerous sections of works in the contract, the actual length of the suspension, etc. However, it should be noted that implementation of CRIII works with a contract period of

55 months is only at an early stage and if CRIII were to be aborted now the total value of the suspended works and other works that would be consequentially affected amounts to 95% of the value of the contract.

4.12 The current suspension of the CRIII works has been ordered in a way to enable the Government to preserve its flexibility to respond to the court decisions expeditiously for provision of the much needed infrastructure. There is no basis for the Engineer to order a suspension for a sufficient time for the requested review to be undertaken (Mr Humphrey has assumed that the review of OZP by the TPB will take only between 4-6 months to complete), as the TPB review process will take at least 14 months and carries with it the uncertainty that CRIII may or may not proceed in the same manner.

4.13 Based on the available limited information as at end January 2004 and subject to substantiation by the contractor and consultant, TDD has estimated that termination of the CRIII contract on 1 April 2004 could involve a substantial loss of over $600 million, broken down as follows –

(a)	Cost of abortive works physically completed up to 31.3.2004	$166M
(b)	Materials on Site	$23M
(c)	Precasting works in Mainland China	$46M
(d)	Materials ordered but not yet delivered	$37M
(e)	Demobilization of plant	$10M
(f)	Resident site staff (RSS) cost up to end 31.3.2004 plus 3-month notice period plus RSS for finalization of contract account	$75M
(g)	Consultants'cost	$6M
(h)	Reinstatement cost	$60M
(i)	Contractor's claim for loss of profit etc	$236M

4.14 Third parties' rights have been created under the CRIII works.

Contractors and subcontractors have already raised strong concerns over the deferral or termination of the project as they have made a huge upfront investment in the project. This includes the purchase of precast materials, electrical and mechanical equipments and water pumps. They are also concerned about the storage cost in both Hong Kong and the Mainland that has to be incurred due to the temporary suspension of some of the CRIII marine works in Hong Kong.

Chapter 5 – Conclusion

5.1 This Review shows that there are cogent and convincing materials demonstrating that CRIII meets the "overriding public need test" laid down in the CFA judgment. To obtain community support and third-party endorsement of the project, CRIII has undergone a five-year due and diligent process of scrutiny. During the various statutory processes, objections had been carefully considered and amendments made to the OZP with the benefit of a comprehensive feasibility study that helps identify the minimum reclamation option. All these satisfy the heavy demand in terms of standard of proof. Reinforced by the reviews conducted in the light of the court judgment, there is no reasonable alternative to reclamation.

PART TWO

<u>List of Enclosures</u>		***Ref. Para.***

	Kong	
Enclosure 2.7	Letter dated 6.2.2004 from Professor C O Tong, Associate Professor of the Department of Civil Engineering, the University of Hong Kong	2.3.5
Enclosure 2.8	Letter dated 2 February 2004 from the Hong Kong Institute of Planners	2.3.5
Enclosure 2.9	Letter dated 16 March 2004 from Mr Koo Yuk-chan, Civil and Geotechnical Engineer	2.3.10
Enclosure 2.10	Extract of Minutes of the LegCo Joint-Panel Meeting of 27 November 2003 – Comments and Alternatives on the CWB voiced by Conservancy Association, Urban Watch, (中重型貨車關注組), Rights of Taxi Owners and Driver Association	2.3.11
Enclosure 2.11	Opinion dated 17 February 2004 from Professor Andrew Leung, Head and Professor of the Department of Building and Construction at the City University of Hong Kong	2.3.13.6.6
Enclosure 2.12	Letter dated 16 February 2004 from the Hong Kong Institute of Architects	2.3.27
Enclosure 2.13	Letter dated 11 February 2004 from The Real Estate Developers Association of Hong Kong	2.3.28
Enclosure 2.14	Letter dated 6 February 2004 from Mr. R J Black, Project Director of MTRCL	2.5.2
Enclosure 2.15	Report dated 30 March 2004 by Mr Albert Cheng Wai-shing, Chartered Engineer from Black & Veatch Hong Kong Limited	2.6.3
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土木工程拓展署
CEDD Civil Engineering and
Development Department

Supplemental Agreement No. 1
to
Agreement No. CE 54/2001 (CE)

Wan Chai Development Phase II
Planning and Engineering Review

REPORT ON
COGENT AND CONVINCING MATERIALS
TO DEMONSTRATE
COMPLIANCE WITH THE OVERRIDING PUBLIC NEED TEST

February 2007
Document Ref. 97103_CCM1 (27Feb07)

MAUNSELL CONSULTANTS ASIA LTD

SA1 to Agreement No. CE54/2001 (CE)

**WAN CHAI DEVELOPMENT PHASE II
PLANNING AND ENGINEERING REVIEW**

COURT OF FINAL APPEAL RULING ON THE PRESUMPTION AGAINST RECLAMATION IN THE PROTECTION OF THE HARBOUR ORDINANCE:

COGENT AND CONVINCING MATERIALS TO DEMONSTRATE COMPLIANCE WITH THE OVERRIDING PUBLIC NEED TEST

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ANNEXES

1 INTRODUCTION

1.1 Background

1.1.1 Wan Chai Development Phase II (WDII) is the conclusion of a number of planning studies commissioned by Government, covering transport infrastructure and development along the shoreline of Central and Wan Chai, that date back to the early 1980s. The WDII project is undergoing a process of statutory town planning procedures and public consultation, in which there has been thorough public discussion on matters including the scale of reclamation and the usage of the land to be made available by the project.

1.1.2 The need for the Central and Wan Chai Reclamation was first identified in the strategic study on "Harbour Reclamations and Urban Growth" undertaken between March 1982 and October 1983. The need was further confirmed in various planning studies, including the Territorial Development Strategy of 1984, the Port and Airport Development Strategy 1989, Metroplan 1991, and the Territorial Development Strategy Review of 1996. The whole Central and Wan Chai Reclamation project forms land for the construction of, among other things, strategic transport links, associated surface road networks, the Airport Railway and its Hong Kong Station and the Hong Kong Convention and Exhibition Centre Extension. The Central Reclamation Phases I, II and the Wan Chai Reclamation Phase I were completed in 1997 to 1998. Central Reclamation Phase III (CRIII) is currently under construction. WDII is the final phase, and an integral part, of the Central and Wan Chai Reclamation.

1.1.3 The Wan Chai Development Phase II Comprehensive Feasibility Study (the WDIICFS) was commissioned by the then Territory Development Department in June 1999. The main purpose of that assignment was to make provision for key transport infrastructure and facilities along the north shore of Hong Kong Island, in Wan Chai and Causeway Bay. Under the WDIICFS, a layout of the Trunk Road was derived, comprising the Central-Wan Chai Bypass (CWB) running along the Wan

Chai shoreline in tunnel, and the Island Eastern Corridor Link (IECL) running behind the Causeway Bay Typhoon Shelter on elevated roadway, connecting to the existing elevated Island Eastern Corridor (IEC). New land was proposed along the Wan Chai and Causeway Bay shoreline, primarily for the construction of the Trunk Road and other key infrastructure, and also to provide an attractive waterfront with a new public promenade. A total reclamation area of some 28.5 ha along the existing Wan Chai and Causeway Bay shorelines was envisaged under the WDIICFS, from the interface with the CRIII project on the west side of the Hong Kong Convention and Exhibition Centre (HKCEC) Extension, to the east of the Causeway Bay Typhoon Shelter.

1.1.4 The Trunk Road and the associated land use proposals for the WDII project were incorporated in a draft Wan Chai North Outline Zoning Plan No. S/H25/1 (the draft OZP), which was gazetted under the Town Planning Ordinance on 19 April 2002.[1] At the same time, the road works and reclamation proposed under the WDII project were gazetted under the Roads (Works, Use and Compensation) Ordinance and Foreshore and Sea-bed (Reclamations) Ordinance respectively. A copy of the Wan Chai North OZP, which shows the WDIICFS proposals, is attached at **Annex A**, for reference.

1.1.5 Objections to the draft OZP were received and considered by the Town Planning Board, which decided to propose amendments to the draft OZP to meet or partially meet some of the objections after giving preliminary consideration and further consideration to the objections on 6 September 2002, and 29 November 2002 and 6 December 2002, respectively; and after giving consideration to further objections on 14 February 2003.

1.1.6 In February 2003, the Society for the Protection of the Harbour Limited sought a judicial review of the decisions of the Town Planning Board made on 6 December 2002 and 14 February

[1] *The draft Wan Chai North OZP No. S/H25/1 excludes the area between the HKCEC Extension and the CRIII works; this area falls within the approved Central District (Extension) OZP No. S/H24/6. The area of reclamation proposed under the gazetted draft Wan Chai North OZP was 26ha, rather than the 28.5ha proposed under the WDIICFS. The reclamation area proposed in the Wan Chai North OZP included the Harbour Park at the Causeway Bay Typhoon Shelter breakwater.*

2003 in connection with the draft OZP and its compliance with the Protection of the Harbour Ordinance (PHO). The High Court handed down its judgment on 8 July 2003, whereby the decisions of the Town Planning Board made on 6 December 2002 and 14 February 2003 in respect of the draft OZP were quashed. According to the High Court judgment, the purpose and extent of each proposed reclamation ought to be individually assessed by reference to the three tests of (1) compelling, overriding and present need, (2) no viable alternative and (3) minimum impairment (the “Three Tests”). The Court also ordered the Town Planning Board to reconsider the draft OZP and the objections thereto. As this interpretation of the PHO would apply to all future planning of harbour front areas which included reclamation, and due to the great general and public importance of the case, the Town Planning Board appealed directly to the Court of Final Appeal (CFA).

1.1.7 Objections were also received for the WDII road works and reclamation schemes gazetted under the Roads (Works, Use and Compensation) Ordinance and Foreshore and Sea-bed (Reclamations) Ordinance respectively. In the light of the on-going legal proceedings, it was considered not appropriate to submit the road works and reclamation schemes to the Chief Executive in Council for consideration. The above gazettals lapsed on 18 and 19 September 2003 respectively. The WDII project will have to be re-gazetted under the relevant ordinances at an appropriate time.

1.1.8 In October 2003, the Town Planning Board considered the findings of a preliminary planning assessment on the draft OZP conducted by Planning Department according to the High Court’s judgment on the judicial review quashing its decisions related to the draft OZP, and requested Government to conduct a comprehensive review of the planning and engineering proposals of the WDII project and draw up a minimum reclamation option for Wan Chai North that would comply with the law. The Town Planning Board will reconsider the draft OZP and the objections according to the provisions of the Town Planning Ordinance upon completion of the review.

1.1.9 On 9 January 2004, the CFA handed down its judgment on the judicial review. The CFA ruled that the presumption against reclamation in the PHO can only be rebutted by establishing an overriding public need for reclamation (the "Overriding Public Need Test"), and that there must be cogent and convincing materials available to enable the decision-maker to be satisfied that the test is fulfilled for rebutting the presumption against reclamation.

1.1.10 Following the Town Planning Board's request for a review of the WDII proposals in October 2003 and in the light of the CFA judgment handed down in January 2004, Government has undertaken to conduct a comprehensive planning and engineering review of the development and reclamation proposals for the WDII project (the WDII Review). The WDII Review commenced in March 2004.

1.2 The CFA Judgment and the PHO

The Protection of the Harbour Ordinance

1.2.1 The PHO was enacted to protect and preserve the harbour by establishing a presumption against reclamation in the harbour. Section 3 of the Ordinance provides:

> "(1) The harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people, and for that purpose there shall be a presumption against reclamation in the harbour.
>
> (2) All public officers and public bodies shall have regard to the principle stated in subsection (1) for guidance in the exercise of any powers vested in them."

The Court of Final Appeal Judgment

1.2.2 The CFA handed down its judgment on 9 January 2004 in respect of the judicial review on the Draft Wan Chai North OZP (No. S/H25/1). A copy of the CFA judgment is enclosed for reference at **Annex B**. The following is extracted from the summary of the judgment given by the Chief Justice as the unanimous judgment of the CFA, prepared by the Judiciary.

Overriding public need

1.2.3 In order to implement the strong and vigorous statutory principle of protection and preservation, the presumption must be interpreted in such a way that it can only be rebutted by establishing an overriding public need for reclamation ("the overriding public need test"). The statute, in conferring on the harbour a unique legal status, recognises the strong public need to protect and preserve it. The statute envisages that irreversible loss to the extent of the reclamation would only be justified where there is a much stronger public need to override the statutory principle of protection and preservation.

1.2.4 Public needs would of course be community needs. They would include the economic, environmental and social needs of the community.

1.2.5 A need should only be regarded as overriding if it is a compelling and present need.

1.2.6 A compelling and present need goes far beyond something which is "nice to have", desirable, preferable or beneficial. But on the other hand, it would be going much too far to describe it as something in the nature of the last resort, or something which the public cannot do without. A present need takes into account the timescale of planning exercises, and that the need would arise within a definite and reasonable time frame.

1.2.7 Where there is a reasonable alternative to reclamation, an overriding need for reclamation would not be made out. All circumstances should be considered, including the economic, environmental and social implications of each alternative. The cost as well as the time and delay involved would be relevant. The extent of the proposed reclamation should not go beyond the minimum of that which is required by the overriding need. Each area proposed to be reclaimed must be justified.

1.2.8 The overriding public need test should be regarded as a single test and is a demanding one.

Cogent and convincing materials

1.2.9 To enable a public officer or body to be satisfied that the overriding public need test has been met, the materials in the case in question must be cogent and convincing.

1.3 WDII Review Objective

1.3.1 The main purpose of the WDII project is to provide land within the WDII project area for the construction of the Trunk Road (comprising the CWB which runs from Rumsey Street Flyover and the Central Interchange in Central Reclamation Phase I through the CRIII and WDII project areas, and the IECL which provides connection from the eastern portal of the CWB to the IEC), and other key transport infrastructure including the necessary ground level roads for connection to the Trunk Road and to cater for through traffic from Central to Wan Chai and Causeway Bay.

1.3.2 Rail infrastructure that would be accommodated by the WDII project includes the Hong Kong Island section of the Shatin to Central Link (SCL) and the future Mass Transit Railway (MTR) North Hong Kong Island Line (NIL). However, it is expected that the SCL and NIL can be accommodated within existing land and any land that may be formed for the Trunk Road, without further reclamation. In the event that additional reclamation is required for the SCL and NIL, then that reclamation will have to be justified by the SCL and NIL projects.

1.3.3 The land formed for the above transport infrastructure will provide opportunities for the development of an attractive waterfront promenade of international standard for the enjoyment of the public.

1.3.4 The WDII Review seeks to assess individually the purpose and extent of each proposed reclamation by reference to the Overriding Public Need Test and, if needed, to make recommendations on the revised alignment for the Trunk Road and at-grade roads, extent of reclamation and/or the land uses for the review area covered by the assignment. Cogent and convincing materials are required for justifying the conclusion of the WDII Review.

1.4 Harbour-Front Enhancement Review

1.4.1 The Harbour-front Enhancement Committee (HEC) was established in May 2004 to advise Government, through the Secretary for Housing, Planning and Lands, on the planning, land uses and developments along the existing and new harbour-front of Victoria Harbour. As guidance for the planning, development and management of the Victoria Harbour and the harbour-front areas, the HEC has established harbour planning principles which should be followed when examining transport infrastructure, including the Trunk Road, and harbour-front enhancement schemes. These are:

- preserving Victoria Harbour
- stakeholder engagement
- sustainable development
- integrated planning
- proactive harbour enhancement
- vibrant harbour
- accessible harbour
- public enjoyment.

1.4.2 The HEC has set up a Sub-committee, namely the Sub-committee on WDII Review, to advise on the WDII Review. Government has accepted the recommendation by the Sub-committee on WDII Review that enhanced participation should be a key element of the Review. To achieve this, a public engagement exercise, namely the "Harbour-front Enhancement Review – Wan Chai, Causeway Bay and Adjoining Areas" (HER), is being carried out under the steer of the Sub-committee on WDII Review. Results of the HER project will provide inputs to the WDII Review.

1.4.3 In order to achieve a better understanding of the opportunities for waterfront enhancement and to ensure a high degree of community support for the future draft OZPs and the draft Recommended Outline Development Plan (RODP), a 3-stage public engagement strategy has been formulated so as to enable a more structured approach to be adopted to the HER public engagement activities:

(i)	"Envisioning Stage"	Public to provide their visions, wishes and concepts, as well as to compile Sustainability Principles and Indicators as a basis for the development of the Concept Plan
(ii)	"Realization Stage"	Public to evaluate the Concept Plan to arrive at consensus
(iii)	"Detailed Planning Stage"	Ensure draft OZPs and RODP reflect the consensus.

1.4.4 The Envisioning Stage was formally launched on 22 May 2005, with a wide range of public engagement activities taking place over a two-month public engagement period. The envisioning exercise was to engage the public in identifying the key issues and establishing principles in terms of improving the waterfront. The concept of sustainable development underpins the whole HER project. A list of sustainability principles and indicators has been prepared and agreed through the public consultation process; these agreed sustainability principles and indicators will be used to evaluate the Concept Plan that is developed in the Realization Stage.

1.4.5 As part of the Envisioning Stage public engagement activities, the HEC Sub-committee on WDII Review convened an "Expert Panel Forum on Sustainable Transport Planning and Central-Wan Chai Bypass", to explore sustainable transport along the northern shore of Hong Kong Island and to deliberate on whether the CWB (ie the Trunk Road) is needed – one of the key issues of the project.

1.4.6 The HEC Sub-committee on WDII Review convened a "Envisioning Stage – Consolidation Forum" to conclude the Envisioning Stage of the HER project, on 12 November 2005. The aim of the forum was to share with the public the comments and proposals received during the public engagement activities held from May to July 2005 for the Envisioning Stage of HER, and to involve the public in consolidating these views before proceeding with the preparation of the Concept Plans for the development and enhancement of the harbour-front of Wan Chai, Causeway Bay and the adjoining areas. Following the Consolidation Forum, the various issues that were raised by participants during the public engagement process, particularly in respect of Trunk Road alignments and harbour-front enhancement ideas, were extensively considered and addressed by the Sub-committee on WDII Review as part of the process of consolidating harbour-front and Trunk Road ideas. The outcomes of this process then formed the basis of the preparation of the Concept Plan in the Realization Stage.

1.4.7 A Concept Plan, for the development and enhancement of the harbour-front under the ambit of the WDII Review, has been prepared for evaluation and consensus building by the public, using the HEC's harbour planning principles and the sustainability principles and indicators that have been developed during the Envisioning Stage. At a Consensus Building Town Hall meeting on 16 December 2006, there was general agreement with the proposals put forward by the Concept Plan, in respect of the Trunk Road proposal and the envisaged land uses, although there was some discussion on various detailed aspects of the harbour-front enhancement schemes.

1.4.8 On the basis of consensus on the Concept Plan, detailed planning, engineering and environmental assessments will be carried out for the derivation of the relevant OZPs and the RODP, which will reflect the consensus on the Concept Plan.

1.4.9 Hong Kong Island District Councils, Legislative Council, as well as statutory, advisory and professional bodies have been widely consulted throughout the process of the HER project.

1.5 Approach to Demonstrating Compliance with the CFA Judgment

1.5.1 Whilst the emphasis of the HER is on the planning of the harbour-front with a view to protecting the Harbour and improving accessibility, utilisation and vibrancy of the harbour-front areas, a holistic approach must be taken in integrating the harbour-front development with essential transport infrastructure required under the WDII project, this being mainly the need to complete a long-planned strategic road link along the north shore of Hong Kong Island, ie the Trunk Road connecting Rumsey Street Flyover in Central and the IEC to the east of Causeway Bay. Any land that may be formed along the shoreline to facilitate the Trunk Road construction will then provide further opportunity for harbour-front improvement.

1.5.2 It is the Trunk Road which forms the basis of the WDII project proposals and which ultimately determines the form of the waterfront along this part of the north shore of Hong Kong Island. The Trunk Road must, itself, pass the Overriding Public Need Test, such that it satisfies the CFA's ruling on compliance with the PHO.

1.5.3 A step by step approach is taken to ensure that the project satisfies the CFA's judgment.

1.5.4 The first step is to confirm that there is an overriding and present need for the whole Trunk Road in the first place. In Chapter 2, this need is demonstrated through a district traffic study and confirmed by a panel of independent local and overseas experts in their relevant fields: the "Expert Panel on Sustainable Transport Planning and Central-Wan Chai Bypass".

1.5.5 Having established the need for the Trunk Road, the next step is to identify any reasonable alternative to reclamation (ie "no-reclamation" options) in its implementation. If there is a feasible "no reclamation" option, then it should be pursued. Chapter 3 addresses this issue, including ideas put forward by the public, with the emphasis on minimising, if not eliminating, the extent of reclamation, while meeting the public need for the project, and finds that there are, in fact, no feasible "no reclamation" options.

1.5.6 Having established that there is no reasonable alternative to reclamation, the third step is to ensure that reclamation is restricted to only the minimum amount necessary to meet the overriding public need. Chapter 4 examines in more detail feasible and reasonable options in respect of the degree to which they serve to meet the overriding public need, and in terms of their extent of reclamation.

1.5.7 Public views on the need for the Trunk Road and the associated reclamation proposals are an essential part of the process of achieving consensus on the selection of the preferred scheme. Chapter 5 highlights the feedback from the extensive public engagement process.

1.5.8 In Chapter 6, the scheme that meets the overriding public need and that has the minimum extent of reclamation required by the overriding need is recommended as the preferred Trunk Road scheme. For this scheme, the associated ground level road network and requirements for reprovisioning of affected facilities are examined to determine if any additional reclamation, over and above that required for the Trunk Road itself, is necessary. If so, then the overriding public need for that additional reclamation must be satisfied. The public's proposed harbour-front enhancement ideas are taken on board in the development of a Concept Plan, based on the preferred Trunk Road scheme. Any additional reclamation requirements arising from the implementation of the Concept Plan are identified.

1.5.9 In Chapter 7, the reclamation requirements of the preferred scheme are defined more precisely and examined in detail to demonstrate that the extent of reclamation is indeed the minimum required by the overriding need.

1.5.10 Finally, Chapter 8 summarises the conclusions of the compliance with the overriding public need test.

1.6 Purpose of this Report

1.6.1 This Report sets out the process by which the Trunk Road scheme and its associated reclamation has been derived, in response to the CFA judgment handed down on 9 January 2004 in respect of the judicial review of the Draft Wan Chai North OZP (No. S/H25/1).

1.6.2 The report presents cogent and convincing materials to demonstrate the compliance with the Overriding Public Need Test.

1.6.3 The report has been prepared with reference to the requirements of Housing, Planning and Lands Bureau (HPLB) and Environment, Transport and Works Bureau (ETWB) Circular No. 1/04 on Protection of the Harbour Ordinance, for the consideration of the reclamation proposals of the WDII project.

2 THE NEED FOR THE TRUNK ROAD

2.1 Introduction

2.1.1 The basis of the WDII project and the core transport infrastructure for which the project provides is the Trunk Road. The Trunk Road is defined from the connection with the existing Rumsey Street Flyover and the Central Interchange in Central, through to a connection with the existing IEC to the east of the Causeway Bay Typhoon Shelter. At the Rumsey Street Flyover connection, a Central Interchange will provide connections into the Central area, and then the Trunk Road will drop down into tunnel and run along the Central shoreline, through CRIII, to the WDII project area. In WDII, the Trunk Road will continue in tunnel until it needs to rise onto elevated flyover structure to connect with the elevated IEC. The section of the Trunk Road that runs in tunnel through CRIII and WDII is also known as the CWB, whilst the section of the Trunk Road on flyover, for the connection with the IEC, is also known as the IECL.

2.1.2 The Trunk Road will form an east-west strategic route through Central and Wan Chai. The Trunk Road is an essential element of Government’s strategic transport planning for Hong Kong; it is the “missing link” in the strategic highway running along the northern part of Hong Kong Island. The Trunk Road is required to provide relief to the existing main east-west route (Connaught Road Central – Harcourt Road – Gloucester Road).

2.1.3 The Trunk Road was originally proposed under the Central and Wanchai Reclamation Feasibility Study, completed in 1989, where its feasibility was established. The need for the Trunk Road was reaffirmed in the WDIICFS, completed in 2001, which demonstrated an urgent need for the link to be put in place in order to relieve the existing and growing congestion along the east-west corridor of Hong Kong Island North. A number of strategic traffic studies have also confirmed the need to improve the flow of the east-west traffic through Central and Wan Chai, including the Long Term Road Study completed in 1968 and the First, Second and Third Comprehensive Transport

Studies (CTS) completed in 1976, 1989 and 1999 respectively. A recent rerun of the CTS-3 transport model also confirmed the need for the CWB despite changes in land use planning assumptions and population projections.

2.1.4 Following the 9 January 2004 CFA ruling on compliance with the PHO, the compelling and present need for the Trunk Road to meet the transport needs of the community within a reasonable and definite planning time frame, and to meet the social and economic needs of the community, was established under the CRIII project, and is presented in “A Review of Central Reclamation Phase III by applying the Court of Final Appeal’s “Overriding Public Need Test” April 2004”. A full copy of this report is available for viewing on the HPLB website at: http//www.hplb.gov.hk/reclamation/images/review02apr04.pdf.

2.1.5 Under the WDII project, the need for the Trunk Road has also been confirmed. This is the essential first step in complying with the CFA ruling on establishing an overriding public need for reclamation, ie that there must be a compelling and present need for the Trunk Road in the first place.

2.2 Existing Situation

Existing Road Network

2.2.1 The Central Business District (CBD) is currently served by the east-west Connaught Road Central / Harcourt Road / Gloucester Road Corridor (the Corridor). This Corridor is primarily a dual four-lane urban trunk road serving as a key east-west link for Hong Kong Island North. At the same time, it also serves as a distributor road providing north-south connections to various districts.

2.2.2 The Corridor is currently serving as an “Urban Trunk Road”, which bears the responsibility of carrying the long-haul traffic between east and west of Hong Kong Island. It is also serving as a “Distributor Road” providing key accesses to its adjacent areas with very short connecting roads. The Corridor is over-saturated and too heavily used by the traffic towards its adjacent areas to discharge its intended function as an Urban Trunk Road. Furthermore, the Corridor has many junctions with side roads, underpasses and flyovers creating substantial weaving and merging movements. Traffic queues from any bottlenecks at its side roads or its main section result in blockage of other movements and rapid deterioration of traffic conditions. A minor accident or incident occurring along or in the vicinity of the Corridor often results in serious congestion and delay on the road network, and, in some more serious cases, gridlock of the whole CBD and complete blockage of the Corridor. These are clear indications that the stability and reliability of both the strategic road network and the Central and Wan Chai local road network are in an unsatisfactory state.

Existing Traffic Pattern

2.2.3 The existing Corridor is already operating beyond its design capacity. Congestion along the Corridor is not limited to the typical morning and evening peak hours. Regular traffic congestion can be observed between 8am and 8pm during weekdays. Eastbound traffic heading for the CBD often queues back to the Western Harbour Tunnel approach along the Rumsey Street Flyover and also the at-grade Connaught Road Central. Traffic westbound to the CBD often tails back to the Wan Chai Sports Ground along Gloucester Road.

2.2.4 Regular traffic queues along the Corridor are also found in the direction of the Cross Harbour Tunnel, the Aberdeen Tunnel and the Causeway Bay area. These regular traffic queues use up the valuable road spaces of the Corridor, rendering unnecessary delay to the through traffic between the eastern and western parts of Hong Kong Island.

2.2.5 **Annex C** illustrates the existing traffic situation in terms of the extent of traffic queues when the Corridor is blocked.

The "Missing Link"

2.2.6 The need to provide a strategic trunk road along the northern shore of Hong Kong Island has long been identified. The Trunk Road is the missing link required to complete this strategic route (**Annex D**). The Trunk Road is needed to divert through traffic away from the CBD and from the Corridor. It is also needed to cater for the anticipated natural growth of traffic and to alleviate the already existing congestion on the road networks. Without the Trunk Road, there will not be sufficient capacity to serve the heavy demands at both the strategic and local levels. The Trunk Road is needed to ensure the provision of a functional and balanced road network on Hong Kong Island and, to do this, the Trunk Road also needs to have adequate intermediate access points to serve the CBD so as to alleviate the burden of the Corridor.

2.3 Traffic Forecasts

2.3.1 Traffic studies have long predicted the consequences of continued traffic growth on the Corridor without the implementation of the Trunk Road. Recent traffic studies have confirmed the need for the Trunk Road after taking into account the latest land use planning assumptions and population projections, to ensure that traffic forecasts are in line with current strategic and local planning intentions. The Third Comprehensive Transport Study and a District Traffic Study have examined traffic conditions at these strategic and local levels, for the cases with and without the implementation of the Trunk Road.

The Third Comprehensive Transport Study

2.3.2 The Comprehensive Transport Study (CTS) model is based on reasonable assumptions and parameters on land use planning, population, employment, economic growth, vehicle fleet size, rail and road network information and is calibrated regularly using field traffic survey data.

2.3.3 The Third Comprehensive Transport Study (CTS-3) model rerun predicted that the peak-hour traffic demand along the Corridor will increase by about 30% from 2004 to 2016, which will result in longer queue lengths and longer periods of traffic congestion every day in the Corridor. Without the Trunk Road, travelling along the 4-km Corridor will take about 45 minutes at a speed of 5km/hr in 2011. The stagnant traffic will have a spill over effect leading to congestion in the neighbouring roads in Central and Wan Chai, and complete gridlock in the road network may easily occur. With the completion of the Trunk Road, traffic congestion along critical sections of the Corridor can be relieved.

2.3.4 In order to test the effects of different growth rates of the four key planning inputs on population, employment, Gross Domestic Product and vehicle fleet size, sensitivity tests using growth rates different from those being adopted in the base case have been carried out. The results show that variations in the growth rates of these inputs will not result in significant change in traffic demand. Even if the growth rates of all these parameters were reduced by half, the percentage change in traffic demand would be decreased by 10% only. However, based on the historical trends of the parameters, it is most unlikely that this situation will occur. The sensitivity test results reinforce the recommendation that the Trunk Road is required.

2.3.5 Tests had been conducted on the effect of having equal tolls at the three cross harbour tunnels by setting the toll level for private cars using the three tunnels at $20 and $30 respectively. The main effect is a redistribution of traffic among the three tunnels. As the Cross Harbour Tunnel traffic only accounts for about 25% of all traffic along the section of Gloucester Road outside Immigration Tower, the redistribution of traffic will reduce the traffic in Gloucester Road by only 1 to 2 %. However, traffic in Connaught Road Central will be increased by 4 to 5% due to traffic redistributed to the Western Harbour Crossing. Also examined is the effect of having differential toll by time at the Cross Harbour Tunnel. It is noted that hourly traffic volume through the Cross Harbour Tunnel has already reached the saturation level throughout the day time from 7:30am to midnight. There is very little spare capacity at the tunnel before 7:30am and virtually no spare capacity at the tunnel at the inter-peak period (ie between the morning and evening peak periods) to absorb traffic redistributed from the peak periods or from other tunnels if the toll levels of the tunnel were to be increased in the peak periods and decreased in other periods. Again, such toll adjustment would mainly result in a re-distribution of traffic among the three tunnels so that the reduction to Gloucester Road traffic would only be marginal as in the case of adopting equal tolls for the three tunnels.

2.3.6 From 1995 to 2005, the total length of railways in Hong Kong has increased by about 87% whereas the total length of roads has increased by only 13%. About $100 billion was spent on new railway projects as compared with $53 billion on new roads. The railway system has been expanded significantly over the years according to the "railway as backbone" policy, and further expansion is assumed in the traffic demand forecast. The proposed rail lines including Shatin to Central Link, West Hong Kong Island Line (from Sheung Wan to Kennedy Town), and South Hong Kong Island Line, which have direct connection to the existing rail lines along the northern Hong Kong Island, are assumed to be in place by 2016 in the model.

2.3.7 Traffic growth in the Corridor has been about 40% to 70% in the past 15 years. Without the Trunk Road, the future traffic growth will be suppressed due to severe traffic congestion. Longer queue lengths and longer period of congestion will occur. It is estimated that the average delay to the passengers in the Corridor will be 20 minutes and based on the number of passengers in the Corridor in 2004, the time lost will cost the passengers about $1.8 billion per year.

District Traffic Study

2.3.8 In addition to the CTS-3 territorial traffic forecasts, a district traffic model was developed for the review and reappraisal of the need for and the scope of the Trunk Road. The district traffic model covered the Central, Wan Chai and Causeway Bay area and was set up using the SATURN (Simulation and Assignment of Traffic to Urban Road Network) suite of traffic analysis programmes. For the purpose of testing the future traffic situation, the design year 2016 was adopted in the assignment. The corresponding CTS-3 design year cordon matrices were used to define the boundary conditions of the district area traffic model. Five sets of traffic forecasts were undertaken to simulate the traffic situation at the Central, Wan

Chai and Causeway Bay areas. Peak hours traffic flows were simulated for the five test scenarios.

Road network configuration

2.3.9 The configuration of the proposed Trunk Road (CWB) tested in the district traffic model was determined to fulfill the following general functional requirements:

- the CWB would be a dual 3-lane road, with local widening to suit the slip roads;
- with an interchange at the west (the Central Interchange) connecting the existing Rumsey Street Flyover with the CWB with slip roads to the distributor road system on the Central Reclamation Phase I;
- with connection to the existing IEC at the east (the IECL) and with existing connections between the IEC and Gloucester Road and Hing Fat Street maintained;
- with slip road connections at Wan Chai and Causeway Bay to provide essential connectivity between the Trunk Road and the local road network.

2.3.10 The slip road connections in Wan Chai North and Causeway Bay adopted in the District Traffic Study represented the minimum requirement after detailed review; they comprise:

- Slip Road 1, for traffic from Central and the Western districts of Hong Kong Island to exit the eastbound Trunk Road tunnel, going to Wan Chai. This slip road also allows traffic connection from the Trunk Road eastbound to Causeway Bay and Tin Hau, as no direct slip road connection from the Trunk Road is provided in Causeway Bay for this movement.
- Slip Road 2, for traffic from the Admiralty and Wan Chai areas to enter the eastbound Trunk Road tunnel, going to the IEC and then North Point and other Eastern districts of Hong Kong Island.
- Slip Road 3, for traffic from the IEC (ie from North Point and other Eastern districts of Hong Kong Island) to exit the westbound Trunk Road tunnel, going to Wan Chai North and beyond to the Wan Chai hinterland and Admiralty.

- Slip Road 8, for traffic from Causeway Bay, Tai Hang, Fortress Hill and Tin Hau areas to enter the westbound Trunk Road tunnel, going to Central and Western districts of Hong Kong Island.

2.3.11 These slip roads provide essential connectivity between the Trunk Road and the local road network, by drawing traffic away from the overloaded sections of Connaught Road Central / Harcourt Road / Gloucester Road. If access to the Trunk Road is not available, it cannot be properly utilised. The demand for a bypass comes not just from traffic from the western side of Hong Kong Island to the eastern side of the Island and vice versa; traffic to/from intermediate areas such as Admiralty, Wan Chai and Causeway Bay also contribute to the congestion in this area. Restricting access to the Trunk Road for this traffic will undermine its purpose in relieving traffic congestion on the overloaded east-west corridor.

2.3.12 It should be noted that an eastbound slip road from the Trunk Road to Victoria Park Road proposed in the previous Trunk Road scheme has not been further pursued, as its function could be substituted by alternative road improvement schemes and in view of the need to avoid reclamation that would otherwise be required for this slip road.

2.3.13 The at-grade roads within the site of CRIII, which had been authorised and were under construction, were included without change in the district traffic model. Road P2 is the major element of the future ground level road system; it is a primary distributor servicing the Central and Wan Chai North areas, and is an integral component of the road network by distributing traffic through these areas and relieving the existing congestion, including that caused by the growing traffic demand within Central, in particular traffic generated from the completed Central Reclamation Area north of Exchange Square. Road P2 runs east-west through CRIII, and the proposed Road P2 within the limit of CRIII is extended eastward to WDII as a through road and is mainly a dual 2-lane road. In Wan Chai North, the Road P2 would run between the gap of HKCEC Phases 1 & 2 and then connect to the existing Hung Hing Road. Hung Hing

Road would either be widened in-situ or realigned to cope with the anticipated traffic flow.

Traffic modelling scenarios

2.3.14 Traffic modelling was carried out to test various scenarios with and without the Trunk Road, slip roads and Road P2, and with and without the proposed development in CRIII, to robustly ascertain the need for the proposed roads to meet forecast traffic demand. No new development in WDII was assumed for all scenarios.

2.3.15 The assumptions of the test scenarios are as follows:

<u>Scenario A</u>

With the Trunk Road, **with** Road P2, **with** the slip roads in WDII, and **with** the proposed developments in CRIII.

<u>Scenario B</u>

Without the Trunk Road, **without** Road P2, **without** the slip roads in WDII, and **with** the proposed developments in CRIII.

<u>Scenario B1</u>

Without the Trunk Road, **without** Road P2, **without** the slip roads in WDII, and **without** the proposed developments in CRIII.

<u>Scenario C</u>

With the Trunk Road, **with** Road P2, **without** the slip roads in WDII, and **with** the proposed developments in CRIII.

<u>Scenario D</u>

With the Trunk Road, **without** the at-grade road P2, **without** the associated slip roads in WDII, and **without** the proposed developments in CRIII.

2.3.16 The scenario testing shows that a dual 3-lane Trunk Road, with slip roads, and Road P2 are required even if there is no new development in WDII and if all the not-yet-started developments in CRIII are removed. A summary of these results is given in the table below.

Table 2.1 Summary of Modelling Assumptions and Results of the 5 Test Scenarios

	Trunk Road (CWB)	Road P2	WDII Slip Roads	Develop-ment in CRIII	Traffic Modelling Results	
					V/C of Major Road Sections along the Corridor	**RC of Major Road Junctions in Central & Wan Chai**
Scenario A	✔	✔	✔	✔	Generally below 1, except along the westbound Inner Gloucester Road.	Generally with some reserve capacities.
Scenario B	×	×	×	✔	All above 1.2 along both eastbound and westbound. Some as high as 1.55.	Most of the critical junctions have negative reserve capacities.
Scenario B1	×	×	×	×	Most of the west-bound road sections with v/c above 1.2. Some as high as 1.53.	Many of the critical junctions have negative reserve capacities.
Scenario C	✔	✔	×	✔	Many of the east-bound road sections with v/c above 1. Some as high as 1.13.	Some critical junctions have negative reserve capacities.
Scenario D	✔	×	×	×	Most of the east-bound road sections with v/c above 1. Some as high as 1.13.	Most of the critical junctions in Wanchai have negative reserve capacities.

Notes: (1) V/C is Volume to Capacity Ratio
(2) RC is Reserve Capacity

2.4 Traffic Management Measures

2.4.1 A review of alternative traffic management measures, including road pricing, was carried out to determine if the implementation of such measures could resolve the traffic problems along the Corridor and thereby do away with the need for the Trunk Road.

2.4.2 Hong Kong's successful provision of a highly efficient and reliable transport system hinges on the adoption of the long established transport policy with emphasis on a 3-pronged approach, comprising the management of road use, the expansion and improvement of public transport, and the improvement of transport infrastructure. These principles have stood the test of time and they represent solutions from both the supply and demand sides, rather than simply relying on indiscriminately suppressing the demand through high tolls and charges, which alone may not be effective to curb traffic congestion problems. Electronic Road Pricing (ERP), as a form of demand management measure, cannot replace the need of a new strategic infrastructure such as the trunk Road; rather, such measures would complement the Trunk Road.

2.4.3 At present, Hong Kong's transport system can be characterised by:

(i) optimum use of traffic management measures such as one-way gyratory road systems, bus lanes, bus gates, no stopping zones as well as demand management measures like first registration tax, annual licence fee and fuel duty on private car;

(ii) a highly efficient public transport system in the form of both rail and road providing a high level of service and reliability to the general public; and

(iii) a comprehensive road network.

2.4.4 As a result, about 90% of all passenger trips are already carried by public transport mode and Hong Kong has achieved a very low private car ownership rate of 50 per 1,000 population, as compared with London and Singapore of 350 and 120 respectively.

2.4.5 The suggestion of adopting an equal toll for the Western Harbour Crossing and Cross Harbour Tunnel, so as to reduce utilisation of the latter, is not expected to significantly relieve congestion in the Central and Wan Chai areas, as most of the traffic would still need to go through Central.

2.4.6 A Feasibility Study on ERP (2001) concluded that the implementation of an ERP system in Hong Kong was technically feasible, but drastic restraint measures such as ERP were not warranted on traffic management grounds if the growth of the private vehicle fleet was no more than 3% per year.

2.4.7 Overseas experience in London[2] and Singapore has shown that implementation of ERP needs to be supported by alternative routes or bypasses having sufficient capacity to receive the diverted traffic generated from those not intending to enter the charging zone. Such an alternative is fair and necessary as it gives motorists an option whether to pay the charge or not. The consultation results of the PRoGRESS[3] urban road charging demonstration project in Europe have reinforced the need for alternative routes.

2.4.8 In Hong Kong, because of the geographical constraints around the CBD, such an alternative route does not exist. The use of ERP would not be effective in the absence of the Trunk Road, which is needed to divert the east-west through traffic; the through traffic accounts for 40% of the traffic flows across the CBD. Without an alternative route or a bypass, all motorists travelling in the east-west direction would be forced to pay even though they do not intend to go into the CBD.

2.4.9 Furthermore, the percentage of private car traffic going into the London CBD before congestion charging is higher than that in Hong Kong (51% in London compared with 38% in Hong Kong). This shows that we have already removed a lot of non-essential traffic from the CBD through existing traffic and demand management measures. Clearly, it will be harder for

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2 *Road Charging Options for London: A Technical Assessment, ROCOL Working Group, Nov 1999, p.24*

3 *Final Main Project Report of PRoGRESS, July 2004, p.58*

Hong Kong to achieve any further suppression, even with high ERP charges. Assuming that similar effects on different modes of the London scheme apply to Hong Kong, the net traffic reduction in daily volume would only be about 8%, since Hong Kong has a different vehicle composition to that of London. The reduction in peak hour flows along the Connaught Road Central – Harcourt Road – Gloucester Road Corridor would be even lower.

2.4.10 Thus, demand management measures cannot be relied on alone to effectively solve a major congestion problem. New infrastructure is needed to meet the reasonable demand, and to provide an alternative route for through traffic to bypass the ERP charging zone. ERP can complement the Trunk Road, but cannot replace it.

2.4.11 Details of traffic forecasts and traffic management measures are provided in a submission to the "Expert Panel Forum on Sustainable Transport Planning and Central-Wan Chai Bypass" (see below) by Transport Department, in **Annex E**.

2.5 Expert Panel

2.5.1 The diverse views on transport issues, including opposing views on the need for the Trunk Road and the preference for the implementing ERP instead of the Trunk Road, raised during the public engagement activities of the Envisioning Stage of the HER being carried out by the HEC Sub-committee on WDII Review, prompted the Sub-committee to convene an "Expert Panel Forum on Sustainable Transport Planning and Central-Wan Chai Bypass" (the Expert Panel Forum). The Expert Panel was invited to explore sustainable transport along the northern shore of Hong Kong Island and to deliberate on whether the CWB (ie the Trunk Road) is needed.

2.5.2 The Expert Panel comprised local and overseas experts in all relevant fields, including transportation engineering, transport planning, civil and structural engineering, economics, environmental engineering and planning. The Expert Panel members were nominated by the Task Force on HER, Chartered Institute of Logistics and Transport in Hong Kong, Hong Kong

Institution of Engineers, Hong Kong Institute of Planners, Department of Civil and Structural Engineering of the Hong Kong Polytechnic University, Department of Civil Engineering of the Hong Kong University of Science and Technology, and Department of Civil Engineering of the University of Hong Kong. The independence of the Expert Panel is an important aspect in the determination of the need for the Trunk Road; there were no nominees from Government or parties associated with the WDII project and review.

2.5.3 To encourage interflow of views and ideas, the Expert Panel Forum was open to the public and opportunities were provided for stakeholders and interested parties to make written submissions to the Forum. Nineteen submissions were received from different organizations and members of the public prior to the Forum. Transport Department also made a detailed submission. Having reviewed the submission of Transport Department, additional traffic analysis and information were requested from Transport Department to ascertain the robustness of the traffic demand model and to verify the assumptions made in the traffic demand model.

2.5.4 The Expert Panel held five working group meetings and a site visit in August and September 2005 to consolidate members' views and recommendations. Public participation was fully encouraged throughout the Expert Panel Forum, held on 3 September 2005, to canvas the public's views and to engage in dialogue with participants.

The Need for the Central-Wan Chai Bypass (Trunk Road)

2.5.5 The Expert Panel found the recurrent congestion at the east-west Connaught Road Central / Harcourt Road / Gloucester Road corridor and the adjoining areas to be socially, economically and environmentally unacceptable. Analysis of the data showed that using complementary traffic management and fiscal measures to curtail vehicular growth and travel demand, short of draconian measures, would be ineffectual and socially undesirable.

2.5.6 Enhancing transportation infrastructure capacity in the corridor vicinity, which would take several years to fruition, would bring long-awaited relief over the medium haul to the Central and Wan Chai districts and greatly facilitate east-west traffic flow. The Panel therefore recommended the construction of a bypass as a medium term solution to tackle the problem of deteriorating traffic congestion in the Central and Wan Chai area. The Panel considered that the CWB is essential for improving the network reliability of the east-west link.

Recommendations of the Expert Panel

2.5.7 The Expert Panel provided the following short-term, medium-term and long-term recommendations for the sustainable transport planning of the Central and Wan Chai area.

2.5.8 Short-term measures:

(i) Transportation management measures

Measures include loading/unloading restrictions, junction improvement, public transport route rationalisation, etc, prior to the opening of the CWB.

(ii) Tunnel toll adjustment

Government should seriously consider differential tolling (tolling by time of day) by revamping the tolling arrangements of the three tunnels traversing the Victoria Harbour as a mitigating measure prior to the opening of the CWB.

(iv) Managing development programme

Government should address the need to regulate land-use developments throughout the Corridor area in order not to aggravate the congestion problem in the Corridor before the Bypass opens.

(v) Pedestrian access to the waterfront

Facilities for improvement of pedestrian access to the waterfront should also be provided in the interim.

2.5.9 Medium-term measures:

(i) Enhancing the multi-modal transport network

Since the existing transport infrastructure facilities could not meet current and future vehicular demand by 2016, the Panel members support the construction of the CWB to improve the reliability of the road network and to make use of the opportunities for enhancing multi-modal public transportation in the Corridor. They also support the provision of slip roads at the Hong Kong Convention and Exhibition Centre area and at the Victoria Park Road/ Gloucester Road/ Hing Fat Street passageway to magnify the benefits of the CWB.

(ii) Environmental and social concerns

Government should properly address the visual and environmental impacts and social concerns arising from the construction of the CWB.

(iii) Road P2

The Panel recognises the need for Road P2 as an important *ad interim* measure in addressing traffic congestion in the Central reclamation area before the CWB comes about. The Panel suggests that the Government also review the scale of P2 to match the gradual land development programme. While it may be necessary to reserve sufficient land for the full-scale development of Road P2 over the longer term, the Government should explore introducing *pro tempore* traffic calming measures on Road P2 and greening the reserve area in the meantime.

(iv) Road pricing

The Panel recognises the importance of road pricing as a sustainable transport measure. The Panel also recommends that Government should seriously consider implementing road pricing after undertaking a detailed assessment of the viability of alternative pricing schemes (electronic or otherwise), their relative effectiveness and social acceptability.

(v) The complementariness of road pricing and the Bypass

The Panel recognises that road pricing is a complementary measure to the construction of the CWB. The Panel also recognises a window of opportunity exists to introduce ERP at the opening of the CWB. Integrating ERP with road capacity enhancement thereby constitutes a package of measures that is more likely to be publicly acceptable and truly sustainable over the long term.

2.5.10 Long-term measures:

(i) Holistic approach towards transport/land use planning

The Panel recognises that Government has been taking an interactive approach towards land use and transport planning, and recommends that Government should further fortify this integration, placing due emphasis on the limitation of excessive transport infrastructural development in heavily congested areas.

(ii) An area-wide pedestrian network to the harbour-front

An area-wide pedestrian network linking the waterfront with the hinterland as well as to all means of transport modes should be developed, thereby connecting motorised and non-motorised transportation in a holistic way.

(iii) Incident management capability

Government should strengthen the management of traffic incidents along the Corridor to augment the reliability of the expanded road network.

(iv) The maintenance of reserve capacities

Government should review reserve capacities in the transport infrastructure to better the safety margin; these should be taken as a signal for stemming land use development.

(v) Sustainable transportation

Government should review and adopt best practices in sustainable transportation for Hong Kong. Government should also develop integrated policies, strategies and packages for sustainable transportation in Hong Kong for both motorised and non-motorised transportation.

Government's Responses

2.5.11 In addition to agreement on the construction of the CWB and Road P2, Government also agrees with the Expert Panel's recommendation on the need for continued short-term traffic management measures. While Government will continue to enhance its efforts in implementing various traffic management measures and taking a holistic approach to transport / land use planning, the feasibility of other measures as recommended by the Expert Panel are also being actively considered.

Details of the Findings of the Expert Panel

2.5.12 Reference can be made to 'Report of the Expert Panel on Sustainable Transport Planning and Central-Wan Chai Bypass' ('Report of the Expert Panel'). A copy of the Report of the Expert Panel is attached at **Annex F**, and it can also be found on the HEC website at: http://www.harbourfront.org.hk/eng/content_page/doc/report_of_the_expert_panel.pdf.

2.6 Cost Effectiveness of the Trunk Road

2.6.1 In measuring the cost effectiveness of a project, the overall benefit brought to the community by the project is examined. For transport infrastructure, the bulk of such benefit is related to the saving in travelling time for the public and congestion relief to adjacent roads.

2.6.2 The Internal Rate of Return (IRR) refers to the annual discount rate which makes the total return from the project over its project life just equal to the total investment. The IRR is calculated on the basis of benefits accrued from the project annually, through the project life, and the costs incurred in implementing and operating the project. For the proposed Trunk Road, the following parameters have been adopted:

- an estimated capital cost of the project of HK$20.5B (September 2006 price) which includes costs for 5 main works packages:
  - the Central Interchange
  - the CWB tunnel in CRI and CRIII
  - the CWB tunnel in WDII
  - electrical and mechanical works and tunnel installation works
  - the IECL;
- in the first year of operation, about 415,000 road users will benefit from using the new road;
- the average time saved by each passenger is 20 minutes;
- there are 300 days in a year that the Trunk Road will be fully used;
- the cost of passenger time is $67 (September 2006 price) per hour.

2.6.3 The IRR calculation, on the basis of the above parameters, indicates that the investment on the Trunk Road will generate an Economic Internal Rate of Return (EIRR) of about 17% after 40 years of operation, which is considered reasonable for an infrastructure project of this nature.

2.7 Summary of Findings

2.7.1 The existing east-west corridor (Connaught Road Central – Harcourt Road – Gloucester Road) serving the CBD on Hong Kong Island is already operating beyond its capacity, as can be observed on site. Previous and recent strategic transport studies have predicted further increase in traffic demand along the east-west corridor, and confirmed the need for a parallel east-west Trunk Road to avoid more extensive and frequent traffic congestion, and even gridlock, on the road network.

2.7.2 A district traffic study has confirmed that a dual 3-lane Trunk Road (or CWB), together with intermediate slip roads, is required to divert traffic away from the existing east-west corridor and to provide adequate relief to the corridor and the local road network.

2.7.3 Traffic management and fiscal measures are already in place to maximise the capacity of the existing road network and suppress traffic demand. Further measures including ERP have also been considered. However, all these existing and proposed measures, alone, cannot resolve the traffic congestion problem along the east-west corridor. In other words, the Trunk Road is essential, and ERP can complement the Trunk Road but cannot replace it.

2.7.4 The need for the Trunk Road has also been confirmed by the Expert Panel on Sustainable Transport Planning and Central-Wan Chai Bypass, comprising leading independent local and overseas transport planning experts. The Expert Panel supports the construction of the CWB to improve the reliability of the road network and to enhance multi-modal public transportation in the Connaught Road Central – Harcourt Road – Gloucester Road corridor. The Expert Panel agrees that the inability of the present infrastructure capacity to cope with the present and future travel demand would persist even if development in the Central reclamation area were stopped and territory-wide car ownership held unchanged from now until 2016, and therefore recommends the construction of the Trunk Road as a medium term solution to tackle the problem of deteriorating traffic congestion in the Central and Wan Chai area. The Expert Panel further supports the provision of the planned slip roads at the HKCEC area and at the Victoria Park Road / Gloucester Road / Hing Fat Street passageway, to magnify the benefits of the CWB. The Expert Panel also recognises the need for Road P2 both in the longer term and as an important ad interim measure in addressing traffic congestion in the Central reclamation area even before the CWB is implemented.

2.8 Conclusions on the Need for the Trunk Road

Is there an overriding public need for the Trunk Road ?

2.8.1 The Trunk Road is the "missing link" in the strategic road network of Hong Kong and will provide the essential east-west linkage between Rumsey Street Flyover in Central and the IEC in Causeway Bay. The implementation of the Trunk Road will relieve the existing congested east-west corridor of Hong Kong Island North.

2.8.2 The need for the Trunk Road has been clearly established through traffic and transport studies. The Expert Panel has confirmed the need for the Trunk Road and intermediate slip roads. The Expert Panel recommends the construction of a bypass as a medium-term solution to tackle the problem of deteriorating traffic congestion in the Central and Wan Chai area. The Expert Panel considers that the Trunk Road is essential for improving the reliability of the road network.

2.8.3 The findings of the traffic and transport studies, and of the Expert Panel, demonstrate conclusively the compelling and present need for the Trunk Road.

2.8.4 The HEC Sub-committee on WDII Review considered the report of the Expert Panel and supported the construction of a CWB at its meeting on 12 December 2005.

3 NO-RECLAMATION OPTIONS

3.1 Introduction

3.1.1 The need for the Trunk Road has been established; the next step is to determine any reasonable alternative to reclamation that may meet this overriding need. In other words, can an alternative alignment or form of construction for the Trunk Road be adopted that will obviate the need for reclamation? If there is a feasible "no reclamation" option, then it should be pursued. Only if the need for reclamation can be demonstrated to be necessary will scenarios involving minimum reclamation be contemplated.

3.1.2 A detailed examination of Trunk Road needs and constraints, including an exhaustive investigation into the need for reclamation for the Trunk Road construction and of alternative schemes that might do away with reclamation or, at least, minimise reclamation, has been carried out. A "Report on Trunk Road Alignments and Harbour-front Enhancement, April 2006" was submitted to the HEC Sub-committee on WDII Review, which set out the findings of these investigations and the conclusions regarding the need for reclamation and the minimum extent of reclamation.

3.1.3 A copy of the HEC Report on Trunk Road Alignments and Harbour-front Enhancement is attached at **Annex G**.

3.1.4 The investigation of "no reclamation" options starts with the identification of alignment constraints through the WDII project area and, in view of these constraints, the feasible Trunk Road route corridors. Alternative Trunk Road ideas, including suggestions from the public, are examined to determine if any of these would constitute a "no reclamation" option. For the feasible Trunk Road routeing and taking into account engineering constraints, a conclusion can be drawn as to whether there is any feasible "no reclamation" option.

3.2 Trunk Road Route Assessment

3.2.1 Chapter 2 of the HEC Report on Trunk Road Alignments and Harbour-front Enhancement **(Annex G)** presents the findings of the assessment of feasible Trunk Road routeing, taking account of the alignment constraints through the WDII project area. These findings are summarised as follows.

Alignment Constraints through the WDII Project Area

3.2.2 Trunk Road alignments through the WDII project area are constrained by a number of land use and infrastructure constraints.

(i) At the western end of the WDII project area, connection is required to the Trunk Road tunnel which will be constructed under CRIII.

The planning of the Trunk Road, including the designed alignment, has been proven to satisfy the overriding public need test under the Review of CRIII (see paragraph 2.1.4). Therefore, the section of Trunk Road in CRIII is regarded as fixed, and the eastern end of the Trunk Road tunnel in CRIII forms the starting point of the Trunk Road in WDII. The Trunk Road in CRIII is a cut-and-cover tunnel with a road level of around –10mPD at this connection point.

(ii) To the east of the Causeway Bay Typhoon Shelter, the Trunk Road needs to connect to the existing elevated IEC road structure.

The existing IEC is an elevated road structure with road levels between +12mPD and +15mPD. The Trunk Road, if constructed in the form of tunnel, must therefore rise onto elevated road structure to make this connection.

(iii) Provision for slip road connections near the HKCEC and at Victoria Park Road/Gloucester Road/Hing Fat Street.

The following slip road connections have been identified as essential in meeting traffic demand and enabling the Trunk Road to adequately perform its function of relieving traffic from the overloaded Connaught Road Central – Harcourt Road – Gloucester Road corridor:

- slip road from eastbound Trunk Road to Wan Chai North (‘Slip Road 1’)
- slip road from Wan Chai North to eastbound Trunk Road (‘Slip Road 2’)
- slip road from westbound Trunk Road to Wan Chai North (‘Slip Road 3’)
- slip road from Victoria Park Road to westbound Trunk Road (‘Slip Road 8’).

(iv) Need to cross the MTR Tsuen Wan Line.

The MTR Tsuen Wan Line is an immersed tube rail tunnel running across the seabed at the west side of the HKCEC Extension. The Trunk Road and reclamation in this area must not impose any loads on, or cause any significant movement of, the existing MTR Tsuen Wan Line tunnel. A piled Trunk Road tunnel structure spanning across the MTR tunnel can meet statutory limitations on allowable surcharge, lateral pressure and movement. Tunnelling under the MTR tunnel would need to be at sufficient depth to avoid disturbance to the existing ground and movement of the MTR tunnel, and has been found not feasible (see later paragraphs 3.3.7 to 3.3.11).

(v) Need to cross the Cross Harbour Tunnel.

The Cross Harbour Tunnel is an immersed tube tunnel constructed in 1970, comprising a thin steel external shell lined internally with reinforced concrete. The immersed tube section of the Cross Harbour Tunnel is considered to be particularly fragile and susceptible to damage due to movement, particularly when the age of the Cross

Harbour Tunnel is taken into account. Repair work would be extremely difficult. Given the susceptibility of the old Cross Harbour Tunnel to damage, a near zero movement tolerance would need to be imposed for any Trunk Road tunnel crossing, which will be extremely difficult to ensure. As a result, the risk of damage due to any Trunk Road tunnel scheme crossing the immersed tube section of the Cross Harbour Tunnel will be unacceptably high. Any Trunk Road crossing under the Cross Harbour Tunnel must therefore be confined to the zone beneath the portal and approach ramp of the Cross Harbour Tunnel, where risk of damage can be kept within manageable bounds. In this case, though, the Trunk Road tunnel would need to avoid the rock anchors that tie down the approach ramp structure to the underlying rock; these anchors are there to prevent uplift caused by hydrostatic forces (flotation). The rock anchors, based on available as-built information, are installed to a depth of around –17mPD, therefore, allowing for minimum clearance beneath the anchors, the Trunk Road must pass beneath the Cross Harbour Tunnel at a road level of around –30mPD.

(vi) Allowance to be made for proposed rail infrastructure such as the NIL and the SCL.

The NIL is planned to run within existing land along the northshore area of Causeway Bay and Wan Chai to an Exhibition Station located beneath the existing Wan Chai North Public Transport Interchange (PTI). From there, the NIL tunnel will run partly through the HKCEC water channel in cut-and-cover tunnel, crossing over the MTR Tsuen Wan Line in similar form of construction as that proposed for the Trunk Road crossing, and then continuing westwards along the Central shoreline through the CRIII project area. The major impact on the Trunk Road is at the Wan Chai North area where the NIL tunnel and Exhibition Station will conflict with Trunk Road tunnel alignments that turn southwards (inland) after the CRIII connection.

The SCL will be an immersed tube tunnel from Hung Hom across the Harbour (alternative easterly and westerly alignments have been proposed), turning westwards through the Causeway Bay Typhoon Shelter to run within existing land along the northshore area of Wan Chai, along a similar alignment as the NIL, before turning southwards under Fenwick Pier Street to Admiralty Station. The major impact on the Trunk Road is through the Causeway Bay Typhoon Shelter, where the SCL rail tunnels will conflict with Trunk Road tunnel options; avoidance of the conflict dictates the level of the Trunk Road tunnel through the typhoon shelter.

(vii) Major services infrastructure near the harbour-front such as electricity sub-stations and sewage treatment plants.

A major element of the services infrastructure in the Wan Chai North area is the Wan Chai East Sewage Screening Plant (WCESSP), located on Hung Hing Road between the Wan Chai Sports Ground and the ex-Public Cargo Working Area (PCWA) basin. The WCESSP provides primary treatment for sewage from the Wan Chai East catchment area as well as that of the Wan Chai West catchment area. The WCESSP also forms an essential part of the Harbour Area Treatment Scheme (HATS). Other essential services infrastructure includes Hong Kong Electric's Wan Chai Zone Sub-Station on Hung Hing Road and new Electricity Receiving Station, under construction, on Wan Shing Street.

Reprovisioning these major sewerage and electricity supply facilities, even if suitable alternative sites could be found in the already congested northshore area, would result in massive disruption to these essential services, and indeed to the whole of the Wan Chai business and residential district. Relocation of these essential services infrastructure is therefore considered not practically feasible. The major impact on the Trunk Road is therefore the physical obstruction of these facilities to southerly Trunk Road alignments along the Wan Chai northshore area.

(viii) Basement level developments and piled foundations of existing developments and land uses in Wan Chai North, such as the HKCEC Extension, Grand Hyatt Hotel, Wanchai Tower, Central Plaza, Renaissance Harbour View Hotel, Great Eagle Centre, Harbour Centre, China Resources Building, Sun Hung Kai Centre, etc.

All these developments form physical barriers to Trunk Road alignments (whether in tunnel, at-grade or elevated) that turn northwards (offshore) or southwards (inland) after the connection with CRIII.

Trunk Road Route Corridors through WDII Project Area

3.2.3 Three possible corridors have been considered when examining potential Trunk Road alignments between the connection with the Trunk Road tunnel in CRIII and the connection with the IEC to the east of the Causeway Bay Typhoon Shelter:

(i) an 'offshore corridor', where the Trunk Road alignment turns seawards (northwards) after the connection with the Trunk Road tunnel in CRIII and runs through the harbour until turning back to connect with the IEC further east in North Point;

(ii) an 'inland corridor', where the Trunk Road alignment turns inland (southwards) after the connection with the Trunk Road tunnel in CRIII and runs through existing land in tunnel, following roughly the Gloucester Road passageway and joining up with the existing IEC in front of Victoria Park;

(iii) a 'foreshore corridor', where, after passing through the HKCEC water channel in tunnel, the Trunk Road runs along the Wan Chai shoreline and through the Causeway Bay Typhoon Shelter either as tunnel, at-grade or elevated road, joining up with the existing IEC to the east of the typhoon shelter.

Offshore Alignments

3.2.4 Offshore Trunk Road alignments face a major physical constraint in the form of the HKCEC Extension. Even at minimum horizontal curvature, the Trunk Road will not be able to turn northwards sharply enough from its CRIII connection to avoid conflict with the HKCEC Extension building or its foundations.

3.2.5 Nor can the Trunk Road pass above or beneath the HKCEC Extension building: the road cannot rise steeply enough to clear the roof of the HKCEC Extension, therefore an elevated offshore alignment is not possible; nor can the Trunk Road drop low enough to avoid conflict with the basement of the HKCEC Extension and its foundations.

3.2.6 Other constraints to offshore alignments include the high risk of damaging the Cross Harbour Tunnel if tunnelling beneath it, and not being able to provide the necessary slip road connections in Wan Chai and Causeway Bay. However, it is primarily due to the physical conflict with the HKCEC Extension and its foundations that offshore alignments for the Trunk Road are not feasible.

Inland Alignments

3.2.7 Inland Trunk Road alignments face major physical constraints, mainly due to conflicts with existing developments and highway infrastructure, and conflicts with the future rail infrastructure. At-grade or elevated Trunk Road inland alignments are self-evidently not possible in view of the scale of existing building developments and infrastructure, and consideration of inland alignments is therefore confined to tunnel options.

3.2.8 After turning southwards from the connection with the tunnel constructed under CRIII, the Trunk Road will be obstructed by building developments in Wan Chai North. The inland tunnel alignment will conflict with the basement and foundations of the HKCEC Phase I and the Grand Hyatt Hotel (similar to the case with the HKCEC Extension, the Trunk Road tunnel cannot drop low enough to avoid conflict with the foundations of these buildings). Thereafter, the Trunk Road tunnel would also conflict with the China Resources Building, Causeway Centre and Sun Hung Kai foundations.

3.2.9 Other constraints to inland alignments include conflict with the proposed NIL and SCL rail tunnels and Exhibition Station, conflict with major services infrastructure (Electricity Sub-Station and Wan Chai East Sewage Screening Plant at Hung Hing Road), conflict with the foundations of the Cross Harbour Tunnel approach road structures, and the demolition of the northern part of Victoria Park as well as cutting off the westbound Victoria Park Road to facilitate the connection with the IEC.

3.2.10 As a consequence of the above physical obstructions and constraints, Trunk Road inland alignments are found to be not feasible.

Foreshore Alignments

3.2.11 At the western end of the WDII project area, the passageway through the HKCEC water channel presents a physical constraint to the Trunk Road alignment, both horizontally and vertically. An elevated road would clash with the atrium bridge and cannot be constructed without demolishing this essential element of the HKCEC and its Extension. At-grade road options for the Trunk Road would conflict with the ground level road system. An at-grade Trunk Road would also present a physical barrier that will cut off ground level road and pedestrian access to the HKCEC Extension from Wan Chai North. The water channel itself, on the other hand, provides an opportunity for tunnel options that can be constructed in the narrow gap between the foundations of the HKCEC and the HKCEC Extension.

3.2.12 The shallow tunnel through the HKCEC water channel also means that the Wan Chai North slip road connections to the existing ground level road network can be readily provided, while meeting the necessary highway design standards.

3.2.13 After leaving the HKCEC water channel, foreshore alignments of the Trunk Road will run along the Wan Chai shoreline and through the ex-Public Cargo Working Area (PCWA) basin. The alignment here is determined mainly by infrastructure constraints, in particular the crossing at the Cross Harbour Tunnel. As mentioned above, the feasible crossing point (for a Trunk Road in tunnel) is below the Cross Harbour Tunnel portal structure, at a sufficiently deep level to avoid the Cross Harbour Tunnel rock anchors. Alternately, a Trunk Road on flyover can cross over the Cross Harbour Tunnel portal area. Trunk Road tunnel alignments further north will result in high risk of damage to the immersed tube section of the Cross Harbour Tunnel, while more southerly alignments are constrained by the Wan Chai East Sewage Screening Plant and the Electricity Sub-station on Hung Hing Road.

3.2.14 The Trunk Road alignment must then pass through (under or over) the Causeway Bay Typhoon Shelter to connect with the existing IEC to the east of the typhoon shelter. Other potential conflicts in the Causeway Bay area to be avoided for foreshore alignments are the Royal Hong Kong Yacht Club (RHKYC) and the SCL. The provision of the Causeway Bay slip road will also influence the Trunk Road form and alignment; connection from the existing ground level road network can be made to relatively shallow Trunk Road cut-and-cover tunnels or to flyovers, but limitations on tunnel gradients would mean that this slip road connection to deep bored tunnels would not be possible.

3.2.15 Trunk Road tunnels will need to rise up onto elevated road to connect with the IEC to the east of the Causeway Bay Typhoon Shelter. A Trunk Road flyover can connect directly to the elevated IEC at the eastern end of the typhoon shelter.

3.2.16 In conclusion, there are no insurmountable constraints to foreshore alignments for the Trunk Road. Foreshore alignments are feasible, and consideration of these alignments is focussed primarily on the determination of the best practical form of construction in overcoming conflicts and minimising impacts and the extent of reclamation.

Summary of Trunk Road Route Assessment

3.2.17 Alternative routeings for the Trunk Road along offshore, inland and foreshore corridors have been examined to determine practicable and feasible Trunk Road alignments. Trunk Road alignments are, however, constrained by existing developments along the Wan Chai and Causeway Bay northshore area, existing cross harbour tunnels, proposed rail infrastructure and essential services infrastructure.

3.2.18 Offshore alignments are obstructed by the HKCEC Extension, will pose unacceptable risk to the Cross Harbour Tunnel when tunnelling beneath it, and cannot provide the necessary slip road connections. Due primarily to the physical conflict with the HKCEC Extension, Trunk Road offshore alignments are found to be not feasible.

3.2.19 Inland alignments are obstructed by existing developments in Wan Chai North, including the HKCEC Phase I, Grand Hyatt Hotel, Great Eagle Centre and Sun Hung Kai Centre. Trunk Road inland alignments will also conflict with the proposed NIL and SCL rail infrastructure, and existing road and services infrastructure. Due to these physical conflicts, Trunk Road inland alignments are also found to be not feasible.

3.2.20 The feasible Trunk Road routeing is along the foreshore of Wan Chai and Causeway Bay. After crossing over the MTR Tsuen Wan line, the Trunk Road will run in shallow tunnel through the HKCEC water channel and along the Wan Chai shoreline. Thereafter, the Trunk Road can pass either below the Cross Harbour Tunnel portal in tunnel or over the top of the Cross Harbour Tunnel portal as flyover, continuing as either tunnel or flyover through the Causeway Bay Typhoon Shelter to a connection with the existing elevated IEC to the east of the typhoon shelter.

3.3 Engineering Requirements for Reclamation at the Trunk Road Connections

3.3.1 In Section 3.2 above, the feasible Trunk Road routeing was found to be along the foreshore of Wan Chai and Causeway Bay. However, foreshore alignments do require reclamation:

- for Trunk Road tunnel construction at the tie-in to CRIII and for the crossing of the MTR Tsuen Wan Line to the west of the HKCEC Extension, where the Trunk Road tunnel structure will lie above seabed level;

- for the slip road connections in Wan Chai North (Slip Roads 1, 2 and 3) that will require reclamation as they rise above seabed level to their portals at ground level;

- for the Trunk Road tunnel construction where it rises above the seabed to a ground level tunnel portal before rising onto elevated road structure to connect to the IEC to the east of the Causeway Bay Typhoon Shelter.

3.3.2 The connecting constraints mean that all schemes for the Trunk Road alignment through the WDII project area will require some reclamation at least at the western end for all Trunk Road schemes and at the eastern end for tunnel schemes.

3.3.3 The following paragraphs examine the unavoidable reclamation requirements at the critical areas of the MTR tunnel crossing and the IEC connection.

MTR Tsuen Wan Line Crossing

3.3.4 After the connection with the CWB tunnel in the CRIII area, the Trunk Road will have to cross the MTR Tsuen Wan Line tunnel. As noted in Section 2 above, the Trunk Road must not impose any loads on, or cause any significant movement of, this existing MTR immersed tube tunnel.

3.3.5 Piled deck structure over the MTR tunnel is a feasible solution that will meet these conditions. A proposed scheme for this tunnel crossing, developed and agreed in consultation with

MTRC to meet their statutory limitations on allowable surcharge, lateral pressure and movement, involves the construction of a row of bored piles along either side of the Tsuen Wan Line tunnel with precast tunnel sections supported by these piles for the Trunk Road tunnel which spans over the MTR tunnel. Details of the scheme, extracted from the detailed engineering design of the MTR tunnel crossing, are shown in Chapter 3 of the HEC Report on Trunk Road Alignments and Harbour-front Enhancement **(Annex G)**. For this scheme, the Trunk Road will cross over the MTR tunnel at a road level of around –7mPD and, taking into account the height of the Trunk Road tunnel, including ventilation ducts, the top of tunnel structure would be at a level of around +2.5mPD.

3.3.6 Reclamation is required for the adjacent cut-and-cover tunnels that tie into the precast tunnel sections over the MTR tunnel, as these are above seabed level. Moreover, the Trunk Road tunnel structure would be above sea level (even above high tide level: mean higher high water level is around +2.0mPD) at this crossing, and this would effectively be regarded as reclamation, anyway.

3.3.7 Tunnelling under the MTR Tsuen Wan Line has been suggested as a means of eliminating the reclamation for the crossing over the MTR tunnel. This would need to be at sufficient depth to avoid disturbance to the existing ground and movement of the MTR tunnel. The constraints in this case are: (i) the Trunk Road tunnel connection back to existing road links at the Central Interchange, and (ii) the slip road connections to the ground level road network in Wan Chai North. Neither can be achieved for a deep Trunk Road tunnel beneath the MTR tunnel due to gradient limitations.

3.3.8 To illustrate this vertical alignment constraint, a deep tunnel alignment where the Trunk Road drops down from the tie-in with the Central Interchange at Central Reclamation Phase I at the maximum permissible tunnel gradient to pass beneath the MTR Tsuen Wan Line is shown in Annex G.

3.3.9 The location of the Trunk Road tunnel western portal in Central is fixed by the connection of the mainline Trunk Road to the

Rumsey Street Flyover, which has already been constructed, and by slip road connections at the Central Interchange that must tie into existing roads in Central. Moving the portal further west, in order to provide a longer Trunk Road tunnel length over which the deep tunnel can drop to a lower level when it passes beneath the MTR tunnel, will mean that the mainline Trunk Road and slip road connections at the Central Interchange cannot be made as the road alignments will exceed maximum permissible gradients and cannot comply with highway design standards in respect of road geometry. The location of the western portal of the Trunk Road, therefore, cannot be moved.

3.3.10 With the western portal of the Trunk Road being fixed, and the Trunk Road vertical alignment dropping at the maximum permissible gradient to pass under the MTR tunnel, the vertical profile shown in Annex G illustrates the consequences in respect of clearance between the MTR immersed tube tunnel and the Trunk Road bored tunnel. As can be seen, the clearance between the two tunnels would be only around 5m, whereas the Trunk Road bored tunnel diameter is around 15.5m. Clearance of at least around 1.5 to 2 times the bored tunnel diameter needs to be provided to keep disturbance of existing ground and movement of the MTR tunnel to within MTRC’s statutory limits, so as to ensure that the MTR tunnel is not damaged. Quite clearly, the available clearance is totally inadequate.

3.3.11 Therefore, a deep Trunk Road tunnel passing beneath the MTR Tsuen Wan Line is not feasible. The Trunk Road must pass over the MTR tunnel, and reclamation associated with this crossing is unavoidable.

3.3.12 A feasible vertical profile of the Trunk Road tunnel from the western portal in Central, over the MTR Tsuen Wan Line, is presented in Annex G, which also indicates the reclamation required in WDII at the connection with CRIII and the crossing over the MTR tunnel, where the Trunk Road tunnel rises above seabed level. The determination of this vertical profile takes into account essential related infrastructure such as tunnel ventilation adits that pass over the Trunk Road tunnel structure, below ground level in the limited available space.

IEC Connection

3.3.13 At the eastern end of the WDII project area, all Trunk Road tunnel schemes need to rise to a ground level portal and then onto elevated road structure to connect with the existing elevated IEC at a level of around +15mPD. The tunnel will be constructed by cut-and-cover method as the Trunk Road rises to and above the seabed, and reclamation will be required where the tunnel rises above the seabed, through the ground level tunnel portal and up to the start of flyover structure.

3.3.14 Chapter 3 of the HEC Report on Trunk Road Alignments and Harbour-front Enhancement **(Annex G)** illustrates the minimum reclamation situation where a cut-and-cover tunnel rises up to ground level immediately to the east of the Causeway Bay Typhoon Shelter eastern breakwater. The existing land formation in this area, which extends beyond the IEC structure into the harbour, can be put to good use to accommodate the Trunk Road tunnel so as to minimise the extent of new reclamation required. As shown in Annex G, though, this existing area of land is not sufficient to encompass the Trunk Road tunnel and portal entirely; additional reclamation is required both in length and width.

3.3.15 The width of reclamation required to accommodate the Trunk Road tunnel is determined by the cross-sectional elements of the Trunk Road tunnel structure, which is located adjacent to the existing IEC foundation piles, and the wave absorbing seawall alongside the tunnel structure. As illustrated in Annex G, the existing width of the formed land is insufficient to accommodate the Trunk Road tunnel structure and its protecting seawall, and an additional width of reclamation, of around 40m, is required.

3.3.16 The length of reclamation at this connection to the IEC is determined by the maximum gradient of the tunnel as it rises from seabed level to the tunnel portal at ground level, with reclamation continuing to just beyond the flyover abutment, to the point at which the flyover structure rises to a high enough level to span over the sea. As illustrated in Annex G, an overall length of formed land of around 620m is needed, however the length of the existing formed land is only around 430m, therefore an additional length of reclamation, of around 190m, must be provided.

3.3.17 The resulting area of reclamation, of up to 4ha, is therefore required for Trunk Road tunnel schemes rising up to connect to the existing IEC.

3.4 Alternative Trunk Road Ideas

3.4.1 The following alternative Trunk Road ideas, including suggestions received from the public through the Envisioning Stage public engagement exercise, have been examined to determine if they would constitute a feasible “no reclamation” option, or result in an avoidance of reclamation.

Deep Bored Tunnel

3.4.2 A deep bored tunnel option for the Trunk Road has been examined with a view to avoiding reclamation. The idea being that a tunnel constructed by tunnel boring machine (TBM) at sufficient depth below the surface would not require reclamation and can be constructed without disturbing existing facilities and infrastructure.

3.4.3 However, at the western end of WDII, at the connection with the Trunk Road tunnel constructed under CRIII and for the crossing over the MTR Tsuen Wan line, the deep tunnel option must start off as shallow cut-and-cover tunnel, in reclamation, similar to all other Trunk Road options. At the eastern end, as the tunnel rises towards the seabed and ground cover becomes insufficient for the TBM construction, the form of construction needs to change to cut-and-cover tunnel, with associated reclamation to facilitate this construction along the North Point shoreline. Therefore reclamation is still essential and the bored tunnel is not a “no reclamation” option.

3.4.4 The major issue associated with a deep tunnel option is that the longer length of the Trunk Road tunnel along the North Point shoreline, all the way to the connection with the IEC near the

North Point ferry piers, results in extensive reclamation along this part of the shoreline.

3.4.5 The issue of reclamation, and whether it is unnecessarily extensive, is the key concern in this instance, particularly in light of the CFA ruling on reclamation in relation to the PHO, which requires the minimisation of reclamation when examining alternatives for the Trunk Road.

3.4.6 Because the bored tunnel must rise from a deeper level under the Causeway Bay Typhoon Shelter than the alternative cut-and-cover tunnel option, the tunnel portal will need to be located further to the east along the North Point shoreline, where there is no existing formed land that can be put to good use to accommodate the ground level tunnel portal, as is the case for the connection immediately to the east of the Causeway Bay Typhoon Shelter (Section 3.3 above). As a consequence, the deep bored tunnel option will require a greater area of reclamation along the North Point shoreline than the alternative cut-and-cover tunnel option.

3.4.7 Comparison of the extent of reclamation along the North Point shoreline for the bored tunnel option and the alternative tunnel option that can connect to the IEC immediately to the east of the Causeway Bay Typhoon Shelter, indicates that their approximate reclamation areas are:

- deep tunnel option, 14ha
- alternative tunnel option, 4ha.

3.4.8 The reclamation required for the deep tunnel option appears unnecessarily extensive; in the light of the CFA ruling, it must be concluded that, as the deep tunnel option will result in a greater area of reclamation than an alternative available tunnel option, and as in any event the deep tunnel option does not perform as well as the alternative cut-and-cover tunnel option, there is no justification or overriding need to pursue this deep tunnel option.

3.4.9 Moreover, the deep tunnel will render Slip Road 8 (from Victoria Park Road to Trunk Road westbound) not able to join the mainline Trunk Road tunnel in Causeway Bay, as a connection from the ground level Victoria Park Road to the bored tunnel at this deep level will exceed maximum permissible tunnel gradients. Omitting Slip Road 8 for the deep tunnel option means that this scheme will not meet all the functional requirements of the Trunk Road and, as such, the deep tunnel option does not perform as well as other tunnel options that can meet the functional requirements. In this respect, the deep tunnel option will not meet the identified overriding need for the Trunk Road.

3.4.10 Further details of the deep bored tunnel option are provided in Chapter 3 of the HEC Report on Trunk Road Alignments and Harbour-front Enhancement **(Annex G)**.

Alternative Trunk Road Tunnel Schemes submitted by the Public

3.4.11 Alternative Trunk Road and harbour-front enhancement schemes have been submitted by members of the public during the course of the Envisioning Stage consultation, with a view to minimising reclamation and improving the waterfront. Two noteworthy proposals were submitted as full scheme proposals: one from Swire Properties ("A Proposal for the Wan Chai - Causeway Bay Shoreline" submitted to the Sub-committee on WDII Review in July 2005), and another from RHKYC ("Preserving the Vibrancy and Diversity of Victoria Harbour" submitted to the Sub-committee on WDII Review in July 2005). Other public submissions (for example those from the Designing Hong Kong Harbour District and Business and Professionals Federation of Hong Kong) are, in general, ideas that are covered collectively below. The suggestion by several parties, including the Eastern District Council, to move the Trunk Road tunnel eastern portal further eastwards is covered under the examination of the deep bored tunnel proposal above.

3.4.12 An extract from the Swire's proposal is at **Annex H**. Swire's submitted their proposal to demonstrate an idea that would allow Victoria Park unfettered access to the waterfront. As can be seen from Annex H, their scheme involves Trunk Road tunnel construction that does require reclamation along the Wan

Chai shoreline and in the corners of the CBTS. This is therefore not a “no reclamation” idea.

3.4.13 An extract from the RHKYC proposal is at **Annex I**. RHKYC noted that they had brainstormed with and solicited ideas from various stakeholders including Wan Chai District Council and Eastern District Council, NGOs, sports associations and RHKYC members, in deriving their proposal. As can be seen from Annex I, reclamation will be needed for Trunk Road tunnel construction along the Wan Chai shoreline and in the corners of the Causeway Bay Typhoon Shelter for the RHKYC scheme. This scheme is therefore also not a “no-reclamation” idea.

3.4.14 Nevertheless, these proposed schemes have been further investigated in developing variations of Trunk Road tunnel options as discussed in Section 4 of this report.

Double Decking over Gloucester Road

3.4.15 A member of the public has proposed a double-decking idea, which involves the construction of an elevated Trunk Road structure above the existing Connaught Road Central / Harcourt Road / Gloucester Road. The idea being to make use of the air space above the existing road corridor for Trunk Road construction.

3.4.16 The Trunk Road is a dual 3-lane carriageway with an overall elevated deck width of around 30m. This will need to span across the existing Gloucester Road, including over existing flyovers such as Tonnochy Road Flyover and Arsenal Street Flyover, and keep clear of the numerous pedestrian bridges that currently span over Gloucester Road. An extremely bulky portal structure for the Trunk Road will be required that will result in the loss of existing traffic lanes in both the east-bound and west-bound carriageways of Gloucester Road for the supporting piers. Moreover, the structure will be very high, in order to pass over the existing elevated structures along Gloucester Road (the Trunk Road level would be at around the 5^{th} or 6^{th} floor level of the adjacent buildings along Gloucester

Road). Visual impacts and the blocking effects of the double-deck structure will be severe.

3.4.17 Traffic impacts are of primary concern when considering the feasibility of this double-deck idea. During construction, two lanes on Gloucester Road will need to be closed in both east-bound and west-bound directions to allow for the portal frame construction and contractor's working space. With the Gloucester Road corridor already filled to capacity with roads, there is no spare road space for temporary traffic diversions. Then, once the Trunk Road is complete, there will be a permanent loss of one lane in both directions.

3.4.18 The consequence will be a loss of around 40% of road capacity in both directions during construction and a permanent loss of around 25% of road capacity in both directions after construction. This loss of road capacity, from a major strategic road corridor that is already operating over capacity and will continue to operate at or near capacity even after the implementation of the Trunk Road, would most like result in a gridlock situation and cannot be tolerated; this means that the overriding need for the Trunk Road cannot be met.

3.4.19 Therefore, from both visual and traffic impacts points of view, the suggested double-deck arrangement along Gloucester Road is considered to be not feasible.

Full Flyover Idea

3.4.20 It was suggested by a member of the Sub-committee on WDII Review that a Trunk Road in the form of flyover starting from CRIII project boundary all the way to the connection with the IEC should be presented for consideration by the public. This suggestion is in respect of new land formation not being required for flyover, putting aside the question of whether the bridge piers in the harbour would constitute reclamation.

3.4.21 The major obstacle for a Trunk Road in the form of flyover starting from the CRIII project boundary is the existing development in Wan Chai North, in particular, the HKCEC Phase I and the HKCEC Extension, and their connecting Atrium

Link bridge, which form a physical barrier to elevated road structures (as discussed in Section 3.2 above). Full flyover options cannot rise to a high enough level to pass over the HKCEC and/or the Atrium Link.

3.4.22 All Trunk Road alignments must pass through the HKCEC water channel in tunnel, in reclamation. Only after passing through the water channel can the Trunk road rise up onto flyover, therefore a so-called "full flyover" option (having no new land formation) is not feasible.

Total Offshore Idea

3.4.23 Following on from the full flyover idea above, an idea of having the Trunk Road alignment completely offshore (ie not constrained by the connecting point with CRIII to the west of the HKCEC) has been considered.

3.4.24 A flyover running through the middle of the harbour would clearly be unacceptable, due to marine impacts: pleasure, ferry and commercial shipping would be affected.

3.4.25 A Trunk Road tunnel running offshore will be constrained by the crossing beneath the MTR Tsuen Wan Line and the Cross Harbour Tunnel. Similar to the case for the MTR Tsuen Wan Line crossing as discussed in Section 3.3, a Trunk Road alignment that turns northwards into to the harbour from the connection with the Central Interchange in Central will also not be able to drop down deep enough to pass beneath the MTR immersed tube tunnel with sufficient clearance.

3.4.26 Therefore, "total offshore" ideas for the Trunk Road alignment are not feasible.

"Shallow Water" Idea

3.4.27 Another suggestion from a member of the Sub-committee on WDII Review is that, even if the top of the Trunk Road tunnel structure is above the existing seabed level, as long as the top of structure is below sea level, this should be presented as an alternative choice instead of constructing the tunnel in reclamation. The preference being that even a shallow water area should be returned to the harbour.

3.4.28 **Annex J** presents details of the "Shallow Water" Idea and its consequences.

3.4.29 From the engineering and marine impacts points of view, the major concern is that, due to its exposure above seabed, the Trunk Road tunnel structure would be vulnerable to ship impact, including ocean going vessels in the nearby navigation fairways and especially during typhoon periods. The consequences of structural damage to the road tunnel would be severe, and possibly catastrophic, and would take a long time to rectify. Protection in the form of a breakwater is therefore required. A rubble mound breakwater will provide the most effective protection to the tunnel structure from vessels in the harbour, which range from small harbour craft to large ocean going vessels, without compromising navigational safety.

3.4.30 The resulting scheme means that the perceived benefits of "seeing a water surface" along the shoreline rather than reclamation are offset by the reclamation formed by the offshore protective breakwaters, and the shallow water area inside the breakwater will have limited marine or recreational use.

3.4.31 This perceived saving in reclamation is, in fact, countered by an infringement of the principle of protecting and preserving the Harbour under the PHO in respect of:

- the area occupied by offshore breakwaters required for protecting the Trunk Road tunnel against ship impact, which constitutes reclamation under the PHO;
- the area occupied by the tunnel structure above seabed (albeit below sea level), which also constitutes reclamation under the PHO;
- the area between the existing shoreline and the breakwater, where marine access is restricted and where existing drainage outfalls into the embayed body of water will result in poor water quality that will be unsightly, odorous and restrict recreational use of this area – this part of the

Harbour will be so adversely affected that the principle of preserving and protecting the Harbour under the PHO can be regarded as infringed.

3.4.32 This is not a “no-reclamation” idea and, as the affected area of the Harbour is greater than that arising from the conventional cut-and-cover tunnel approach, under the PHO this should not be pursued further.

3.5 Conclusions on “No Reclamation” Options

Is there any “no reclamation” option ?

3.5.1 All possible alignments for the Trunk Road, including suggestions from the public, have been examined, taking into account land use and infrastructural constraints, with a view to determining if there are any that do not require any reclamation for the Trunk Road construction. It is found that the feasible Trunk Road routeing is along the foreshore of Wan Chai and Causeway Bay.

3.5.2 However, foreshore alignments do require reclamation for Trunk Road tunnel construction at the western end of WDII where the Trunk Road tunnel crosses over the MTR Tsuen Wan Line, and at the eastern end of WDII where the Trunk Road tunnel must rise to ground level for the connection with the elevated IEC, at least.

3.5.3 Alternative Trunk Road ideas that have been proposed to avoid reclamation are found to be not feasible, or would result in an even greater area of reclamation or affected area of the harbour.

3.5.4 Consequently, it is concluded that there is no feasible “no-reclamation” alignment for the Trunk Road, and it must be accepted that at least some reclamation will be required for the Trunk Road construction.

4 TRUNK ROAD FEASIBLE OPTIONS

4.1 Introduction

4.1.1 In Section 3 it was found that the feasible Trunk Road routeing is along the foreshore of Wan Chai and Causeway Bay, with the Trunk road in tunnel crossing over the MTR Tsuen Wan line, and staying in shallow tunnel through the HKCEC water channel and along the Wan Chai shoreline. Thereafter, the Trunk Road can pass either below the CHT portal in tunnel or over the top of the Cross Harbour Tunnel portal as flyover, continuing through the Causeway Bay Typhoon Shelter to a connection with the existing elevated IEC to the east of the typhoon shelter.

4.1.2 For tunnel options, cut-and-cover tunnel construction is considered to be a technically feasible form of construction for implementation of the Trunk Road. Nevertheless, determination of the feasible form of tunnel construction must take into account alternative construction methods that may be considered appropriate along the different sections of the WDII project area. In this Section, possible variations of Trunk Road tunnel options are examined, with a view to determining practically feasible tunnel ideas that can be consolidated with harbour-front enhancement ideas for realising the objectives of this project.

4.1.3 There is broad support from the public for a tunnel option, especially where this can incorporate suggested harbour-front enhancement ideas while at the same time provide for the functional requirements of the Trunk Road. However, a flyover option is also technically feasible. Notwithstanding that there is little public support for a flyover option, this option does need to be given further consideration insofar as whether it represents a scheme requiring a lesser area of new land formation. At issue is which option, tunnel or flyover, would comply with the PHO. Accordingly, this section also examines a possible Trunk Road flyover idea and compares it with the Trunk Road in tunnel.

4.1.4 At-grade Trunk Road options are not acceptable as they would require extensive reclamation in the Causeway Bay Typhoon Shelter, thus not complying with the PHO, and the reclaimed land would be used mainly for roads, leaving little opportunity for harbour-front enhancement.

4.2 Alternative Tunnel Construction Methods

4.2.1 With the Trunk Road crossing over the MTR tunnel at the west of the HKCEC, as described previously, and the shallow tunnel (above seabed level) passing through the HKCEC water channel, the most practical construction approach in this area will be to construct the Trunk Road as a cut-and-cover tunnel after reclaiming along the shoreline to the west of the HKCEC and filling the water channel between the two seawalls of the Convention Centres. This reclamation will also accommodate the slip road connections in Wan Chai North.

4.2.2 Along the Wan Chai shoreline, the Trunk Road tunnel remains above the seabed level, therefore, again, cut-and-cover tunnel constructed in reclamation is considered the appropriate form of construction in this area.

4.2.3 Cut-and-cover tunnel construction involves first installing the tunnel walls by using diaphragm walls (these are reinforced concrete wall panels constructed in existing ground from ground level down to the required depth, usually to the underlying rock layer) on both sides of the tunnel, then excavating the soil from between the diaphragm walls, constructing reinforced concrete top and bottom slabs between the diaphragm walls to form the tunnel box and, finally, backfilling over the tunnel. This form of construction is carried out in existing or formed land to provide the necessary construction access from the surface – should the tunnel alignment cross over seabed, reclamation will be required to first form the land through which the diaphragm walls need to be constructed.

4.2.4 Where the tunnel lies above seabed level, the reclamation also provides protection to the tunnel structure. If the tunnel structure were to be left exposed above the seabed level, it would be at risk of damage from ship impact from ferries and local craft in the inshore water area and from ocean going vessels in the adjacent navigation fairways. The consequences of structural damage to the road tunnel would be severe and not tolerable.

4.2.5 Immersed tube tunnel form of construction may be used where the tunnel lies just below seabed level; reclamation would not be required for this form of tunnel construction. However, this form of construction is not suitable where the tunnel level rises above seabed level, as the exposed tunnel section would then be at risk of damage from ship impact, anchors, etc, the tunnel structure would be more susceptible to degradation in the aggressive marine environment, and the protrusion of the tunnel structure above the seabed would restrict marine access to the shoreline. Also, even where the tunnel lies below seabed level, the soft seabed material would need to be excavated so that the immersed tube units lie in a trench on a firm foundation. Along the Wan Chai shoreline, this would involve excavating a deep trench immediately adjacent to the existing seawalls, which would undermine these seawalls. Use of immersed tube is therefore considered not feasible in this instance, and the most practical and reasonable form of construction for the Trunk Road tunnel along the Wan Chai shoreline is cut-and-cover, constructed through reclaimed land.

4.2.6 Through the ex-PCWA basin and the Causeway Bay Typhoon Shelter, where the Trunk Road tunnel lies below seabed level, immersed tube or cut-and-cover tunnel construction may be considered. For both forms of construction, permanent reclamation is not required. In the case of cut-and-cover tunnel, temporary reclamation may be formed to facilitate the tunnel construction, but this can be removed on completion of construction so that the finished product, ie retention of the existing seabed condition, is the same for both methods. (Alternative methods of construction may be proposed by the future contractor, however, any such alternative method must not result in permanent reclamation.) Factors to be considered in selecting an appropriate construction method include: whether the tunnel alignment runs wholly through seabed or partly in existing seabed and partly under existing seawalls and land formation, the latter making cut-and-cover construction more practically feasible (more efficient and cost effective construction with less disruption to existing shoreline facilities and infrastructure) than use of precast immersed tunnel sections that need to be placed in open trenches; the depth of the tunnel (where the tunnel lies at a significant depth below the seabed, for example near the Cross Harbour Tunnel crossing, at –30mPD, major deep and wide trenches will need to be excavated, making immersed tube construction more disruptive with greater impacts); or the tunnel length available for immersed tube construction (short lengths will not be cost effective for the precast fabrication of tunnel units). The form of tunnel construction is an important consideration in respect of avoiding conflict with the SCL, as Trunk Road cut-and-cover tunnel can be constructed across the future SCL alignment with much closer separation allowance. Because the Trunk Road tunnel is on diaphragm wall (piled) supports, it will not be structurally adversely affected by the construction of the SCL tunnels.

4.2.7 Where the Trunk Road tunnel rises up above the seabed to ground level, for the connection with the IEC at the eastern end of the Causeway Bay Typhoon Shelter, cut-and-cover tunnel in reclamation will again be the feasible form of construction.

4.2.8 In summary, cut-and-cover tunnel construction is considered to be the practical and feasible form of construction for implementation of the Trunk Road at the west of the HKCEC, through the HKCEC water channel, along the Wan Chai shoreline and through the Causeway Bay Typhoon Shelter. Permanent reclamation will be required at the HKCEC, along the Wan Chai shoreline and at the eastern end of the Causeway Bay Typhoon Shelter, for the cut-and-cover tunnel, where it lies above the seabed level.

4.3 Trunk Road Tunnel Variations

4.3.1 Three feasible Trunk Road tunnel variations have been developed that will meet the overriding public need for the Trunk Road are presented. Chapter 4 of the HEC Report on Trunk Road Alignments and Harbour-front Enhancement

(Annex G) describes the tunnel option variations and their corresponding harbour-front enhancement potential in more detail, and the major issues associated with these tunnel variations. Key features of the three tunnel variations are described briefly as follows.

Trunk Road Tunnel Variation 1

4.3.2 In this tunnel option, the Trunk Road starts off at the connection with CRIII in cut-and-cover tunnel, crosses over the MTR Tsuen Wan Line tunnel and continues through the HKCEC water channel and along the Wan Chai shoreline, in cut-and-cover tunnel, in reclamation.

4.3.3 The Trunk Road tunnel passes beneath the Cross Harbour Tunnel portal at sufficient depth (–30mPD) to avoid conflict with the existing rock anchors of the Cross Harbour Tunnel portal structure. The low level of the Trunk Road tunnel means that the tunnel structure lies entirely below the seabed level of the ex-PCWA basin and the Causeway Bay Typhoon Shelter, only rising up above seabed level to ground level to the east of the Causeway Bay Typhoon Shelter, where the Trunk Road then rises up to connect with the existing elevated IEC. Permanent reclamation in the ex-PCWA basin and in the Causeway Bay Typhoon Shelter is not essential. While temporary works will be required (which may include temporary land formation for tunnel construction purposes) these can be removed afterwards and the existing seabed and water area reinstated.

4.3.4 Connection to the IEC is made to the northern side of the existing IEC elevated road structure, which is considered to be the least disruptive form of connection. The existing IEC links back into Causeway Bay (to Victoria Park Road and Hing Fat Street) are retained.

Trunk Road Tunnel Variation 2

4.3.5 This scheme has been based on a submission from the public (Swire Properties Ltd) during the Envisioning Stage. The Trunk Road tunnel runs along the HKCEC and Wan Chai shorelines in cut-and-cover tunnel similar to Trunk Road Tunnel Variation 1, but turns southwards around the Cross Harbour Tunnel portal to avoid the anchorage zone of the portal structure. The Trunk Road tunnel then connects directly into the IEC at the eastern side of the Causeway Bay Typhoon Shelter, with the existing IEC connections to Victoria Park Road reconstructed. So as to free up more waterfront space along the southern edge of the Causeway Bay Typhoon Shelter and to construct a wide landscaped deck to extend Victoria Park to the waterfront, Victoria Park Road and associated connecting roads are proposed to be reconstructed further to the south (within the existing Victoria Park).

4.3.6 The shallower tunnel through the south-western corner of the Causeway Bay Typhoon Shelter for this Tunnel Variation 2 requires reclamation in this area, and reclamation is required in the south-eastern corner of the Causeway Bay Typhoon Shelter for the reconstruction of the IEC and Victoria Park Road connections in tunnel (above seabed level).

Trunk Road Tunnel Variation 3

4.3.7 Instead of pulling the tunnel southwards to go around the Cross Harbour Tunnel portal anchorage zone, the Trunk Road tunnel passes beneath the Cross Harbour Tunnel portal in order to improve the road alignment and to avoid the disruption that would be caused by construction across the entrance to the Cross Harbour Tunnel. Other details are similar to Trunk Road Tunnel Variation 2. This scheme, too, has been based on a submission from the public (the RHKYC) during the Envisioning Stage.

4.3.8 Whilst the straightened alignment avoids the need for reclamation in the south-western corner of the Causeway Bay Typhoon Shelter, reclamation is still required in the south-eastern corner of the Causeway Bay Typhoon Shelter for the reconstruction of the IEC and Victoria Park Road connections in tunnel.

Comparison of the Trunk Road Tunnel Variations

4.3.9 **Table 4.1** provides a comparison between the Trunk Road Tunnel Variations 1, 2 and 3, in broad terms, in respect of key indicators: area of reclamation, impacts to existing traffic, technical highway concerns and impacts to existing highway structures, impacts to existing development, planning and land use considerations, environmental concerns, time for construction and costs.

4.3.10 The following major issues are highlighted as being of particular concern:

- more reclamation due to filling in of the corners of the Causeway Bay Typhoon Shelter (south-east and south-west corners for Variation 2, south-east corner for Variation 3);
- major road diversions and traffic impacts during construction (particularly for Variations 2 and 3);
- intrusion into and demolition of Victoria Park for the construction of the realigned Victoria Park Road (both Variations 2 and 3);
- need for the reconstruction of major existing highway structures, including the IEC, Gloucester Road Flyover and the newly constructed Causeway Bay Flyover (both Variations 2 and 3);
- demolition of the Police Officers’ Club (Variation 2);
- air quality concern at the tunnel portal, due to close proximity of residential units (all tunnel variations, but more so for Variations 2 and 3).

4.3.11 It should be noted that the areas of reclamation given in Table 4.1 are the areas of permanent reclamation, and include a notional allowance for reprovisioning requirements (for ferry pier, salt water pumping station, cooling water pumping stations, etc) associated with each of these tunnel variation options.

Table 4.1 Comparison of Trunk Road Tunnel Variations

	Tunnel Variation 1	Tunnel Variation 2	Tunnel Variation 3
Area of permanent reclamation	15 ha	18.5 ha	16.5 ha
Impact to existing traffic	• Some disruption at new tie-in to IEC	• Major disruption due to demolition of IEC and new tie-in to IEC • Major disruption due to reconstruction of Victoria Park Road, Causeway Bay Flyover and Gloucester Road Flyover • Major disruption at CHT approach roads due Trunk Road tunnel construction	• Major disruption due to demolition of IEC and new tie-in to IEC • Major disruption due to reconstruction of Victoria Park Road, Causeway Bay Flyover and Gloucester Road Flyover
Other technical concerns (impacts to highways structures, etc.)	• Localised reconstruction of existing IEC at City Garden for merging with the Trunk Road	• Reverse curves at the CHT area: undesirable for Trunk Road in tunnel • Reconstruction of Victoria Park Road and associated connections and Causeway Bay Flyover and Gloucester Road Flyover • Demolition of existing IEC from Victoria Park Road to City Garden	• Reconstruction of Victoria Park Road and associated connections and Causeway Bay Flyover and Gloucester Road Flyover • Demolition of existing IEC from Victoria Park Road to City Garden
Impacts to existing development	Existing development not affected	POC needs to be demolished	Existing development not affected

		Tunnel Variation 1	**Tunnel Variation 2**	**Tunnel Variation 3**
Planning and land use concerns	Along Wan Chai shoreline	Land formed can be used for harbour-front enhancement and pedestrian access to the waterfront	Land formed can be used for harbour-front enhancement and pedestrian access to the waterfront	Land formed can be used for harbour-front enhancement and pedestrian access to the waterfront
	PCWA basin	PCWA basin can be developed into a vibrant marine recreational facility	PCWA basin can be developed into a vibrant marine recreational facility	PCWA basin can be developed into a vibrant marine recreational facility
	Northern side of Victoria Park	Victoria Park can be extended to the harbour-front via a landscaped deck over the ground level roads	Victoria Park is reconstructed with a wide landscaped deck over the ground level roads, to a widened promenade	Victoria Park is reconstructed with a wide landscaped deck over the ground level roads, to a widened promenade
	CBTS	The existing CBTS is preserved as far as possible	Filling in the corners of the CBTS can be used for additional waterfront uses	Filling in the south-east corner of the CBTS can be used for additional waterfront uses
Environ-mental concerns	Noise & Air	• (Lesser) air quality concern at tunnel portal • Noise at tie-in to IEC (short 'new road' section)	• Air quality concern at tunnel portal • Noise along reconstructed IEC (long 'new road' section)	• Air quality concern at tunnel portal • Noise along reconstructed IEC (long 'new road' section)
	Water Quality	No major operational impacts due to the scheme	No major operational impacts due to the scheme	No major operational impacts due to the scheme
	Visual	No significant visual impacts	No significant visual impacts	No significant visual impacts
Time for construction		7 years	8 years	8 years
Costs *(incl WDII works & CWB in WDII)*	Total Construction	HK$20B	HK$28B	HK$25B
	Total Annual Recurrent	HK$110M	HK$125M	HK$123M

4.3.12 It should also be noted that there will be a requirement for temporary works (including temporary reclamation) to facilitate cut-and-cover tunnel construction and for temporary traffic diversions. These temporary works will be required in the ex-PCWA basin and in the Causeway Bay Typhoon Shelter. In the Causeway Bay Typhoon Shelter, the extent of the temporary works, for all three tunnel variations, will be such that the existing moorings will need to be relocated outside the typhoon shelter during the construction period.

4.3.13 As can be seen, neither Tunnel Variation 2 nor 3 perform as well as the Trunk Road Tunnel Variation 1. The major drawbacks of Tunnel Variations 2 and 3 include additional reclamation for filling in of the corners of the Causeway Bay Typhoon Shelter, major traffic disruption, demolition of a large part of Victoria Park, demolition and then reconstruction of major highway structures, and air quality concerns at the tunnel portal area in North Point.

4.3.14 The reclamation issue is particularly important in respect of the PHO. The Trunk Road Tunnel Variation 1 requires a lesser extent of reclamation than that associated with the Tunnel Variations 2 and 3.

4.4 Trunk Road Flyover

4.4.1 The Trunk Road flyover option and the comparison with the tunnel option are presented in Chapter 4 of the HEC Report on Trunk Road Alignments and Harbour-front Enhancement **(Annex G)**.

4.4.2 Same as for the tunnel option, the Trunk Road starts off at the connection with CRIII in cut-and-cover tunnel, crosses over the MTR Tsuen Wan Line and continues through the HKCEC water channel and along the Wan Chai shoreline, in cut-and-cover tunnel. Alignment constraints through the HKCEC water channel, including the HKCEC atrium link bridge and ground level road access, mean that the Trunk Road will need to stay in tunnel through the HKCEC water channel, only rising up to a tunnel portal along the Wan Chai shoreline. As for the case with tunnel options, reclamation is required along this part of the shoreline for Trunk Road construction.

4.4.3 The road then rises up onto elevated road structure to cross over the ex-PCWA basin, then over Kellett Island (and the Cross Harbour Tunnel portal), and stays on elevated structure to the connection with the existing IEC at the eastern side of the Causeway Bay Typhoon Shelter, at a level of around +14mPD. No permanent reclamation (that is, land formation) is required in the ex-PCWA basin, the Causeway Bay Typhoon Shelter or along the North Point shoreline.

Comparison of Tunnel and Flyover Options

4.4.4 **Table 4.2** provides a comparison between the tunnel and flyover options in broad terms, in respect of key indicators: affected area of the Harbour, impacts to existing traffic, technical highway concerns and impacts to existing highway structures, planning and land use considerations, environmental concerns, time of construction, and costs. Trunk Road Tunnel Variation 1 is used as the basis of tunnel option comparison. The key issue that is of concern in respect of the PHO is the area of the Harbour that will be affected by the tunnel and flyover options.

Area of the Harbour affected by the Trunk Road Tunnel and Flyover Options

4.4.5 The PHO requires the Harbour to be protected and preserved as a special public asset and a natural heritage of the Hong Kong people, and establishes a presumption against reclamation in the Harbour. Notwithstanding that there is an overriding need for reclamation for the project, it is essential to find the option that will best serve to protect and preserve the Harbour, with the minimum area of the Harbour affected by reclamation. In this regard, the area of the Harbour affected by the alternative Trunk Road tunnel and flyover options is of concern. The flyover structures over water will impinge upon the water area of the Harbour and their visual impacts do not promote the protection and preservation of the Harbour. Moreover, where the marine use of existing water areas is restricted due to the presence of highway structures and the like, these affected water areas may not be regarded as "protected" or "preserved" for the purposes of the PHO.

4.4.6 Therefore, when examining Trunk Road options, and especially when examining the flyover option, the land formation by physical reclamation is taken into account together with the water areas of the Harbour affected by flyover structures in order to determine which option may serve best to protect and preserve the Harbour.

Table 4.2 Comparison of Tunnel and Flyover Options

		Tunnel Option (Tunnel Variation 1)	**Flyover Option**
Affected area of the Harbour: (a) Land formed (b) Flyover structures over water (c) Affected water area		 15 ha 0.5 ha -	 11.5 ha 3 ha 4 ha
Impact to existing traffic		Some disruption at new tie-in to IEC	• Major disruption at new tie-in to IEC • Major disruption due to reconstruction of Victoria Park Road connections
Other technical concerns (impacts to highways structures, etc)		Localised reconstruction of existing IEC at City Garden for merging with the Trunk Road	Reconstruction of existing IEC from Victoria Park Road to Victoria Centre
Planning and land use considerations	Along Wan Chai shoreline	Land formed can be used for harbour-front enhancement and pedestrian access to the waterfront	Land formed is partly occupied by the tunnel portal which constrains the extent of area for harbour-front enhancement and pedestrian access to the waterfront
	PCWA basin	PCWA basin can be developed into a vibrant marine recreational facility	Highway bridge piers and the low headroom clearance of the flyover restrict the development of the PCWA basin as a recreational facility

		Tunnel Option (Tunnel Variation 1)	**Flyover Option**
	Northern side of Victoria Park	Victoria Park can be extended to the harbour-front via a landscaped deck over the roads	With the flyover running along the northern side of Victoria Park, the landscaped deck over Victoria Park Road and extension of Victoria Park are impractical
	CBTS	The existing CBTS is preserved as far as possible	Part of the water area and the existing promenade will be occupied by bridge piers
	North Point	Seaward portions of existing and planned developments from Hing Fat Street to Oil Street are affected. Part of land formed can be used for harbour-front enhancement and pedestrian access	No major impact on existing and planned developments
Environmental concerns	Noise & Air	• Air quality concern at tunnel portal • Noise at tie-in to IEC (short 'new road' section of IEC)	Significant air and noise impacts along flyover section in Causeway Bay and reconstructed IEC at North Point ('new road')
	Water Quality	No major operational impacts due to the scheme	No major operational impacts due to the scheme
	Visual	No significant visual impacts	Significant impacts in Wan Chai and (especially) in Causeway Bay (flyover along part of Wan Chai shoreline and through CBTS)
Time for construction		7 years	6 years
Costs *(including WDII works & CWB in WDII)*	Total Construction	HK$20B	HK$11B
	Total Annual Recurrent	HK$110M	HK$75M

4.4.7 In most respects, it is found that the Trunk Road tunnel option (Tunnel Variation 1) performs better than the flyover option. The tunnel option:

- will result in a lesser affected area of the Harbour;
- will cause less traffic disruption during construction;
- will not require any major reconstruction of existing highway structures;
- will have more opportunities for harbour-front enhancement and providing access to the waterfront;
- will cause less extensive air and noise impacts (although air quality at the tunnel portal will need to be carefully addressed);
- will have no significant visual impacts (the flyover, on the other hand, will have significant visual impacts along the harbour-front).

4.4.8 Only in respect of time for construction and costs can the flyover option be seen as performing better than the tunnel option.

4.4.9 The key issue of concern is: "which option would serve best to protect and preserve the Harbour?" In addressing this question, the area of the Harbour that is affected by the Trunk Road options should be taken into account, including not only land formed by reclamation but also the impingement of highway structures on the existing water areas and the restricted use of water areas due to the presence of the highway structures (ie the areas where the functionality of the Harbour is adversely affected). In addition, the visual aspects of the flyover option (viewed in terms of "preserving the Harbour") should be considered. In these respects, the Trunk Road tunnel option is clearly the option that would serve best to protect and preserve the Harbour.

4.5 Conclusions of the Review of Feasible Options

> Which Trunk Road option has the minimum extent of reclamation or, more pertinently, affects the minimum area of the Harbour ?

4.5.1 Tunnel and Flyover Options along the foreshore of Wan Chai and Causeway Bay have been found to be feasible options that can meet the overriding need for the Trunk Road. Three variations have been developed for the Tunnel Option; these variations differ mainly in the manner that the Trunk Road crosses the Cross Harbour Tunnel and the way it connects to the existing IEC, with Variations 2 and 3 being based on submissions from the public.

4.5.2 Comparing the tunnel variations, Tunnel Variation 1 is found to require the least extent of reclamation, would cause the least disruption to traffic during construction, has the least impacts to existing highway infrastructure and the least impacts to Victoria Park. It should be noted that, when considering Trunk Road variations having similar functional/traffic performance (ie in meeting the overriding need), the CFA ruling on the PHO requires that the one with the least amount of reclamation (in this case Tunnel Variation 1) should be selected. Therefore, of these tunnel variations, Trunk Road Tunnel Variation 1 is recommended, in compliance with the requirements of the PHO.

4.5.3 Although both capital and annual recurrent costs would be higher for the Tunnel Option when compared with the Flyover Option, the Tunnel Option is recommended, in compliance with the requirements of the PHO, primarily because the affected area of the Harbour would be smaller and it would cause less visual impact than the Flyover Option.

4.5.4 Trunk Road Tunnel Variation 1 affects the minimum area of the Harbour and serves best to protect and preserve the Harbour, among all the options that have been assessed.

5 PUBLIC VIEWS

5.1 Public Engagement Activities

5.1.1 The first stage of the HER project, the Envisioning Stage, had as its purpose the engagement of the community at an early stage to solicit their visions on the need for and the form of Trunk Road as well as the types of harbour-front developments they aspire for at Wan Chai, Causeway Bay and the adjoining areas. Five public forums and two community design charrettes were convened during May to July 2005, and opinion surveys were carried out. These public engagement activities were well received by the public, in particular by the key stakeholders, as providing a platform for thorough exchange of views, rational discussions and consensus building.

5.1.2 The public's views collected and findings of the Envisioning Stage are presented in a Public Engagement Report, March 2006. A copy of the report is attached at **Annex K** for reference, and the report can be viewed on the HEC website at: http://www.harbourfront.org.hk/eng/content_page/doc/engagement_report/Main_Report.pdf.

5.1.3 In addition, discussions with the Town Planning Board, Legislative Council (LegCo), District Councils and relevant statutory and advisory bodies have also been held, as part of an on-going and continuous process of public engagement for seeking consensus on the project proposals. In particular, the Town Planning Board, relevant District Councils, LegCo Planning Lands and Works (PLW) Panel, Transport Advisory Committee and professional institutions were further engaged from April to June 2006 on the findings regarding alignments and construction forms for the Trunk Road and harbour-front enhancement ideas.

5.2 Public Views on the Trunk Road Ideas

5.2.1 The outcome of the public engagement activities and the public views received on the Trunk Road ideas are summarised as follows.

Public Forums and Submissions

5.2.2 Public views and opinions were received during engagement exercises including community charrettes, where most participants agreed that if there is no alternative and there is a need for the construction of the Trunk Road to solve the traffic congestion problem, they prefer a tunnel form of construction, to allow more flexible use of the waterfront with least adverse visual impacts.

5.2.3 Many parties realise that some reclamation may be necessary for building the Trunk Road. However, all agree that minimum reclamation should be an overriding principle in the design of transport infrastructure. Most participants in the public engagement exercises accept the need for reclamation at the HKCEC and along the Wan Chai shoreline for shallow cut-and-cover tunnel construction, but there is a clear preference for tunnel options that do not result in reclamation in the Causeway Bay Typhoon Shelter (although some parties have suggested limited reclamation in the corners of the typhoon shelter for waterfront enhancement).

5.2.4 The written submission by Swire Properties Ltd, “A Proposal for the Wan Chai - Causeway Bay Shoreline”, incorporates a shallow Trunk Road tunnel, in reclamation, through the HKCEC water channel and along the Wan Chai shoreline. In the Swire’s scheme the Trunk Road tunnel swings southwards around the Cross Harbour Tunnel portal and through the south-west corner of the typhoon shelter, in reclamation, before turning northwards to connect into the IEC at North Point. This Trunk Road option has been developed as Trunk Road Tunnel Variation 2, presented in Section 4 above.

5.2.5 The written submission by RHKYC, “Preserving the Vibrancy and Diversity of Victoria Harbour”, also involves a shallow

Trunk Road tunnel, in reclamation, through the HKCEC water channel and along the Wan Chai shoreline. The Trunk Road tunnel then passes under the Cross Harbour Tunnel portal area and under the Causeway Bay Typhoon Shelter (deep enough not to require reclamation) before connecting to the outside of the existing IEC at North Point. This Trunk Road option has been developed as Trunk Road Tunnel Variation 3, presented in Section 4 above.

5.2.6 The Eastern District Council held a concept design competition "A New Face for the Eastern Harbourfront". Whilst the designs were focussed on the harbour-front design rather than on the Trunk Road, the basis of the design of the winning entry, "Healthy Life Healthy City", is a Trunk Road tunnel option similar to Trunk Road Tunnel Variation 2.

5.2.7 In general, therefore, public views clearly favour a Trunk Road tunnel option, very much in line with the tunnel variation schemes presented in Section 4. There is consistency in the views and proposals for a shallow cut-and-cover tunnel along the Wan Chai shoreline, in reclamation; and for a deeper tunnel, beneath the seabed, that does not require reclamation through the Causeway Bay Typhoon Shelter, although there are different views about the need for reclamation in the corners of the typhoon shelter.

Town Planning Board

5.2.8 Members paid particular attention to potential impacts on traffic arising from temporary traffic diversions associated with the various Trunk Road ideas, potential impacts to Victoria Park and whether any of the Trunk Road ideas would jeopardize the railway projects being planned.

5.2.9 There was view that the Flyover Option is unlikely to be acceptable to the general public and Variation 1 of the Tunnel Option was the most viable option. On these premises, it was advisable for the Government and the consultants to clearly explain the merits of this option to the public with a view to soliciting the widest possible community support. The Town Planning Board also saw the need to focus on the practicality and details of the feasible options in the Realization Stage of public consultation in HER.

Transport Advisory Committee

5.2.10 The Transport Advisory Committee maintained their full support for the construction of the Trunk Road with its two sets of planned slip roads in Wan Chai and Causeway Bay. It also looked forward to the early completion of this last piece of infrastructure of the strategic road link along the northern shore of the Hong Kong Island.

5.2.11 It was stressed that due regard should be paid to the need to minimise traffic disruption and nuisance caused to the public during the construction stage.

5.2.12 The Committee also noted that considerable attention had been given to limit the reclamation required in examining how to build the Trunk Road and to maximise the opportunities the reclamation may provide for enhancing the harbour-front.

District Councils

5.2.13 There was a general support for the construction of the Trunk Road and quite a number of members urged for early completion of the Trunk Road.

5.2.14 As for the construction forms of the Trunk Road, there was a majority support for Variation 1 of the Tunnel Option in the Southern District Council and there were also views expressed in the other three District Councils in support of it. On the other hand, the Flyover Option had little support.

5.2.15 Another main concern of the members was on traffic impacts during the construction stage and members stressed that such impacts must be minimised.

5.2.16 Members requested for maximising harbour-front enhancement opportunities, but there were views expressed that this should not be a reason for reclaiming the Harbour.

5.2.17 Members of the District Councils pointed out that there was a need to ensure that all ideas have already been exhausted in arriving at the conclusion that there is no possible "no-reclamation" alignment for constructing the Trunk Road. The Central and Western District Council passed a motion objecting to the conclusion of no possible "no reclamation" alignment and requesting the Administration to review the planning for Central and Wan Chai and to reduce the commercial development in CRIII and Tamar Development so as to minimise the transport need. The Eastern District Council passed a motion urging for extending the Trunk Road eastern tunnel portal and the North Point waterfront promenade to the eastern side of the ex-North Point Estate. (However, locating the tunnel portal further east at the ex-North Point Estate would result in more reclamation and would therefore not satisfy the "overriding public need test" under the PHO.)

Professional Institutions

5.2.18 The need for the Trunk Road with its planned slip roads at Wan Chai and Causeway Bay was supported by many participants and reaffirmed by the representatives from Hong Kong Institute of Architects, Hong Kong Institution of Engineers, Hong Kong Institute of Landscape Architects, Hong Kong Institute of Planners and Hong Kong Institute of Surveyors, that organised a Joint Institute Seminar to discuss the matter.

5.2.19 Regarding the various options and ideas for the Trunk Road, Variation 1 of the Tunnel Option was considered to be the most feasible solution.

5.2.20 There was a suggestion of achieving the effect of retaining the harbour at the reclaimed land through the introduction of water related landscape features, such as large fountains, lakes, etc, to create a 'water theme'.

5.2.21 The Hong Kong Institution of Engineers also convened a separate forum on the same topic. In the closing remarks, support for building the Trunk Road was reiterated and Tunnel Variation 1 was considered the best option in compliance with the PHO and enhancement of the harbour-front.

LegCo PLW Panel

5.2.22 The Consultants explained the reasons for the conclusion that there was no possible "no reclamation" alignment for constructing the Trunk Road and the fact that all ideas and proposals from the public have been carefully assessed; nevertheless there was some debate about such conclusion and members requested further consideration in that respect.

5.2.23 On the other hand, there was a view that out of the options/variations considered by the Consultants, Trunk Road Tunnel Variation 1 serves best in complying with the PHO.

5.2.24 As for harbour-front enhancement, there was a view to introduce some water-related features on part of the reclaimed land above the sea level so as to mitigate the impact due to reclamation. There was a request to enhance the continuity of the pedestrian walkways/footbridges along the northern shore of the Hong Kong Island as well as to enhance the accessibility to the harbour-front of Hong Kong Island.

5.2.25 The LegCo PLW Panel also invited deputations to express views. Twelve parties/individuals presented their views in person with written submissions from two others. Majority of the views supported the construction of the Trunk Road and Tunnel Option Variation 1. They also stressed on seizing the opportunity to enhance the harbour-front. There were some divergent views that traffic measures alone, including electronic road pricing, may be sufficient to resolve the traffic congestion problems. There was also the view suggesting to submerge the whole length of the IEC, or a substantial section of it, as part of the harbour-front enhancement measures; in response, Government noted that submerging the whole of the existing IEC was beyond the ambit of the WDII project and, as explained to LegCo, there is no plan at this stage to demolish the IEC and reconstruct it in the form of tunnel.

5.3 Conclusions Drawn from the Public Engagement

What does the Public think ?

5.3.1 The general sentiment of the public, in respect of the Trunk Road ideas and aspirations for harbour-front enhancement, expressed through the Envisioning Stage consultation, includes:

- a preference for having the Trunk Road in tunnel;
- generally, an acceptance of the need for reclamation for shallow tunnel construction at the HKCEC and along the Wan Chai shoreline;
- but, rather have tunnel options that do not result in reclamation in the Causeway Bay Typhoon Shelter.

5.3.2 Overall, Trunk Road Tunnel Variation 1 is seen as the best option in complying with the PHO, and this Trunk Road option has clearly expressed support as the preferred Trunk Road scheme.

6 PREFERRED TRUNK ROAD SCHEME

6.1 Confirmation of Preferred Trunk Road Option

6.1.1 The conclusion of the review of feasible Trunk Road options, which is supported by the views of the Public, is that Trunk Road Tunnel Variation 1 affects the minimum area of the Harbour and serves best to protect and preserve the Harbour, among all the options and variations that have been assessed.

6.1.2 After due consideration of these investigations, the HEC Sub-committee on WDII Review agreed at their meeting on 13 June 2006 to endorse Trunk Road Tunnel Variation 1 as the basis for proceeding to the next stage of the WDII Review, the preparation of the Concept Plan.

6.2 Trunk Road Scheme Engineering Details

6.2.1 The engineering layout of the preferred Trunk Road scheme, Trunk Road Tunnel Variation 1, is presented in **Annex L**. Whilst the various elements of the scheme have been discussed in the preceding sections, for completeness, the overall Trunk Road scheme is described briefly below.

Overall Trunk Road Layout

6.2.2 At the western end of the WDII project area, connection is made to the Trunk Road tunnel which will be constructed under CRIII. The eastern end of the Trunk Road tunnel in CRIII is located to the west of the HKCEC Extension, near Lung King Street, and forms the starting point of the Trunk Road at the western end of the WDII project area. The Trunk Road is a cut-and-cover tunnel with a road level of –10mPD and top of tunnel structure at around –1mPD (ie above existing seabed level) at this connection point. Reclamation is required for this cut-and-cover tunnel above seabed level.

6.2.3 Then, the Trunk Road tunnel must cross over the top of the MTR Tsuen Wan Line tunnel. A piled Trunk Road tunnel structure spanning across the MTR tunnel has been developed and agreed previously in consultation with MTRC. In this case, the Trunk Road tunnel structure will lie completely above the seabed level, with a road level of around –7mPD. Taking into account the height of the Trunk Road tunnel, the top of the tunnel structure would then lie above sea level, at a level of around +2.5mPD, and needs to be contained within reclamation.

6.2.4 The Trunk Road tunnel continues through the HKCEC water channel and along the Wan Chai shoreline, with the tunnel structure still above seabed level. Again, reclamation is required for the shallow cut-and-cover tunnel construction and to contain the tunnel structure above seabed level. This reclamation will also accommodate the slip road connections in Wan Chai North.

6.2.5 Further east, the tunnel passes beneath the Cross Harbour Tunnel portal at a level of around –30mPD; this depth is required in order to avoid conflict with the existing rock anchors of the CHT portal structure.

6.2.6 The low level of the Trunk Road tunnel under the Cross Harbour Tunnel means that the tunnel structure lies entirely below the seabed level of the adjacent ex-PCWA basin and the Causeway Bay Typhoon Shelter, only rising up above seabed level to a ground level tunnel portal east of the Causeway Bay Typhoon Shelter. Permanent reclamation in the ex-PCWA basin and in the Causeway Bay Typhoon Shelter is not essential. While temporary works will be required (which may include temporary land formation for tunnel construction purposes) these can be removed afterwards and the existing seabed and water area reinstated.

6.2.7 To the east of the Causeway Bay Typhoon Shelter, along the North Point shoreline, the Trunk Road rises up above seabed level to the ground level portal, where once again, reclamation is required for the cut-and-cover tunnel construction and to contain and protect the tunnel structure. The Trunk Road then rises on flyover structure to connect with the existing elevated IEC. Connection to the existing IEC elevated road structure, at road levels between +12mPD and +15mPD, is made to the northern side of the IEC. The existing IEC connections back into Causeway Bay (to Victoria Park Road and Hing Fat Street) are retained.

Horizontal Alignment

6.2.8 The horizontal alignment of the Trunk Road through the WDII project area is governed by a number of constraints, including highway design standards that dictate the geometry of the road and physical obstructions or restrictions that result in “fixed alignment points”. Together, these determine the road curvature and the extent of intrusion of the Trunk Road tunnel into the harbour. The following fixed alignment points largely determine the horizontal alignment.

6.2.9 At the western end of WDII, connection is required to the Trunk Road tunnel under CRIII; this location has already been fixed. Then the tunnel must pass through the HKCEC water channel, between the HKCEC foundations (alignment options both to the north and south of the water channel have been examined in Section 3 above, but found not feasible due to conflict with existing development). The HKCEC foundations limit the possible movement, both northward and southward, of the Trunk Road alignment through the water channel.

6.2.10 Through the centre of the WDII project area, along the Wan Chai shoreline, the existing electricity substation and the Wan Chai East Sewage Screening Plant obstruct the Trunk Road from turning southwards. The northern boundary of the existing Wan Chai East Sewage Screening Plant defines the southern limit of the Trunk Road tunnel alignment: immediately inside this boundary are existing sewage outfall facilities and the planned dropshafts of the Harbour Area Treatment scheme, which restrict any further southward shifting of the Trunk Road alignment. The crossing under the Cross Harbour Tunnel is restricted southwards by the foundations of the Police Officers’ Club and northwards by the extent of the Cross Harbour Tunnel portal structure (crossing any further north, beyond the zone of the Cross Harbour Tunnel portal structure, would result in unacceptably high risk of damage to the Cross Harbour Tunnel).

6.2.11 At the eastern end of WDII, the Trunk Road tunnel structure is located adjacent to the existing IEC foundation piles, which constrain the extent to which the Trunk Road alignment can be moved any further southwards; this therefore fixes the horizontal alignment of the Trunk Road at this location.

6.2.12 The Trunk Road horizontal alignment from the connection with CRIII in the west to the connection to the IEC in the east is then determined by fitting a smooth curve between all these fixed points. Road curvature is in accordance with highway design standards with regard to geometric values for radii and sight distances requirements.

6.2.13 The resulting horizontal alignment for the Trunk Road, as shown in Annex L, is found to be the optimal alignment in meeting the necessary highway design standards within physical alignment constraints. The alignment ensures the least intrusion into the harbour, and therefore the minimum extent of reclamation.

Slip Roads

6.2.14 The following slip road connections have been identified as essential in meeting traffic demand and enabling the Trunk Road to adequately perform its function of relieving traffic from the overloaded Connaught Road Central – Harcourt Road – Gloucester Road corridor:

- a slip road for traffic from Central and western Hong Kong Island exiting the eastbound Trunk Road at Wan Chai North (‘Slip Road 1’);
- a slip road for traffic from Wan Chai North entering the eastbound Trunk Road to the IEC (North Point and eastern Hong Kong Island) (‘Slip Road 2’);
- a slip road for traffic from the IEC exiting the westbound Trunk Road at Wan Chai North (‘Slip Road 3’); and
- a slip road for traffic from the Causeway Bay and Tin Hau area entering the westbound Trunk Road to Central and western Hong Kong Island (‘Slip Road 8’).

6.2.15 The Wan Chai slip roads (Slip Roads 1, 2 and 3) will rise up from the Trunk Road tunnel, which is above seabed level in reclamation, to their ground level tunnel portals. The slip roads will also be constructed as cut-and-cover tunnel and, as the slip roads also lie above seabed level (and above sea level), they need to be contained within reclamation.

6.2.16 The Causeway Bay slip road (Slip Road 8) would ordinarily require reclamation if aligned from the connection with Victoria Park Road directly through the Causeway Bay Typhoon Shelter, due to its shallow level (above seabed). Under the Trunk Road Tunnel Variation 1 scheme, however, an alternative alignment for Slip Road 8 has been proposed, where the slip road connects to the southern side of Victoria Park Road, running along the northern boundary of Victoria Park before dropping into tunnel to cross under Victoria Park Road to connect with the Trunk Road tunnel at a deep enough level below the seabed of the Causeway Bay Typhoon Shelter, such that, similar to the mainline Trunk Road tunnel, permanent reclamation for the slip road is not required.

Trunk Road Lane Configuration

6.2.17 As recommended by previous traffic studies at various stages of the project and endorsed by the Expert Panel, a dual 3-lane configuration for the mainline tunnel is required to meet forecast traffic flows along the Trunk Road generally. However, traffic/safety restrictions will affect the Trunk Road lane configuration and will result in additional lanes at some sections of the tunnel. These include:

- no merging or weaving in tunnels (so slip roads entering the Trunk Road tunnel cannot join the mainline lanes but need to maintain their own lane);
- nearside lanes should be continuous through the mainline tunnel for buses to keep to these lanes.

6.2.18 The restriction on merging and weaving in tunnels means that Slip Roads 2 and 8 will join the mainline tunnel as separate lanes, in which case a mainline 3-lane configuration will increase to 4 lanes in the respective directions at those locations. To minimise the extent of reclamation, efforts have been made to investigate whether the restriction on continuity of nearside lanes for buses and the need to maintain 3 mainline lanes through the tunnel length could be relaxed, without undermining safety or compromising traffic capacity. By allowing buses to use the middle lane as well as the nearside lane, still leaving the offside lane unobstructed for lighter/faster traffic (ie continuity need only be maintained for the middle lane rather than the nearside lane), and by matching the number of mainline lanes closely with the actual traffic demand through the various sections of the Trunk Road, rather than looking at the overall traffic demand, a reduction in the number of lanes can be achieved, with the Trunk Road having the following lane configuration:

- For the eastbound direction – initially three lanes run through CRIII to Slip Road 1, which exits as a lane drop. Two mainline lanes continue through the HKCEC water channel. Slip Road 2 joins the Trunk Road in Wan Chai and provides the third lane again to meet traffic demand along this section, through to the tunnel portal at the IEC connection in North Point.

- For the westbound direction – initially three lanes from the eastern portal in North Point run through Causeway Bay until they are joined by an additional lane from Slip Road 8, on the offside (centre of tunnel). This is so as to enable the Slip Road 8 traffic, which will be limited to passenger cars and light goods vehicles, to continue through to Central rather than having to exit the Trunk Road at Slip Road 3 in Wan Chai. From the Slip Road 8 connection, a short section of the westbound Trunk Road will consist of four lanes, to the exit of Slip Road 3 in Wan Chai, where one lane is dropped, leaving three lanes running westbound through the HKCEC water channel and through CRIII.

6.2.19 This Trunk Road lane configuration provides a more efficient and effective use of traffic lanes, a reduced width of Trunk Road tunnel structure and consequently a reduced extent of reclamation for construction of the Trunk Road.

Ancillary Trunk Road Tunnel Infrastructure

6.2.20 Tunnel ventilation buildings are required at around the centre of the Trunk Road tunnel, near the HKCEC, and near the eastern tunnel portal. A tunnel administration building, for the tunnel operator, is required near the eastern tunnel portal, and operator's roads need to be provided at the eastern portal to facilitate emergency and breakdown vehicle access to and from both the eastbound and westbound tunnels.

6.2.21 All of these facilities will be located on existing land or on reclaimed land already formed for the Trunk Road tunnel, and therefore no additional reclamation for this ancillary infrastructure is required.

6.3 Ground Level Roads

6.3.1 The ground level road layout associated with the Trunk Road Tunnel Variation 1 scheme, is presented at **Annex M**.

6.3.2 The major element of the future ground level road system is Road P2, which runs east-west from Central to connections with the existing road network in Wan Chai North. Road P2 is mainly a dual 2-lane primary distributor that serves both local east-west movements and the distribution of north-south traffic movements. Occasionally, additional right-turning pockets are provided at road junctions to ensure the operational efficiency of the junctions.

6.3.3 Road P2 also serves to provide access to the existing and new development areas through CRIII and WDII, drawing local traffic away from the Connaught Road Central – Harcourt Road – Gloucester Road corridor.

6.3.4 The Road P2 alignment has been planned to run over the top of the Trunk Road tunnel through CRIII and the HKCEC water channel, to the connection with Fleming Road, in order to minimise the overall road "footprint" and the area of land sterilised by highway infrastructure.

6.3.5 Along the Wan Chai shoreline, the existing Hung Hing Road in front of the Wan Chai North PTI is realigned to connect with the new Road P2 / Fleming Road junction, but the current Hung Hing Road alignment in front of the Wan Chai Sports Ground is retained. The retention further east of the existing Hung Hing Road alignment means that there is no intrusion by new roads into the new Wan Chai waterfront area.

6.3.6 All the new ground level roads and the modifications to the existing ground level road network, is accomplished within existing land areas or (in the case of Road P2) over the top of the Trunk Road tunnel. Therefore, no additional reclamation is required for the ground level roads over and above that already required for the Trunk Road construction.

6.4 Reprovisioning of Affected Facilities

6.4.1 The construction of the Trunk Road will affect a number of existing facilities and services along the HKCEC / Wan Chai / Causeway Bay / North Point shoreline, which will need to be reprovisioned.

Wan Chai Ferry Pier

6.4.2 The Wan Chai ferry pier is a single storey finger pier with double deck of exit ramps, which at present is used by three ferry services, including two cross harbour ferry services (one between Wan Chai and Tsim Sha Tsui and the other between Wan Chai and Hung Hom) and one Harbour Tour service. The former two are regular services and are well patronised, carrying, respectively, an average of 21,000 and 2,600 passengers daily (as at December 2006). The Harbour Tour service shares the pier facilities and carries 260 passengers per day on average (as at December 2006). There is a present and compelling need to maintain these services. There are no available alternative ferry piers in the vicinity that are suitable for maintaining the operation of these ferry services. The existing Expo Drive East pier is a single berth facility, which is insufficient to handle the two cross harbour ferry services. The existing ferry operator has pointed out that the pontoon-type berthing facilities located along Expo Drive East would not be acceptable from an operations point of view. As the existing ferry pier will need to be demolished for the Trunk Road construction, it must be reprovided at the new seawall to the north of the existing location, so that it can continue to serve the cross harbour ferry services from Wan Chai North.

6.4.3 The new pier will take up an area of the harbour which is not already designated as Trunk Road reclamation. Although the ferry pier will be constructed on piled deck, and not on reclaimed land, its construction could nevertheless be viewed as, in effect, forming 'land' to accommodate a permanent building structure. Under the PHO, the area occupied by the ferry pier would be regarded as affected water area, or 'reclamation', over and above that already required for the Trunk Road construction.

Services and Utilities

6.4.4 Affected services such as water mains, stormwater drains, sewers, utility cables, etc, will be relocated within the existing formed land, and no additional reclamation will be required. Drainage outfalls will need to be extended through the new reclamation formed for the Trunk Road construction, but will not themselves require additional reclamation. The existing Wan Chai East sewage outfall will need to be reprovisioned, however this is a submarine pipeline that will be constructed below the seabed and therefore does not constitute reclamation. Likewise, the reprovisioning of the existing cross harbour watermains, which will be cut off by the Trunk Road tunnel construction, will lie beneath the seabed.

6.4.5 Existing cooling water intakes and pumping chambers along the HKCEC seawall, that will be subsumed by the Trunk Road reclamation, will be relocated at existing pumping chambers that have already been provided for this purpose at the north side of the HKCEC Extension, under the earlier Wan Chai Reclamation Phase I project. The existing cooling water intake and pumping chamber for the Sun Hung Kai building, which is located on the Wan Chai seawall, will need to be reprovisioned at a similar location behind the new seawall of the Trunk Road reclamation; the smaller pumping chamber requirements and lesser operational access requirements for this single cooling water facility means that the new pumping chamber can be designed to be located within the available area of land formed for the Trunk Road, therefore no additional reclamation will be required.

6.4.6 The salt water pumping station, located at the seawall next to the Wan Chai ferry pier, will also be subsumed by the Trunk Road reclamation. The reprovisioned facility is proposed to be relocated to the existing vacant site at Wan Shing Street, next to the Wan Chai East Sewage Screening Plant. The reprovisioned salt water pumping station therefore does not require reclamation.

6.4.7 In summary, with the exception of the Wan Chai ferry pier, all affected facilities along the existing shoreline can be reprovisioned without the need for additional reclamation over and above the reclamation required for the Trunk Road construction.

6.5 Provision for Harbour-Front Enhancement

6.5.1 The provisions of the PHO apply to the implementation of harbour-front enhancement ideas in the same way as they do to the implementation of the Trunk Road. Consideration should therefore be given to the need for any additional reclamation that may be required for harbour-front enhancement, which in turn will need to satisfy the Overriding Public Need Test.

6.5.2 A Concept Plan has been developed based on the public's visions, wishes and concepts proposed during the first round public engagement exercise of the HER project, the Envisioning Stage. The Concept Plan is at **Annex N**.

6.5.3 Harbour-front enhancement ideas, where these are confined to the existing land areas and the areas of reclamation formed for the construction of the Trunk Road, that have been suggested by the public through the Envisioning Stage consultation, have been consolidated with the Trunk Road scheme in the Concept Plan. These have resulted in:

- the development of an "arts and culture precinct" to the west of the HKCEC, for arts and cultural fairs, performance venues, and an expo promenade, etc;
- a "water park precinct" along the Wan Chai shoreline, with landscaped recreational areas and alfresco dining (outdoor cafes, etc.) to add vibrancy to the waterfront;
- a "water recreation precinct" at the ex-PCWA basin for water sports and recreation including public sailing activities, and berthing for visiting sailing ships or yachts;
- a "heritage precinct" at the Causeway Bay Typhoon Shelter, preserving the existing typhoon shelter and taking advantage of the presence of the floating Tin Hau Temple, Noonday Gun, etc, and with a landscaped deck providing an extension of Victoria Park to the waterfront;
- a "leisure and recreation precinct" at the North Point waterfront, with landscaped recreational areas.

6.5.4 The Concept Plan and these harbour-front enhancement ideas have been presented to the Public for their comment and evaluation through the Realisation Stage of the public engagement exercise of the HER. The Concept Plan proposals, and the public views on these, will be presented in a Realisation Stage Public Engagement Report, which will be available for viewing on the HEC website: www.harbourfront.org.hk.

6.5.5 Returning to the need for reclamation, it is noted that the harbour-front enhancement ideas as presented in the Concept Plan do not require any additional reclamation over and above the reclamation required for the Trunk Road construction, and hence do not compromise the provisions of the PHO.

6.6 Summary of Reclamation Requirements of the Trunk Road Scheme

What are the reclamation requirements associated with the preferred Trunk Road scheme ?

6.6.1 A Trunk Road scheme has been proposed with the minimum reclamation necessary to meet the overriding need for the Trunk Road, in conformance with the PHO.

6.6.2 Reclaimed land will need to be formed along the existing HKCEC, Wan Chai and North Point shorelines, for the construction of the Trunk Road. Modification of the local road network (ground level roads) and reprovisioning of existing affected facilities (other than the Wan Chai ferry pier) can be implemented without the need for additional reclamation over and above that required for the Trunk Road. An attractive waterfront with a new public promenade can be provided within existing land areas and within the new reclamation areas formed for the Trunk Road.

6.6.3 The new reclamation will form a narrow strip of land along the Wan Chai shoreline from the interface with the CRIII project west of the HKCEC Extension to the ex-PCWA basin, and along the North Point shoreline immediately to the east of the Causeway Bay Typhoon Shelter. In total, an indicative area of around 15 ha of permanent reclamation was found in preliminary studies to be required for the Trunk Road construction. The earlier indicative estimate of reclamation area also made provisional allowance for reprovisioning of affected facilities, most of which have now been determined as not requiring additional reclamation, and allowed for some flexibility in defining the reclamation edge in order to cater for uncertainties of the seawall design.

6.6.4 This area of reclamation is examined in more detail in the following section to ensure that it is the minimum necessary for the implementation of the Trunk Road scheme with reclamation requirements that have now been more clearly defined.

7 MINIMUM RECLAMATION

7.1 Introduction

7.1.1 In this section, the area of reclamation is defined more accurately, based on the Trunk Road alignment and configuration that have now been established in more detail, seawall construction details arising from more detailed engineering design, and on the more clearly established reprovisioning requirements, as described in Section 6 above. The resulting reclamation will then be the minimum required by the overriding public need for the Trunk Road, in compliance with the CFA ruling on the PHO.

7.2 Minimum Extent of Reclamation

7.2.1 Details of the extent of reclamation, in respect of the engineering requirements for the construction of the Trunk Road tunnel, reclamation and seawalls, are presented in a Minimum Reclamation Report, a copy of which is appended at **Annex O**.

7.2.2 In the preceding sections, reclamation for the preferred Trunk Road scheme is shown to be required in the area to the west of the HKCEC Extension, in the HKCEC water channel, along the Wan Chai shoreline and along the North Point shoreline. Permanent reclamation is not required in the ex-PCWA basin and in the Causeway Bay Typhoon Shelter. These areas of reclamation are required for the Trunk Road tunnel construction. In addition, there is a need to reprovision the Wan Chai ferry pier, which is considered as 'reclamation' under the PHO. There is no other requirement for reclamation, over and above that for the Trunk Road tunnel construction, for reprovisioning, ground level roads or harbour-front enhancement.

HKCEC West and Water Channel

7.2.3 The Trunk Road tunnel structure lies above the seabed in the area to the west of the HKCEC, where it crosses over the MTR Tsuen Wan Line tunnel, and remains above seabed level through the whole of the HKCEC water channel. The extent of reclamation in the area to the west of the HKCEC is set by the extent of seawall protection in front of the tunnel structure, while the HKCEC water channel will need to be filled in to enable the Trunk Road construction.

7.2.4 Previous WDII and CRIII proposals included a marine basin between the HKCEC Extension and the CRIII project area, with the seawall at the HKCEC West area curved outwards to tie in with the shoreline as gazetted under the CRIII project. A causeway was proposed across the front of the marine basin.

7.2.5 Although the causeway was proposed as a piled structure, it nevertheless affects that area of the Harbour over which it passes. In line with the need under the PHO to reduce the affected harbour area, the causeway has been deleted from the current proposal. With the deletion of the causeway from the current proposal, the extent of reclamation at the northeast corner of CRIII can be reduced, as described in Annex O.

7.2.6 The separation between the edge of the Trunk Road structure and the seawall copeline is determined by the width of the seawall structure and it's foundations, with the seawall kept clear of the diaphragm walls of the Trunk Road tunnel, for constructability reasons. In compliance with Works Branch Technical Circular (WBTC) No. 3/95, which specifies requirements for Control of Wave Reflection in Victoria Harbour, and in response to public calls to minimise waves in Victoria Harbour to improve safety, the use of wave attenuating seawalls is considered a must. Precast caisson seawall units, similar to those already being used in CRIII, are proposed for WDII. The design of these seawalls has been optimised through physical hydraulic modelling studies undertaken by specialist consultants to meet the limiting requirements for wave reflection.

7.2.7 A typical section through the caisson seawall in the HKCEC West area is shown in the Minimum Reclamation Report, in Annex O. Allowing for dredging of soft marine sediments (the typical dredge level is –15mPD in this area, as determined from ground investigation), and maintaining the necessary clearance between the seawall foundation and the diaphragm wall of the Trunk Road tunnel, a distance of 32.5m needs to be maintained between the outer edge of the Trunk Road tunnel and its slip roads, and the seawall copeline, in general. Dredged levels are lower towards the CRIII interface (dredged levels at the eastern end of CRIII are around –18mPD), which means that, moving westwards towards CRIII, the separation between the seawall copeline and the diaphragm wall of the Trunk Road tunnel will increase, to around 37m at the eastern end of CRIII.

7.2.8 At the MTR Tsuen Wan Line crossing, the caisson seawall cannot be constructed over the MTR tunnel; instead, a wave absorbing and tunnel protection structure will be incorporated in the piled deck over the MTR tunnel, which will serve both to protect the Trunk Road tunnel structure from ship impact and for wave energy absorption. This wave wall structure, of minimum width around 7m, means that the seawall copeline can be pulled back closer to the Trunk Road tunnel structure, and hence reduce the extent of reclamation at the MTR tunnel crossing point. Special MTR tunnel interface wave walls on piles will be constructed for the seawall adjacent to the MTR tunnel protection zone, to avoid disturbance to the MTR tunnel during construction. These are tied back into the caisson seawalls on either side, with blockwork landing steps providing a transition between the piled wave walls and the gravity caisson seawall units.

7.2.9 The area of new WDII reclamation in the HKCEC West area, as defined by this seawall copeline, is 3.7 ha.

7.2.10 In the HKCEC water channel, the Trunk Road tunnel structure, together with the proposed NIL tunnel, occupies the entire area of the channel. The whole of the water channel will need to be filled in for the Trunk Road construction. Whilst the NIL will occupy part of the reclaimed water channel, this reclamation is required for Trunk Road construction and additional reclamation is not required for the NIL tunnel.

7.2.11 The area of new WDII reclamation in the HKCEC water channel is 1.6 ha.

Wan Chai Shoreline

7.2.12 After crossing over the MTR Tsuen Wan Line, the vertical alignment of the Trunk Road drops down to the crossing beneath the Cross Harbour Tunnel portal, at road level around –30mPD. The Trunk Road tunnel structure would lie above the seabed along this shoreline and therefore requires reclamation for the cut-and-cover tunnel construction.

7.2.13 The extent of reclamation along the Wan Chai shoreline is determined primarily by the extent of seawall protection in front of the Trunk Road tunnel structure. As noted above, the use of wave attenuating seawalls is considered a must, and precast caisson seawall units, similar to those currently designed for CRIII, will also be used for the Wan Chai seawall.

7.2.14 A typical section through the seawall at the Wan Chai shoreline is shown in the Minimum Reclamation Report, in Annex O. For a typical dredge level of –14mPD in this area, as determined from ground investigation, and maintaining the necessary clearance between the seawall foundation and the diaphragm wall of the Trunk Road tunnel, a distance of 31m needs to be maintained between the outer edge of the Trunk Road tunnel and the seawall copeline (the lesser dimension than for the HKCEC West area due to the less deep dredging requirement along the Wan Chai shoreline).

7.2.15 This minimum 31m separation between Trunk Road tunnel and seawall copeline is maintained along most of the Wan Chai shoreline. The seawall copeline follows the curvature of the Trunk Road tunnel edge.

7.2.16 A splay in the seawall is incorporated at the corner with Expo Drive East to accommodate the outfall of the drainage Culvert M, which must be extended from Fleming Road through the reclamation to the new seawall. The splay is curved to enhance flows through this corner and prevent accumulation of pollutants at the culvert discharge area.

7.2.17 At the eastern end of the Wan Chai shoreline, the Trunk Road tunnel and its protection layer dips below the seabed just before reaching the existing seawall of the ex-PCWA. Practical and sensible engineering design suggests that the new seawall along the Wan Chai shoreline nevertheless be continued the short distance eastwards until joining the ex-PCWA seawall (ie maintaining generally the width of reclamation along the whole of the Wan Chai shoreline). However, the PHO's minimum reclamation criterion dictates that the seawall be cut back in the area where it is deemed not to meet the overriding need (for the Trunk Road). For water quality reasons, the drainage culvert N must discharge outside the embayment that is created by this cutting back of the seawall (outfalls should not discharge into embayed areas to avoid entrapment of pollutants and consequent deterioration of water quality and odour problems), therefore the seawall is extended eastwards to accommodate the box culvert outfall structure, before the return seawall is introduced. The return seawall is curved to provide a smooth shoreline, also for water quality reasons; this is in order to avoid sharp corners and to enhance tidal flows through the small embayed area that is created, so that pollutants and flotsam are not trapped, which would otherwise give rise to adverse water quality, odour and unsightliness.

7.2.18 The extent of reclamation along the Wan Chai shoreline is also determined by the water area occupied by the reprovisioned Wan Chai ferry pier.

7.2.19 Existing ferry pier facilities at the Wan Chai shoreline include the Wan Chai (East) ferry pier (which has a plan area of 1,970m^2) and the Wan Chai (West) ferry pier (which has a plan area of 450m^2).

7.2.20 The reprovisioned Wan Chai ferry pier will provide for the continuation of the three ferry services currently operating at the affected site. The new pier, of plan area 2,270m^2, represents a reduction in size when compared with the aggregate area of around 2,420m^2 occupied by the two existing piers.

7.2.21 There have been rising expectations among passengers for better facilities at ferry piers. Central Piers No. 7 and 8, which came into service in November 2006, provide facilities for people with disabilities, in accordance with the Disability Discrimination Ordinance, and facilities for different operators to have shared use of the pier (eg separate ticketing offices and pier offices). Each ferry pier occupies a plan area of around 2,270m^2. Passengers will expect the newly reprovisioned pier in Wan Chai be of similar standard, with facilities comparable to those available at the Central Piers No. 7 and 8.

7.2.22 The reprovisioned ferry pier is the minimum size required to meet the above-mentioned needs.

7.2.23 The area of new reclamation along the Wan Chai shoreline, as defined by the seawall copeline, is 3.9 ha. The area of the reprovisioned ferry pier structure is around 0.2 ha. Therefore, altogether, the area of new reclamation at Wan Chai is 4.1 ha.

North Point Shoreline

7.2.24 To the east of the Causeway Bay Typhoon Shelter, the Trunk Road rises up above seabed level to a ground level tunnel portal, and then rises on elevated road structure to connect with the existing IEC. The vertical alignment of the Trunk Road in this area is determined by ensuring that the tunnel is at a low enough level through the adjacent typhoon shelter to avoid the need for reclamation there, but then rising as quickly as possible (at a maximum tunnel gradient of 3%) to ground level at North Point. From the tunnel portal, the Trunk Road rises to connect with the existing IEC, at a level of +15mPD, near City Garden. Although the existing formed land area is occupied as much as possible, by keeping the Trunk Road alignment as close as possible to the existing IEC structure foundations, the tunnel structure will nevertheless extend beyond the existing seawall and the existing area of land will therefore need to be widened.

7.2.25 Similar to above, the use of wave attenuating seawalls is considered a must, and precast caisson seawall units, similar to those currently designed for CRIII, will be used for the North Point seawall.

7.2.26 Typical sections through the seawall at the North Point shoreline are shown in the Minimum Reclamation Report, at Annex O. For a typical dredge level of –14mPD in this area, and maintaining the necessary clearance between the seawall foundation and the diaphragm wall of the Trunk Road tunnel, a distance of 31m needs to be maintained between the outer edge of the Trunk Road tunnel and the seawall copeline.

7.2.27 This minimum 31m separation between Trunk Road tunnel and the seawall copeline is maintained along the entire length of North Point shoreline. The eastern limit of the reclamation is determined by the provision of a 1.5m headroom clearance beneath the bridge abutment as the Trunk Road rises onto elevated bridge structure, for maintenance purposes. The resulting 15m separation between the abutment and the seawall copeline is occupied by the caisson seawall structure, which must be set in front of the piled foundations of the abutment.

7.2.28 The area of new reclamation along the North Point shoreline, as defined by this seawall copeline, is 3.3 ha.

7.2.29 As noted earlier when examining the flyover option for the Trunk Road, new flyover structures over water are considered to result in affected water area which may be equated to "reclamation" under the PHO. At the eastern end of the Trunk Road, flyover structures will tie into the existing IEC. The area of new flyover structures over water is 0.4 ha. Together with the area of land formation, the total affected area of the harbour in respect of the PHO along the North Point shoreline is 3.7 ha.

7.3 Summary of Minimum Reclamation Requirements

Is this the minimum area of reclamation ?

7.3.1 The minimum reclamation required in the area to the west of the HKCEC Extension, in the HKCEC water channel, along the Wan Chai shoreline and along the North Point shoreline is summarised as follows:

(i)	HKCEC West :	3.7 ha
(ii)	HKCEC Water Channel :	1.6 ha
(iii)	Wan Chai Shoreline:	4.1 ha
(iv)	North Point Shoreline :	3.3 ha [4]

7.3.2 In total, an area of 12.7 ha of reclamation (in addition to an area of 0.4 ha of affected water area by flyover structures) is needed to meet essential engineering requirements for construction of the Trunk Road. This is considered to be the minimum extent of reclamation required for implementation of the Trunk Road and associated reprovisioning requirements.

7.3.3 The reduction from the previous indicative estimate of 15 ha of reclamation under the earlier preliminary studies arises mainly from a smaller reclamation area at HKCEC West due to the modification of the interface with CRIII, a smaller reclamation area at the Wan Chai shoreline by cutting back the seawall at the eastern end, a smaller reclamation area at the North Point shoreline which is now calculated based on more precise dredge levels determined using recently available site investigation data, and by not having to provide additional reclamation for reprovisioning of facilities such as cooling water pumping chambers, salt water pumping station, etc.

[4] *This area excludes the affected water area by flyover structures (0.4 ha); the total affected area of the harbour under the PHO at the North Point shoreline is 3.7ha.*

8 CONCLUSIONS

8.1 Overriding Public Need for the Trunk Road

8.1.1 The first, and essential, part of the test laid down by the CFA ruling on compliance with the PHO, is: "is there an overriding public need for the Trunk Road?"

8.1.2 The existing east-west corridor (Connaught Road Central – Harcourt Road – Gloucester Road) serving the CBD on Hong Kong Island is already operating beyond its capacity, as can be observed on site. Previous and recent strategic transport studies have predicted further increase in traffic demand along the east-west corridor, and confirmed the need for a parallel east-west Trunk Road to avoid more extensive and frequent traffic congestion, and even gridlock, on the road network.

8.1.3 A district traffic study has confirmed that a dual 3-lane Trunk Road, together with intermediate slip roads, is required to divert traffic away from the existing east-west corridor and to provide adequate relief to the corridor and the local road network.

8.1.4 The need for the Trunk Road has also been confirmed by the Expert Panel on Sustainable Transport Planning and Central-Wan Chai Bypass. Among the package of measures recommended, the Expert Panel recommends the construction of a bypass as a medium-term solution to tackle the problem of deteriorating traffic congestion in the Central and Wan Chai area. The Expert Panel considers that the Trunk Road is essential to improve the reliability of the road network.

8.1.5 The conclusion is, therefore, that the need for the Trunk Road has been clearly established through traffic and transport studies, and the need for the Trunk Road has been confirmed by the Expert Panel.

8.1.6 Is there an overriding public need for the Trunk Road? The findings of the traffic and transport studies, and of the Expert Panel, demonstrate conclusively the compelling and present need for the Trunk Road.

8.2 The Need for Reclamation

8.2.1 Having established the need for the Trunk Road, is there any reasonable alternative to reclamation (ie "no reclamation" options)?

8.2.2 All possible alignments for the Trunk Road, including suggestions from the public, have been examined, taking into account land use and infrastructural constraints, with a view to determining if there are any that do not require any reclamation for the Trunk Road construction. It is found that the feasible Trunk Road routeing is along the foreshore of Wan Chai and Causeway Bay.

8.2.3 However, foreshore alignments do require reclamation for Trunk Road tunnel construction at the western end of WDII where the Trunk Road tunnel crosses over the MTR Tsuen Wan Line, and at the eastern end of WDII where the Trunk Road tunnel must rise to ground level for the connection with the elevated IEC, at least.

8.2.4 Alternative Trunk Road ideas that have been proposed to avoid reclamation are found to be not feasible, or would result in an even greater area of reclamation or affected area of the harbour.

8.2.5 Is there any "no reclamation" option? After exhaustive investigation into the need for reclamation, it is concluded that there is no feasible "no-reclamation" alignment for the Trunk Road. It must be accepted that at least some reclamation will be required for the Trunk Road construction at the western and eastern ends of the Trunk Road through WDII.

8.3 Minimum Reclamation Required to Meet the Overriding Public Need

8.3.1 A feasible scheme that meets the overriding need for the Trunk Road must also be demonstrated to have the minimum extent of reclamation required to meet the overriding need.

8.3.2 A Trunk Road scheme has been developed that satisfies the traffic and functional requirements for the Trunk Road in meeting the overriding public need, and affects the least area of the Harbour. The scheme also accommodates harbour-front enhancement ideas that have been proposed by the Public, and the scheme has the broad support of the Public.

8.3.3 Trunk Road Tunnel Variation 1, as described in Section 6.2, affects the minimum area of the Harbour and serves best to protect and preserve the Harbour, among all the options that have been assessed. Overall, Trunk Road Tunnel Variation 1 is considered the best option in complying with the PHO. This option has clearly expressed support as the preferred Trunk Road scheme, following extensive consultations with various public, advisory and relevant statutory bodies. Trunk Road Tunnel Variation 1 has been endorsed by the HEC Sub-committee on WDII Review as the basis for the preparation of the Concept Plan for the WDII project.

8.3.4 Construction of this Trunk Road scheme will, though, require reclamation in the areas to the west of the HKCEC, through the HKCEC water channel, along the Wan Chai shoreline and along the North Point shoreline. Permanent reclamation is not required in the ex-PCWA basin or in the Causeway Bay Typhoon Shelter.

8.3.5 Is this the minimum area of reclamation required by the overriding public need? Detailed examination of the engineering requirements in respect of highway geometric design and construction of the Trunk Road tunnel, reclamation and seawalls, and reprovisioning requirements, has been carried out to accurately determine the minimum extent of reclamation. In total, an area of 12.7 ha of reclamation (in addition to an area of 0.4 ha of affected water area by flyover structures) is needed to meet essential engineering requirements for construction of the Trunk Road. This is the minimum reclamation required to meet the overriding public need for the Trunk Road.

MTR

Annex G

Consultancy Agreement No. NEX/2202

Shatin to Central Link Cross Harbour Section

Preliminary Design

Cogent and Convincing Materials to Demonstrate Compliance with the Overriding Public Need Test (CCM Report for SCL)

MAY 2010

ATKINS

SHATIN TO CENTRAL LINK

COGENT AND CONVINCING MATERIALS
TO DEMONSTRATE COMPLIANCE WITH THE OVERRIDING PUBLIC NEED TEST
(CCM REPORT FOR SCL)

MAY 2010

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1. INTRODUCTION

1.1 Background

1.1.1 The Shatin to Central Link (SCL) is a major infrastructure project that is being developed in accordance with the Government's transportation policy. The SCL alignment is shown in Figure 1.1 and comprises 17 kilometres of railway line that will connect several existing railway lines, creating two distinct east-west and north-south railway corridors as shown on Figure 1.2. It will also provide interchange opportunities at six of its ten stations (Tai Wai, Diamond Hill, Homantin, Hung Hom, Exhibition and Admiralty).

1.1.2 From east to west, it will connect the Ma On Shan Line and the West Rail Line allowing commuters to travel direct from Wu Kai Sha to Tuen Mun. The north-south corridor will be formed by extending the existing East Rail Line from Hung Hom (HUH) Station across Victoria Harbour to the planned Exhibition (EXH) Station, where it will connect with the future North Island Line, and Admiralty (ADM) Station, allowing passengers to travel from Lo Wu or Lok Ma Chau to Hong Kong Island without having to switch trains. At ADM Station, interchanges will be provided with the Tsuen Wan Line, Island Line and the proposed South Island Line (East).

1.1.3 The SCL is strategically important for connecting the existing railway lines into an integrated rail network. The east-west connection, will allow the creation of a 57km east-west corridor across the city connecting Wu Kai Sha with Tuen Mun via Kowloon. The north-south connection will operate over a 41km north-south corridor with services originating in Lok Ma Chau and Lo Wu travelling via the existing East Rail Line to ADM Station. This will facilitate a direct link between Mainland China and Hong Kong Island.

1.1.4 Regarding the Cross Harbour Section from HUH Station to ADM Station, the Legislative Council Brief on the SCL submitted by the Transport and Housing Bureau (THB) in March 2008 indicated that completion of this section would be around 2019.

1.2 Cross Harbour Section

1.2.1 The objective of the SCL and Cross Harbour Section is to extend the East Rail Line from HUH Station to the north shore of Hong Kong Island and the Central Business District, providing convenient interchanges at HUH, EXH and ADM Stations.

1.2.2 The preferred scheme that was adopted during the Merger Study for the Cross Harbour Section of the SCL included an immersed tube tunnel (IMT) on an alignment to the East of the existing Cross Harbour Tunnel and through the Causeway Bay Typhoon Shelter (CBTS).

1.2.3 A key aspect of the construction of the SCL inside the (CBTS) will be coordination of the interfaces with the Central Wanchai Bypass (CWB) project. The CWB will be constructed in cut-and-cover tunnel from temporary reclamation in the CBTS. Construction of the CWB will start soon but will overlap with the target construction period of the SCL. There is a need to address how the SCL can be integrated with the proposed CWB project to minimize the extent and duration of reclamation for both projects in the CBTS.

1.2.4 Taking into account engineering, construction and operational requirements, health and safety considerations, costs and programme constraints, it is recommended in Chapter 5 of this Report that the Cross Harbour Section is constructed using an immersed tube tunnel construction method. This method has been used in the construction of all the existing cross-harbour road and rail tunnels in Hong Kong. It involves dredging a trench in the seabed, sinking the IMT tunnel units and backfilling around it.

1.2.5 The IMT option would require:

(1) Temporary reclamation close to the tunnel landfall on Kowloon and on Hong Kong Island. This temporary reclamation would be removed after construction; and

(2) Replacement of the fender piles for the protection of the Hung Hom Bypass.

1.2.6 Any work carried out or intended to be carried out for the purpose of forming land from the sea-bed or foreshore within the harbour boundary (either of a temporary or permanent nature) is subject to the Protection of the Harbour Ordinance (PHO) Cap 531 As such, the IMT option would need to satisfy the “overriding public need test”.

1.3 Implications under the PHO

1.3.1 The PHO Cap 531 recognises the harbour as a special public asset and a natural heritage of Hong Kong to be protected and preserved. Judicial reviews on other projects have further clarified the legal principles behind the PHO [1] and have established a presumption against reclamation within Victoria Harbour, irrespective of the reclamation being permanent or temporary.

1.3.2 The presumption against reclamation can only be rebutted by establishing an overriding public need for the reclamation work. Guidance for addressing the public need for reclamation (referred to as “the overriding public need test”) is provided in the Housing, Planning and Lands Bureau Technical Circular No. 1/04 (HPLB TC 1/04). This applies to all reclamations within the boundaries of Victoria Harbour and cogent and convincing materials are required to support and justify the overriding public need for reclamation.

[1] The Court of First Instance's Judgment for a Judicial Review on March 2008, applied by the Society for Protection of the Harbour on 3 Oct 2007.

1.4 Report Structure

1.4.1 This Report describes the background of the SCL project and provides the supporting information and assessment of the options reviewed and includes cogent and convincing materials for demonstrating compliance with the PHO.

1.4.2 The structure of this report, after this Section, is as follows:

- Section 2: Describes the PHO, the recent judicial reviews that have been undertaken for other relevant projects under the Ordinance, and relevant guidelines and principles for projects that may involve reclamation within Victoria Harbour.
- Section 3: Describes the overriding public need for the SCL project, including the strategic nature of the project, social and community, environmental and economic needs and the timing requirements.
- Section 4: Addresses the feasibility of the "no reclamation option" and provides information on this option.
- Section 5: Describes the various options considered which require reclamation to enable their construction.
- Section 6: Describes the approach that has been taken to reduce temporary reclamation to a minimum with regard to the IMT option and the construction sequencing for concurrent working with the CWB in the CBTS.
- Section 7: Describes the public consultation activities to date and summarises the comments from the public on the SCL project.
- Section 8: Provides a conclusion and describes the recommended scheme.

2. PROTECTION OF THE HARBOUR

2.1 PHO (Cap 531)

2.1.1 The PHO originally resulted from a private member's bill proposed in 1996 by the Society for Protection of the Harbour. The bill was first enacted as the original Ordinance in June 1997 and was then modified in the course of the legislative process. The PHO provides protection and preservation of the harbour by establishing a presumption against reclamation. In December 1999, the Ordinance was further amended to its present form by expanding its scope to cover the whole of Victoria Harbour.

2.1.2 Section 3 of the Ordinance states:

(1) The harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people and for that purpose there shall be a presumption against reclamation in the harbour. [Section 3(1)]

(2) All public officers and public bodies shall have regard to the principle stated in subsection (1) for guidance in the exercise of any powers vested in them. [Section 3(2)]

2.1.3 The PHO specifically defines the term "reclamation" as "any work carried out or intended to be carried out for the purpose of forming land from the sea-bed or foreshore". The definition of "reclamation" in the PHO is specific to the formation of land, implying works that exceed the sea level. It is considered that even small-scale reclamation required for the construction of piers, landing steps, etc. should also comply with the PHO.

2.1.4 Legal opinion has been sought on a number of key issues which affect the form of the project. These are summarised in paragraphs 2.1.5 to 2.1.6.

Slight Raising of the Sea-bed

2.1.5 The legal view is that any slight raising of the sea-bed which does not result in any dry surface or land formed, provided also that this slight raising of the sea-bed level would not affect the use or access to that part of the harbour, (i.e. the public could still continue to enjoy that part of the harbour), then this raising of the sea-bed level is not considered to be reclamation or to have contravened the statutory principle of protection and preservation of the harbour under Section 3(1) of the PHO.

Reinstatement of Existing Marine Structures

2.1.6 The areas of sea-bed upon which existing marine structures are located are considered to already be reclaimed land. If they are removed and reinstated in the same position and same extent, they are not considered to be reclamation for the purpose of the PHO.

2.2 Court of Final Appeal Judgment (9 Jan 2004)

2.2.1 The Town Planning Board made decisions on the Draft Wan Chai North Outline Zoning Plan (OZP) (No. S/H25/1), in December 2002 and February 2003, that included proposals for reclamation within Victoria Harbour. This was challenged in the legal system by the Society for Protection of the Harbour on the grounds that the Town Planning Board made decisions that were unlawful and/or unreasonable and irrational.

2.2.2 In January 2004, the Court of Final Appeal handed down its judgment on the Town Planning Board appeal against the High Court's ruling in respect of the Outline Zoning Plan. The Court of Final Appeal found that the Town Planning Board had misinterpreted the PHO and provided further guidance to clarify the interpretation of the legal principles behind it. Applying a purposive construction of the PHO, the Court held that the presumption (against reclamation) will only be rebutted where three tests are satisfied:

(1) There is an overriding public need for reclamation;

(2) There is no reasonable alternative to reclamation; and

(3) The proposed reclamation involves minimum impairment to the harbour.

2.2.3 The Court further stated that the above must be demonstrated by clear cogent and convincing evidence. The presumption against reclamation can only be rebutted by establishing an overriding public need for reclamation in recognition of the strong public need to protect and preserve the harbour.

2.2.4 In the judgment it states that reclamation would result in permanent destruction and irreversible loss of what should be protected and preserved under the statutory principle. The statutory presumption was therefore enacted to implement the principle of protection and preservation. Its legislative intent is to confer a unique legal status on the harbour by enacting a strong and vigorous principle that it is to be protected and preserved as a special asset and a natural heritage of the Hong Kong people, a principle that all public officers and public bodies must have in exercising their powers.

2.2.5 In order to implement this, the judgment specifies that there must be established an overriding public need for reclamation. The public needs include the needs of the community and include the economic, environmental and social aspects. A need should only be regarded as overriding if it is a compelling and present need. A compelling and present need goes far beyond something which is "nice to have", desirable, preferable or beneficial. But on the other hand it is not a last resort or something that the public "cannot do without". A present need takes into account the timescale of planning exercises, and the need would arise within a definite and reasonable time frame.

2.2.6 The judgment further states that where there is a reasonable alternative to reclamation, an overriding need for reclamation would not be made. All circumstances should be considered including the economic, environmental and social implications of each alternative. The cost as well as the time and delay involved would be relevant. The extent of the proposed reclamation should not go beyond the minimum of that which is required by the overriding need. Each area proposed to be reclaimed must be justified.

2.2.7 In order to enable a public officer or body to be satisfied that the overriding public need test has been met, the materials in the case in question must be cogent and convincing.

2.3 Court of First Instance Judgment (20 Mar 2008)

2.3.1 A new trunk road, the Central-Wanchai Bypass (CWB), was proposed by government that would traverse along much of the northshore of Hong Kong Island to divert traffic away from the existing east-west corridor. The new road was proposed to be constructed using methods that required temporary reclamation works to be undertaken within Victoria Harbour. It had been believed by government that temporary reclamation would not be subject to the requirements of the PHO and this was challenged by the SPH within the High Court.

2.3.2 The temporary reclamation was required for the cut and cover tunnel section of the CWB scheme. Further, a temporary breakwater was proposed to shelter displaced small craft. The temporary reclamation works were expected to last about 6 years. Upon completion of construction, the temporary reclamation would be removed and the sea-bed would be reinstated.

2.3.3 The Society for Protection of the Harbour applied to the High Court on the grounds that the PHO did not differentiate in specific terms between reclamation that is intended to result in permanent land formation and temporary reclamation. The Society for Protection of the Harbour sought a declaration that even reclamation works that are intended to be transitory, or even intended to avoid the very need for permanent reclamation, are nevertheless subject to the presumption against reclamation and may not lawfully be carried out unless it can be demonstrated that they are necessary by meeting the “overriding public need test”.

2.3.4 The judgment found in favour of Society for Protection of the Harbour and that all formation of land from the foreshore and/or sea-bed within the boundaries of the harbour, either of a permanent or temporary nature, shall comply with the requirements of the PHO. The government then proceeded to review the need for the CWB project under the PHO requirements (the overriding public needs test) and demonstrated the need for the temporary reclamation works to facilitate construction through cogent and convincing materials supporting this choice.

2.4 HPLB TC No. 1/04

2.4.1 On 19 August 2004, the Housing, Planning and Lands Bureau issued Technical Circular No. 1/04 (HPLB TC No. 1/04) which sets out the requirements of the PHO and provides guidance for public officers and public bodies in considering and approving reclamation proposals.

2.4.2 The guidelines describe the Court of Final Appeal Judgment in 2004. It extracts key definitions related to the overriding public needs test and provides examples of the cogent and convincing materials required to justify the overriding public need, including those related to economic, environmental and social aspects.

2.4.3 Reference has been made to these guidelines as part of the preparation of this Report. In particular, each question that is posed as being critical in the Technical Circular for consideration during the decision making process has been addressed, including the following:

- Question 1 – Is there a compelling and present public need?
- Question 2 – Is there any reasonable alternative to reclamation?
- Question 3 – Is the proposed reclamation extent minimum?

2.4.4 The Technical Circular also includes information on the public consultation process for reclamation proposals within the harbour.

2.5 Harbour-Front Enhancement Review

2.5.1 The Harbour-front Enhancement Committee was established in May 2004 to advise Government, through the secretary for Housing, Planning and Lands, on the planning, land uses and developments along the existing and new harbour-front of Victoria Harbour.

2.5.2 As guidance for the planning, development and management of Victoria Harbour and the harbour-front areas, the Harbour-front Enhancement Committee established harbour planning principles that should be followed when examining transport infrastructure and harbour-front enhancement schemes. These are:

- Preserving Victoria Harbour
- Stakeholder engagement
- Sustainable development
- Integrated planning
- Proactive harbour enhancement
- Vibrant harbour
- Accessible harbour
- Public enjoyment

2.5.3 The Harbour-front Enhancement Committee members are from diverse backgrounds and include representatives from conservation and environmental organisations, business representatives, associations, institutes and academics. Specific subcommittees have been established within the Harbour-front Enhancement Committee to review and advise government on various harbour front projects, including the CWB, the Kai Tak Planning Review and Hung Hom District Planning Study, amongst others. In addition to providing feedback on projects, the role of the Committee is to advise on means to enlist greater public engagement on projects.

3. OVERRIDING PUBLIC NEED

3.1 Introduction

3.1.1 The guidelines provided in HPLB TC No. 1/04 have been referred to with regard to the approach taken for assessing the overriding public need for the project. The Technical Circular states that the first step is to establish if there is a compelling and present public need for the project. The term “public needs” is defined as economic, environmental and social needs of the community. It is taken that community refers to the greater need of the public rather than meeting the special needs or interests of a few.

3.1.2 The term “compelling” is defined in HPLB TC 1/04 as having the requisite force to prevail over the strong public need for protection and preservation of the harbour. This is required to be supported by cogent and convincing materials (such as findings of studies, forecasts, costs and benefit analysis, etc.) that support the overriding need for reclamation aspects of the project.

3.1.3 The term “present need” is defined as time scale requirements and demonstrating that the need would arise within a definite and reasonable time frame. To satisfy this, there must be a concrete programme of implementation and firm commitment from the concerned government departments, with endorsement by relevant authorities, as applicable.

3.1.4 The following describes the compelling and present public need for the SCL and the benefit it will provide to the community of Hong Kong. The programme requirements associated with the SCL project and the commitments that have been made by government have also been highlighted to demonstrate the urgent and present need for the Cross Harbour Section.

3.2 Overriding Need for the Project

Strategic Transport Planning

3.2.1 The need to alleviate traffic congestion within the business areas of Hong Kong Island has been identified in strategic planning and development studies since the early 1980’s and the need for improvements to the mass transit rail system to help alleviate traffic has been part of the Railway Development Strategy and Transport Strategy in the Hong Kong Special Administrative Region (SAR) since the 1990’s.

3.2.2 Due to the importance of the mass transit rail system in Hong Kong, the Government commissioned the Second Railway Development Study (RDS-2) in 1998 to examine how best to further expand the rail network to meet the rail transport needs for the Hong Kong SAR over the next two decades. Based on the findings of RDS-2, the Government formulated the Railway Development Strategy 2000 (RDS-2000), reaffirming the policy objective that railways will form the backbone of the public transport system.

3.2.3 The RDS-2000 confirmed the importance of railways for relieving pressure and congestion on the road networks and for developing safe, efficient, reliable and environmentally friendly transport infrastructure that meets present and future economic, social and recreational needs of the community. The SCL forms an integral part of this strategy and was one of the railway projects recommended for priority implementation in RDS-2000, with a target completion date of 2011.

3.2.4 The Third Comprehensive Transport Study, completed in 1999, identified the need for urgent measures to relieve anticipated congestion through the Central and Wanchai districts. The Wan Chai Development Phase II Comprehensive Feasibility Study identified the need to provide land to construct key transport infrastructure, including the Hong Kong Island section of the SCL to improve cross-harbour access from the North East New Territories and South East Kowloon and to relieve heavy loading on existing harbour crossing routes.

3.2.5 Following from the Wan Chai Development Phase II Comprehensive Feasibility Study, updates were made to the Third Comprehensive Transport Study transport model as part of the Transport Department’s Submission to the Expert Panel of the Harbour-front Enhancement Committee Sub-committee on Wan Chai Development Phase II Review in 2005. The updated model took into account more recent land use planning and population projections and traffic forecast predictions. These predictions were based on the assumption that proposed rail lines, including the SCL, West Island Line and South Island Line (East), would be in place and operational by year 2016 to help alleviate traffic. Even with these rail networks in place, the CWB was found to be essential to divert traffic from the existing east-west corridor to provide adequate traffic relief to these areas.

3.2.6 The need for the Tai Wai to Hung Hom Section and Cross Harbour Section of the SCL are intimately related. The Tai Wai to Hung Hom section will provide essential relief to East Rail congestion at the Beacon Hill Tunnel from Tai Wai to Kowloon Tong and provide support to the transport needs of the new development areas in Kai Tak. These benefits were highlighted in the RDS-2000 and are supported by up to date transport modelling analysis.

3.2.7 The Cross Harbour Section provides Hong Kong with a Fourth Rail Harbour Crossing, which will provide essential relief to existing congestion on the Tsuen Wan Line, connect the new development areas in Kai Tak with Hong Kong Island and, importantly, provide much needed relief to the cross harbour road tunnels by effecting a significant modal shift to rail which underpins both prevailing railway development and environmental policy.

3.2.8 Together, both sections of the SCL form part of an expanded railway network that provides wider benefits in terms of congestion relief of the Kwun Tong Line and much improved railway access to harbour front areas at the Hong Kong Convention and Exhibition Centre and Tsim Sha Tsui East. The benefits of this expanded railway network, as set out in RDS-2000, include:

- Improved accessibility - placing 70% of the population and 80% of the workforce within one km of a railway station;
- Integrating transport modes – maximizing passenger service efficiency by coordinating rail services with feeder services at key interchange stations;
- Improving route choice and accessibility – by crossing the Harbour to interchange with the future North Island Line at EXH Station and with the Tsuen Wan Line, Island Line and South Island Line (East) at ADM Station;
- Reducing journey times – providing faster and more reliable travel throughout the SAR; and
- Environmental benefits – reduced reliance on road based transport resulting in significant reductions in roadside air pollutants, respirable suspended particulates and CO_2.

3.2.9 Due to its strategic importance with Hong Kong's future economic development, and to meet the transport needs, the Chief Executive, in his 2007-2008 Policy Address included the SCL as one of the ten large-scale infrastructure projects to be taken forward. Aside from the SCL, other infrastructure projects that interface with SCL were also listed, including the South Island Line (East) and the Kai Tak Development Plan. Accordingly, on 11 March 2008, the Government announced its decision for the MTR Corporation to proceed with the further planning and design of the SCL.

Social & Community Implications

3.2.10 The SCL is strategically important for transport planning in Hong Kong and will provide numerous benefits to society and the overall community of Hong Kong through improvements to the integration and accessibility of the public transport system. The relevant District Councils have recognised these benefits and have requested early implementation of the SCL.

3.2.11 The social benefits of SCL include facilitating cross-boundary integration with China, serving new strategic commercial and tourism development areas, providing opportunity for redevelopment, opening up harbour access by providing a new station close to the waterfront on Hong Kong Island and encouraging patronage through convenience and time savings and reducing the need for road travel. These aspects are addressed further below.

Improving New Development & Redevelopment

3.2.12 The SCL will provide an important component of the Kai Tak Development as it will provide a public transport connection between Hong Kong Island and this strategic development area. The provision of mass transit to Kai Tak is integral to its accessibility and in turn its overall success to bring in tourists and the public to events held at the site. The SCL will provide public transport service to new commercial and residential developments proposed in the area, the multi-purpose stadium complex, cruise terminal and other sports and recreation facilities planned for Kai Tak. There will be new employment opportunities created in this area as new businesses and employees will benefit from the improved accessibility.

3.2.13 The SCL will also help to stimulate the revitalisation of areas including Hung Hom, To Kwa Wan, Kowloon City and San Po Kong, which have previously long been constrained by the lack of a reliable mass transportation system. The SCL will remove this constraint and allow these districts to rejuvenate and prosper and will generate substantial economic and social benefits to these areas. It will also provide service to a large population residing and working in Kowloon East that do not presently have convenient mass transit transportation.

Harbour Access

3.2.14 During the Expert Panel Review on the Sustainable Transport Planning and CWB[2], members of the public expressed their views that railways could help improve the public accessibility to the waterfront. The SCL will improve accessibility to the harbour by providing a direct link between Hung Hom and Hong Kong Island. With this link, there will be increased opportunities for the public to access this area and enjoy the harbour and the promenade area of Tsim Sha Tsui East. It will also allow more possibilities for the planning and development of leisure and tourism for this area.

Time Savings and Convenience

3.2.15 The public will benefit greatly from shorter time required between interchange stations and inter-platform changes for other lines and from more direct travel routes associated with the SCL. The success of the rail line in attracting passengers will be through time savings and convenience and the ability to serve the customers needs.

Congestion Relief on Existing Rail Lines

3.2.16 The SCL considerably enhances connectivity across the network and with 6 interchange stations allows flexibility in route choice. It will serve new catchment areas such as Kai Tak and To Kwa Wan and carry about 1 million passengers a day by 2021.

[2] Report of the Expert Panel on Sustainable Transport Planning and Central – Wan Chai Bypass, Oct 2005

3.2.17 As noted above the project is important for redistributing railway passenger flows to relieve congestion within existing railway lines in the urban Kowloon area and on Hong Kong Island. The SCL will relieve the bottlenecks at the Beacon Hill Tunnel section of theEast Rail Line, the Prince Edward Section of Kwun Tong Line from Prince Edward Station to Kowloon Tong Station and the Nathan Road / cross harbour section of Tsuen Wan Line by providing parallel routes.

3.2.18 The SCL is important for alleviating bottlenecks on the Tsuen Wan Line morning peak line flow. It is predicted that if the SCL is not built on time, the Tsuen Wan Line morning peak line flow in 2021 will exceed the desirable capacity When the SCL is in place the Tsuen Wan Line peak hour line flow in 2021 would be significantly reduced and would be well within the desirable capacity.

3.2.19 The first step in getting traffic off the roads is in providing an efficient and easily accessible public transport system. The SCL helps integrate many parts of the existing rail network and also brings rail to new areas of Hong Kong. These improvements to the network means passengers can get to more destinations conveniently or quicker thus attracting more passengers to use the rail and mitigate traffic congestion.

Reducing Road-based Transport

3.2.20 There are therefore several benefits that SCL will provide to travellers, regardless if they are travelling on the railway or road. The SCL will help to divert traffic from existing road-based public transport systems and encourage commuters to switch to rail as an alternative. This is because the expanded rail network will link more origins and destinations with services that provide the journey time, cost and reliability benefits associated with rail based trips in comparison with road based trips, which are subject to traffic conditions, particularly during commuter peak periods. In particular, the SCL will help to alleviate the demand on the Cross Harbour Tunnel, and will thus alleviate traffic congestion and associated vehicle emissions and environmental nuisance on existing road networks. Commuters will benefit from the safe, reliable and faster service of the railway and the public will benefit overall from a less congested road network.

3.2.21 As highlighted in Paragraph 3.2.5, the operation of SCL, along with South Island Line (East) and West Island Line, will contribute to an overall reduction in traffic flows. It was assumed in the transport models for the updated Third Comprehensive Transport Study forecasts that these rail projects would be implemented and operational by year 2016, and this has formed part of the basis of the traffic forecasts developed for the CWB project. In order to complete the SCL as quickly as practical and taking into account the time required for design and construction of the project, the SCL must be implemented now.

Cross-boundary Integration

3.2.22 The Cross Harbour Section will contribute to a direct rail link between Mainland China and Hong Kong Island allowing a journey from Shenzhen to the Central Business District to be made in around an hour. It will provide the required mass transportation centre at HUH Station to serve as a convenient transport hub and gateway to the Mainland and will support the intercity connection with Hong Kong Island. This has immense significance for Hong Kong’s growing cross-boundary economic and social integration with Mainland China.

Environmental Benefits from Operations

3.2.23 The trains will be powered electrically. The SCL will increase public transport patronage, by making it more convenient and accessible, and will thus result in overall reduction in road traffic. This will lead to improvements in air quality, noise pollution, on-road safety and the overall quality of the ambient environment.

3.2.24 If the SCL Cross Harbour Section was not constructed there would be a significant increase in roadside air quality and noise pollution from vehicles travelling similar distances.

3.2.25 The use of electrical rail systems is widely recognised as a more sustainable form of transport as its capacity to transport large number of people is much greater than road transport. Adverse environmental implications are far less for rail with regard to vehicle fleets and roadside pollutants, in particular air and noise pollution, are largely reduced through the use of rail. As most of the rail line is below ground, the visual quality and landscape character and land amenity can also be maintained whilst still providing convenient access to areas by the public.

Economic Implications

3.2.26 There will be new employment opportunities associated with the construction and operation of the rail line and increased employment opportunities from linkages with new tourism and commercial developments. The new railway will create more than 11,000 jobs during construction and the project will generate significant employment opportunities during its operations both for the operation of the railway as well as commercial opportunities at the stations and will enhance the economic development of the areas it serves.

3.2.27 Owing to the direct connection and faster travelling to and from Hong Kong Island, the SCL will attract passengers from road-based transport modes to rail. The annual transport benefit in terms of time savings to passengers in 2021 is expected to be equivalent to HK$4.1 billion in monetary terms.

3.2.28 There will be economic initiatives from increasing the number of tourists visiting the Kai Tak Development Area. The provision of the SCL will bring economic advantages to areas in need of redevelopment, as described in Sections 3.2.12 and 3.2.13 above.

3.3 Present Needs Requirement

3.3.1 The SCL is part of the overall network rail planning and it has been listed as a priority project in RDS-2000. The development of the rail lines takes time and there will be a significant lead time for design, construction and testing prior to operation. As such, any delay at this stage of the project could significantly delay the commencement of operations.

3.3.2 The SCL, along with the South Island Line (East) and West Island Line, was assumed in the transport models for the updated Third Comprehensive Transport Study forecasts to be implemented and operational by year 2016. Taking into account the time required for design and construction of the project, the SCL must be implemented now.

3.3.3 The original programme for the SCL has already been delayed. It was previously expected to be implemented and operational by year 2011 (RDS-2000), which was then extended to year 2016 Third Comprehensive Transport Study). However, due to the necessary time duration for design and construction and the complexity of the project, the anticipated year for operation for the Cross Harbour Section is now 2019 (LegCo Brief submitted by THB in March 2008).

3.3.4 Should the project not be constructed within this time period, further congestion would result on roads and there will be delays to the social, economic and environmental benefits of the project as stated above.

3.3.5 Based on feedback received from the public and District Councils, and also based on passenger forecasts, there is an urgent need to progress with the SCL and to commence construction to enable operation of the Cross Harbour Section as soon as possible.

3.4 Summary of Findings

3.4.1 There is an overriding public need for the SCL Cross Harbour Section due to the strategic nature of the project and the benefits that it will provide. These include:

- Relieving congestion on existing rail lines
- Supporting cross-boundary integration
- Relieving traffic congestion of the Cross Harbour Tunnel and in Hong Kong
- Mitigating deterioration of road-side air quality

3.4.2 The project will expand and upgrade the rail network in Hong Kong SAR, which will result in significant social, economic and environmental benefits. The project has been endorsed by government and is one of the priority infrastructure developments proposed by the Hong Kong SAR Chief Executive.

3.4.3 Based on the time duration required to design and construct the rail scheme, it is believed that there is a compelling and present need for the immediate implementation of the project.

4. NO RECLAMATION OPTIONS

4.1 Introduction

4.1.1 After establishing the compelling and present public need for the project, the next step is to determine if there is any reasonable alternative to reclamation, such as an alternative alignment, or employing different design and construction methods.

4.1.2 The HPLB TC No. 1/04 states that a "no reclamation" scenario must be taken as the starting point in considering alternatives and that it is imperative to examine if an overriding public need can be met without reclamation through a reasonable alternative. It further states that all circumstances should be considered in determining whether there is a reasonable alternative to reclamation, including the economic, social and environmental implications, cost and time incurred, and other relevant considerations, including technical feasibility and safety considerations.

4.1.3 In accordance with the PHO, alternative alignments and construction options have been considered for the Cross Harbour Section to address the "no reclamation" scenario.

4.1.4 Options of using a tunnel boring machine (TBM) for constructing the tunnels to avoid the use of temporary reclamation and a crossing by bridge have firstly been considered.

4.1.5 The following sections summarise the constraints in the area that have largely guided the route alignment corridor, describes the types of construction options that are available for the tunnels and the implications of constructing the Cross Harbour Section using a TBM and addresses the question if the "no reclamation" option is considered to be a reasonable alternative.

4.2 Alignment and Design Constraints

Alignment Constraints

4.2.1 The preferred alignment of the rail line for the connection between HUH Station and the new EXH Station is a direct connection with minimum distance to reduce construction costs, maintain operational efficiency and to minimise passenger travelling time.

4.2.2 There are a number of key constraints which govern the alignment, irrespective of the construction method. These include:

(i) Connecting with the HUH Station whilst:

- Having minimum impact on the operation of the existing station.
- Ensuring an efficient interchange between the east-west rail corridor and north-south rail corridor of the SCL.
- Allowing for practical construction under the Coliseum.

(ii) Crossing through the Hung Hom Bypass piers and the fender piles that have a depth of up to -20mPD.

(iii) Minimising impacts to the existing freight pier.

(iv) Avoiding impacts to the Cross Harbour Tunnel and the tension anchors under the southern approach ramp holding down the structure.

(v) Minimising operational impacts to the CBTS including the existing breakwater and existing moorings/anchorages within the Typhoon Shelter.

(vi) Crossing the CWB tunnel running east-west through the CBTS planned for construction within 2010 – 2017 (a similar time frame as the SCL).

(vii) Connecting with the future North Island Line at EXH Station.

Seabed & Ground Conditions

4.2.3 The seabed and ground conditions also have a direct effect on the horizontal alignment and vertical profile of the rail line. The seabed profile along the alignment is undulating and there are two notable areas of lower seabed, including a relatively large scour area depression, located about 260m south from the seawall at, Hung Hom south of the freight pier, approximately 5,000m2 in size with a maximum recorded depth of around -23.2mPD.

4.2.4 The ground conditions across this section of the Harbour comprise a sequence of marine deposits, alluvium and a weathered mantle of bedrock overlying medium grained granitic bedrock. Occasional corestones have been recorded. The rockhead is undulating with a high section in the middle of the Harbour.

Operational Requirements

4.2.5 The operational requirements for the railway that need to be considered include the following:

- A minimum radius of 300m for horizontal curves.
- A maximum vertical gradient of 3% should be achieved with minimum gradients for long lengths of track to improve energy efficiency.
- In view of the length of the Cross Harbour Section, tunnel ventilation studies, based on patronage forecasts and fire safety requirements, show that ventilation ducts need to be provided for each tunnel. These ducts are essential to ensure that adequate number of trains can run through the Cross Harbour Section to achieve the headway required to cope with the passenger demand. Tunnel simulation indicates that the size of the ventilation ducts is approximately $15m^2$.
- Cross passages between tunnels must be provided at a spacing of around 250m centres for emergency evacuation/access.

- A tunnel ventilation building is required at the southern end of the Cross Harbour Section. This also provides essential facilities for access and evacuation in an emergency. The shorter the tunnel, the more quickly emergency access and evacuation can be achieved.

4.3 Bridge Option

4.3.1 Consideration was given to a bridge option extending from the HUH Station area across the harbour to the area west of the CBTS (see **Figure 4.1**).

4.3.2 This option would have huge impacts on existing infrastructure and buildings on both sides of the harbour as well as significant visual impact. The problems arise from the need to provide sufficient navigation clearance under the bridge deck and the limiting 3% gradient for the railway. The approach ramps on other side of the harbour would have to be 1km long for every 30m of clearance.

4.3.3 On the Kowloon side the approach ramps would impact on East Rail, existing roads and other infrastructure. The Coliseum would require to be demolished and the resulting HUH station would provide for an unacceptable interchange due to the significant level differences between the east-west and north-south corridors.

4.3.4 On the Hong Kong side the approach ramp would have to extend a significant distance along the north shore on Hong Kong Island, including sections at grade and in trough and would fail to provide acceptable interchange stations at EXH and ADM because of the significant level differences involved.

4.3.5 This is not a viable option.

4.4 Bored Tunnel Option – Alignment Corridor

4.4.1 A wide range of alignment options have been considered. A review of the locations for HUH and EXH stations has been conducted. Findings are presented in **Annex A**.

4.4.2 The fundamental objective of the alignment is to extend East Rail across the harbour to provide passengers from the Mainland and eastern parts of the New Territories and Kowloon with convenient access to the north shore of Hong Kong Island and the Central Business District. It will also provide improved transport options for passengers from Southern District to ADM Station by the South Island Line (East) and elsewhere on Hong Kong Island.

4.4.3 As noted in Annex A, the location of the new SCL station at Hung Hom is constrained by the existing operating railway (the existing platforms and plant rooms on one side) and the Metropolis's supporting structure on the other side. There are also constraints on how far to the east the existing line from East Tsim Sha Tsui can be realigned to form the east-west corridor of the SCL.

4.4.4 This leaves the stabling/freight area in the centre as the only reasonable location (see **Figure 4.2**). The rail alignment is then dictated by the need to thread the SCL tunnels between the foundations of the Coliseum to where the SCL landfall on the Kowloon side must be located.

4.4.5 Alternative station locations were considered including to the west of the existing Cross Harbour Tunnel under Salisbury Road. This proved to be unfeasible because of constraints caused by existing infrastructure and the impacts on the existing operating railway.

4.4.6 Alignments to facilitate cross platform interchange at HUH Station were also considered but proved to be unfeasible because of various alignment constraints including those posed by the connection to the existing tunnels to and from East Tsim Sha Tsui Station.

4.4.7 The HUH Station configuration therefore has the tracks for the east-west corridor at grade, with tracks for the north-south corridor below to facilitate crossing the harbour.

4.4.8 In order to optimise the benefits to passengers the alignment must cross the harbour to interchange with the future North Island Line at EXH Station and with the Tsuen Wan Line, Island Line and South Island Line (East) at ADM Station.

4.4.9 The proposed location for EXH Station is under the existing Wan Chai North Public Transport Interchange, Harbour Road Sports Centre and Wan Chai Swimming Pool, to the north of Great Eagle and Harbour Centres. The sports centre and swimming pool will be reprovisioned in a new facility immediately to the south of the existing building.

4.4.10 Alternative locations for EXH Station were reviewed including different locations along Harbour Road and Gloucester Road. These were not taken forward due to a combination of poor interchange with the North Island Line, unfeasible railway alignment, unacceptable impacts during construction and impacts on existing buildings and infrastructure.

4.4.11 Options which connected to the rail network on Hong Kong Island at North Point and Fortress Hill Stations, instead of Exhibition Station were also considered.

4.4.12 These options proved to be impractical for a number of reasons. The most significant being:

- They are not taking passengers in the direction they want to go i.e. to the Central, Admiralty and Wanchai areas.
- The current station configurations with platform tunnels for both North Point and Fortress Hill Stations are not designed to cope with large numbers of interchanging passengers. North Point station is already stretched as an interchange between the Island Line and Tseung Kwan O Line. As such both stations would essentially have to be rebuilt with major impacts on the existing operating railway.

- Passengers arriving at either North Point or Fortress Hill would have to interchange to the Island Line to travel westwards to their destinations. The Island Line is already crowded and would be overloaded by the numbers of SCL passengers.

4.4.13 These alignment options are, therefore, not feasible.

4.4.14 It is concluded that the EXH Station must be located on the designated site to the North of the Great Eagle and Harbour Centres and the SCL must continue to Admiralty.

4.4.15 Given the objective to find a suitable alignment from Hung Hom to Exhibition / Admiralty and the elimination of options to the west of the Cross Harbour Tunnel and connections to the rail network to the east of Causeway Bay, the principal constraints define an envelope for alignment options as shown on **Figure 4.3**. There is no benefit to align the SCL tunnels further to the East as it just increases the journey length and time.

4.5 Shallow Bored Tunnel Options

4.5.1 These options would have to be constructed by Tunnel Boring Machine (TBM) because of the anticipated ground conditions along the alignment. The TBM options are presented in the following sections, with detailed information documented in **Annex B**.

4.5.2 A "no reclamation" option, using a TBM to drive the two tunnels under the Harbour using shafts located at Hung Hom and in the Police Officers' Club site on Hong Kong Island, has been considered. The use of TBM tunnelling has been undertaken previously in Hong Kong for the construction of railway, drainage and utilities tunnels of various sizes. The TBMs are specialised custom built equipment that require specification and ordering several years prior to construction.

4.5.3 There are several types of TBM available on the market and the type that can be used for a project largely depends upon the ground conditions, size and the depth of tunnel required. Due to the variable ground conditions in the harbour area, the type of TBM would generally be limited to either an Earth Pressure Balance or a slurry type shielded TBM, which can be applied to the mixed face ground conditions that are present along the alignment.

4.5.4 Sufficient ground cover is required over the TBM to enable ground control and steering and for safety requirements. The absolute minimum ground cover above the tunnel is generally one TBM diameter and preferably two diameters. It is expected that for an internal diameter of 9m would be required for a single track SCL tunnel with ventilation duct. The external diameter of the TBM would be about 10.35m. Accordingly, to allow for sufficient ground cover, the tunnel would require an absolute minimum depth below seabed of 10.35m and preferably more than 20m clearance from the top of the tunnel to the seabed.

4.5.5 A typical longitudinal section along the western part of the alignment corridor is shown on **Figure 4.4**.

Alignment

4.5.6 The alignment is driven by the need to pass under the CWB tunnels with adequate clearance to avoid damaging the CWB tunnels during SCL tunnel construction and also to maintain adequate cover under the seabed which is typically in the range of -17mPD to -20mPD.

4.5.7 On the Hung Hom side of the harbour, the main constraints are crossing through the fender protection piles of the Hung Hom Bypass and ensuring sufficient depth is achieved below the 'scour area' depression near the HUH seawall to maintain adequate ground cover during tunnelling to meet safety requirements.

4.5.8 Due to these constraints, a TBM "no-reclamation" option through the western part of the corridor, would require twin deep bored TBM tunnels with an invert level of approximately -50mPD, at the lowest point under the CWB tunnel, and a general depth below -44mPD within the remaining areas of the harbour. At these levels the tunnel would pass in and out of rockhead several times. It is expected that corestones will be encountered in the areas above rockhead.

Tunnel Construction

4.5.9 Due to the particularly onerous tunnelling conditions, the TBM would need to be capable of operating in mixed face conditions at deep tunnel depths. Based on previous experience, and in view of high cutter wear expected and risk of damage to the cutterhead, daily interventions would be required at the tunnel face for inspection, maintenance and repair. These works would require man entry into the pressurised cutterhead via air locks in the pressure bulkhead of the TBM. This would need to be undertaken in a small and confined space at deep tunnel depths under the harbour at pressures exceeding 3.45 bar.

4.5.10 Special techniques have to be employed to maintain the stability of the tunnel face. In Hong Kong any work using compressed air is regulated by the Factories and Industrial Undertakings Ordinance (Cap. 59), which provides for the safety and health protection to workers in the industrial sector. The current regulations provide for work up to a maximum pressure of 50psi (approx. 3.45 bar) and for work exceeding this pressure they state that:

"Except in the case of an emergency, no person shall be employed in compressed air at a pressure exceeding 50 pounds per square inch without permission from the Commissioner."

4.5.11 This limit is in place to protect tunnel personnel from being unnecessarily exposed to more hazardous conditions to health and safety than necessary. In all such cases the objective must be to keep the risk as low as reasonably practicable to these personnel. This, therefore, means that any requirement to exceed the current regulated level must be supported by an argument that there is no reasonable, safer way of carrying out the construction.

4.5.12 In this particular case the situation is even more complicated as compressed air is not considered to be practical for face interventions due to the limited working time available at the face at such high pressures.

4.5.13 Generally, Employers, tunnel designers and contractors try to avoid creating situations where the tunnel face has to be pressurised to enable access.

4.5.14 This is an approach that the MTR Corporation fully supports. In this particular case, as shown in Section 5, there is an alternative way to construct these tunnels which would avoid the need to unnecessarily expose personnel to pressures in excess of 3.45 bar on a regular basis.

4.5.15 Construction of the cross passages at around 250m intervals between the bored tunnels is also very difficult and risky under the harbour.

Design Implications

4.5.16 The deeper alignment across the harbour would mean that a cross platform interchange could not be provided at EXH Station resulting in a poorer level of service to passengers.

4.5.17 The TBM tunnel option also has significant disadvantages for connecting with stations and achieving operational requirements. Due to the tunnel depth requirements for the TBM, the platform at HUH Station for the SCL north-south corridor would need to be up to 15m lower than an option using immersed tube tunnel construction with the following implications:

- Increased interchange times, as the vertical separation between the east-west and north-south corridor platforms would be increased.
- Increased construction risks and costs associated with construction adjacent to the existing station foundations and under the Coliseum.
- Impacts on the Coliseum may occur due to increased volumes of rock excavation adjacent to and under it.
- Approximately 2km of the existing East Rail north of HUH Station would have to be lowered to tie into the deeper platforms at the station.

4.5.18 With this tunnel option there will be several major impacts on the community. The section of East Rail to be lowered would extend to the north of Waterloo Road, where a new bridge and new track would be required on the embankment to the north of Waterloo Road. Resumption of land would be required and traffic impacts would need to be resolved in the Wylie Road area. However, the most significant impacts would be the increased construction risks arising from works required immediately adjacent to the existing East Rail tracks.

4.5.19 The overall design implications of the above would be significant and the poor vertical interchange arrangement for the east-west corridor and the north-south corridor at HUH Station would not meet the project objectives of providing a direct and convenient interchange for passengers. Further, much of the construction work would be difficult and risky and the overall construction programme would be greatly increased.

Costs & Programme

4.5.20 It is estimated that the TBM tunnel ”no reclamation” option would cost up to approximately HK$3.3 Billion[3] more to construct than an IMT option, primarily due to the additional station depth and connection requirements.

4.5.21 The TBM option will take up to 25 months longer to construct than the IMT option, primarily due to the increased rock excavation at HUH Station.

Summary of Findings

4.5.22 For the shallow TBM alignment options along the alignment corridor identified on **Figure 4.3**, tunneling will be required at depths where interventions for maintenance and repair will need to be done under pressures in excess of 3.45 bar.

4.5.23 The MTR Corporation considers that the risks to health, life and the project associated with this shallow TBM option cannot be justified. There are alternative ways of constructing the project which avoid these risks.

4.5.24 The TBM option would also cost more, provide a considerably poorer level of service to rail users and has increased impacts on the community which extend over a wider area.

4.5.25 As such the shallow TBM “no-reclamation” option is not considered to be a reasonable alternative to options which require reclamation.

4.6 Deep Tunnel Options

4.6.1 MTR stations are preferably kept as shallow as possible in order to make them as easily accessible as possible for passengers. This dictates that the tunnels between them generally be kept shallow. However, the problems with the shallow TBM options listed above dictate that deeper tunnels in rock be considered.

4.6.2 Previous and currently planned drainage projects have deep tunnels under the harbour which are located in rock. These are aimed at avoiding the need for pressurized face interventions.

[3] December 2007 Prices

4.6.3 For the SCL Cross Harbour Section, this would mean that the tunnels would have to be lowered to approximately 80m below sea level in bedrock. The problems are that the stations would also have to be deepened significantly as shown on **Figure 4.5,** HUH station would have to be approximately 50m deep and EXH station 43m deep. Cross platform interchange would not be possible at EXH station. This option has not been taken forward as it would provide an unacceptable level of service for passengers entering or leaving these stations and an impractical interchange due to the level difference. This does not satisfy the project objectives as set out in para. 1.2.1 to provide efficient interchanges.

4.6.4 There would also be a knock on effect to the alignment to the west of EXH to ADM and also particularly along East Rail north of Hung Hom. A significant length of East Rail would have to be lowered to suit this new level including Mong Kok East Station. Tunnelling at depths with intervention pressures greater than 3.45 bar would also be required along this section as the tunnel climbs above rockhead.

4.6.5 This is not considered to be a viable option.

4.7 Conclusions

4.7.1 A number of “no-reclamation” options have been investigated and are considered to be not viable or not a reasonable alternative to reclamation (see section for the IMT option in Chapter 5). These options include: (i) Bridge Option; (ii) Shallow Bored Tunnel Option; and (iii) Deep Tunnel Option.

4.7.2 The Bridge Option would cause very significant adverse impacts on both sides of the Harbour. It is not possible to engineer a scheme which meets the SCL project objective. This option is therefore rejected.

4.7.3 The Deep Tunnel Option is not considered to be viable because of the impractical interchanges created and the need for tunnelling at pressures greater than 3.45 bar.

4.7.4 The shallow bored tunnel option would require working in high pressures exceeding the statutory limit of 3.45 bar. The MTR Corporation are not prepared to accept the risks to health, life and the project with this option when there is an acceptable alternative option available as described in the remainder of this Report which avoids these risks, Also, the poor interchange arrangement would not meet the SCL project objective.

5. ALTERNATIVE OPTIONS WHICH REQUIRE RECLAMATION

5.1 Immersed Tube and Cut-and-Cover Tunnel Option – Construction Approach

5.1.1 The construction of tunnels using IMT has been the approach used for all existing cross-harbour transport tunnels in Hong Kong, including the Eastern Harbour Crossing, Western Harbour Crossing, Airport Railway and the Cross Harbour Tunnel across Victoria Harbour. The construction process and technology for this method is well established with relatively little risk involved. Both local and overseas Contractors have the skills to undertake this type of construction and the construction plant and materials are locally accessible.

5.1.2 The standard practice for IMT construction is to dredge a trench in the seabed to remove soft materials, provide a foundation base within the trench, float in precast tunnel units, sink the precast units into the trench and backfill the trench with a rock blanket or other suitable material for protection and anchoring the tunnels. This construction method would be used for most of the SCL within the harbour and would require no permanent or temporary reclamation.

5.1.3 The maximum depth and portion of IMT extending above the seabed is generally dictated by marine clearance requirements. For the SCL Cross Harbour Section, the reinstated seabed above the IMT would be at a similar but generally lower level than the adjacent Cross Harbour Tunnel, to ensure sufficient water depth for marine traffic is achieved whilst reducing the amount of dredging for installation of the IMT units. For a length of approximately 100m north of the CBTS breakwater, the protection layer for the SCL tunnels would be approximately 550mm higher than the adjacent Cross Harbour Tunnel. However, this is not under the fairway and minimum available water depths remain at approximately 10m thus not impacting on the use of the Harbour.

5.1.4 At the shore ends either side of the tunnel at Hung Hom and the CBTS, the tunnel could be constructed without the need for permanent reclamation, except for the reinstatement of the fender piles of the Hung Hom Bypass at a different location (see para 5.2.11). However, temporary reclamation would be required to facilitate construction as described below.

5.2 Alignments

Alignment Constraints

5.2.1 The various alignment constraints described earlier for the “no reclamation” tunnel options also apply to the immersed tube and cut-and-cover tunnel option. A similar envelope covering alignment options can be generated as shown on **Figure 5.1**. This is bounded by the existing Cross Harbour Tunnel on the west and the need to identify a suitable landfall on Hong Kong Island which is not constrained by existing buildings or infrastructure.

5.2.2 The major difference from the envelope shown in **Figure 4.3** is that alignments along the central part of the envelope shown in **Figure 5.1** are not feasible. The IMT must be kept as shallow as possible and, therefore, must pass above the CWB tunnels. In the central part of the corridor, the SCL tunnels would clash with CWB Slip Road No. 8 which extends above the main CWB Tunnel Box.

5.2.3 This therefore leaves two alignment corridors to be considered: a Western Alignment Corridor and an Eastern Alignment Corridor which both pass through the CBTS as shown on **Figure 5.1**.

5.2.4 Alternative alignment options to the west of the Cross Harbour Tunnel and to the east of CBTS were considered but rejected for the reasons given in Sections 5.2.5 to 5.2.9.

Alternative Alignment to West of Cross Harbour Tunnel

5.2.5 This would require the SCL tunnels to pass under the Cross Harbour Tunnel on the Kowloon side of the tunnel, run along Salisbury Road before crossing to the ex-Public Cargo Working Area in Wanchai. It would pass under the CWB tunnels before entering EXH Station located adjacent to the CWB tunnels to the north of the Harbour Centre.

5.2.6 There are a number of major challenges with this alignment which renders it unfeasible. These include conflicts with the Coliseum foundations, foundations for the East Rail tunnels and the adjacent flyover structure. Mined tunnelling under the existing Cross Harbour Tunnel on Kowloon side would be particularly risky as the existing structure is sensitive to movements.

5.2.7 The tunnel across the harbour would be particularly deep (approximately 40m below sea level) as it would have to pass below the CWB tunnels. This would lead to excessive dredging and significant areas of temporary reclamation. EXH Station would have to be much deeper and a cross platform interchange could not be provided.

5.2.8 The risks associated with this alignment, the impacts of construction and poorer interchange at EXH Station mean that this option is unacceptable.

Alternative Alignment to East of CBTS

5.2.9 Immersed tube SCL alignment options which terminate at North Point and Fortress Hill stations have the same fundamental problems as the bored tunnel options as set out in Section 4.4.12 i.e. the ISL has insufficient capacity and the existing stations would need to be essentially totally reconstructed.

Eastern Alignment Options – Hung Hom Section

5.2.10 For both the Eastern and Western Alignment Corridors, the requirements at the Hung Hom Landfall are common.

5.2.11 At the Hung Hom landfall, the SCL tunnel would need to pass under the Hung Hom Bypass. During construction of the SCL tunnels, some of the fender piles for protecting the Hung Hom Bypass would need to be removed and reprovisioned in a slightly different form. The reprovisioned fender piles are considered to be permanent reclamation but are not considered to affect the use or enjoyment of the Harbour.

5.2.12 Temporary reclamation (including the temporary cofferdam and steel platform) as shown on **Figure 5.2** is required in this area as the final section of tunnel across the harbour at the interface with the Hung Hom landfall would be constructed by cut-and-cover method within a cofferdam. There are a number of reasons for adopting this method:

- To avoid underwater blasting of rock close to the Cross Harbour Tunnel (CHT).
- To control impacts of construction on the Hung Hom Bypass and its foundations.
- To protect existing pumping station intakes.

5.2.13 Temporary steel platforms will be required adjacent to the cofferdam area to provide temporary construction works area.

5.2.14 Temporary reclamation with diaphragm walls was also considered at this location but the tunnel construction with cofferdam supported by temporary steel piles is considered more suitable due to the high rock level.

5.2.15 During construction a small portion of the existing Hung Hom Freight Pier within the limits of the dredging area would need to be removed, as shown in **Figure 5.3**. Upon completion, the pier could be reinstated.

Eastern Alignment Options – Alignment on Hong Kong Island

5.2.16 The options are shown on **Figures 5.4 to 5.7** and the key characteristics are summarised below:

- Option 1A: Alignment runs under CWB tunnels along the same corridor as far as possible.
- Option 1B: Alignment runs partly under the CWB tunnels and then to the south of the tension anchor zone at the CHT portal and then parallel to and just to the south of the CWB tunnels.
- Option 1C non-stacked: This is a similar alignment to Option 1B through the CBTS but then follows a non-stacked inland alignment to EXH station. A similar alignment option to provide a cross platform at EXH station was also considered but found to be unfeasible.
- Option 1D: Shallow alignment above the CWB tunnels.

5.2.17 Essentially they fall into two categories:

- Those which pass above the CWB : Option 1D.
- Those which run below it : Options 1A to 1C.

5.2.18 The assessment of Option 1D has shown that the currently proposed CWB tunnels would have to be lowered to avoid the SCL tunnels either clashing with the CWB Slip Road No. 8 or protruding above the seabed as shown on **Figure 5.7**.

5.2.19 The CWB project team have advised that any such deeper CWB alignment would result in the CWB tunnel portal being moved further east towards North Point. This would increase the permanent reclamation in North Point from 3.3 hectares to around 10 hectares.

5.2.20 Options 1A to 1C would require construction of the SCL tunnels beneath the CWB tunnels within the CBTS. These works would have to be carried out under the CWB contract and it is estimated that due to the extra depth of construction and complexity, it would delay completion of the CWB tunnels and prolong the period of disruption in the CBTS by approximately 3 years.

5.2.21 Added problems with Options 1A to 1C are increased construction complexity and risk, particularly for the construction of the combined CWB and SCL tunnels under the Cross Harbour Tunnel, and adverse impacts on the interchange at Exhibition Station for Options 1A and 1C.

5.2.22 All Options would require temporary reclamation up to 2ha while Option 1B would also require additional permanent reclamation to allow the SCL to be constructed parallel to the CWB tunnels adjacent to the Wanchai East Screening Plant and Hong Kong Electric Sub-station.

5.2.23 The Eastern Alignment Options are therefore not favoured because of a combination of the need for permanent reclamation and the prolonged period of construction required in CBTS. In addition, the route length for the Eastern Alignment Options would be longer than for the Western Alignment Option, resulting in greater construction impacts and longer journey times during operation.

Western Alignment Options

5.2.24 The horizontal alignment is shown on **Figure 5.8**. Inside the CBTS, the SCL tunnels will pass over the CWB tunnels.

5.2.25 After passing through the Hung Hom landfall section, the alignment will run in a southerly direction towards the CBTS, to the east and generally parallel to the existing Cross Harbour Tunnel. South of the CBTS breakwater, the alignment will then run in a south westerly direction towards the Police Officers' Club site where a ventilation building will be located.

5.2.26 The tunnel between the Hung Hom landfall and a point approximately 72m north of the breakwater will be constructed using the IMT method. South of the IMT section, cut-and-cover method will be adopted. The cut-and-cover section requires temporary reclamation, with a total area of approximately 2.2ha, including the temporary reprovisioned jetty for the Royal Hong Kong Yacht Club.

5.2.27 The existing breakwater will be removed after the area around it has been temporarily reclaimed. The breakwater will be reinstated at the existing location and in a similar form after completion of the SCL tunnels below. The typhoon shelter will be protected at all times by the temporary seawalls and reclamation provided while the existing breakwater is removed for the SCL tunnel construction.

5.2.28 There are several challenges with constructing the SCL tunnel through the CBTS section, these include:

- The need to reduce disturbance to the moorings and operations of the typhoon shelter as much as possible and ensuring the works are undertaken as quickly as possible to avoid prolongation of any impacts.
- Ensuring the tunnels are placed at a sufficient depth to reduce the potential risk of damage from ship impact, anchors, etc. and are not exposed, whilst minimising the amount of materials to be dredged from within the typhoon shelter during construction, due to the high levels of contaminants in the sediment, and ensuring that contaminants are contained as best as possible when removed.
- Interfacing with the CWB construction which will commence earlier than the SCL.

5.2.29 The above requirements contribute to the need for temporary reclamation to be undertaken for construction works. In particular, the most significant implication to the project is the interface requirements with CWB.

5.2.30 There is a need to integrate the CWB project and SCL works within the CBTS to optimise the use of temporary reclamation provided by CWB for construction of the SCL and also the requirement to mitigate impacts on the users of the CBTS. It would also reduce project costs and risks during construction. Although, temporary reclamation would be required, in addition to that proposed in the CWB project, it would be significantly reduced in terms of size and duration in comparison to that which would be required if the SCL above the CWB was constructed after completion of the CWB.

5.3 Summary Comparison of Western and Eastern Corridor Options

5.3.1 A summary comparison of key aspects of the Eastern and Western Alignment Corridor options is provided in **Table 5.1**.

Table 5.1 : Summary Comparison of Eastern and Western Alignment Options

	Eastern Alignment Options				Western Alignment Corridor
	Option 1A	Option 1B	Option 1C	Option 1D	
Permanent reclamation	Nil	Required	Nil	Additional 6.7 ha	Nil
Construction Complexity & Risk	High	Medium	Medium	Medium	Low
Temporary Reclamation	0.6 ha	2 ha	2 ha	0.6 ha	2.2 ha
Extended Duration of Works in CBTS	+ 3 years causing delay to CWB	+ 3 years causing delay to CWB	+ 3 years causing delay to CWB	+ 3 years causing delay to CWB	+ 1.5 years but no delay to CWB
Disturbance	Prolonged occupation of moorings	Prolonged occupation of moorings	Prolonged occupation of moorings	Prolonged occupation of moorings	Limited moorings affected
Railway Operation	Longer tunnels; X-platform interchange at EXH not ok	Longer tunnels; X-platform interchange at EXH ok	Longer tunnels; X-platform interchange at EXH not ok	Longer tunnels; X-platform interchange at EXH not ok	Min. length; X-platform interchange at EXH ok

Notes: This table shows the approximate areas of reclamation and approximate duration for comparison purposes (excludes Hung Hom landfall which are common to both Eastern and Western Alignment Options as noted in para. 5.2.10)

5.3.2 Based on feedback from the public consultation process particularly from the Professional Forum and taking into account construction risks and programme, the Western Alignment Option is considered to be a better option than the Eastern Alignment Options.

5.4 Conclusion of Options Reviewed

5.4.1 Based on an analysis of the alignment options for the IMT, it has been concluded that the IMT alignment should follow the Western alignment as it minimises interfaces with CBTS and is the most direct railway alignment. As described in Section 5.2.2, the central alignment is not feasible and the Eastern alignments have more significant impacts on reclamation durations and significant greater construction risks.

5.4.2 The Western Alignment Option by immersed tube and cut-and-cover tunnel would not require permanent reclamation, as all permanent works would be below seabed or lowest astronomic tide level, other than the reprovisioned fender piles for the Hung Hom Bypass. Temporary reclamation will, however, be required.

5.4.3 It is concluded that there is no reasonable alternative to the IMT tunnel option which requires temporary reclamation for construction at the Hung Hom landfall and adjacent to and in the CBTS and replacement of the fender piles for the Hung Hom Bypass (which is considered as permanent reclamation). This option is the most appropriate option that can achieve the project needs and benefits to the public and be constructed with proven technology, with lower costs and less risk to programme.

6. IMMERSED TUBE TUNNEL OPTION – EXTENT OF RECLAMATION

6.1 Introduction

6.1.1 As it has been established that there is an overriding public need for SCL and that there is no reasonable alternative to reclamation, the next step is to ensure that reclamation must be restricted to only the amount necessary to meet the overriding public needs.

6.1.2 The following presents the minimum reclamation options for the IMT tunnel and Cut-and-Cover based on the Western Alignment Option.

6.2 Hung Hom Landfall

6.2.1 A section of cut and cover construction is required adjacent to the existing seawall at Hung Hom for the reasons set out in Section 5.2 and illustrated on **Figure 5.2**. This would involve the construction of a temporary cofferdam with an elevated platform supported on piles to provide sufficient works access and to provide marine protection to the existing piers of the Hung Hom Bypass.

6.2.2 The width of the cofferdam is just sufficient to accommodate the permanent structure, temporary support and sufficient working space for installation of formwork and external waterproofing.

6.2.3 The temporary decking on either side of the cofferdam is required to provide for safe and efficient working conditions and for the delivery of plant, equipment and materials to the area of construction. It also goes around the pier of the Hung Hom Bypass to prevent damage to the Bypass from marine impacts

6.2.4 The length of the cofferdam (see **Figure 5.2**) is dictated by the high rockhead along the alignment as explained in Section 5.2.12.

6.2.5 The temporary cofferdam and decking is considered to be temporary reclamation. The total area of temporary reclamation (cofferdam plus temporary decking) is approximately 1.0ha and it would be in place for approximately 28 months. There is considered to be no impact to the use or enjoyment of the harbour associated with this temporary reclamation since it is located partly under the Hung Hom Bypass close to the existing Freight Pier and in an area where public access to the waterfront is not possible.

6.2.6 Several piles for the fender piers protecting the Hung Hom Bypass are located within the width of the proposed SCL tunnel. These piles will be demolished and re-instated upon completion of the tunnel section.

6.2.7 It is considered undesirable to reinstate the fender piles in the same location as anchorage directly above the tunnel would have to be resolved, this would likely involve transfer of impact loads directly to the SCL tunnels.

6.2.8 These piles will be relocated close to, but in different locations to the existing locations as shown on **Figure 5.3** in order to maintain protection of the Hung Hom Bypass. They are considered to be permanent reclamation but they will occupy approximately the same area of the harbour as the existing piles.

6.2.9 There is considered to be no impact to the use and enjoyment of the harbour associated with either the proposed temporary or permanent reclamation.

6.2.10 A portion of the existing freight pier has to be removed to facilitate construction of the IMT tunnels. The pier could be reinstated after SCL construction, at the existing location. The reinstatement of the freight pier is not considered to be permanent reclamation.

6.3 Works In and Adjacent to the Causeway Bay Typhoon Shelter

CBTS Breakwater

6.3.1 Temporary reclamation will be required to construct the portion of the SCL tunnel running through the existing CBTS breakwater and inside the CBTS as shown on **Figure 6.1**. The temporary reclamation would be located on the northern side of the breakwater and would not be removed until the breakwater is fully reinstated in order to provide protection to the CBTS.

6.3.2 Options to reduce the area of reclamation, such as the use of a pipe piled cofferdam without temporary seawalls and reclamation, were considered for the section of SCL works adjacent to the breakwater. However, these were rejected due to the risks associated with the depth of the piles and excavation, and also the risk of marine collisions.

6.3.3 Given the above, temporary reclamation is required to construct the cut-and-cover tunnel to connect with the IMT and inside the CBTS.

6.3.4 The cut-and-cover method for this section would involve constructing a temporary reclamation area to provide a dry working platform and the installation of temporary walls propped by steel struts. The soil between the temporary walls would then be excavated and a reinforced concrete tunnel box would be constructed to form the permanent structure. Backfilling would then be undertaken on top of the tunnel and the temporary reclamation materials would then be removed.

6.3.5 The extent of temporary reclamation north of the existing breakwater is dictated by the distance required from the breakwater to avoid undermining the breakwater during dredging works for the immersed tube tunnel. This dictates that it extends approximately 92m from the centre line of the breakwater as shown on **Figure 6.2**.

6.3.6 The reclamation would be protected by a vertical seawall which will also protect CBTS while the seawall is provided.

6.3.7 The width of the temporary reclamation is driven by the following requirements (see **Figure 6.3** for the section near the existing breakwater):

- Twin tunnels plus ventilation ducts
- Working space for construction of tunnels
- Temporary walls
- The need to minimise conflicts between the seawall foundation and temporary wall construction.

6.3.8 This approach is similar to that adopted by the CWB tunnels for construction within the CBTS.

Works within the CBTS

6.3.9 Based on feedback from consultation with stakeholders and users of the CBTS and taking into account constraints on availability of off-site reprovisioning, the general view is that no additional moorings (i.e. over what CWB has proposed) should be relocated outside of the CBTS to facilitate SCL construction. For vessels to be relocated to other locations within the CBTS to suit the construction works, buoy and sinker moorings and/or pontoons could be used.

6.3.10 It is therefore proposed that the section of SCL tunnel above the CWB tunnel will be constructed in conjunction with the CWB tunnel under the CWB project as shown on **Figure 6.4**.

6.3.11 The CWB project would construct the SCL tunnels from adjacent to the shoreline to just north of the CWB tunnel. This will require some modification to the limits of temporary reclamation carried out under the CWB project on authorisation of the SCL scheme under the Railways Ordinance. A small part of the temporary reclamation would be left in place adjacent to the shoreline to allow the SCL project to construct the SCL tunnels through the seawall. This temporary reclamation would be removed by the SCL project from land.

6.3.12 As explained in paragraph 6.3.4, this section of SCL would utilise the similar construction methods as the CWB project i.e. cut-and-cover construction, temporary reclamation and seawalls. Certain provisions would be built into the end of the tunnel to enable subsequent extension of the tunnels by the SCL project.

6.3.13 The remaining section of the SCL tunnel in the CBTS would commence construction during the last stage of CWB construction, using the same method.

6.3.14 The width of temporary reclamation within the CBTS is driven by the same requirements as that required for cut-and-cover construction north of the existing breakwater except that it can be reduced slightly as the ventilation ducts can be combined over this section reducing the width of the temporary reclamation by approximately 4m. Some limited dredging of the CBTS may be required to provide sufficient water depth to allow the relocation of moorings.

6.3.15 Consideration was given to forming a permanent or temporary breakwater to the north of the existing breakwater in order to create additional sheltered space for moorings so that the construction of the SCL works within the CBTS could be expedited. However, this could not be justified under Section 3(1) of the PHO as it will require additional reclamation to that required for the proposed scheme which can also be carried out without moving any additional moorings out of the CBTS.

6.3.16 An option of extending the immersed tube tunnel into the CBTS was also considered with the aim of reducing the extent of temporary reclamation required. However, during consultation with the users of the CBTS, clear views have been expressed that there should be no reduction in the protection provided to their moorings by the existing breakwater. Construction of the IMT through the breakwater would require a significant section of the breakwater to be removed. The extent of mooring area affected in the CBTS would also be similar to the proposed cut-and-cover option.

Reprovision of Affected Royal Hong Kong Yacht Club Facilities

6.3.17 Certain facilities required for operation of the Royal Hong Kong Yacht Club will be affected by the SCL and CWB construction works. These will require temporary reprovisioning during SCL construction and reinstatement at its original position upon completion of the project. These include the pontoon and the jetty for hoisting boats from the water for maintenance etc. The jetty will require to be piled both in its temporary location (see **Figure 6.1**) and when reinstated in its permanent position. The temporary reprovisioning of the jetty is considered to be temporary reclamation. The floating pontoon system will not be piled and this is not considered to involve either temporary or permanent reclamation.

Area of Temporary Reclamation

6.3.18 The total area of temporary reclamation (measured as the area within the copelines of the vertical seawall) including the reclamation outside the CBTS is approximately 2.2ha in addition to that required for CWB construction (see **Figure 6.1**). This is considered to be the minimum overall extent of temporary reclamation required to facilitate the construction of the SCL tunnels.

6.3.19 However, this is not the extent of temporary reclamation at any one time. The staging of the works will have a significant affect on the extent of temporary reclamation at any one time, as described in section 6.4.

6.4 Staging of the Works at CBTS

6.4.1 The proposed construction staging for the CWB works within the CBTS is set out in Annex J of the Report "Construction of Trunk Road Tunnel in Causeway Bay Typhoon Shelter and ex-Wan Chai Public Cargo Working Area (October 2008)" issued by Highways Department. Whilst the entire CWB works in the CBTS will require an overall construction period of around 6 years, there will actually be four main stages of works within the CBTS and the temporary reclamation areas under each stage will only need to be in place for a much shorter period of time than 6 years. Construction of the CWB project is currently planned to commence in 2010.

6.4.2 It is anticipated that construction of the SCL tunnels could commence in 2011 following project authorisation and funding approval.

6.4.3 In determining the staging for construction of the SCL works adjacent to and within the CBTS, due consideration has been taken of views expressed in consultation with the District Councils, the public and affected stakeholders. The principal concerns were:

- The SCL works should be integrated with the CWB works where possible with a view to minimizing the duration of construction.
- Stakeholders don't want to have any more moorings reprovisioned out of the CBTS (i.e. over what CWB has already proposed) as described in Section 7.
- Adequate separation should be provided between moorings and marine construction plant. The level of protection provided by the existing breakwater should be maintained.

6.4.4 The construction of the SCL tunnels through the CBTS would be carried out in stages, using the same approach to dealing with the moorings as developed under the CWB project. Whilst it is envisaged that the SCL works within the CBTS can be completed within 18 months of completion of the CWB works within the CBTS, the full area of temporary reclamation would not be in place up until that time. Illustrative construction staging plans for the works through the CBTS are shown on **Figures 6.5 to 6.7.**

6.4.5 Key aspects of the staging are:

- The section of SCL tunnels which run above the CWB tunnel and to the south of the CWB tunnel within the CBTS will be constructed under the CWB construction contract.
- Construction of the SCL tunnels immediately to the north of the existing breakwater will commence during Stage 3 of the CWB construction to allow the connection between the immersed tube tunnel and the cut-and cover-tunnel to be completed.
- Construction of the SCL tunnels through the breakwater and into the northern part of the CBTS would commence once the CWB Stage 3 works are completed. These works will extend as far as possible into the CBTS without affecting CWB construction or requiring additional moorings to be relocated out of CBTS. Earlier commencement of these works is not possible without additional moorings being relocated out of CBTS.
- The final stage of SCL construction would commence once all of the CWB works within the CBTS are completed. These would take a further 18 months to complete.

6.4.6 The durations of the temporary reclamation stages for SCL works from the time of starting seawall construction and filling above the seabed to the time when the temporary reclamation is removed and the seabed reinstated will vary from 15 months to 28 months, except for a small area near the shoreline (Area SCL 1.4 in **Figures 6.5 and 6.6**) which will stay for a longer period.

6.4.7 Upon completion of each stage, the temporary reclamation would be removed and the seabed reinstated. There would be some overlapping of temporary reclamation between stages. At any one time the maximum area of temporary reclamation for SCL would be around 1.6ha (excluding temporary reclamation for CWB).

6.4.8 Therefore, whilst the overall area of temporary reclamation required for SCL construction at the CBTS is approximately 2.2ha, the additional affected area of the harbour in respect of temporary reclamation in the CBTS will only be around 1.6ha for approximately 8 months. This would be reduced to approximately 0.8ha for the final 10 months of SCL construction after completion of the CWB.

6.5 Summary & Conclusions

6.5.1 Given the above, the preferred minimum reclamation would involve the integration of a section of the SCL tunnels with the CWB project subject to timely authorisation of the SCL project to this end. The area of temporary reclamation required for the SCL is limited to the section within and adjacent to the CBTS and the landfall area at Hung Hom.

6.5.2 In Hung Hom, an area of approximately 1.0ha would be required for a duration of 28 months.

6.5.3 At the CBTS, a total area of approximately 8.6ha of temporary reclamation would be required to construct both the CWB and SCL projects, rather than 6.4ha to only construct the CWB within the CBTS. The duration of the temporary reclamation would be approximately 92 months for both projects, rather than approximately 74 months for the CWB project only. The maximum area of temporary reclamation for both projects at any stage would be approximately 4.2ha, rather than approximately 3.7ha for the CWB project only.

6.5.4 Reinstatement of the fender piles for the Hung Hom Bypass is considered to be permanent reclamation but is not considered to affect the use or enjoyment of the harbour. Reprovisioning of the CBTS breakwater and Royal Hong Kong Yacht Club facilities will be on a 'like for like' basis.

6.5.5 A minimum extent of temporary reclamation has been identified to facilitate the SCL construction. The extent of temporary reclamation within the CBTS has been minimised by entrusting a section of the SCL tunnel construction works to the CWB project.

6.5.6 The extent of temporary reclamation at any one time has been limited to a level which provides a balance between overall duration and imposing additional impacts on the users of the CBTS.

7. PUBLIC CONSULTATION

7.1 Introduction

7.1.1 Public consultation activities were conducted to brief the public on the issues associated with the proposed SCL Cross Harbour Section works in the harbour and seek their views. These included public forums, professional forums and seminars, presentations to and discussions with District Councils and Harbour-front Enhancement Committee. The activities held are tabulated below:.

Date	Public consultation activity
16 June 2009	First Professional Forum
6 July 2009	CBTS Stakeholder Briefing cum Forum
21 July 2009	Presentation to Wan Chai District Council
23 July 2009	Presentation to Eastern District Council
5 August 2009	Seminar for The Hong Kong Institute of Planners (HKIP)
17 August 2009	Presentation to Harbour-front Enhancement Committee (HEC)
18 August 2009	Seminar for The Chartered Institute of Logistics and Transport in Hong Kong (CILTHK)
19 August 2009	Seminar for The Hong Kong Institute of Architects (HKIA)
24 August 2009	Public Forum – The New Territories
29 August 2009	Public Forum – Kowloon
1 September 2009	Public Forum – Hong Kong Island
10 September 2009	Presentation to Yau Tsim Mong District Council
14 September 2009	Presentation to North District Council
29 September 2009	Presentation to Kwun Tong District Council
9 November 2009	CBTS Stakeholder Briefing cum Forum (PMA users)
20 November 2009	Seminar for Hong Kong Construction Association (HKCA)
30 November 2009	Presentation to Southern District Council
4 December 2009	Second Professional Forum

7.1.2 An information paper was circulated to all 18 District Councils to describe the proposed works for SCL Cross Harbour Section. A Digest on SCL Cross Harbour Section detailing the same was published and is available on the MTRCL website.

7.1.3 Roving exhibitions on SCL were held from July to September 2009, with information panels and an SCL video introducing this new railway project to the general public. These exhibitions were held in different MTR stations, shopping malls and public areas in Hong Kong.

7.1.4 Records of the forums and the seminars are enclosed in **Annex C**. Meeting minutes of the District Councils and the Harbour-front Enhancement Committee can be found in their respective websites.

7.1.5 In addition, a number of individual meetings with stakeholders were held to understand their concerns. General views sought are summarized in Paragraphs 7.2.14 to 7.2.20.

7.2 Public views sought

Professional Institutes / Harbour Protection Concern Groups

7.2.1 Consultation with the professionals / concern groups commenced when the first Professional Forum was held in June 2009. Representatives from professional institutions, academics and harbour protection groups were invited to the forum to understand the scheme and provide their views. A series of seminars were subsequently given to various professional institutes / associations up to December 2009.

7.2.2 In the first Professional Forum and subsequent seminars, most of the participants agreed that there was an overriding public need for SCL. It was recognised that it could not only relieve congestion of existing lines, but also increase mobility especially for those from the New Territories and older urban districts. in East Kowloon.

7.2.3 Most of them supported the finding that there was no reasonable “no reclamation” option.

7.2.4 It was generally agreed that the Western Alignment was a better option as it would cause less disruption to the CBTS than the Eastern Alignment, and was a more direct route.

7.2.5 There was a view expressed that the extent of the proposed temporary reclamation in the CBTS should be minimised. As explained in Chapter 6 of the Report, the SCL works have been integrated with the CWB project to optimise the use of temporary reclamation formed under that project for SCL tunnel construction. Other areas of temporary reclamation required for SCL construction have been minimised and presented at the second Professional Forum.

7.2.6 In response to suggestions by the public, including one raised at the HKIA seminar, alternative alignments which avoided passing through the CBTS were investigated as discussed in Chapter 5 of this Report and in Annex A. These options were found to be unacceptable.

7.2.7 There was a view expressed that the SCL and CWB projects teams should work closely together to avoid repeated temporary reclamation and also if possible to reduce the period of construction to minimize disruption to the stakeholders and the public. As described in Chapter 6, this close liaison has taken place with the result that it is now intended approximately 160m of the SCL tunnel be constructed under the CWB project subject to the timely authorisation of the SCL project.

7.2.8 The second Professional Forum was held in December 2009 to report the public consultation activities conducted, to update the design development and to explain how the reclamation would be minimized. The invitees were the same as those for the first Professional Forum, plus the non-official members of the Harbour-front Enhancement Committee. Participants recognized the coordination work undertaken between the SCL and CWB projects and supported the findings on the duration and the extent of temporary reclamation.

Harbour-front Enhancement Committee (HEC)

7.2.9 Most of the HEC members supported the SCL project. They opined that the option that would be completed in the shortest period of time should be pursued, and coordination with the CWB project should be necessary. They were concerned about the temporary occupation of the harbour-front areas by different railway projects and asked for mitigation measures to be implemented.

7.2.10 Suggestions were offered that the temporary reclamation at CBTS could be further reduced by extending the immersed tube tunnel method into the CBTS or by moving the breakwater outward to provide more sheltered space and allow the SCL construction to be expedited. However, as described above in Paragraphs 6.3.15 and 6.3.16, the former impacted a similar extent of mooring area in the CBTS and the latter option contravened the requirements of the PHO. These findings were reviewed and supported at the second Professional Forum. .

District Councils

7.2.11 An information paper on the SCL Cross Harbour Section was sent to all 18 District Councils. Presentations were given to Wan Chai, Eastern, Yau Tsim Mong, North, Kwun Tong and Southern District Councils as requested to introduce the scheme.

7.2.12 Most of the District Councillors considered that there is an overriding public need for the SCL. Many District Councils urged for its early implementation. There was no specific view on the findings that there would be no reasonable “no reclamation” option but there was a preference for the Western Alignment.

7.2.13 Eastern District Councillors expressed objection to any SCL works being carried out in the CBTS, unless the agreement from all stakeholders of CBTS was obtained. Follow-up meetings with the key Councillors representing the fishermen were held to further explain the need for SCL to pass through CBTS, and a written reply was subsequently sent to the District Council. As noted above it was concluded in Chapter 5 that the alignment must pass through the CBTS.

Stakeholders at CBTS

7.2.14 The major stakeholders affected by the SCL Cross Harbour Section works are the users of the CBTS. They include:

- The Royal Hong Kong Yacht Club (RHKYC) – About 152 moorings at the western side of the CBTS (adjacent to where the club facilities on land are located) are designated for the club’s use. These are to be reprovisioned within the CBTS during the construction of both the CWB and SCL projects.
- Private mooring area (PMA) users – About 147 moorings at the northern side of the CBTS are leased by Marine Department to private vessel owners. Under the CWB project, these moorings are to be reprovisioned offsite but the SCL may delay their return to the CBTS for a period of up to 18 months.
- Anchorage area users – Vessels using the anchorage area at the eastern side of the CBTS include fishing boats, dwelling boats, sampans, vessel-related business, temple boat etc. Anchorage areas of the same size are to be reprovisioned within the CBTS during the construction of both the CWB and SCL projects.
- Vessels at the southwest corner – About 5 vessels and 2 dwelling vessels at the southwest corner are primarily affected by the construction of the SCL and will be relocated within the CBTS.
- Commercial boats – Some of the private moorings in the CBTS are for commercial boats operating marine passenger carrying businesses in the harbour. Under the CWB project, those moorings for commercial boats in PMA would remain in the CBTS during CWB Stages 1 and 2 and would be reprovisioned at the ex-Wan Chai Public Cargo Working Area (PCWA) basin during CWB Stages 3 and 4.

7.2.15 A Stakeholder Briefing cum Forum for CBTS users, except those in the Private Mooring Area (PMA), who would be affected by the construction of SCL was held in early July 2009. Another briefing specifically for PMA users in CBTS was organised in early November 2009.

7.2.16 Meetings with individual stakeholders were held from June 2009 onwards in order to better understand their concerns. Their views are summarised in the following paragraphs.

7.2.17 RHKYC: RHKYC did not object to the construction of the SCL. They had a number of principal concerns and requirements including: the moorings that they had should remain in CBTS; facilities for their operational and sailing activities should be reprovisioned; the protection level offered by the existing breakwater should not be compromised; and, sufficient depth should be provided at reprovisioned locations for their moorings. These issues have been considered in the development of the proposed construction approach described in Chapter 6.

7.2.18 Anchorage area users: The anchorage users preferred that the SCL be realigned to avoid passing through the CBTS. However, on the understanding that the SCL would pass through the CBTS, their primary concerns were: on the duration of the works; the existing breakwater would be removed exposing their moorings to risk, and, dredging would affect the marine ecology and in turn their catches. The alternative alignment has been reviewed and is not considered viable, as explained in Annex A and Chapters 4 and 5. Protection to the vessels in the CBTS has been a major factor considered in developing the SCL scheme. The preferred scheme as presented in Chapter 6 has ensured that the level of protection will not be undermined during construction of SCL. The impact due to dredging will be addressed in the SCL EIA report and where necessary mitigation measures will be proposed.

7.2.19 PMA users: The PMA users expressed no particular strong views on the possible postponement of their return to the CBTS for a period of up to 18 months after completion of the CWB but were concerned about whether they would be able to moor in the same location if they were able to return to the CBTS within the 18-month period. Further discussions with the PMA users will be held to address their concerns.

7.2.20 Commercial boats: The commercial boat operators did not object to the SCL and the possible postponement of their return to the CBTS for a period of up to 18 months after completion of CWB works in CBTS. Some requested to reprovision their moorings temporarily within the harbour to accommodate their operational requirements. They were concerned about the lack of sufficient protection during typhoon if the moorings were to be reprovisioned at non-typhoon shelter areas and asked for earlier completion of the works in the CBTS. The approach adopted for the CWB project (see last bullet in Para. 7.2.14) will continue to be followed for the integrated CWB and SCL works.

Public Forums

7.2.21 At the three public forums held from late August to early September, most of the participants showed strong support for the SCL project and many urged for earlier completion of the SCL. The general view was that reclamation should be minimized and close coordination with interfacing projects would be necessary. There was a preference that the duration of construction be minimised through close integration with the CWB project but there was recognition that impacts on existing moorings also be mitigated. These issues have been addressed in this Report, i.e. the extent of reclamation and duration minimized.

7.2.22 Throughout the forums, no disagreement with the findings that there was no reasonable ‘no-reclamation’ option was raised.

7.2.23 The majority of the queries from the public were on future railway operations, e.g. the capacity of 9-car trains, SCL stations and alignments, interchange arrangements etc. These issues do not affect the selection of the scheme for the SCL Cross Harbour Section, however they have been addressed in the SCL preliminary design and will be further studied during the detailed design.

7.3 Summary of views

7.3.1 The majority agreed that there is an overriding public need for the SCL. Many people urged for its early completion.

7.3.2 The finding that there is no reasonable “zero reclamation” option is supported.

7.3.3 The vast majority preferred the Western Alignment as it requires a shorter construction period. It also provides a shorter routing between Hung Hom Station and Exhibition Station.

7.3.4 Many people opined that there should be better coordination with the CWB project to minimize disturbance to the CBTS.

7.3.5 There are on-going discussions with the stakeholders, in particular the users of the CBTS, in order to develop a construction sequence and reprovisioning schemes that meet their needs.

8. CONCLUSIONS

8.1 Overriding Public Need

8.1.1 The Shatin to Central Link comprises 17 kilometres of railway line that will connect several existing railway lines, creating two district east-west and north-south railway corridors.

8.1.2 From east to west, it will connect the Ma On Shan Line and the West Rail Line allowing commuters to travel direct from Ma On Shan to Tuen Mun. The north-south corridor will be formed by extending the existing East Rail Line to Hung Hom Station across Victoria Harbour to the planned Exhibition Station and to Admiralty Station allowing passengers to travel from Lo Wu or Lok Ma Chau to Hong Kong Island.

8.1.3 It is planned for implementation in two phases with the east-west corridor being put into operation first and the north-south corridor, across the harbour, being completed around 2019 in accordance with the LegCo Paper No. CB(1) 1036-08(03) dated 27 March 2008.

8.1.4 Due to the sensitivity of Victoria Harbour the presumption against reclamation can only be rebutted where three tests are satisfied:

(1) There is an overriding public need for reclamation;

(2) There is no reasonable alternative to reclamation; and

(3) The proposed reclamation involves minimum impairment to the harbour.

8.1.5 The first step in the process is, therefore to establish a compelling and present need for the Shatin to Central Link project.

8.1.6 The Railway Development Strategy 2000 (RDS 2000) reaffirmed Government's policy objective that railways form the backbone of the public transport system. The SCL formed an integral part of the strategy and was one of the priority railway projects recommended for priority implementation in RDS 2000 with a target completion date of 2011.

8.1.7 Due to its strategic importance with Hong Kong's future economic development, and to meet the transport needs, the Chief Executive, in his 2007-2008 Policy Address included the SCL as one of the ten large-scale infrastructure projects to be taken forward.

8.1.8 Implementation of the SCL will fulfil a number of key transport objectives:

- It will enhance connectivity across the rail network and with 6 interchange stations allow flexibility of choice. Through the creation of parallel routes it will provide relief to congestion on the Cross Harbour Section of the Tsuen Wan Line and also the Beacon Hill Section of East Rail.
- It will support Hong Kong's needs for greater cross-boundary integration.
- Improved accessability to key new development area at Kai Tak, including the tourist related facilities and assist in revitalising other areas such as Kowloon City.
- Provide greater accessability for all to the harbourfront.
- Relieve traffic congestion of the Cross Harbour Tunnel and in Hong Kong.
- Significant social economic and environmental benefits through journey time savings and improved road-side air quality.

8.1.9 Significant support for the early implementation of the SCL has been expressed at the various public and professional forums held to consult the public about the project.

8.1.10 Based on the time required to design and construct the railway, there is a compelling and present need for the immediate implementation of the railway.

8.1.11 Chapter 3 of this Report establishes the overriding public need for the SCL.

8.2 The Need for Reclamation

8.2.1 Having established the need for the railway the next step is to establish if there is any reasonable alternative to reclamation (i.e. "no reclamation" options)?

8.2.2 A number of "no-reclamation" options have been investigated and are considered to be not viable or not a reasonable alternative to reclamation. These options include:

- Bridge Option;
- Shallow Bored Tunnel Option; and
- Deep Tunnel Option.

8.2.3 The Bridge Option would cause very significant adverse impacts on both sides of the Harbour due to the length of the approach ramps. It is not possible to engineer a reasonable scheme which would meet the SCL project objectives. This option is therefore not considered to be viable.

8.2.4 For the shallow TBM alignment options along the identified alignment corridor, tunnelling will be required at depths where daily tunnel face interventions for maintenance and repair will need to be done under pressures in excess of 3.45 bar, under Victoria Harbour and in the area where the geology is quite difficult for tunnelling work. However, generally, Employers, tunnel designers and contractors try to avoid creating situations where the tunnel face has to be pressurised to enable access.

8.2.5 It is considered that the risks to health, life and the project associated with this shallow TBM option cannot be justified. There are alternative ways of constructing the project which avoid these risks as discussed in Chapter 5 of this Report.

8.2.6 The TBM option would also cost more, provide a considerably poorer level of service to rail users and has increased impacts on the community which extend up to 2 kilometres north of Hung Hom.

8.2.7 As such the shallow TBM "no-reclamation" option is not considered to be a reasonable alternative to the options which require reclamation.

8.2.8 Very deep tunnels in rock under the harbour could not provide an acceptable level of service to passengers due to the excessive depths (over 50m below ground) of stations. In addition tunnelling would still be required at depths in mixed ground conditions whose interventions at face pressures exceeding 3.45 bar would be required. This is not considered to be a viable option.

8.2.9 It is, therefore, concluded, that there is no acceptable "no-reclamation" option for the cross-harbour section of the SCL. It must be accepted that some reclamation will be required to enable its construction.

8.3 Minimum Reclamation Required to Meet the Overriding Public Need

8.3.1 A minimum extent of temporary reclamation has been determined that will serve solely to facilitate the SCL construction. This involves constructing the SCL on an alignment from Hung Hom Station essentially parallel to the Cross Harbour Tunnel and passing through the Causeway Bay Typhoon Shelter.

8.3.2 It will employ the tried and tested methods used on all the six existing major transport crossings of the harbour i.e. immersed tube tunnel with short sections of cut and cover tunnel at either and adjacent to the tunnel landfall.

8.3.3 Approximately 1 ha of temporary reclamation will be required at the Hung Hom landfall, comprising the temporary cofferdam with an elevated platform supported on piles. A number of existing fender piles protecting the existing Hung Hom Bypass will conflict with the SCL tunnels and need to be permanently relocated. These are the only permanent reclamation works required for the SCL. None of this work is considered to impact on the user or enjoyment of the harbour given its location.

8.3.4 Approximately 2.2 ha of temporary reclamation will be required for cut-and-cover tunnel construction adjacent to and within the CBTS.

8.3.5 It is planned that, subject to timely authorisation of the SCL project, a proportion of the SCL tunnels within the CBTS, above the Central - Wanchai Bypass tunnels will be constructed under the Central - Wanchai Bypass project in order to make full use of temporary reclamation put in place by that project.

8.3.6 Construction of the remainder of the SCL tunnels within the CBTS will start later in the CWB construction programme when it is possible to accommodate the temporary reclamation area required for both projects without the need to reprovision additional moorings out of the CBTS. There has been very strong feedback obtained during the public consultation process that no additional moorings are to be relocated out of the typhoon shelter.

8.3.7 A staged SCL reclamation / construction sequence is therefore proposed. The maximum additional reclamation required for SCL construction in the CBTS at any one time would be approximately 1.6ha. The SCL construction on the CBTS would continue for 18 months after completion of the CWB works. Temporary relocation of an existing Royal Hong Kong Yacht Club jetty will be required.

8.3.8 The sequence of construction through the CBTS breakwater will be such that at all times the users of the typhoon shelter will be protected.

8.3.9 All reclamation other than the relocated fender piles will be temporary and removed progressively as the SCL tunnels are completed.

8.4 Public Consultation

8.4.1 A comprehensive public consultation exercise has been undertaken to brief and consult the public on the issues associated with the construction of the Shatin to Central Link across the harbour. Public consultation activities include public and professional forums, seminars, consultation with District Councils and theHarbour-front Enhancement Committee, as well as liaison with other concerned parties. Strong support for the implementation of the project was expressed during the public consultation.

8.4.2 Construction of the tunnel with a combination of immersed tube and cut and cover methods on a western alignment was supported.

8.4.3 Further on-going consultation with the concerned bodies and stakeholders will continue to be undertaken to address concerns regarding details of the project and its implementation.

8.5 Compliance with the PHO

8.5.1 In conclusion, it is clear that the three tests in rebutting the presumption against the reclamation as set out in the PHO have been satisfied:

- In facilitating the construction of the Shatin to Central Link and therefore in meeting the overriding public need for the railway, there is consequently a compelling and present need for the reclamation in the CBTS and adjacent to Hung Hom landfalls. All of the reclamation is essentially temporary and will be removed upon completion of construction, with the seabed reinstated to the original level.
- No reasonable alternative to temporary reclamation is found for constructing the Cross Harbour Section of the SCL.
- The extent of reclamation has been determined to be the minimum required.

Figures

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NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
SHATIN TO CENTRAL LINK

SCALE	FIGURE NO.	REV.
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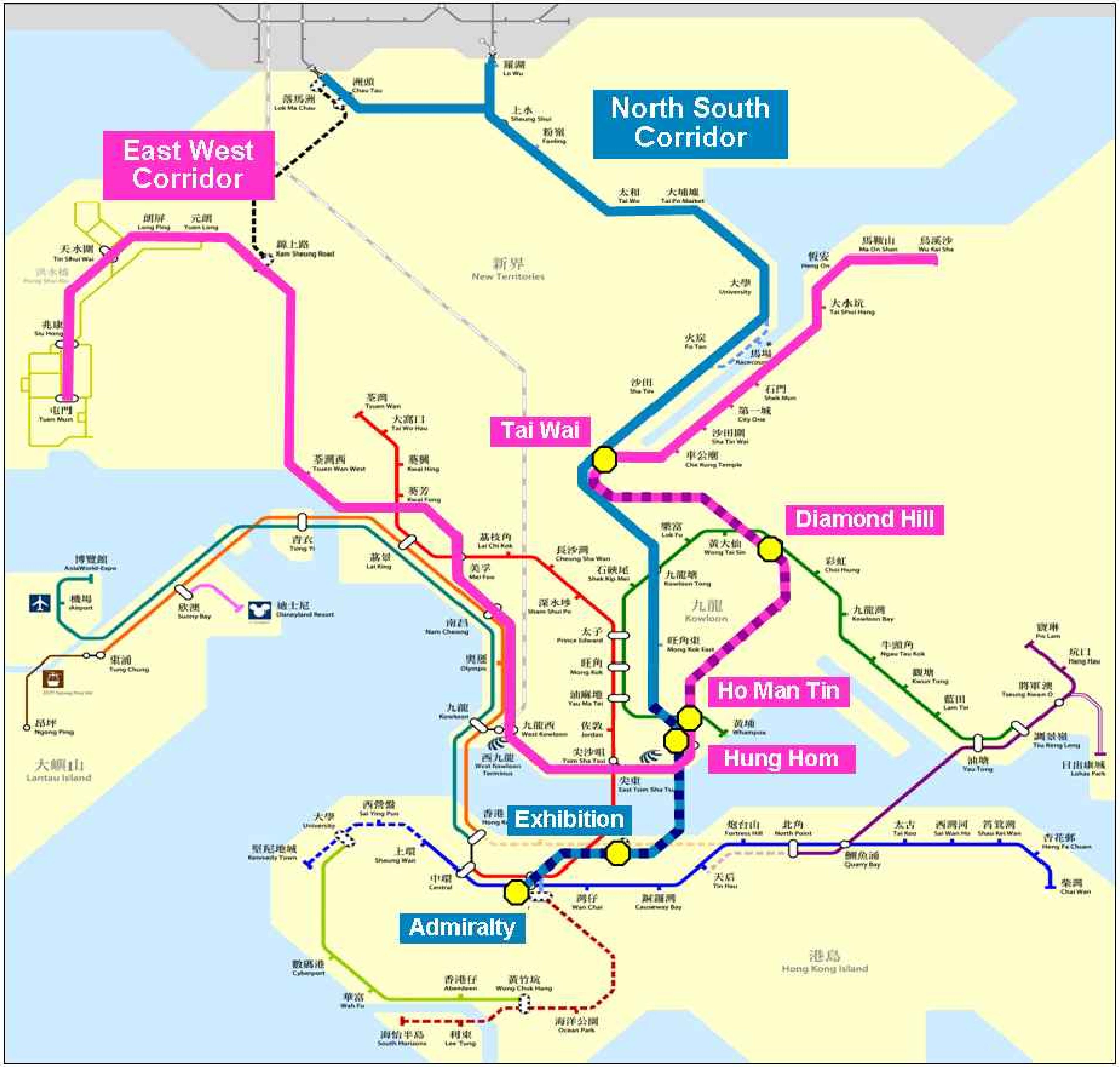

East West Corridor

- Ma On Shan Line
- SCL (Tai Wai to Hung Hom Section)
- West Rail Line

North South Corridor

- East Rail Line
- SCL (Hung Hom to Admiralty Section)

Interchange Station

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TITLE

NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
EAST WEST CORRIDOR & NORTH SOUTH CORRIDOR

SCALE: AS SHOWN (A1)

FIGURE NO.: FIGURE 1.2

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TITLE

NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
BRIDGE OPTION - TYPICAL LONGITUDINAL SECTION

SCALE
AS SHOWN (A1)

FIGURE NO.
FIGURE 4.1

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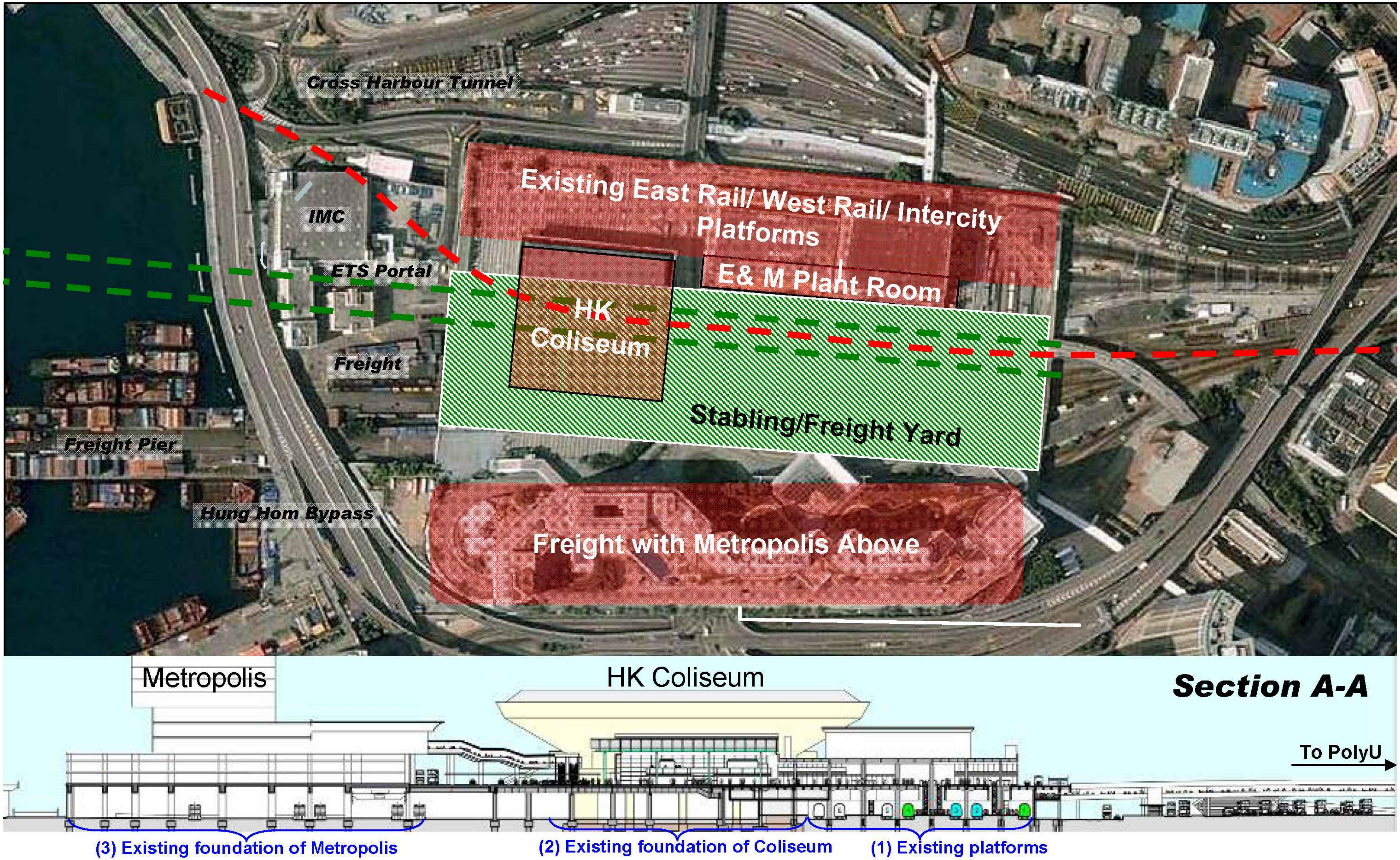

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TITLE
NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
HUNG HOM STATION HORIZONTAL CONSTRAINTS

SCALE AS SHOWN (A1)
FIGURE NO. FIGURE 4.2
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TITLE

NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

SHALLOW BORED TUNNEL - ALIGNMENT CORRIDOR

SCALE AS SHOWN (A1)

FIGURE NO. FIGURE 4.3

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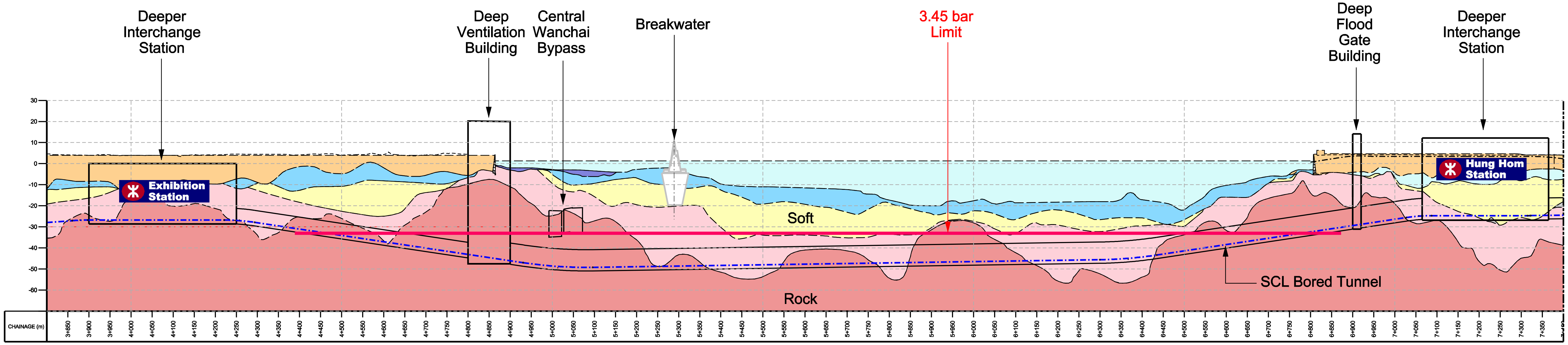

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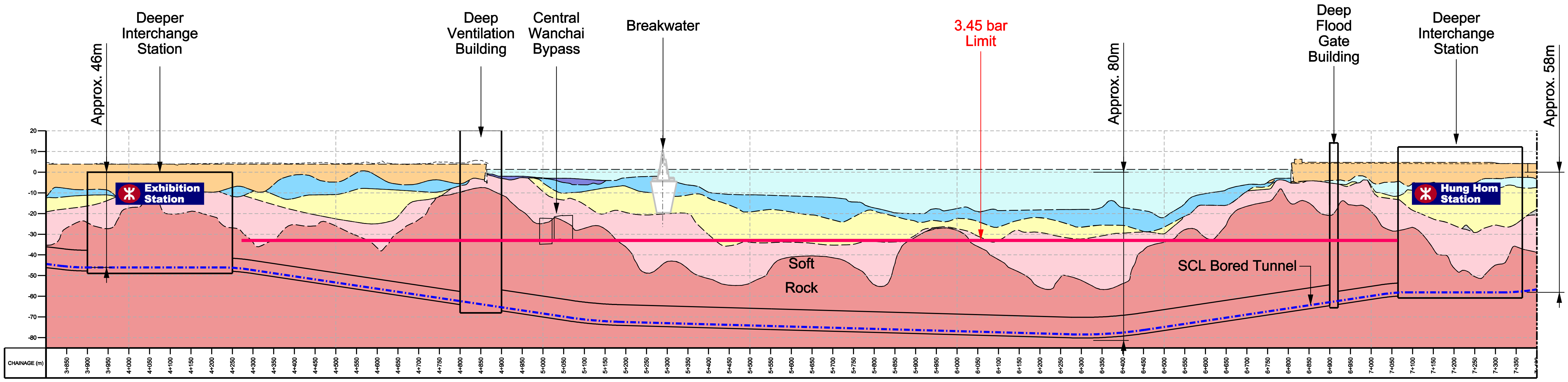
NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
SHALLOW BORED TUNNEL -
TYPICAL LONGITUDINAL SECTION

SCALE	FIGURE NO.	REV.
AS SHOWN	FIGURE 4.4	



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NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
DEEP BORED TUNNEL -
TYPICAL LONGITUDINAL SECTION

SCALE: AS SHOWN
FIGURE NO.: FIGURE 4.5
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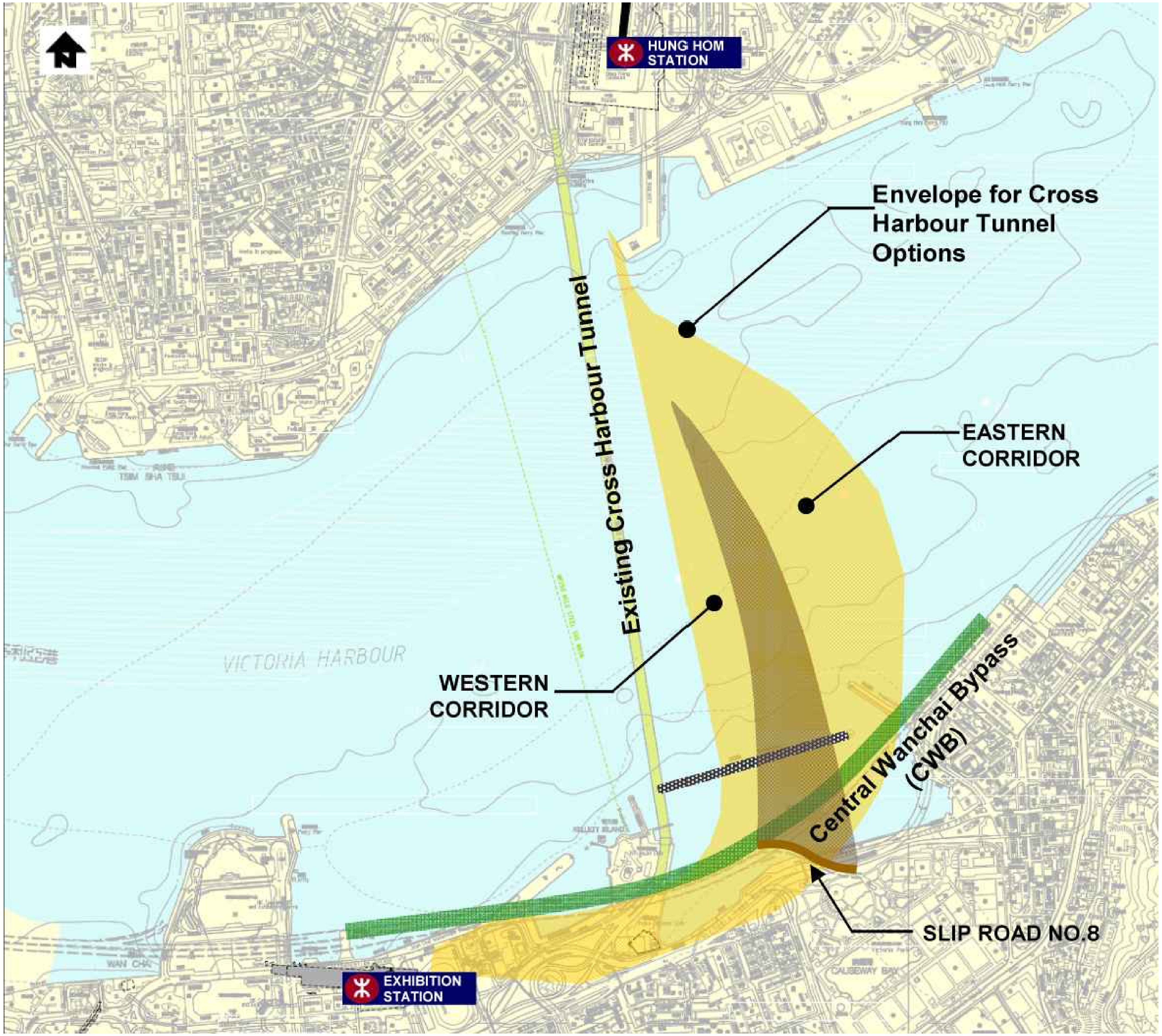

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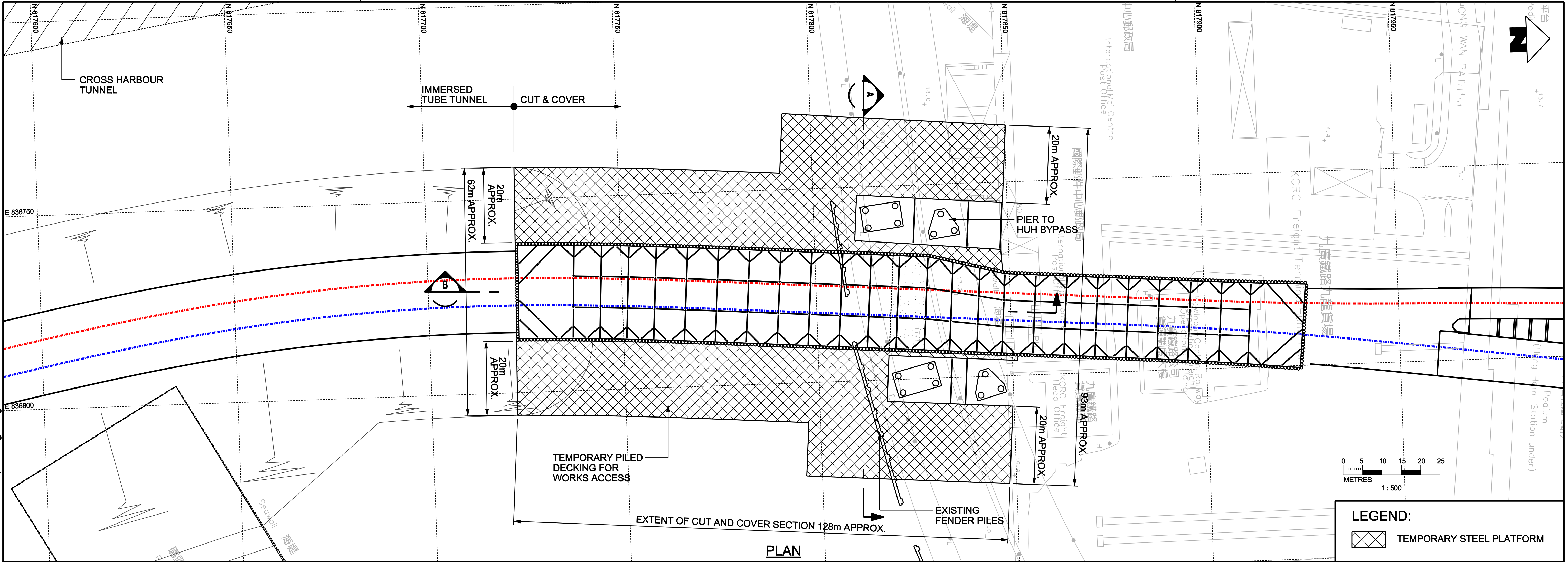
NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

IMMERSED TUBE TUNNEL - ALIGNMENT CORRIDOR

SCALE	FIGURE NO.	REV.
AS SHOWN (A1)	FIGURE 5.1	



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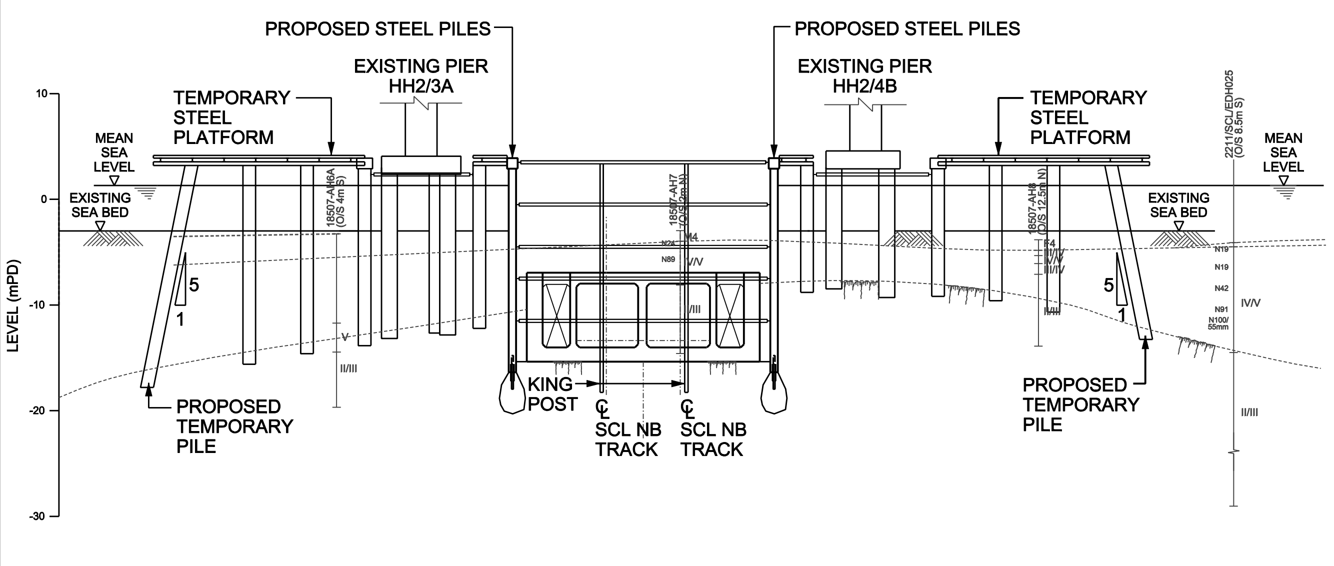
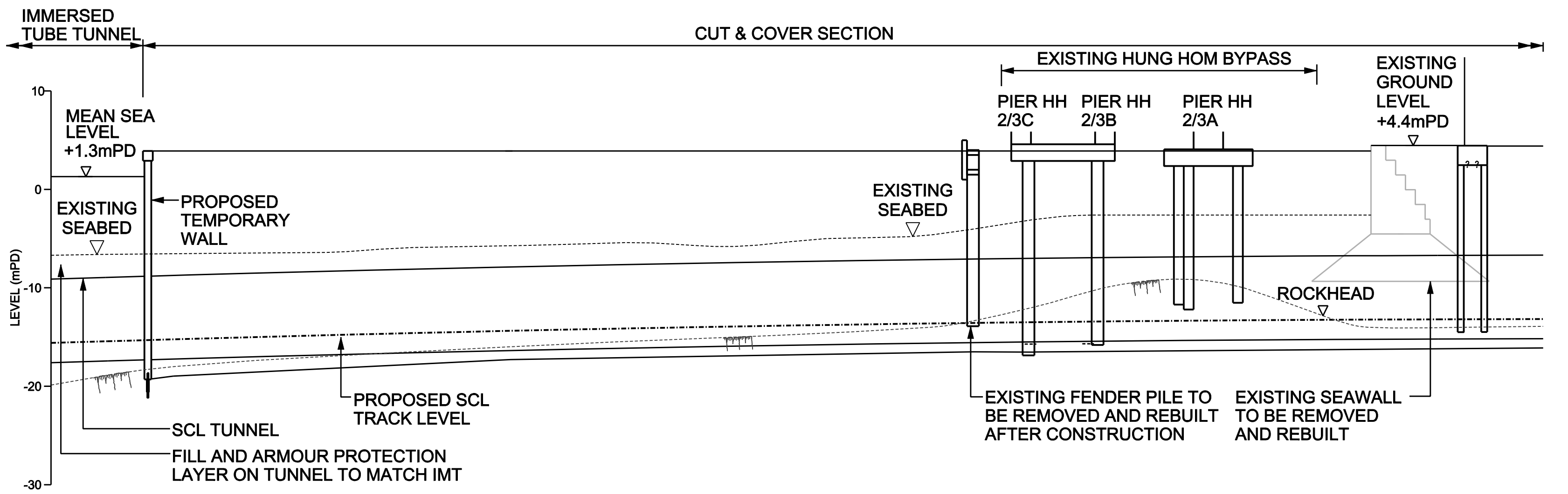


SECTION A-A
TYPICAL CROSS SECTION THROUGH TEMPORARY WORKS



SECTION B-B
LONGITUDINAL SECTION THROUGH TEMPORARY WORK

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TITLE
NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
TEMPORARY RECLAMATION AT HUNG HOM LANDFALL

SCALE: AS SHOWN (A1)
FIGURE NO.: FIGURE 5.2
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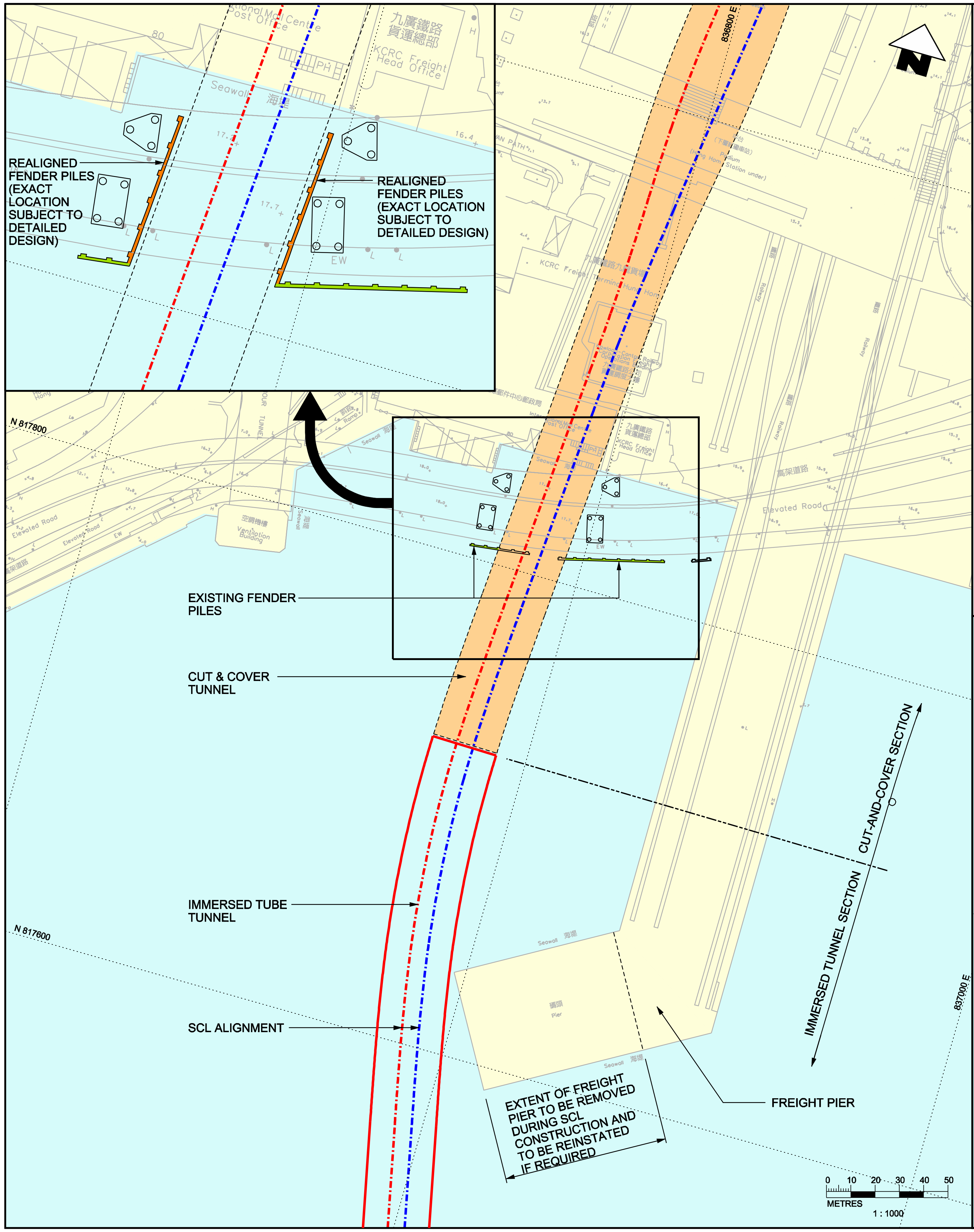
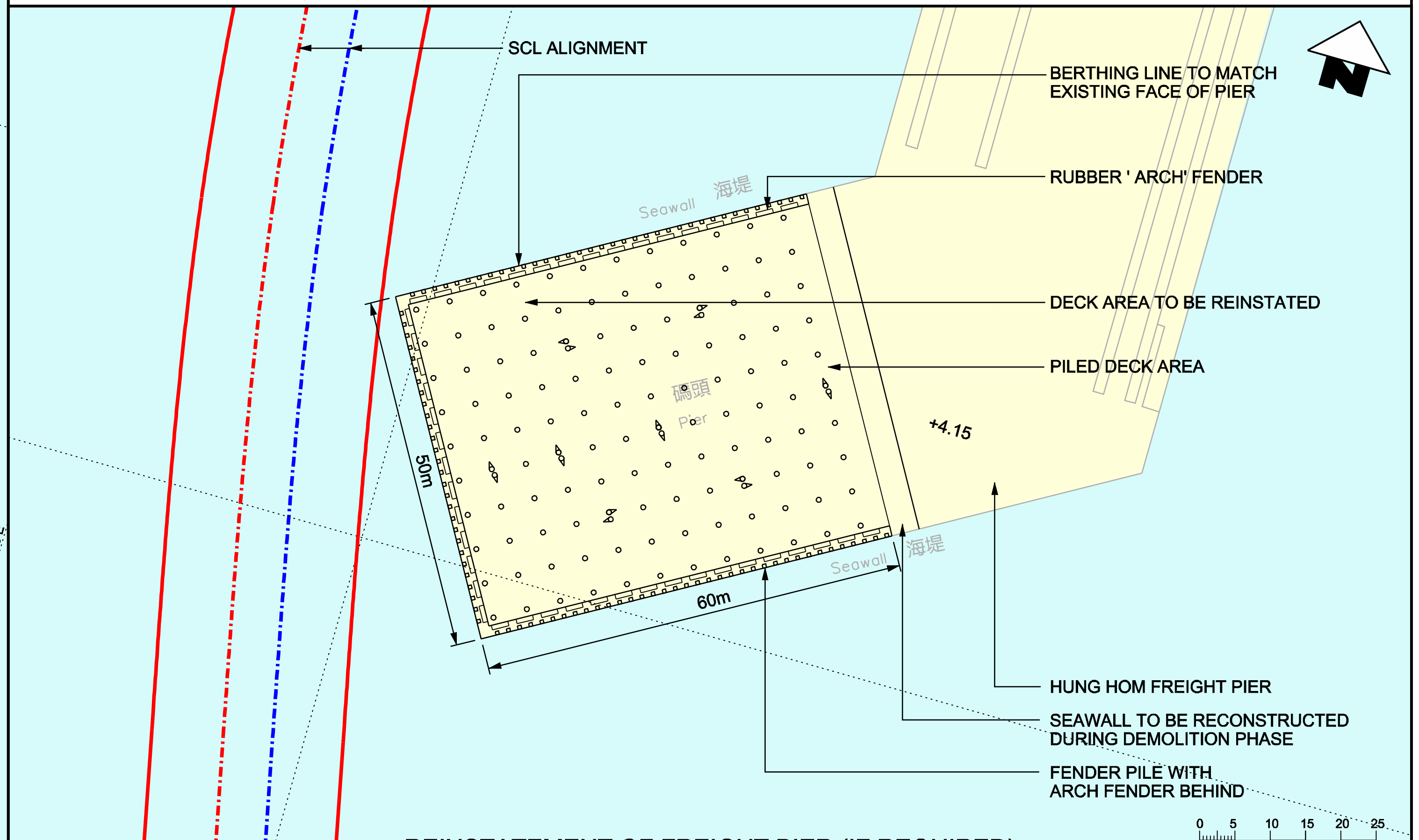


HUNG HOM BYPASS FENDER PILES TO BE REINSTATED



REINSTATEMENT OF FREIGHT PIER (IF REQUIRED)

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PRELIMINARY DESIGN
FENDER PILE AND FREIGHT PIER REINSTATEMENT

SCALE AS SHOWN (A1)

FIGURE NO. FIGURE 5.3

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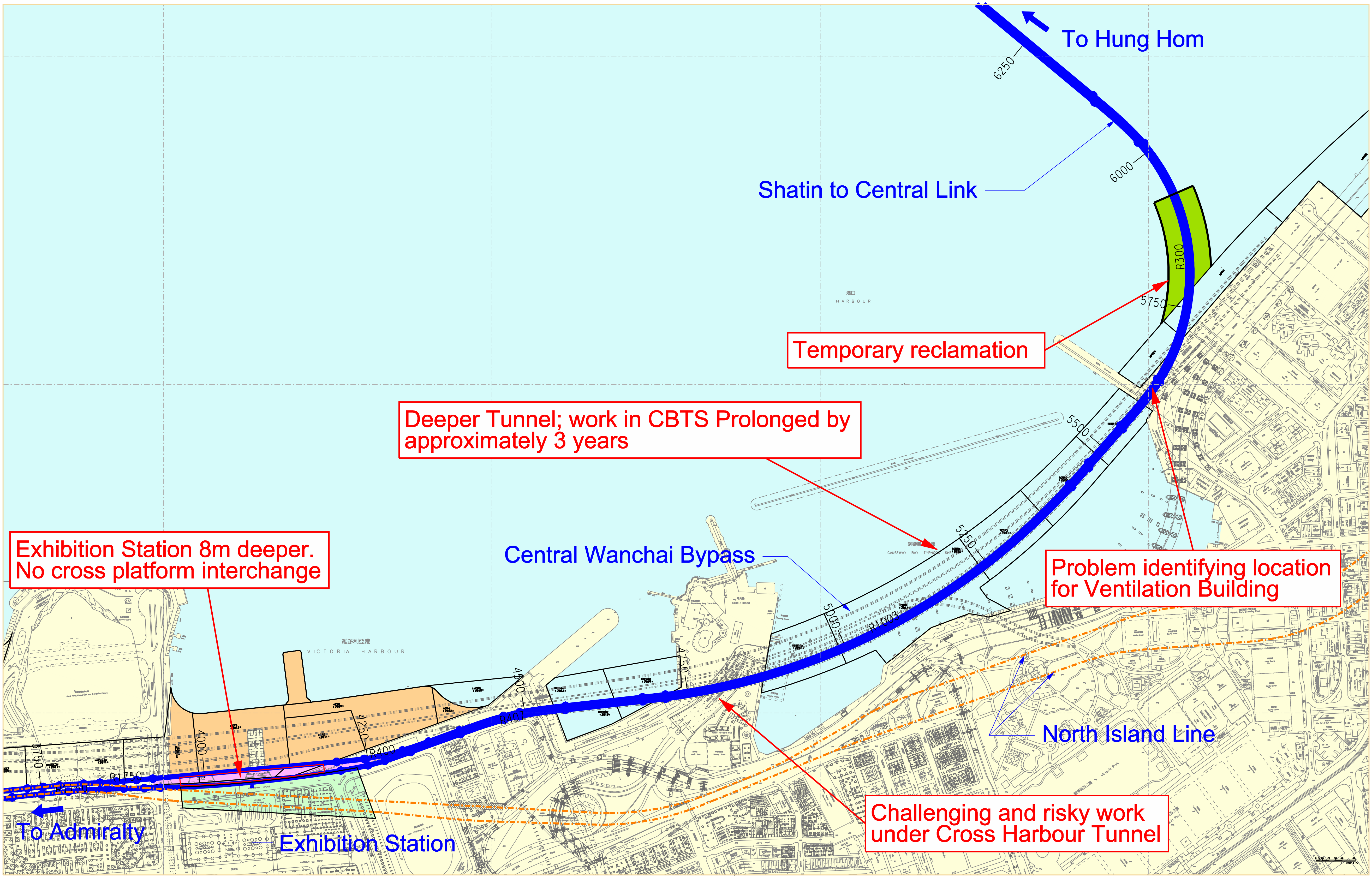

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TITLE
NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
EASTERLY ALIGNMENT - OPTION 1A
(SCL FULLY BELOW CWB)

SCALE: AS SHOWN (A1)
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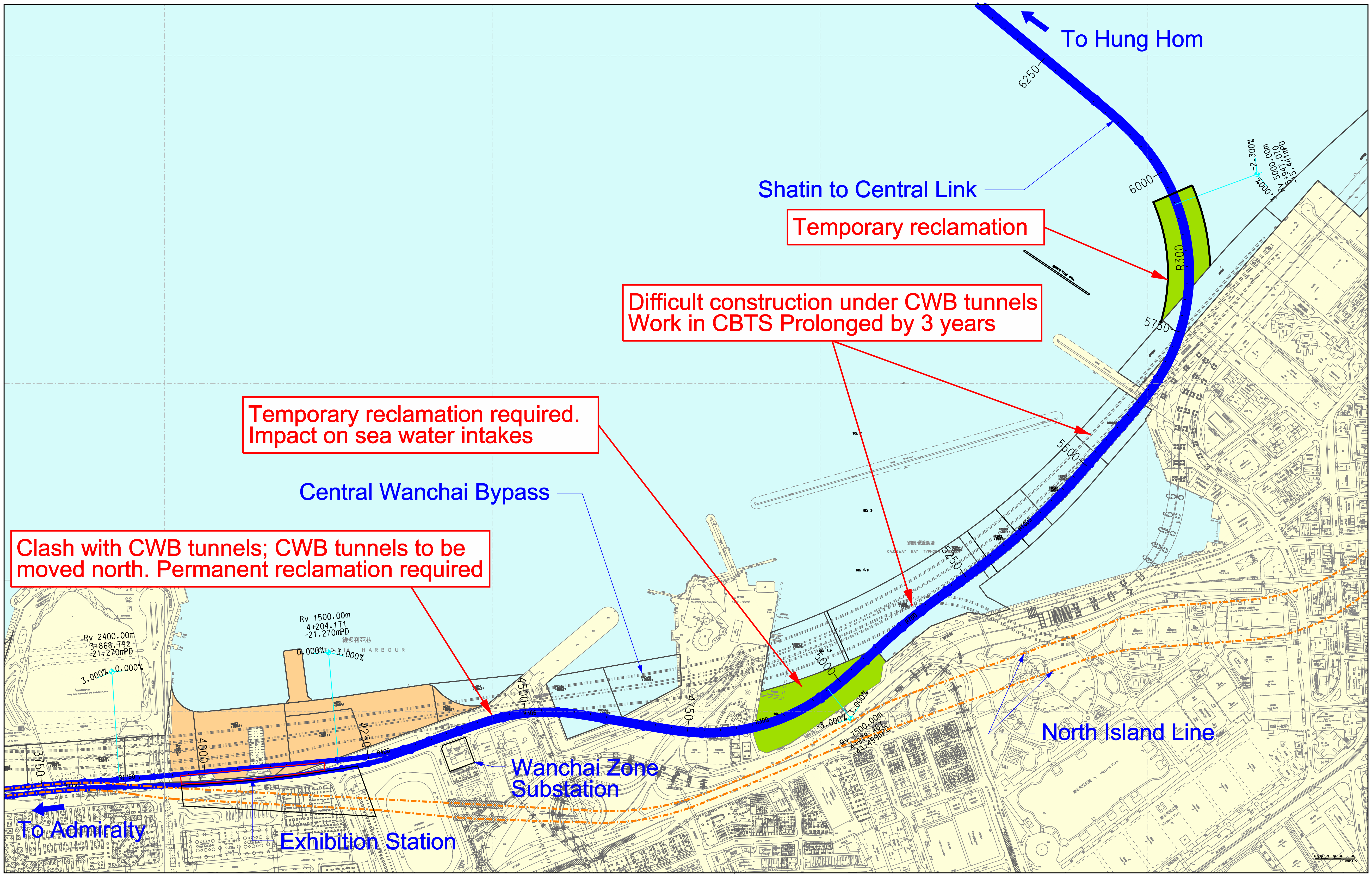

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NEX/2202 - CROSS HARBOUR SECTION
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EASTERLY ALIGNMENT - OPTION 1 B
(SCL PARTLY BELOW CWB)

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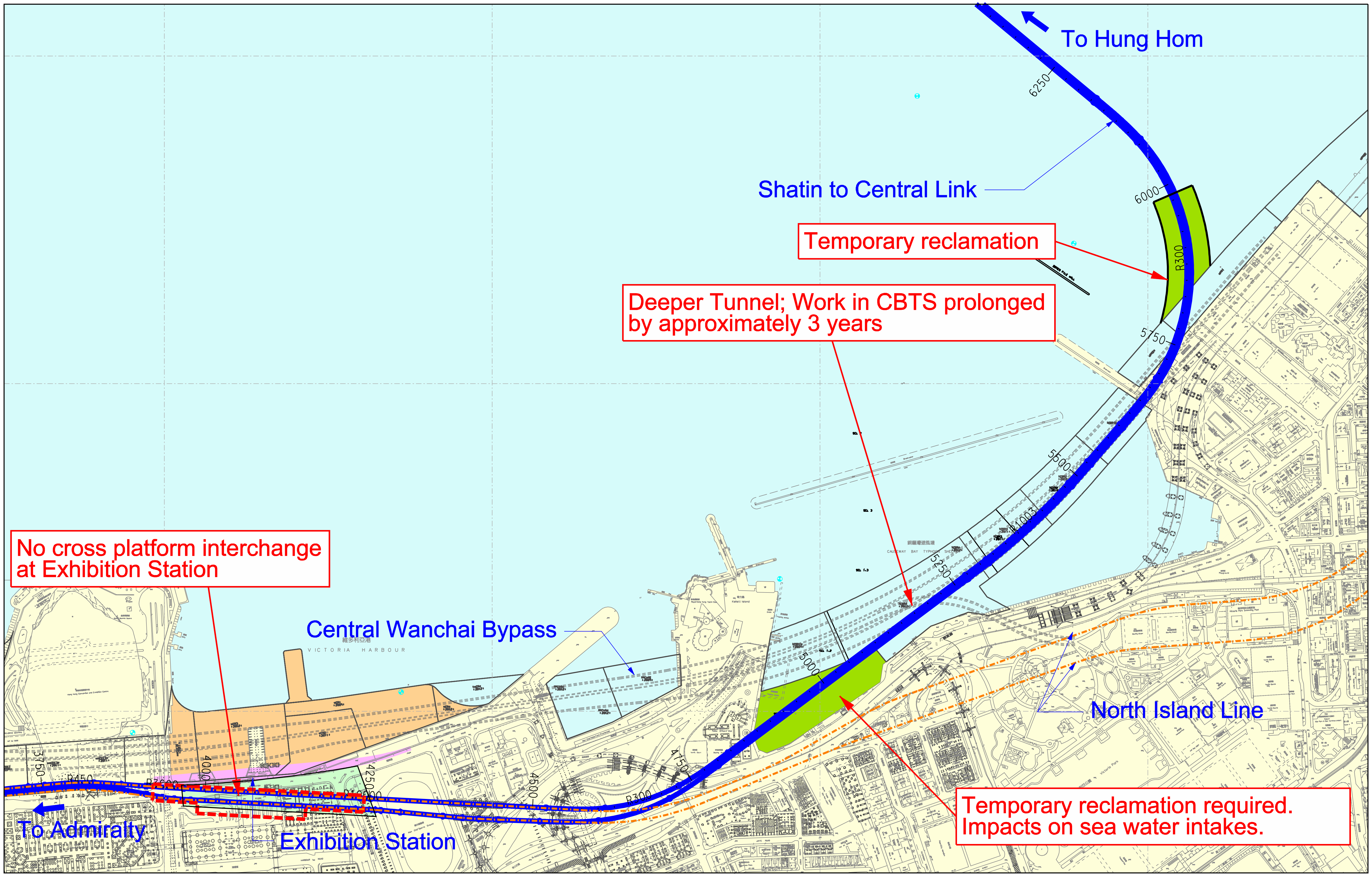

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NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
EASTERLY ALIGNMENT - OPTION 1C
(SCL PARTLY BELOW CWB)

SCALE
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FIGURE 5.6

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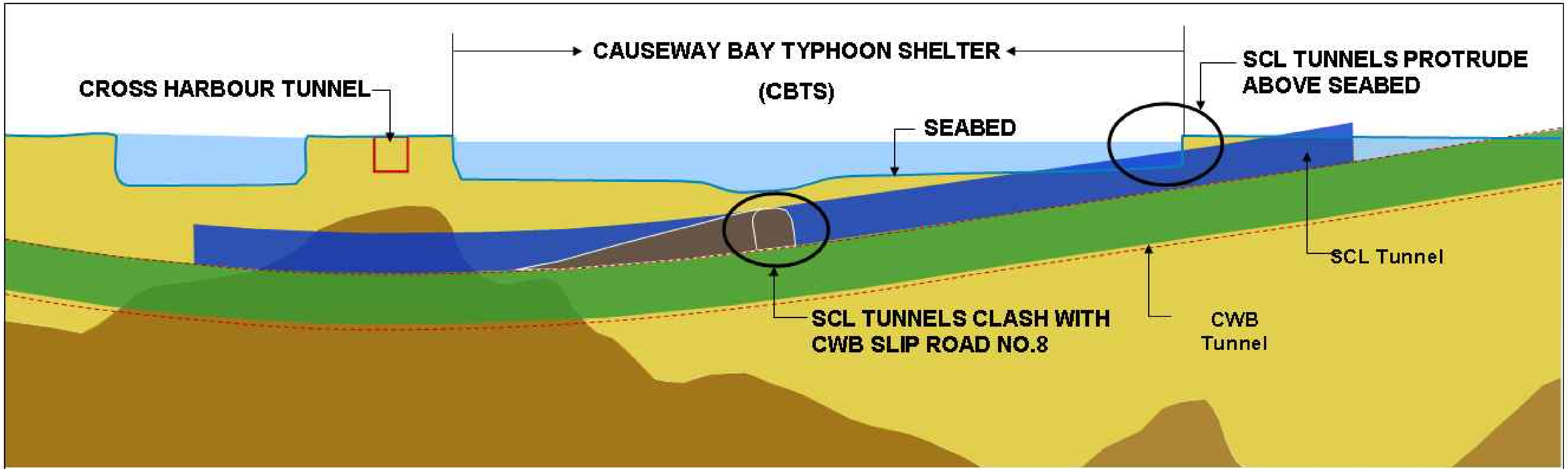
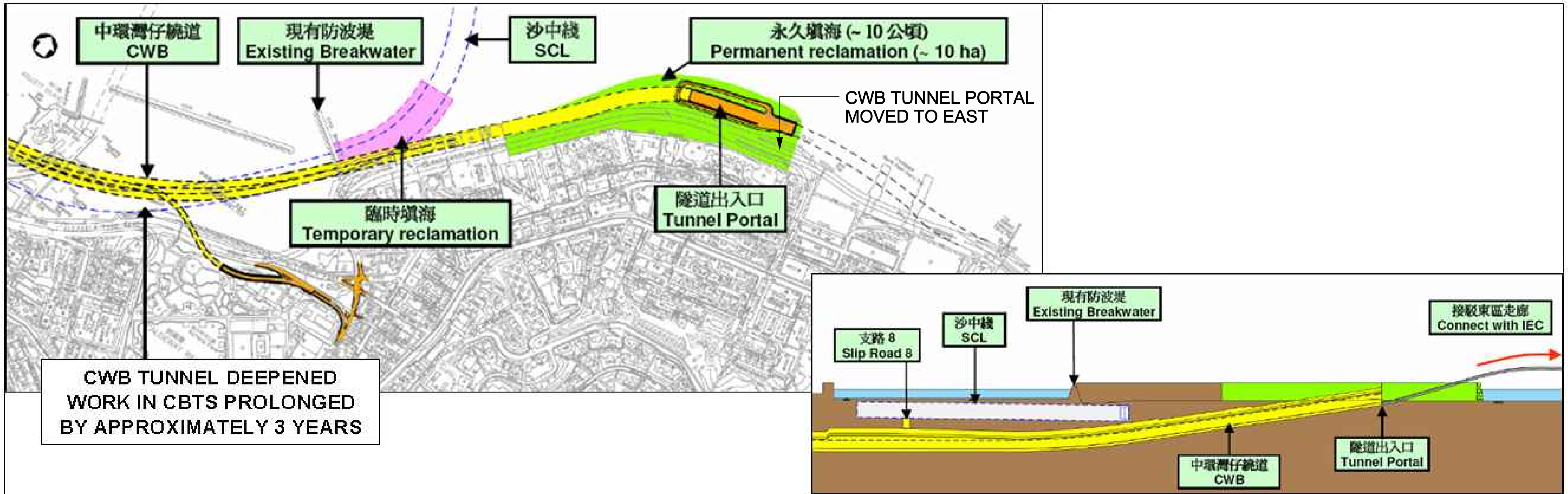


SCL TUNNEL ABOVE CWB TUNNELS
(CWB TUNNELS NOT LOWERED)



SCL TUNNEL ABOVE CWB TUNNELS
(CWB TUNNELS LOWERED)

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PRELIMINARY DESIGN
EASTERLY ALIGNMENT - OPTION 1D
(SCL ABOVE CWB)

SCALE: AS SHOWN (A1)
FIGURE NO.: FIGURE 5.7
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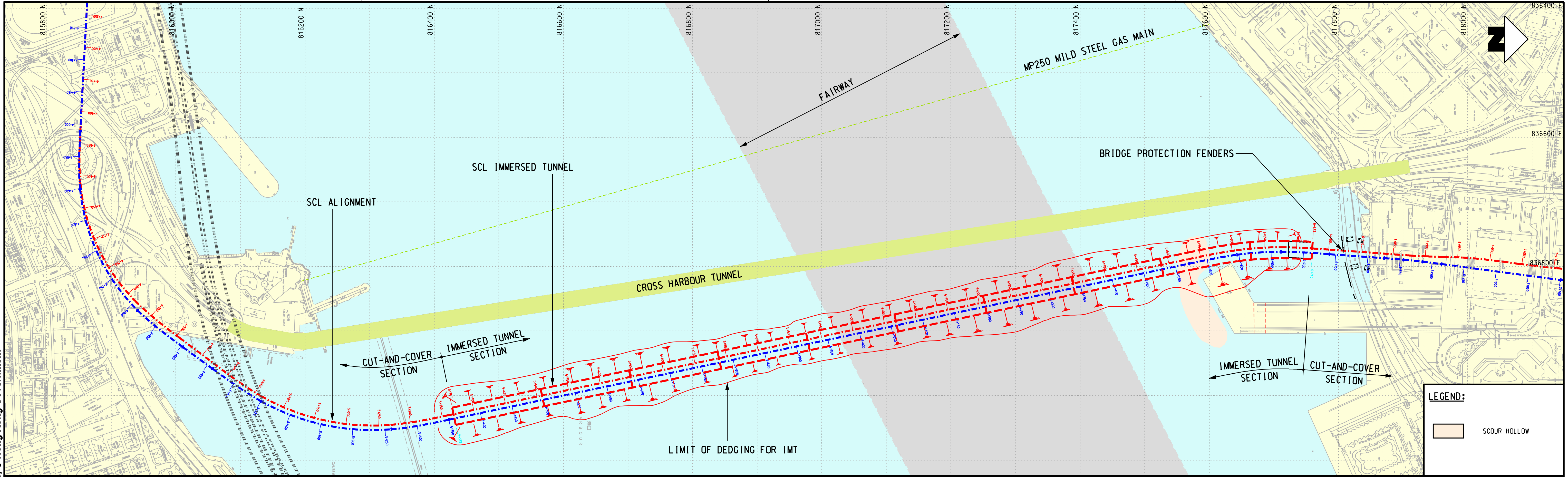

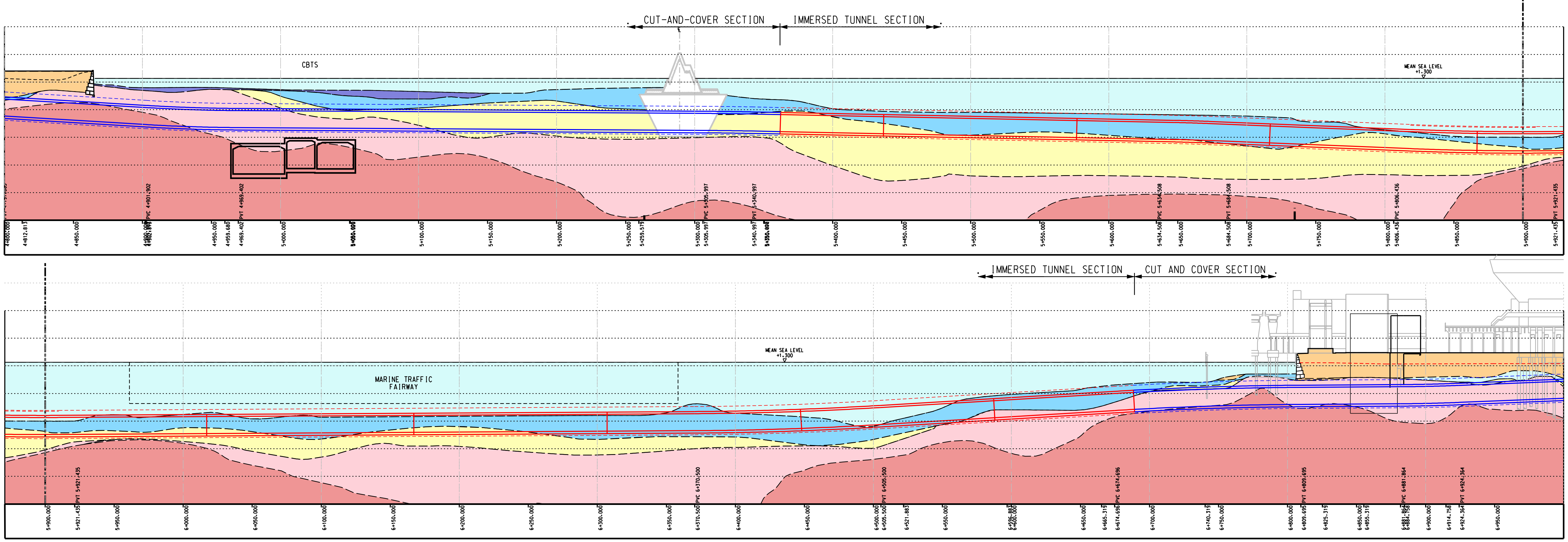

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TITLE

NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

IMMERSED TUNNEL
WESTERN ALIGNMENT OPTION

SCALE 1 : 3000 (A1)

DRAWING NO. FIGURE 5.8

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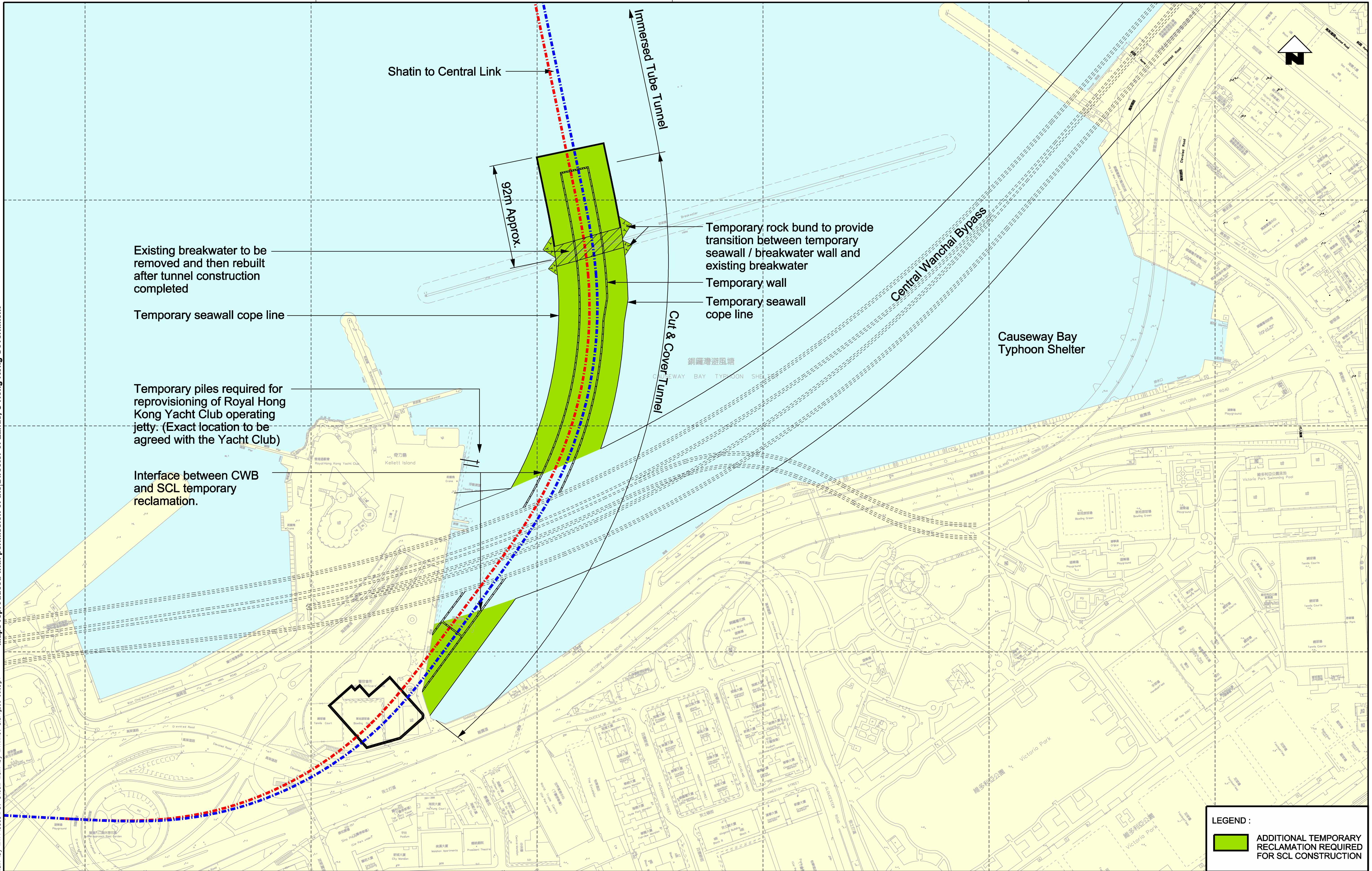

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TITLE
NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
EXTENT OF TEMPORARY RECLAMATION REQUIRED WITHIN AND ADJACENT TO CAUSEWAY BAY TYPHOON SHELTER

SCALE N.T.S. (A1)
FIGURE NO. FIGURE 6.1
REV.

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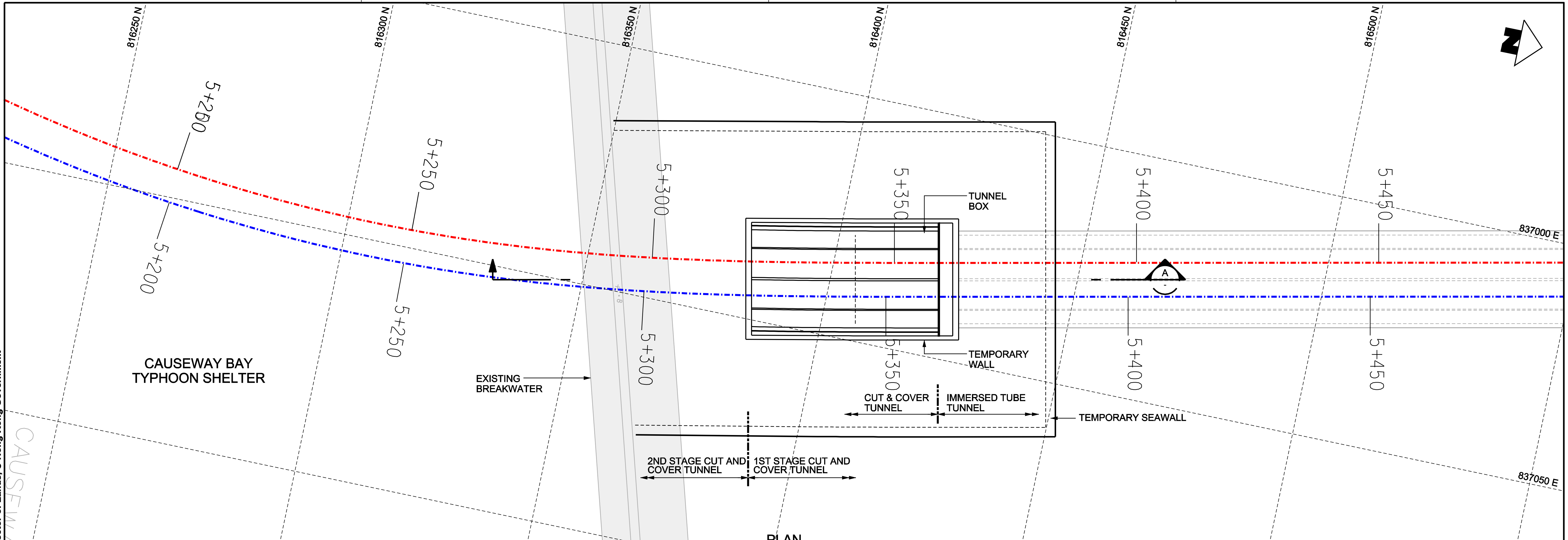
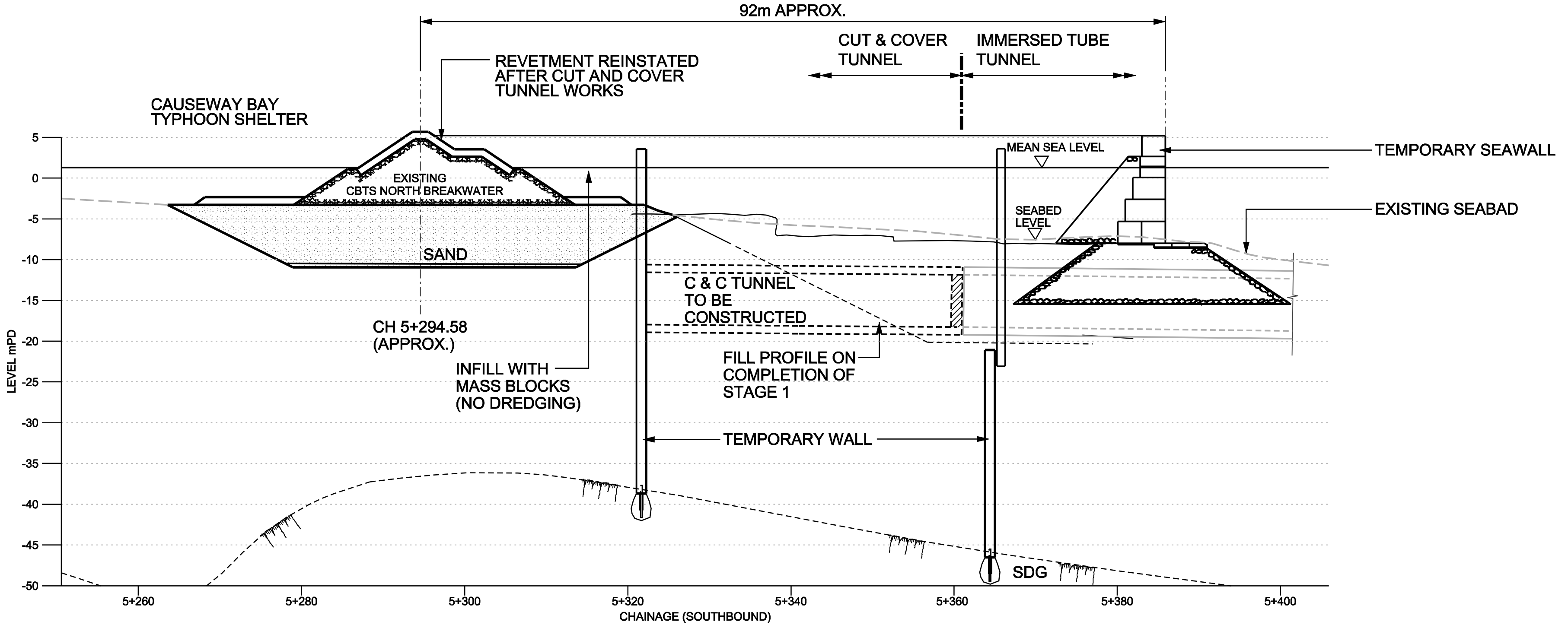


PLAN



SECTION A-A

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TITLE

NEX/2202 - CROSS HARBOUR SECTION

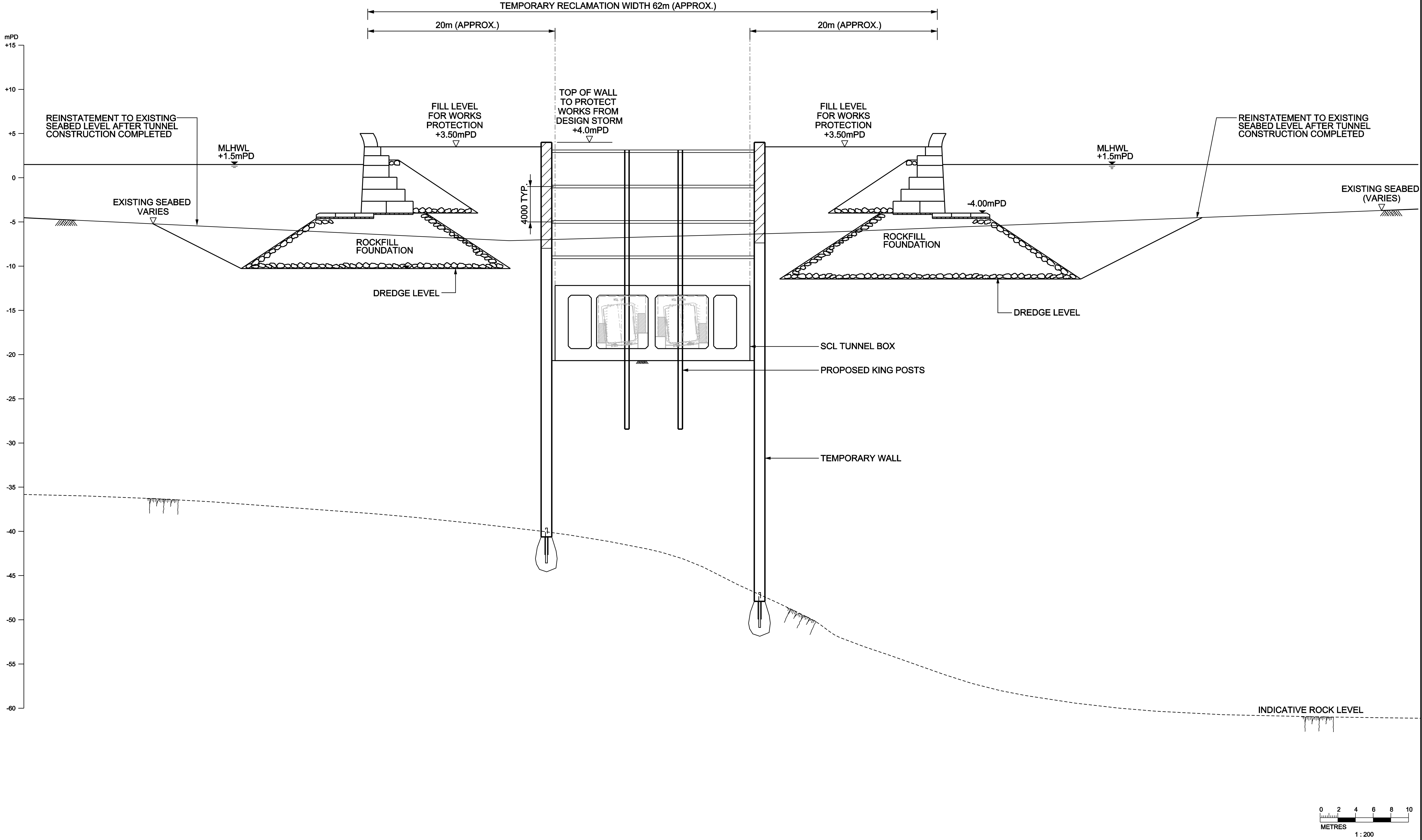
PRELIMINARY DESIGN

CAUSEWAY BAY TYPHOON SHELTER BREAKWATER

SCALE: AS SHOWN

FIGURE NO.: FIGURE 6.2

REV.



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TITLE
NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
TYPICAL CROSS SECTION THROUGH TEMPORARY RECLAMATION NEAR BREAKWATER OF CAUSEWAY BAY TYPHOON SHELTER

SCALE 1 : 200 (A1)
FIGURE NO. FIGURE 6.3
REV.

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TITLE
NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
PROPOSED EXTENT OF SCL TUNNEL WORKS TO BE ENTRUSTED TO CENTRAL WANCHAI BYPASS PROJECT

SCALE 1 : 1000 (A1)
FIGURE NO. FIGURE 6.4
REV.

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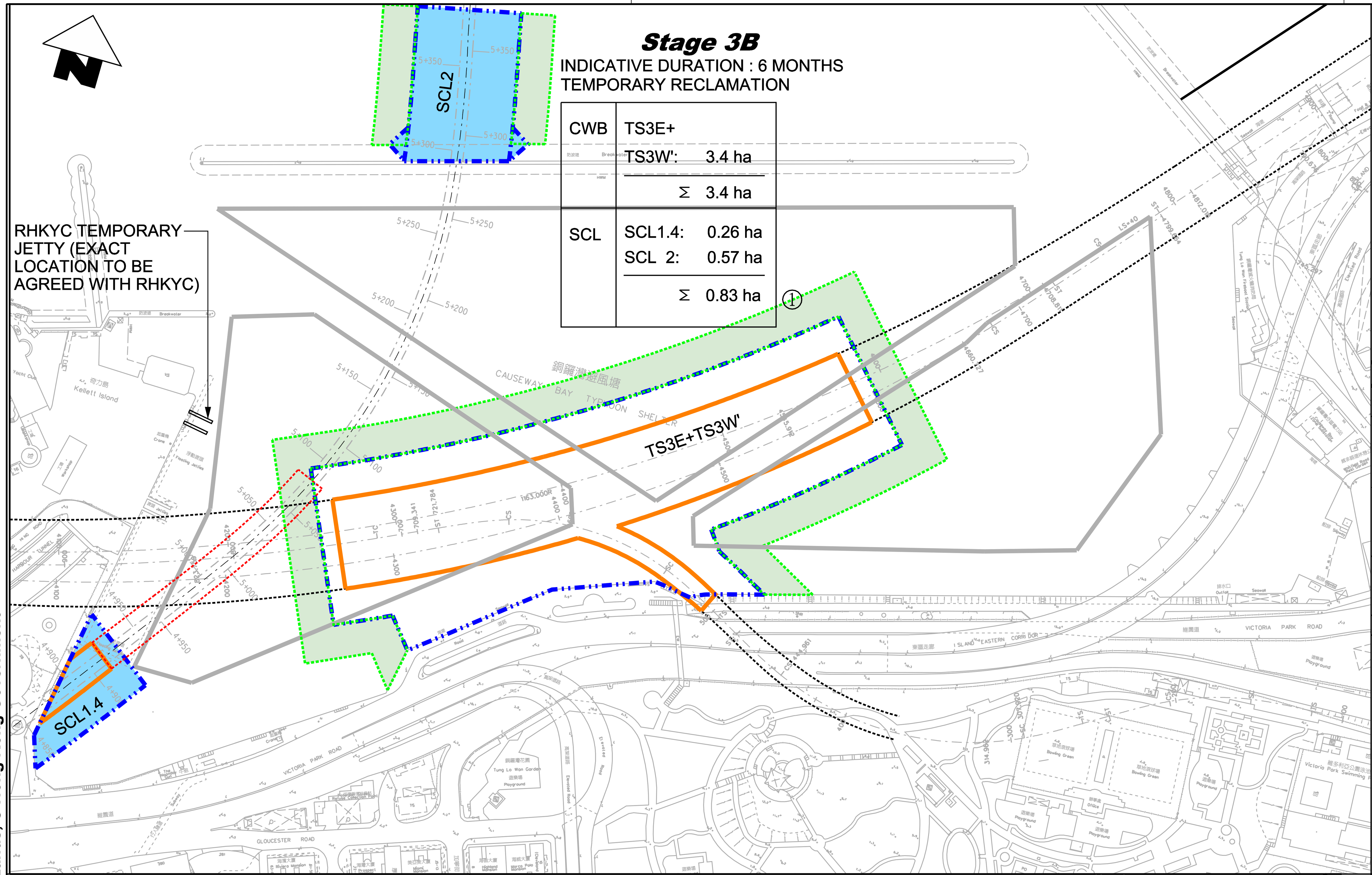
TITLE

NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
TEMPORARY RECLAMATION STAGING FOR SCL CONSTRUCTION
PLAN 1 OF 3

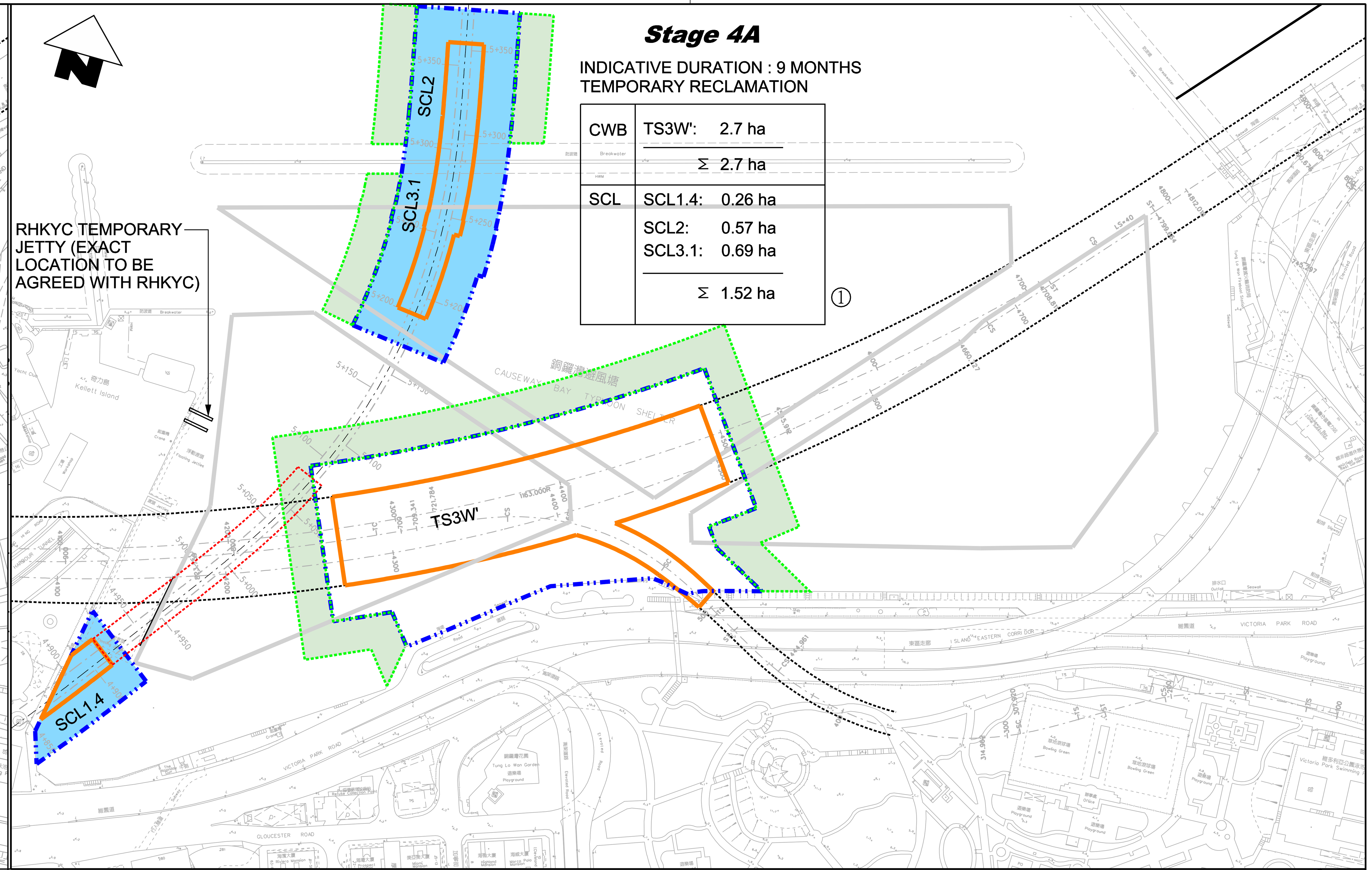
SCALE	FIGURE NO.	REV.
N.T.S (A1)	FIGURE 6.5	



Stage 3B

INDICATIVE DURATION : 6 MONTHS
TEMPORARY RECLAMATION

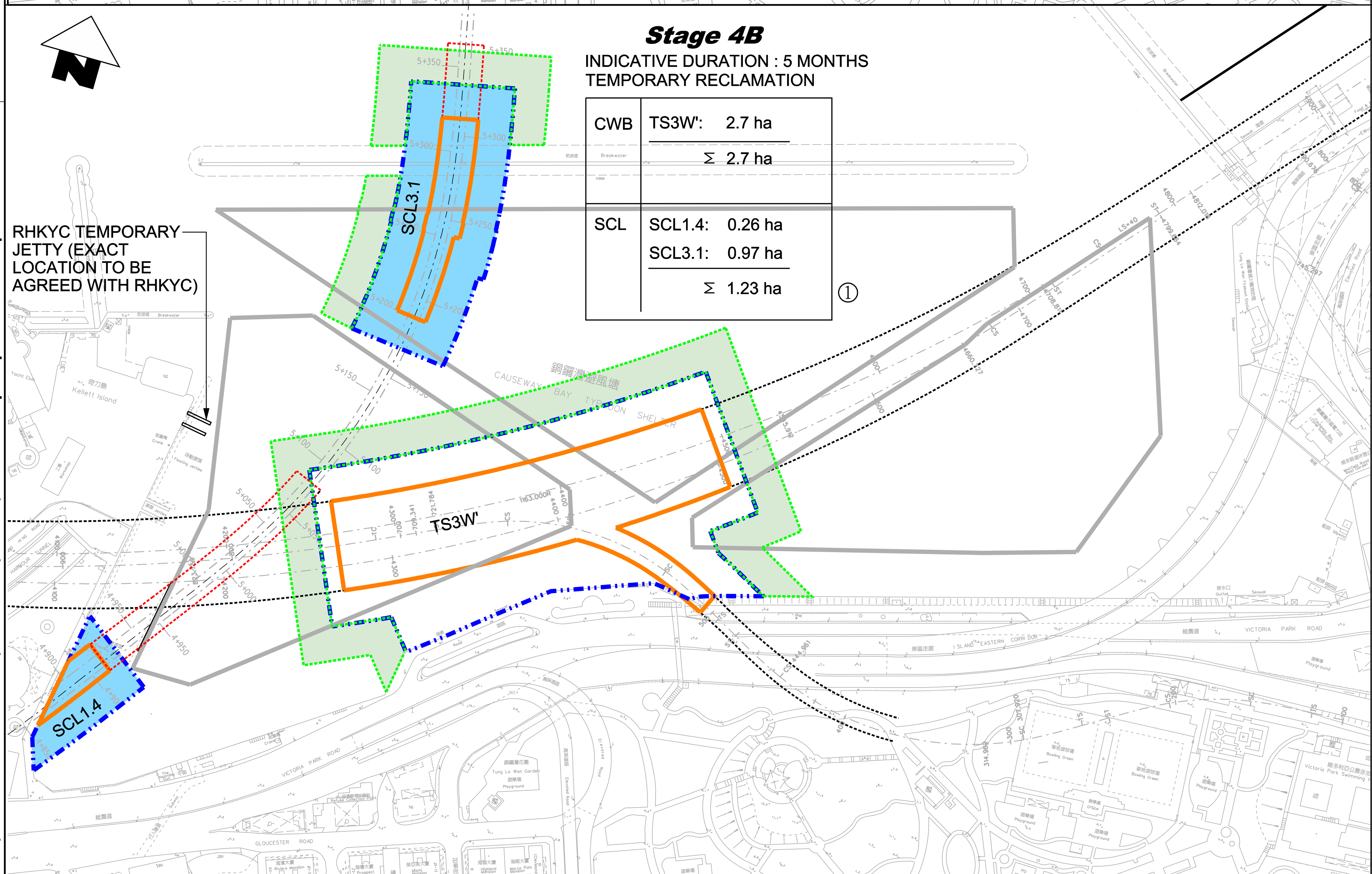
CWB	TS3E+	
	TS3W':	3.4 ha
	Σ	3.4 ha
SCL	SCL1.4:	0.26 ha
	SCL 2:	0.57 ha
	Σ	0.83 ha ①



Stage 4A

INDICATIVE DURATION : 9 MONTHS
TEMPORARY RECLAMATION

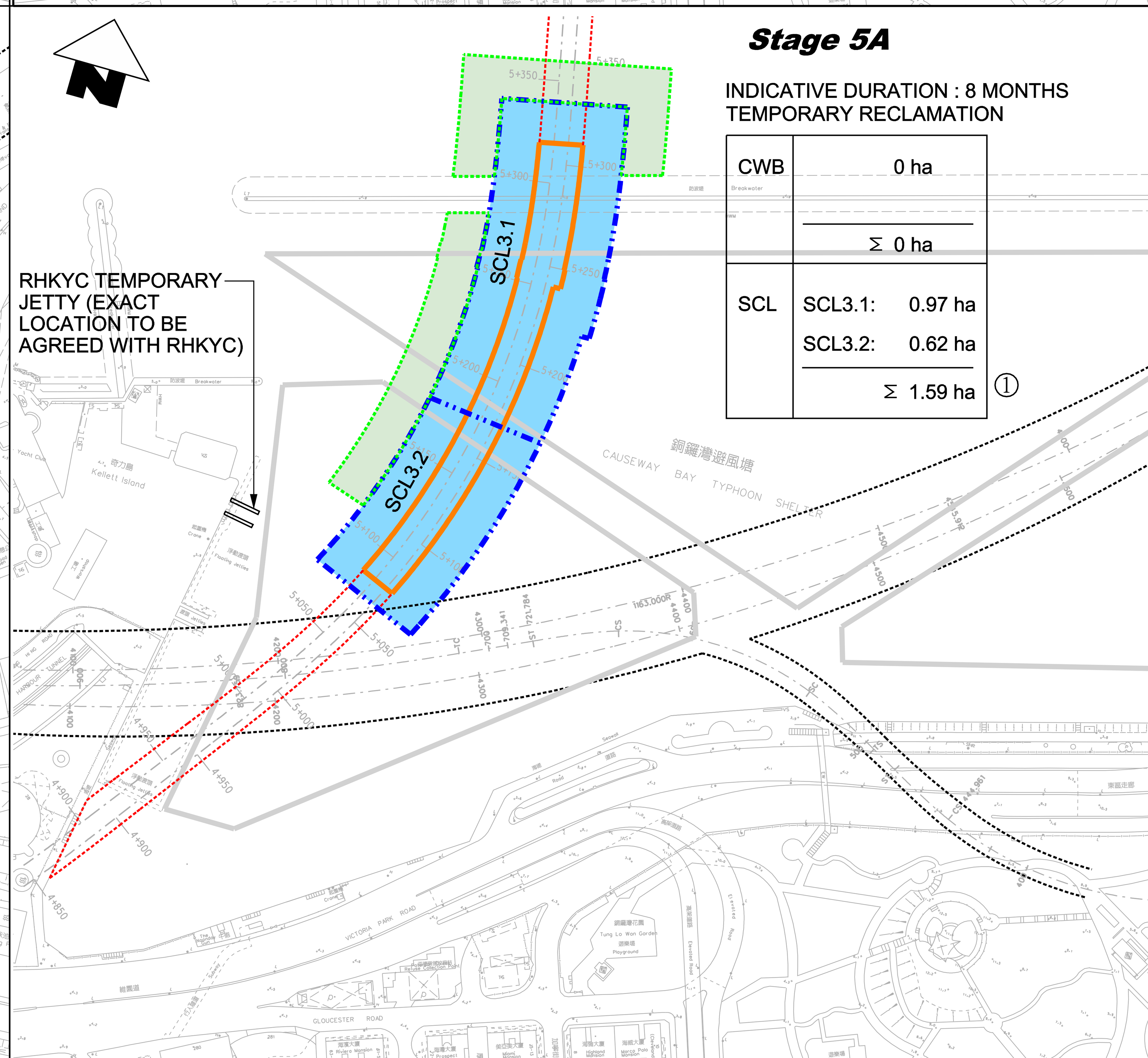
CWB	TS3W':	2.7 ha
	Σ	2.7 ha
SCL	SCL1.4:	0.26 ha
	SCL2:	0.57 ha
	SCL3.1:	0.69 ha
	Σ	1.52 ha ①



Stage 4B

INDICATIVE DURATION : 5 MONTHS
TEMPORARY RECLAMATION

CWB	TS3W':	2.7 ha
	Σ	2.7 ha
SCL	SCL1.4:	0.26 ha
	SCL3.1:	0.97 ha
	Σ	1.23 ha ①



Stage 5A

INDICATIVE DURATION : 8 MONTHS
TEMPORARY RECLAMATION

CWB		0 ha
	Σ	0 ha
SCL	SCL3.1:	0.97 ha
	SCL3.2:	0.62 ha
	Σ	1.59 ha ①

LEGEND

- CWB TUNNEL ALIGNMENT
- COMPLETED SCL TUNNEL ALIGNMENT
- ACTIVE TEMPORARY RECLAMATION EXTENT
- ACTIVE CWB/SCL TUNNEL STRUCTURE
- EXISTING MOORING AREAS
- RECLAMATION FOR SCL WORKS
- WORKS AREA ON SEA

NOTE 1 : AREA INCLUDES RHKYC TEMPORARY JETTY (TEMPORARY RECLAMATION)

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TITLE

NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

TEMPORARY RECLAMATION STAGING FOR SCL CONSTRUCTION

PLAN 2 OF 3

SCALE	FIGURE NO.	REV.
N.T.S (A1)	FIGURE 6.6	

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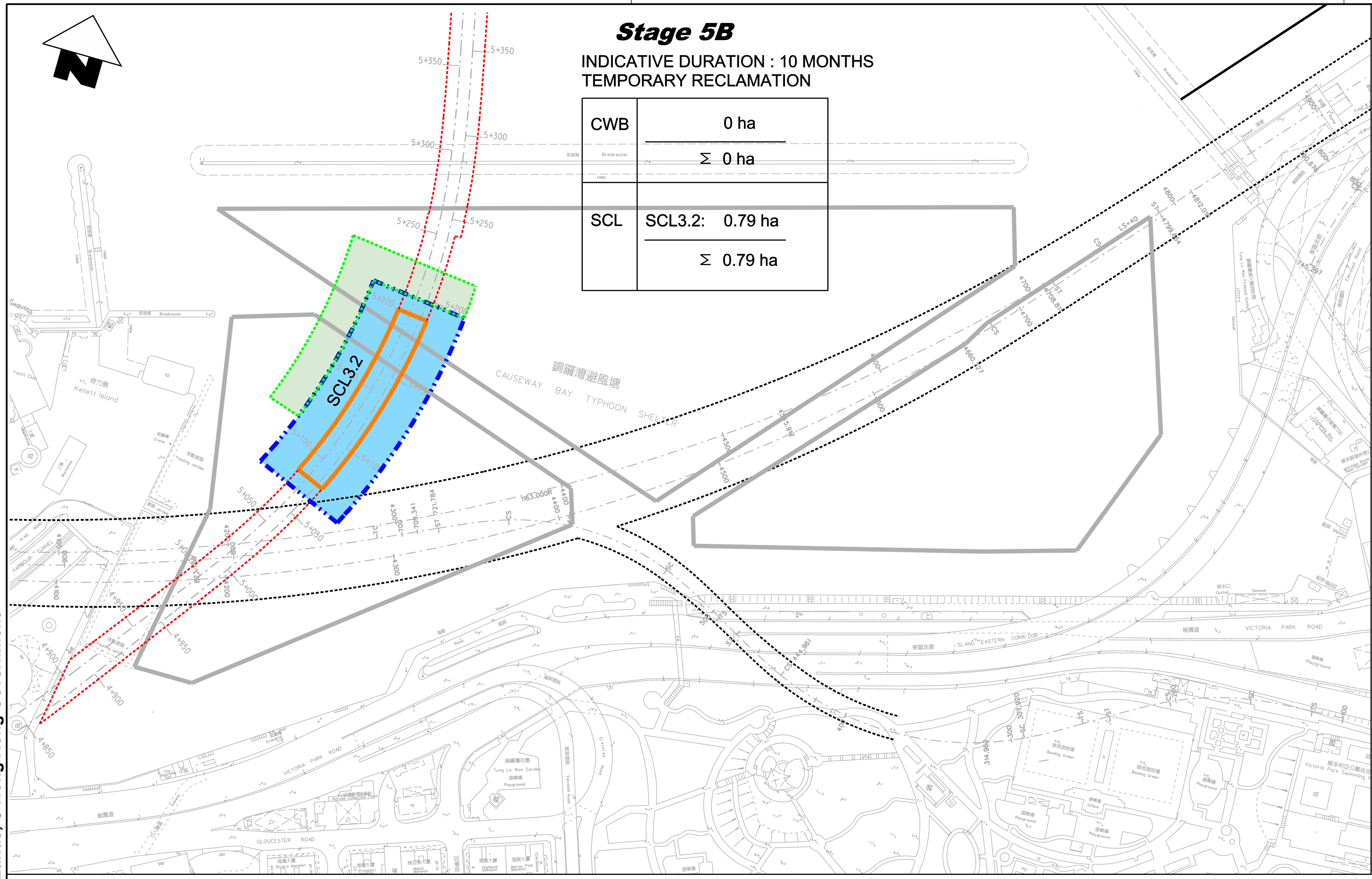
Stage 5B

INDICATIVE DURATION : 10 MONTHS
TEMPORARY RECLAMATION

CWB		0 ha
	Σ	0 ha
SCL	SCL3.2:	0.79 ha
	Σ	0.79 ha



LEGEND

- CWB TUNNEL ALIGNMENT
- COMPLETED SCL TUNNEL ALIGNMENT
- ACTIVE TEMPORARY RECLAMATION EXTENT
- ACTIVE CWB/SCL TUNNEL STRUCTURE
- EXISTING MOORING AREAS
- RECLAMATION FOR SCL WORKS
- WORKS AREA ON SEA

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NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

TEMPORARY RECLAMATION STAGING FOR SCL CONSTRUCTION
PLAN 3 OF 3

SCALE N.T.S (A1) | FIGURE NO. FIGURE 6.7 | REV.

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Annex A

HUH and EXH Stations

1. INTRODUCTION

1.1 The proposed locations for Hung Hom (HUH) Station and Exhibition (EXH) Station in the Merger Study were at the following locations:

HUH – Freight yard between the existing platforms 1 to 6 for East Rail / West Rail / Intercity and the Metropolis.

EXH – The site currently occupied by the Wanchai North Public Transport Interchange, Wanchai Swimming Pool and Harbour Road Sports Centre.

1.2 A review of the station locations has been conducted. Findings are presented in this Annex.

2. HUNG HOM STATION

Function of Station

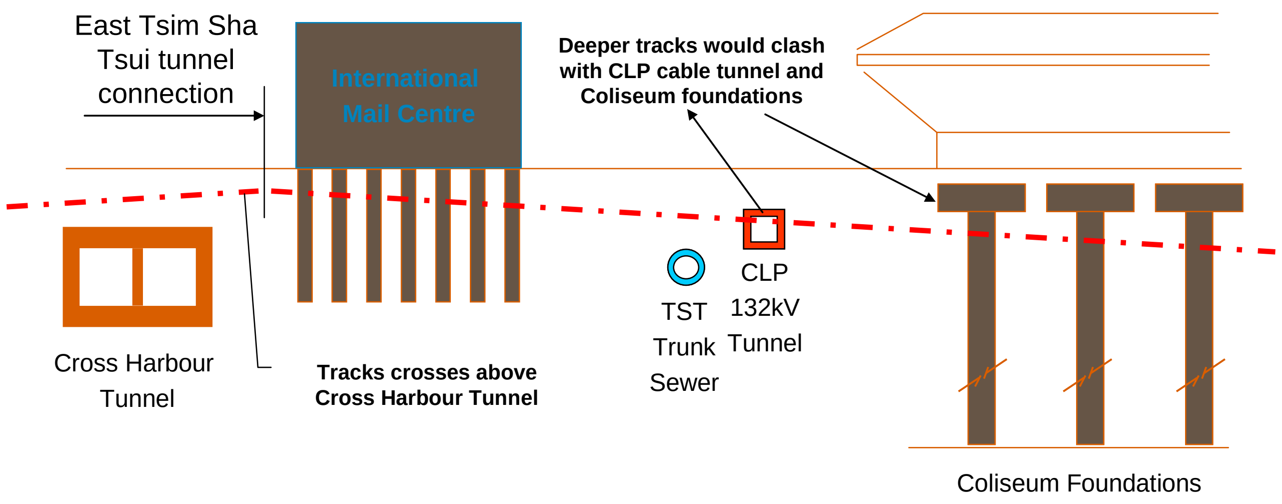
2.1 Following the opening of the Kowloon Southern Link in mid August 2009, the station has become an interchange between West Rail, East Rail, Intercity and the existing Cross Harbour Tunnel (CHT) bus routes.

2.2 This important function will have to be maintained throughout the construction of the new SCL station.

2.3 On completion of the SCL, the station will be required to provide as efficient an interchange as possible between the north-south and east-west corridors. These facilities must also recognize the need to efficiently interchange with Intercity services and the cross harbour tunnel bus routes.

2.4 Alignment constraints on the east-west corridor where it crosses above the CHT, dictate that a cross platform interchange with the north-south corridor, which would be preferred, cannot be achieved. There is insufficient distance from the CHT to the station to achieve a stacked tunnel arrangement for cross-platform interchange. In addition, there would be major clashes with existing infrastructure along the alignment.

Vertical Constraints



Alternative Location for Hung Hom Station

2.5 HUH Station is located in a heavily developed area. Key constraints on the location of the new SCL station are shown on **Figure A1**.

To the West of Existing Station

2.6 Alignments to the west of the existing station are constrained by the approach roads to the CHT. These are heavily trafficked and any major construction under these by cut and cover means would create unacceptable traffic impacts.

2.7 In addition it would also bring the alignment for the north-south corridor too close to the existing CHT. Construction so close to the CHT would create unacceptable impacts due to potential settlement / movements of that structure.

2.8 The area to the west of the CHT Approach Road is currently occupied by the Hong Kong Polytechnic University. Large portions of the existing facility would have to be demolished to allow a station to be constructed in that location.

2.9 The Tsim Sha Tsui East area is heavily developed as shown on **Figure A1**. There is no suitable alignment into Tsim Sha Tsui East through this area from Hung Hom and then also to get cross the harbour, without demolition of major buildings. Any alignment would have to be around the periphery of this area to the south, such as the existing West Rail Line between Hung Hom and East Tsim Sha Tsui Stations.

To the East of Existing Station

2.10 The area to the east of the station is equally constrained due to the major Metropolis development and its foundations. These foundations obstruct any possible East Rail Line alignment in this area. An added problem is that it is not possible to realign the tracks from East Tsim Sha Tsui Station into this area because of horizontal alignment constraints.

To the South of Existing Station

2.11 The Hong Kong Coliseum constrains how far the station can be located to the south because it occupies all of the podium level where the station concourse would be located. Due to the size of the structure it is founded on major columns and shear walls. These severely constrain the SCL tunnel alignment. There is insufficient space to allow station platforms to be located under the central supporting core of the Coliseum.

2.12 There is, therefore, extremely limited options available for relocating HUH Station elsewhere to enable an SCL alignment across the harbour on the western side of the CHT.

2.13 A possible location was considered as shown on **Figure A2** but rejected for a number of significant reasons:

- Insufficient space available between the Hung Hom Bypass and existing buildings fronting Salisbury Road to build the station.
- Major impacts on Hong Kong Coliseum foundations.
- Station would be too close to East Tsim Sha Tsui but too far from Intercity and the various public transport interchanges including the CHT services.
- Extremely challenging and risky construction under the CHT.
- Impossibility of realigning the existing West Rail tracks to this station.

Conclusions

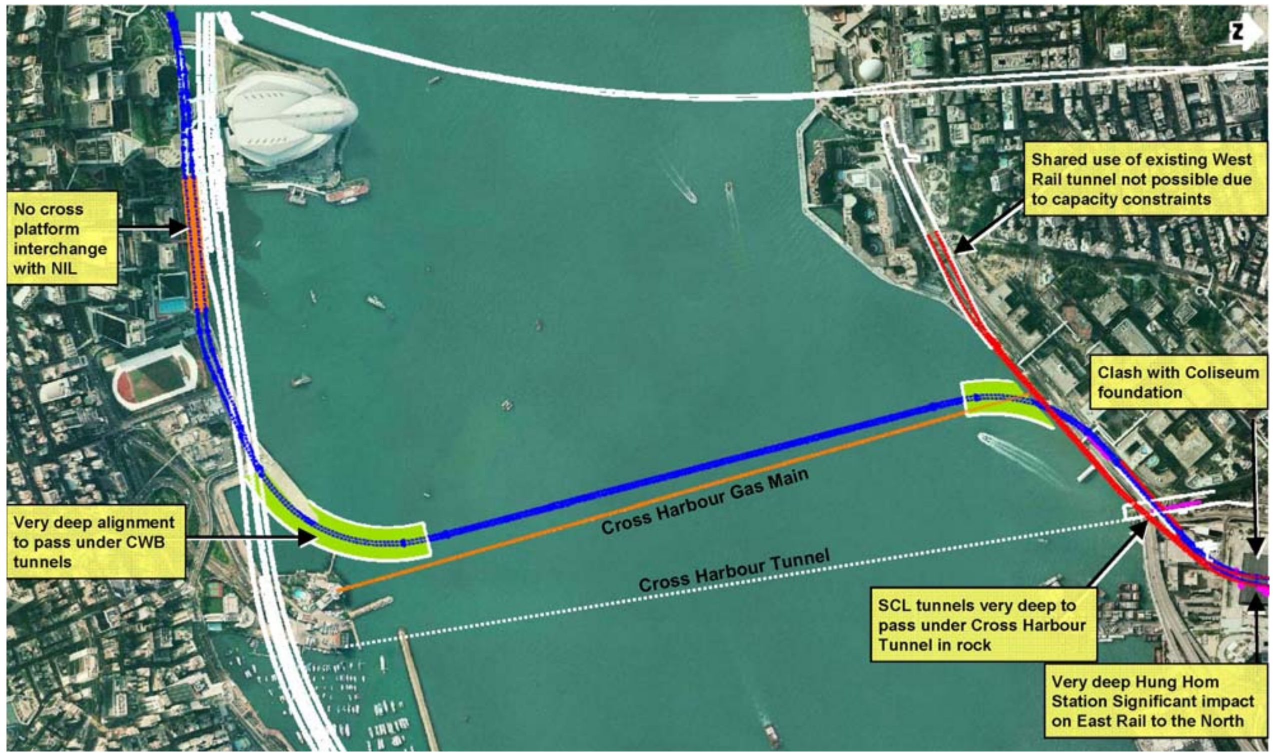
2.14 Hung Hom SCL station must be located as shown below i.e. to the East of the CHT.

Location of Hung Hom Station

Alternative Alignment to the West of Existing Cross Harbour Tunnel

2.15 Although the alternative HUH Station location shown on **Figure A2** was not considered to be practical, an alternative of following an alignment which crossed under the CHT on the Kowloon side of the Harbour as shown below was considered.

Alignment to West of Existing Cross Harbour Tunnel



2.16 This alignment would avoid the SCL having to pass through the CBTS but has also been rejected for a number of significant reasons:

- The alignment would clash with the foundations of the Hong Kong Coliseum, existing West Rail Tunnels and the elevated section of Salisbury Road.
- In order to enable less risky tunnelling to pass under the CHT in rock (as has been adopted by the CWB project on the southern side of the Harbour), the SCL tunnels would have to be very deep. This would mean that HUH Station would need to be approximately 15m deeper resulting in an inefficient interchange station and significantly increased risks during construction. In addition it would result in approximately 2km of the East Rail Line north of HUH Station having to be lowered.
- Difficult and risky construction would be required along Salisbury Road and where the SCL tunnels cross under the existing West Rail tunnels to the West. A significant area of temporary reclamation would be required adjacent to the Tsim Sha Tsui shoreline.

- The tunnels would have to be approximately 40m below sea level to pass under the CWB tunnels on Hong Kong Island. This would result in an extensive area of temporary reclamation adjacent to the Hong Kong shoreline at the interface with the immersed tube tunnel. Significant rock excavation would be required adjacent to Kellett Island.
- It would not be possible to have a cross platform interchange at EXH Station.
- The SCL tunnel alignment to the west of EXH Station would clash with the Hong Kong Convention & Exhibition Centre structure.

2.17 It is not feasible for the SCL alignment to cross above the existing CHT on the Kowloon side:

- North of WRL tunnels: Any SCL alignment above the CHT would clash with the existing West Rail Line tunnels and block existing roads in the area.
- South of WRL tunnels: The existing CHT ventilation building obstructs this alignment but even if this was ignored the SCL alignment would have to pass to the south of the existing seawall and protrude above sea level. This would require permanent reclamation which would not only have a significant adverse impact on the CHT structure but also could not be justified under the PHO since there are alternatives which would avoid the need for this permanent reclamation.

2.18 The SCL tunnel cannot cross the existing CHT within the Harbour for the following reasons.

- Above the CHT: the SCL would block the existing fairway to marine traffic.
- Below the CHT: not only would this involve very risky construction but the SCL tunnels would have to be very deep requiring tunnels to be constructed at pressures in excess of 3.45 bars. This is unacceptable for the reasons set out in Chapter 4 of the Main Report.

Conclusions

2.19 An alignment to the West of the CHT is not practical.

3. EXHIBITION STATION

3.1 The possibility of locating EXH Station in either Harbour Road or Gloucester Road was considered.

Harbour Road Alignment

3.2 Keeping the future North Island Line (NIL) station at the Wan Chai North PTI site while moving the SCL alignment to Harbour Road is considered to have too great an adverse impact on the interchange movements between the stations, even if pedestrian connections could be provided. The NIL would therefore also have to be realigned to Harbour Road to enable an integrated NIL / SCL station to be provided.

3.3 The alignment and consequent station location is shown on **Figure A3**.

3.4 The station location and alignment at Harbour Road is subject to a number of significant constraints and was rejected for the reasons given below:

- The unacceptable construction constraints imposed by the alignment including the requirement for cut and cover works across the critical Fleming Road / Harbour Road junction, which are deemed to be virtually unbuildable.
- The insufficient width remaining for a station in Harbour Road once allowances have been made for working space.
- The unfeasibility of constructing a launch chamber for a Tunnel Boring Machine (TBM) at the junction of Fenwick Pier Street, Convention Avenue and Harbour Road.
- The need for a major 1800mm diameter sewer to be diverted out of Harbour Road.
- The inferior interchange that results between the SCL and the NIL. A cross platform interchange cannot be engineered.
- The unsatisfactory alignment that results with a station at this location including curves with radii of 250m back to back on the approach to Admiralty station.
- The requirement to demolish part of the podium and basement structures of the Great Eagle and Harbour Centres.
- The requirement for modifications to the foundations of Pedestrian Plaza.
- The lack of available space to undertake support works to Fenwick Pier Street Flyover.
- The severe disruption caused to traffic in Harbour Road as cut and cover construction would be required from adjacent to the Hong Kong Academy for Performing Arts to Wan Chai Sports Ground.
- The loss of the NIL ‘pocket track’ which is essential for its operation
- Increased noise and vibration levels on the Hong Kong Academy for Performing Arts.
- Permanent resumption of part of Harbour Road Garden.

Gloucester Road Alignment

3.5 This option is similar to the Harbour Road alignment except that the station would be located under Gloucester Road. The alignment is illustrated on **Figure A4**.

3.6 As illustrated in **Figure A4** the alignment from ADM to Gloucester road results in curves with radii of 200m. This does not represent a feasible alignment given that MTRC’s desirable minimum horizontal curve radius is 300m.

3.7 The tunnels would also clash with the foundations of the Hong Kong Academy for Performing Arts and require major cut and cover construction under Gloucester Road.

3.8 Based on this it would not be possible to achieve the objectives of the project and have stations serving EXH and ADM and this option was rejected.

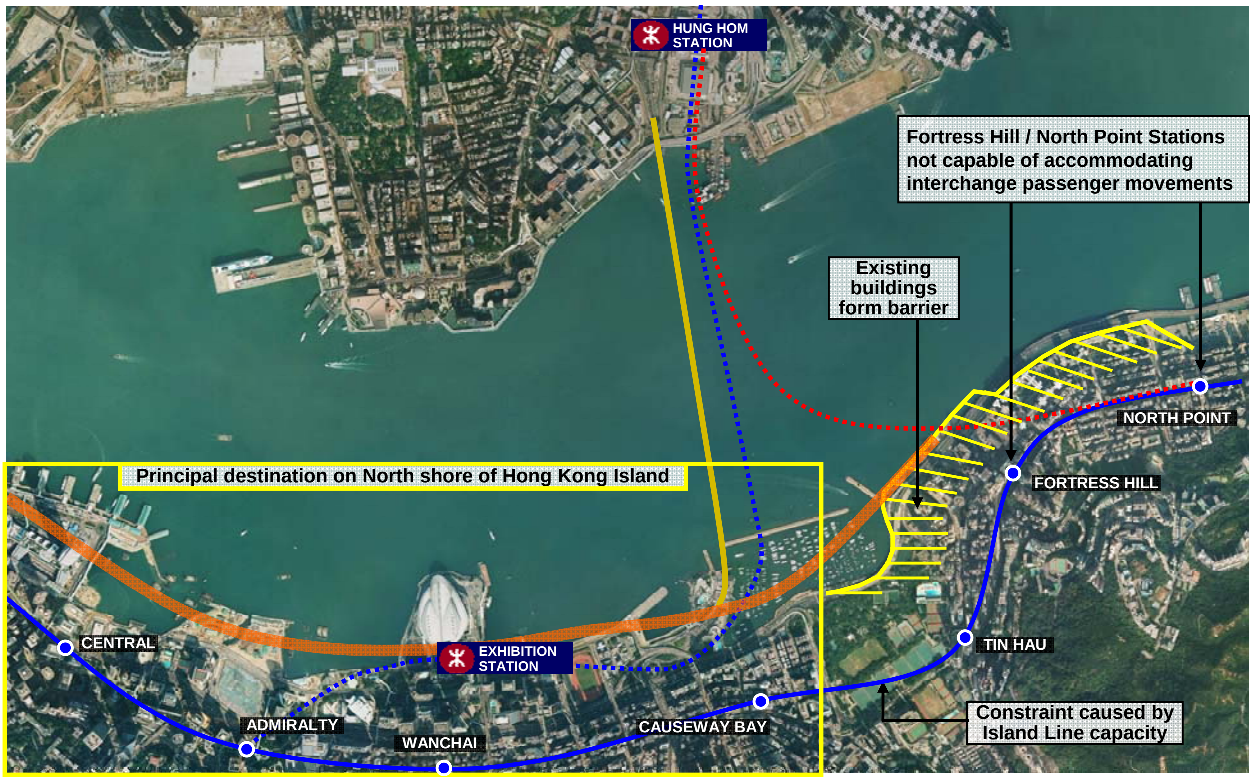
Alternative Cross Harbour Alignment to Fortress Hill or North Point Stations

3.9 In order to avoid an alignment passing through CBTS, alignment options with the SCL terminating at Fortress Hill Station or North Point Station on the Island Line have been investigated. However, there are a number of fundamental problems of taking the SCL to either Fortress Hill or North Point Stations.

Desired Destination

3.10 The key destinations for people crossing the harbour on the SCL are to Central, Admiralty, Wanchai and Causeway Bay. An SCL alignment to North Point or Fortress Hill Stations would not be taking passengers where they want to go. It therefore provides a poorer level of service. Passengers wishing to access the eastern part of the Hong Kong Island from the New Territories / Mainland can do so via the SCL to Diamond Hill Station and then across the harbour via the Tseung Kwan O Line.

Key Issues for Eastern Alignment



3.11 Once implemented, the North Island Line will also provide convenient and quick access from Fortress Hill and North Point to the SCL via Exhibition station.

Design and Capacity of North Point and Fortress Hill Stations

3.12 North Point station currently provides for interchange between the Tseung Kwan O Line and the Island Line.

3.13 It is configured with platform tunnels on two levels to effectively provide cross platform interchange via a number of horizontal adits. The interchange capacity is already stretched as the original platform tunnels have limited width and therefore capacity. There is limited flexibility to enhance this capacity.

3.14 Fortress Hill station is configured as two island platforms connected by a number of adits which in turn connect to a single principal bank of escalators connecting to the concourse level. The platforms are limited in width.

3.15 Neither station would be able to cope with the large numbers of passengers crossing the harbour, and having to interchange with the Island Line. Both stations would essentially have to be reconstructed to suit this purpose. The adjacent Island Line tunnels would also have to be realigned causing major disruption to the Island Line services and the community.

Capacity of Island Line

3.16 As most people eventually want to go to central business district in the morning peak, a large number of passengers would be trying to board the Island Line. The Island Line is already crowded and would be overloaded by the number of SCL passengers.

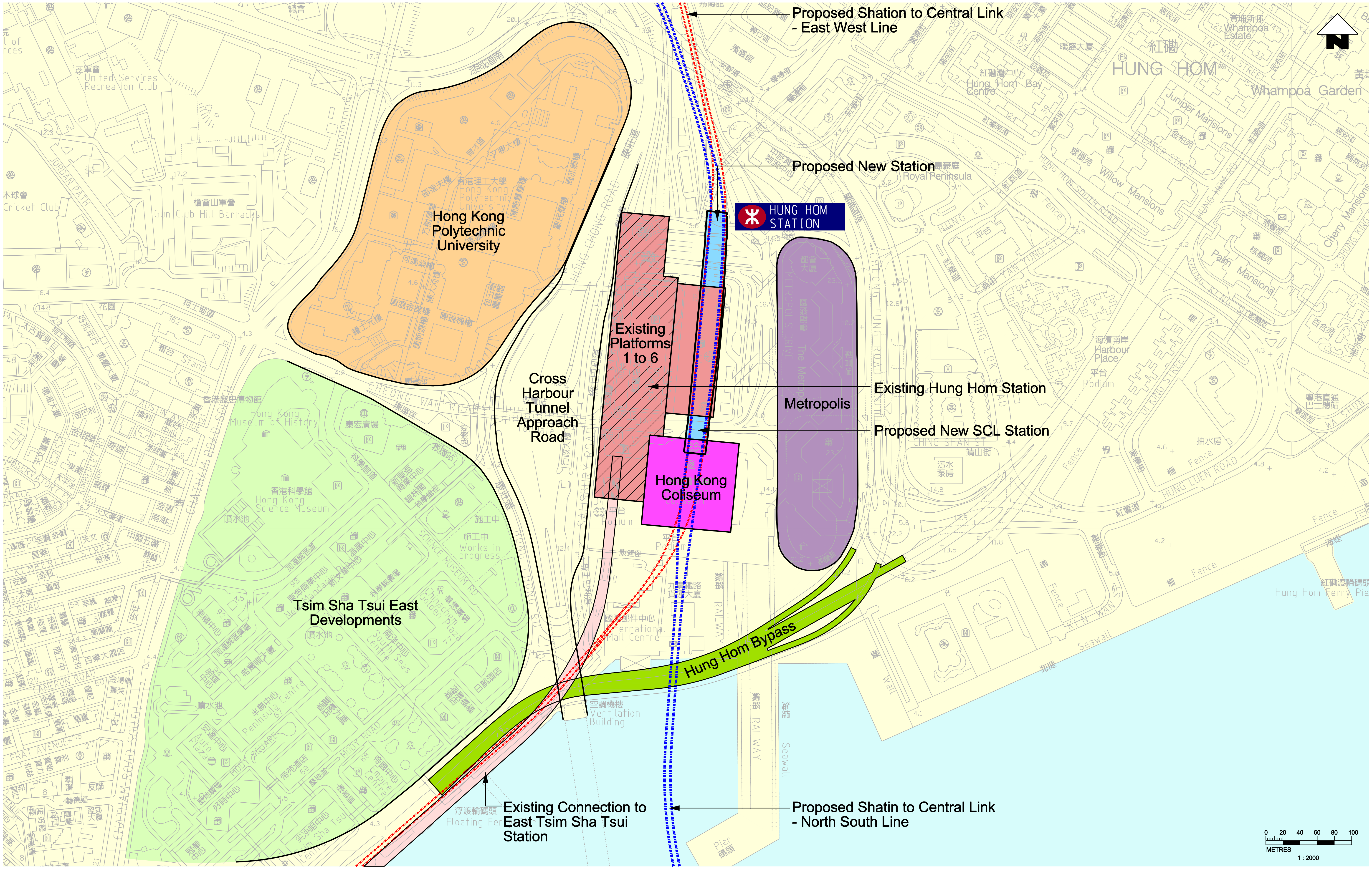
Conclusions

3.17 The option of running the SCL to either North Point or Fortress Hill Stations is not feasible because of capacity constraints on the Island Line and the need to re-build / re-configure either North Point or Fortress Hill stations.

Summary

3.18 It is concluded that HUH Station must be located to the east of existing platforms 1 to 6 and to the west of the Metropolis. EXH Station must be located to the north the Great Eagle and Harbour Centres under the site currently occupied by the public transport interchange, Harbour Road Sports Centre and Wan Chai Swimming Pool.

3.19 The SCL across the habour must be compatible with the requirements for SCL interchange stations at these two locations.



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TITLE

NEX/2202 - CROSS HARBOUR SECTION
PRELIMINARY DESIGN
CONSTRAINTS ON HUNG HOM STATION LOCATION

SCALE 1 : 2000 (A1)

FIGURE NO. FIGURE A1

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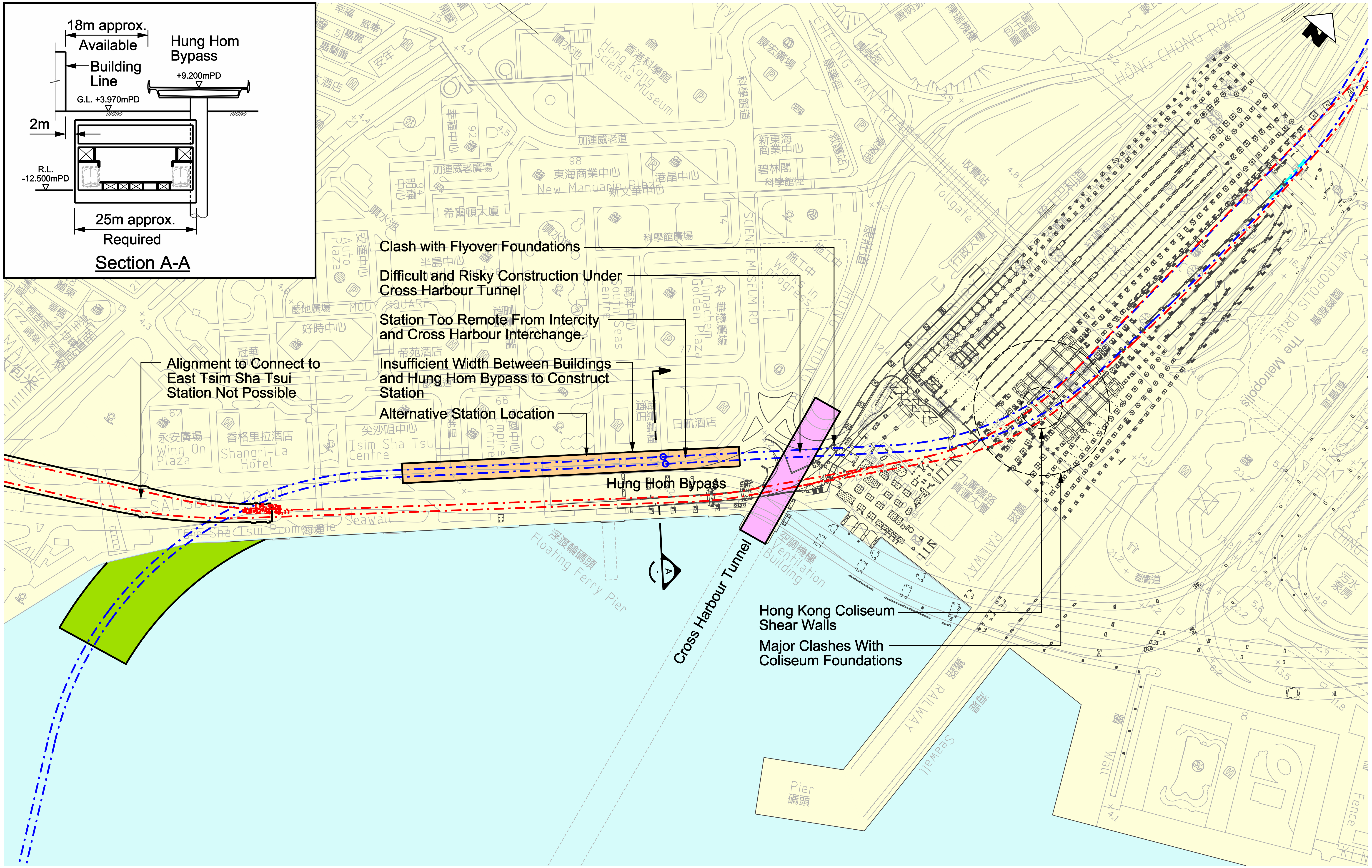

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TITLE

NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

ALTERNATIVE LOCATION OF HUNG HOM STATION TO THE WEST OF THE CROSS HARBOUR TUNNEL

SCALE: AS SHOWN (A1)

FIGURE NO.: FIGURE A2

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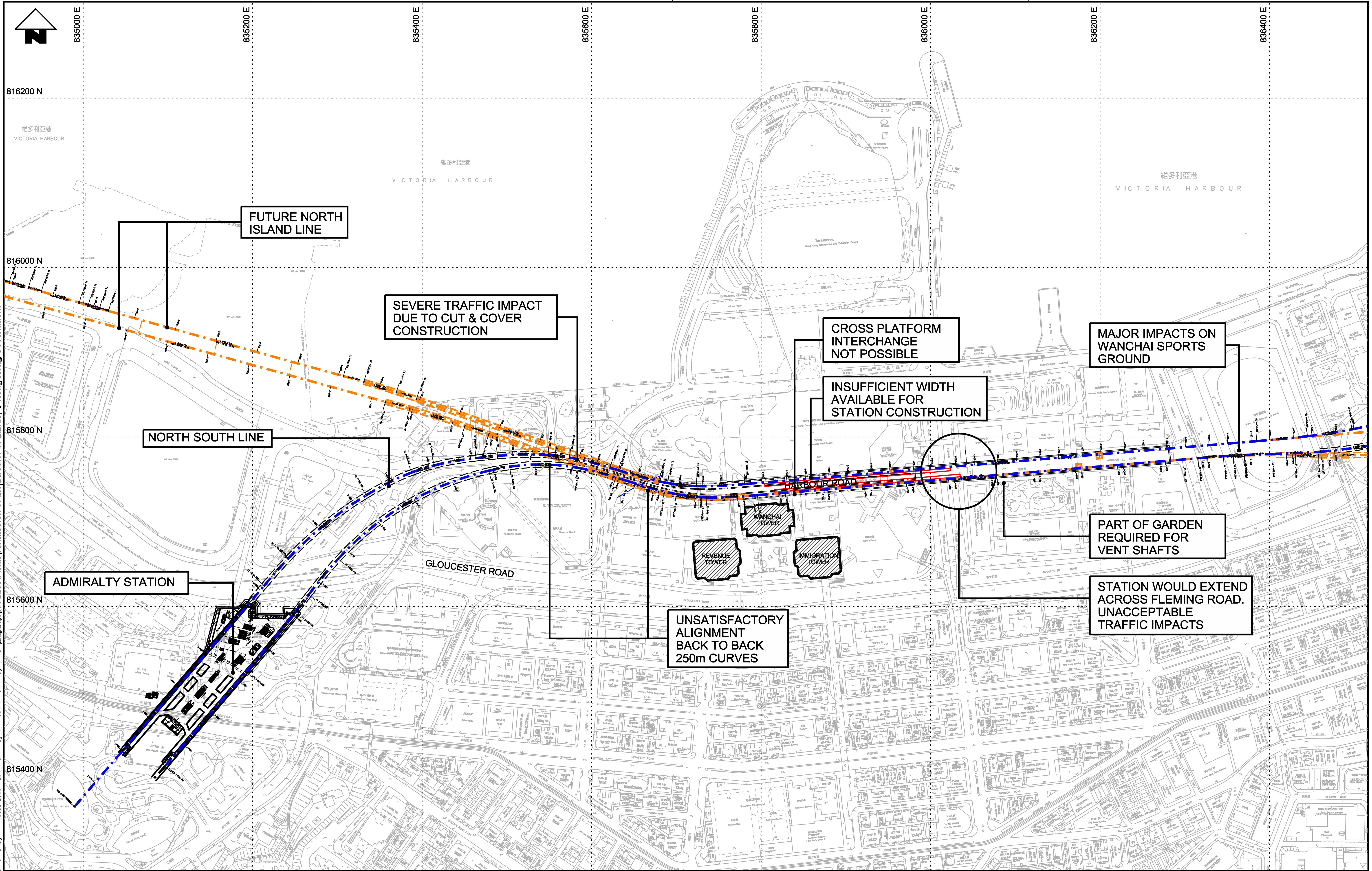

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TITLE

NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

POSSIBLE ALTERNATIVE LOCATION FOR EXHIBITION STATION IN HARBOUR ROAD

SCALE 1 : 2000 (A1)

FIGURE NO. FIGURE A3

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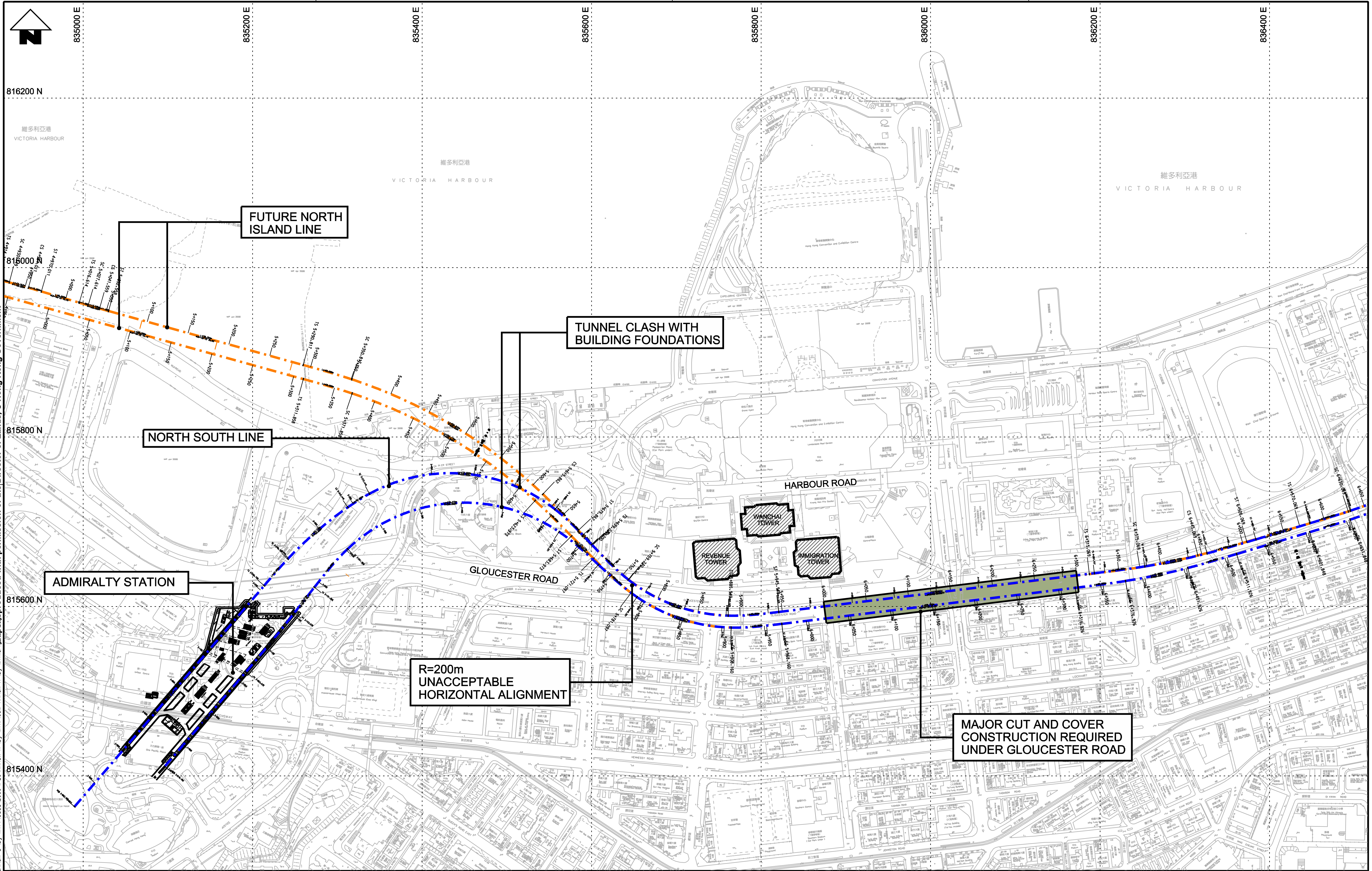

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TITLE

NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

POSSIBLE ALTERNATIVE LOCATION FOR EXHIBITION STATION IN GLOUCESTER ROAD

SCALE: 1 : 2000 (A1)

FIGURE NO.: FIGURE A4

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Annex B

Shallow Bored Tunnel Options

1. SHALLOW BORED TUNNEL OPTIONS

Tunnel Diameter

1.1 The normal internal diameter for the SCL running tunnels is around 6.5m. This cross section is applicable for the bored running tunnels between the South Ventilation Building, Exhibition Station and Admiralty Station only. Due to the length of the tunnel between Hung Hom Station and the South Ventilation Building, fire safety and ventilation requirements must be added to the standard considerations of structure gauge and kinematic envelope in determining the tunnel cross section. As highlighted in Section 4.2.5 in the main CCM Report, a $15m^2$ ventilation duct is required for the cross harbour tunnel.

1.2 After taking the above into account the internal tunnel diameter increases to 9.0m. This equates to a Tunnel Boring Machine (TBM) external diameter of approximately 10.35m. A typical cross-section is shown on **Figure B1**.

Constraints on Vertical Alignment

1.3 Stations are generally kept as shallow as possible in order to make them as easily accessible as possible for passengers. This dictates that the tunnels between them also be kept shallow.

1.4 In this case the vertical alignment is also dictated by the need to pass under the CWB tunnels and also to maintain adequate cover under the seabed.

1.5 For safe tunnelling, ground control and steering, the TBM must have sufficient ground cover. The cover required is summarized below:

- 1 x TBM diameter (absolute minimum)
- 2 x TBM diameter (preferred minimum)

1.6 The preferred alignment for the tunnel would be along the western side of the corridor referred to in Section 4.4.15 of the CCM Report since this would be the shortest and would, therefore, provide the shortest journey time for passengers. Model simulations indicate that the journey time would be extended by 25 seconds if an alignment via the eastern part of the alignment corridor is followed.

1.7 A typical section along the western alignment is shown on **Figure 4.4** in the CCM Report. This shows that the tunnel will pass in and out of rock.

Geological Conditions

1.8 The stratigraphy along the tunnel alignment can be summarized as:

- Marine deposits
- Non-cohesive silt and fine sand interbedded with clay
- Contaminated soft clay
- Alluvium
- Silt and sand, laminated with clay layers
- Completely to highly decomposed Granite with occasional core stones
- Moderately decomposed to fresh Granite

1.9 In addition core stones have been encountered during the course of past excavations in the harbour. The core stones have been located both within the completely to highly decomposed Granite and the alluvium resting at the interface with the decomposed granitic soil.

1.10 With the exception of the marine deposits all the other strata may be considered to be competent tunnelling strata. However, the marine deposits that are either very loose or soft could result in steering problems if care is not exercised during the construction phase. The bored tunnel alignment lies beneath the interface of the alluvium and marine deposits except for a discrete section between the Hung Hom Freight Pier and the northern edge of the harbour fairway where marine deposits will be encountered in the tunnel face. The available geotechnical data indicates that the marine deposits in the harbour main channel are sufficiently competent to ensure minimal problems with tunnelling. However, it is prudent to minimize the length of tunnelling through this stratum as much as is reasonably practicable. All the other strata will be encountered both full face and in mixed face conditions.

1.11 Tunnel construction must be carried out by Tunnel Boring Machine (TBM) at the depths, and in the ground conditions, envisaged. The combination of hard rock and soft ground conditions are particularly challenging for TBM tunnelling.

1.12 In Hong Kong, recent experience of TBM tunnelling using both Slurry and Earth Pressure Balance TBMs has confirmed that tunnelling within mixed face conditions can result in excessive wear of the TBM cutter head disc cutters and soft ground picks.

1.13 Recent experience on the Kowloon Southern Link Canton Road to Salisbury Road tunnels (KDB200, Hake and Chau (2008)), has indicated that mixshield TBMs are considered to be superior to Earth Pressure Balance TBMs for tunnelling in mixed face conditions, as it is able to maintain more accurate and reliable face control, particularly at the soil/rock interface zones and by the use of a rock crusher when excavating corestones. The issue of rock excavation performance was indistinguishable between either slurry or Earth Pressure Balance type TBMs as the TBM was designed for the anticipated rock conditions. Further important issues for TBM selection, such as groundwater control, managing wear of the cutters and cutter head and coping with blocks or boulders were also considered superior with the mixshield TBM.

1.14 Experience with the Earth Pressure Balance TBM “Mulan” on the West Rail Kwai Tsing Tunnels (DB320) and the Lok Ma Chau Spur Line (LDB201) indicates that cutterhead inspections are required to be undertaken every day and that interventions to maintain the cutterhead are required at regular intervals with the longest period between interventions being approximately 3 days. Similar experience was gained on the Kowloon Southern Link project and daily interventions should be allowed for.

1.15 Face interventions will be required for the regular inspection and maintenance of the cutterhead tools. This will require man entry into the pressurised cutterhead (in front of the TBM) via air locks in the pressure bulkhead of the TBM.

1.16 Typically, during a manned intervention the level of the slurry, or soil plug, in the cutterhead is reduced to allow access and the support pressure it provides to the ground is replaced by compressed air. Work in compressed air in Hong Kong is regulated by the Factories & Industrial Undertakings Cap 59M. The current regulations provide for work up to a maximum pressure of 50 psi (approximately 3.45 bar) and state that:

‘Except in the case of an emergency, no person shall be employed in compressed air at a pressure exceeding 50 pounds per square inch without permission from the Commissioner.’

1.17 This limit is in place to protect tunnel personnel from being unnecessarily exposed to more hazardous conditions to health and safety than necessary. In all such cases the objective must be to keep the risk as low as reasonably practicable (ALARP) to these personnel. This, therefore, means that any requirement to exceed the current regulated level must be supported by an argument that there is no reasonable, safer way of carrying out the construction.

1.18 Key features of the alignment are summarised below:

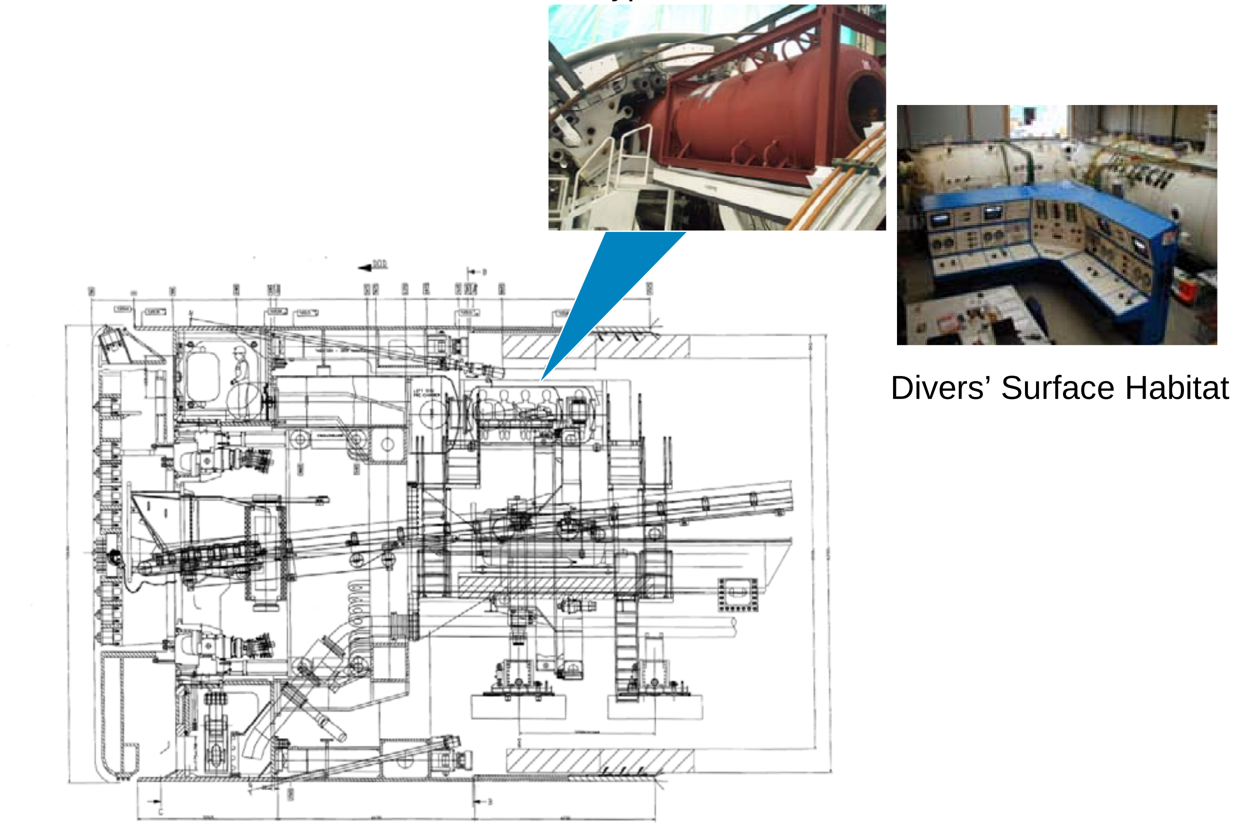
- It will be -49.2mPD at its deepest.
- Approximately 1800m of the alignment will be deeper than the 3.45 bar level.
- The tunnel will pass in and out of rockhead and through areas with boulders. This has a significant impact on the number of cutterhead interventions required both for cutter replacement and TBM head repair.
- Approximately 800m of tunnel will have less than the 2 diameter desired minimum cover.

1.19 A review of alternative techniques for tunnel face intervention has been conducted. Reference has been made to the saturation diving techniques which has been used in the oil industry for carrying out marine works at great depth below sea level. This technique would enable tunnel personnel to remain at the tunnel face under pressure for longer periods than would be possible where personnel were required to undergo decompression after each visit to the face. This would be important given the large number of cutterhead interventions anticipated because of the expected difficult mixed face tunneling conditions. Divers have to go through special training. However, it should be noted that there is only a small group of divers in the world who are qualified to carry out works using the saturation diving technique.

1.20 For application on tunneling works, divers would have to be shuttled to and from the tunnel face in a special shuttle and would be able to spend up to 4 hours at the face of the TBM at any one time. Two divers would be used with a further 2 on standby for an emergency. A doctor would also be on standby at the surface.

Saturation Diving Hardware

Hyperbaric Shuttle



Divers’ Surface Habitat

1.21 There are concerns that although a doctor would be on standby at the surface, the time taken for decompression could limit the level of treatment that could be provided in the event of injury or illness to any of the divers.

1.22 Holzhaüser et al (2006) have researched "Global Experience with Soft Ground and Weak Rock Tunnelling under Very High Groundwater Heads". It should be noted that these are not really representative of the conditions expected in Hong Kong where the rock tends to be significantly stronger and more abrasive involving greater cutter wear and a significantly increased number of interventions.

1.23 The paper recorded that only the Westerschelde Tunnel project in the Netherlands (1998-2001), has used saturation diving techniques:

"In total 6 excursions in saturation were performed with a total saturation time of 40 days at pressures of up to 6.9 bar within the excavation chamber. The decompression time was 4 days each time. Additionally 10 inspection excursions with mixed gases were performed, in addition to 1652 hours of work within compressed air involving 546 transfers. In total 5 cases for decompression sickness occurred, all of which were successfully treated in the on site recompression chamber".

1.24 Substantial technical progress of pressured TBM tunnelling has been made and new tunnels are being planned at significant tunnel depths but as yet there is very limited precedent practice and there is limited proposed use of saturation diving. The international tunnelling industry has been slow, and even reluctant, to adopt these techniques. It is only generally being considered as a fall back or emergency technique, not as an essential day to day requirement of the project. It is a 'last resort' technique and would not be considered if there was a suitable alternative. Designers try to design out the need for compressed air or other similar techniques and the tunnel construction industry has a general aversion to its use.

1.25 Typical examples where the use of higher face pressures are being considered in Hong Kong are the Tuen Mun – Chep Lap Kok Link and the Lai Chi Kok Transfer Scheme project. In both these cases it is understood that all possible alternatives to avoid tunnelling with pressures above 3.45 bar have been investigated and no practical alternatives exist. Its use cannot be avoided if the projects are to proceed.

Cross Passage Provision

1.26 Cross passages would be required to provide fireman's access and potentially for passenger evacuation. The extent of provision is to be determined but the current working assumption is that cross passages would be required at approximately 250m centres. The construction of the cross passages in the soil and mixed ground would require stabilization before excavation and support. The options for stabilization are:

- Grouting
- Compressed air
- Ground freezing

1.27 Construction of these adits will be challenging with the most likely and least risky technique involving ground freezing.

Impacts on Hung Hom (HUH) Station and East Rail

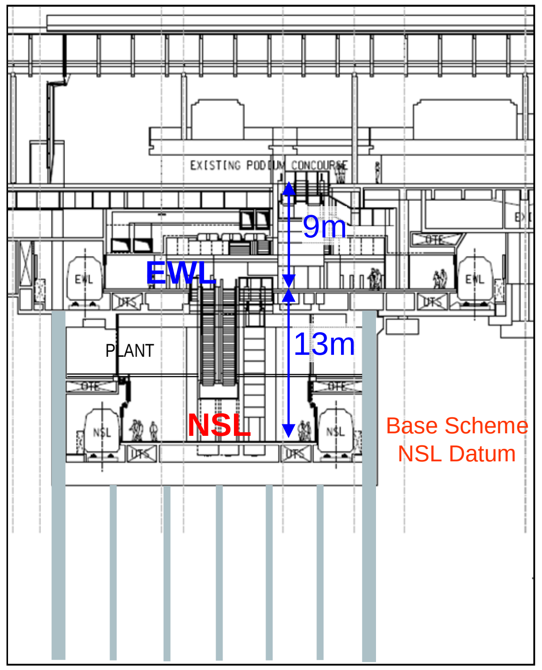
1.28 This bored tunnel option requires the alignment under the harbour to be significantly deeper than the immersed tube tunnel option. This has a number of impacts on the depth and configuration of HUH Station and also on the extent of East Rail Line that has to be lowered to match the profile across the harbour.

Hung Hom Station

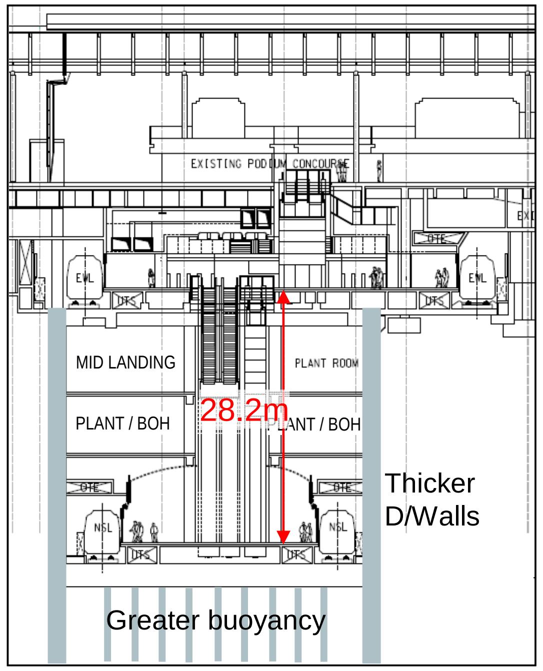
1.29 The rail level of the SCL north-south corridor at HUH Station must be lowered from the preferred level of –10mPD to approximately -25mPD. This increased depth could be reduced slightly to approximately -19mPD if the 'scour' area was filled in and this wasn't regarded as reclamation. It should, however, be noted that if the scour area was backfilled and 'the tunnels' raised in level at this location, they would clash with the fender pier piles protecting the Hung Hom Bypass. These would have to be reprovisioned off line and this would technically be classified as permanent reclamation i.e. it would not be a 'no-reclamation' option. In addition it would not eliminate the need for a significant length of the tunnel across the Harbour to be carried out at depths where 3.45 bar pressures would be required.

Implication on Station Vertical Circulation

1.30 The extra station depth will reduce the efficiency of the station interchange and increase the interchange time or for people going to concourse, by approximately 65 seconds Two escalators with an intermediate platform must be used between the north-south and east-west corridor platforms instead of a single escalator. This does not meet the SCL project objective of providing convenient interchange.



Base Scheme (IMT)
Escalator I/C **35 secs**



Deep Option (TBM)
Escalator I/C **+65 secs approx.**

Deeper Station

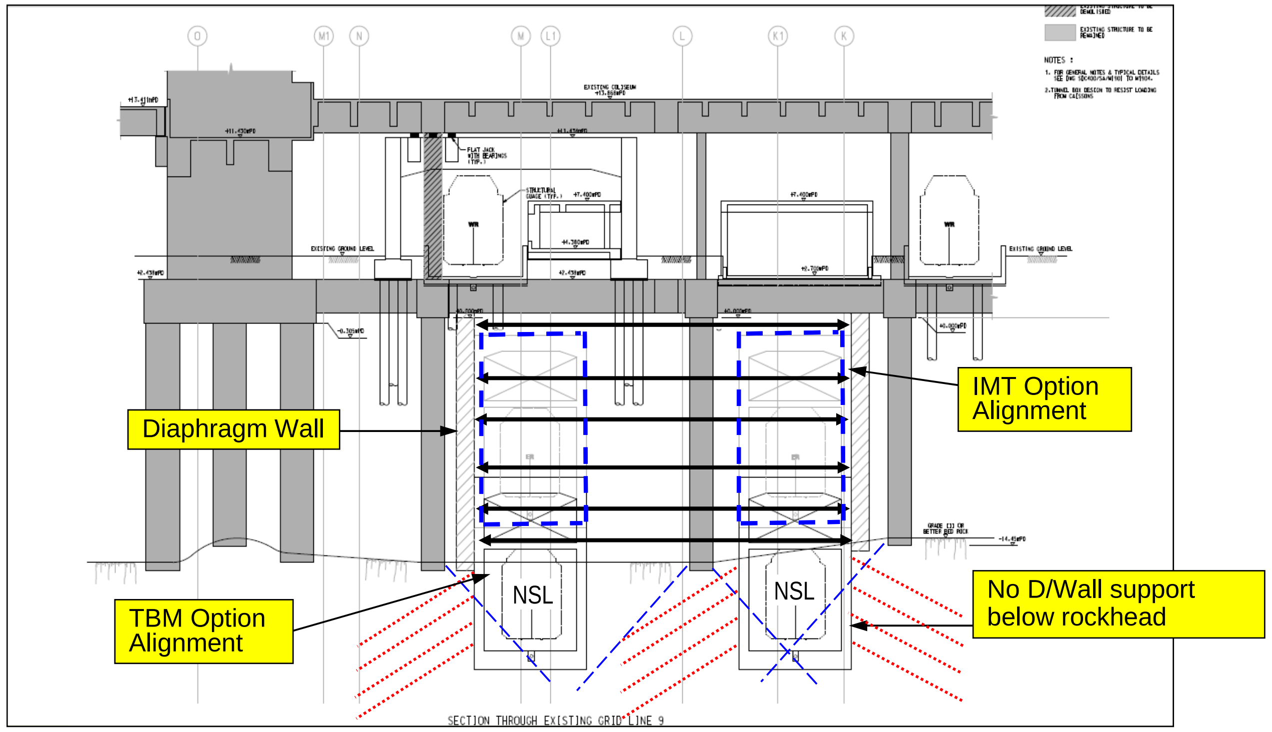
1.31 The deeper station will have the following impact:

- Increased cost due to thicker diaphragm walls, increased excavation and structure.
- Increased risk due to greater depth of construction adjacent to existing station foundations.

Impacts on Hong Kong Coliseum Foundations

1.32 The tunnels must be constructed through and below the Coliseum foundations. The added depth creates a number of problems.

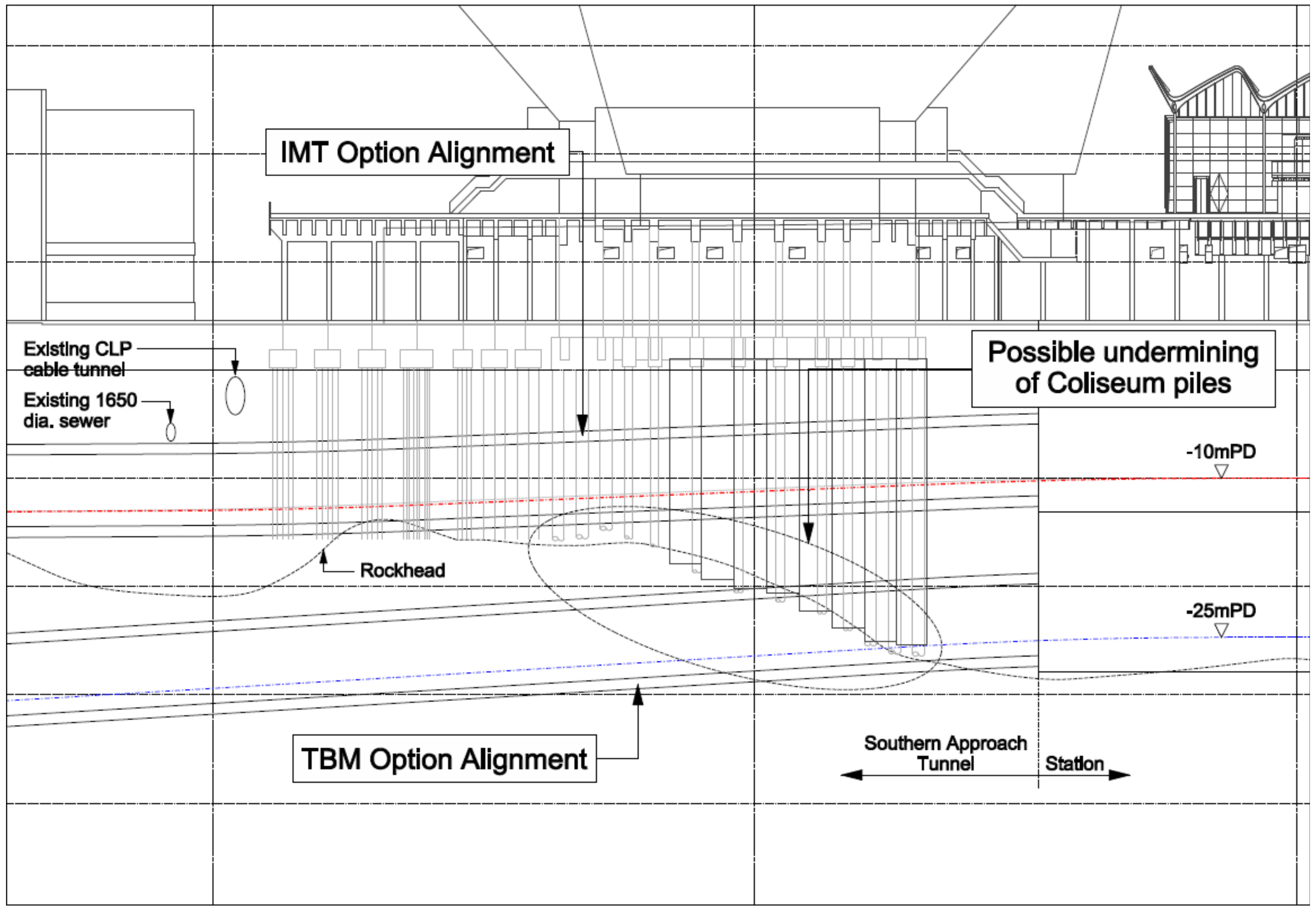
Construction Under Coliseum



1.33 There is limited space between the existing foundations and the rail tunnel diaphragm walls. At increased depths the construction tolerances become even more critical.

1.34 An alignment above rockhead is preferred under the Coliseum to avoid undermining the existing foundations and to avoid the requirement for major rock excavation in an environmentally sensitive environment.

NSL Cut & Cover Tunnels – Long Section



1.35 Typical expected construction constraints are resulting from this deeper alignment are:

- Challenging construction beneath the level of the Coliseum foundations and the need to avoid movements affecting the building structure.
- Constraints on hours of working because of potential impacts on rehearsals and performances in the building.
- Restrictions on blasting leading to significantly greater time and costs required to excavate the rock.

1.36 This will significantly add to the cost, programme and disruption to the community.

Tunnels to North of Hung Hom Station

1.37 The preferred alignment for the SCL involves branching off from the East Rail Line alignment just south of Tunnel 1A (about 0.8km north of HUH Station) to enable a tunnel to be constructed using a combination of horizontal pipe piled and cut and cover methods to lower the tracks north of HUH Station.

1.38 The problem with the deeper HUH Station is that, the tracks cannot connect into the existing alignment south of Tunnel 1A. As a consequence it must be extended to join with the existing East Rail Line almost 2km to the north as shown on **Figure B2**.

Impacts on Tunnels to the North

1.39 Key features of the scheme would be:

- 350m of cut and cover tunnel in the HUH Station north fan track area.
- 980m of twin bored tunnel to a reception shaft in Wylie Road.
- 350m of cut + cover and trough along Wylie Road immediately adjacent to the existing operating railway.
- New bridge over Waterloo Road.
- New track on embankment to the north of Waterloo Road.

1.40 Overall the length would be increased by 1.2km.

1.41 Much of this work will be difficult and risky and the extent of impacts of SCL construction will be significantly increased.

Connection to East Rail Line

1.42 This must occur to the north of Waterloo Road because the existing tracks south of Waterloo Road are on a curve and cannot be fitted with turnouts. Key features of this element of work are:

- A new retaining wall and extended embankment must be constructed. This will require occupation of the existing footpath and part of Yim Po Fong Street.
- A new noise barrier must be constructed before the existing noise barrier adjacent to the East Rail Line is removed if operation of the East Rail Line is to be maintained.

Waterloo Road Crossing

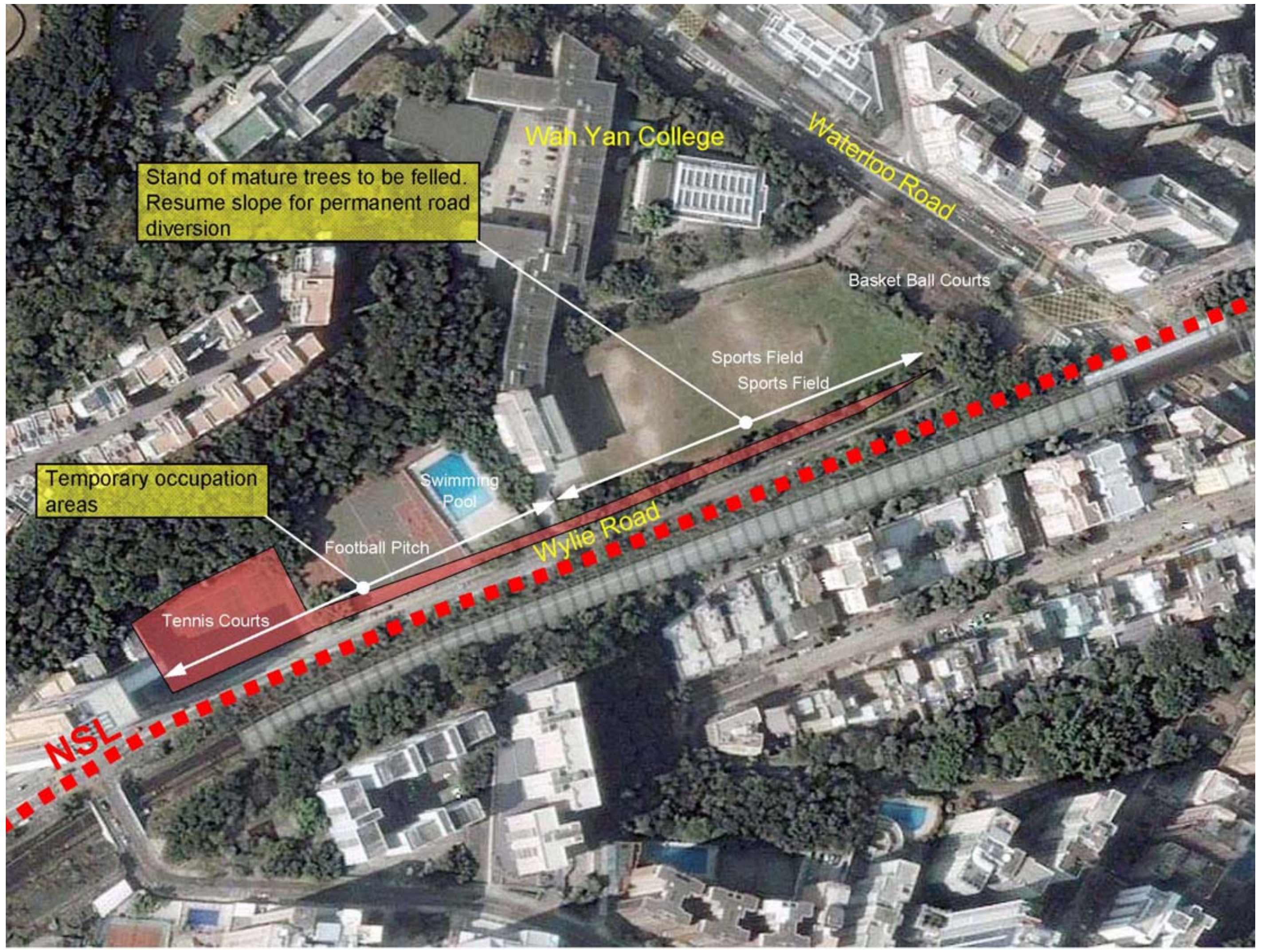
1.43 This will require the existing rail bridge be extended to the west. There are a number of significant constraints in carrying out this work:

- Interface and protection of a CLP substation.
- Access for new pier construction on either side and middle of the road junction with consequent traffic impacts.
- Replacement of existing footbridge across Waterloo Road.

Wylie Road Section

1.44 Once the new tracks have crossed to the south of Waterloo Road they can then descend to the TBM reception shaft at the southern end of Wylie Road. The extent of the proposed works is shown below. The new works will be constructed by open cut and cut and cover works between Waterloo Road and the TBM reception shaft.

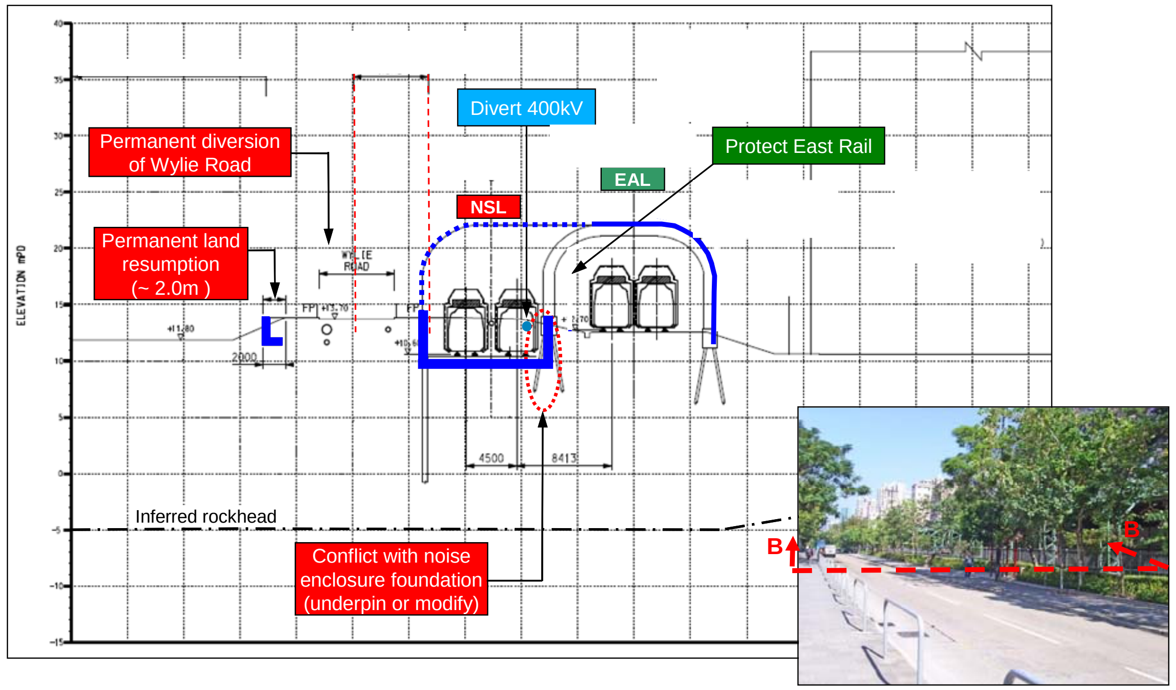
Alignment along Wylie Road



1.45 The proposed scheme depends on:

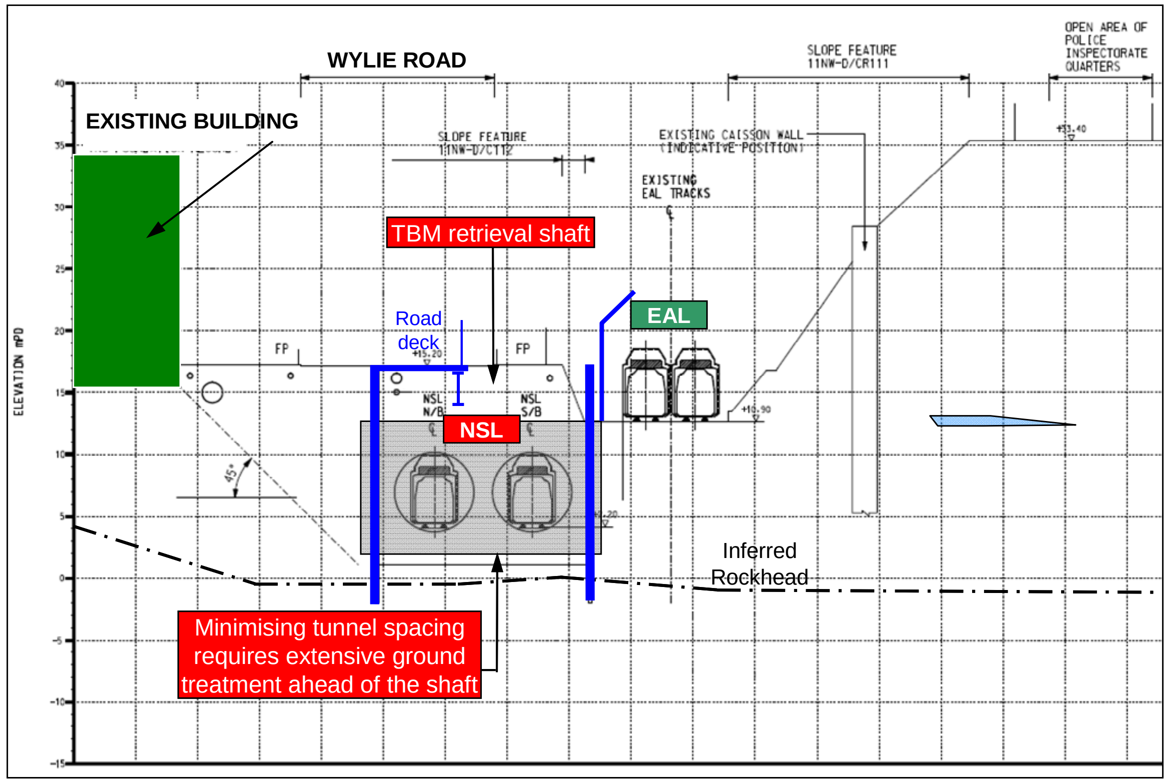
- Being able to divert Wylie Road to the West, partly into land occupied by adjacent facilities. A permanent retaining wall would be required to be installed to minimise the extent of permanent land take. A number of trees will have to be felled.
- Existing utilities including 400kv electric cables will need to be diverted with a 2 year lead time.
- Major cut and cover works are required immediately adjacent to the existing East Rail Line whilst ensuring that its operation is not affected.

Wylie Road Trough Section



- Excavation up to 17m deep will be required within the road and landscaped verge, immediately adjacent to the existing track. The existing noise barrier will need to be replaced as the western foundations will clash with the new track structure. This will be a difficult and time consuming exercise as the existing barrier must be maintained during any modification works. It is expected that some form of temporary barrier would have to be provided. If a workable solution could not be developed the new tracks have to be moved westwards increasing the impacts on adjacent facilities.
- The TBM retrieval shaft would need to be located immediately adjacent to the southern tennis courts and football field of Wah Yan College, and extensive ground treatment along the approach to the shaft would be required. Temporary occupation of land west of Wylie Road would be required to facilitate proposed Temporary Traffic Measures including footpath closures and lane diversions.

Wylie Road Bored Tunnel Section at (Retrieval Shaft)



Wylie Road Bored Tunnel Retrieval Shaft Location

- A new tunnel ventilation building would have to be constructed above the tracks part way along Wylie Road at the tunnel portal.

Wylie Road to HUH Station Bored Tunnel

1.46 There are two areas of concern for this section:

- TBM tunnels in soft ground within the zone of influence of foundations of existing buildings. Access for any ground treatment if required, will be difficult in this area.
- TBM tunnels in soft ground close to and adjacent to Tunnel 1A. Tunnel 1A was constructed about 50 years ago as a portal frame structure and backfilled. This is a critical feature for the operation of East Rail.

Costs

1.47 This bored tunnel option would cost up to approximately HK$3.3 Billion more than an immersed tube tunnel option across the Harbour.

Summary of Findings

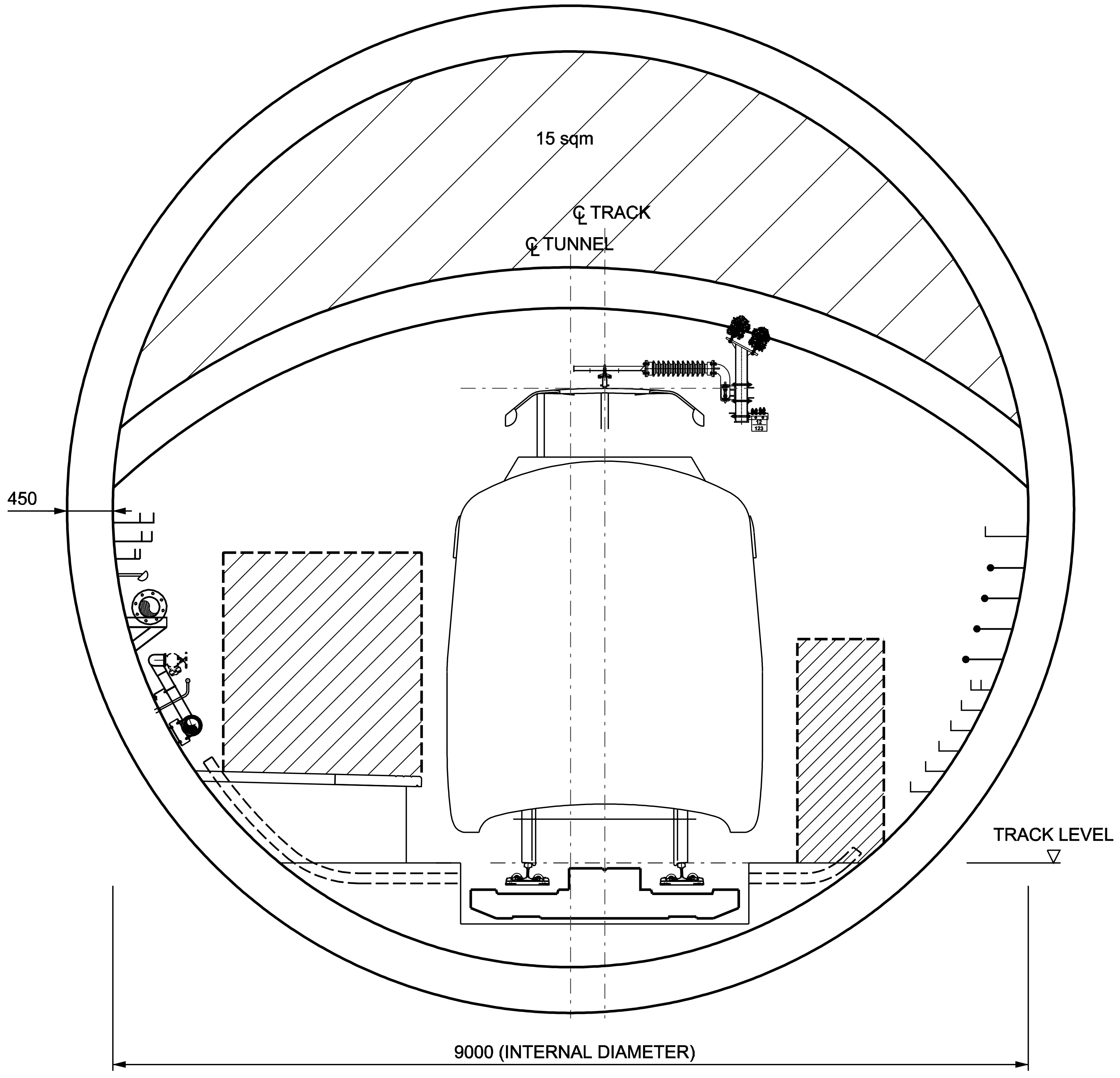
1.48 Generally, Employers, tunnel designers and contractors try to avoid creating situations where the face has to be pressurised to enable man access..

1.49 For all of the shallow TBM alignment options along the alignment corridor identified in Section 4.4.15 of the main report, tunnelling will be required at a depth where interventions for maintenance and repair will be in access of 3.45 bar.

1.50 It is considered that the risks to health, life and the project associated with these shallow TBM options cannot be justified. There are alternative ways of building the project which avoid these risks.

1.51 This option would also cost more, provide a considerably poorer level of service to rail users and has increased impacts on the community which extend over a wider area.

1.52 As such the shallow TBM option is not considered to be a reasonable alternative to the immersed tube options which require reclamation.



CROSS HARBOUR BORED TUNNEL CROSS SECTION

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TITLE
NEX/2202 - CROSS HARBOUR SECTION
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CROSS HARBOUR BORED TUNNEL
CROSS SECTION

SCALE	FIGURE NO.	REV.
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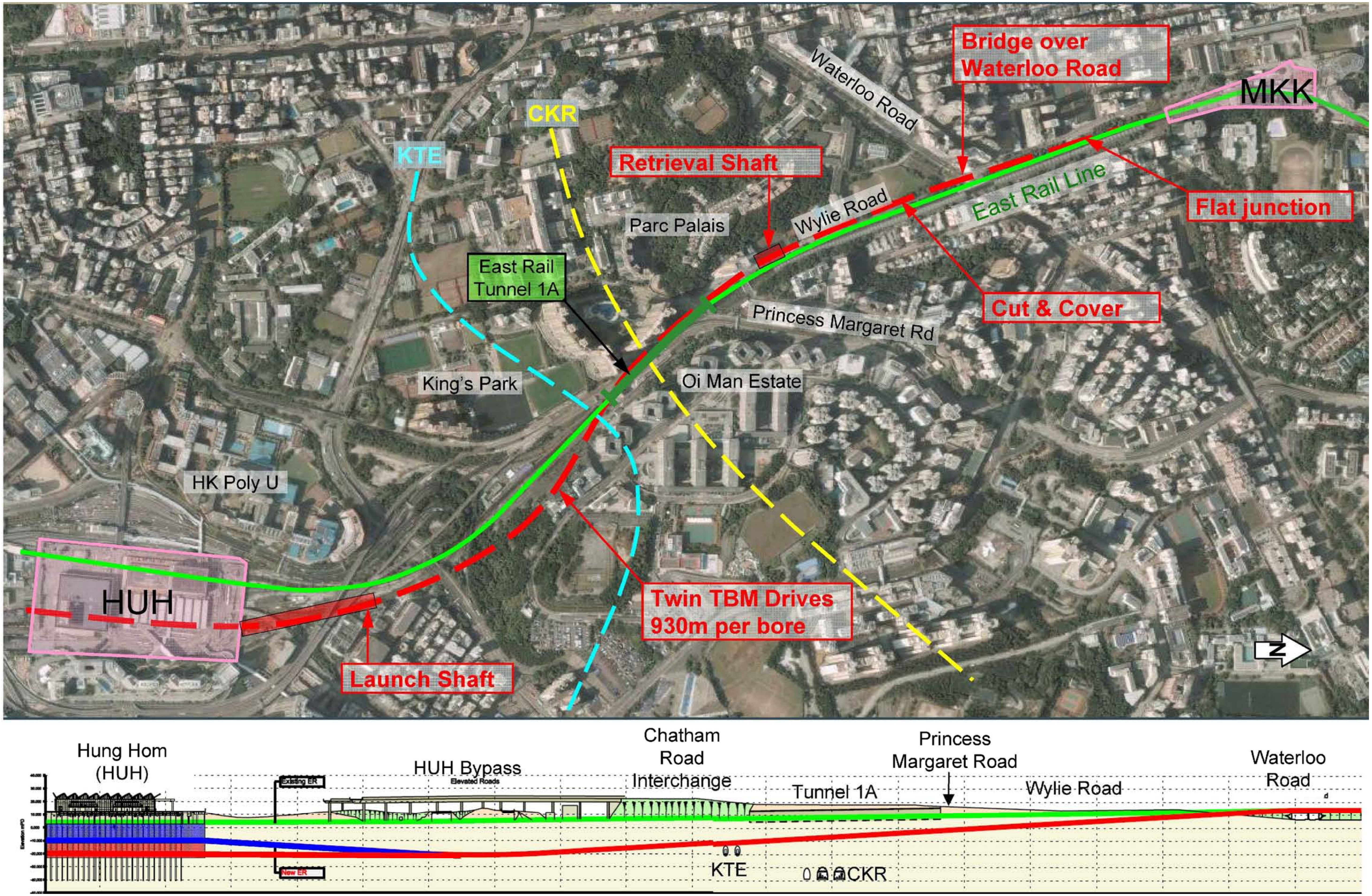

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NEX/2202 - CROSS HARBOUR SECTION

PRELIMINARY DESIGN

TUNNELS NORTH OF HUNG HOM - BORED TUNNEL SCHEME

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FIGURE NO. FIGURE B2

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Annex C

Public Consultation

First Professional Forum

Date : 16 June 2009
Time: 9.30am – 12.00pm
Venue: 5/F, Pacific Place, 88 Queensway, Hong Kong

Major Views/Questions Raised:

The attendees generally agreed that there was an overriding public need for SCL, and that there was no reasonable "no reclamation" option. Most of the attendees preferred the western alignment. All participants considered that there should be better planning and more consultation to get a balanced view of the typhoon shelter users as well as the residents of Wan Chai and Causeway Bay areas.

1. An attendee asked whether a deep tunnel option is feasible if the cross-harbour section is not linked to the East Rail. MTRCL explained that either railway line (East Kowloon Line or existing East Rail) would need to get down 80m for the Deep Tunnel option. The railway would need to be 50m below ground at Hung Hom and the interchange would still be inconvenient to the passengers whichever line crosses the harbour.

2. An attendee enquired if twin tunnels would be used by the MTRCL, with one for the up track and the other one for the down track, and commented that the 10m diameter tunnel for one track would be quite big. MTRC advised that two separate tunnels would be required, one for each track. The 10m diameter was required to accommodate not only the train but also the tunnel ventilation duct, evacuation walkway and various tunnel and railway systemwide services.

3. An attendee pointed out that it was mentioned in the presentation that a cross passage was required approximately every 250m. He asked what is the required cover and separation between the tunnels. MTRCL stated that 1-2 diameter cover should be provided for the tunnels and around 1-2 diameter separation should be maintained between tunnels.

4. An attendee asked if another tunnel could be constructed for the ventilation duct so that the diameter of the tunnel could be reduced to 6m or so. MTRCL advised that the external diameter of a tunnel without ventilation duct would be around 7.5m and would not change the SCL profile and construction difficulties very much. In addition it would require the use of a third tunnel which would increase the overall length of tunnel to be driven at significant depth. Additional difficulties would also be created with regard to cross connections between the ventilation tunnel and the running tunnel and connections to be provided for fireman's access and evacuation.

5. An attendee stated that the need for compressed air was related to the rock mass of the tunnel as well as permeability. If the alignment were deep enough, the rock mass would be less permeable allowing the use of lower air pressures. MTRCL advised that, as noted in the presentation, a tunnel wholly in rock (i.e. deep tunnel) would be approximately 80m deep which would provide unacceptably deep interchange stations.

6. An attendee pointed out that to minimize disturbance to the CBTS and the extent of reclamation (temporary or permanent), the CWB and SCL should be considered and planned together. He further enquired if the CWB and SCL tunnel would be constructed together at the area where the SCL passes above the CWB tunnels, and whether this had been included in the application of funding for the CWB project submitted to the Legislative Council. HyD advised that the CWB funding had included for the necessary protection works to enable the SCL tunnels above the CWB tunnels to be constructed at the same time as the CWB project. This could avoid repeated temporary reclamation in the overlapping area.

7. An attendee stated that Option 2 (i.e. Western Alignment) was a good way for highway and railway to work together. Since a section between the breakwater and intersection of CWB and SCL would need to be constructed subsequent to the completion of CWB, he suggested that MTRCL should investigate how it could be constructed at the same time as CWB to further reduce the 18 months' work duration after CWB completion. MTRCL advised that this was currently under investigation with the CWB project team but as was highlighted in the presentation, it was subject to a number of constraints. These included the provision of sufficient working and mooring spaces and navigation channels in the CBTS. Any temporary mooring arrangements would be subject to the agreement of the stakeholders and it was recognized that it was unlikely that any reduction in construction duration could be achieved without further moorings being reprovisioned out of CBTS during the construction period. The views of the users of the CBTS would have to be sought on these issues.

8. An attendee asked if any calculations of the not only fiscal, but also the wider social and environmental costs of various options had been conducted by MTRCL. MTRCL's view was that the economic and social implications of the eastern alignment options would be poorer than the western alignments. Firstly, they would cost more in capital cost and operating terms since they are longer. Secondly, the extra length means that the journey time for this alignment would be increased. This extra journey time has negative economic "value of time" implications.

9. An attendee stated that the SCL definitely had an overriding public need. He enquired if the completion date of 2019 had already been fixed and if not, he asked why earlier authorization could not be obtained to advance the project. He was also interested in what procedures needed to be followed to enable the SCL and CWB projects to be constructed to together with a view to minimizing the overall duration of construction. MTRCL advised that the 2019 date for completion was a target set by Government. The actual completion date would be dependent on the outcome of the CWB funding application and the ongoing detailed liaison between the SCL and CWB projects teams to determine how the construction of the two projects could best be integrated with the aim of reducing the overall duration. Once all the views had been obtained and considered, a Cogent and Convincing Materials Report for the SCL would be prepared and published. This would be followed by gazettal of the SCL project. After the SCL scheme is authorized and funding approved, construction of the SCL works could commence. This would be after the CWB construction had commenced although it would still be at an early stage of construction.

10. The same attendee enquired about the relationship between the 1.5 years extra duration and the 2.2 hectares of temporary reclamation. MTRCL advised that the 2.2 hectares was the estimated amount of temporary reclamation required from just north of the breakwater to the landfall on Hong Kong Island. It was considered to be the minimum necessary to enable safe and efficient construction of the SCL tunnels in this area by cut and cover methods. It did, however, assume that full use could be made of the temporary reclamation constructed under the CWB project to construct the SCL tunnels above the CWB tunnels by the CWB project. If this cannot be achieved, the area of SCL temporary reclamation and construction duration would be increased.

11. Some queries / suggestions regarding other non-Cross Harbour sections of SCL / rail operation were raised which did not have a specific impact on the selection of the SCL across the Harbour:
    - Pedestrian connectivity between Exhibition Station and Causeway Bay.
    - Pedestrian connectivity between Hung Hom Station and Tsim Sha Tsui East / Hong Kong Polytechnic University

CBTS Stakeholder Briefing cum Forum

Date : 6 July 2009
Time: 6.30pm – 8.30pm
Venue: Room 201, The Duke of Windsor Social Service Building, 15 Hennessy Road, Wan Chai, Hong Kong

Major Views/Questions Raised:

Many attendees agreed that there was an overriding public need for the SCL, and that there was no reasonable "zero reclamation" option. The attendees were concerned about the additional duration of the construction works in the CBTS due to the SCL project. Some suggested that the SCL alignment should be shifted westward to avoid passing through the CBTS. They expressed their views that there should be proper protection to the vessels inside the typhoon shelter.

1. Some attendees asked whether SCL and CWB works in CBTS would be carried out concurrently or separately, and expressed concern about the prolonged impact due to the SCL work. They also raised concern about navigation channel and reprovisioning arrangements during construction, and the protection to moorings when construction was in progress through the existing breakwater. MTRCL and HyD replied that part of the SCL works would be carried out concurrently with CWB works, and the last section of the western alignment would require approximately 18 months to construct after completion of the CWB works. The reprovisioning arrangements to facilitate this construction sequence were being studied. The forum was intended to gather opinions and consultation would be on-going afterwards.

2. Some attendees suggested that the SCL alignment be shifted westward to avoid passing through the CBTS. MTR and HyD replied that there were many constraints which dictated the alignment of the SCL Cross Harbour Section. These included the existing Cross Harbour Tunnel, existing buildings, location of HUH, existing rail service etc., and these prevent a practical alignment to the west of the CBTS.

3. An attendee asked whether the area of the CBTS would be reduced after the CWB and SCL works. HyD replied that all the temporary reclamation would be removed upon completion of the works and the typhoon shelter would be reinstated without reduction in area.

4. An attendee asked if anchoring on the seabed above the completed tunnels would be prohibited. HyD/MTRCL replied that there would be sufficient soil cover and protection above the tunnels for anchoring.

5. An attendee raised concern about the ecological and fisheries impacts due to dredging work, and considered that the "no reclamation" options should be pursued. MTRCL stated that the Environmental Impact Assessment was being carried out as a statutory requirement and the ecological and fisheries impacts would be assessed.

Presentation to The Hong Kong Institute of Planners

Date : 5 August 2009
Time: 7:00pm – 8:30pm
Venue: Room 804, Stanhope House, 734-738 King's Road, Quarry Bay, Hong Kong

Major Views/Questions Raised:

Attendees agreed that there was an overriding public need for the SCL. The general view was that it would benefit the residents in the New Territories who had been waiting for a more direct cross-harbour transport link for a long time, and that the existing cross-harbour rail lines were very congested. They did not object to the findings that there was no reasonable "zero reclamation" option.

1. An attendee raised a concern about whether the SCL could be integrated with the CWB so as to minimize the impact to the CBTS, and whether the works in the CBTS would affect the sea-front enhancement proposals. MTRCL replied that close coordination with CWB was on-going to develop a scheme that could minimize disruption to the CBTS. In order that no additional vessels would be relocated out of the CBTS, a section of the SCL tunnel had to be constructed after completion of the CWB construction and this would take 18 months more. The temporary reclamation in the CBTS would be removed following the SCL tunnel construction and there would be no permanent impact to the harbour-front.

2. An attendee asked by how long the duration of works in the CBTS could be shortened. MTRCL replied that detailed coordination with CWB was in progress with the objective of developing a reasonable scheme that would minimize disruption to the CBTS.

3. An attendee asked whether the SCL could connect to Fortress Hill or North Point instead. HyD replied that the majority of people would go to the Central Business District and the Island Line would have insufficient capacity to cope with passengers who crossed the harbour and wished to journey to these areas from Fortress Hill or North Point. A more direct route would be more suitable to save the journey time.

4. Some queries regarding other non – Cross Harbour sections of SCL / rail operation were raised:
   - Provision of stations at Central and Causeway Bay
   - Connection between Kai Tak Station and the future stadium
   - Underground Street at Causeway Bay
   - Increase in construction cost due to the vast number of infrastructure projects

Presentation to The Chartered Institute of Logistics and Transport in Hong Kong

Date : 18 August 2009
Time: 6:30pm – 8:00pm
Venue: Room Y302, Hong Kong Polytechnic University, Hung Hom

Major Views/Questions Raised:

Attendees agreed that there was an overriding public need for the SCL. It would be beneficial to residents in New Territories that there would be a direct route to cross the harbour. They did not object to the findings that there was no reasonable "zero reclamation" option.

1. An attendee asked whether the immersed tube tunnel section above sea bed would be regarded as reclamation, and whether there would be impacts to the marine life. MTRCL advised that the use of the harbour would not be affected as the top of the SCL tunnel would still be well below sea level and the section above seabed would be clear of the existing fairway. MTRCL stated that an EIA was being conducted to assess the possible impacts and propose mitigation measures.

2. An attendee asked how the East Rail Line would be modified to suit the SCL Cross Harbour Section alignment. MTRCL stated that a section of the East Rail Line to the north of HUH Station would be lowered to enable it to pass under the harbour.

3. An attendee suggested that the toll for the three vehicular cross harbour tunnels be evened to resolve the traffic congestion problem instead of building the SCL. MTRCL and HyD replied that the SCL could provide more transport benefits than just relieving the existing cross harbour road tunnels. It would also relieve future congestion on the existing railway network including the existing cross harbour section of the Tsuen Wan Line.

Presentation to The Hong Kong Institute of Architects

Date : 19 August 2009
Time: 6:30pm – 8:00pm
Venue: 19/F, One Hysan Avenue, Causeway Bay, HK

Major Views/Questions Raised:

Attendees agreed that there was an overriding public need for the SCL. They did not object to the findings that there was no reasonable "zero reclamation" option.

1. An attendee enquired about the works to the existing CBTS breakwater, and asked the views of providing a temporary breakwater to the north to enlarge the typhoon shelter. MTRCL replied that a small part of the breakwater needed to be demolished for SCL tunnel construction and it would be reinstated afterwards. Temporary seawalls would be in place to the north of the existing breakwater throughout tunnel construction period to ensure protection of the vessels in the CBTS. The provision of a temporary breakwater would also require more temporary reclamation in addition to the 2.2 ha. This could not be justified under the PHO.

2. An attendee asked whether there was any permanent reclamation other than the reinstated fender pile. MTRCL replied that the fender pile was the only element under SCL Cross Harbour Section that was considered as permanent reclamation.

3. An attendee asked why the completion date would be in 2019. MTRCL responded that the SCL would be completed in two phases. The East West Line would be completed earlier but the Hung Hom to Admiralty Section would have to be completed later due to the complicated interfaces with Central – Wan Chai Bypass and Wan Chai Development Phase II projects.

4. An attendee asked whether the SCL could connect to Fortress Hill or North Point. MTR replied that the majority of people would go to the Central Business District and the ISL would have insufficient capacity to cope with the additional numbers of passengers crossing the harbour who wished to journey to these areas from Fortress Hill or North Point. A more direct route would be more suitable to save the journey time.

5. Some queries / views regarding other non – Cross Harbour sections of SCL / rail operation were raised:
   - Provision of stations at Central and Causeway Bay
   - Design of ADM extension
   - Design of Kai Tak Station to integrate with the future surrounding

Public Forum (New Territories)

Date : 24 August 2009
Time: 8:00pm – 10:00pm
Venue: North District Town Hall, 2 Lung Wan Street, Sheung Shui, NT

Major Views/Questions Raised:

Most attendees showed support to the SCL project as it would provide a direct route from northern NT to HK Island and many of them urged for earlier completion of the Cross Harbour Section. The attendees considered that reclamation should be minimized and understood close coordination with interfacing projects would be necessary. Some had no preference on the alignment options of the Cross Harbour Section and would support the one that could be completed earliest. It was suggested that there should be thorough consultations with green groups / harbour protection concern groups so as to streamline implementation (and thus timely completion) of the SCL.

1. Some attendees queried why the completion date would be as late as 2019, and asked if the two phases of SCL could be implemented together. HyD advised that the Cross Harbour Section would have to be completed later due to the complicated interface with Central – Wan Chai Bypass and Wan Chai Development Phase II projects.

2. Some queries / views regarding other non – Cross Harbour sections of SCL / rail operation were raised:
   - Capacity of 9-car train for East Rail Line after completion of SCL
   - Automatic platform gates at East Rail Line stations
   - Provision of stations at Central and Causeway Bay
   - Extension of SCL Tai Wai to Hung Hom Section across the harbour instead of East Rail Line
   - Early implementation of North Island Line and Northern Link
   - Feeder services to villages
   - Interchange capacity and arrangement at Hung Hom Station and Admiralty Station
   - Energy conservation

Public Forum (Kowloon)

Date : 29 August 2009
Time: 2:00pm – 4:00pm
Venue: Henry G. Leong Yaumatei Community Centre, 60 Public Square Street, Yau Ma Tei, Kowloon

Major Views/Questions Raised:

Most attendees expressed general support for the SCL Cross Harbour Section and they requested the completion of the SCL Cross Harbour Section before 2019 as they have been expecting SCL for a long time. They did not object to the findings that there was no reasonable “zero reclamation” option. It was noted that the western alignment was preferable as it could be completed earlier.

1. Some attendees asked if the two phases of SCL could be implemented together. MTRCL advised that the Cross Harbour Section would have to be completed later due to the complicated interface with Central – Wan Chai Bypass and Wan Chai Development Phase II projects. MTRCL stated that public support would be of paramount importance for early completion of the SCL.

2. Some queries / views regarding other non – Cross Harbour sections of SCL / rail operation were raised:
   - Capacity of 9-car train for East Rail Line after completion of SCL
   - Automatic platform gates at East Rail Line stations
   - Provision of stations at Central and Causeway Bay
   - Extension of SCL Tai Wai to Hung Hom Section across the harbour instead of East Rail Line
   - Implementation of North Island Line
   - Interchange capacity and arrangement at Hung Hom Station and Admiralty Station
   - SCL platform and track arrangement
   - Impact on Police Officers’ Club
   - Progress of Environmental Impact Assessment

Public Forum (HK Island)

Date : 1 September 2009
Time: 8:00pm – 10:00pm
Venue: The Duke of Windsor Social Service Building, 15 Hennessy Road, Wan Chai, Hong Kong

Major Views/Questions Raised:

Most attendees expressed general support to SCL Cross Harbour Section. They did not object to the findings that there was no reasonable "zero reclamation" option. An attendee opined that all works within CBTS (i.e. SCL plus CWB) should be carried out by one single Contractor in order to complete the works on time, and to minimize disruption to CBTS.

1. An attendee considered that the CBTS breakwater should be moved outward in order to increase the size of the typhoon shelter for the better enjoyment of the harbour and to minimize temporary reclamation. MTRCL and HyD advised that the permanent reclamation for a new breakwater could not be justified under the SCL as it could not satisfy the requirements of the Protection of the Harbour Ordinance. It would also not reduce the extent of temporary reclamation required inside the CBTS.

2. Some attendees asked why the remaining part of the SCL tunnel needed to be completed 18 months after CWB completion, if the two projects could be carried out concurrently. MTRCL and HyD stated that there had been close coordination among departments regarding the interface between the CWB and SCL. The primary aim was not to move any more moorings out of the CBTS during the construction period. This constrains the length of the SCL that can be constructed concurrently with the CWB which in turn constrains how fast the works can be constructed.

3. Some attendees expressed concern on the mooring reprovisioning arrangement during SCL construction. They opined that their moorings should be reprovisioned within CBTS in order to minimize impact to their business. MTRCL replied that the reprovisioning of the PMA users adopted in the CWB project would be followed. Further discussion on the reprovisioning of the other vessels inside the CBTS would be carried out.

4. Some queries / views regarding other non – Cross Harbour sections of SCL / rail operation were raised:
   - Connectivity at Exhibition Station and Admiralty Station to the harbour-front and to nearby community
   - Capacity of 9-car train for East Rail Line after completion of SCL
   - Provision of station at Causeway Bay
   - Implementation of North Island Line
   - Reprovisioning of facilities affected by Exhibition Station
   - Works area at Harbour Road Garden
   - Aesthetic design of stations
   - Design of Diamond Hill Stabling Sidings
   - Water quality at Causeway Bay Typhoon Shelter
   - Extension of SCL Tai Wai to Hung Hom Section across the harbour instead of East Rail Line
   - SCL Victoria Park option in RDS-2000

CBTS Stakeholder Briefing cum Forum (PMA users)

Date : 9 November 2009
Time: 8:00pm – 9:00pm
Venue: 8/F, Auditorium, The Hong Kong Federation of Youth Groups Building, 21 Pak Fuk Road, North Point, Hong Kong

Major Views/Questions Raised:

The PMA users expressed no particular concern on the possible postponement of their return to the CBTS for a period of up to 18 months after completion of the CWB. Some of them were concerned about whether they would be able to moor in the same location when they returned.

1. An attendee asked whether the construction work would start after gazette, whether the affected mooring users would be informed before the commencement of construction and how to determine which moorings are to be moved away from the CBTS permanently. MTRCL replied that construction work would normally start approximately one year after gazettal. Part of the SCL works would be carried out under the CWB project, and part would be constructed within the 6-year duration of CWB construction. The remaining part would be constructed during an 18 months period after CWB completion. On-going communication with the mooring users would be conducted to understand their concerns and to keep them advised of progress on construction. MTR clarified that no moorings would be permanently moved away from the CBTS due to the SCL.

2. An attendee asked if the area of the CBTS would be reduced. MTRCL and HyD replied that the temporary reclamation would be removed after completion of CWB and SCL projects, and the CBTS would be reinstated.

3. An attendee asked whether the construction barges would obstruct the navigation channels for other vessels. MTRCL replied that sufficient and safe navigation channels would be provided in the CBTS to ensure normal operation and safety during construction.

4. An attendee queried whether his vessels which were moored at the southwest corner of the CBTS would be affected and asked for the reprovisioning arrangement. MTRCL replied that some moorings at the southwest corner would likely be affected by the SCL work, and the reprovisioning arrangement, would be discussed with them during the subsequent detailed design stage.

5. Some attendees expressed concerns on the reprovisioning arrangement under the CWB project. MTRCL responded that the forum was to seek the views of mooring users about the time to return to the CBTS during the 18-month period of SCL works after CWB completion. MWPMO of HyD and Marine Department were responsible for their temporary reprovisioning under the CWB project.

Presentation to Hong Kong Construction Association

Date : 20 November 2009
Time: 2:30pm – 4:30pm
Venue: 16/F, 180-182 Hennessey Road, Wan Chai, Hong Kong

Major Views/Questions Raised:

The attendees agreed that there was an overriding public need for the SCL. They did not object to the findings that there was no reasonable “no reclamation” option. The principal observation was that the CWB and SCL works within the CBTS should be integrated as far as possible and suggested that consideration be given to entrusting all of the SCL works within the Causeway Bay Typhoon Shelter to the Central – Wan Chai Bypass project.

1. An attendee said he understood that the Tuen Mun – Chek Lap Kok Link opted for a deep bored tunnel due to environmental concerns and asked how the environmental issues associated with dredging for IMT construction inside the harbour could be addressed. MTRCL replied that an Environmental Impact Assessment was being carried out to study the potential impacts and determine necessary mitigation measures. The vertical alignment had been determined to minimize the volume of dredging required.

2. An attendee asked whether the overriding public need for Cross Harbour Section would be based to the revenue generated. MTRCL replied that the overriding need was not related to financial return, but the actual need of the community, e.g. relieving the congestion of existing railway lines, especially the cross harbour section of the Tsuen Wan Line.

3. An attendee asked whether any potential site for casting IMT units been identified. MTRCL replied that the use of Shek O Quarry as the casting yard was under investigation, and consultation with the Southern District Council would be conducted.

4. An attendee asked how the contract for the Cross Harbour Section would be procured. MTRCL replied that this would be studied in the detailed design stage.

Second Professional Forum

Date : 4 December 2009
Time: 2:30pm – 4:00pm
Venue: 28/F, The Park Lane Hong Kong, 310 Gloucester Road, Causeway Bay

Major Views/Questions Raised:

The attendees generally agreed with the scheme presented at the forum and the findings on the duration and the extent of temporary reclamation. They recognized the coordination work that had taken place between the SCL and CWB projects.

1. An attendee considered that the coordination issue between SCL and CWB seemed to have been resolved, and asked if there would be any chance to further shorten the programme. MTRCL replied that the SCL programme would be dependent on the CWB construction programme and the SCL statutory procedures (e.g. gazettal, EIA). The 18-month period beyond the CWB completion date was a genuine estimate of the duration taking into account the sequence of work and the disruption to the typhoon shelter caused by both projects.

2. An attendee asked if the temporary working platform supported on piles adjacent to the piled cofferdam at the Hung Hom landfall could be adopted for the cut-and-cover tunnel section in the CBTS instead of the proposed vertical seawalls and temporary reclamation. MTRCL stated that the area of temporary reclamation required would be similar whichever method was deployed in the CBTS. Temporary reclamation similar to that adopted by CWB had been proposed within the CBTS taking account of the depth of excavation, marine traffic in the CBTS, and the need to construct the tunnel through the breakwater.

3. An attendee queried about the public engagement plan after the forum. MTR advised that the Cogent and Convincing Materials Report that summarized the public's views received over the past 6 months was under preparation and would be made public. The SCL would then be gazetted and the public could formally express their views during the gazettal process.

4. An attendee raised a concern over the aggregate impacts resulting from the occupation of the harbour-front as works area by several railway projects. MTRCL advised that this was a necessary part of construction but these areas would not be occupied for longer than necessary. Public access to the harbour-front would also be maintained wherever possible. It was recognized that the permanent use of these areas would be determined by the Government but MTRCL were willing to carry out any long term works to these areas on Government's behalf.

5. Some queries regarding other non – Cross Harbour sections of SCL / rail operation were raised:
   - Impact on Longjin Bridge at Kai Tai
   - Provision of Central South Station
   - Location of EXH and the future HKCEC Phase 3

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Agreement No. CE 43/2010(HY)

Annex H

Central Kowloon Route
中九龍幹線

Cogent and Convincing Materials for
Temporary Reclamation at Kowloon Bay

February 2013

路政署
Highways Department

Highways Department

Agreement No. CE 43/2010 (HY)
Central Kowloon Route –
Design and Construction

Cogent and Convincing Materials for Temporary Reclamation in Kowloon Bay

217722-REP-044-02

Revised Final | February 2013

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Appendices

1 INTRODUCTION

Background

1.1 Central Kowloon Route (CKR) is a 4.7 km long dual 3-lane trunk road across central Kowloon linking West Kowloon at Yau Ma Tei Interchange with the Kai Tak Development and road network at Kowloon Bay in East Kowloon. **Figure 1-1** shows the layout plan and longitudinal section of CKR.

1.2 In the investigation and preliminary design stage in 2007 to 2009, we reviewed over 40 alignment options in the previous CKR studies. The present alignment was selected after comparing the impacts of the various options on buildings/community facilities, environment, land and transport and making reference to public comments collected in the public engagement exercise. The selected alignment was generally supported by Legislative Council, Yau Tsim Mong, Kowloon City and Kwun Tong District Councils.

Underwater Tunnel in Kowloon Bay

1.3 A 370 m long section of the CKR tunnel between the Kowloon City Ferry Pier to the Kai Tak Development Area will pass through the seabed of Kowloon Bay. Due to various site constraints, it will have to be constructed using the temporary reclamation method.

Figure 1-1 – Alignment of CKR

Protection of the Harbour Ordinance (PHO)

Presumption against Reclamation

1.4 The PHO originally resulted from a private member's bill proposed in 1996 by the Society for Protection of the Harbour. The bill was first enacted as the original Ordinance in June 1997 and was then modified in the course of the legislative process. The PHO provides protection and preservation of the harbour by establishing a presumption against reclamation. In December 1999, the Ordinance was further amended to its present form by expanding its scope to cover the whole of Victoria Harbour.

1.5 Section 3 of the Ordinance states:

(1) The harbour is to be protected and preserved as a special public asset and a natural heritage of Hong Kong people and for that purpose there shall be a presumption against reclamation in the harbour. [Section 3(1)]

(2) All public officers and public bodies shall have regard to the principle stated in subsection (1) for guidance in the exercise of any powers vested in them. [Section 3(2)]

1.6 The PHO specifically defines the term "reclamation" as "any work carried out or intended to be carried out for the purpose of forming land from the sea-bed or foreshore". The definition of "reclamation" in the PHO is specific to the formation of land, implying works that exceed the sea level. It is considered that even smallscale reclamation required for the construction of piers, landing steps, etc. should also comply with the PHO.

Judgment of Court of Final Appeal (CFA) in Town Planning Board v Society for Protection of the Harbour Ltd. (on 9 January 2004)

1.7 The Town Planning Board made decisions on the Draft Wan Chai North Outline Zoning Plan (OZP) (No. S/H25/1), in December 2002 and February 2003, that included proposals for reclamation within Victoria Harbour. This was challenged in the legal system by the Society for Protection of the Harbour on the grounds that the Town Planning Board made decisions that were unlawful and/or unreasonable and irrational.

1.8 The appeal was dismissed in the judgment of the CFA handed down on 9 January 2004. The CFA held that –

(a) in order to implement the strong and vigorous statutory principle of protection and preservation, the presumption against reclamation must be interpreted in such a way that it can only be rebutted by establishing an overriding public need for reclamation. This can conveniently be referred to as "the overriding public need test";

(b) where there is a reasonable alternative to reclamation, an overriding need for reclamation would not be made out. There would be no such overriding need since the need could be met by the alternative means; and

(c) the extent of the proposed reclamation should not go beyond the minimum of that which is required by the overriding need.

1.9 Public needs would be community needs. They would include the economic, environmental and social needs of the community. A need should only be regarded as overriding if it is a compelling and present need. The need has to be compelling so that it has the requisite force to prevail over the strong public need for protection and preservation. The need has to be a present need in the sense that taking into account the time scale of planning exercises, the need would arise within a definite and reasonable timeframe. If the need would not arise over such a timeframe, it would not have the strength to displace the presumption. A compelling and present need goes far beyond something which is "nice to have", desirable, preferable or beneficial. But on the other hand it is not a last resort or something that the public “cannot do without”. A present need takes into account the timescale of planning exercises, and the need would arise within a definite and reasonable time frame.

1.10 The judgment further states that where there is a reasonable alternative to reclamation, an overriding need for reclamation would not be made. All circumstances should be considered including the economic, environmental and social implications of each alternative. The cost as well as the time and delay involved would be relevant. The extent of the proposed reclamation should not go beyond the minimum of that which is required by the overriding need. Each area proposed to be reclaimed must be justified.

1.11 In order to enable a public officer or body to be satisfied that the overriding public need test has been met, the materials in the case in question must be cogent and convincing.

Court of First Instance Judgment in Society for Protection of the Harbour v Secretary for Justice (on 20 March 2008)

1.12 Government proposed to construct the Central-Wan Chai Bypass (CWB) along the north shore of Hong Kong Island to relieve the traffic congestion along the existing east-west corridor. The cut-and-cover tunnel of CWB in the ex-Public Cargo Working Area in Wan Chai and the Causeway Bay Typhoon Shelter would be constructed using temporary reclamation. The temporary reclamation works were expected to last about six years. Upon completion of construction, the temporary reclamation would be removed and the sea-bed would be reinstated. Government considered that the temporary reclamation would not be subject to the requirements of the PHO.

1.13 The Society for Protection of the Harbour applied to the High Court on the grounds that the PHO did not differentiate in specific terms between reclamation that is intended to result in permanent land formation and temporary reclamation. The Society for Protection of the Harbour sought a declaration that even reclamation works that are intended to be transitory, or even intended to avoid the very need for permanent reclamation, are nevertheless subject to the presumption against reclamation and may not lawfully be carried out unless it can be demonstrated that they are necessary by meeting the “overriding public need test”.

1.14 The Court of First Instance ruled in favour of the Society and declared that the PHO and the presumption against reclamation do apply to the proposed temporary reclamation for CWB.

Report Structure

1.15 This Report includes the CCM for demonstrating that the proposed temporary reclamation in Kowloon Bay for constructing the underwater tunnel of CKR complies with the requirements of the PHO. It has been prepared in accordance with Housing, Planning and Lands Bureau Technical Circular No. 1/04 issued by the then Housing, Planning and Lands Bureau on 19 August 2004 to provide guidance for public officers and public bodies in considering and approving reclamation proposals including information on the public consultation process for such proposals.

1.16 The contents of the subsequent chapters of this Report are as follows –

(a) **Chapter 2** presents information and assessment supporting the overriding public need for the CKR project;

(b) **Chapter 3** shows that there are no reasonable alternatives to the proposed temporary reclamation in Kowloon Bay;

(c) **Chapter 4** shows that the extent of the proposed temporary reclamation will be the minimum;

(d) **Chapter 5** describes the public consultation conducted on the temporary reclamation and summarizes the feedback from the public; and

(e) **Chapter 6** provides the conclusion on the temporary reclamation and describes the recommended scheme.

2 OVERRIDING PUBLIC NEED

Introduction

2.1 The guidelines provided in HPLB TC No. 1/04 have been referred to with regard to the approach taken for assessing the overriding public need for the project. The Technical Circular states that the first step is to establish if there is a compelling and present public need for the project. The term “public needs” is defined as economic, environmental and social needs of the community. It is taken that community refers to the greater need of the public rather than meeting the special needs or interests of a few.

2.2 The term “compelling” is defined in HPLB TC 1/04 as having the requisite force to prevail over the strong public need for protection and preservation of the harbour. This is required to be supported by cogent and convincing materials (such as findings of studies, forecasts, costs and benefit analysis, etc.) that support the overriding need for reclamation aspects of the project.

2.3 The term “present need” is defined as time scale requirements and demonstrating that the need would arise within a definite and reasonable time frame. To satisfy this, there must be a concrete programme of implementation and firm commitment from the concerned government departments, with endorsement by relevant authorities, as applicable.

2.4 The following describes the compelling and present public need for the CKR and the benefit it will provide to the community of Hong Kong.

Traffic Justifications

(A) Overview

2.5 The traffic on existing major east-west link in Kowloon, including Lung Cheung Road, Boundary Street, Prince Edward Road West, Argyle Street, Waterloo Road, Gascoigne Road Flyover and Chatham Road North is nearing saturation and traffic congestion frequently occurs. The Government has implemented local traffic management and improvement measures. However, since the areas on both sides of the existing east-west corridors are highly developed, there is little or no room for improvement. As a result, these measures can only alleviate local traffic problems in the short term.

2.6 CKR is a proposed dual 3-lane trunk road across central Kowloon linking the West Kowloon in the west and the proposed Kai Tak Development in the east. Its western end at West Kowloon would connect to Yau Ma Tei Interchange and via the interchange traffic could access to Western Harbour Crossing, Tsim Sha Tsui, West Kowloon Cultural District, West Kowloon Highway, Route 8, and Route 3 respectively. Its eastern end at Kai Tak area, would connect to Kowloon Bay, Kowloon East, Kwun Tong Bypass, Tseung Kwan O Tunnel, T2, and Tseung Kwan O Lam Tin Tunnel respectively. CKR together with T2 and Tseung Kwan O Lam Tin Tunnel would form a strategic highway link, namely Route 6, connecting West Kowloon and TKO.

2.7 With the substantial developments in West Kowloon Cultural District and Kai Tak Development at the west and east ends of CKR respectively, the completion of these developments in stages, their traffic impacts to the strategic east-west link roads and the critical junctions within Kowloon area would be significant.

2.8 The need for a direct traffic route linking West and East Kowloon was identified two decades ago under numerous studies to cater for the cross-Kowloon traffic demand and to relieve the congestion on the existing traffic routes in central Kowloon. In the intervening years, traffic volume has grown and cross-Kowloon traffic demands have increased as a result of developments in West Kowloon, Kowloon Bay and Tseung Kwan O. The need to provide a relieving west-east route has become a priority to road users and the public at large and the provision of CKR should meet the need. In addition, the proposed developments at Kai Tak, Anderson Road and the West Kowloon Cultural District as shown in **Figure 2-1** will no doubt further increase the demand for such a link.

Figure 2-1 – Proposed Development in Kowloon East and West

2.9 The road traffic between West and East Kowloon is currently served by Lung Cheung Road, Boundary Street, Prince Edward Road, Argyle Street, Waterloo Road and Chatham Road North. Apart from Lung Cheung Road and Gascoigne Road Flyover, these existing east-west road links have capacities constrained by frequent frontage access and signal controlled junctions, which are constraining the traffic flows. Based on the comprehensive traffic surveys conducted in 2011, a baseline review on the performance of existing junctions and road as well as the existing traffic issues have been summarised. It is also noted in the 2011 Annual Traffic Census that over 60% of vehicular traffic travelling between east and west of Kowloon (crossing the Screenline A-A in **Figure 2-2**) are commercial vehicles (i.e. taxi, public light buses, goods vehicles, coaches and buses).

Figure 2-2 – Level of Services of Existing Routes in Kowloon

2.10 It was determined that, the existing major east-west running road corridors (Lung Cheung Road, Prince Edward Road West and Boundary Street) in Kowloon have long been plagued by the problem of inadequate traffic capacities. It can be partly attributed to the increase in property developments on both the western part (e.g. West Kowloon Reclamation, Lantau) and the eastern part (e.g. Tseung Kwan O) of the Kowloon Peninsula and the New Territories in recent years, without an upgrade in west-east traffic capacity of a comparable scale. Some examples of traffic congestion are shown in **Figure 2-3**.

Figure 2-3 – Existing Traffic Conditions at Central and West Kowloon

2.11 Many of these road corridors have already reached their traffic-carrying capacities during peak travel hours. For example, the traffic flows of Prince Edward Road West and Boundary Street during peak hours in a single direction can reach volume-to-capacity ratios of 0.8 and 1.1 respectively, indicating that they are already operating close to or above capacity. The volume-to-capacity ratio between West Kowloon and East Kowloon, for year 2011, is summarised in **Table 2-1** below.

Table 2-1 Performance of Critical East-West Kowloon Roads in 2011

Road	Direction	V/C Ratio 2011 (Existing)	
		AM	PM
Lung Cheung Rd (from Lion Rock Tunnel Rd to Chuk Yuen Rd)	EB	0.9	0.8
	WB	0.9	0.9
	WB (slip road from Chuk Yuen Road)	0.9	0.6
Boundary St (from Tai Hang Tung Rd to Embankment Rd)	EB	**1.0**	**1.1**
Prince Edward Rd West (from Embankment Rd to Kadoorie Ave)	WB	0.8	0.7
Argyle St & FO (from Gullane Rd to Tin Kwong Rd))	EB	0.8	0.9
	WB	0.8	0.8
Waterloo Road (from Pitt Street to Dundas Street)	NB	0.9	1.0
	SB	0.9	0.7
Gascoigne Road Flyover (Eastern side of Nathan Road)	EB	0.8	**>1.3**
	WB	**1.2**	**1.1**

Road	Direction	V/C Ratio	
		2011 (Existing)	
		AM	PM
Chatham Road North (from Wuhu St to Ping Chi Street)	EB	**1.1**	**1.1**
	WB	0.8	1.2
	WB (farside free flow lane)	**1.3**	0.4
East Kowloon Corridor (from Ma Tau Kok Rd to Chatham Rd North)	EB	1.0	**1.1**
	WB	0.8	0.6

Note:
Volume to capacity (v/c) ratio is an indicator which reflects the performance of a road. A v/c ratio equal to or less than 1.0 means that a road has sufficient capacity to cope with the volume of vehicular traffic under consideration and the resultant traffic will flow smoothly. A v/c ratio above 1.0 indicates the onset of congestion; that above 1.2 indicates more serious congestion with traffic speeds deteriorating progressively with further increase in traffic.

2.12 CKR will provide an alternative route for the traffic to bypass the congested road network thus significantly reducing the journey time. For example, it is estimated that during the peak hours in 2021, the journey time between west and east Kowloon via CKR would take around only 5 minutes, compared to 30-35 minutes without CKR. CKR will also substantially reduce the traffic volumes around major east-west corridors and relieving their traffic congestion. The improved traffic conditions will also benefit the adjacent areas including Wong Tai Sin, Ho Man Tin and Kowloon City.

2.13 CKR will also connect with the high speed roadways on both sides of Kowloon to form the key component of a strategic road network. In this regard, the Kai Tak Interchange on the eastern side will connect CKR with the road network in Kowloon Bay, Kwun Tong and Kai Tak Development thus enhancing the convenience of travelling between these areas and West Kowloon and providing the transport infrastructure for supporting the Energizing Kowloon East initiative introduced by the Government. CKR together with the proposed Trunk Road T2 at Kai Tak Development and Tseung Kwan O – Lam Tin Tunnel will form Route 6 with a total length of 12.5 km that will directly link up West Kowloon and Tseung Kwan O.

2.14 The Yau Ma Tei Interchange located on the western side will provide comprehensive slip roads connecting West Kowloon Highway and Lin Cheung Road. Vehicles can use West Kowloon Highway to access Hong Kong Island in the south, Kwai Tsing Container Terminal and Hong Kong International Airport in the west as well as Northwest New Territories in the north. Vehicles can also access the West Kowloon Development Area, West Kowloon Terminus of Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL) and West Kowloon Cultural District through Lin Cheung Road.

2.15 The following summarises traffic issues within East, West and Central Kowloon.

(B) Traffic Situation in West Kowloon

2.16 The total traffic flows observed at the junctions (e.g. Austin Road West / Austin Road / Canton Road, Lin Cheung Road / Jordan Road and Canton Road / Wui Cheung Road) within West Kowloon area are generally more critical during the weekday peak periods due to the traffic to/from newly residential and office developments. At the more critical junctions, some of the queues are mainly extended from the downstream junction, e.g. the traffic queue at Jordan Road eastbound at Jordan Road/ Ferry Street/ Canton Road junction has extended to Lin Cheung Road/ Jordan Road junction during Saturday Noon peak period.

2.17 From the result of road link capacity assessment at Gascoigne Road, the long traffic queue at both Gascoigne Road Flyover eastbound and westbound has also affected the actual demand of vehicles that can pass through that section of road. From the observation, the maximum queue at Gascoigne Road Flyover eastbound and westbound would be up to Waterloo Road and Fat Kwong Street, respectively.

(C) Traffic Situation in Central Kowloon

2.18 The road network in the Central part of Kowloon Peninsula is characterised by essentially a grid format made up of east-west and north-south running roads. Of particular concern in the current study are the roads higher in the road hierarchy system, i.e. trunk roads, primary distributors and district distributors, which have the important role of providing high throughput capacity for cross-district traffic.

2.19 While some of the above roads are classified as primary distributors with the planning intention of serving mostly cross-district traffic, in reality a significant portion of traffic on these roads is local district traffic.

2.20 Most of the junctions within the Central Kowloon district are generally more critical during the weekday peak periods (e.g. J/O Austin Road / Chatham Road South / Cheong Wan Road, J/O Argyle Street / Nathan Road, J/O Argyle Street / Waterloo Road / Princess Margaret Road, J/O Argyle Street / Sai Yee Street and J/O Chatham Road North / Wuhu Street). The queue length results also indicated that most of the critical east-west road arms such as Prince Edward Road West and Boundary Street would have longer queue length than weekend peak periods.

2.21 Long traffic queue was also observed at the J/O Argyle Street/ Sai Yee Street and the J/O Argyle Street/ Yim Po Fong Street. Based on the observation, traffic queue at Sai Yee Street northbound at the J/O Sai Yee Street/ Mong Kok Road would affect the actual demand of vehicles that can pass through the junction at Sai Yee Street northbound at the J/O Argyle Street/ Sai Yee Street during weekday and weekend periods. With the effect of the traffic queue, the calculated R.C. at this junction during weekend period is higher than weekday period. With similar situation at the J/O Argyle Street/ Yim Po Fong Street, the traffic queue at Argyle Street westbound at the J/O Argyle Street/ Sai Yee Street would also affect the actual demand of vehicles that can pass through the junction at Argyle Street westbound at the J/O Argyle Street/ Yim Po Fong Street. The short distance of carriageway of Argyle Street between Sai Yee Street and Yim Po Fong Street is also one of the constraints in the road network that exacerbate the issue with traffic queue.

2.22 The results of journey time survey have also indicated that the average speed along the critical roads (i.e. Boundary Street, Prince Edward Road West, and Jordan Road) at Central Kowloon area were travelling slower than other critical road links during both AM and PM peak periods. This is mainly affected by junction stoppages (e.g. J/O Ferry Street / Waterloo Road and J/O Argyle Street / Tong Mi Road) and frontage accesses.

(D) Traffic Situation in East Kowloon

2.23 The road network in East Kowloon is characterised by a series of major road corridors closely spaced apart running in a northwest-southeast orientation (Kai Tak Tunnel-Kai Fuk Road corridor, Kwun Tong Bypass, Prince Edward Road East-Kwun Tong Road corridor, and Clear Water Bay Road) intersected more-or-less perpendicularly by three strategic links, namely Lung Cheung Road, Tseung Kwan O Tunnel and Eastern Harbour Crossing, and a number of roads lower in the road hierarchy. Of particular relevance to the current study of Trunk Road T2 are the aforementioned northwest-southeast major road corridors, as T2 is running in the same orientation and could possibly offer traffic relief impacts on these roads. Separately, roads and junctions within Kowloon Bay will be of relevance to the study of roads and development at the Kai Tak South Apron as these would be the immediate connecting links between the South Apron and the areas outside Kai Tak.

2.24 The junctions within the East Kowloon area are mainly critical during the weekday peak hour periods due to the traffic from the industrial and office developments. However, as indicated in the junction capacity assessment results, these critical junctions would still operate at an acceptable level of operation during weekday peak periods except the J/O of Wai Yip Street / Wai Fat Road are likely to perform with overloaded reserve capacity due to the heavy traffic flow from Kwun Tong Bypass access through this junction toward Kwun Tong and Lam Tin area during weekday peak periods.

(E) Network Reliability

2.25 There was a major incident of scaffolding collapse at Prince Edward Road East shown in **Figure 2-4**, which is one of the most important West and East corridors, on 9 May 2005 that led to severe traffic congestion in the whole Kowloon area.

Figure 2-4 – Scaffolding Collapse at Prince Edward Road East on 9 May 2005

2.26 The proposed CKR can serve as an emergency corridor for eastbound and westbound traffic in Central Kowloon. As discussed in the “Report of the Task Force on Emergency Transport Coordination” in June 2005, the eastbound and westbound traffic in Central Kowloon was severely affected due to inclement weather condition. The task force also commented that the north-south bound traffic in Kowloon is more developed yet the east-west bound roads are inadequate. They considered that there is a need to increase the capacity for east-west bound traffic.

(F) Traffic Management Schemes

2.27 The Government has implemented local traffic management and improvement measures. However, since the areas on both sides of the existing east-west corridors are highly developed, there is little or no room for improvement. As a result, these measures can only alleviate local traffic problems in the short term. To effectively resolve the east-west traffic problems in Central Kowloon, CKR should be commissioned as soon as possible to provide an alternative route to bypass congested road sections and increase the capacity for east-west movement.

(G) Traffic Forecasts

2.28 Traffic studies have long predicted the consequences of continued traffic growth along the major east-west corridors without the implementation of CKR. The traffic forecast for year 2021 have also confirmed the need for the trunk road after taking into account the latest land use planning assumptions and population projections, to ensure that traffic forecasts are in line with the current strategic and local planning intentions. The Third Comprehensive Transport Study (CTS 3), Base District Transport Model (BDTM) as well as Territorial Population and Employment Data Matrices (TPEDM) have been referenced to examine the traffic conditions at the strategic and local levels, for the cases with and without the implementation of CKR.

2.29 The future traffic condition, as shown in **Figure 2-5**, is expected to be worsening in 2021 without CKR in place. **Table 2-2** below summarises the road link performance for the scenario with and without CKR in 2021.

Figure 2-5 – Year 2021 Traffic Conditions in East and West Kowloon

Table 2-2 Performance of Critical East-West Kowloon Roads in 2021

Road	Direction	V/C Ratio			
		2021 Without CKR		2021 With CKR	
		AM	PM	AM	PM
Lung Cheung Rd (from Lion Rock Tunnel Rd to Chuk Yuen Rd)	EB	**1.2**	**1.1**	0.9	1.0
	WB	1.0	1.0	0.9	0.8
	WB (slip road from Chuk Yuen Road)	**1.1**	0.6	0.9	0.5

Road	Direction	V/C Ratio			
		2021 Without CKR		2021 With CKR	
		AM	PM	AM	PM
Boundary St (from Tai Hang Tung Rd to Embankment Rd)	EB	**1.2**	**1.3**	0.9	0.9
Prince Edward Rd West (from Embankment Rd to Kadoorie Ave)	WB	**1.1**	0.8	0.9	0.7
Argyle St & FO (from Gullane Rd to Tin Kwong Rd))	EB	**1.1**	1.0	0.7	0.7
	WB	**1.1**	0.9	0.7	0.8
Waterloo Road (from Pitt Street to Dundas Street)	NB	1.0	0.9	1.0	0.9
	SB	**1.2**	0.8	**1.1**	0.7
Gascoigne Road Flyover (Eastern side of Nathan Road)	EB	**1.3**	**>1.3**	**1.1**	**1.2**
	WB	**1.3**	**1.3**	**1.1**	**1.2**
Chatham Road North (from Wuhu St to Ping Chi Street)	EB	**1.3**	**1.2**	**1.1**	1.0
	WB	1.0	**1.2**	1.0	0.7
	WB (farside free flow lane)	**1.3**	0.9	**1.1**	**1.1**
East Kowloon Corridor (from Ma Tau Kok Rd to Chatham Rd North)	EB	**1.3**	**1.3**	**1.1**	**1.1**
	WB	0.7	0.7	**1.1**	1.0
Central Kowloon Route	EB	-	-	0.6	0.7
	WB	-	-	0.7	0.6

Note:
Volume to capacity (v/c) ratio is an indicator which reflects the performance of a road. A v/c ratio equal to or less than 1.0 means that a road has sufficient capacity to cope with the volume of vehicular traffic under consideration and the resultant traffic will flow smoothly. A v/c ratio above 1.0 indicates the onset of congestion; that above 1.2 indicates more serious congestion with traffic speeds deteriorating progressively with further increase in traffic.

2.30 In general, it is expected that the level of service of those existing main routes is "F", i.e. "Crawling Travel Speed" if there is no CKR in 2021 whereas the level of service will be improved to "D", ie. "Reduced Travel Speed" as shown in **Figure 2-2**.

2.31 For Reserve / Capacity ratio (R/C) at major junctions, **Table 2-3** below and **Figure 2-6** summarises the performance for the existing, with and without CKR scenario in 2021.

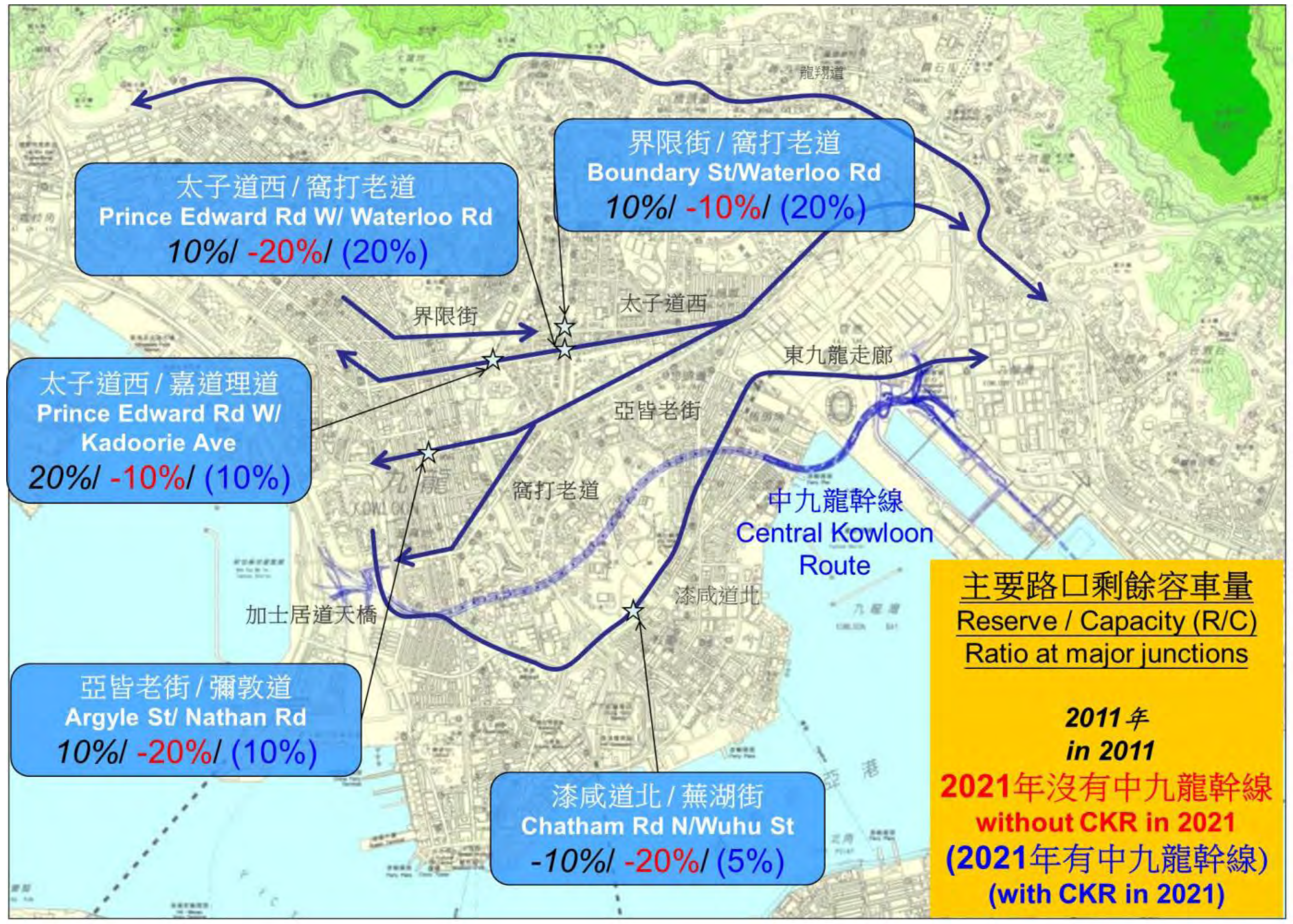

Figure 2-6 – Reserve / Capacity (R/C) Ratio at Major Junctions in Kowloon

Table 2-3 Performance of Critical Junctions

Road Junction	At 2011	At 2021 without CKR	At 2021 with CKR
Boundary Street / Waterloo Rd	10%	-10%	20%
Prince Edward Road West / Waterloo Road	10%	-20%	20%
Prince Edward Road West / Kadoorie Ave.	20%	-10%	10%
Argle Street / Nathan Road	10%	-20%	10%
Chatham Road North / Wuhu Street	-10%	-20%	5%

2.32 It is observed that all R/C ratio become negative values if there is without CKR at 2021. It means the junctions do not have reserve capacity that implies the situation of traffic congestion is worsen.

(H) Conclusions

2.33 The existing east-west corridors serving Kowloon Central, East and West are operating beyond their capacity, as can be observed on site. Previous and recent strategic transport studies have predicted further increase in traffic demand along the east-west corridor, and confirmed the need for an additional east-west trunk road to avoid more extensive and frequent traffic congestion, and even gridlock, on the road network.

2.34 The traffic forecast for year 2021 has also confirmed that a dual 3-lane trunk road (such as CKR), together with connecting roads, is required to divert traffic away from the existing east-west corridor to provide adequate relief to the corridor and the local road network.

2.35 CKR is the strategic road network of Kowloon and will provide the essential east-west linkage between Kowloon East and Kowloon West. The implementation of CKR will relieve the existing congested east-west corridors of Kowloon. The anticipated travel time between Kowloon East and West is estimated to decrease from the ~30-35 minutes to ~5 minutes in 2021 with CKR.

2.36 The need for CKR has been clearly established through traffic and transport studies. The findings of the traffic and studies demonstrate conclusively the compelling and present need for CKR.

Benefits of the Project

(A) Economic Returns

2.37 Savings resulting from travel distance and travel time are the primary source of economic benefits from CKR. Direct benefits accrue to travellers to/from East-West Kowloon who enjoy both more direct and quicker journeys. Indirect benefits accrue to Central Kowloon traffic (for example across Waterloo Road) that enjoys higher travel speeds, and therefore reduced travel time, as traffic diverts from congested routes such as Argyle Street, Waterloo Road and Jordan Road onto the new CKR corridor. Although bus vehicle travel time savings are relatively smaller, the higher vehicle occupancy means that public transport travel time savings are a significant component of the overall time savings.

2.38 It is estimated that the journey time between West Kowloon and Kowloon Bay in the morning peak in 2021 would only take about 5 minutes resulting in a saving of 25 to 30 minutes as compared to that without CKR. CKR is more important if there is any serious traffic congestion resulting from blockage of any east-west corridor.

2.39 Time savings are converted into monetary values by multiplying the respective time savings in hours for each passenger group by that group's value of time (VOT). VOT therefore reflects the willingness to pay for an hour of time savings. The VOT for each passenger group is assessed based on Travel Characteristics Survey 2002 and inflated to current prices. It is estimated that by 2030, the daily travel time savings will reach 120 thousands passenger hours bringing an economic value of $2.6 billion per annum.

2.40 Accident benefits will arise as travellers are diverted to use tunnel from local roads. According to the accident statistics provided by the Transport Department, the accident rate per veh-km for tunnels is 85% lower than local road during 2006 – 2010.

2.41 Based on an assessment period of 48 years covering construction and operational periods and assuming the real discount rate, the CKR project is estimated to produce a positive Net Present Value (NPV) of $ 19,503 million with Economic Internal Rate of Return (EIRR) of 7.5% and Benefit Cost Ratio (BCR) of 1.8. It is clear from the analysis that the economic benefits from the development of CKR are sufficient to cover the economic costs and the CKR project is economically viable.

(B) Environmental Benefits

2.42 Some of the key east-west corridors in Kowloon are approaching or have exceeded their design capacities, resulting in traffic congestion and long traffic queues. The main objective of the proposed CKR is to relieve traffic congestion at peak hours on the existing east-west corridors, including the Lung Cheung Road, Boundary Street, Prince Edward Road West, Argyle Street, Waterloo Road, Gascoigne Road Flyover and Chatham Road North.

2.43 As the traffic on the existing major routes across Kowloon could be diverted by CKR, the traffic volume on at-grade corridors will be reduced. Pollution resulted from traffic congestion could therefore be alleviated and the environment would be improved.

2.44 With CKR in place, the traffic conditions (e.g. in terms of average travelling speed) along these key east-west corridors would be improved and this would lead to a reduction in the substances such as CO_2, NO_x and RSP released from vehicles.

2.45 Through the adoption of advanced technology like Air Purification System (APS), exhaust concentrations from the 3 ventilation buildings along CKR are largely decreased by the Electro-Static Precipitator (ESP) and NO_2 removal system.

2.46 The Year 2021 traffic forecast for the key east-west corridors has been input to EPD's latest EmFAC-HK v2.1 which has been implemented with the latest emission control measures. The same EmFAC model has been adopted in the CKR Environmental Impact Assessment (EIA). The EmFAC-HK model would consider a number of factors including traffic flow, travel speed, territory-wide Vehicle-Kilometre-Travelled (VKT), vehicular mix etc and estimate the total annual emissions of CO_2, NO_x and RSP from the road sections concerned. The following **Table 2-4** summarises the results.

Table 2-4 Estimation of Annual Emission for Key East-West Corridors

Substances from Vehicular Emission	Reduction by CKR at 2021[1], Ton / year
CO_2	Approx 20,000
NOx	Approx 18
RSP	Approx 2

[1] Considering key East-West Corridors ONLY

(C) Social Benefits

2.47 In the future when CKR is completed, there will be a reduction in journey time, which will improve the connection between districts supporting the social developments.

Conclusions

2.48 Since there is an urgent need for the construction of CKR to alleviate the existing traffic congestions, and since CKR can also improve the environment as well as yield economic and social benefits, there is an overriding public need for constructing CKR.

3 NO REASONABLE ALTERNATIVES TO RECLAMATION

Introduction

3.1 This chapter examines whether there are reasonable alternatives to the proposed temporary reclamation in Kowloon Bay for the construction of the underwater tunnel of CKR. We will first consider if the underwater tunnel for the selected alignment can be constructed using reasonable alternative methods that will not require temporary reclamation. We will then consider if there are alternative alignments that will not involve reclamation.

Constraints in Design and Construction Arrangements

Layout at Eastern End

3.2 As shown in **Figure 1-1**, the drill-and-blast tunnel of CKR starting from Yau Ma Tei and running through King's Park, Ho Man Tin and Ma Tau Wai will be constructed in bed rock about 40 m to 140 m below ground level to ensure that the construction and operation of CKR will not affect the structural integrity and normal use of the buildings along the tunnel alignment. As CKR will have to connect to the road network in Kowloon Bay and Kai Tak Development area, the vertical alignment will rise at 4% starting from the eastern side of Ma Tau Wai Road. The vertical profile of CKR beneath Kowloon Bay can be seen in **Figure 3-1**.

3.3 As the length of the section on 4% gradient exceeds 500 m, a climbing lane is provided for the eastbound carriageway starting at Lucky Building in accordance with relevant design standards for use by heavy vehicles. Furthermore, as the horizontal alignment of the section in Kowloon Bay is on a circular curve of 330 m radius, both the east bound and west bound carriageways have to be widened to a maximum of 3 m to provide adequate sight distances in accordance with design standards, which is the minimum requirement, and to ensure traffic safety.

3.4 With these geometric functional requirements and geological conditions, the need for a very deep and unusually wide tunnel section (approximately 47m to 58m) complicates the engineering design of the underwater tunnel and demands a very robust design scheme.

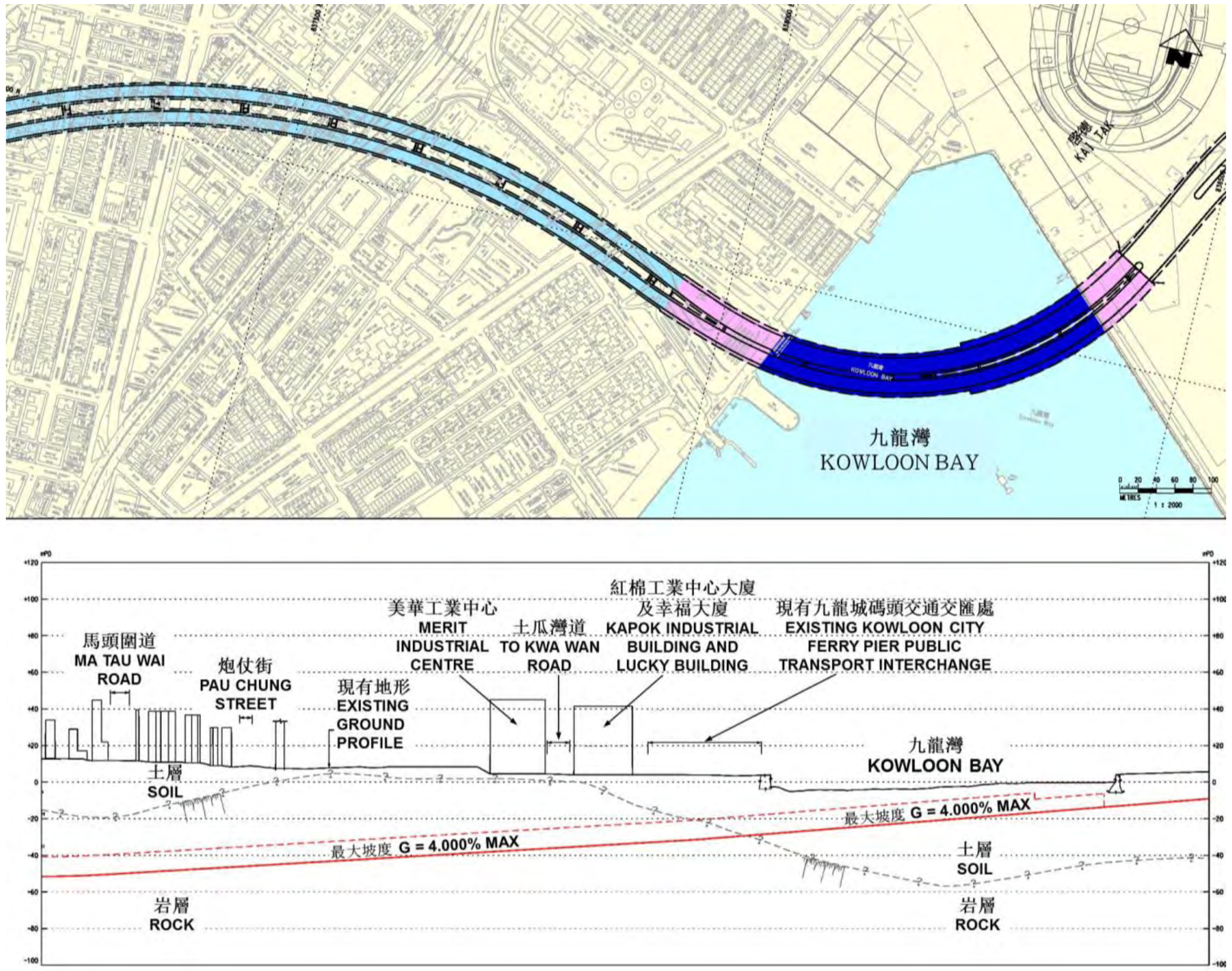

Figure 3-1 – Layout at Eastern End

Kowloon City Ferry Pier

3.5 The pier is currently used for the passenger ferry service between Kowloon City and North Point. Construction works will be carried out on the northern side of the pier. Suitable arrangements will be implemented so that normal ferry operation can continue during construction stage.

Ma Tau Kok Public Pier

3.6 The Ma Tau Kok Public Pier will have to be demolished to facilitate the construction of the underwater tunnel. The public pier will be re-provided temporarily at the waterfront promenade near King Wan Street during the construction period and reinstated upon the completion of the construction works.

Hong Kong & China Gas Company (HKCG) Naphtha Jetty

3.7 The jetty is currently used for off-loading naphtha delivered by ships and delivery to the nearby HKCG Ma Tau Kok Plant. According to HKCG, 36 shipments of naphtha are currently delivered each year. Marine access will have to be maintained during construction stage to continue normal shipment.

Construction Methods Not Involving Reclamation

3.8 We have considered whether the underwater tunnel can be constructed using the following methods that would not involve temporary reclamation –

(a) Immersed Tube Tunnel (IMT); and

(b) Tunnel Boring Machine (TBM).

(A) Immersed Tube Tunnel (IMT)

3.9 Under this method, a trench of about 220 m and 30 m deep will be excavated in the seabed along the tunnel alignment by dredging of marine mud as shown in **Figure 3-2**. The tunnel units (about 47 m to 58 m wide, and 16.5 m high) will be cast off site and floated to the tunnel site for sinking into pre-determined locations on the trench. The tunnel units will be joined. Upon the completion of jointing, the trench will be backfilled to the original seabed level. An IMT typical section and backfilling arrangement are shown in **Figure 3-3** and **Figure 3-4** respectively.

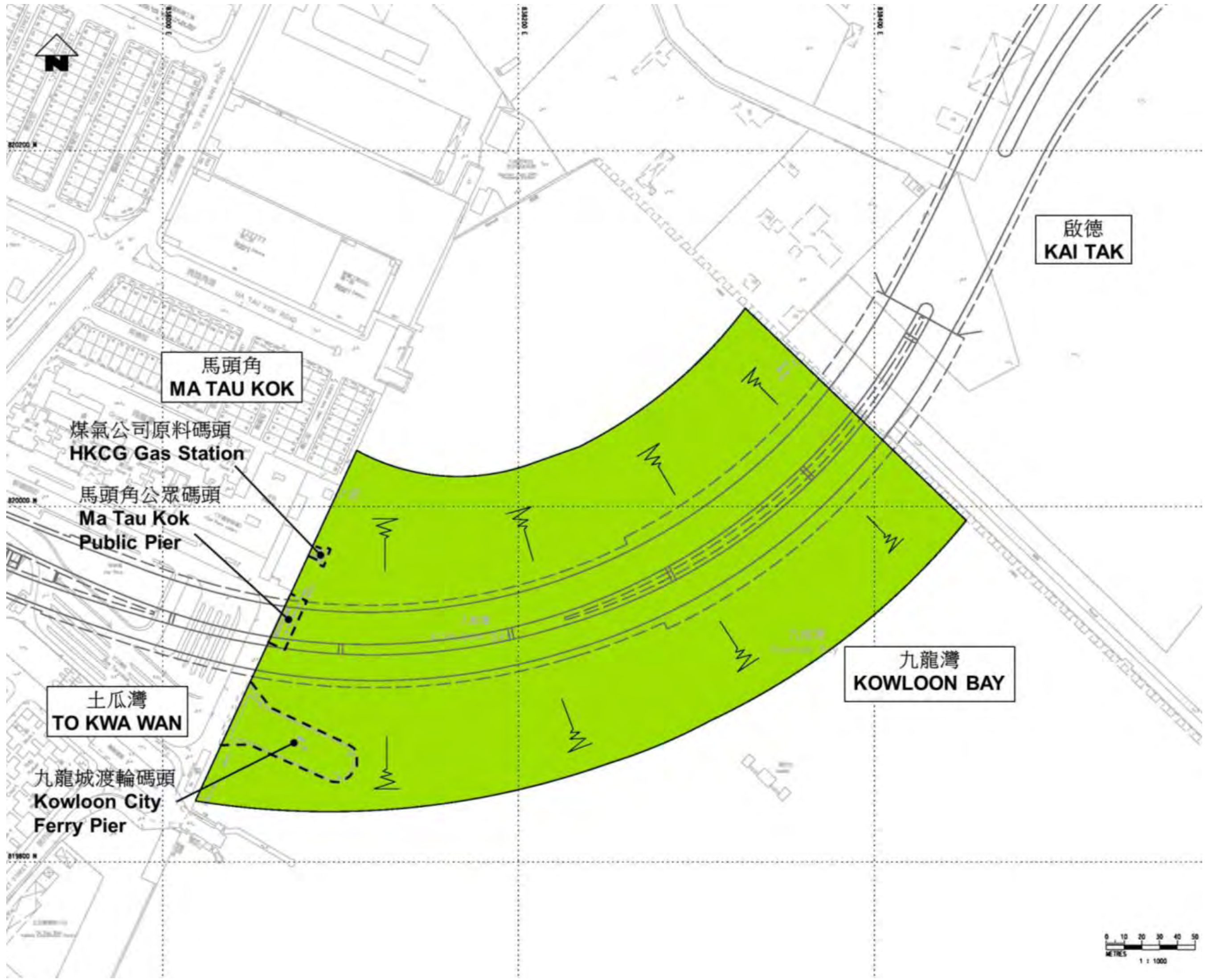

Figure 3-2 – Facilities Affected by Construction Works

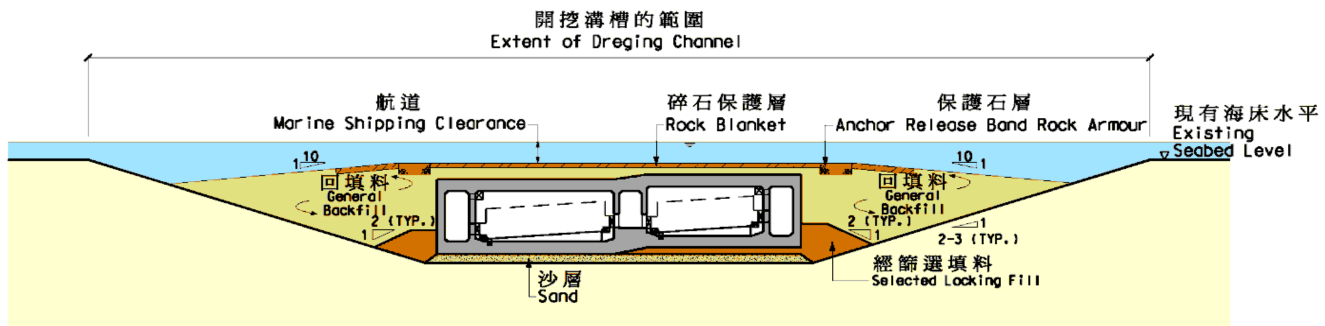

Figure 3-3 – Typical Section through Immersed Tube Tunnel (IMT)

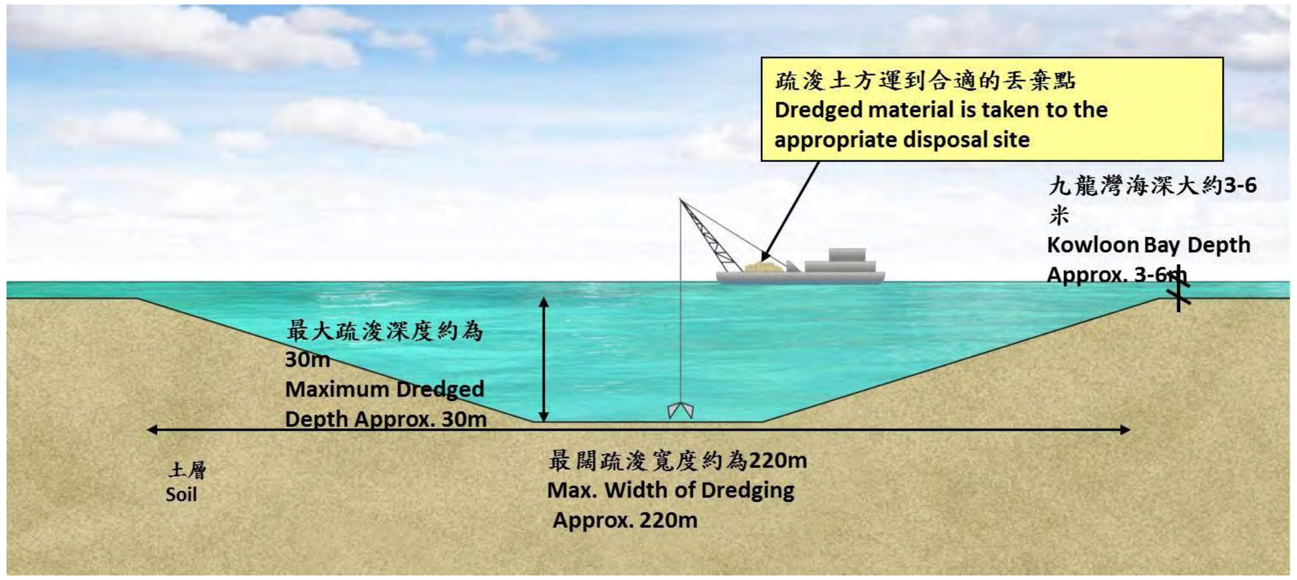

Figure 3-4 (a) Step 1 – Extensive Dredging of Existing Marine Sea Bed

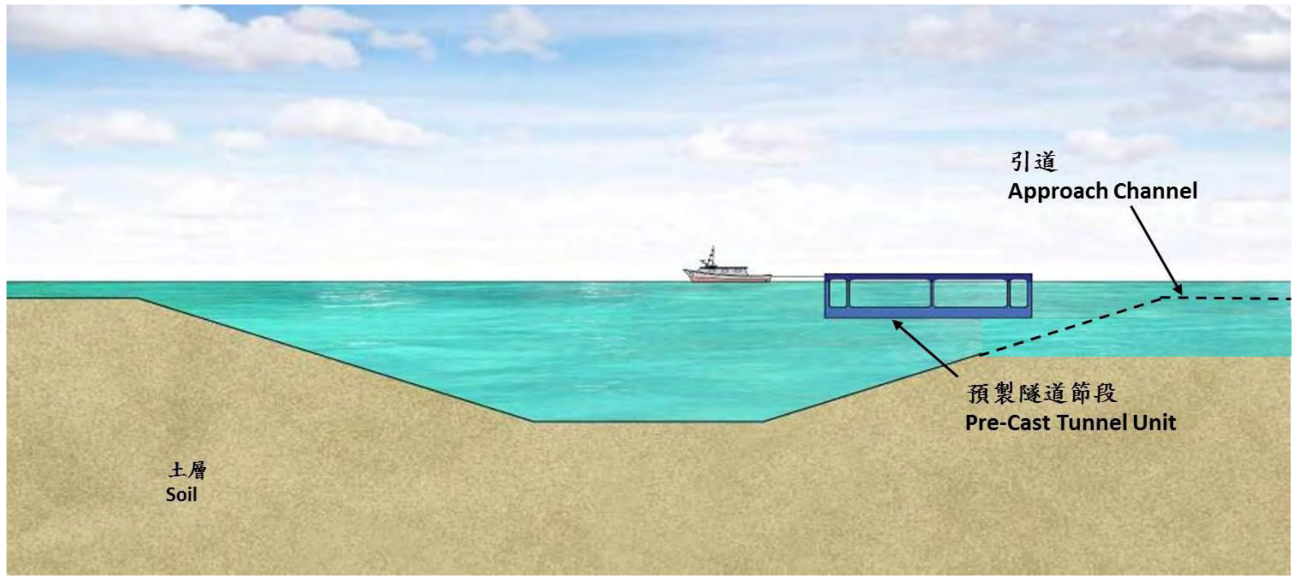

Figure 3-4 (b) Step 2 – Float Pre-Cast Tunnel Unit into Position

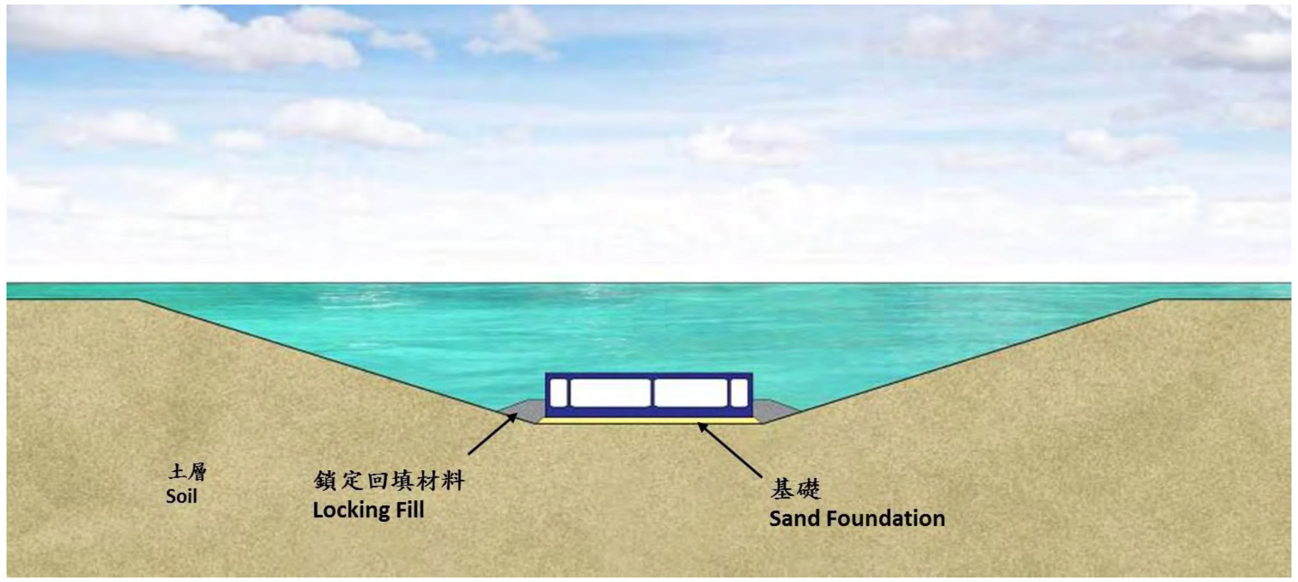

Figure 3-4 (c) Step 3 – Sink and Merge Pre-Cast Tunnel Units and Place Locking Fill

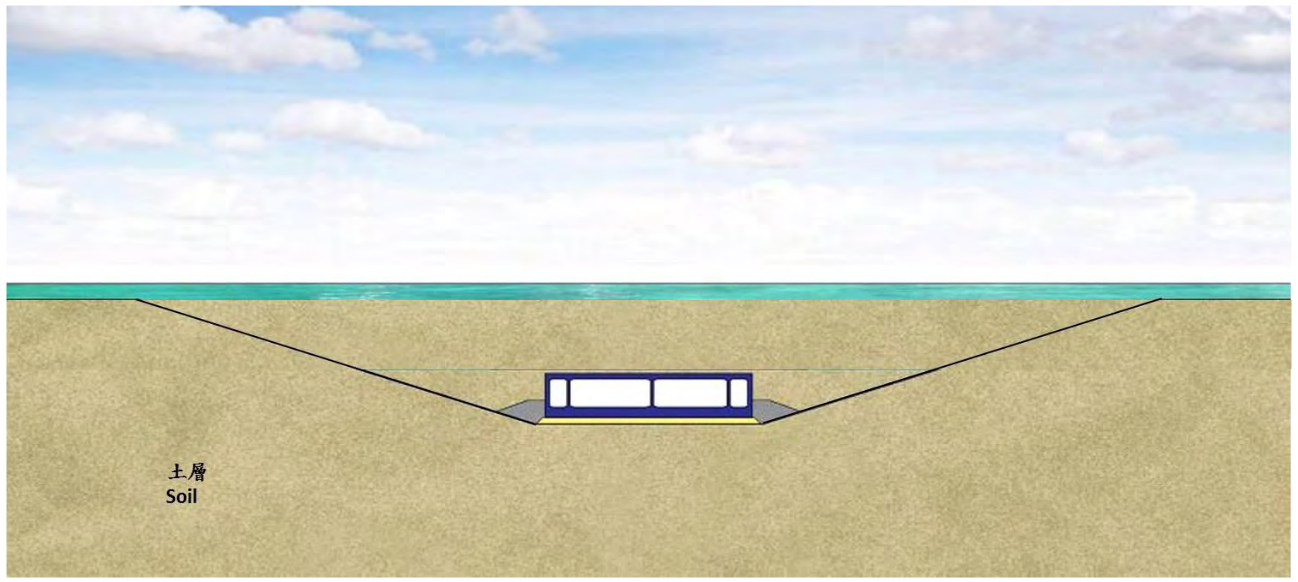

Figure 3-4 (d) Step 4 – Backfill Pre-Cast Units and Restore Sea Bed to Previous Conditions

3.10 An example of floating the immersed tunnel tube precast unit is shown in **Figure 3-5** for information.

Figure 3-5 – Example of Immersed Tube Tunnel (IMT)

3.11 The dredging of the trench for placement of IMT box will involve the removal and disposal of approximately 0.75 million m^3 of marine mud. Furthermore, as the sea in Kowloon Bay is only about 6m to 8m deep, an approach channel of about 1,300 m long, 150 m wide and 12 m deep will have to be formed adjacent to the tunnel site to provide sufficient draft for floating the precast units thus resulting in the dredging and disposal of approximately 1.8 million m^3 of marine mud in total, as shown in **Figure 3-6**.

Figure 3-6 – Dredged Trench and Approach Channel for IMT

3.12 The trench will also affect the structural integrity of the existing Ma Tau Kok and Kai Tak seawalls, and foundation of the private buildings adjacent to the seawall as shown in **Figure 3-7**. The jetty of Hong Kong China Gas Co for transporting raw materials and the Kowloon City Ferry Pier would also have to be relocated during the construction period.

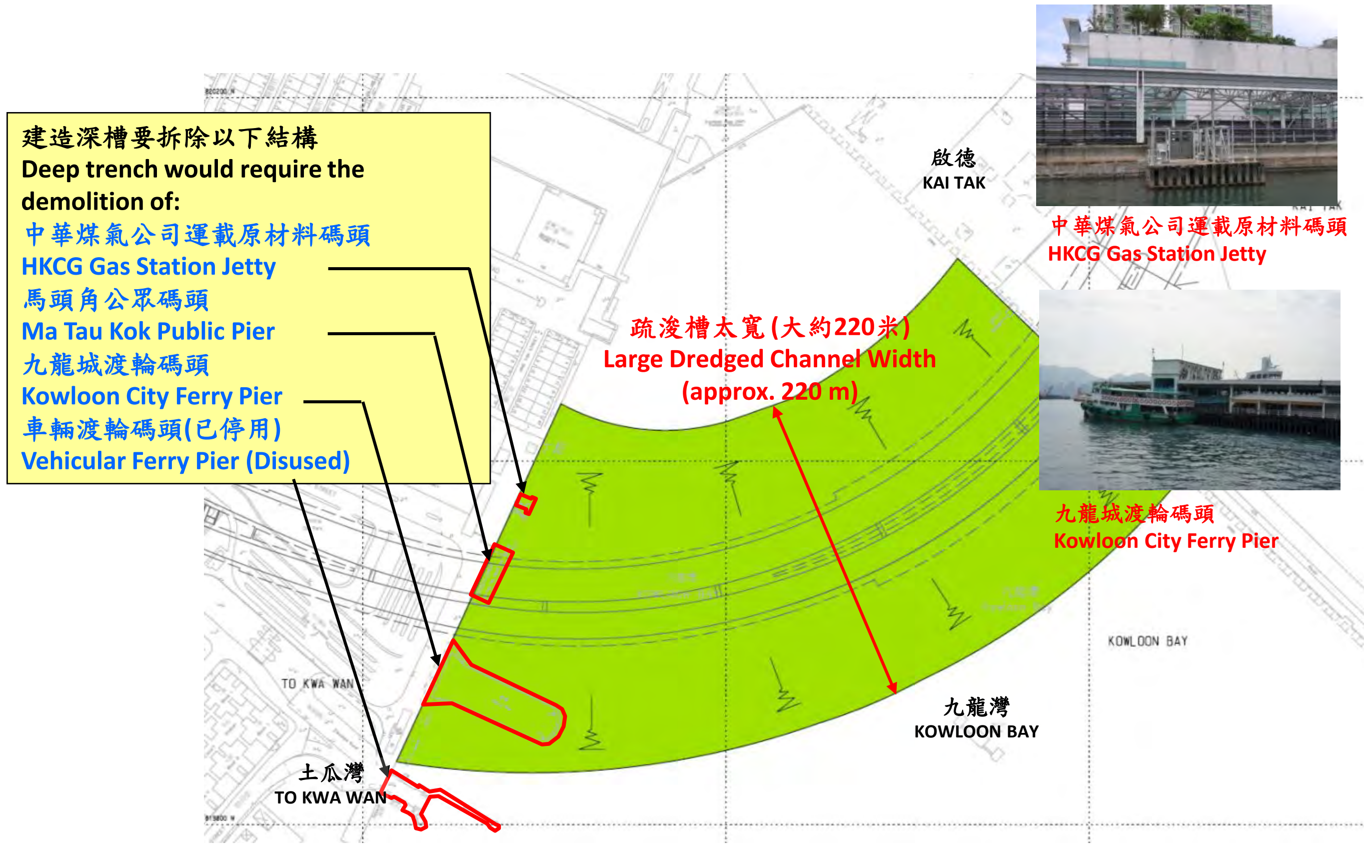

Figure 3-7 – Structure to be Affected by Trench Excavation for IMT

3.13 Given the large volume of marine mud that will have to be dredged to form the trench for placing the immersed tube units; the equally large volume of marine mud to be dredged for forming the approach channel for floating these units; and the impacts on the seawall, the adjacent private buildings, the HKCG jetty and operation of passenger ferry, IMT is therefore not a reasonable alternative.

(B) Tunnel Boring Machine

3.14 This method involves boring of circular tunnel section using Tunnel Boring Machine (TBM) through the stratum along the tunnel alignment. The bored tunnel surface will then be protected with concrete lining. An example of TBM is shown in **Figure 3-8** for reference.

Figure 3-8 – Tunnel Boring Machine (TBM)

3.15 Before the construction of the concrete lining, air pressure about 300 kPa to 500 kPa (or three to five times the atmospheric pressure) will have to be applied inside the tunnel to uphold the excavated face of the tunnel and to prevent the seepage of water into the tunnel. As such, sufficient soil cover will be required for containing the pressure inside the tunnel. The amount of cover required will depend on the ground conditions. Given the relatively low strength (undrained shear strength down to about 4kPa) of the soil in the seabed of Kowloon Bay the cover required will be about 1.5 times the diameter of the tunnel as illustrated in **Figure 3-9**. The diameter of the eastbound tunnel (with three traffic lanes and one climbing lane) will be 20.5 m. The diameter of the westbound tunnel (with three traffic lanes) will be 17 m. The cover required will be about 30.75 m and 25.5 m respectively.

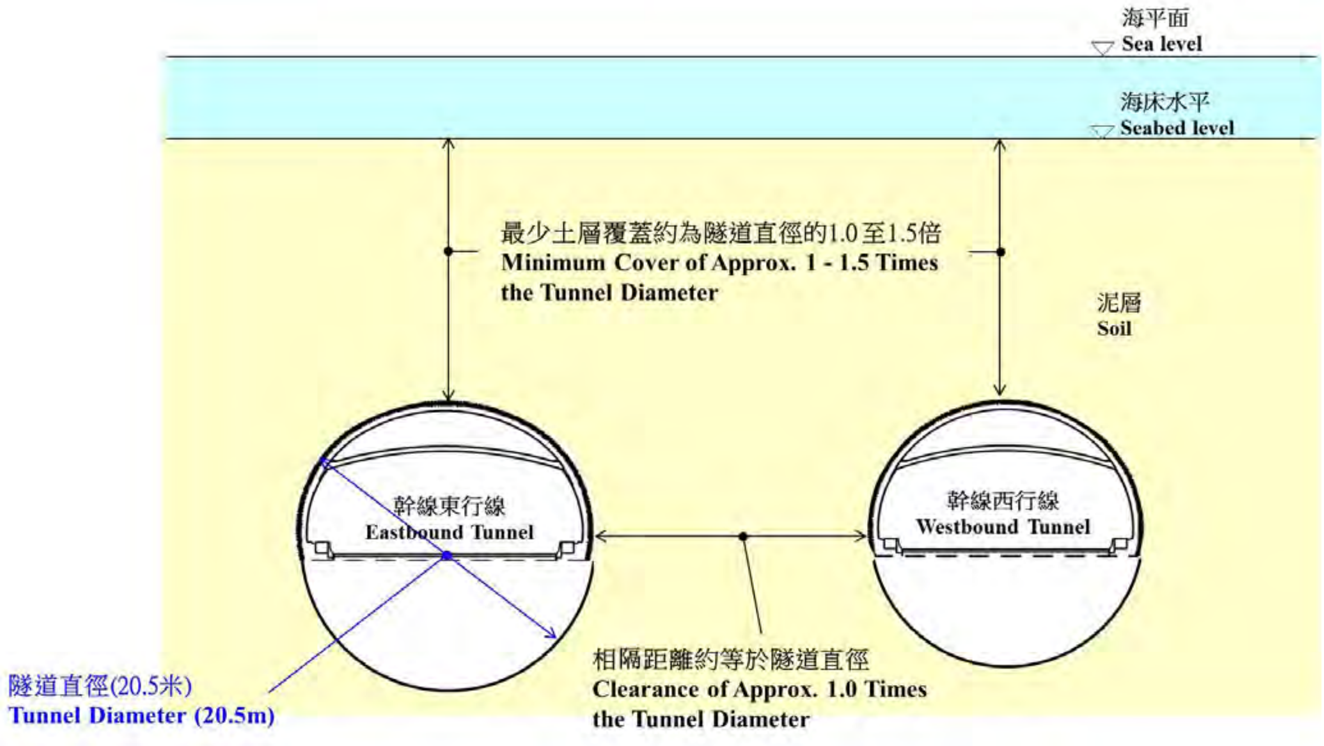

Figure 3-9 – Required Soil Cover for Tunnel Boring Machine

3.16 As the tunnel will have to gradually rise to ground level to connect to the road network in Kowloon Bay and KTD, the maximum soil cover will only be 17 m at the western end and the minimum soil cover will only be 2 m at the eastern end as illustrated in **Figure 3-10**. This will be less than 1.5 times the diameter of the tunnel.

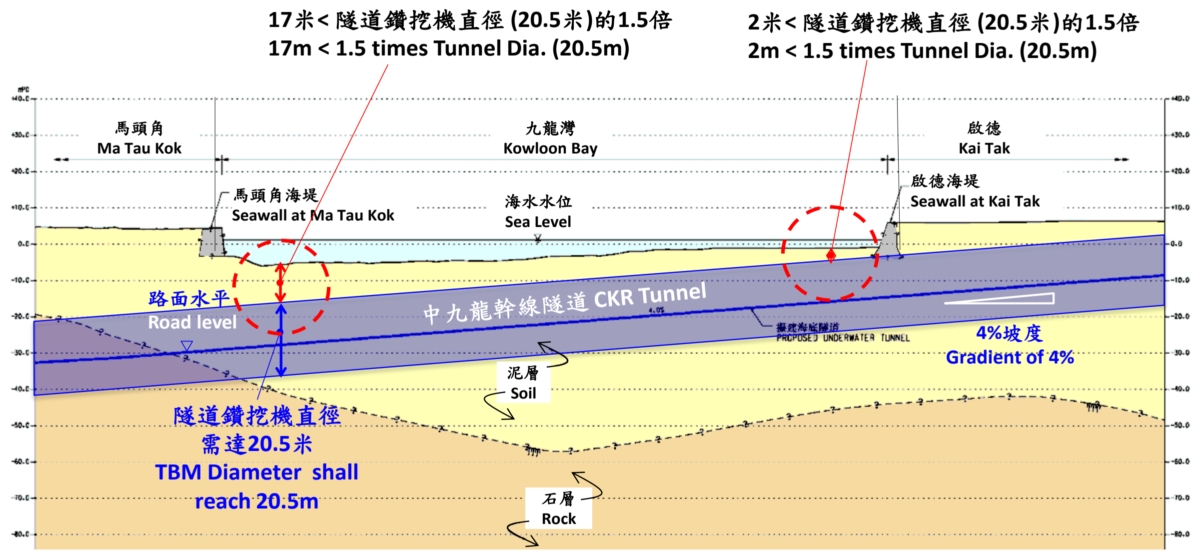

Figure 3-10 – Available Soil Cover at Kowloon Bay

3.17 The available soil cover would be inadequate for containing the air pressure that would be required for upholding the excavated tunnel face and preventing the seepage of ground water thus leading to blow out failure as illustrated in **Figure 3-11**.

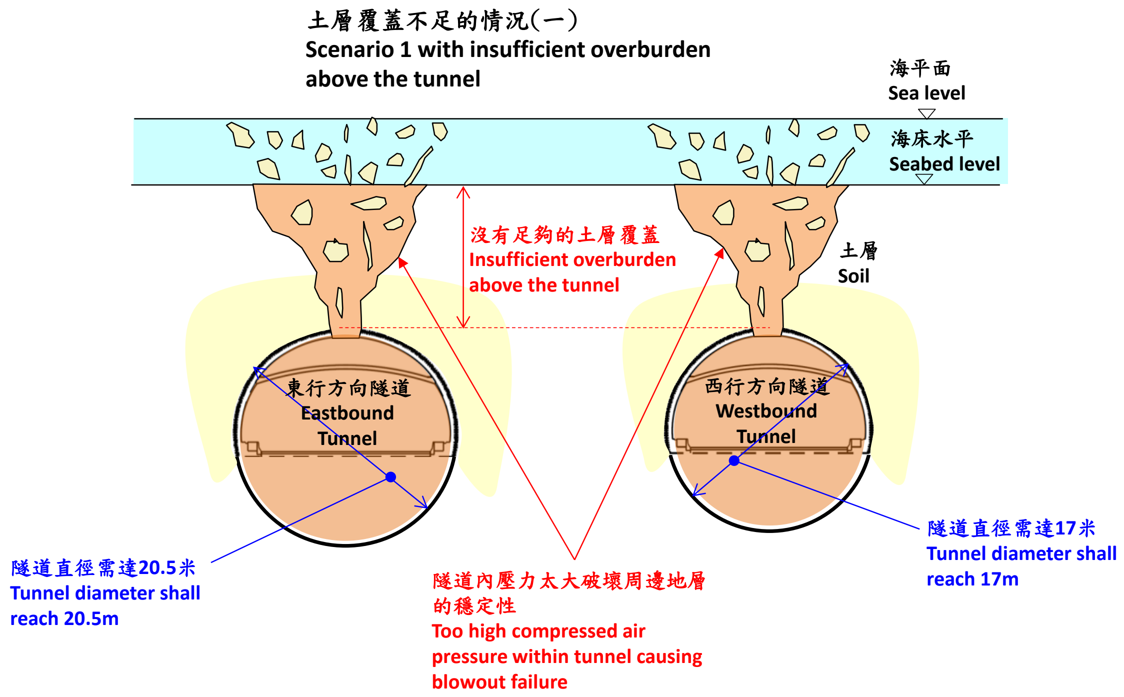

Figure 3-11 – Blow-out Failure Scenario

3.18 On the other hand, if the air pressure were reduced, the pressure would be insufficient for upholding the excavated sections and for preventing the seepage of ground water. As such, the tunnel could also fail because of the collapse of the excavated face and excessive seepage of ground water as illustrated in **Figure 3-12**.

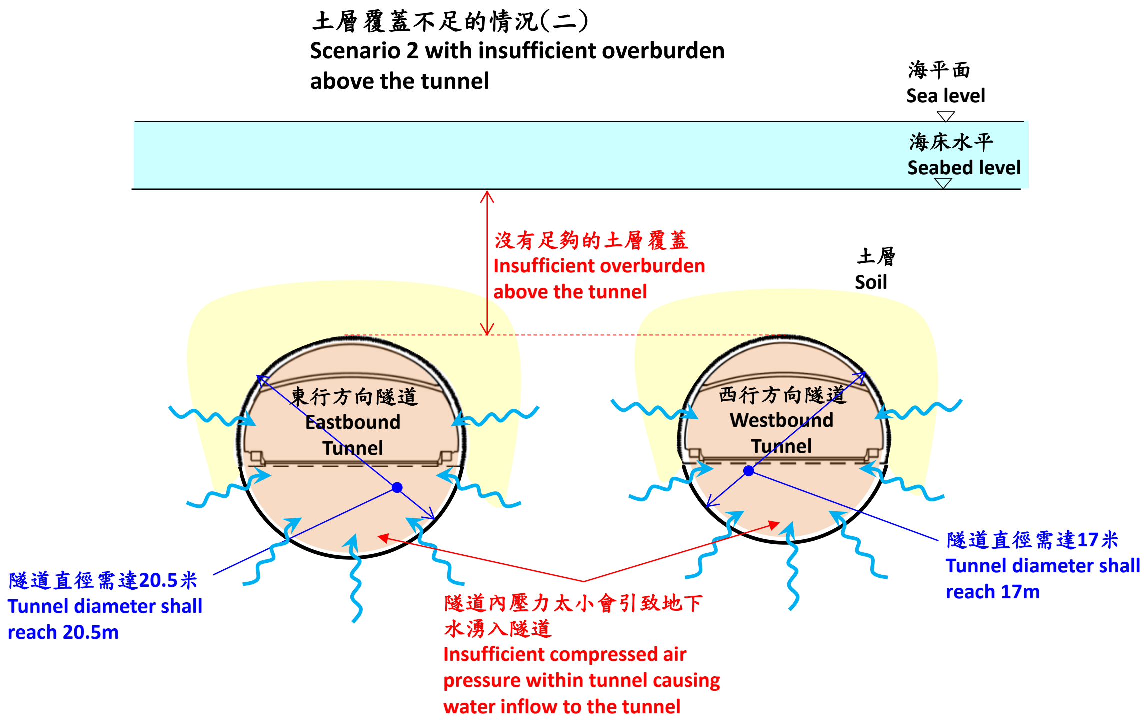

Figure 3-12 – Seepage Failure Scenario

3.19 For the foregoing reasons, the use of TBM for constructing the underwater tunnel would be unsafe both for construction personnel and the public. TBM is therefore not a reasonable alternative.

(C) Construction Method Involving Reclamation

3.20 Since both the IMT and TBM methods are not reasonable alternatives, we have considered whether the underwater tunnel can be constructed on temporary reclamation using the cut-and-cover method as shown in **Figure 3-13**.

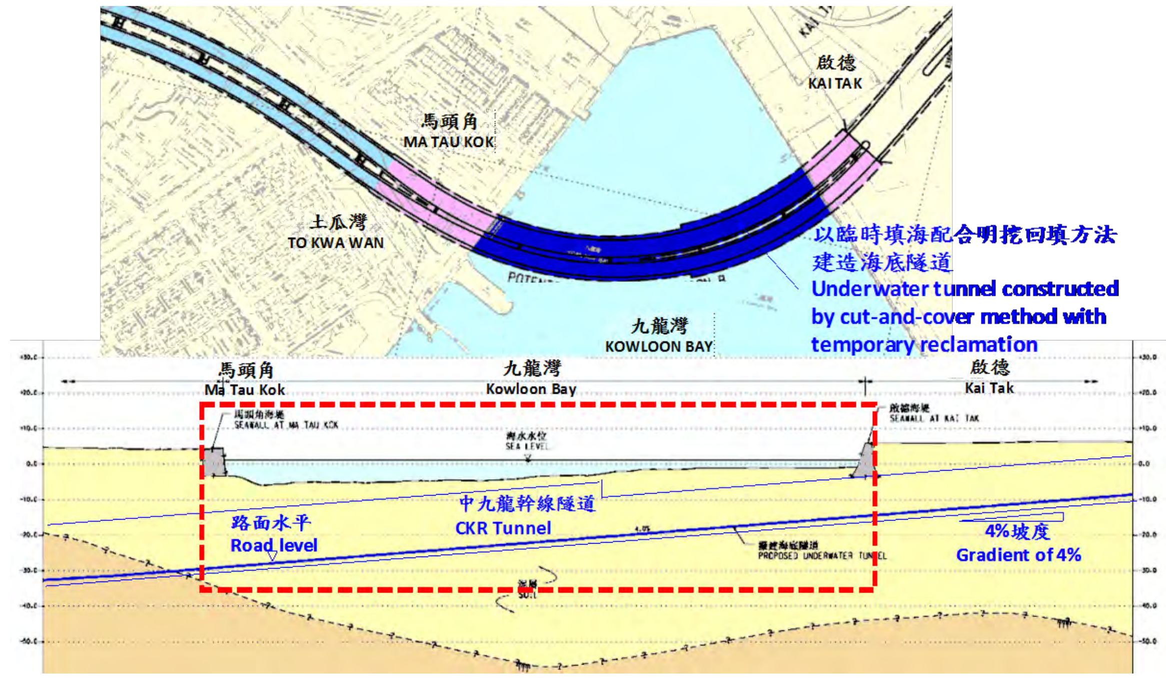

Figure 3-13 – Temporary Reclamation with Cut-and-cover Method

3.21 The construction of tunnel using cut-and-cover tunnel method has been widely adopted in Hong Kong for many different building, railway and infrastructure projects. For the construction of underwater tunnel or depressed road connecting underwater tunnel, the combination of temporary reclamation to provide a dry working platform and cut-and-cover method for tunnel construction has also been widely adopted and considered as the one of the most practical and effective method. An example of construction of tunnel by cut-and-cover method within temporary reclamation is shown in **Figure 3-14**.

Figure 3-14 – Example of Temporary Reclamation with Cut-and-cover Method

3.22 Under this method, temporary seawall will be constructed using large pipe-piles along the underwater tunnel alignment. The space enclosed by the temporary seawall will then be reclaimed to form a working platform. Diaphragm walls will be constructed on this platform to form a cofferdam. Excavation work will be carried out within the cofferdam to facilitate the construction of the tunnel structure. The temporary reclamation and seawall will be removed after the completion of the tunnel, and the seabed will be reinstated to its original levels. An illustrative construction sequence is shown in **Figure 3-15** for reference.

3.23 After the formation of the working platform by temporary reclamation, temporary retaining structure will be installed for the subsequent bulk excavation. Type of temporary retaining structure is dictated by depth of excavation, water level and ground condition. For underwater tunnel with more than 20m deep excavation required, high water level up to over +2.0mPD (sea level) and presence of up to around 9m soft marine deposits, the temporary retaining wall is expected to retain large pressure from adjacent ground and sea. Diaphragm wall is hence considered as the preferred type of retaining structure in view of its large structure capacity to resist the soil and water pressure. The diaphragm will need to penetrate sufficient depth or even into bedrock (if the rockhead level is not deep) to provide overturning stability and water cut-off.

3.24 Bulk excavation together with installation of lateral support will hence be carried out after diaphragm wall installation to provide a dry working platform for the in-situ construction of the tunnel structure. After the construction of tunnel structure, backfill will be carried out up to the seabed level and the remaining temporary reclamation will be removed. At last, the seabed will be restored back to the original seabed profile.

Figure 3-15 (a) - Cut-and-Cover Method with Temporary Reclamation - Step 1

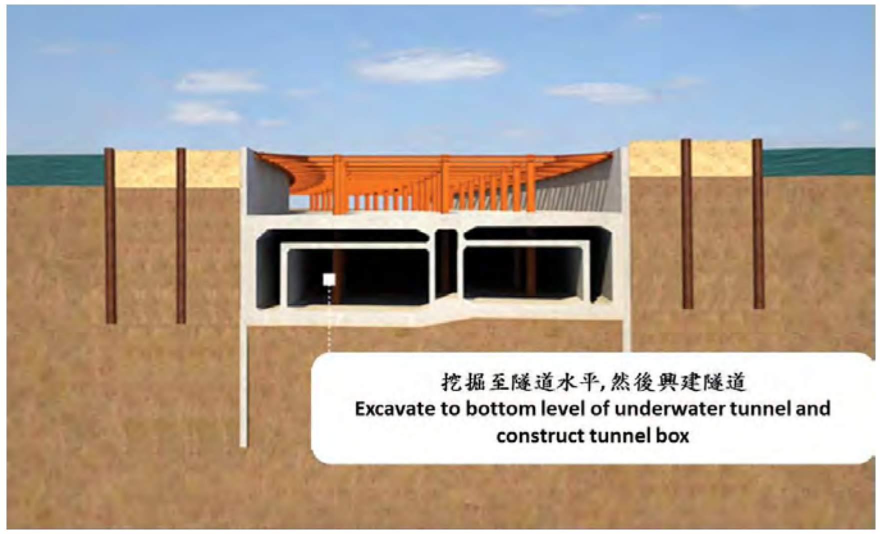

Figure 3-15 (b) - Cut-and-Cover Method with Temporary Reclamation - Step 2

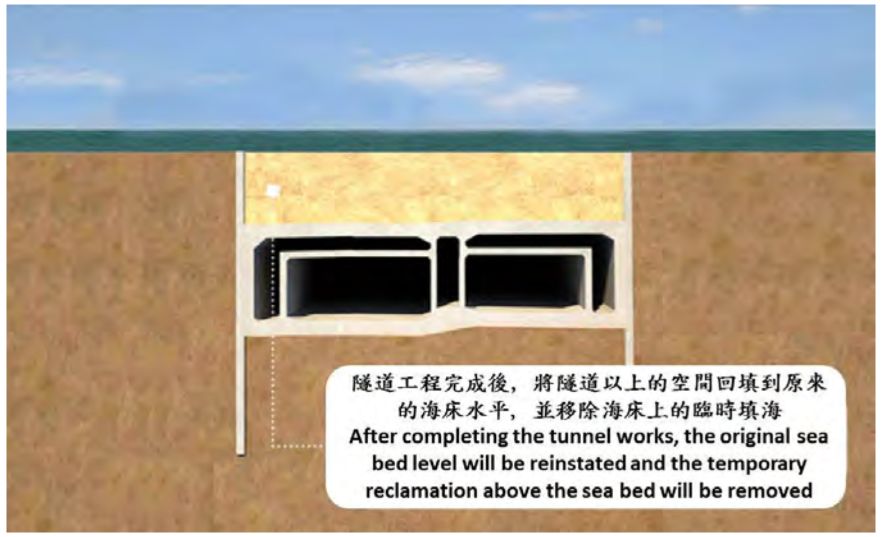

Figure 3-15 (c) - Cut-and-Cover Method with Temporary Reclamation - Step 3

3.25 The temporary reclamation would be implemented in two stages so as to maintain marine access to HKCG naphtha jetty and avoid affecting the discharge of an existing stormwater box culvert, which is between the ex-airport runway and Ma Tau Kok, into Kowloon Bay. Stage 1 will proceed in the Kowloon Bay sea area near the Kai Tak Development Area to reclaim an approximately 1.8 hectares site for the construction of a 180 m long section of the tunnel which will take about 26 months to complete and reinstate the seabed to its original level. Stage 2 will proceed in the sea area fronting Kowloon City Ferry Pier to reclaim an approximately 2.0 hectares site for the construction of a tunnel of about a 190 m long section of the tunnel which will also take about 26 months to complete and reinstate the seabed to its original level. Normal operation of the passenger ferry service on Kowloon City Ferry Pier will be maintained during the construction period. This two stage temporary reclamation arrangement is illustrated in **Figure 3-16** and **Figure 3-17**.

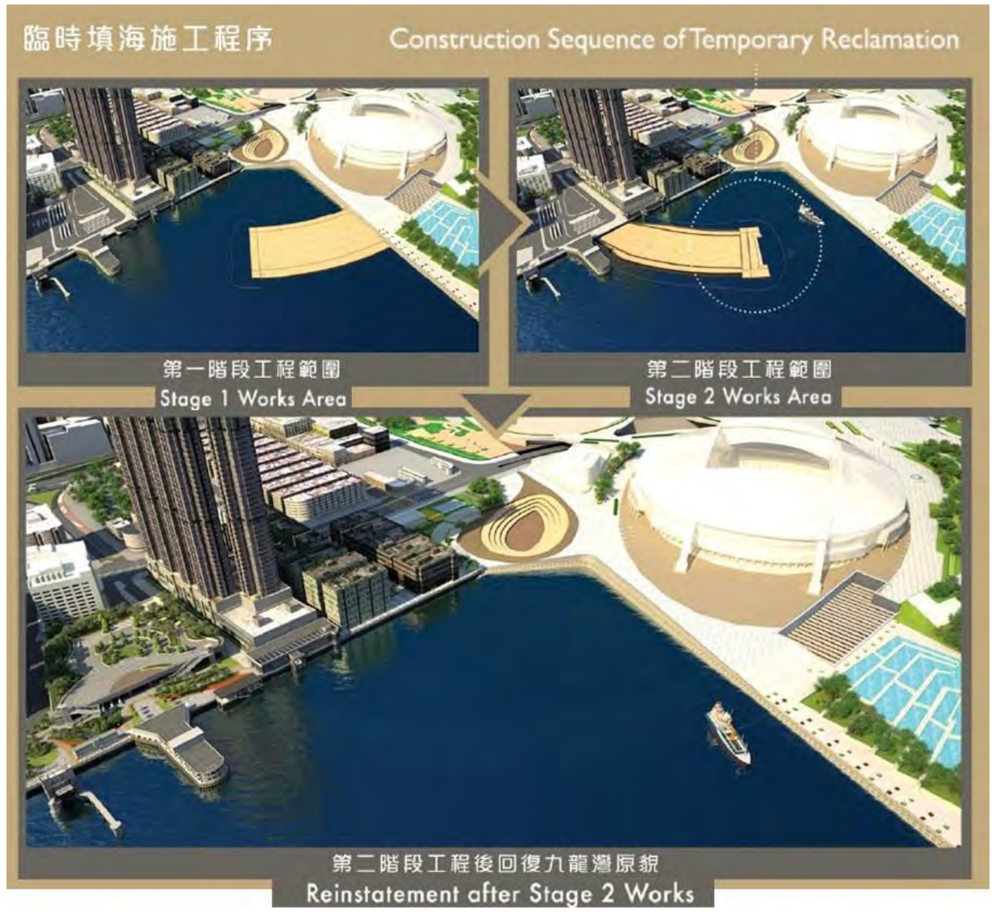

Figure 3-16 – Two Stage Temporary Reclamation Arrangement in Kowloon Bay

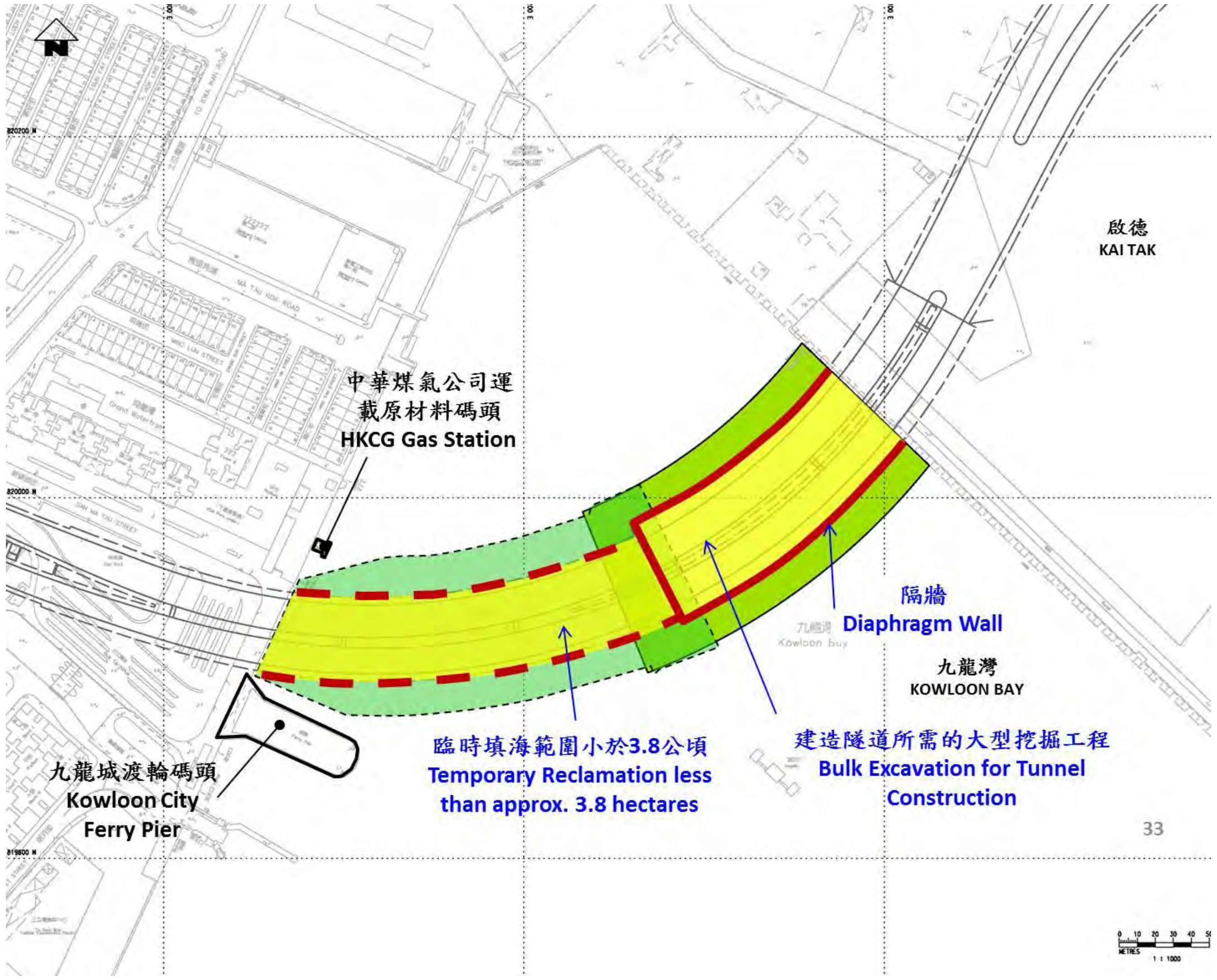

Figure 3-17 – Two Stage Temporary Reclamation Arrangement in Kowloon Bay

3.26 For the foregoing reasons, the construction of the underwater tunnel using the cut-and-cover method on temporary reclamation is feasible and is indeed the only safe and practical construction method.

(D) Alternative Alignments

3.27 In the Investigation and Preliminary Design stage between 2007 and 2009, we explored if there were other alternative alignments, including Alignments A, C to E, and the present Alignment (Alignment B) as shown in **Figure 3-18**.

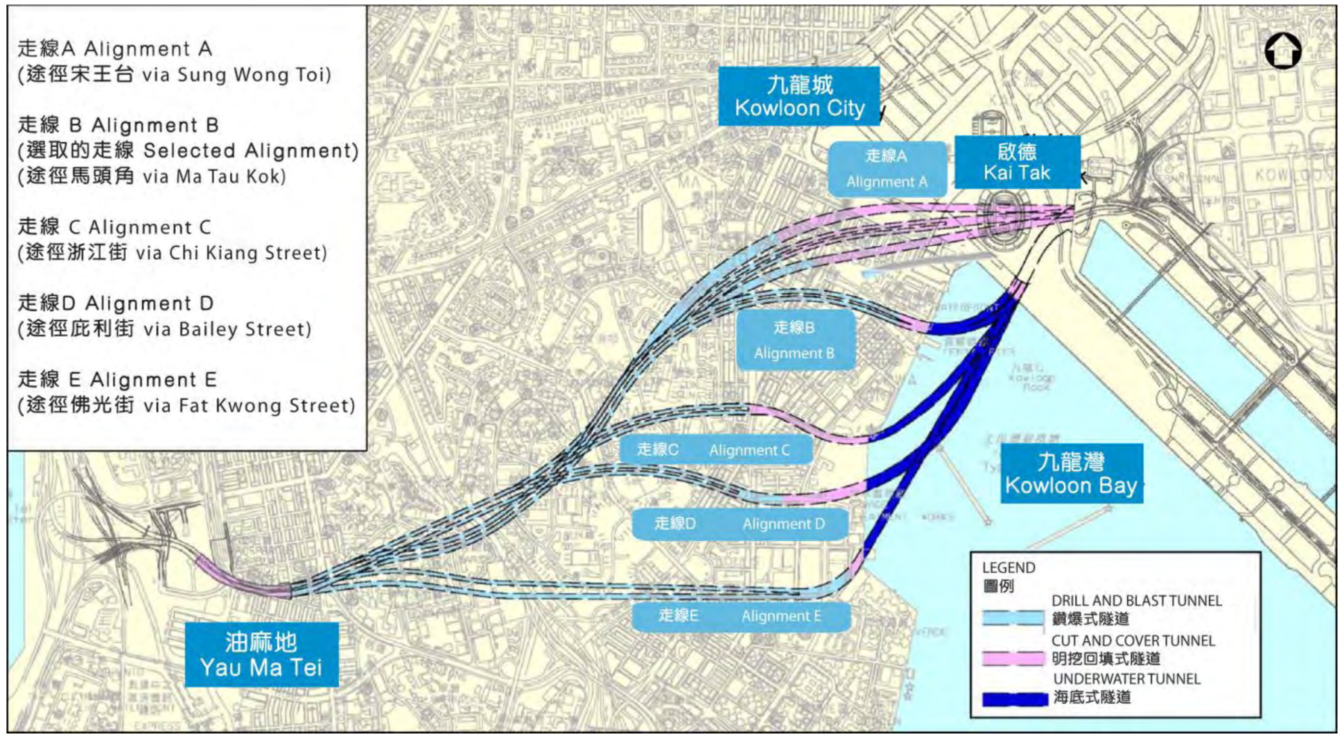

Figure 3-18 – Alternative Alignment in Investigation and Preliminary Design Stage

3.28 Alignment A is an inland option which does not involve reclamation. However, it includes a 600 m long tunnel which passes under tens of private buildings along Mok Cheong Street in To Kwa Wan. The affected private buildings would have to be resumed and demolished to implement the project. Alignment A is therefore not a reasonable alternative.

3.29 While Alignments C to E pass through existing roads and undeveloped areas along seashore and then across the sea to connect with Kai Tak Interchange, they also involve resumption and demolition of private buildings, and larger extent of temporary reclamation when compared with Alignment B. Therefore, Alignments C to E are also not reasonable alternatives. On the other hand, Alignment B only requires use of the Kowloon City Ferry Pier Public Transport Interchange for construction works but does not involve resumption and demolition of private properties, and the extent of temporary reclamation is the minimum.

4 MINIMUM EXTENT OF TEMPORARY RECLAMATION

Introduction

4.1 This chapter examines the factors related to the extent of temporary reclamation required for construction of the underwater tunnel in Kowloon Bay and identifies a scheme involving the minimum extent of temporary reclamation.

Length of Reclamation

4.2 As shown in **Figure 4-1** below, the underwater tunnel is on a circular curve with a radius of 330 m at the centreline. It is the shortest reverse curve alignment in minimum desirable radius between the locations of Kowloon City Ferry Pier Public Transport Interchange and Kai Tak River. The length of the underwater tunnel and hence the length of the temporary reclamation are also the minimum required.

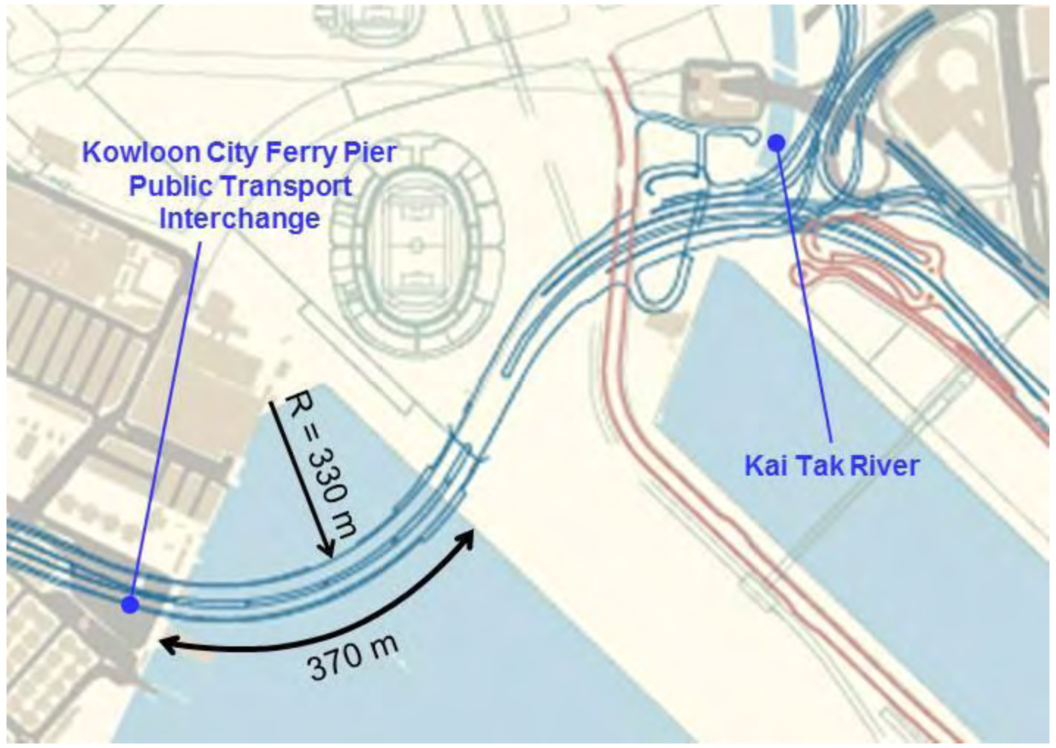

Figure 4-1 – Length of Reclamation

Width of Reclamation

4.3 The width of the tunnel is governed by the curve radius of 330 m. As shown in Figure 4-2, this is the minimum radius for providing the sight distance required under Volume 2, Section 3.3.5 of TPDM for ensuring traffic safety with adequate forward visibility.

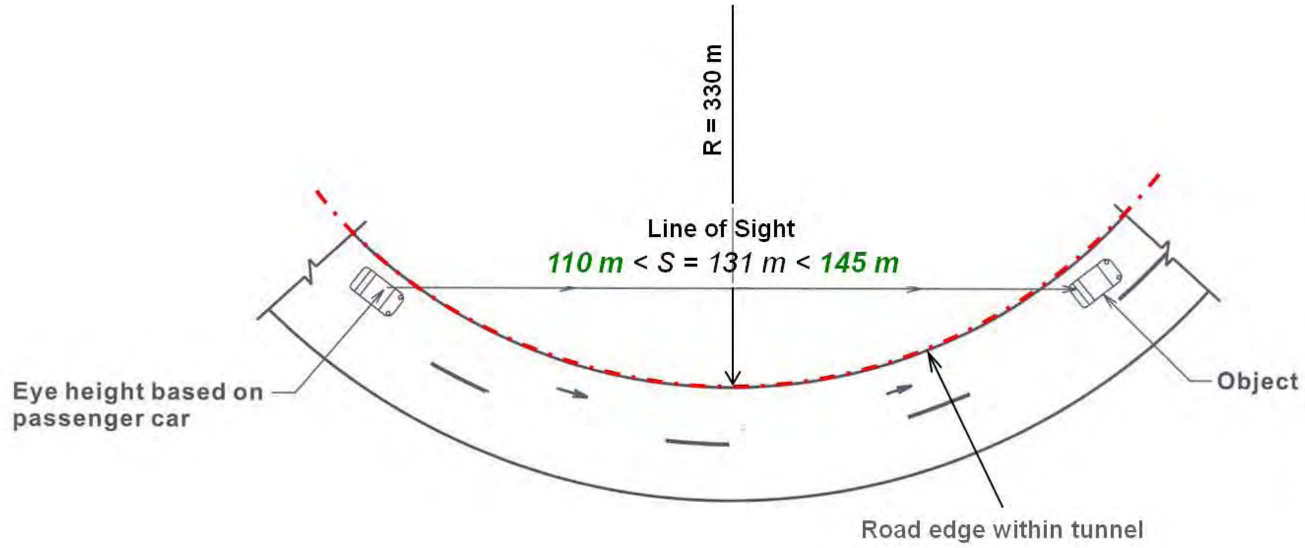

Figure 4-2 – Sight Distance Requirement

4.4 As shown in **Figure 4-3** below, the width of the temporary reclamation varies from 87 m to 98 m and is made up as follows –

(a) the width of the cofferdam formed by the diaphragm walls which varies from 47 m to 58 m; and

(b) a working platform 20 m wide on each side of the diaphragm wall.

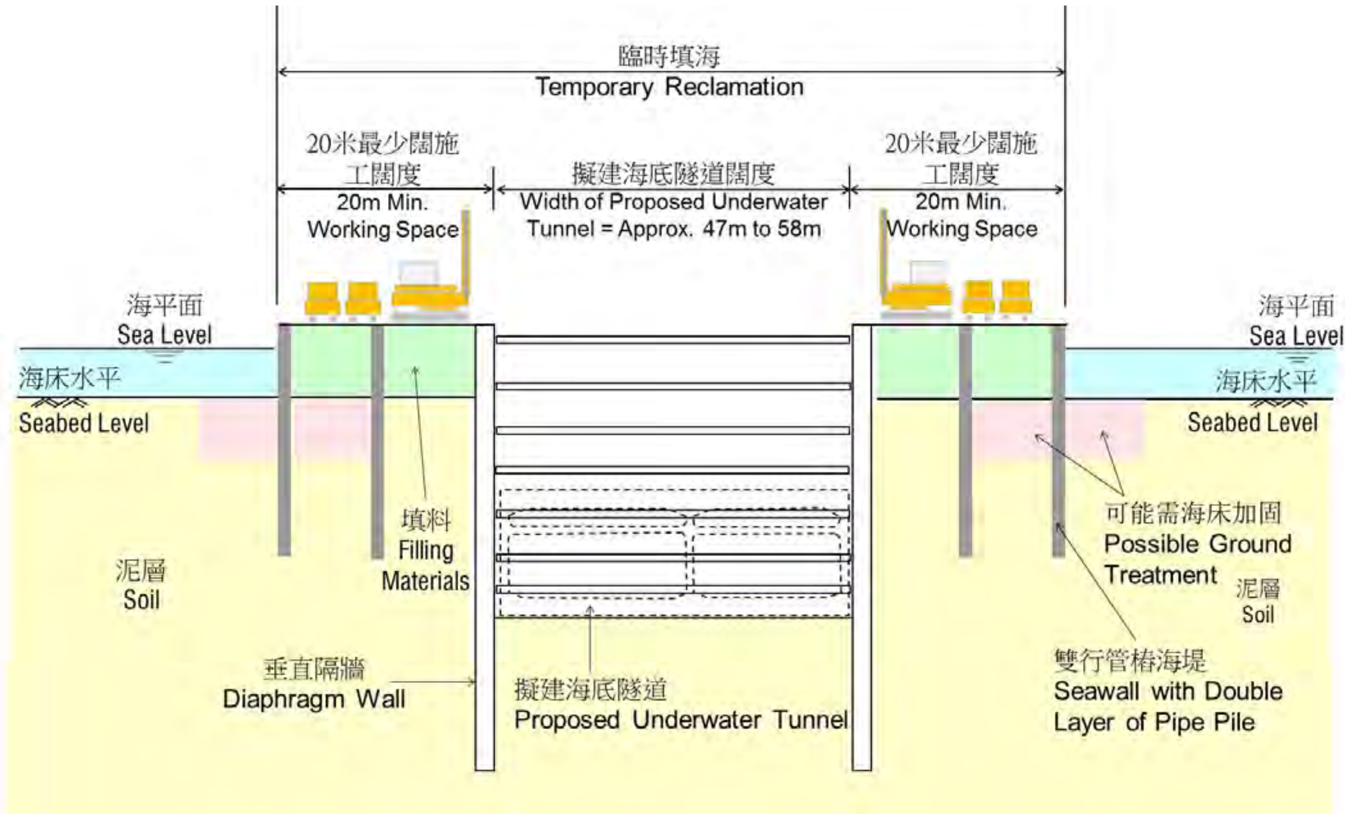

Figure 4-3 – Typical Cross Section of Temporary Reclamation

4.5 The width of the underwater tunnel and hence the width of the temporary reclamation are also the minimum required.

4.6 Regarding paragraph 4.4(a), as explained in paragraph 3.25 of Chapter 3, the tunnel will be constructed in two stages as follows –

(a) Stage 1 will proceed in the Kowloon Bay sea area near the Kai Tak Development Area to reclaim an approximately 1.8 hectares site for the construction of a 180 m long section of the tunnel which will take about 26 months to complete and reinstate the seabed to its original level; and

(b) Stage 2 will proceed in the sea area fronting Kowloon City Ferry Pier to reclaim an approximately 2.0 hectares site for the construction of a tunnel of about a 190 m long section of the tunnel which will also take about 26 months to complete and reinstate the seabed to its original level.

4.7 For the section of the tunnel to be constructed in Stage 1, the ventilation duct is located on both sides of the tunnel given the limited headroom under the vertical seawall along KTD. The width of this section is therefore about 58 m. For the section of the tunnel to be constructed in Stage 2, as more headroom is available, the ventilation duct is located on top of the tunnel to minimize the extent of reclamation. The width of this section is therefore about 47 m.

4.8 Regarding paragraph 4.4(b), the working platform will be required to provide working space for construction plant (such as cranes, dump trucks, excavators and etc.), loading and unloading of materials delivered by barges and circulation of construction traffic. According to the experience of construction of underwater tunnel by similar method in Central-Wan Chai Bypass, this 20 m width is just adequate for these uses. As such, the width of the proposed temporary reclamation is also the minimum as illustrated in the photographs in **Figures 4-4** and **4-5**.

Duration of Temporary Reclamation

4.9 The total duration for temporary reclamation will take approximately 52 months. Stone column construction, seawall construction, diaphragm wall construction, excavation and tunnel box construction will each take 5 to 6 months to complete, while reclamation filling, backfilling and reclamation removal and restoration will take 1 to 2.5 months to finish. As some of these tasks can be carried out in parallel, each of the two stages of reclamation will take approximately 26 months to complete.

Summary of Minimum Reclamation Requirements

4.10 Detailed examination of the engineering requirements in respect to the construction of the underwater tunnel, reclamation, seawalls, and re-provisioning of affected facilities has been conducted to accurately define the minimum extent of required temporary reclamation.

4.11 Each of the two stages of the reclamation will last less than approximately 26 months, starting from early-2015 to mid/late-2019 tentatively.

4.12 It is concluded that the area of temporary reclamation has been minimized. The total area of temporary reclamation does not exceed 3.8 ha, with a maximum of 2.0 ha at any given time.

Figure 4-4 – Temporary Reclamation of Central-Wan Chai Bypass

Figure 4-5 – Temporary Reclamation of Central-Wan Chai Bypass

5 PUBLIC CONSULTATION

Public Engagement in Previous Stage of Study

5.1 Highways Department (HyD) commissioned the Investigation and Preliminary Design (I&PD) of CKR in 2007. Since the project would have significant impacts on traffic, land use and environment, a comprehensive public engagement strategy was adopted by organizing public forums, focus group meetings, outreach activities, interviews, questionnaire survey, site visits and planning competition to collect public views on major key issues. Through these activities, good communication was established with various stakeholders, including residents, owners' committees, community organizations, business operators and District Councils. We have also consulted Yau Tsim Mong, Kowloon City and Kwun Tong District Councils as well as the Legislative Council Panel on Transport about CKR.

5.2 One of the major tasks of the I&PD study was to select a preferred alignment. We have reviewed more than 40 options that were formulated under previous CKR studies and 14 new options were developed. The present alignment was selected after comparing the impacts of the options on reprovisioning of community facilities, environment, land and transport and making reference to comments collected during the public engagement process. The alignment was generally supported by Legislative Council Panel on Transport, Yau Tsim Mong, Kowloon City and Kwun Tong District Councils.

5.3 Through the public engagement activities, we understood that the public generally supported the construction of CKR. The public also expected that CKR would effectively connect to the road networks in East Kowloon and West Kowloon in order to alleviate traffic congestion and would properly preserve the Yau Ma Tei Police Station, Temple Street Night Market, Tin Hau Temple and Yung Shu Tau culture at the same time.

Public Forum on 18 July 2009

5.4 The proposal of temporary reclamation was discussed at length with residents at the east end of the proposed CKR alignment. The general consensus was without objection to the proposed temporary reclamation, but it was wholly agreed that environmental concerns should be addressed and that the reclamation should only be carried out if no reasonable alternative exists.

5.5 Several members of the public in fact opined desire for minor permanent reclamation of Kowloon Bay with the aim of providing new community facilities such as parks, libraries, sitting out areas and an opportunity to provide a continuous promenade linking Ma Tau Kok with Kai Tak Development. It was also suggested by the public that minor permanent reclamation would provide opportunity for mitigating concerns over Kowloon Bay odour problems.

5.6 The proposals received from the public regarding minor permanent reclamation were noted by the design team, but it is well understood that the proposal will be acceptable only if the three tests as laid down by the High Court with regard to the presumption against reclamation under section 3 of the Protection of the Harbour Ordinance can be satisfied. This should be considered separately as no such permanent reclamation is required under the CKR proposal.

Focus Group Meeting on 20 June 2009

5.7 Attendees were introduced to the history of the project. Recent developments of the alignment options were discussed along with likely project impacts to public facilities and the environment.

5.8 Attending parties included Society for Protection of the Harbour, Friends of the Harbour, the Hong Kong Institute of Engineers, the Hong Kong Institute of Architects, Hong Kong Institution of Surveyors and members of the Kowloon City District Council.

5.9 It has been suggested that the proposed demolition of Ma Tau Kok Public Pier and the associated re-provisioning of the other ferry piers will provide opportunity to enhance the Harbour front and renew public facilities in the area.

Conclusions from Previous Stage Public Engagement

5.10 The members of the public, with Yau Tsim Mong, Kowloon City and Kwun Tong District Councils as well as the Panel on Transport of the Legislative Council have been consulted in the previous stage of study on the CKR preferred alignment and proposed works.

5.11 Overall, most members of the public and their appointed representatives have shown support for the preferred alignment with no significant opposition expressed to the proposed temporary reclamation.

Public Engagement in Current Stage of Study

5.12 Phase 2 Public Engagement for CKR was launched on 5 December 2012 to collect public views on the detailed design and construction arrangement of CKR.

5.13 Various public engagement activities including focus group meetings and briefing sessions with residents along the proposed alignment of CKR, public forums, focus group meetings with green groups and professional institutes, jade market operators and briefing sessions to District Councils and Harbourfront Commission were carried out throughout the 3-month consultation period.

5.14 Since temporary reclamation at Victoria Harbour would be required for the construction of CKR Kowloon Bay section, the project proponent is required to establish an overriding public need for the proposed reclamation work under the Protection of the Harbour Ordinance. In this regard, the cogent and convincing materials supporting and justifying the overriding public need for reclamation were reviewed with the public through various public engagement activities. Consultation with Harbourfront Commission, a professional forum on temporary reclamation at Kowloon Bay and a public forum on temporary reclamation in Kowloon Bay were carried out.

5.15 To facilitate public discussion, Phase 2 Public Engagement Digest, in both Chinese and English and bilingual newsletters (Issue No. 26 and 27) covering the key issues, including introduction of detailed design of Central Kowloon Route, benefit of Central Kowloon Route, greening and landscaping opportunities, preservation of cultural heritage, reprovisioning arrangement of public facilities affected by CKR, environmental impact of CKR and the mitigation measures, and construction arrangement of CKR including temporary reclamation at Kowloon Bay section, were prepared and widely distributed. Roving exhibitions with physical model and Virtual Reality model in various locations in Yau Ma Tei, Kwun Tong, Kowloon City and Ho Man Tin were also carried out.

5.16 Around 50,000 invitations were sent to residential units, schools, local organisations and commercial buildings along and near the alignment of CKR, district councillors, members of area committees, professional institutes and green groups to invite them to participate in the public engagement activities. Advertisements of the public forum were posted on two Chinese newspapers, Oriental Daily (東方日報) and HK Headline (頭條日報), and one English newspaper, The Standard on 4th, 11th, 18th, 25th January and 1st February 2013 respectively to reach out the general public as much as possible and invite the general public to the public forums. Stakeholders with different backgrounds, knowledge and views were brought together to discuss on various issues related to the detailed design of CKR.

5.17 The public engagement activities carried out are summarized in **Table 5-1** below.

Table 5-1 – Summary of Stakeholder Engagement Activities in Current Stage of Study

Date	Public Engagement Activities
11 Dec 2012	Meeting with Residents of Prosperous Gardens
12 Dec 2012	Focus Group Meeting with Residents in King's Park Constituency
13 Dec 2012	Consultation with Yau Tsim Mong District Council
13 Dec 2012	Focus Group Meeting with Residents in Ma Hang Chung Constituency
14 Dec 2012	Focus Group Meeting with Residents in Ma Tau Kok Constituency
15 Dec 2012	Focus Group Meeting with Residents in Jordan West Constituency
15 Dec 2012	Focus Group Meeting with Residents in Yau Ma Tei Constituency
16 Dec 2012	Meeting with Residents of Grand Waterfront
17 Dec 2012	Focus Group Meeting with Residents in Lok Man Constituency
18 Dec 2012	Focus Group Meeting with Residents in Hoi Sham Constituency
19 Dec 2012	Focus Group Meeting with Residents in Sheung Lok Constituency
19 Dec 2012	Focus Group Meeting with Residents in Oi Chun Constituency
20 Dec 2012	Focus Group Meeting with Residents in Oi Man Constituency
2 Jan 2013	Focus group meeting with Jade Hawkers
4 Jan 2013	Focus group meeting with Green Groups
7 Jan 2013	Consultation with Harbourfront Commission
8 Jan 2013	Consultation with Kwun Tong District Council
8 Jan 2013	Consultation with Wong Tai Sin District Council
10 Jan 2013	Professional Forum on Temporary Reclamation at Kowloon Bay
12 Jan 2013	Public Forum in Yau Tsim Mong District
17 Jan 2013	Consultation with Traffic and Transport Committee, Yau Tsim Mong District Council
17 Jan 2013	Consultation with Kowloon City District Council
18 Jan 2013	Meeting with Residents of Wyler Gardens
19 Jan 2013	Public Forum in Kowloon City District
22 Jan 2013	Meeting with Hong Kong Institute of Architects
26 Jan 2013	Meeting with Residents in King's Park
1 Feb 2013	Consultation with Community Building Committee, Yau Tsim Mong District Council
2 Feb 2013	Public Forum on Temporary Reclamation in Kowloon Bay
4 Feb 2013	Meeting with Hong Kong Institute of Planners, Hong Kong Institute of Urban Design and Hong Kong Institute of Landscape Architects

Public Views on Temporary Reclamation in Current Stage of Study

5.18 This section outlines the major comments from the public and other stakeholders received in Phase 2 Public Engagement regarding temporary reclamation at Kowloon Bay for the construction of CKR.

5.19 The general public and local residents along or near the alignment of CKR generally agreed that CKR could improve the east-west traffic in Kowloon and relieve the congestion in existing east-west corridors. Many requested early implementation of the project. However, some individual green groups and members of the public raised that the solution for traffic congestion should be traffic demand management rather than building more roads. This concern was subsequently reviewed by independent expert who considered that the car ownership in Hong Kong was relatively low and very high percentage of road users was in fact commercial vehicles, and there was need for the construction of CKR.

5.20 Vast majority of participants, which included local residents and the general public, did not have strong view on the proposed temporary reclamation at Kowloon Bay for the construction of CKR. Some members of the public even suggested the government to carry out permanent reclamation at that corner of the Harbour at Kowloon City Ferry Pier to solve the odour problem and provide pedestrian linkage to Kai Tak Development.

Briefing Sessions and Consultations with District Councils

5.21 Yau Tsim Mong, Kowloon City, Wong Tai Sin, and Kwun Tong District Councils, agreed that CKR could improve the east-west traffic in Kowloon and relieve the congestion in existing east-west corridors. They urged the Government to implement the CKR construction as soon as possible. Many district councillors considered that diverting traffic into CKR could reduce the number of vehicles on road in areas of Yau Ma Tei, Ho Man Tin and Kowloon City, so it would improve the traffic condition and the environment.

5.22 Some district councillors expressed their support to the temporary reclamation and they agreed with the professional judgement on the need for reclamation. Some Kowloon City district councillors further proposed to consider suitable mitigation measures to prevent the worsening of odour problems in the area.

Consultation with Harbourfront Commission

5.23 The cogent and convincing materials required to support and justify the overriding public need for reclamation, as well as the detail design and construction arrangement of CKR, were presented to Harbourfront Commission.

5.24 Harbourfront Commission in general agreed on the strategic need, its alignment and recognised the need for the proposed temporary reclamation works required for the construction of CKR.

Professional Forum on Temporary Reclamation at Kowloon Bay

5.25 In order to establish an overriding public need for the reclamation work under the Protection of the Harbour Ordinance, the cogent and convincing materials required to support and justify the overriding public need for reclamation were presented to professionals and academics in the professional forum. After the presentation from the consultant, two independent experts were invited to review the cogent and convincing materials presented by the consultant.

5.26 The professionals and academics did not have disagreement to the justifications of the need of CKR presented by the consultant and reviewed by two independent experts.

5.27 The professionals and academics generally agreed that there were no alternative construction and alignment options that did not require reclamation. They considered that tunnel boring machine (TBM) and immersed tube tunnel (IMT) were not reasonable construction methods for the underwater tunnel at Kowloon Bay.

5.28 The professionals and academics generally considered that the proposed temporary reclamation construction method with cut-and-cover would involve less dredging and disturbance to the seabed, when compared to other construction methods. The proposed arrangements were considered reasonable.

Public Forum on Temporary Reclamation at Kowloon Bay

5.29 A Public Forum on Temporary Reclamation in Kowloon Bay was held to establish an overriding public need for the reclamation work under the Protection of the Harbour Ordinance with the general public. The forum was conducted to discuss: (1) whether there is an overriding need for the project; (2) whether there is alternative to reclamation; and (3) whether the extent of reclamation is the minimum. After the presentation from the consultant, two independent experts were invited to review the cogent and convincing materials presented by the consultant.

5.30 Members of the public agreed that there was an urgent need to resolve the traffic congestion, and there was overriding public need for the construction of CKR. It was also agreed that there was no safe, reliable and reasonable alternative method to the proposed reclamation method and that the current proposed extent of reclamation is the minimum.

6 CONCLUSIONS

Whether There is an Overriding Public Need for Reclamation

6.1 Yau Tsim Mong, Kowloon City, Wong Tai Sin, and Kwun Tong District Councils, local residents along or near the alignment of CKR and the general public agreed that CKR could improve the east-west traffic in Kowloon and relieve the congestion in existing east-west corridors. They urged the Government to implement the construction of CKR as soon as possible. Harbourfront Commission also stated their acceptance on the strategic need of CKR. Various professional institutes did not challenge the need for CKR.

6.2 Many district councillors and local residents considered that diverting traffic into CKR could reduce the number of vehicles on road in areas like Yau Ma Tei, Ho Man Tin and Kowloon City, so that it would improve the overall traffic condition and the environment.

6.3 In the Public Forum on Temporary reclamation in Kowloon Bay, the public agreed that there was urgent need to resolve the traffic congestion in the East-west traffic, and there was overriding public need for the construction of CKR.

6.4 Therefore, it was agreed with the public that there is an overriding public need for the construction of CKR.

No Reasonable Alternative to Reclamation

6.5 Harbourfront Commission stated that they would not challenge the justifications for the temporary reclamation required for the construction of CKR which were presented by the consultant and reviewed by two independent experts. These included the justifications on no reasonable alignment that did not require reclamation and no reasonable construction methods that did not require reclamation.

6.6 In the Professional Forum, professionals and academics generally agreed that there were no alternative construction and alignment options that did not require reclamation. They considered that tunnel boring machine (TBM) and immersed tube tunnel (IMT) were not reasonable construction methods for the underwater tunnel at Kowloon Bay.

6.7 In the Public Forum on Temporary reclamation in Kowloon Bay, the public agreed that there were no safe and reliable alternative construction and alignment options that did not require reclamation.

6.8 Therefore, it was agreed with the public that there was no reasonable alternative to reclamation.

Minimum Extent of Reclamation

6.9 Harbourfront Commission stated that they would not challenge the justifications for the temporary reclamation required for the construction of CKR which were presented by the consultant and reviewed by two independent experts. These included the justifications on the proposed construction arrangement would involve minimal impairment to the Harbour.

6.10 In the Professional Forum, professionals and academics generally considered that the proposed temporary reclamation construction method would involve minimal impairment to the Harbour.

6.11 In the Public Forum on Temporary reclamation in Kowloon Bay, the public agreed that the extent of reclamation is the minimum.

6.12 Therefore, it was agreed with the public that the proposed extent of temporary reclamation is the minimum.

Phase 2 Public Engagement Exercise

6.13 We started the Phase 2 Public Engagement for CKR in early December 2012 to gather public views on the detailed design and construction arrangements of the project. A series of public engagement activities were carried out as scheduled, including over 10 focus group meetings with residents along the alignment of CKR, green groups, professional institutes and other stakeholders and five rounds of roving exhibitions at various locations in Yau Ma Tei, Ho Man Tin, To Kwa Wan and Kwun Tong.

6.14 We have also consulted Yau Tsim Mong, Kowloon City, Wong Tai Sin and Kwun Tong District Councils, as well as the Harbourfront Commission. We have also conducted three public forums on 12, 19 January 2013 and 2 February 2013 in Yau Tsim Mong District and Kowloon City District respectively to collect views from the general public on CKR. We would like to express our gratitude to different sectors of the community for their active participation and valuable comments.

Independent Expert Review

6.15 In the interest of the Protection of the Harbour Ordinance and as part of the public engagement activities associated with this report, two independent expert reviewers, Professor William H.K. LAM and Professor Charles W.W. NG, had been appointed to:

a) Provide a critical review of this report with consideration to the need for reclamation of Kowloon Bay for CKR.

b) Confirm that the argument for the proposed temporary reclamation is cogent and convincing.

c) Ascertain that the "overriding public need test" has been satisfied.

d) Confirm that there is no reasonable alternative to the reclamation.

e) Confirm that the proposed extent is the minimum requirement.

6.16 The Independent Expert Review Reports by Professor William H.K. LAM and Professor Charles W.W. NG are attached in **Appendix A** and **Appendix B** respectively.

Compliance with the PHO

6.17 In conclusion, it is clear that the three tests in rebutting the presumption against the reclamation as set out in the PHO have been satisfied:

- In facilitating the construction of the CKR and therefore in meeting the overriding public need for the route, there is consequently a compelling and present need for the reclamation in Kowloon Bay. All of the reclamation is temporary and will be removed upon completion of construction, with the seabed reinstated to the original level.

- No reasonable alternative to temporary reclamation is found for constructing the Underwater Tunnel Section of the CKR.

- The extent of reclamation has been determined to be the minimum required.

Appendix A

Independent Expert Review of Cogent and Convincing Materials Report for Temporary Reclamation at Kowloon Bay by Professor William H.K. LAM

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Traffic justification for the need of Central Kowloon Route –Independent Expert Review (Quotation Ref. Hy(S)Q/062/2012)

Project Ref. No.: P12-0276

William H.K. LAM
18 February 2013

1. Introduction

On 28th December 2012, Highways Department (HyD) of the Government of the Hong Kong Special Administrative Region appointed Ir Prof. William H.K. Lam of PolyU Technology & Consultancy Company Limited (PTeC), under Agreement No. Hy(S)Q/062/2012, to provide independent EXPERT review services in respect of traffic justification for the need of the Central Kowloon Route (CKR).

THE EXPERT has also been asked to comment on the minimum extent of temporary reclamation in relation to the length of the preferred alignment of CKR being the shortest and complying with the relevant highway design standards.

2. Description of the Project

CKR is a proposed dual 3-lane trunk road (including a tunnel section with 3.9km) across Central Kowloon linking the West Kowloon in the west and the proposed Kai Tak development in the east. Its western end at West Kowloon would connect to Yau Ma Tei Interchange and via the interchange traffic could access to Western Harbour Crossing, Tsim Sha Tsui, West Kowloon Reclamation Development Area, West Kowloon Highway, Route 8, and Route 3 respectively. Its eastern end at Kai Tak area, would connect to Kowloon Bay, Kowloon East, Kwun Tong Bypass, Tseung Kwan O (TKO) Tunnel, T2, and TKO-LTT respectively. CKR together with T2 and TKO-LTT would form a strategic highway link, namely Route 6, connecting West Kowloon and TKO new town.

The construction of CKR was previously targeted for completion in 2016. The current target is to start construction of CKR in early 2015 for completion and commissioning in end 2020.

3. Traffic Review

The following review was based on the draft updated traffic impact assessment (TIA) report for the Central Kowloon Route – Design and Construction (Ref: REP-081-00), the final report of supplementary traffic study for Central Kowloon Route (Ref. HMW 1/2010 (TT)), the revised draft report on updated economic assessment (Ref. REP-077-01), and the supplementary documents provided by THE CONSULTANT of Highways Department (HyD), Arup-Mott MacDonald Joint Venture.

3.1 Existing Road Network

The Central Kowloon area is currently served by the east-west Corridor ("the Corridor") comprising of major roads such as Lung Cheung Road, Boundary Street, Prince Edward Road West, Argyle Street & Flyover, Chatham Road North, East Kowloon Corridor, Gascoigne Road Flyover. This Corridor is primarily serving as a key east-west link with the responsibility of carrying the long-haul traffic between east and west of Kowloon peninsula.

At the same time, the Corridor also serves as a major link providing north-south connections to various local districts and providing key accesses to its adjacent areas with very short connecting roads. Unfortunately, the numerous junctions with side roads as well as underpasses and flyovers integrated with the Corridor create substantial weaving and merging movements. As a result, the Corridor is over-saturated and too heavily used by local traffic accessing its adjacent areas such that it is unable to perform its intended function for serving the long-haul east-west traffic. Traffic queues from any bottlenecks along the Corridor's side roads or its main section usually result in blockage of other movements and rapid deterioration of traffic condition.

A minor accident or incident occurs along or at the vicinity of the Corridor often results in serious congestion and delay in the road network, and in some more serious cases, gridlock of the whole Central Kowloon area and complete blockage of the Corridor (e.g. the serious incident at Prince Edward Road East on 9 May 2005). These are clear indications that the stability and reliability of both the strategic road network and the Central Kowloon local road network are in an unsatisfactory state.

3.2 Existing Traffic Pattern

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The existing Corridor is already operating beyond its design capacity. Regular traffic queues along the Corridor are found at major road junctions in the Corridor. The maximum queue length of these major road junctions are observed up to 200m long or above. These critical east-west approach arms of junction include:

- Lai Cheung Road EB of Hoi Wang Road / Lai Cheung Road junction;
- Ma Tau Chung Road SB of Ma Tau Chung Road / Sung Wong Toi Road junction;
- Austin Road WB of Austin Road West / Austin Road / Canton Road junction;
- Jordan Road EB of Jordan Road / Ferry Street / Canton Road junction;
- Jordan Road EB of Jordan Road / Nathan Road junction;
- Boundary Street EB of Boundary Street / Waterloo Road junction;
- Argyle Street EB of Argyle Street / Waterloo Road / Princess Margaret Road junction;
- Argyle Street WB of Argyle Street / Yim Po Fong Street junction;
- Mong Kok Road EB of Sai Yee Street / Mong Kok Road junction;
- Chatham Road North SB of Chatham Road North / Wuhu Street junction;
- Kai Cheung Road WB of Kai Cheung Road / Wang Chiu Road junction;
- Lam Fung Street EB (outside MegaBox) of Sheung Yee Road / Wang Chiu Road junction;
- Wai Yip Street EB of Wai Yip Street / Wai Fat Road junction; and
- Wui Cheung Road EB of Canton Road / Wui Cheung Road junction.

The above road junction capacity assessment indicates that some of the major road junctions are operating with close to or above capacity at the moment. Most of the junctions within the Central Kowloon area are generally more critical during the peak periods with low reserved capacities (R.C.) such as Argyle Street / Sai Yee Street, Argyle Street / Nathan Road, Austin Road / Chatham Road South / Cheong Wan Road.

These regular traffic queues occupy the road spaces of the Corridor and impose unacceptable delay to the through traffic between the eastern and western parts of Central Kowloon area.

3.3 Traffic Forecasts

The opening year of Central Kowloon Route is scheduled at end 2020/early 2021. The updated traffic impact assessment has been carried out by comparing the traffic forecast of

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reference (without CKR) and design (with CKR) scenarios. Based on standard traffic forecasting techniques, THE CONSULTANT has undertaken five sets of traffic forecasts to simulate the peak hour traffic situation at the Central Kowloon areas in future years. These test scenarios are listed below and their results are summarized in Table 1:

1. 2016 Reference Scenario: S2016 – constitute the pre-commissioning and construction stage of CKR scenario (i.e. without CKR and Route 6 components);
2. 2021 Reference Scenario: S2021/A – constitute the without CKR scenario and other components of Route 6;
3. 2021 Design Scenario: S2021/C – constitute the with CKR and TKO-LTT scenario whilst T2 is not in place as a conservative approach to test under this study;
4. 2026 Reference Scenario: S2026/A – constitute the without CKR and other components of Route 6 scenario; and
5. 2026 Design Scenario: S2026/G – constitute the with CKR and other component of Route 6 scenario.

Table 1 : Summary of Modeling Assumptions and Results of the 5 Test Scenarios

	CKR	Other components of Route 6	Road T2	TKO-LTT	Traffic Modeling Results	
					V/C Ratio of Major Road Sections along the Corridor	RC of Major Road Junctions in Central Kowloon
Scenario S2016	×	×	×	×	Many of road links with v/c ratio above 1.0.	Some of the critical junctions have negative RCs.
Scenario S2021/A	×	×	×	×	Most above 1.0. Some as high as 1.30.	18 critical junctions have negative RCs (6 with RC < -15%).
Scenario S2021/C	✔	✔	×	✔	Most of the road sections with v/c ratio below 1.0. Few as high as 1.1.	Many of the critical junctions have positive RCs (3 with RC < -15%).
Scenario S2026/A	×	×	×	×	Many of the road sections with v/c ratio above 1. Some as high as 1.40.	18 critical junctions have negative RCs (RC less than that of S2021A).
Scenario S2026G	✔	✔	✔	✔	Most of the west- bound road sections with v/c ratio below 1. Few above 1.20	Many of the critical junctions have positive RCs (3 with RC < -15%).

Notes: V/C Ratio = Volume over Capacity Ratio for road links; RC = Reserve Capacity for signal junctions

3.4 Summary of Findings

Due to the economic growth in future, it has predicted further increase in traffic demand in the east-west Corridor. As a result, most of the major roads in this Corridor (without CKR

by 2021) will be oversaturated ranging from 10% to 30 % during typical morning and evening peak hours.

For the design year scenarios (with CKR), there is a general improvement in the congestions in the study areas when comparing with the corresponding reference year scenario. The reserved capacities of the critical road junctions are generally increased when comparing with those of do-nothing / reference (without CKR) scenarios in the corresponding years of 2021 and 2026.

Considering the apparent improvement along the major road links and the corresponding locations of the congested road junctions, it is revealed that the junction problems are mainly induced by the population and employment growth of the subject areas, but not induced by CKR.

In the draft updated TIA report, THE CONSULTANT has also proposed some interim/long-term local traffic improvement measures at critical road links/road junctions. It is however considered that these measures are unable to replace the CKR in terms of overall traffic benefits to the road network in the Central Kowloon area.

THE CONSULTANT confirmed that the proposed CKR configuration is required to divert traffic away from the existing east-west Corridor and to provide adequate relief to it.

In addition, the provision of CKR can allow passengers to benefit from a shorter journey which is reflected in travel time savings. Based on the transport model developed by THE CONSULTANT, the average time savings due to the provision of CKR are estimated and shown in **Table 6** of the revised draft report on updated economic assessment (Ref. REP-077-01). It is noted that the annual time saving benefit shares of CKR from 2021 to 2060 are ranged from 23% to 29% for private cars only. Over 70% of these annual time saving benefit shares is mainly distributed to different types of commercial vehicles including: taxi, special purpose bus (e.g. coach), van, goods vehicles and public transport vehicles etc.

Table 6 Annual Time Savings (passenger hours) from 2021 to 2060 with CKR

Item	**2021**	**2030**	**2040**	**2050**	**2060**
Car	**(23%) 10470**	33,525	42,155	50,001	**(29%) 57847**
Taxi	4,362	12,652	15,981	19,008	22,035
Special Purpose Bus (SPB)	3,649	11,011	14,480	17,634	20,789
Van	1,100	3,661	4,658	5,565	6,472
Light Good Vehicle (LGV)	887	2,991	3,802	4,539	5,277
Medium Good Vehicle (MGV	715	2,096	2,670	3,191	3,713
Heavy Good Vehicle (HGV)	134	368	466	555	644
Tractor Unit (TU)	326	1,048	1,293	1,516	1,738
Public Transport (PT)	23,846	57,388	65,740	73,333	80,926
Total (100%)	**45,490**	124,740	151,246	175,343	**199,440**

Source: The revised draft report on updated economic assessment (Ref. REP-077-01)

4. Minimum Extent of Temporary Reclamation

4.1 Sites Constraints of CKR

In order to assess whether the minimum extent of temporary reclamation is used for construction of CKR, THE EXPERT has been asked to comment on the length of the preferred alignment being the shortest and complying with relevant highway design standards. It can be seen in the Figure 1 that the proposed S-curve alignment of CKR at the Kai Tak area has significant impacts on the minimum extent of temporary reclamation required. THE EXPERT recognized that there are at least four site constraints of the proposed CKR in relation to the length of the preferred S-curve alignment being the shortest. They are summarized as below:

(1) On the east end, CKR is required to link up with T2 to complete Route 6.

(2) One of the key connection for CKR is an interchange at Kai Tak. It connects to Kai Fuk Road, Kai Cheung Road, and roads to future Kai Tak Development. The CKR mainline has to climb up to ground level in order to make an interchange as shown in Figure 1.

(3) The route has avoid any resumption of existing residential buildings. Under this principle, there is no feasible non-subsea option and the option with the shortest underwater

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section is to go under the corridor of the Kowloon City Pier (near the Public Transport Interchange, PTI) and towards the Kai Tak area.

(4) There is a constraint at the bend over the Kai Tak River. A minimum 15m promenade width has to be fulfilled. Therefore the reverse curve (S curve) in minimum desirable radii is required.

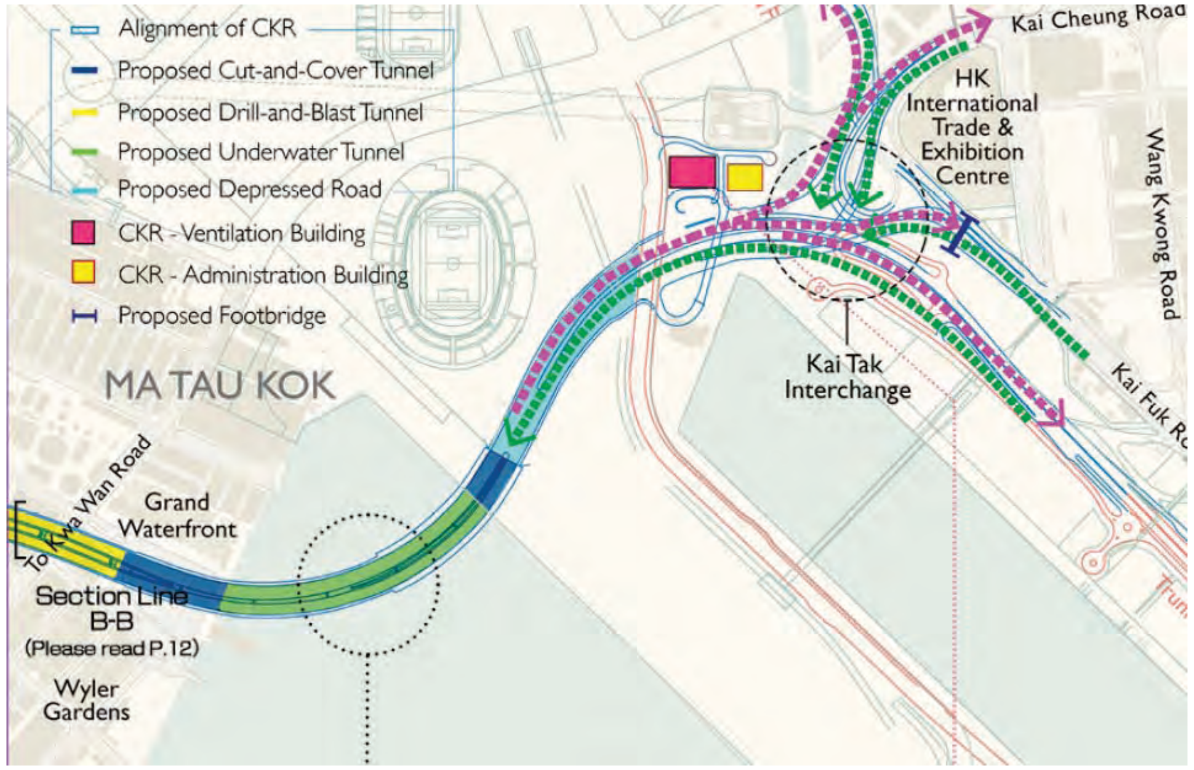

Figure 1 - The Proposed S-Curve Alignment of CKR at Kai Tak area

4.2 Highway Design Standards

In view of the proposed S-curve alignment of CKR at the Kai Tak area, there is a need to assess whether it can comply the relevant highway design standards (particularly on the minimum desirable radius of the S-curve) so as to justify the minimum extent of temporary reclamation used for construction of CKR. Given that the design speed of the CKR mainline is 80km/hr, the minimum radius of the S-curve used at the underwater section of CKR is 330m, and the maximum 4% gradient is about 900m long.

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In Hong Kong, the Transport Planning Design Manual (TPDM) has different requirements for determining the design speed of highway.

- The design speed of a road is the speed chosen to correlate the various features of design of the road, such as the minimum radii of horizontal and vertical curves, superelevation, sight distance, gradient, signs and road markings etc. The following table (a) compares the design speeds adopted for rural and urban areas in Hong Kong (HK), United Kingdom (UK) and United States of America (USA).

(a) Design speed

	HK	UK	USA
Rural area	100 km/h	120 km/h	80 - 110 km/h
Urban area	70 km/h (80 km/h for new roads) or above	Less than 120 km/h	80 - 110 km/h

As CKR is located in Kowloon urban area for serving long-haul traffic travelling between east and west of Kowloon, it can be found in the above table (a) that the design speed of 80 km/hr for the CKR mainline is on the lower bound from the international highway design standards.

In order to counter-balance the centrifugal force at the horizontal curve of CKR in Kai Tak, the desirable maximum superelevation of 7% is chosen. As a result,

Desirable Minimum Radius of Horizontal Curve > Rmin = $V^2/2.822$ (7%)
CKR – Design Speed V = 80 km/hr; Rmin = $V^2/2.822$ (7%) = 324 m < 330 m

From the above analysis, it is shown that the minimum radius 330 m of the S-curve used at the underwater section of CKR is close to the desirable minimum radius of horizontal curve required.

On the other hand, it is required to check whether the minimum S-curve radius of 330 m can provide the minimum sight distance (***S***) at the underwater section of CKR for road safety

purpose. The following table (b) displays the minimum sight distances by design speeds adopted in HK, UK and USA.

(b) Sight distance

Design speed (km/h)	Minimum sight distance (m)				
	HK		UK		USA
	Desirable	Absolute	Desirable	Absolute	
120	295	215	295	215	250
110	-	-	-	-	220
100	215	160	215	160	185
90	-	-	-	-	160
85	160	120	160	120	-
80	145	110	-	-	130
70	120	90	120	90	105

As the design speed of CKR mainline is 80 km/hr, it is noted in the above table (b) that the minimum sight distance (***S***) which should not be less than 110 - 145 m is affected by the minimum curve radius (***R***) of 330m as shown below:

$$s = \sqrt{8RT}$$

Within the road tunnel of the underwater section of CKR, the clearance (***T***) from the centre of the nearside lane to the obstruction is equal to (3.65/2) + 3.0 + 1.7 = 6.525m.

By substitution of ***R=330*** and ***T=6.525m*** into the above equation, ***S*** is found to be ***131 m***. Therefore the minimum sight distance (***S***) is falling in the range between 110 m and 145 m.

Given that the design speed of CKR is 80 km/hr. Based on the table (c) below, the maximum desirable gradient of 4% is adopted for the option with the shortest underwater section in order to go under the corridor of the Kowloon City Pier PTI and climb up to the ground level at Kai Tak area.

(c) Gradients

Design speed (km/h)	Maximum gradient				
	HK		UK		USA
	Desirable	Absolute	Desirable	Absolute	
120	4%	8%	3%	4%	-
110					5%
70 - 100					between 5% and 12%

In view of the above analysis, it was demonstrated that the relevant highway design standards adopted for the proposed S-curve alignment of CKR at the Kai Tak area are considered as the desirable minimum so as to minimize the extent of temporary reclamation required for the construction of CKR.

5. Independent Review and Recommendations

5.1 Overriding Public Need

In order to assess the traffic impacts of the CKR project, THE CONSULTANT has conducted comprehensive surveys for calibration and validation of the local traffic model (LTM). It was shown that the model validation results are satisfactory with a maximum error of less than 10% in general. With the use of the calibrated LTM, THE CONSULTANT has made traffic forecasts and economic assessment for scenarios with and without CKR in future design years. It was demonstrated that CKR is essential for alleviation of the traffic congestion problem in the Central Kowloon area. THE EXPERT considers that the assumptions made by THE CONSULTANT to be reasonable and confirm in support of their results for the captioned project.

Previous strategic transport studies (e.g. CTS-3) have predicted further increase in traffic demand along the east-west Corridor, and confirmed the need for a east-west trunk road, the CKR, to avoid more extensive and frequent traffic congestion and even gridlock in the road network due to an incident (e.g. 9 May 2005) at the critical road link or major junction.

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The east-west Corridor serving the Central Kowloon areas is already operating beyond its capacity as can be observed on site. Congestion along the Corridor is not limited to the typical morning and evening peak hours of weekdays. It was reported in the 2011 Annual Traffic Census, the vehicular traffic flows travelling between east and west of Kowloon (crossing the screenline A-A) are saturated between 8:00 am and 7:00 pm during weekdays.

Based on the traffic forecasts of THE CONSULTANT for the year of 2021 with and without CKR, THE EXPERT has conducted the level-of-service (LOS) analysis on the screenline of the Corridor (for vehicles travelling between east and west of Kowloon). It was found that LOS D and F will be provided at this screenline in the year of 2021 with and without CKR respectively. The following table shows the criteria for different LOS.

Level of Service	V/C Ratio	Corresponding Traffic Condition
A	Up to 0.3	**Free-flow conditions** Travel speeds at the free-flow speed generally prevail Ability to manoeuvre within traffic stream almost unimpeded Minor disruptions are easily absorbed without change in speed.
B	>0.3 - 0.5	**Easy flow conditions** Travel speeds close to free-flow speed Ability to manoeuvre within traffic stream slightly restricted Minor disruptions are easily absorbed with localised reduction in speed.
C	>0.5 - 0.75	**Generally easy flow conditions.** Travel speeds begin to be restricted by traffic conditions. Ability to manoeuvre within traffic stream is noticeably restricted. Minor disruptions may cause local congestion with short traffic queues.
D	>0.75 – 0.9	**Well used flow conditions.** Travel speeds reduced by increasing traffic volumes. Ability to manoeuvre within traffic stream is severely restricted. Minor disruptions may cause local congestion with traffic queues.
E	>0.9 - 1.1	**Unstable flow conditions.** Travel speeds substantially reduced and are highly variable & unpredictable. Little or no room to manoeuvre within traffic stream. Minor disruptions will cause substantial congestion with long traffic queues.
F	> 1.1	**Forced or breakdown flow conditions.** Crawling travel speed. Highly unstable traffic operations with widespread congestion and extensively long traffic queues.

THE EXPERT regards the LOS F at the Corridor without CKR by the year 2021 to be ineffectual and socially undesirable.

Traffic management measures are already in place to maximize the capacity of the existing road network and suppress the peak hour traffic demand. All these existing measures, however, cannot resolve the traffic congestion problem along the existing east-west

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Corridor. Hence, the CKR is essential, even the Journey Time Indication System (JTIS) and Electronic Road Pricing (ERP) can complement the CKR but cannot replace it. It is because without CKR, there is no reserved capacity at the existing Corridor to cater for the private car and commercial vehicular traffic.

It is also noted in the 2011 Annual Traffic Census, over 60% of vehicular traffic travelling between east and west of Kowloon (crossing the screenline A-A) is commercial vehicles (i.e. taxi, public light buses, goods vehicles, coaches and buses). In order to cater for the commercial traffic demand generated by economic growth in future, there is a need to provide CKR for improving the network connectivity and reliability of the east-west Corridor in Kowloon Peninsula. However, the EXPERT recommends that Government should address the need to regulate land-use developments throughout the Corridor areas in order not to aggravate the congestion problem in the Corridor before the opening of CKR.

In general, THE EXPERT agrees with the findings of the TIA for the dual-3 CKR project. THE EXPERT recognizes the need for the CKR project from traffic ground so as not to bring unacceptable traffic congestion to the Central Kowloon areas.

5.2 Minimum Extent of Temporary Reclamation

In view of the above 4 site constraints of CKR, the reverse curve (S curve) in minimum desirable radii is required for minimum extent of temporary reclamation in relation to the length of the preferred alignment being the shortest and complying with the relevant highway design standards.

In order to minimize the extent of temporary reclamation used for construction of CKR, the design parameters (e.g. design speed of 80 Km/hr, curve radius of 330 m and maximum gradient of 4%) adopted for the proposed S-curve alignment of CKR in Kai Tak area are acceptable but are on the lower bound of the desirable minimum in comparison with the international highway design standards.

The minimum extent of temporary reclamation for the Central Kowloon Route is therefore justified in relation to the relevant site constraints and highway design standards for road safety purpose.

5.3 Conclusions

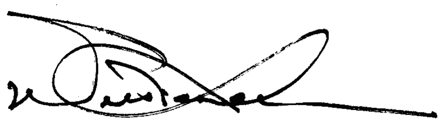
(1) It was found that when the V/C ratio (Volume over Capacity Ratio) for road links or reserve capacity of the major intersections is close to 0.9 or less than 10%, there will be unstable flow conditions with stochastic long traffic queues. These unstable conditions will be getting worse and unacceptable in the future years without the opening of CKR.

(2) In conclusion, the dual-3 CKR project is justified for overriding public need from the traffic ground in order to provide reserved capacity at the Corridor for catering the increasing traffic demand due to the economic growth in future. Moreover, THE EXPERT reckons that THE CONSULTANT's traffic forecasts may even be under-estimated as the effects of the recent increase in the economic growth and further development plan in Hong Kong have not been considered in the drafted and supplementary TIA reports.

(3) Finally, THE EXPERT agrees that the S-curve of CKR (at Kai Tak area) in minimum desirable radii is justified for minimum extent of temporary reclamation in relation to the length of the preferred alignment being the shortest and complying with the relevant highway design standards. THE EXPERT recognizes that the minimum extent of temporary reclamation for the Central Kowloon Route is adopted on the basis of the relevant site constraints and highway design standards for the road safety purpose.

********** END **********

Prepared by



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Appendix B

Independent Expert Review of Cogent and Convincing Materials Report for Temporary Reclamation at Kowloon Bay by Professor Charles W.W. NG

Independent Expert Review Report

Review of Construction Method for the Central Kowloon Route (CKR)

Table of Contents

By
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1. Introduction

The Highways Department (HyD) of HKSAR proposes to construct a 4.7 km long dual three-lane trunk road across central Kowloon, linking West Kowloon to the proposed Kai Tak Development (KTD) in the east. The trunk road will start from the Yau Ma Tei Interchange, link to the future Trunk Road T2 at KTD, which will then connect with the future Tseung Kwan O – Lam Tin Tunnel. These trunk roads will form part of a strategic highway link called Route 6, connecting West Kowloon and Tseung Kwan O.

The Highways Department appointed a Joint Venture (JV) consisting of consultants from Mott MacDonald – Meinhardt – Hyder to carry out a preliminary design under the Agreement No. CE58/2006(HY) – Central Kowloon Route (CKR) and Widening of Gascoigne Road Flyer in 2007 and subsequently appointed Arup - Mott MacDonald Joint Venture (AMMJV) to start detailed design at the end of 2010 under the Agreement No. CE43/2010 (HY).

This reviewer has been engaged as an Independent Expert since the preliminary design stage (Ng, 2009). For the proposed CKR, there are two major technical challenges including the selection of appropriate alignment, near Kowloon City and Kowloon Bay in particular, and the corresponding construction method to be adopted. In previous independent expert review report (Ng, 2009), the need of the CKR and the selection of alignments have been discussed and concluded. In this current report, the construction methods proposed by the AMMJV are independently and critically reviewed.

2. Review Principles and Documents

During this independent review, the following four documents have been reviewed carefully:

- Central Kowloon Route – Design and Construction: Draft Geotechnical Risk Management for Tunnel Works (27 July 2012)
- Central Kowloon Route – Design and Construction: Revised Draft Report on Updated Economic Assessment (24 October 2012)
- Central Kowloon Route – Design and Construction: Final Updated Cogent and Convincing Materials for Temporary Reclamation in Kowloon Bay (21st December 2012)
- Central Kowloon Route – Construction of Underwater Tunnel at Kowloon Bay prepared for Professional Forum held on 11 January 2013

In addition, this Reviewer attended a meeting with Harbourfront Commission held on 7 January 2013, a Professional Forum conducted on 11 January and two Public Forum held in Yau Ma Tei and Kowloon City on 12th and 19th January 2013, respectively.

In this report, independent research works, findings and publications by this Reviewer are also used to insist in the assessment described.

3. Local Geology and Ground Conditions at Kowloon Bay

This reviewer carried out an **independent** site investigation in the Kowloon Bay area for a separate research project to investigate the performance of a 40 m long barrette in Kowloon Bay in 1999. Fig 1 shows the location of a pile load test of the 40 m deep barrette conducted by Ng et al. (2000) on the Kowloon peninsula to the east of a runway of the old Kai Tak airport whereas Fig. 2 illustrates observed ground conditions from borehole logs and measured STP-N (standard penetration) numbers. A copy of the paper is enclosed in Appendix. The measured vertical and horizontal ground movements due to the construction of the barrette are reported by Ng et al. (1999). As shown in Fig. 2, the site is on marine reclaimed land and the ground level is at approximately 4.5m above Principal Datum (PD). The ground water level is at about 3m below ground surface. The ground conditions consist of about 6.0m fill material overlying a succession of approximately 9.5m marine clay deposits, 7.5m of sandy clay (probably alluvial), 4.8m alluvial sand of Quaternary age, and about 12m of weathered granitic saprolite which overlie granitic rocks of Upper Jurassic to Lower Cretaceous age. It can be seen from the figure that measured SPT-N values are low and scattered in all soil strata. As the first approximation, the undrained shear strength (in terms of kPa) of soils may be correlated to SPT-N values by a factor of 4 empirically, it is obvious that the shear strength of the first 30-40m depth of the ground is low in the Kowloon Bay area. This is supported by the back-analysed effective shear strength parameters (c' and ϕ') from three-dimensional numerical analyses of the performance of a diaphragm wall panel constructed at Kowloon Bay (see Fig. 11 of Ng et al., 1999). Other details of the ground response are given in the paper, which is enclosed in Appendix. In addition, from borehole information collected at the test site reported by Ng et al (1999), it is evident that the depth to rock head can increase significantly at the Kowloon Bay area. The findings from these previous investigations are consistent with those concluded by the AMMJV consultants.

4. Selection of Construction Methods

Any construction method selected for underground structures such as tunnels must consider ground conditions and soil/rock properties. As for the CKR is concerned, the ground conditions are fairly good for tunnelling at the west of the proposed route since the rock head there is very high. However, the ground conditions deteriorate quite dramatically beyond To Kwa Wan Road to the east. The depth of rock head drops to about 50m below the sea level in the Kowloon Bay area.

Regarding the selection of the best tunnel alignment option for the proposed CKR, there are some governing constraints that were identified in the areas of Kowloon City and Kowloon Bay. These constraints that must be addressed and resolved are listed as follows:

- Congested areas, private lands and buildings – all these mean that any required demolition of buildings and consumption of lands for the proposed CKR will face ownership problems, and possible ground movements/building damages due to construction must be addressed carefully as public risk will be involved.
- Poor ground conditions at the east end of the proposed Route – deep rock head and thick weak soil layers (low shear strength) as discussed in Section 3 above, i.e., shallow bored tunnelling is not suitable with economy and safety.
- Road gradient limit must be observed for safe and proper designs.

Among over 40 alignments studied by previous JV, there are five preferred options (i.e., A-E) as described in the CCM report. Although alignment A (i.e., the In-land option which consists of a number of routes) can avoid the need for temporary reclamation, there is no enough rock cover to protect building foundations above in the affected areas. If the cut and cover method is selected, there is a strong likelihood of demolition of some private buildings along its route. This is almost an impossible task to accomplish it within a reasonable time frame and cost. Moreover, as alignment A requires steep road gradient for the road level of the CKR to match with the road level at Kowloon Bay and T2 trunk road, these requirements essentially rules out the feasibility of this option. Also proposed depressed road section will conflict with the proposed multi-purpose stadium complex at the Kai Tak development.

For alignments C, D and E, they are required to pass through many private lands and buildings. Any demolition of private buildings and consumption of private lands will face ownership difficulties and problems. Other tunnel construction problems associated with these three alignments are discussed later. Therefore, these three alignments should not be considered further.

Given alignment B is the only viable option, three possible construction methods were considered and investigated by the AMMJV consultants. They are listed as follows:

(i) immersed tube tunnel (IMT),
(ii) bored/drill-and-blast tunnel
(iii) the cut-and-cover cofferdam methods (temporary reclamation needed)

They former two methods will not require reclamation but the latter one needs limited amount of temporary reclamation in the Kowloon Bay area. The proposed IMT will involve a large quantity of dredging of marine bed for up to 30m deep and up to 220m wide. The dredging of this large quantity of materials may impose serious environmental problems and the disposal of the dredged materials will not be an easy task. To facilitate the required bulk dredging, Kowloon City Ferry Pier, HKCG Jetty and the Ma Tau Kok Public Pier will have to be demolished and the permanent seawall at Ma Tau Kok needs stabilization work for minimizing excessive ground movements. Comparing with the amount of dredging involved for alignment B, the quantity of dredging required for any alignment C, D and E will be much larger.

For the bored/drill-and-blast tunnel method, favorable ground conditions are required to provide sufficient cover and hence safety. Given the high water table, poor ground conditions and soil properties at Kowloon Bay, closed face tunneling using either slurry or earth pressure balance bored tunnel should be considered (see Fig. 3). A large diameter tunnel boring machine shown in Fig. 4 serves as a reference. Due to the dual 3-lane trunk road configuration and the elevation requirement at the Kai Tak Interchange in the East, these led to an unfavorable but no other alternative design option as given in Fig. 5, in terms of the required super large-diameter (up to 20.5m) bored tunnel at the west and very small cover to diameter (C/D) ratio (i.e., less than 1.5) at the east of Kowloon Bay. It will be extremely difficult and risky to apply a constant pressure inside the tunnel face to balance a triangular distribution of earth and water pressures outside the tunnel face. These unfavorable conditions impose considerable construction risk to construction personnel and the public. For instance, a major blowout failure at the tunnel head occurred on 23rd

February 1998 during the construction of Docklands Light Rail extension in the UK (see Figs 6 and 7). Due to the insufficient overburden above the bored tunnel using a slurry shield (i.e., small C/D ratio), blowout failure (or passive failure) occurred and a 22m diameter and 7m depth crater was created in the playground of a local school at 5am in the morning and windows located at 100m away were damaged due to the failure (ICE, 1998; 2004). It is not difficult to imagine that the failure may have caused substantial injuries or even casualties if it happened when pupils were gathering in the playground during normal schooling hours. It should be note that the diameter of bored tunnel used at Docklands Light Rail extension was only 5.2m which is significantly smaller than the one (up to 20.5m diameter) proposed for the CKR in Kowloon Bay.

Recent **independent** research carried out to investigate passive failure (or blowout) due to the advancement of a 4.46m diameter tunnel at the Geotechnical Centrifuge Facility in the Hong Kong University of Science and Technology (see Fig 8) also reveals that passive failure mechanism is governed by C/D ratio and difficult to be predicted (Wong et al., 2012; Ng & Wong, 2012). The smaller the C/D ratio, the higher the risk will be during construction. Deepening the vertical profile of tunnel in Kowloon Bay for the CKR to achieve adequate rock cover is also not a viable option since a deeper tunnel alignment will make it impossible to link with the road interchange at Kai Tak.

Some engineers may consider grouting and/or ground freezing techniques to be used in Kowloon Bay prior to tunnelling. These techniques are very risky, and most importantly, they may cause environmental problems in the Bay. Worldwide tunnelling experience illustrates that bored tunnel construction in shallow and poor ground conditions is an extremely dangerous and risky method. It should be also noted that this TBM option for the proposed CKR is not a feasible option since the required tunnel diameter will be up to 20.5m. At present, there is no such large diameter tunnelling boring machine available in the world. Therefore, any shallow tunnelling work beyond the To Kwa Wan Road in the Kowloon Bay can be very risky, time consuming and costly for any of alignments B, C, D and E. In addition, there will be floating problems associated with such a large diameter hollow bored tunnel, should it be selected.

It is this Reviewer's opinion that the only reasonable and viable option proposed by the AMMJV consultants is the use of cut and cover tunnel together with vertical stiff diaphragm wall cofferdam. This is a well-known technique locally and internationally. Hong Kong engineers and contractors are familiar and experienced with it and hence it can be a low risk operation. The proposed two-stage construction of the diaphragm wall cofferdam can minimize adverse effects on water circulation in the Bay. Although temporary reclamation (1.8 and 2.0 hectares for Stages 1 and 2, respectively) is required, this method can minimize the amount of dredging by more than 300% as compared with that of the IMT method. The proposed duration for each stage of works (i.e., 26 months each) is reasonable, given the current knowledge of design constraints and parameters, and ground conditions and soil properties.

Regarding the proposed width and extent of reclamation for construction, the proposed underwater cut and cover tunnel is very effective to minimize the reclamation since the tunnel will be cast directly against the vertical diaphragm wall, eliminating the need of formwork and hence minimizing the width of reclamation. This independent Reviewer is satisfied and convinced that there is no other reasonable alternative and the proposed method of using vertical diaphragm wall can minimize impairment and reclamation. It

should also be pointed out that the extent of temporary reclamation is the smallest among all proposed alignments such as C, D and E in the Kowloon Bay.

Concerns were raised about building safety and integrity due to tunnelling underneath Celestial Heights during the Public Forum held for the Kowloon City District on 19 January 2013. Based on **independent** research carried out by this Reviewer recently on tunnelling effects on piles (Ng et al., 2012), one can be assured that boring tunnelling in good quality of rock should not impose any unreasonable threat to building safety and integrity if the design and construction were carried out properly.

5. Conclusions

Based on the cogent and convincing materials provide and reviewed, and also **independent** research work carried out, this Reviewer is convinced that the selection of the alignment B and the proposed use of cut and cover tunnel construction method with temporary reclamation pass the three tests: (i) compelling, overriding and present need, (ii) no reasonable alternative and (iii) minimum impairment and reclamation. There is no other reasonable alternative to the proposed CKR and the proposed reclamation is the minimum.

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1. ICE (1998). Bulkhead location blamed for DLR blast. New Civil Engineer, Institute of Civil Engineers, February Issue, 3-4.
2. ICE (2004). Docklands tunnel blowout down to "elementary error", says judge. New Civil Engineer, Institute of Civil Engineers, January Issue, 8-9.
3. Ng, C.W.W., Rigby, D., Lei, G. & Ng, S. W.L. (1999). Observed performance of a short diaphragm wall panel. *Géotechnique.* Vol. 49, No.5, 681-694.
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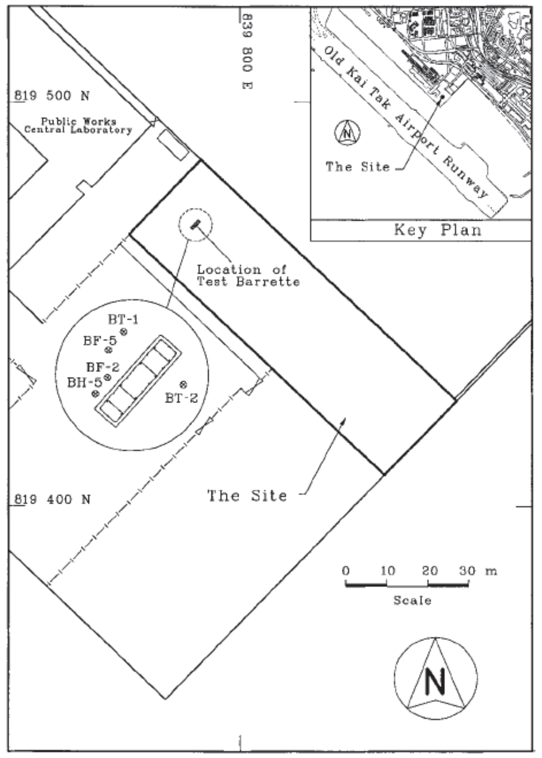


Fig. 1 Independent Study -Ground Conditions at Kowloon Bay (Ng et al, 2000)

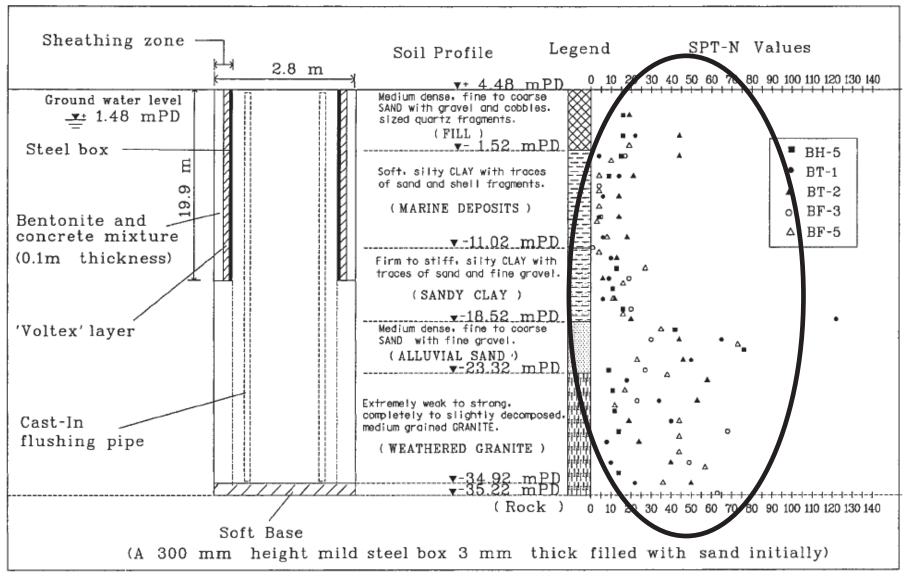
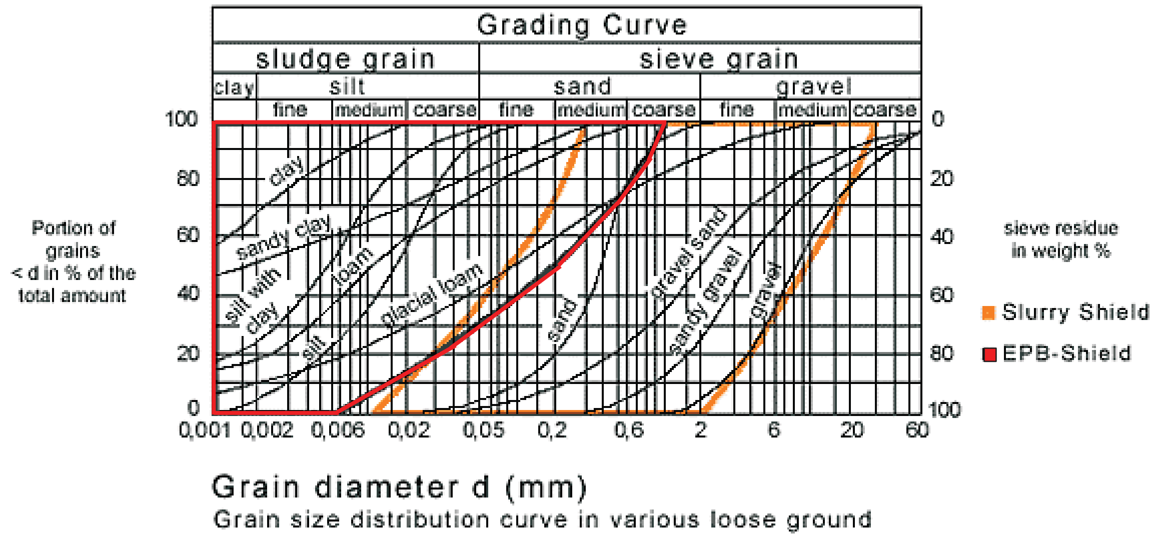


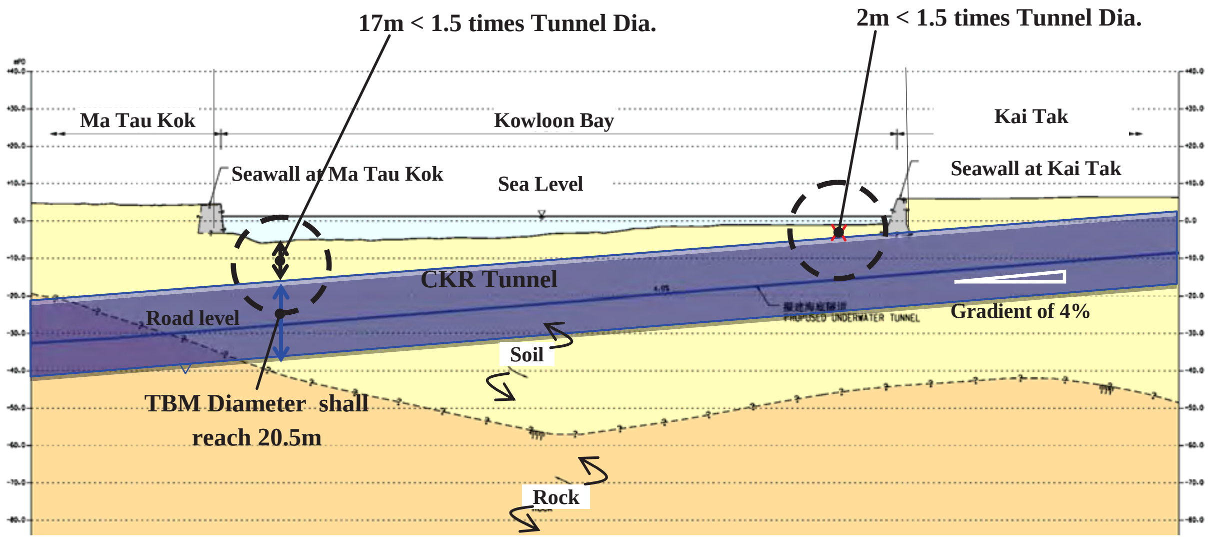
Fig. 2 Poor Ground Conditions at Kowloon Bay (Ng et al, 2000)



EPB is generally applicable for clay to clayey sand where permeability is relatively low

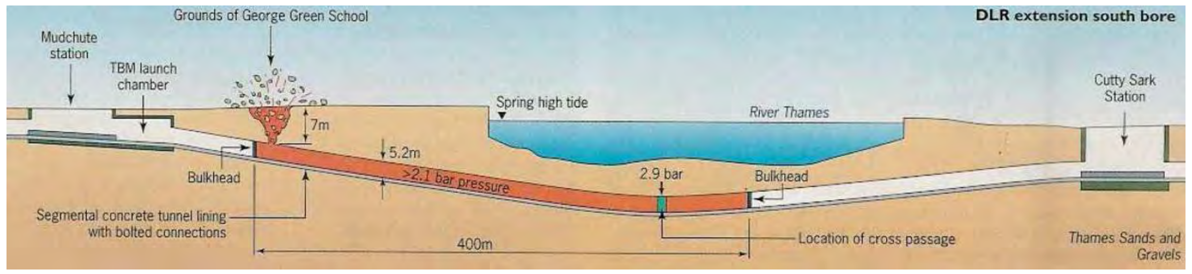
Fig. 3 Grading Curve Related to the Choice of EPB Shield

Fig. 4 Tunnel Boring Machine (about 14m Diameter)



Bored tunnel method is not feasible since tunnel with large diameter (20.5 m) constructed in thick soft soil underlained by rock (very risky)

Fig. 5 Proposed Bored Tunnel Construction Method for CKR



ICE (1998)

- Diameter = 5.2 m
- Slurry shield boring machine using compressed air

Possible causes of failure

- Insufficient overburden above the tunnel
- High compressed air pressure (2.2 bar) within tunnel causing blowout failure

Fig. 6 Blowout Failure of Docklands Light Rail (extension) on 23 Feb. 1998 in UK

The compressed air blast left a huge crater in a Docklands school playing field.

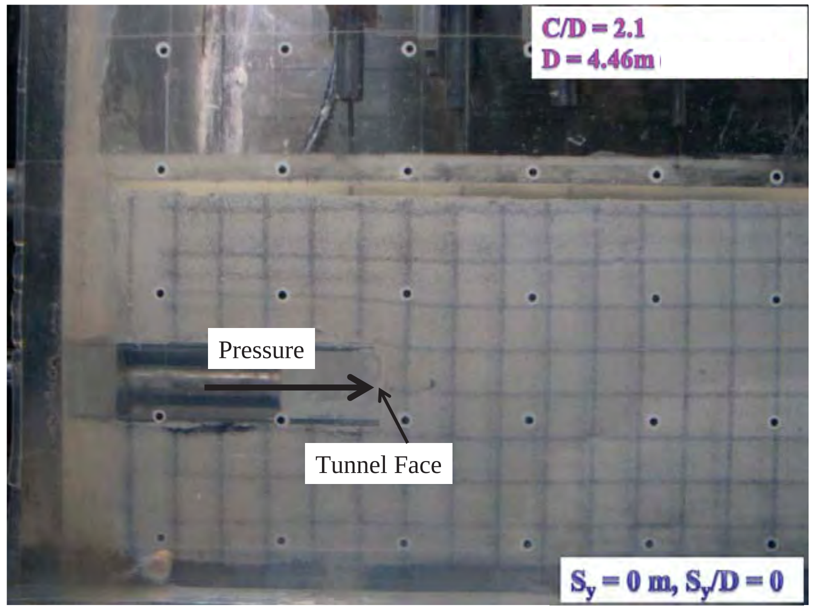
The crater is 22 m wide and 7 m deep in the playground of a school

A crater 22m wide and 7m deep was created by the blast in the grounds of George Green school.

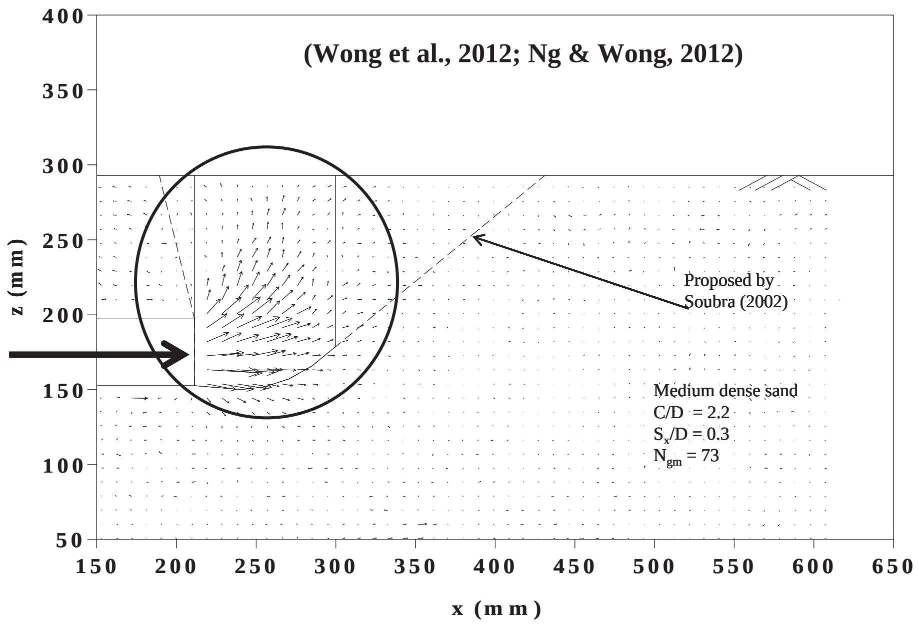
Massive crater due to compressed air blast

- ICE (1998). Bulkhead location blamed for DLR blast. New Civil Engineer, Institute of Civil Engineers, February Issue, 3-4.
- ICE (2004). Docklands tunnel blowout down to "elementary error", says judge. New Civil Engineer, Institute of Civil Engineers, January Issue, 8-9.

Fig. 7 Crater Formed in the Playground of George Green School (ICE, 1998 & 2004)



(a)



(b)

1. Ng, C. W. W. & Wong, K.S. (2012). Investigation of passive failure and deformation mechanisms due to tunnelling in clay in centrifuge. *Canadian Geotechnical Journal.* Provisionally Accepted.
2. Wong, K. S., Ng, C. W. W., Chen, Y.M. & Bian, X.C. (2012). Centrifuge and numerical investigation of passive failure of tunnel face in sand. *Tunnelling and Underground Space Technology.* Vol. 28, 297-303.

Fig. 8(a) Passive Failure (blowout) of Tunnel Face; (b) Measured displacement vectors leading to blowout

Appendix

a. **Ng, C.W.W**., Rigby, D., Lei, G. & Ng, S. W.L. (1999). Observed performance of a short diaphragm wall panel. *Géotechnique.* Vol. 49, No.5, 681-694.

b. **Ng, C.W.W**., Rigby, D., Ng, S. W.L & Lei, G. (2000). Field studies of well-instrumented barrette in Hong Kong. *Journal of Geotechnical and Geo-environmental Engineering, ASCE*. Vol. 126, No. 1, 60-73.

c. **Ng, C.W.W**., Lu, H. & Peng, S.Y. (2012). Three-dimensional centrifuge modelling of twin tunnelling effects on an existing pile. *Tunnelling and Underground Space Technology.* In Press. http://dx.doi.org/10.1016/j.tust.2012.07.008.

d. Wong, K. S., **Ng, C. W. W**., Chen, Y.M. & Bian, X.C. (2012). Centrifuge and numerical investigation of passive failure of tunnel face in sand. *Tunnelling and Underground Space Technology.* Vol. 28, 297-303.

Ng, C. W. W., Rigby, D. B., Lei, G. H. & Ng, S. W. L. (1999). *Géotechnique* **49**, No. 5, 681–694

Observed performance of a short diaphragm wall panel

C. W. W. NG,* D. B. RIGBY,* G. H. LEI* and S. W. L. NG*

The construction in Hong Kong of a 40 m deep excavated, large, rectangular-section barrette (i.e. a short diaphragm wall panel, 2·8 m long by 0·8 m wide) in sedimentary and weathered soils under bentonite has been heavily instrumented and closely monitored. During excavation, the maximum measured horizontal ground movements were only a few millimetres, with similar subsurface settlements around the panel. On the basis of three-dimensional numerical simulations of the excavation of the trench, an average mobilized shear strain greater than 0·1% around the excavated trench can be deduced. At the soil–wall interface, the initial lateral earth pressures decreased to hydrostatic bentonite pressures during excavation and increased above their initial K_0 pressures after concreting. The measured lateral pressures just after concreting support a theoretical bilinear pressure envelope.

KEYWORDS: deformation; diaphragm and *in situ* walls; earth pressure; numerical modelling; pore pressures.

La construction d'une barrette à grande section rectangulaire excavée à 40 m de profondeur (c'est-à-dire d'un court panneau de mur souterrain de 2,8 m de long par 0,8 m de large) dans des sols sédimentaires et désagrégés sous de la bentonite a fait l'objet de nombreux contrôles aux instruments et a été observée de près à Hong Kong. Pendant l'excavation, les mouvements horizontaux maximum du sol qui ont été mesurés n'ont été que de quelques millimètres, avec des tassements similaires sous la surface autour du panneau. En nous basant sur des simulations numériques en trois dimensions de l'excavation de la tranchée, nous avons pu déduire une déformation de cisaillement mobilisée moyenne supérieure à 0,1% autour de la tranchée excavée. À l'interface sol-mur, les pressions terrestres latérales initiales baissent pour arriver au niveau des pressions de bentonite hydrostatiques pendant l'excavation et elles passent au-dessus de leurs pressions K_0 initiales après le bétonnage. Les pressions latérales mesurées juste après le bétonnage soutiennent la théorie d'une enveloppe de pression bilinéaire.

INTRODUCTION

The use of slurry trenches to construct diaphragm walls for underground structures has become a well-known technique in civil engineering. The construction of the diaphragm walls will inevitably cause initial stress changes and deformations in the ground (Clough & O'Rourke, 1990; Farmer & Attewell, 1973; Ng, 1992; Stroud & Sweeney, 1977; Symons & Carder, 1993). Various techniques, such as numerical modelling (Ng, 1992; Ng *et al*., 1995) and centrifuge modelling (Powrie & Kantartzi, 1996), have been attempted to investigate stress transfer mechanisms and ground deformations due to diaphragm walling. Field monitoring of different panel sizes in different ground conditions is vital to provide essential data for verifying numerical and centrifuge results. In the Far East, well-documented case histories of diaphragm walling are rarely reported in the literature, with one exception. Stroud & Sweeney (1977) carried out a detailed field trial of a diaphragm wall panel, 6·1 m long by 1·2 m wide and about 36 m deep, constructed at Chater Road on Hong Kong Island. Maximum horizontal subsurface movements of 28 mm and 10 mm were recorded at 1 m and 2 m, respectively, away from the face of the trench at about 16 m below ground level. A settlement trough with a maximum value of 6 mm was observed 3 m away from the face of the trench.

Recently the authors have had the opportunity to measure ground deformations and stress changes during the construction of a large, excavated, rectangular-section pile (barrette) for a University-led and industry-supported research project (Shen *et al*., 1998). The excavation and concreting procedures used for the barrette were identical to those used in the construction of a diaphragm wall panel. The barrette was tested for its ultimate vertical load capacity three weeks after construction. However, in this paper, only the performance of the short diaphragm wall panel during construction is documented as a case history. The observed ground deformations during the excavation of the trench of the diaphragm wall panel are compared with a three-dimensional numerical analysis. Moreover, stress and pore water changes at the soil/wall interface during concreting are reported and discussed.

Manuscript received 24 September 1998; revised manuscript accepted 16 February 1999.
Discussion on this paper closes 30 April 2000; for further details see p. ii.
* Hong Kong University of Science and Technology.

SITE LOCATION AND GROUND CONDITIONS

The site is located on the Kowloon peninsula of Hong Kong, to the east of a runway of the old Kai Tak International Airport, adjacent to the Public Works Central Laboratory at Kowloon Bay (Fig. 1). Figs 2 and 3 show a cross-section of the test barrette and the location of some relevant boreholes, together with uncorrected N values from standard penetration tests (SPTs) measured in each soil stratum. The site is on marine reclaimed land and the ground level is at approximately 4·5 m above sea level or Principal Datum (PD). The groundwater level is at about 3 m below the ground surface. The ground conditions consist of, in succession, approximately 6 m of fill material, 10 m of marine deposits, 12 m of alluvium of Quaternary age and 12 m of weathered granitic saprolites overlying granitic rocks of Upper Jurassic to Lower Cretaceous age (Strange, 1990). The ground succession is similar to the site at Chater Road (Stroud & Sweeney, 1977).

It can be seen from Fig. 2 that very scattered SPT N values were obtained in both the alluvium sand and the weathered granite. It should be noted that the idealized geological strata shown in the figure may only be applicable to a local area around the trench. From borehole information, the depth to the rock head has been found to increase quite significantly from the south-east to the north-west direction at the site. The initial horizontal stresses in the ground are not known for certain at Kowloon Bay. However, it is generally believed that the initial K_0 values are less than 0·5 for soils in Hong Kong (Geotechnical Engineering Office, 1993).

DETAILS OF CONSTRUCTION

The test barrette or diaphragm wall trench was excavated using a traditional cable-operated grab. The size of the excavated trench was 2·8 m by 0·8 m in plan and 39·7 m deep (Figs 2 and 3). During construction, the trench was temporarily supported by bentonite slurry with a unit weight (γ_b) of 10·8 kN/m^3. Soil spoil, suspended in the bentonite slurry, was removed after pumping to a desanding unit at the ground surface. After desanding, the bentonite was recharged into the trench. Chiselling of the base took place when the excavated depth reached about 39·6 m below ground level. This caused a small overbreak at the base which was detected by a sonic profiling system. When the excavation reached its final level (39·7 m below ground level), three instrumented reinforcement cages were lowered and spliced together one by one into the trench, which was then concreted at an average rate of 10·32 m/h (or 23·12 m^3/h) using a tremie pipe. The ordinary Portland cement (OPC) concrete used was grade C30/20 (design $f_{cu} = 30$ MPa) with a unit weight (γ_c) of 23·2 kN/m^3. It had a water-to-cement ratio of 0·47 and an average slump of 180 mm. The average uniaxial compressive strength measured from a core taken from the centre of the barrette was 37·5 MPa at 28 days. During concreting, the average temperature measured inside the trench was 27·6°C. The excavation and concreting procedures of the barrette were in fact identical to those of the construction of a typical diaphragm wall panel.

At the upper reinforcement cages, a sheathing zone was formed (see Fig. 2) with the intention of minimizing the skin friction developed between the pile and the upper layers of the surrounding soil during axial load testing.

INSTRUMENTATION

The test barrette at Kowloon Bay was heavily instrumented. The prime objectives of the instrumentation were to study ground deformations due to the construction of the barrette (the diaphragm wall panel) and, more importantly, to investigate the load transfer mechanism and load–settlement characteristics of the barrette during axial load testing. In this paper, only the instrumentation related to the construction of the barrette is reported. Details of other instrumentation and the research strategy are described by Shen *et al*. (1998). Figs 3 and 4 show the locations of various instruments both in and around the trench.

Four Geokon vibrating-wire-total-earth-pressure cells, together with four vibrating-wire piezometers, were installed at the soil–wall interface at four elevations. Two total-earth-pressure cells were installed in both the alluvium and the weathered granite layers to measure total horizontal pressures at the soil–wall interface. The locations of the vibrating-wire piezometers were at about 80 mm above the corresponding pressure cells.

In addition, one pneumatic piezometer was installed inside borehole BF-4 (see Fig. 4) at 35 m below ground level in the weathered granite to monitor pore water pressure changes during the construction and testing of the barrette.

Magnetic extensometers were installed into three boreholes (see Fig. 4). The datum magnets were set into the rock, except in BF-3, owing to some construction difficulties encountered. The extensometers allowed subsurface soil movements to be measured by monitoring the location of each magnetic target with respect to the datum magnet.

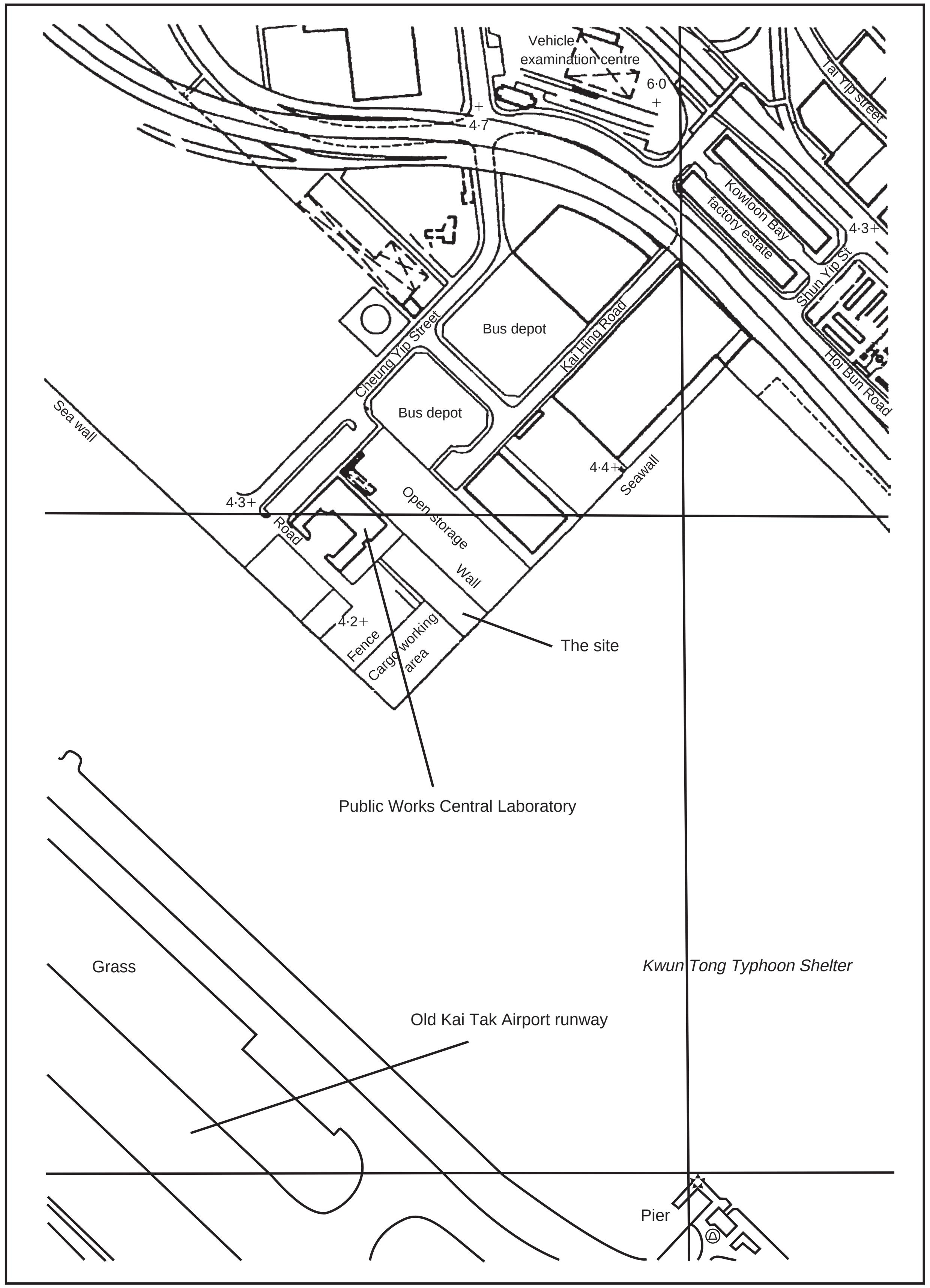


Fig. 1. Location plan of test pile site in Kowloon, Hong Kong

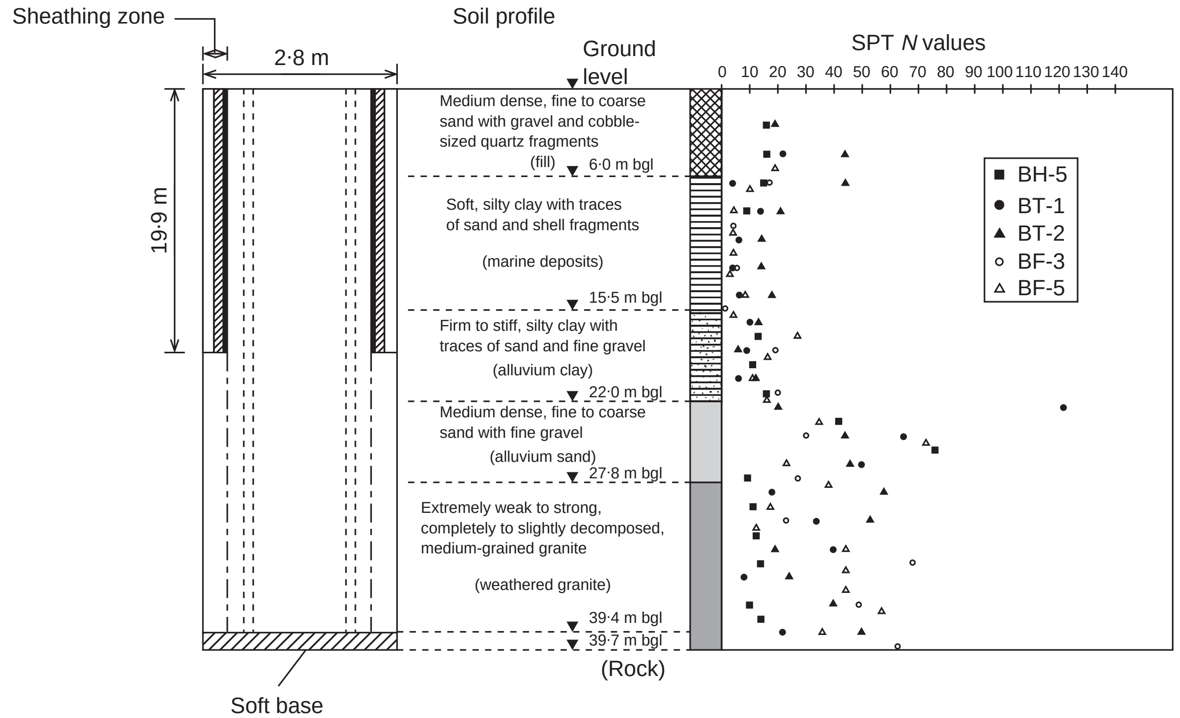


Fig. 2. Borehole logs and SPT *N* values at Kowloon Bay, Hong Kong (bgl, below ground level)

Three conventional inclinometer systems were installed in three boreholes, as shown in Figs 3 and 4. The bottoms of the inclinometers were fixed in rock. The inclinometers were used to measure rotations and hence the lateral movement of the soil around the trial barrette. In addition, settlement markers were installed around the trench, as shown in Fig. 3. The settlement monitoring system consisted of a steel rod. The bottom of the rod was concreted in a hole of 1·5 m depth below ground level. The settlement markers were used to measure surface settlements of the ground due to the construction of the diaphragm wall panel.

GROUND DEFORMATIONS DURING CONSTRUCTION OF THE BARRETTE

The excavation of the trench started on the morning of 5 December 1997 and was completed at midnight 7 December 1997. During excavation, the level of bentonite was kept at about 1·5 m above the ground water table (i.e. at about 3 m PD). The trench was then concreted in the afternoon of 9 December 1997. The horizontal deformation profiles measured are illustrated in Fig. 5. The measurements from the conventional inclinometers are of poor quality. This was probably because the actual movements were too small, only about 2·5 mm maximum horizontal ground movement towards the trench was observed at the ground surface in BF-5 (4 m away from the trench). The resolution of the inclinometers (0·1 mm deviation per metre or a maximum deviation of 4 mm over the 40 m trench) was simply not good enough to differentiate any small movements induced on site.

The measured horizontal displacements generally decrease with depth, except for the localized large displacements appearing at about 32 m below ground level. This localized large ground deformation could be due to overbreak and loss of ground during chiselling at the base of the trench. Generally, small lateral deformations were observed and these may be attributed to limited stress relief during excavation (i.e. the initial horizontal stresses in the ground were not very different from the bentonite pressure) and the significant effect of soil arching (Ng, 1992; Ng *et al*., 1995) around the relatively short panel length. Owing to the limited accuracy of the conventional inclinometers, no clear trend can be identified among the measured values from the three boreholes.

In the measured profiles at Chater Road (Stroud & Sweeney, 1977) and at Kowloon Bay, more significant deep-seated deformation was observed at the former than at the latter site. This was probably due to substantial soil yielding at deeper levels (large deviatoric shear stress) for the longer panel (6·1 m) at Charter Road. Deviatoric shear stress due to the difference between the vertical and horizontal effective stresses would be induced in the soil around trenches during excavation. On the other hand, soil arching around the shorter panel (2·8 m) seems to minimize the ground deformation at Kowloon Bay. Details of soil arching and stress transfer mechanisms due to the construction of a diaphragm wall panel are discussed by Ng *et al*. (1995).

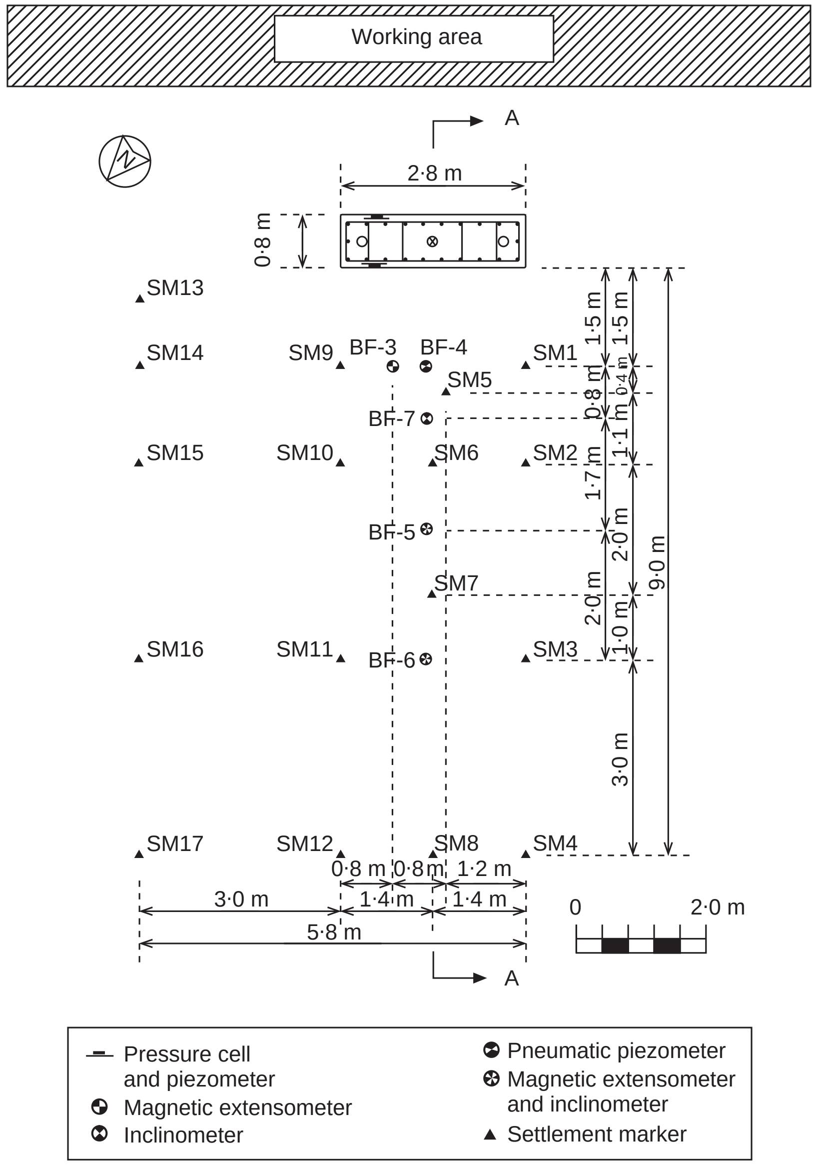


Fig. 3. Plan view of locations for instrumentation

During concreting, the ground surface was pushed, on average, about 1 mm outward laterally away at 4 m and 6 m from the trench by the wet-concrete pressure (see Fig. 5). It should be noted that the theoretical concrete pressure acting on the soil face was higher than the initial horizontal stresses in the ground. At 2·3 m from the trench (BF-7), the observed ground deformation is somewhat unexpected as the measurements indicate that there was a significant lateral movement (about 11 mm) away from the trench at 11 m below ground level (−6·5 m PD). Confirmation of the reliability of this substantial lateral movement can be obtained by considering the subsurface vertical movements measured by the extensometer installed in BF-3 (1·5 m away from the trench).

Figure 6 shows the subsurface vertical movements recorded by the extensometer in BF-3. During the excavation, the measurements showed an increase in settlement at all levels as excavation continued, with a maximum settlement of 2 mm at ME3-5. After concreting, a small recovery of ground settlements was recorded by the uppermost two spider magnets, except at ME3-5, which recorded a substantial upward movement (heave) of 7·5 mm in the soft marine deposit. ME3-5 is 9 m below ground level, just above the spike of ground movement measured by the inclinometer in BF-7. The consistency between the inclinometer and magnetic extensometer readings suggests that these large local deformations in the two orthogonal directions adjacent to the trench might be due to the presence of a weak soil layer or an overbreak and loss of ground during excavation. All other spider magnets in the same borehole show an increase in settlement during concreting and that the settlement ceased after concreting.

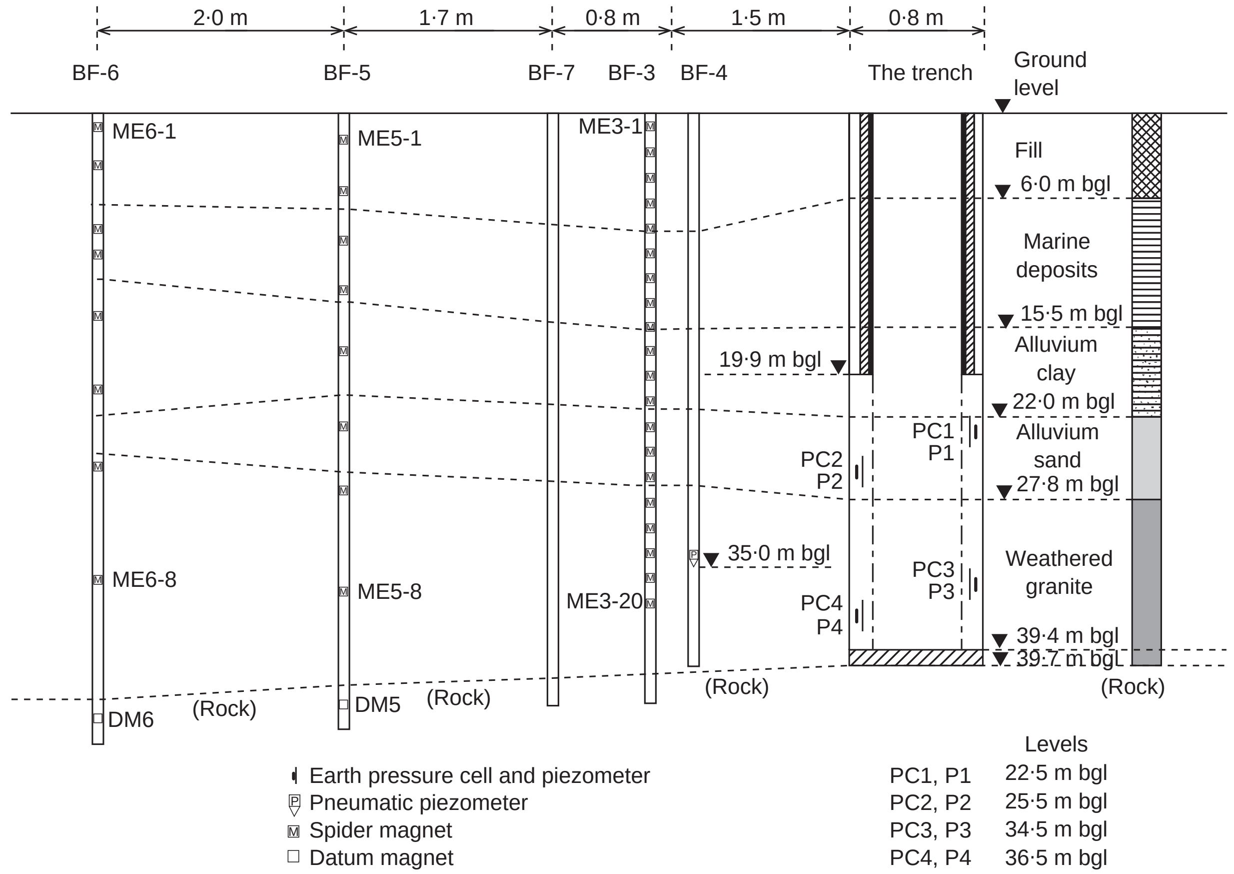


Fig. 4. Typical schematic cross-section A–A showing layout of instrumentation (not to scale)

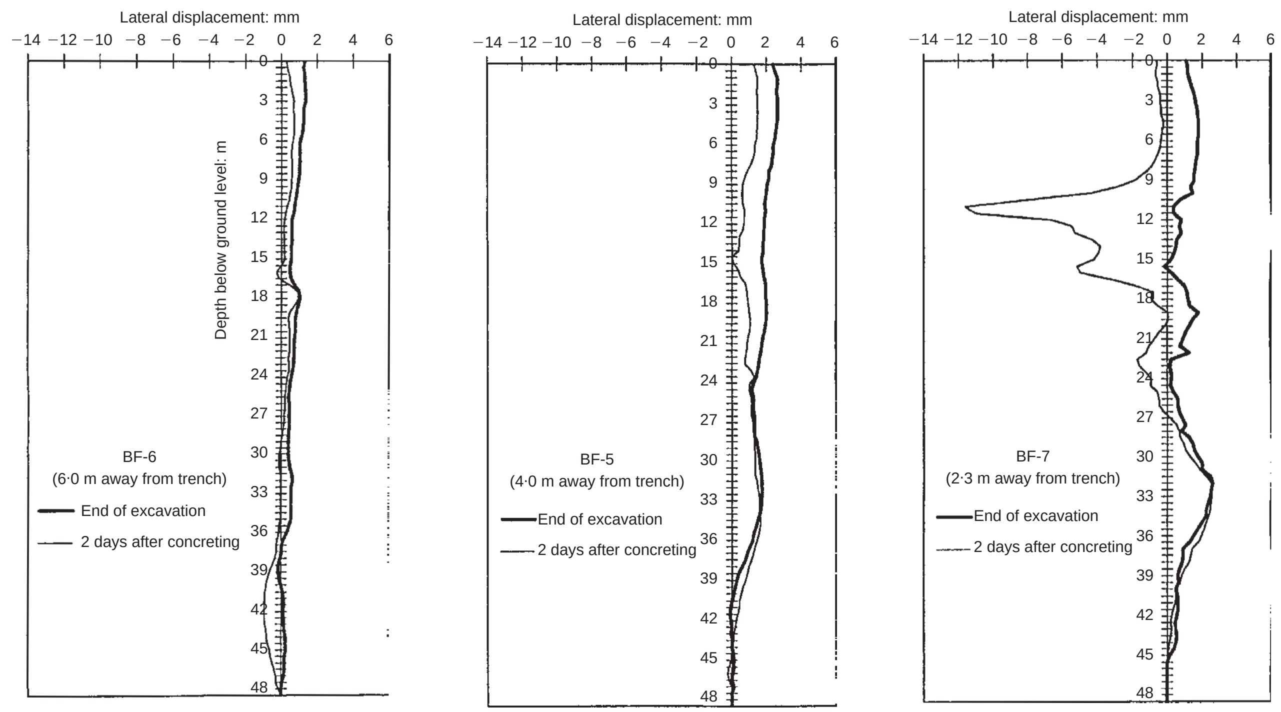


Fig. 5. Ground deformation profiles at different stages of barrette construction (positive lateral displacement: towards the trench; best resolution 0·1 mm deviation/1 m depth)

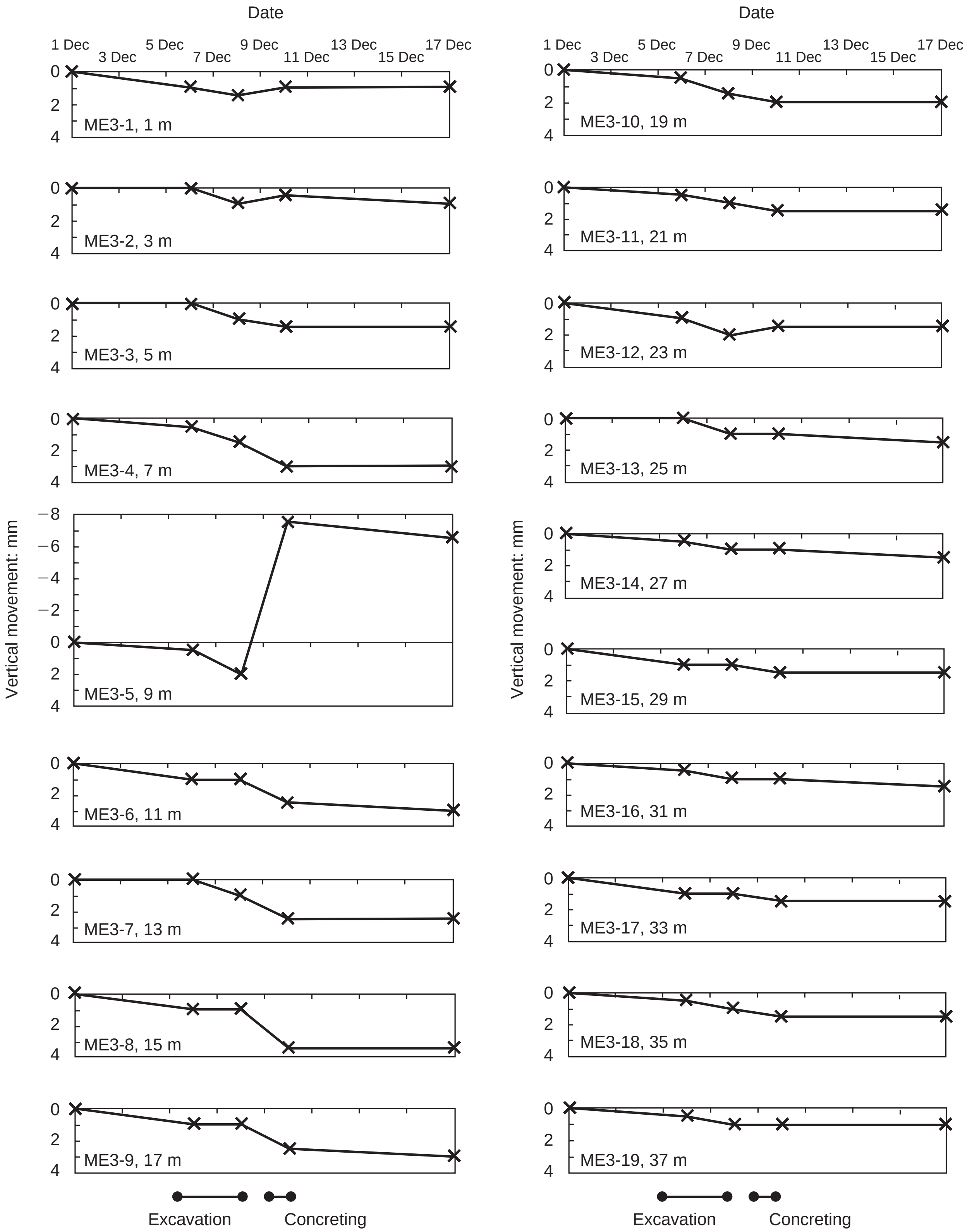


Fig. 6. Variations of subsurface vertical movement with time at BF-3 (1·5 m away from trench) (measured by magnetic extensometer: positive, settlement; negative, heave)

Figure 7 summarizes the subsurface vertical movements measured by the upper magnets installed in both BF-5 and BF-6. The excavation of the trench caused maximum downward movements of 1·5 mm and 2·5 mm, at 2 m depth in BF-5 and at 1 m depth BF-6, respectively. Generally, the deeper the magnet, the smaller the settlement recorded. Recovery of ground loss due to concret-

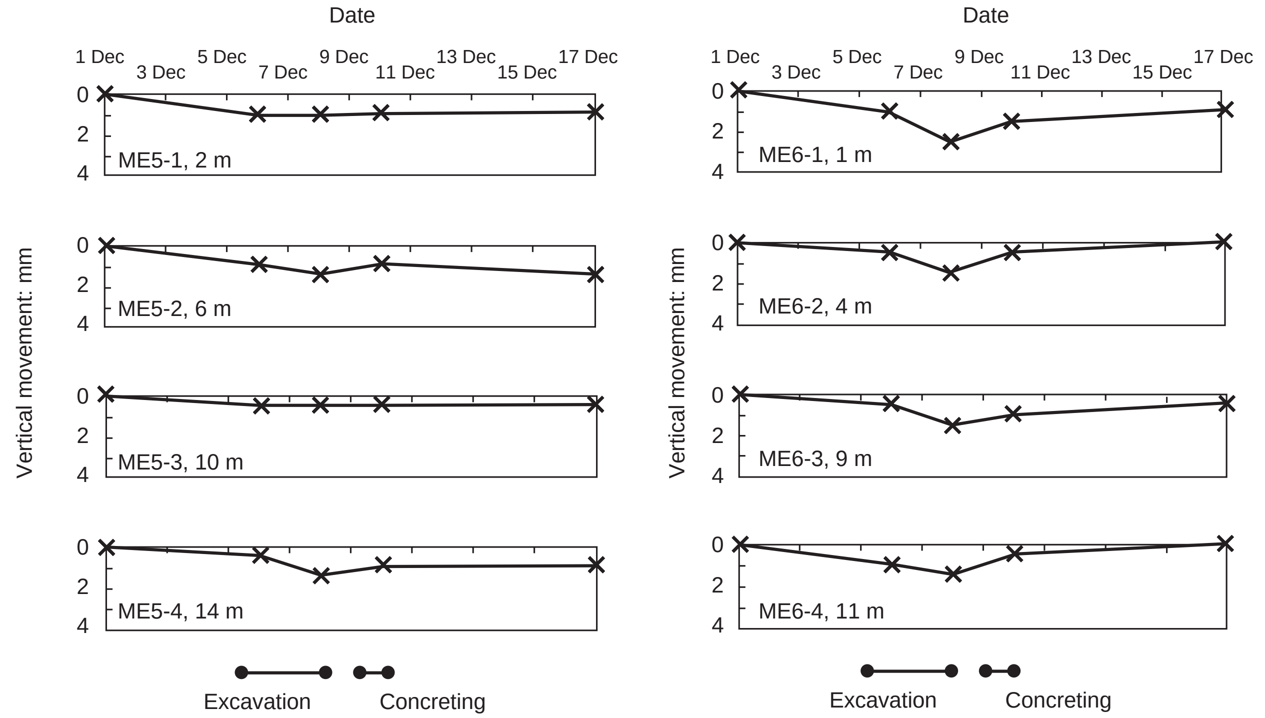


Fig. 7. Variations of subsurface vertical movement with time at BF-5 and BF-6 (measured by magnetic extensometer)

ing resulted in a substantial reversal of settlement in each borehole. This recovery of ground loss indicates that the lateral stress in the ground could not possibly be larger than the concrete pressure during construction. Low initial lateral stress in the ground can thus be deduced.

Surface ground settlements were monitored using ordinary levelling techniques. Even allowing for the typical accuracy of $\pm 1{\cdot}0$ mm of the levelling instrument, the observed settlements at various distances from the trench are unexpectedly very small. The maximum settlement measured was 1 mm during the excavation of the trench. During concreting, no recovery of ground loss can be identified.

CONTACT PRESSURES AT THE SOIL–WALL INTERFACE

Four vibrating-wire-total-earth-pressure cells and piezometers were attached to appropriate locations of the reinforcement cage during the construction of the barrette. Once in position, the instruments were jacked horizontally from the ground surface to ensure contact with the surrounding soil. The prime objective of installing the piezometers was to record changes of pore water pressures during the proposed vertical-load test of the barrette a few weeks after construction. In order to prevent the ceramic tips of the piezometers from clogging with bentonite, the ceramic tips were plugged with solid soap. This was expected to take a few days to dissolve before allowing the piezometers to function properly after concreting.

Initial readings of the piezometers and earth pressure cells were taken before the instruments were jacked into position. This allowed a comparison to be made with the calculated bentonite pressures, using a measured unit weight (γ_b) of 10·8 kN/m^3. There was very good agreement between the calculated bentonite pressures and the readings recorded by the vibrating-wire earth pressure cells (Fig. 8). The maximum difference between the calculated and measured pressures was less than 10 kPa. Some minor adjustments were made to the calibration factors.

Some piezometers showed higher pressures than the calculated values (Fig. 9). This was possible because the solid soap used to plug the ceramic tips of the piezometers had little time to dissolve. After taking initial readings, the earth pressure cells and piezometers were bedded in by jacking them out horizontally against the excavated soil surface until cell readings equal to the assumed initial K_0(=0·5) earth pressure were achieved. The jacking pressure was reduced once the concrete level went a few metres above the location of each pressure cell.

Since the initial horizontal stresses in the ground are not known for certain at Kowloon Bay, an initial K_0 value, equal to $(1-\sin\phi')$, was assumed for each soil layer at Kowloon Bay, and the calculated lateral earth pressures are shown in Fig. 8. Low initial K_0 values in fill and decom-

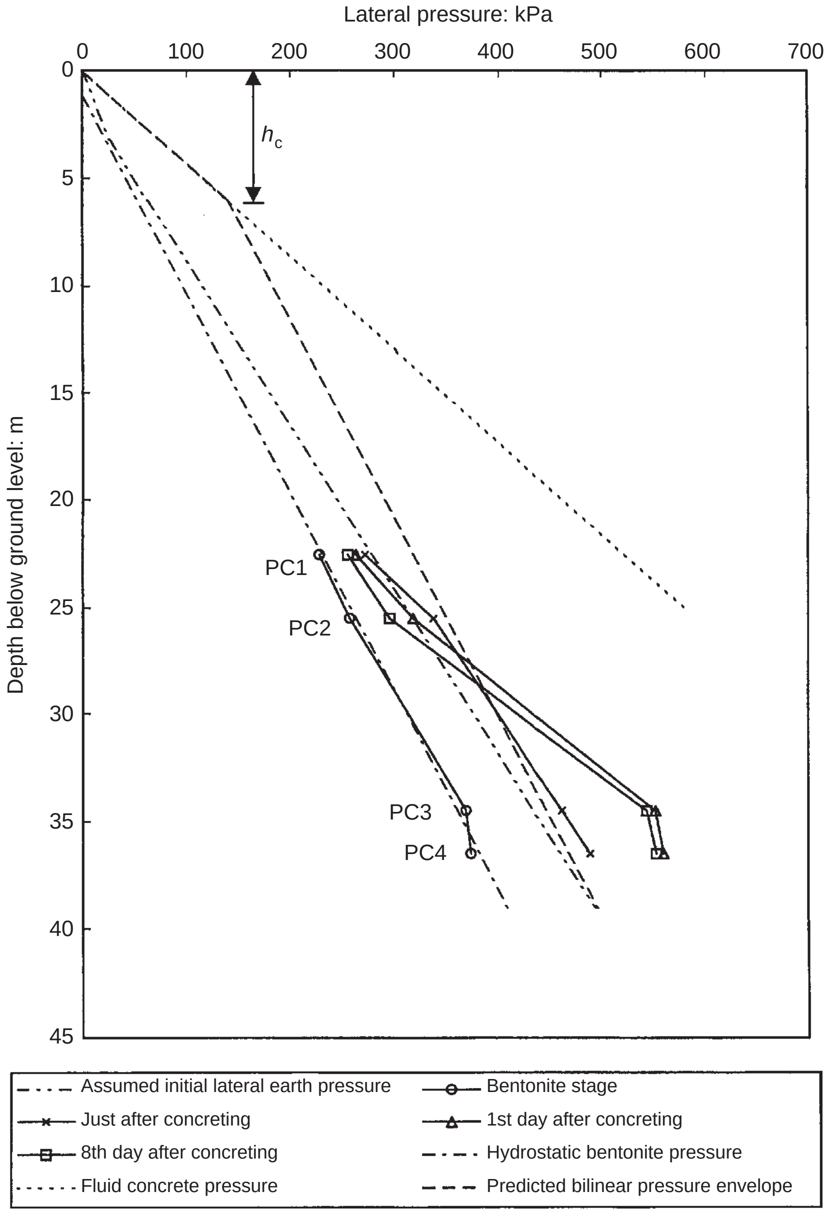


Fig. 8. Variations of lateral pressure distribution with depth

posed granite have recently been verified by back-analysing a deep excavation using the non-linear Simpson's brick model (Malone *et al.*, 1997). It was thus expected that there could be a stress reduction during the excavation of the barrette. For equilibrium, the initial total earth pressure had to reduce to the bentonite pressure. The reduction of the total initial stress in the ground due to excavation resulted in mainly horizontal ground movements. Swelling and softening of the soils followed and hence led to a decrease in shear strength and stiffness.

On the basis of field observations and theoretical considerations, Ng (1992) and Lings *et al.* (1994) proposed a theoretical bilinear pressure envelope for predicting lateral pressures developed at the soil–wall interface during concreting in a diaphragm wall panel. The theoretical bilinear equation derived is as follows:

$$\sigma_h = \begin{cases} \gamma_c z & z \leqslant h_c \\ (\gamma_c - \gamma_b)h_c + \gamma_b z & z > h_c \end{cases} \quad (1)$$

where σ_h, z and h_c are the total lateral pressure, the depth below the top of the panel and the critical depth, respectively. According to the guidelines given in CIRIA Report 108 (Clear & Harrison, 1985), the value of the critical depth is mainly governed by the type of cement used, the rate of concreting, the temperature and the size and shape of the trench. The critical depth calculated for the panel at Kowloon Bay is 6·03 m and the predicted bilinear envelope is shown in Fig. 8. The measured values just after concreting agree well with the

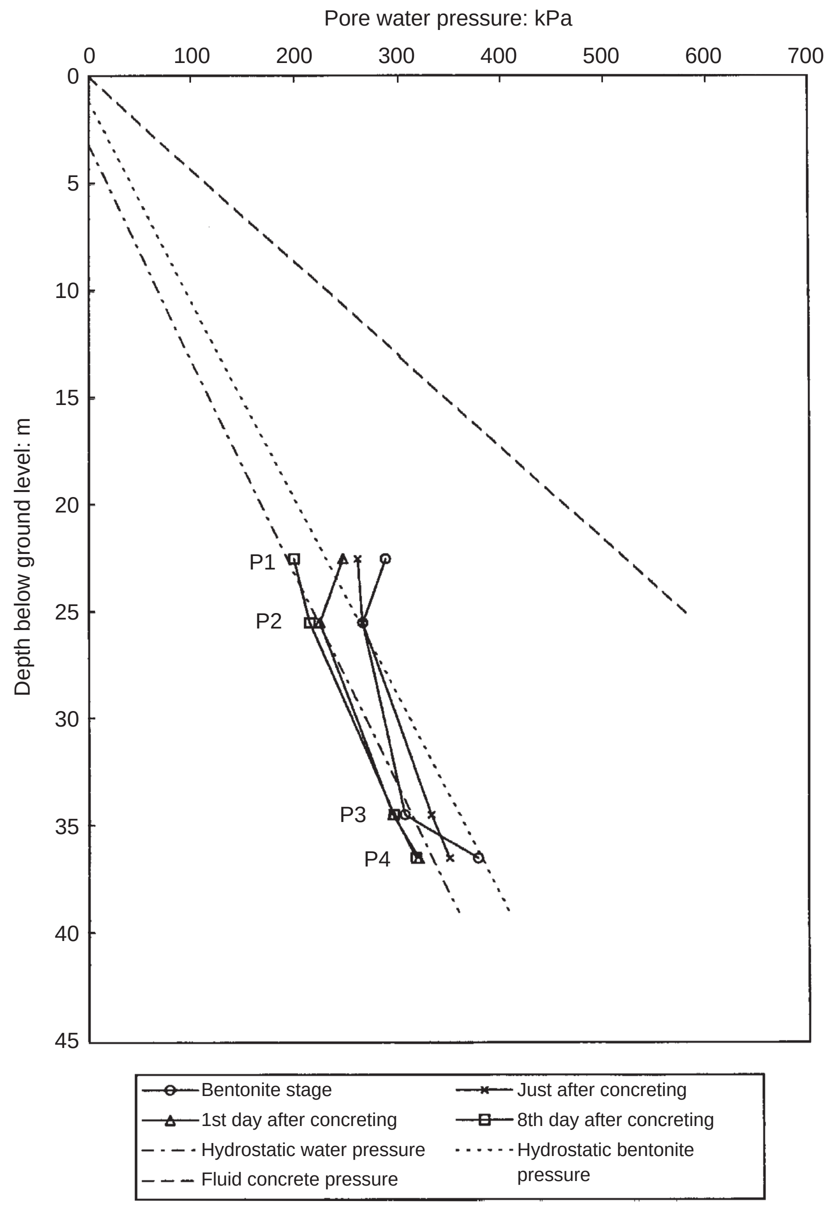


Fig. 9. Variations of pore water pressure distribution with depth

theoretical line predicted by the equation, except at PC1. It is clear that the full fluid concrete pressure did not develop over the full depth of the wall during concreting. The horizontal total pressures increased to some values higher than the assumed initial K_0 pressures, except at PC1, and they pushed the surrounding soil away from the trench, as shown in Fig. 5.

Measurements of lateral earth pressures 1 and 8 days after concreting are also shown in Fig. 8. There were substantial increases in lateral pressure at PC3 and PC4 in the weathered granite, but slight decreases at PC1 and PC2 in the alluvium sand. The increase of pressure in the weathered granite is somewhat unusual and might be due to swelling of the soil and stress redistribution.

Figure 9 shows the observed pore water pressures at the soil–wall interface. As discussed previously, the measured values at the bentonite stage do not fall on the hydrostatic bentonite pressure line, probably because the ceramic tips were plugged with soap initially. Readings taken during and one day after concreting show that excess pore water pressures were generated because of concreting. Dissipation of the excess pore water pressure seemed to be complete 8 days after concreting. The pore water pressures at the soil–wall interface resemble hydrostatic conditions.

Figure 10 shows the measured pore water pressures 1·5 m away from the face of the trench in BF-4 (at 35 m below ground level). The piezometer recorded an increase of 7 kPa above an average pore water pressure of 311 kPa during concreting. The excess pore water pressure largely dissipated

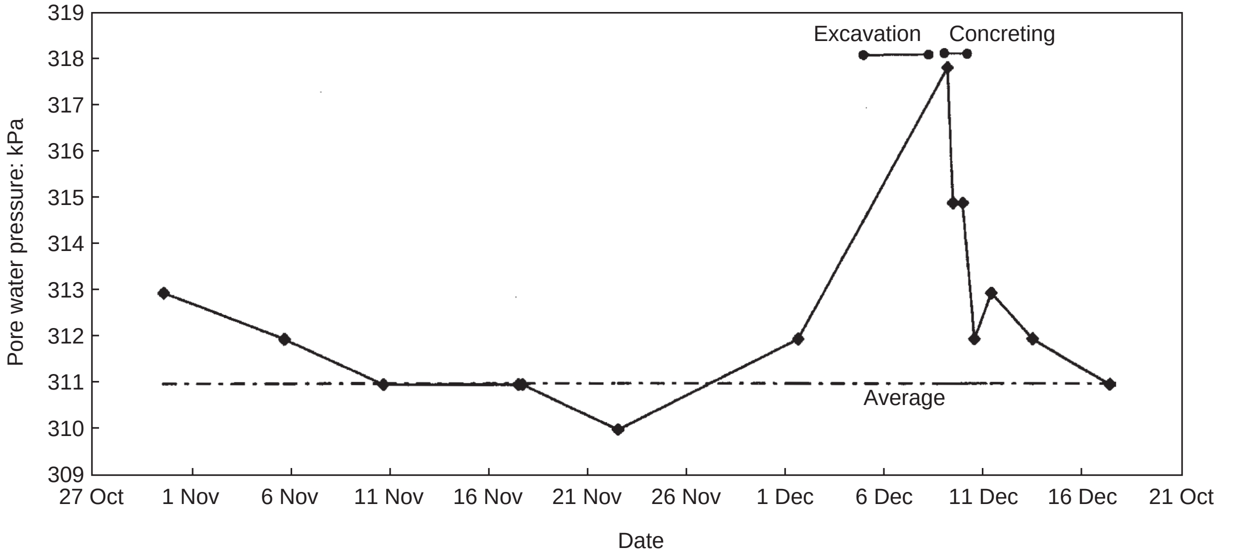


Fig. 10. Variations of pore water pressure with time at BF-4 (1·5 m away from trench) (measured by pneumatic piezometer at −35 mbgl)

within 2 days after concreting, indicating a high permeability of the weathered granite. The rate of pore pressure dissipation is consistent with the case history reported by Stroud & Sweeney (1977).

THREE-DIMENSIONAL MODELLING OF THE TRENCH EXCAVATION

Soil model, parameters and modelling procedures

To model the three-dimensional installation processes of the diaphragm wall panel construction, the finite-difference program FLAC3D (Itasca, 1996) was adopted. Since the three-dimensional soil–structure interaction of diaphragm walling is rather complex, it was decided to choose a relatively simple soil model for ease of interpretation of the computed results. All the soils at Kowloon Bay have been modelled as simple linear elastic and perfectly plastic isotropic materials with a Mohr–Coulomb yield surface. The elastic shear modulus adopted for each soil layer was based on the measured velocity of shear waves (geophysical method) at the same site, from which the maximum shear stiffness at very small strains was determined (Ng *et al*., 1999). The model parameters are summarized in Fig. 11.

To estimate the shear stiffness at moderate shear strains (0·1%) for each soil layer, field-measured shear moduli of the weathered granite obtained from a self-boring pressuremeter (SBPM) were compared with the measured values obtained by the geophysical method. It was found that the elastic moduli of the weathered granite at very small strains obtained by the geophysical method were approximately three times higher than the stiffness at moderate strains measured by the SBPM (Ng *et al*., 1999). An assumption was thus made that the shear moduli at moderate shear strains in other soil strata would also be three times smaller than the elastic moduli obtained using the geophysical method. In this paper, two three-dimensional analyses are described: one uses the small-strain elastic moduli obtained by the geophysical method; the other adopts the deduced shear moduli at moderate strains. The shear strength parameters are taken from published data available in the literature (Cowland & Thorley, 1984).

For comparing the maximum observed ground deformations, only the excavation of the diaphragm wall trench was simulated. This was done by removing model soil elements inside the trench and applying a normal hydrostatic bentonite pressure on the trench faces simultaneously.

Comparisons between measurements and computed results

Figures 12 and 13 compare the measured and computed horizontal deformation profiles and vertical subsurface movements, respectively at various distances from the trench. It can be seen that the accuracy of the magnetic extensometers was generally better than that of the inclinometers. If the elastic moduli obtained from the geophysical method are used, the numerical simulation significantly underpredicts the actual ground deformations, especially for the vertical subsurface movements. This implies that the actual ground response substantially deviated from the elastic behaviour assumed in the three-dimensional analysis. Substantial plastic strains seem to have been induced during the excavation of the trench.

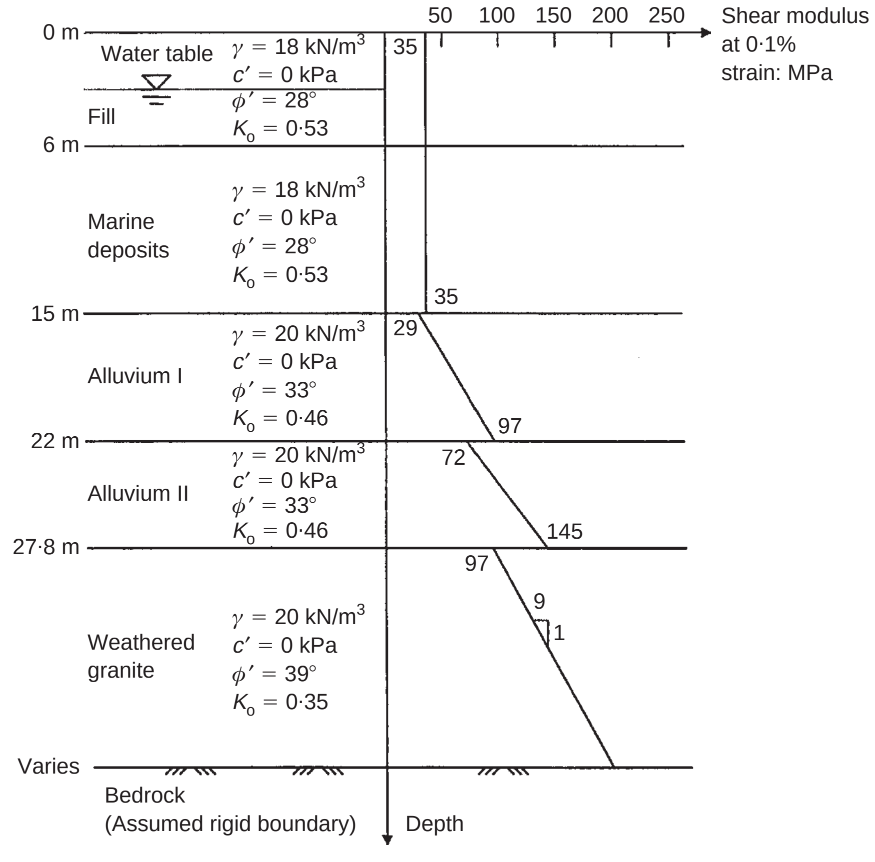


Fig. 11. Summary of soil parameters

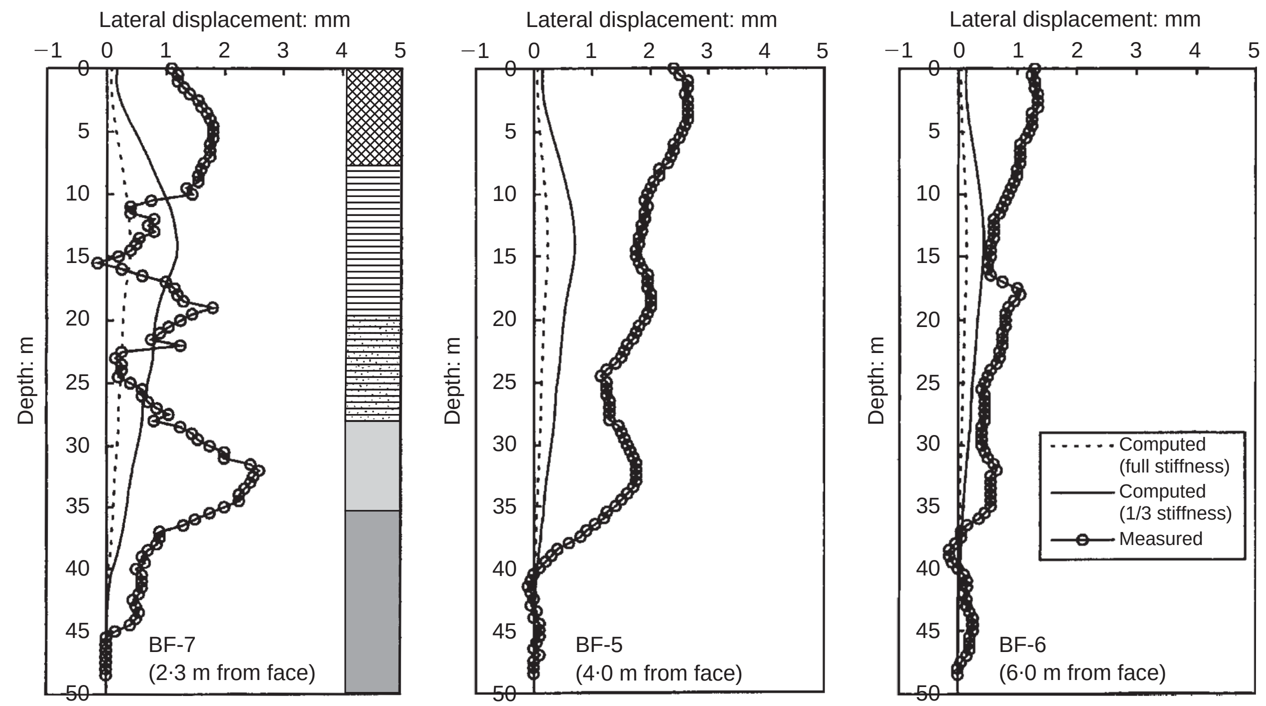


Fig. 12. Comparison between measured and computed horizontal deformation profiles after excavation (positive lateral displacements towards the trench)

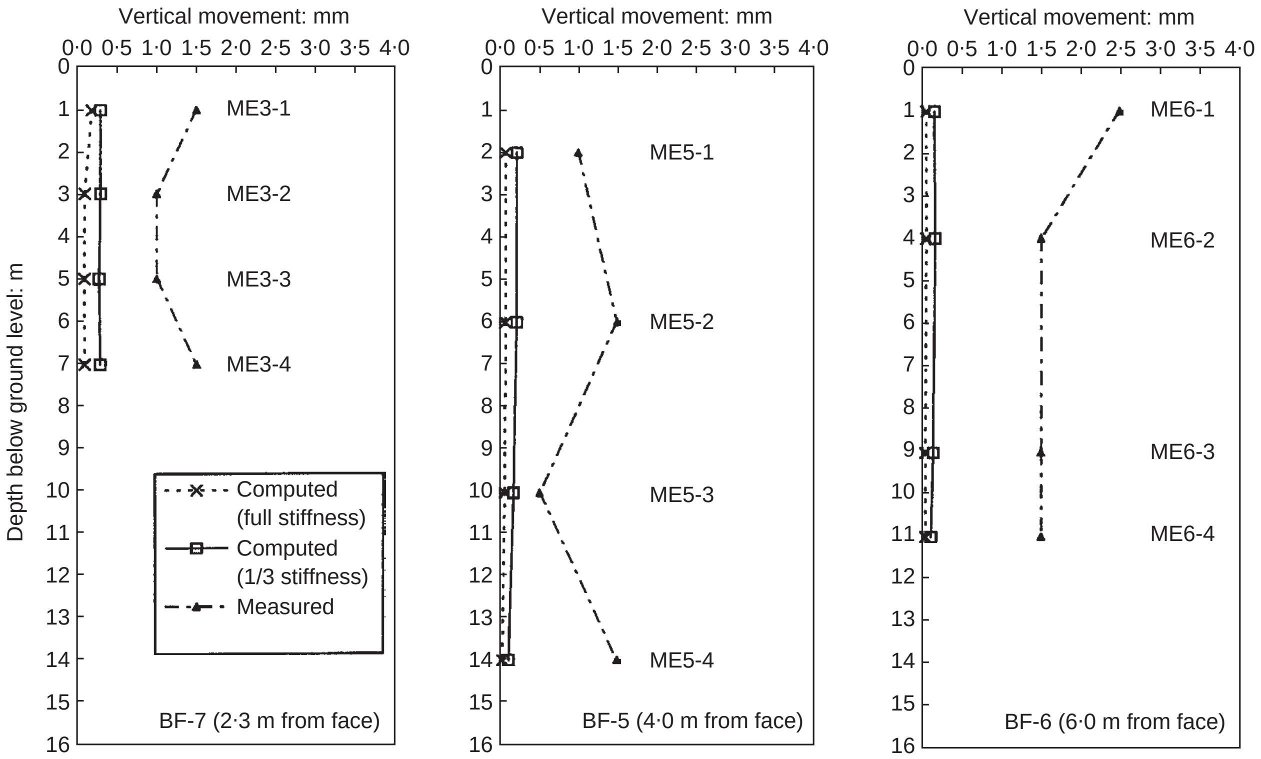


Fig. 13. Comparison between measured upper four magnets and computed subsurface vertical deformations after excavation

On the other hand, if all the soils are assumed to have operated at moderate shear strains (0·1%) during the excavation, the discrepancies between the computed and measured horizontal deformations generally become smaller. However, the discrepancy between the measured and computed vertical movements is still substantial. This discrepancy may be attributed to inappropriate soil parameters or the model used, or both. As an isotropic model was adopted in the analysis, the different responses in the two orthogonal directions seem to suggest that the soils exhibited a certain degree of anisotropy.

The large discrepancies between the measured and computed deformations using the shear moduli at moderate shear strains (0·1%) may be attributed to the presence of the 30 m thick soft, layered strata (i.e. fill, marine deposit, alluvium clay and sand) above the decomposed granite. The stiffness of these soft strata is likely to be considerably less than the assumed moduli adopted in the analysis, possibly owing to the onset of substantial plastic yielding. This would result in a significant reduction of soil stiffness and lead to larger ground movements during excavation. Of course, larger ground deformations would have been computed if a degradation of soil stiffness with increasing strain was allowed in the analysis. According to the comparisons between the measured and computed results, an average shear strain well in excess of 0·1% was mobilized around the trench during the excavation.

No further analyses have been attempted, owing to the limited accuracy of the inclinometers and the unavailability of good-quality soil stiffness parameters (small-strain shear moduli) for any of the soils except the weathered granites.

CONCLUSIONS

The construction in Hong Kong of an excavated large, rectangular-section barrette (i.e. a short diaphragm wall panel) in weathered and sedimentary soils under bentonite has been heavily instrumented and closely monitored. The size of the panel was 2·8 m long by 0·8 m wide by 40 m deep. During excavation, the maximum horizontal ground movements recorded were of the order of a few millimetres, with negligible surface settlements around the panel. A small amount of recovery of the horizontal ground movement was measured during concreting. The observed ground deformations are substantially smaller than the measured values obtained during the construction of a longer panel (6·1 m long by 1·23 m wide in plan) excavated on a site with similar ground conditions.

On the basis of three-dimensional numerical simulations of the excavation of the trench, an average mobilized shear strain greater than 0·1% around the excavated trench can be deduced.

At the soil–wall interface, the initial lateral earth pressures decreased to the hydrostatic bentonite pressures during excavation and then increased above the assumed initial K_0 pressures after concreting. The measured lateral pressures just after concreting show some agreement with a pressure distribution based on a theoretical bilinear pressure envelope.

Excess pore water pressures at the soil–wall interface and around the panel were recorded during construction. Dissipation of the excess pore water pressures seems to have been rapid and to have been completed within a few days.

ACKNOWLEDGEMENTS

This research project is supported by a research grant (HIA96/97.EG03) from the Hong Kong University of Science and Technology and a research grant (CRC96/99.EG04) from the Research Grant Council of Hong Kong. The authors would like to acknowledge the contribution provided by Paul Y. Foundation Ltd, who constructed and tested the heavily instrumented barrette. Other sponsors of this test barrette include the Geotechnical Engineering Office of the Hong Kong Government, Fong On Construction Ltd, Mass Transit Railway Corporation and Geotechnical Instruments Ltd. Technical input and support from Professors C. K. Shen and Wilson Tang of the Hong Kong University of Science and Technology and Messrs Martin Pratt and David Ng of Bachy Soletanche Group are highly appreciated.

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Field Studies of Well-Instrumented Barrette in Hong Kong

By Charles W. W. Ng,[1] Member, ASCE, Douglas B. Rigby,[2] Member, ASCE, Sean W. L. Ng,[3] and G. H. Lei[4]

Abstract: A large excavated rectangular pile (barrette) with lateral earth pressure and pore-water pressure cells was successfully constructed and tested in a sequence of marine, alluvial, and weathered granite soils. A ''soft'' base formed beneath the bottom of the barrette permitted over 100 mm of vertical settlement, completely mobilizing the shaft friction at the barrette-soil interface. During the vertical load tests, an unusual and complex response of pore-water pressures and earth pressures at the barrette-soil interface was measured. During each vertical loading cycle (except the last one) and before interface slippage of the barrette occurred, excess positive pore-water pressures were recorded in all soil layers. Upon the initiation of slip at the barrette-soil interface, a sudden drop in the measured pore pressures as well as a substantial drop in lateral earth pressures generally resulted. Subsequent loading or unloading slippage events did not show the same dramatic behavior unless a period of consolidation/recovery was allowed first. This implies that caution must be used in design of barrettes relying heavily on skin friction when shearing induces contractive soil behavior. The current test results indicated that the empirical uncorrected SPT-N value approach and the effective stress β-method were inconsistent.

INTRODUCTION

Limited space and high demand have made land in Hong Kong extremely expensive. Tall buildings are built to optimize the floor area to land area ratio. Many of the tall buildings located along the Victoria Harbor on the Hong Kong Island and the Kowloon peninsula are commonly founded on reclaimed land. Thus deep foundations are required to resist both vertical and horizontal loads due to the weight of the building and wind, respectively. The prevailing deep foundation types for tall buildings on these reclaimed lands are large bored and excavated piles, which are very long, normally in excess of 50 m. These piles can be circular (bored piles/drilled shafts) or rectangular (barrette) in shape and must extend through the fill, underlying soft marine clay, sandy clay, and alluvial sand deposit down into the deep weathered granite soil (saprolite), which is typically less weathered with an increase in depth. The thickness of the weathered granite can be up to 80 m in some places, and its depth can extend to more than 100 m from the ground surface.

Over the last 15 years, barrette foundations have become increasingly popular in parts of Asia such as Hong Kong and Malaysia for many civil engineering structures and tall buildings. The construction method for barrettes is very similar to that adopted for diaphragm walls, where a rectangular trench is excavated under bentonite by heavy grabs or hydrofraise and filled with tremie concrete. In Hong Kong, single barrettes up to a size of 1.5 m wide × 6.6 m long (on plan) have been constructed (Pratt and Sims 1990). Due to their rectangular shape, barrette foundations are particularly suitable to resist large vertical and significant horizontal loads in a chosen direction.

For deep rectangular piles, the current design procedures adopted in Hong Kong are relatively conservative, and they assume a heavy reliance on end-bearing resistance of bedrock in many instances. Without performing at least one full-scale pile load test on site, skin friction in excess of 10 kPa is not permitted normally by the regulations. In some areas, however, bedrock is found at depths of over 100 m. Under such circumstances, excavation of deep foundations to bedrock becomes difficult, time consuming, and expensive. Exceeding the nominal permitted skin friction requires costly and time-consuming full-scale pile tests to verify design values of skin friction. Many Hong Kong engineers would welcome improved design guidelines based on more rational design approaches that would allow for higher default values of skin friction along a pile to be used, or a reduction in the number of verification piles in similar site conditions.

The problem is that estimation of skin friction development along a long barrette (between 40 and 100 m) is a very difficult task. The method of construction, workmanship, rheological properties of the slurry, and concrete placement affect its behavior. Any attempt to increase the design skin friction value must be done with caution. A task force has recently been formed, with participants from the government, some contractors and consultants, and the Hong Kong University of Science and Technology, to carefully study this problem aiming at the development of a more reasonable design guideline for deep pile foundations in Hong Kong. Currently a university-led and industry-supported three-year research project is under way to study skin friction on barrettes founded in weathered granites in Hong Kong by full-scale pile testing, laboratory tests, numerical and centrifuge modeling, and reliability analysis (Shen et al. 1997). Initially, two piling test sites are investigated: one at Kowloon Bay and the other in the Central district. In this paper, the construction of a 2.8 m long by 0.8 m wide and 39.7 m deep barrette at Kowloon Bay, its vertical load-deflection characteristics, and its pore-water pressure and lateral stress changes at the soil/barrette interface are reported and discussed. In addition, the measured skin friction is compared with other test results in Hong Kong.

SITE LOCATION AND GROUND CONDITIONS

The test site is located on the Kowloon peninsula of Hong Kong, to the east of a runway of the old Kai Tak international airport, at the Kowloon Bay area (Fig. 1). Fig. 2 shows the geology and some relevant borehole information obtained at Kowloon Bay. The site is on marine reclaimed land and the ground level is at approximately 4.48 m above Principal Datum (PD). The ground-water level is about 3 m below ground surface. The ground conditions consist of about 6.0 m fill material overlying a succession of approximately 9.5 m marine clay deposits, 7.5 m of sandy clay (probably alluvial), 4.8 m alluvial sand of Quaternary age, and about 12 m of weathered granitic saprolites that overlie granitic rocks of Upper Jurassic to Lower Cretaceous age (Strange 1990). Detailed descriptions and measured N-values by Standard Penetration Tests (SPT) for each type of materials are given in Fig. 2. It can be seen that scattered SPT-N values were obtained in both alluvial sand and weathered granite. The former shows a decreasing N-values with depth, whereas the latter illustrates an opposite trend. Based on results of drained triaxial compression tests on weathered granites, effective cohesion and angle of friction were found to be 0 kPa and 39°, respectively. Typical Atterberg limits for the sandy clay are 40, 20, and 20 for the LL, PL, and PI, respectively (GEO 1996a).

Strictly speaking, the site is not ideal for studying skin friction of excavated piles in weathered granite as the thickness of the granite is relatively thin and the measured SPT-N values are relatively low. However, due to the limited availability of land in Hong Kong for purely research purposes and the time restraints, this existing government test site was chosen. A distinct advantage is that the site investigation records are very comprehensive as this site has been a test site for the Geotechnical Engineering Office of the Hong Kong Special Administrative Region over the years. Various in situ and laboratory tests (Ng et al., unpublished paper, 1999) have been carried out on this site, resulting in ground conditions that are well known.

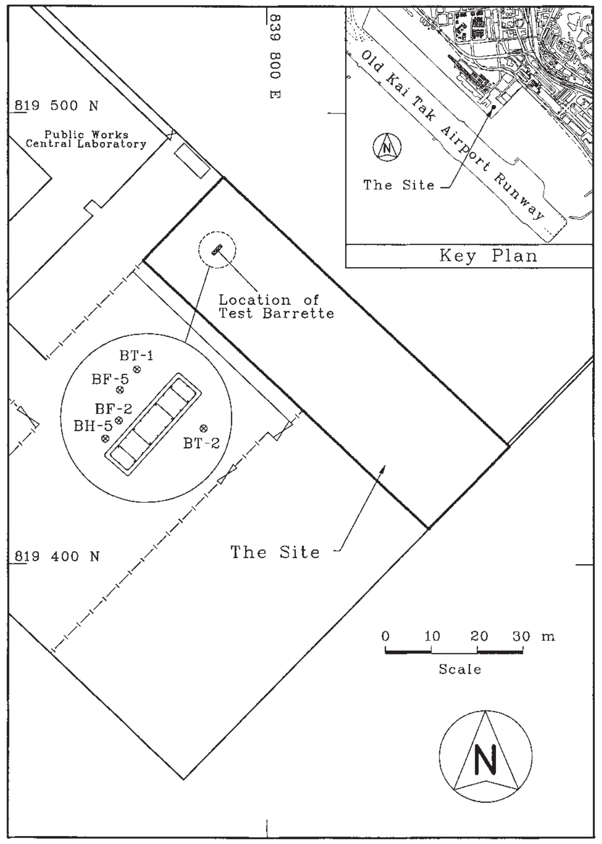

FIG. 1. Location of Test Barrette at Kowloon Bay, Hong Kong

DETAILS OF CONSTRUCTION

The test barrette or the diaphragm wall trench was excavated using a traditional cable-operated grab. The size of the excavated trench was 2.8 by 0.8 m on plane and 39.7 m deep (Figs. 2 and 3). During construction, a concrete guide wall was first placed, and at deeper levels the trench was supported

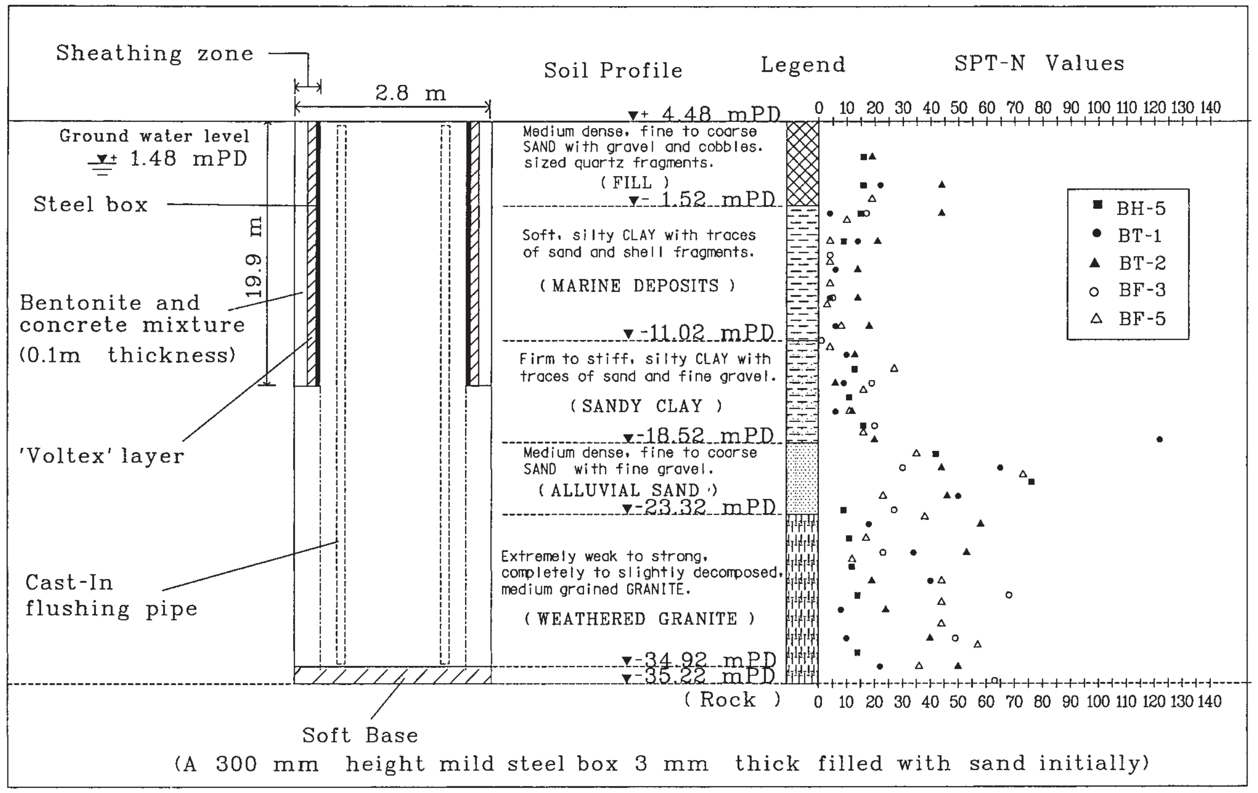

FIG. 2. Borehole Logs and SPT-N Values at Kowloon Bay, Hong Kong

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Note. Discussion open until June 1, 2000. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on April 1, 1999. This paper is part of the ***Journal of Geotechnical and Geoenvironmental Engineering***, Vol. 126, No. 1, January, 2000. ©ASCE, ISSN 1090-0241/00/0001-0060–0073/$8.00 + $.50 per page. Paper No. 20602.

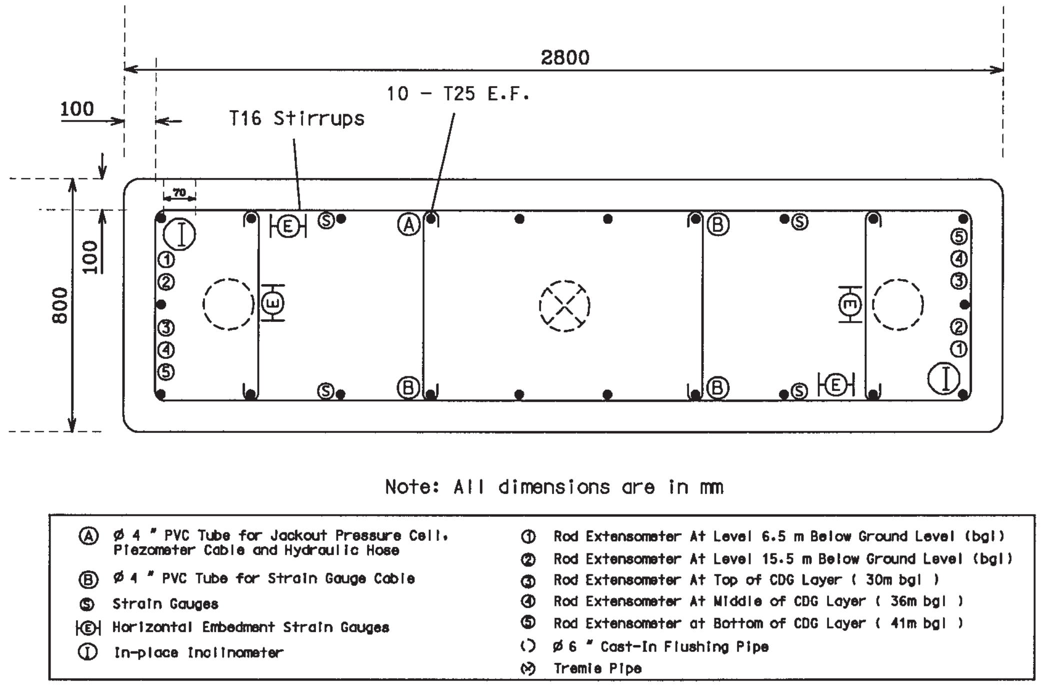

FIG. 3. Layout of Instrumentation (Plan View)

by bentonite with unit weight (γ_b) of about 10.8 kN/m^3. Soil spoil, suspended in the bentonite slurry, was pumped to a desanding unit at the ground surface. After desanding, the bentonite was recharged into the trench. Chiseling of the base was carried out when rock was encountered at a more shallow depth than expected, about 39.6 m below ground. This caused a small overbreak at the base, which was detected by a sonic profiling system. The entire excavation took 62 h to complete and the final excavated depth was 39.7 m below ground. The rate of excavation could have been improved if a 24-h nonstop excavation schedule were followed, as is the normal practice for commercial test barrettes in Hong Kong.

After completion of the excavation, three instrumented reinforcement cages were lowered one-by-one into the trench. Concreting was carried out 43 h after completion of the excavation. The average rate of concreting was 10.32 m/h by using a tremie pipe. The whole barrette trench was filled with concrete in 4.5 h. The Ordinary Portland Cement (OPC) concrete used was grade C30/20 with unit weight (γ_c) of 23.2 kN/m^3. It had a water-to-cement ratio of 0.45 and an average slump of 180 mm. During concreting, the average temperature measured inside the trench was 27.6°C inside the slurry. The excavation and concreting procedures of the barrette, in fact, were identical to the construction of a typical diaphragm wall panel.

The top 20 m of the barrette consisted of a reduced-section sheathing zone (Fig. 2) built with the intention of minimizing the interface skin friction developed between the barrette and the upper soil layers. This sheathing layer consisted of four layers: a 3 mm steel plate welded onto the reinforcement cage, a coating of bitumen, a flexible and weak ''voltex'' layer (geotextile infilled with sodium bentonite), and a thin sheet of plywood. However, the final result was that the plywood was unfortunately attached to the steel plate with a dense matrix of high-strength screws, precluding the possibility of shear between the intermediate ''soft'' layers. As a consequence, the theoretical gap of about 80 mm between the plywood and the surrounding soil was not back-filled with gravel as planned, so that a ''weak'' friction zone would hopefully exist. However, steel rods inserted into this suspected bentonite-filled gap about 2 weeks after concreting were unable to probe beyond a meter or two all round the barrette. Either concrete overflow had partially filled the gap, construction activities failed the soil infilling the gap, or surface materials mixed with solidified bentonite. Thus, in the end, the sheathing zone was not expected to function to effectively reduce skin friction over the top half of the barrette.

At the bottom of the barrette, a ''soft'' base was formed to minimize the effects of end-bearing for mobilizing full skin friction at the soil-wall interface. This was done by placing a 2.8 × 0.8 × 0.3 m in height steel box to the bottom of the trench, before the lowering of the main reinforcement cages. The box was made of 3 mm thick steel plate, and it was initially filled with fine round sand. Seven days after concreting, the sand-filled steel box was drilled through and flushed with pressurized water via two cast-in flushing pipes and one concrete core hole in the middle of the barrette (Fig. 3). Great care was taken to ensure that most of the sand was flushed out to form a ''soft base'' (i.e., void) underneath the barrette.

INSTRUMENTATION

To study the load transfer mechanism and load-settlement characteristics of the barrette constructed at Kowloon Bay, a substantial amount of instrumentation was installed. A summary of the instruments installed inside the barrette is given in Table 1. In addition, four sets of standard dial gauges together with surveying were used to monitor the vertical settlement of the top of the barrette and reference beams during testing.

Strain gauges were placed at 27 levels on the reinforcement cages (Figs. 3 and 4). Four surface mounted and four embedded strain gauges were placed alternatively at different levels to measure vertical strains induced in the reinforcing bars and in concrete, respectively. Moreover, four levels of horizontally embedded strain gauges, with four gauges in each level, and four levels of dummy gauges (eight in total) were installed in the cage. The horizontally embedded strain gauges were used to determine any Poisson's ratio effects (results are not relevant to this paper). A total of 132 gauges, typically at 3 m and 1 m intervals in the sheathed and unsheathed zones, respectively, were installed to determine the strain distributions along the entire depth. It was found that similar results were recorded by both the surface mounted and embedded strain gauges. Thus, no further distinctions between the two types of gauges are made in this paper.

TABLE 1. Summary of Instrumentation at Kowloon Bay

Instrument (1)	Quantity (2)
Strain gauges	132
Rod extensometers	10
In-place inclinometers	2
Vibrating wire piezometers	4
Earth pressure cells	4

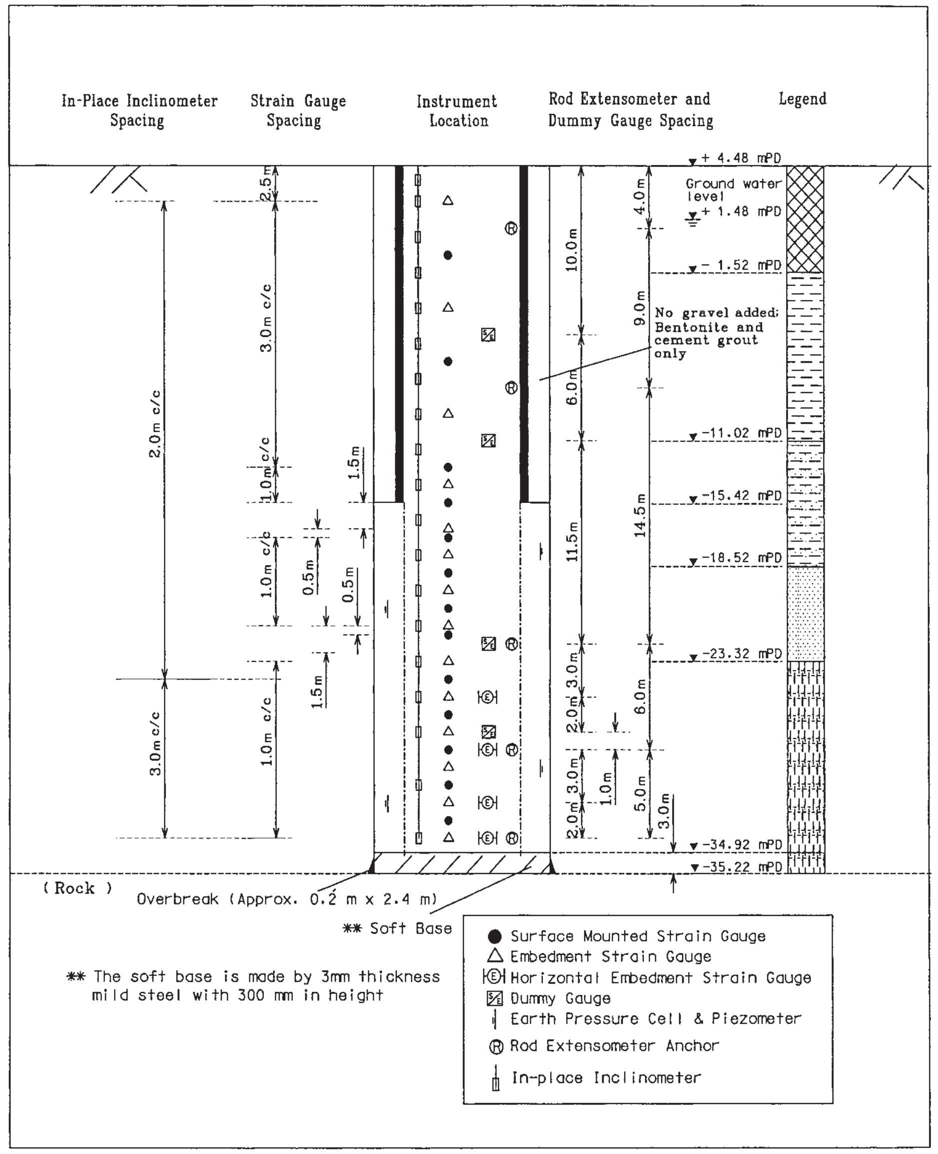

FIG. 4. Layout of Instrumentation (Elevation)

Ten aluminum rod extensometers were sleeved individually in PVC tubes and installed to five depths at two different locations inside the barrette to monitor displacements between each depth and reference steel plate at the top of the barrette (Figs. 3 and 4). After the pile test it was found that although the extensometers reflected a reasonable pattern of elastic pile shortening and rebound during loading and unloading cycles, some of the relative magnitudes measured were clearly unreliable. This was likely caused by friction developed between the metal rods and the PVC tubes having a 12.5 mm outer diameter and 12.6 mm inner diameter, respectively. Recently, extensometers consisting of 15 mm steel rods placed in 50 mm steel tubes filled with oil have given reliable results in Hong Kong.

A total of 38 biaxial servoaccelerometer sensors were installed at 19 levels (most of them at 2 m interval) in two cast-in pipes inside the barrette. The locations of the in-place inclinometers and the levels of sensors were indicated in Figs. 3 and 4, respectively. The bottoms of the inclinometers were socketed in rock. These two in-place inclinometers were designed to measure rotations and hence horizontal movements of the barrette during loading. From the measurements, it was concluded that no significant bending deflection of the barrette was induced during the vertical load tests.

A total of four vibrating wire total earth pressure cells, together with four vibrating wire piezometers, were installed at the barrette-soil interface at four levels within the layers of sandy clay, alluvial sand, and weathered granite. The depths of the earth pressure cells and piezometers are shown in Fig. 4. These total earth pressure cells and piezometers were attached to appropriate locations of the reinforcement cage during the construction of the barrette. Once in position, the instruments were jacked out horizontally to ensure contact at reasonable pressures with the surrounding soil. Each vibrating wire piezometer was located about 80 mm above the corresponding pressure cell.

LOAD AND DISPLACEMENT BEHAVIOR OF PILE

The loading system for the test barrette consisted of two 1,000 ton hydraulic jacks pushing against kentledge formed from steel billets. The kentledge rested on two parallel sets of concrete blocks spaced 6 m apart, center to center. A pile cap at the top of the barrette and a steel spreader beam above the jacks were used to transfer the manually applied loads. The pile head displacement was measured by using four dial gauges symmetrically resting on two reference beams. Settlement of these reference beams was monitored by the conventional surveying technique.

The test program originally comprised four loading and unloading cycles (Fig. 5). However, after the applied load reached 7,455 kN at the second cycle, substantial settlement was recorded and the applied load could not be held constant within the prescribed maximum settlement tolerance of 0.05 mm/10 min. It was therefore decided to unload the barrette to 4,555 kN and to hold it for 80 h (about 3 days). After the holding period, the testing program resumed and two more loading cycles were performed. The barrette-soil interface appeared to gain strength as a result of consolidation, which is discussed later. Due to the presence of the ''soft base'' (i.e., void) underneath the barrette, the barrette ultimately settled about 100 mm, enabling the skin friction to be fully mobilized along the shaft.

Prior to calculating the distribution of axial load and shear stress along the length of the barrette, it is necessary to adopt appropriate values of Young's modulus for the barrette. Since the conditions of concrete curing inside the trench are very different from those in a standard curing tank in the laboratory, continuous concrete cores were taken from at the center along the depth of the barrette to determine the Young's modulus of the in situ concrete. The measured secant Young's modulus varying with depth (at about 1 m spacing) is shown in Fig. 6. Although there is a general increase of Young's modulus with depth due to the natural compaction process of the concrete under its own weight, the measured data are fairly scattered. For accurately converting the measured strains in the barrette to stresses, the actual measured modulus at each tested depth and corrected for steel present was adopted in the calculations.

Fig. 7 shows the deduced axial load versus depth for the

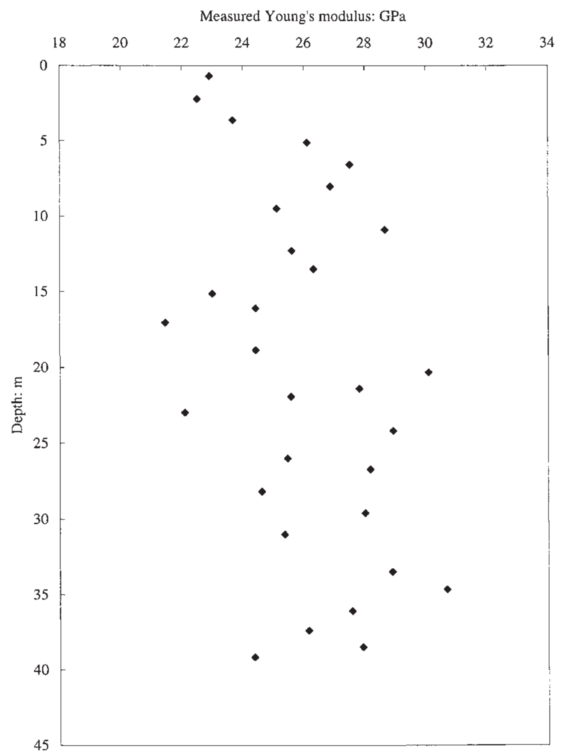

FIG. 6. Variation of Measured Young's Modulus of Concrete with Depth

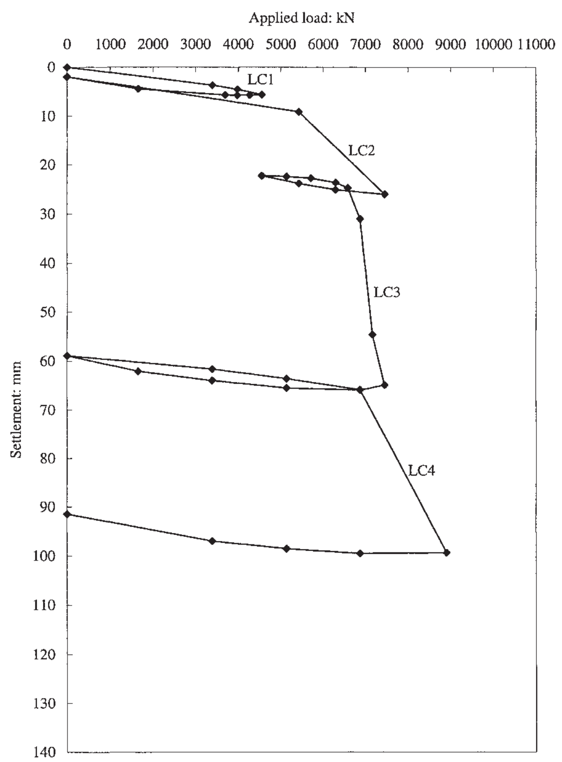

FIG. 5. Load-Settlement Response of Test Barrette

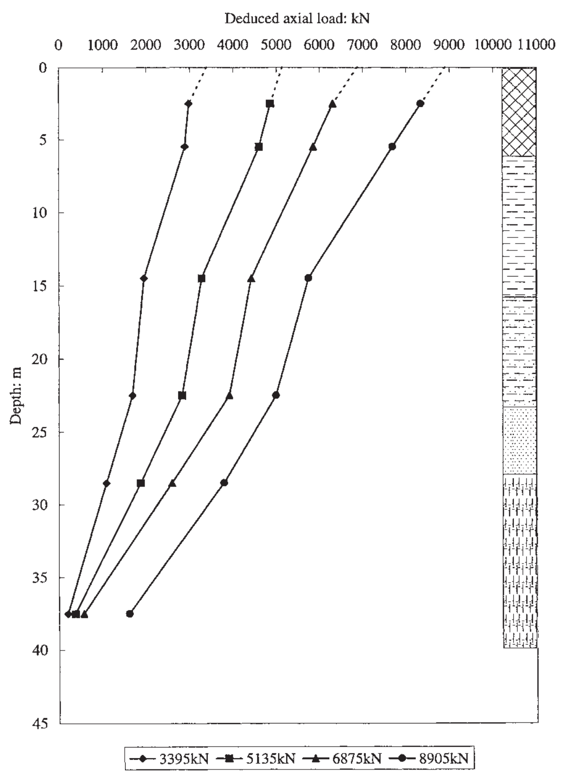

FIG. 7. Deduced Axial Load Distribution at Load Test Cycle 4

last loading cycle. An axial stress was calculated from the average measured strains at each level and the corresponding measured Young's moduli (Fig. 6) from concrete cores taken from the center of the barrette. From the calculated axial stress, the axial load with depth was then determined considering the local barrette cross-sectional area. It can be seen that the deduced axial load at the top of the barrette is consistent with the applied load recorded by the hydraulic jacks (shown as dotted lines). The load distribution along the depth shows features common to a typical friction barrette. Due to the presence of the ''soft base,'' minimal base resistance was mobilized, except at the maximum load of 8,905 kN, where the base resistance increased substantially from 560 to 1,600 kN. This substantial increase was likely caused by the mobilization of some end bearing resistance due to the crushing of the 300 mm steel box underneath the barrette (possibly not all of the sand was flushed out from the box).

BARRETTE SKIN FRICTION

From the gradient of the barrette normal stresses with depth, mobilized skin friction (interface shear stress, τ) is calculated and plotted against deduced local displacement of the barrette in each soil stratum as shown in Fig. 8. Shear stress was fully mobilized in all soil strata when the displacement reached approximately 40 mm (or at 2.4% of the 1.7 m equivalent diameter of the barrette), after which the magnitude of shear stress remained essentially constant. Some peak strength behavior with softening at the interface was observed in the fill, sandy clay, and alluvial sand. The large skin friction mobilized in the fill material may possibly be attributed to the surcharge effects resulting from the dead weight of the concrete blocks supporting the kentledge load. On the other hand, no peak strength behavior could be identified at the barrette-weathered granite interface. Fig. 9 shows the distribution of mobilized skin friction with depth. Within the sheathed zone, a constant and substantial amount of shear stress was mobilized, apparently indicating that no ''weak'' zone existed around the sheathed barrette (except at depth below 15 m; see Fig. 7). The mobilized shear stress in the sandy clay was smallest, whereas the mobilized shear stresses in the fill, marine deposits, and weathered granite are in the same order of magnitude at the maximum applied load. Below the sheathed zone, the distribution of maximum mobilized shear stress follows the trend of the measured SPT-N values (Fig. 2). At the maximum applied load (8,905 kN), the mobilized skin friction of about 30 kPa was found for the fill, marine clay, alluvial sand, and weathered granite, and about 15 kPa for the sandy clay.

For comparing shear stress mobilized in similar soils at different construction sites, it is a common practice to normalize the measured shear stress with an average uncorrected SPT-N value, i.e., $\tau/\bar{N}$, (before construction) in Hong Kong. Fig. 10 shows the comparison between the normalized maximum shear stress measured at the current test site and at the International Trademart, which is about 1.4 km away in Kowloon Bay (Ho 1994). At the latter site, a 2.2 m by 0.8 m by 56.8 m deep barrette was also excavated by cable-operated grabs and founded in about 20 m thick layer of weathered granite, which has an average higher value of SPT-N value (typically ranging from 15 to 110) than the former site. For SPT-N values smaller than 35, the magnitude of measured skin friction is consistent between two sites. No comparison can be made between the measurements from the two sites for higher SPT-N values. However, the ranges of the values $\tau/\bar{N}$ obtained from the former and the latter sites are 0.9 to 2.9 and 1.3 to 2.3, respectively.

PORE PRESSURE RESPONSE AT SOIL/BARRETTE INTERFACE

After installation of the piezometers, readings were taken continuously to compare them with the initial hydrostatic pore-water pressures in the ground (the initial ground-water table was located at about 1.3 mPD). It was found that the measured pore-water pressure at gauge P1 at the sandy clay layer (Fig. 11) was slightly higher than the corresponding hydrostatic value (1.3 mPD) before the loading test. Piezometric level (head) is defined as the sum of the pore-water pressure head and the elevation head at each location. The measured piezometric heads recorded at P3 and P4 were a little lower than the hydrostatic conditions in the weathered granite before the commencement of the load test. Labels LC1–LC4 denote the commencement of the first to the fourth load cycles, respectively. Similarly, labels UC1–UC4 represent the start of the first to the fourth unloading cycles.

When the first loading cycle (LC1) was carried out, all piezometers responded positively to each increment of applied load [Fig. 11(b)], recording an ultimate increase of head of almost 3 m in the sandy clay (P1) and about 1 m in both the alluvial sand (P2) and weathered granite (P3 and P4). During the first unloading cycle (UC1), the pore pressure in the sandy clay and alluvial sand remained steady while a slight and gradual reduction of pore pressure was recorded at P3 and P4 in the weathered granite. Each loading and unloading increment is clearly confirmed by the pile shortening and rebound measurements from the rod extensometer data.

During loading cycle 2 (LC2), again increments of applied load resulted in increments of positive pore pressure until failure occurred. A further increase of approximately 6 m head of water was measured in the sandy clay, 2 m in the alluvial sand

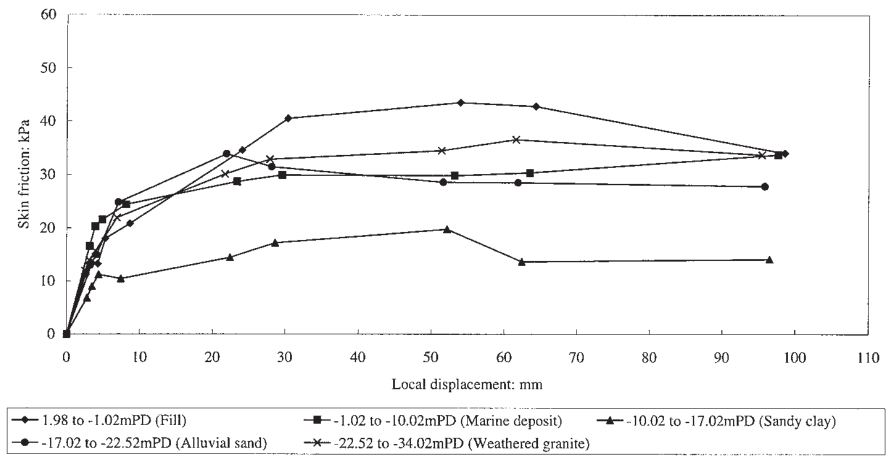

FIG. 8. Mobilization of Skin Friction with Local Displacement

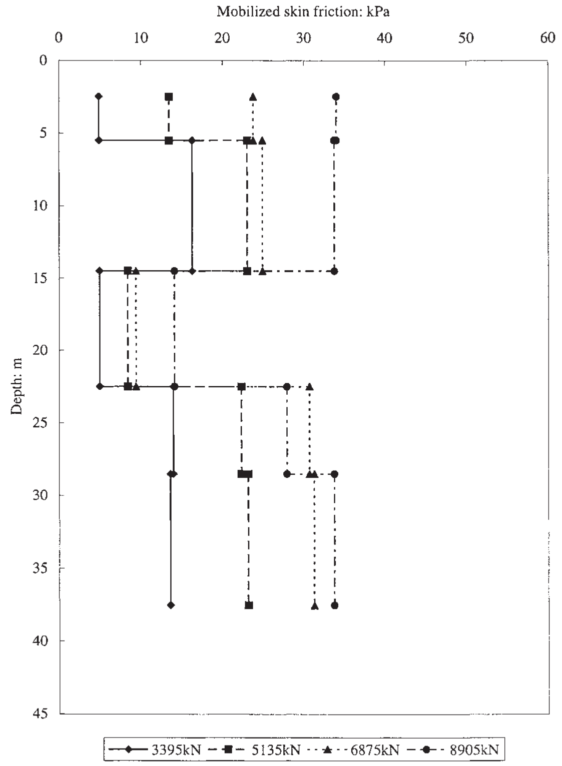

FIG. 9. Distribution of Mobilized Skin Friction (LC4)

and 4–5 m in the weathered granite, respectively. The minor drops in water pressure occur together with reduction in applied loading due to continued settlement of the pile. At failure the settlement rate of the barrette increased significantly and the settlement increased to about 25 mm (Fig. 5) and the pore pressures began to suddenly drop at the same time in all soil layers [after the loading slip shown in Fig. 11(b)]. Slip at the barrette-soil interface is inferred at failure since all rod extensometer data held constant, indicating that the entire barrette was moving downward as a rigid body (about 20 mm). After about 5 min of slippage, the load was reduced and then subsequently maintained for a holding period of 80 h. During this time the excess pore pressures dissipated almost completely in the weathered granite but only slightly in the sandy clay and, surprisingly, in the alluvial sand [Fig. 11(a)]. Also visible in this figure at P2 in the alluvial sand are measurements of tidal action. The shifted frequency and the attenuated relative magnitudes of the high and low tides correspond to actual tidal values from 12/30/97 to 1/2/98 (''Quarry'' 1997, 1998) almost perfectly, indicating proper functioning of the P2 pore-water pressure gauge.

Pore pressure behavior during the third loading cycle (LC3) was very similar to cycle 2. Loading increments resulted in corresponding increases in all four piezometers; overall, the increase of excess pore water pressure amounted to about 4 m head in the sandy clay, 3 m in the alluvial sand, and 2.5 m head in the weathered granite [Fig. 11(c)]. Failure and slippage of about 40 mm occurred at approximately the same load (7,455 kN) as cycle 2, again accompanied by significant and sudden drops of pore pressure at all the piezometers (due to

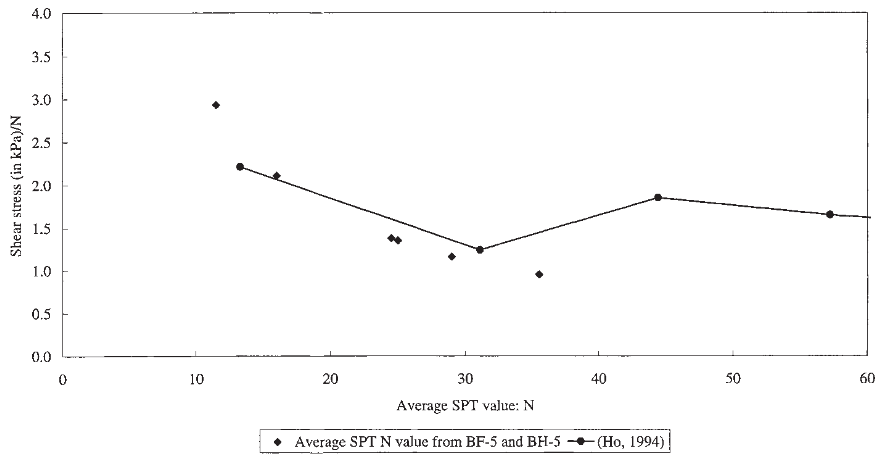

FIG. 10. Relationship between Normalized Maximum Shear Stress in Weathered Granite and Average SPT Value, N

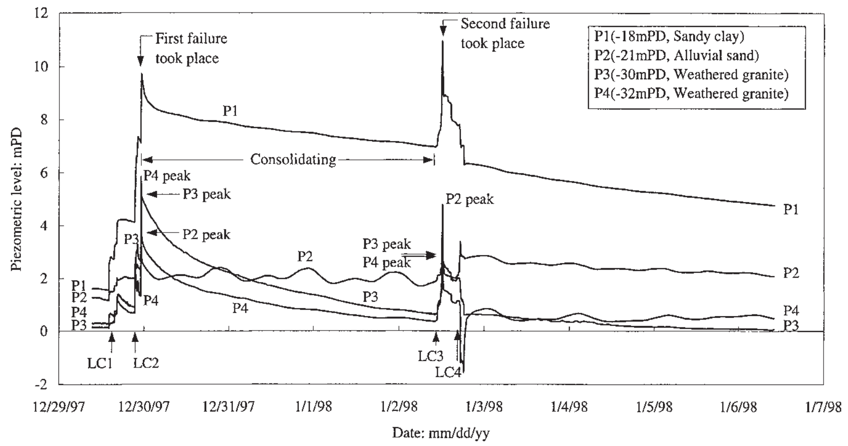

FIG. 11(a). Variations of Piezometric Level During Load Testing

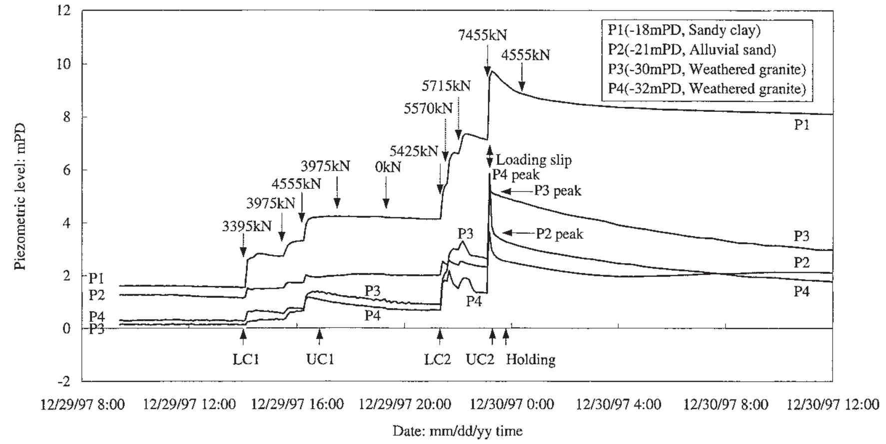

FIG. 11(b). Variations of Piezometric Level during First Two Load Test Cycles

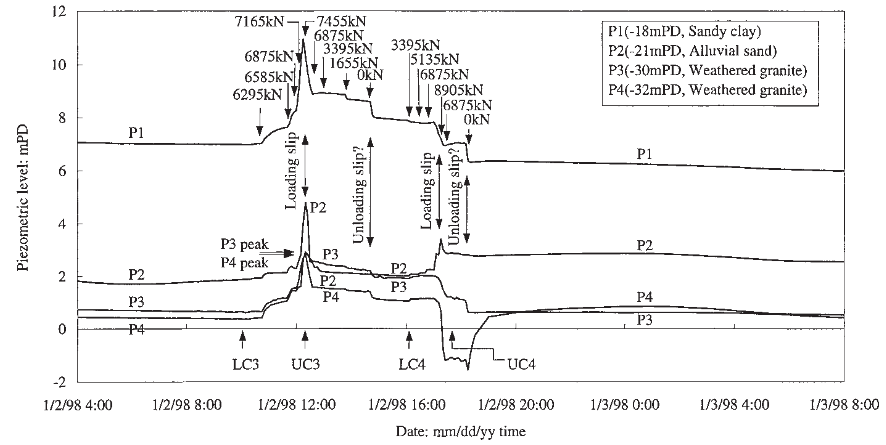

FIG. 11(c). Variations of Piezometric Level during Last Two Load Test Cycles

loading slip). During unloading (UC3) the measured pore pressures continued to drop slightly until another sudden drop of pore pressures was observed at the last unloading stage to 0 kN (except P2) which was most significant in the sandy clay.

Loading cycle 4 (LC4) varied from previous loading cycles since it occurred shortly after a barrette-soil interface failure. Increments of applied load in LC4 caused only slight increases of pore-water pressure in the alluvial sand and weathered granite while pore pressures remained essentially steady in the sandy clay [Fig. 11(c)]. As the load reached its maximum value of 8,905 kN (Fig. 5), failure occurred (about 30 mm of downward slippage), again resulting in substantial drops of pore-water pressures in all soil layers but the alluvial sand where an increase of water pressure followed by a drop was measured [Fig. 11(c)]. One piezometer in the weathered granite recorded a significant drop in pore pressure to a ''negative'' value, lower than the original in situ water pressure. Like UC3, water pressure values were steady until the last unloading step, when sudden changes in pore-water pressure resulted in all layers except the alluvial sand. Two of the piezometers recorded the standard drop in pore pressure, while the third ''negative'' reading piezometer showed a sharp increase back to a more reasonable value.

After the load test, dissipation of excess pore-water pressures continued [Fig. 11(a)]. As expected, the rate of dissipation was much slower in the sandy clay soil (P1) than in the weathered granite (P3 and P4). Dissipation at the alluvial sand interface was slow during loading, but generally the excess pore pressures generated returned near their equilibrium value (around 2 m of head) fairly quickly after slip. Nearly all the excess pore-water pressure was dissipated in the weathered granite by January 6, 1998, i.e., 80 h after the load test. On the other hand, about 3 m and 1 m excess pore-water head still remained in the sandy clay and alluvial sand layers, respectively, at this same time. What appeared to be tidal behavior was picked up at P2 and P4, but it is difficult to see since actual peak tide magnitudes dropped by 50% and the scan frequency of instruments was reduced substantially after the pile test.

CHANGES OF LATERAL STRESS AT SOIL/ BARRETTE INTERFACE

After the vibrating wire earth pressure cells had been lowered into the excavated trench filled with bentonite, initial readings were taken before the instruments were jacked into position. This allowed an in situ calibration of the pressure cells to be made between the measured values and the theoretical bentonite pressures, using a measured unit weight of bentonite (γ_b) = 10.8 kN/m^3. It was found that there was good agreement between the calculated bentonite pressures and the readings recorded by the earth pressure cells; the maximum difference between the calculated and measured pressure was less than 10 kPa. At this point the cells were jacked out laterally to engage the soil.

Just after concreting, the lateral earth pressures increased to values close to the assumed in situ earth pressures before excavation. The measured total earth pressures at the soil/concrete interface also corresponded well with the theoretical bilinear concrete pressure envelope proposed by Ng (1993) and Lings et al. (1994) for concrete case under bentonite during diaphragm wall construction. Over the next two days lateral pressures remained essentially unchanged in the sandy clay and alluvial sand soils, but increased about 100 kPa in the weathered granite. Further details of the earth pressure measurements and interpretations during the construction of the barrette are reported by Ng et al. (1999).

During the subsequent three-week curing period before the vertical load test, a gradual continuous decrease of lateral earth pressure was measured at all lateral earth pressure cells (about 30 kPa in the sandy clay and alluvial sand and about 60 kPa in the weathered granite). The observed reduction in the contact earth pressure may in large part be due to soil consolidation as indicated by the dissipation of excess positive porewater pressures generated during the construction of the barrette. In addition, the reduction in earth pressure might be caused by small shrinkage of the pressure cell units as a result of a fall in temperature after hydration of cement in the concrete. Lings et al. (1994) also reported reductions in earth pressure at the soil/diaphragm wall interface of a heavily overconsolidated stiff clay.

After the three-week curing period, the final result was an overall decrease of about 20–30 kPa below the assumed initial lateral earth pressures in the sandy clay and alluvial sand, and an increase of about 60 kPa above the original pressures in the weathered granite. This observed net increase in lateral earth pressure could be attributed to the swelling of weathered granite as result of stress relief during the excavation of the trench for constructing the barrette. Davies and Henkel (1981) have reported swelling behavior in weathered granite during the construction of diaphragm wall panels.

The measured earth pressures during the four cycles of load testing are shown in Fig. 12. The earth pressure cells all remained virtually constant during the first load and unload cycles (LC1 and UC1) when the barrette displacement was small [Fig. 5; Figs. 12(a and b)]. With the beginning of load cycle 2, some small drops of lateral earth pressure were seen in the weathered granite soil layer until the onset of pile failure (interface slip). Upon application of the maximum vertical load of 7,455 kN, a sudden and large reduction of about 100 kPa was measured at cells PC3 and PC4 in the weathered granite. At the same time there were noticeable falls in the other earth pressure cells also (about 20 kPa at PC1 in sandy clay and 45 kPa at PC2 in the alluvial sand). During the partial unloading and early holding period, there was a small recovery in earth pressure at all cells. Over the rest of the holding period, a slow but steady 25 kPa increase of pressure was measured in the weathered granite, while pressures in the sandy clay and alluvial sand remained almost constant [Figs. 12(a and b)]. Twice-a-day uniform fluctuations in lateral pressure were visible at all cells due to tidal pressures.

After the period of maintained load, further loading (LC3) did not cause a significant variation in earth pressures until a vertical load of 7,455 kN was applied and slip at the barrette-soil interface occurred. At this time a significant reduction in earth pressures (75 to 100 kPa) was again recorded by PC3 and PC4 [Fig. 12(c)] in the weathered granite. Small drops in the other earth pressure cells were also recorded at this time. During unloading of cycle 3 (UC3), pressure at PC1 and PC2 basically held constant while a slight recovery was again observed for the cells in the weathered granite.

Application of loading and unloading cycle 4 resulted in an

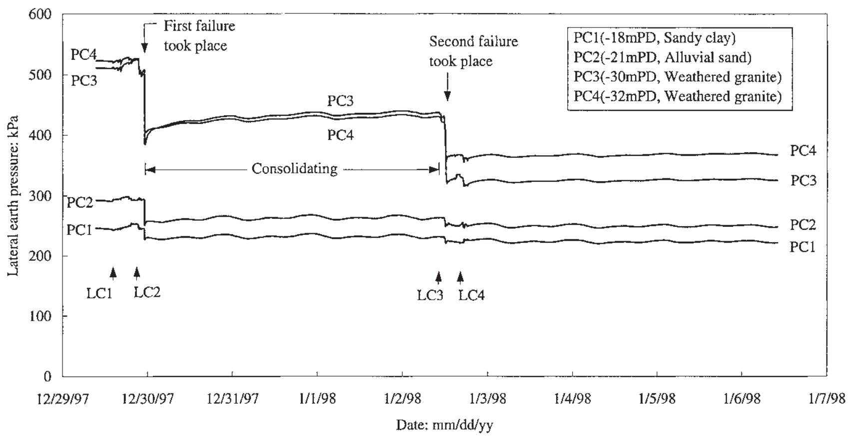

FIG. 12(a). Variations of Lateral Earth Pressure during Load Testing

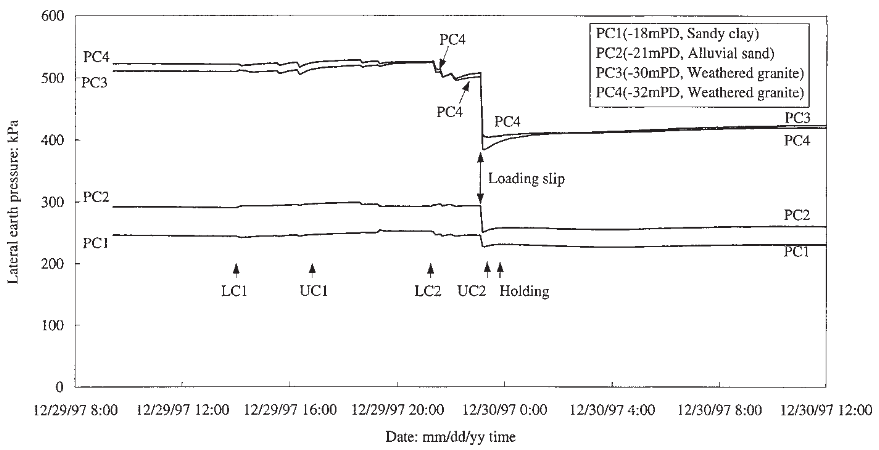

FIG. 12(b). Variations of Lateral Earth Pressure during First Two Load Test Cycles

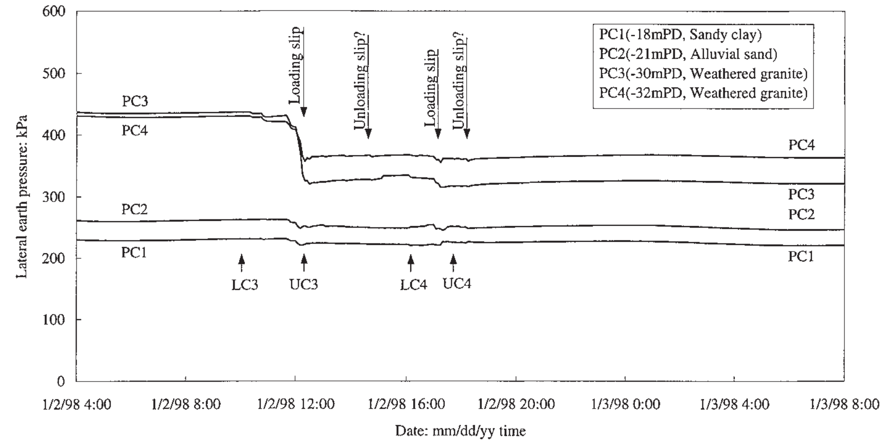

FIG. 12(c). Variations of Lateral Earth Pressure during Last Two Load Test Cycles

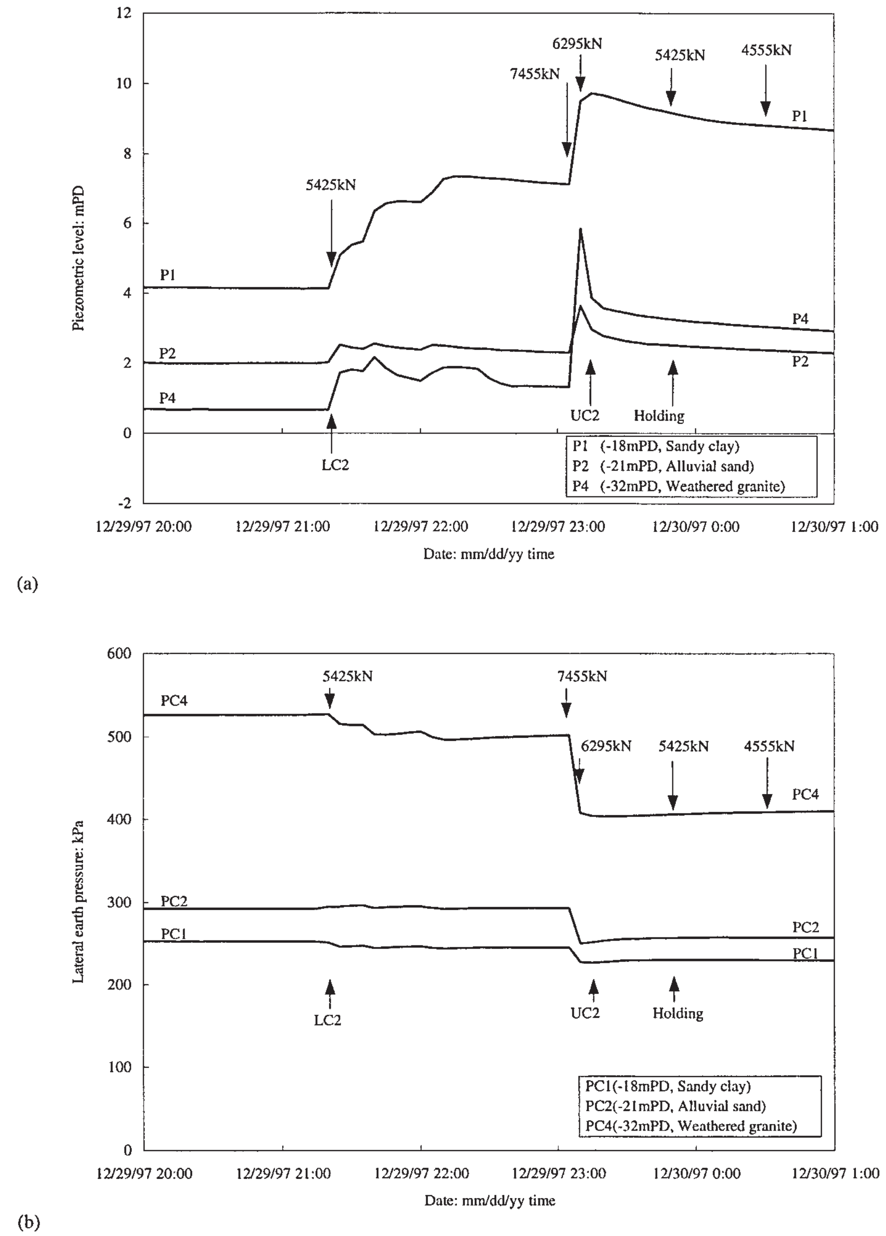

FIG. 13. Details of Pressure Changes at Interface during Load Cycle 2

overall constant lateral stress readings at all cells except for minor drops in pressure in three of the four cells at the onset of slip at about 7,000 kN. The lateral earth pressure over the next week remained constant in all soil layers.

SUMMARY AND POSSIBLE EXPLANATION OF BARRETTE-SOIL INTERFACE BEHAVIOR

The barrette-soil interface behavior consisting of shear strains, relative movements, pore pressure changes, and lateral earth pressure changes are clearly related. To more easily examine the relationships involved, pore pressure and lateral earth pressure measurements are combined on the same figure for two load cycles. Fig. 13 presents cycle 2 data illustrating virgin loading, slip, and partial unloading behavior (see also cycle 1 and 3 data). Fig. 14 gives details of cycle 4, which shows nonvirgin loading, slip, and unloading behavior soon after pile failure (cycle 3). In general, the behavior can be summarized as follows:

- Vertical pile loading produces shear strains in the soil near the barrette, inducing increased pore-water pressure and no significant changes in lateral earth pressures (highest in the sandy clay, lowest in the alluvial sand).
- Vertical pile unloading leaves pore pressures and lateral earth pressures essentially unchanged.
- At relatively large loading increments near pile failure, virgin slippage (shear failure) along the barrette-soil interface results in a reduction of pore pressures (usually highest in the sandy clay) and significant drops in lateral earth pressures (highest in the weathered granite).
- Finally, subsequent reloading of the pile soon after a failure does not result in pore pressure increases (except in alluvial sand), but when slip initiates, pore pressures again drop while lateral earth pressures maintain their values.

The mainly elastic simple shear of the interface soils apparently produces a ''loose'' or contractive volumetric response at the soil layers. Since the sandy clay and weathered granite soils have significant clay content, their shearing occurs under undrained conditions, producing increases in the pore-water pressure. Induced excess pore pressures may be higher in the normally consolidated sandy clay layer because of the higher clay content and since more simple shear occurs higher up the barrette (due to increased shortening of the pile). The increases in pore pressure in the alluvial sand layer are somewhat difficult to understand, but the excavation under bentonite would produce a normally consolidated bentonite cake layer at the barrette-sand boundary.

With its high clay content, the sandy clay may act in an undrained manner with no reductions in lateral earth pressure, while the small drops of earth pressure in the weathered granite are likely the result of higher permeability, allowing some consolidation to occur. The very slow dissipation of pore pressures in the sandy clay and relatively rapid dissipation in the weathered granite soil provide further confirmation [Figs. 11(a and b)].

Barrette-soil interface slip triggers consequential new behavior with the general sudden drop in both pore pressure and lateral earth pressure. The mechanisms involved in this basically consistent and repeated behavior are complex. It is possible that the soil behaves or tends to behave in a contractive manner when it is subjected to shearing. The pore pressure may drop because slip occurs during stress reversal, and this allows relaxation of the shear strains leading to a reduction of previous undrained pore-water pressure buildup. On the contrary, this slip also apparently permits some localized drainage and hence contraction of the soil to occur (possibly due to the sudden stress/strain reversal or reorganization of stresses in the local soil matrix). This would cause a release of the large confining stresses induced during previous shearing because the concrete wall of the barrette is rigid and does not act as a constant pressure interface. Any contraction of the soil away from the wall will lead to a reduction in total contact pressure. This might explain the sudden and large reductions of lateral earth pressure compared to the much smaller reductions in pore-water pressure. It should be noted that the concrete wall has a much higher stiffness relative to that of the adjacent soils. The observed complex pattern of interface pore pressure behavior described in the present barrette field test has been observed both in the field (Earth 1986; Matlock 1992) and the laboratory where pile/normally consolidated clay interface tests have been carried out measuring excess pore pressures during two-way cyclic loading as reported by Rigby and Desai (1996) and Rigby (1997). One observation of these authors is that the two-way cyclic shear of a pile-clay interface results in a continuous increase in excess pore pressure unless interface slip failure occurs, causing a sudden drop in excess pore-water pressure.

After cycle 2, at the Kowloon Bay test, when the soil was allowed to consolidate and strengthen, subsequent shearing of the soil during load cycle three resulted in the type of virgin loading behavior described previously for cycle 2 [Figs. 11(b and c)]. In contrast, load cycle 4 immediately followed cycle 3 so the behavior was more consistent with continued slip behavior since the interface was still weak.

A further interesting point is the occurrence of the same ''slip'' pattern of behavior at a small scale [Figs. 11(c) and 12(c)], during the last pile unloading step for cycles 3 and 4. In cycle 1 failure had not occurred yet, and in cycle 2 the barrette was not fully unloaded, so the sudden drops of pore pressure observed in both cycles 3 and 4 seem to be indicative of possible additional slip occurring.

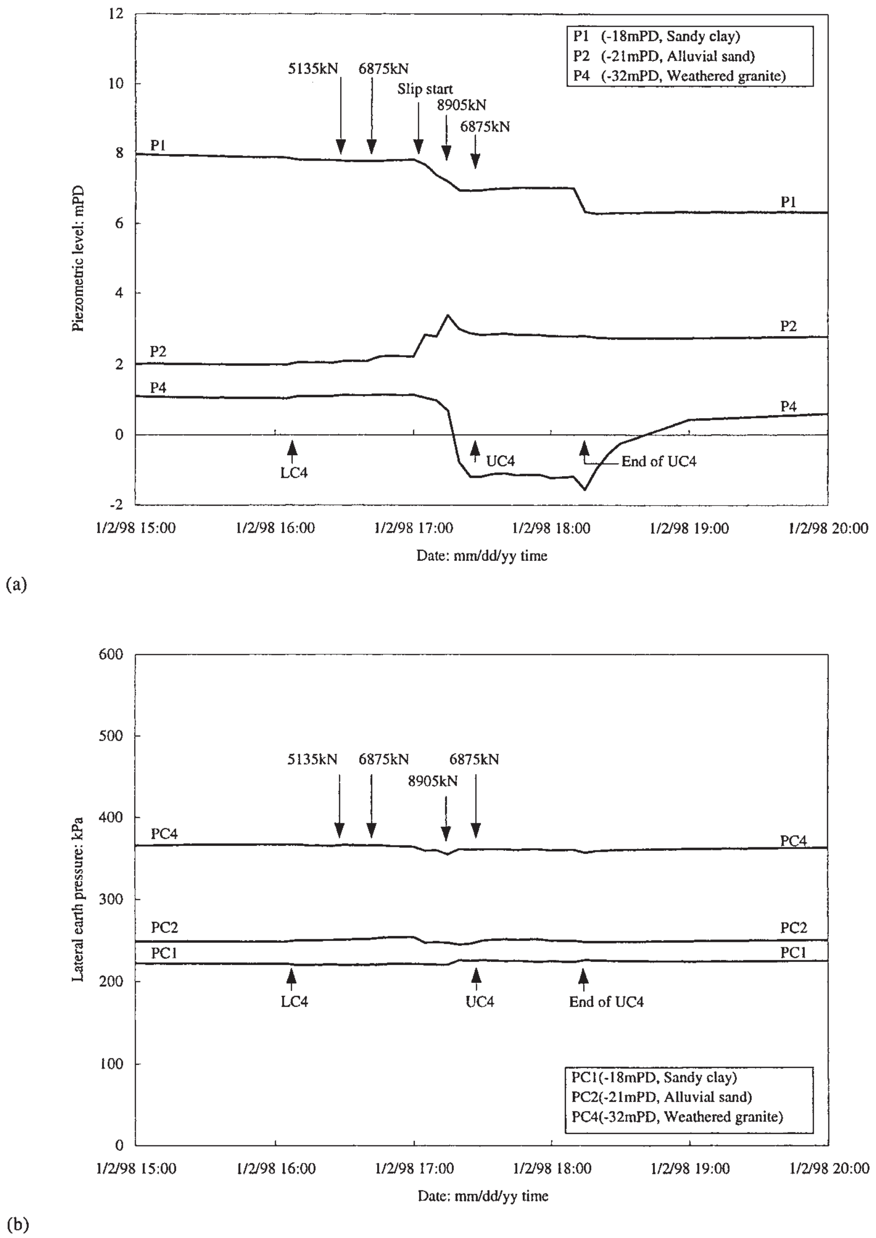

FIG. 14. Details of Pressure Changes at Interface during Load Cycle 4

STANDARD PRACTICE FOR DESIGN OF BARRETTES IN HONG KONG

Barrette design in weathered granite in Hong Kong has been essentially based on empirical approaches (Pratt and Sims 1990). An empirical relationship between an uncorrected SPT-N value before construction and allowable skin friction of 0.5N kPa with a limit of 100 kPa and an allowable end bearing pressure of 5N with a limit of 1,200 kPa are commonly used in Hong Kong. With this allowable load approach, the overall factor of safety (FOS) is not explicitly defined. However, a FOS greater than 2 is anticipated according to experience gained in Hong Kong.

To compare the current measured skin friction at Kowloon Bay with other tested barrettes in weathered granite in Hong Kong, the two most common approaches are adopted. Figs. 15 and 16 show the interpreted field test results from seven relatively well-documented case histories for barrette construction in weathered granite. Details of B1–B5 tests and test B6 are given by GEO (1996b) and Lo (1997), respectively. The test at the International Trademart in Kowloon Bay (Ho 1994) is identified as B5, and the current test is marked as B7 in the figures. The shaft friction coefficient β (GEO 1996b) is defined as the ratio between the ultimate skin friction and the mean vertical effective stress, assuming that the effective cohesion is zero. It can be seen that there is a large scatter in the deduced skin frictions; β varies from 0.1 to 0.46 whereas τ/N falls between 0.77 and 2.3. The variability may be a result of different methods of construction, quality of workmanship, quality and consistency of SPT testing, natural variations of ground conditions, and methods of interpretation.

By plotting the current test result (B7) in Fig. 15, the mobilized shear stress over SPT-N ratio is close to 1.5. This suggests an implicit FOS greater than 2. On the other hand, the deduced β value based on the effective stress principle is only 0.1 (Fig. 16), which is only half of the value obtained from a

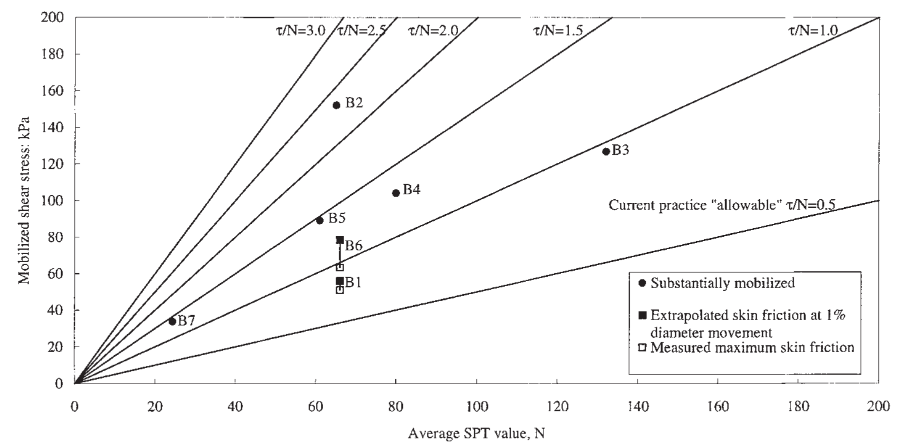

FIG. 15. Relationship between Skin Friction and Mean SPT Value, N for Barrettes

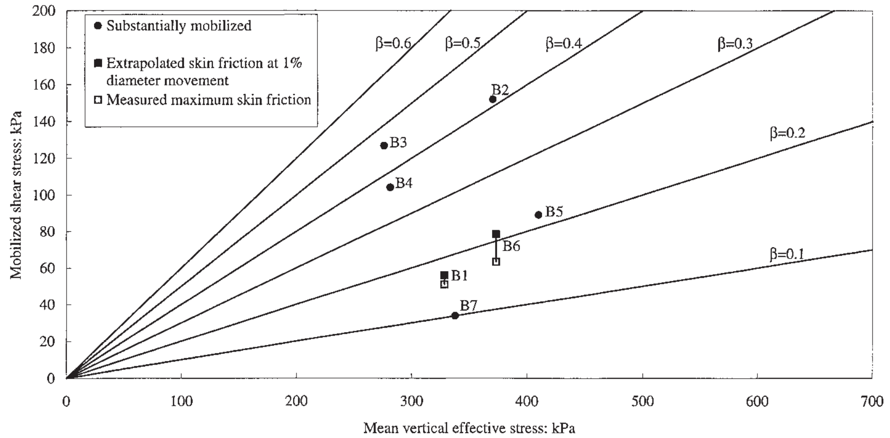

FIG. 16. Relationship between Skin Friction and Mean Vertical Effective Stress for Barrettes

similar site (i.e., B5). This low β value may be attributed to the unintended long delay in concreting after completion of the excavation (43 h). A thicker bentonite cake may have formed at the granite/barrette interface leading to a lower skin friction mobilized at the granite/barrette interface. The test results shown in Figs. 15 and 16 clearly indicated that the current empirical uncorrected SPT-N value approach and the effective stress β-method were inconsistent.

CONCLUSIONS

1. A well-instrumented 2.8 m by 0.8 m by 39.7 m deep excavated concrete pile (barrette) was successfully constructed and tested purely for research purposes in Hong Kong. This test pile was a joint effort and collaboration between the university, government agencies, and the industry. Due to the formation of a ''soft'' base at the bottom of the barrette, vertical displacement of more than 100 mm (6% of equivalent diameter) was permitted. This large vertical displacement of the barrette enabled skin friction at the barrette/soil interface to be fully mobilized.
2. The shear stress in all soil layers was fully mobilized at about 2.4% of the equivalent pile diameter with no or little softening behavior observed. At the maximum applied load (8,905 kN), the mobilized skin friction of about 30 kPa was found for the fill, marine clay, alluvial sand, and weathered granite, and about 15 kPa for the sandy clay. Normalized shear stress ($\tau/\bar{N}$) of the weathered granite ranged from 0.9 to 2.9 were obtained.
3. During the vertical load tests, specially installed instrumentation allowed the measurement of an unusual and complex response of pore-water pressures and earth pressures at several points along the barrette/soil interface. During each load cycle (except LC4), a buildup of excess positive pore-water pressure was recorded in the sandy clay and weathered granite as the vertical applied load on the barrette increased. The increase in pore-water pressure was likely caused by the undrained contractive behavior of the soils. There was no significant change in lateral earth pressure during each load and unload cycle, except at the occurrence of a large vertical displacement of the barrette. When loading caused significant slippage of the barrette within the soil, a consistent and substantial reduction in lateral total earth pressures resulted together with a drop of excess pore-water pressures. The earth pressure drop was most significant in the weathered granite soils, the changes in pore-water pressure more significant in the sandy clay.
4. The increases of pore-water pressure during pile loading and the sudden significant drop of lateral earth pressure at the onset of pile failure for some soil layers illustrate that the complex barrette-soil interaction will likely be best understood using a soil mechanics perspective. A possible mechanism to explain the behavior is that slip occurring during stress reversal permits some localized drainage and contraction of the soils. Since the concrete wall of the barrette is rigid and does not act as a constant pressure interface, any contraction of the soils away from the wall will lead to a reduction in total contact pressure.
5. The current test results indicated that the empirical SPT-N value approach and the β-method were inconsistent.

ACKNOWLEDGMENTS

The writers are grateful for the contribution provided by Paul Y. Foundation Ltd., who constructed the heavily instrumented research pile. Other sponsors of this test barrette include the Geotechnical Engineering Office of the Hong Kong Government, Fong On Construction Ltd., MTRC, Geotechnical Instruments Ltd., and the Hong Kong Institution of Engineers. In addition, the writers would like to acknowledge the financial support from the two research grants, HIA and CRC, awarded by the Hong Kong University of Science and Technology and the Research Grant Council of Hong Kong, respectively. Technical input and support from Professors C. K. Shen and Wilson Tang of the Hong Kong University of Science and Technology, and Martin Pratt and David Ng of Bachy Soletanche Group, are highly appreciated.

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Tunnelling and Underground Space Technology xxx (2012) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Tunnelling and Underground Space Technology

journal homepage: www.elsevier.com/locate/tust

Three-dimensional centrifuge modelling of the effects of twin tunnelling on an existing pile

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A R T I C L E I N F O

Article history:
Received 6 March 2012
Received in revised form 11 July 2012
Accepted 23 July 2012
Available online xxxx

Keywords:
Twin tunnelling
Piles
Three-dimensional
Soil–structure interaction
Centrifuge modelling
Dry sand

A B S T R A C T

Tunnelling activity inevitably induces soil stress changes and ground deformation, which may affect nearby existing pile foundations. Although a number of studies have been carried out to investigate the effects of tunnelling on existing piles, the excavation of only one tunnel is often considered. The fundamental interaction between twin tunnel construction and an existing pile foundation has not been thoroughly studied. In this study, a series of three-dimensional centrifuge model tests investigating the effects of twin tunnel construction on an existing single pile in dry sand were conducted. The influence of the depth of each tunnel relative to the pile was investigated by constructing the twin tunnels either close to the mid-depth of the pile shaft or near the pile toe. The pile settlement induced by the excavation of the twin tunnels is found to be closely related to the depth of each tunnel relative to the pile. The measured cumulative pile settlement due to tunnelling near the toe is about 2.2 times of that due to tunnelling near the mid-depth of the pile shaft. Apparent losses of pile capacity of 36% and 20% are identified due to the construction of twin tunnels near the pile toe and at the mid-depth of the pile, respectively. Although there is an increase in the axial force induced in the pile when a tunnel is constructed at the mid-depth of the pile, significant increases in bending moment is not observed in any of the tests.

1. Introduction

Tunnel construction inevitably causes soil stress changes in the ground and hence induces ground movements. Uncontrolled ground movements induced by tunnelling may cause cracking in buildings and gas mains, or induce additional loads on piles of nearby structures. In urban cities, it is not uncommon to encounter existing piles during tunnel constructions. Estimation of the effects of tunnelling on existing pile foundations of buildings poses a major challenge to designers. It is particularly vital to estimate the tunnelling effects when two new tunnels are to be built near an existing pile.

Bezuijen and Schrier (1994) studied the influence of bored tunnels on pile foundations. They pointed out that the pile settlement can be quite significant if the distance between pile and tunnel is less than the tunnel diameter. Loganathan et al. (2000) assessed tunnelling-induced ground deformations and their adverse effects on pile foundations in clay. Tunnelling-induced bending moment and axial force in the piles of a pile group were investigated by modelling volume loss of a tunnel in a single stage. They concluded that the tunnelling-induced bending moment may be critical when the centerline of the tunnel is located near the pile toe. Jacobsz et al. (2004) investigated the adverse effects of tunnelling beneath a pile in dry sand. An influence zone was identified above and around the tunnel in which the pile could suffer significant settlement, depending on the volume loss induced by the tunnelling. Lee and Chiang (2007) studied the tunnelling-induced bending moment and axial force in a single pile in saturated sand. Tunnels were embedded at various cover-to-diameter ratios. The authors concluded that the depth of the tunnel relative to the pile has a significant influence on the distribution of the bending moment along the pile. As far as the authors are aware, the three-dimensional centrifuge modelling of the effects of twin tunnelling on a single pile has not been reported.

Mroueh and Shahrour (2002) carried out three-dimensional elastoplastic finite element analyses to study the influence of a tunnel construction on a single pile as well as on pile groups. The numerical results showed that there is a significant reduction in the tunnelling-induced axial force and bending moment in the piles furthest away from the tunnel due to the group effect. Lee and Ng (2005) carried out a three-dimensional, elasto-plastic, coupled-consolidation numerical analysis to investigate the effects of an open face tunnel excavation on an existing loaded pile. It is shown that the factor of safety (FOS) of a pile can be reduced from 3.0 to 1.5 due to the additional settlement of a pile induced by tunnelling when a settlement-based failure criterion (Ng et al., 2001a) is used.

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http://dx.doi.org/10.1016/j.tust.2012.07.008

The effects of tunnel construction on the nearby pile foundations are obviously three dimensional. A fundamental understanding of the three-dimensional tunnel-soil-pile interaction is needed. In addition, few researchers have investigated the effects of twin tunnelling on piles, except Pang (2007), who reported the field monitoring and numerical study of the effects of twin tunnelling on an adjacent pile foundation in Singapore. A northbound tunnel and a southbound tunnel were constructed near piles one after the other. The smallest clear distance between the tunnels and piles was 1.6 m. Results of the field study showed that the piles were subjected to a large dragload due to an induced soil settlement in residual soil. However, strain gauges are only instrumented along pile portion near tunnels. The pile settlement due to tunnelling is not reported.

In this study, a series of three-dimensional centrifuge model tests were performed to investigate the behavior of a single pile due to the construction of twin tunnels one after the other. The effects of the three-dimensional tunnel excavation process were simulated in-flight by controlling the volume loss at 1.0% in each stage of the three-dimensional excavation of each tunnel. The twin tunnels in each test are located at either mid-depth of the pile or the pile toe. In addition to measurements of ground surface settlement and pile settlement, the bending moment and axial force induced in the pile by the tunnelling in different stages of construction were captured. The objective of this study is to investigate the response of an existing pile when a new tunnel excavation is to be carried out nearby. It is intended that results from this study can assist engineers and designers to choose and design the location (i.e., the depth) of the new tunnel.

2. Centrifuge modelling

2.1. Experimental program and setup

The fundamental principle of centrifuge modelling is to recreate the stress conditions, which would exist in a full-scale problem, in a model of a greatly reduced scale. This is done by subjecting model components to an enhanced body force, which is provided by centripetal acceleration ($r\omega^2$) when a centrifuge rotates at a constant angular velocity (ω) about the center of the centrifuge arm with radius, r. For instance, an 100 m prototype stress conditions can be replicated in a centrifuge by an 1 m height model when the Earth's gravity (g) is enhanced by 100 times (i.e., $r\omega^2 = Ng = 100g$). Thus, centrifuge is suitable for simulating stress-dependent materials such as soils. More details, scaling laws and centrifuge applications are given by Schofield (1980), Taylor (1995) and Ng et al. (2006). Table 1 summarizes all the relevant scale laws in this study.

In total, four centrifuge model tests were carried out at the Geotechnical Centrifuge Facility of the Hong Kong University of Science and Technology (Ng et al., 2001b, 2002). The 400g ton centrifuge has an arm radius of 4.2 m and is equipped with a two-dimensional hydraulic shaking table and a four-axis robotic manipulator. All of the centrifuge tests were carried out at an acceleration of 40g.

Table 1
Centrifuge scaling factor.

Physical quantity	Scaling factor (model/prototype)
Gravitational acceleration	n
Length	$1/n$
Area	$1/n^2$
Volume	$1/n^3$
Settlement	n
Stress	1
Strain	1
Force	$1/n^2$
Density	1
Mass	$1/n^3$
Flexural stiffness	$1/n^4$
Bending moment	$1/n^3$

Fig. 1a shows the schematic elevation view of Test T. A single pile is located at the center of each model container. Test T is designed to investigate the behavior of a pile due to a single tunnel constructed near pile toe in dry sand. The model pile had a diameter of 20 mm (0.8 m in prototype) and was 600 mm long (24.0 m in prototype). The pile cap was elevated by 110 mm and therefore the embedded depth of each pile was 490 mm (19.6 m in prototype). The tunnel diameter (D) was 152 mm (6.08 m in prototype). The C/D ratio (cover-to-diameter ratio) of the tunnel is 2.7. The horizontal distance from the centerline of the tunnel to the pile was 0.75D. In addition, a separate test (Test L) is carried out to obtain the load settlement curve of the single pile without tunnelling effects. This test has the same configuration of Test T but only without the model tunnel.

As shown in Fig. 1b, Test TT was designed to study the effects on the pile induced by the construction of twin tunnels, one after the other, near the pile toe. The C/D ratio of each tunnel is 2.7, same as that in Test T. Fig. 1c shows the schematic elevation view of Test SS. This test was designed to investigate pile responses induced by the construction of twin tunnels near the mid-depth of pile shaft. The C/D ratio of each tunnel is 1.5. A summary of the test program is given in Table 2.

Fig. 2a and b shows the plan views for Test T and Tests TT and SS, respectively. In Test T, the model tunnel had a length of 228 mm, which was equal to 1.5D. The three-dimensional tunnel construction was simulated in three stages, with the tunnel face advancing by a distance of 0.5D in each stage. In Tests TT and SS, the longitudinal length of each tunnel was 380 mm, which was equivalent to 2.5D. The tunnel excavation was simulated in five stages, again with the tunnel face advancing by a distance of 0.5D in each stage. A photograph of the model package is shown in Fig. 3a.

2.2. Simulation of tunnel construction

In simulating of tunnel advancement, it is common to model overall volume loss resulting from tunnelling effects in practice (Taylor, 1995; Mair, 2008), rather than trying to simulate different construction steps in centrifuge. Obviously, this implies that some construction details like erection and deformation of tunnel liners, stiffness of liners and workmanship are not simulated separately. Only the overall result like volume loss due to actual tunnelling is simulated. Obviously, this type of modelling is not ideal. However, it does capture the essential effects (i.e., volume loss) of tunnelling and can meet the comparative objective of different simulated cases in this paper.

In the single tunnel test, the model tunnel consisted of three cylindrical rubber bags. In the twin tunnel tests, each model tunnel consisted of five cylindrical rubber bags (see Fig. 3b). Between two rubber bags was a rigid aluminum divider to control and separate the volumes of water inside so that volume change in each rubber (i.e., the tunnel volume loss) can be controlled independently. Each rubber bag was filled with de-aired water. Three-dimensional tunnel construction was simulated in-flight by draining away a controlled amount of water from each rubber bag one by one. The amount of water drained away was controlled as 1.0% of the total volume of the cylindrical rubber bag. This is to simulate an equivalent volume loss of 1.0% of excavated cross section area of the tunnel face during each stage of tunnel construction. Since the effects of tunnel excavation were modelled by inducing an equivalent volume loss resulting from various construction factors and tunnel

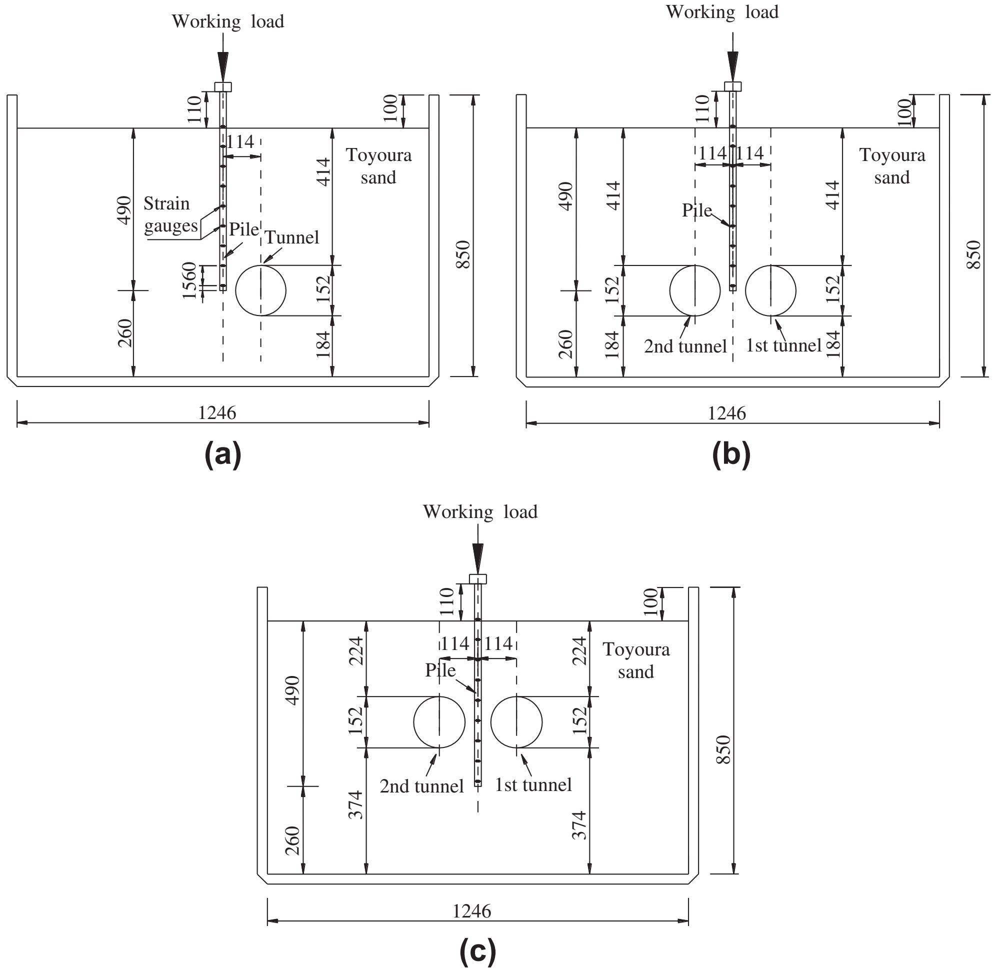

Fig. 1. Elevation view of centrifuge model: (a) Test T; (b) Test TT; (c) Test SS. All dimensions are in mm in model scale.

Table 2
Test program.

Test ID	C/D	Remark	Relative density of sand (%)
L	N/A	Pile load test	60
T	2.7	Single tunnelling near pile toe	60
TT	2.7	Twin tunnelling near pile toe	65
SS	1.5	Twin tunnelling near pile shaft	62

N/A denotes not applicable.

liner in the field, model tunnel liner is not needed to be simulated in the centrifuge tests.

2.3. Model piles and instrumentation

The instrumented model pile was fabricated from an aluminum tube (see Fig. 1a). Nine levels of full Wheatstone bridge of strain gauges were installed to record bending moment and axial force along the entire pile length. The strain gauges were protected by a thin layer of epoxy. Prior to a centrifuge test, calibration was carried out to obtain a relationship between an applied bending moment to the pile and the corresponding reading of each full Wheatstone bridge. For structural elements, the bending stiffness (EI) of pile was chosen as the vital governing property to be satisfied. It can be derived that the scaling requirement for a model pile $(EI)_m$ is equal to $N^{-4}(EI)_p$ (refer to Table 1), where N is the number of times of gravity enhanced in a centrifuge test, E is Young's modulus, I is the second moment of area for a cross-section, and subscripts m and p refer to the model and prototype scale, respectively. The model pile had an axial rigidity (E_mA_m) of 7473 kN and a bending rigidity (E_mI_m) of 273 N m^2, which are corresponding to prototype E_pA_p of 11,957 MN and E_pI_p of 701 MN m^2 of a real concrete pile, respectively. The pile is "wished-in-place" in the sand bed. Thus, pile installation effects are not simulated.

In each test, the pile was loaded in-flight (i.e., while the centrifuge is spinning) using a hydraulic jack. A load cell was installed at the piston of the jack to control applied load. Settlement of the pile was measured by a linear variable differential transformer (LVDT) located at the pile head.

2.4. Model preparation

Dry Toyoura sand (G_s = 2.65, e_{max} = 0.977, e_{min} = 0.597, $\varphi'_{cv} = 31^\circ$) (Ishihara, 1993) was used in each test. Each centrifuge model was prepared by the pluvial deposition method. Sand was "rained" from a hopper, which was kept 500 mm above the surface. The measured average relative density of each test is also given in Table 1. Since the scaling factor for soil density is one (see Table 1), soil with a relative density of 60–65% (refer to Table 2) in prototype was modelled in each centrifuge test. It is well understood that the stiffness of a soil (i.e., shear modulus, G or Young's modulus, E_s) is

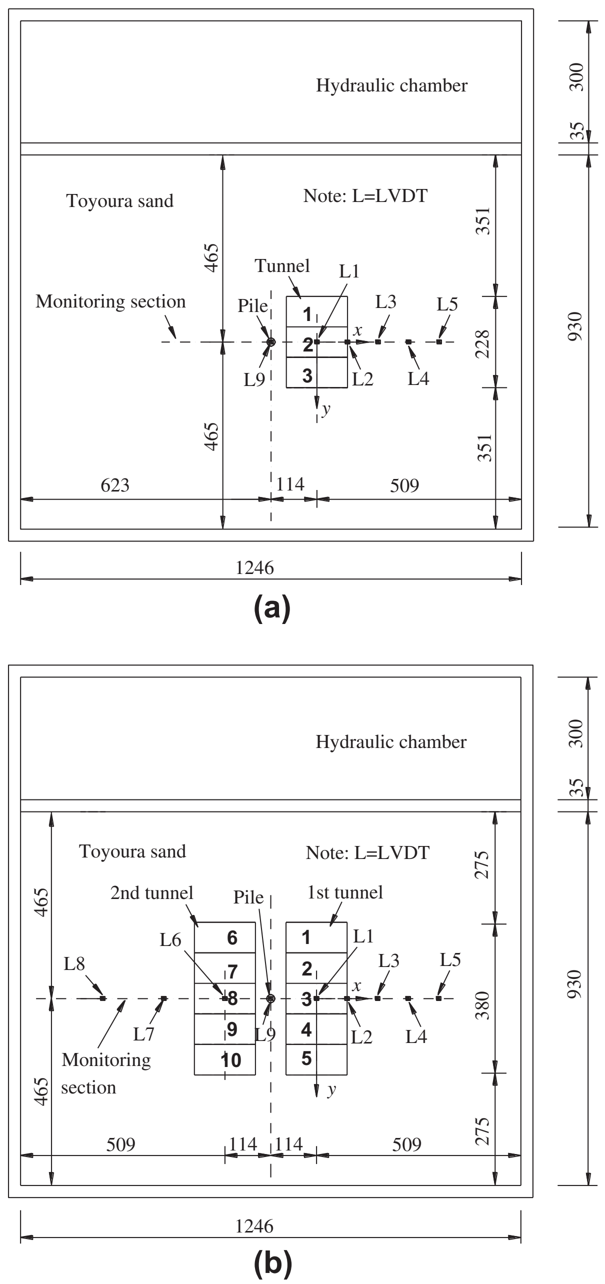

Fig. 2. Plan view of centrifuge model: (a) Test T; (b) Test TT and Test SS. All dimensions are in mm in model scale.

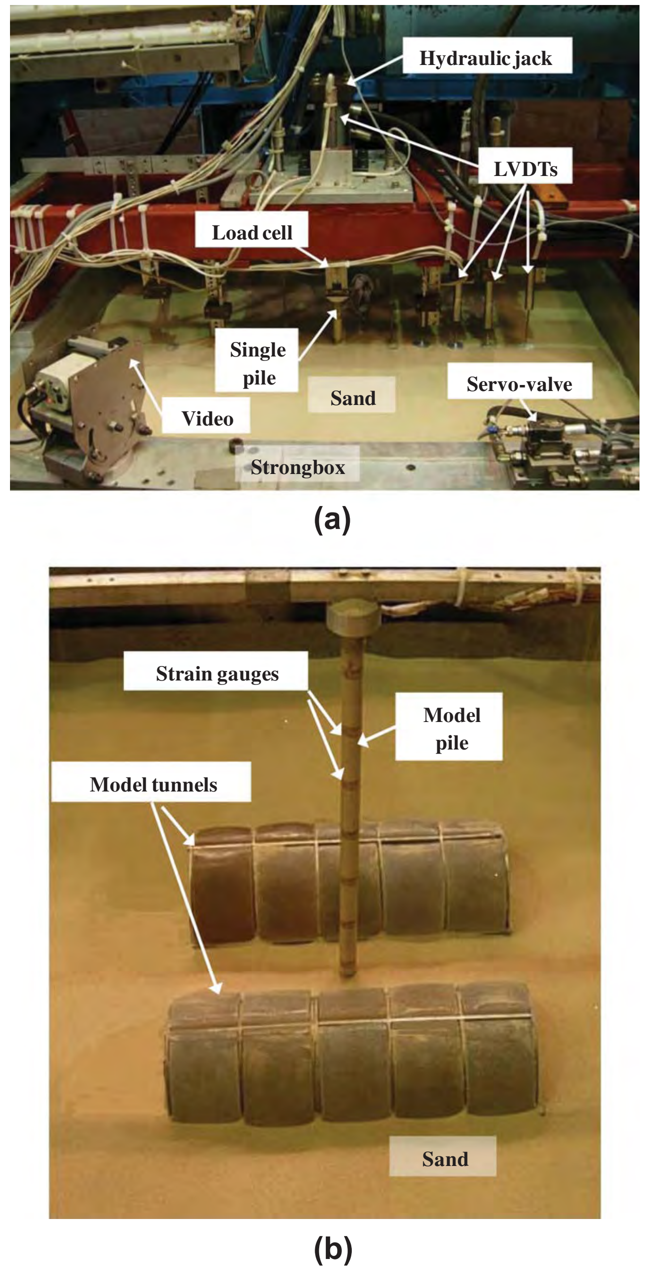

Fig. 3. (a) A typical model setup; (b) model tunnels and model pile.

dependent on its density and stress level. The stress level is simulated correctly and prototype soil density is prepared in a centrifuge. Therefore, the stiffness of the ground should be comparable to that of full scale in prototype.

2.5. Test procedure

After model preparation, the acceleration of the centrifuge was increased to 40g. The model pile was loaded in-flight at 40g in a number of steps. In each step, an incremental vertical load of 100 N (160 kN in prototype) was applied. Each load increment was maintained for 3 min. Once the load had reached the working load (1200 N), tunnel construction with the designed volume loss of 1.0% was carried out. Three construction stages were simulated in-flight by draining away water from each of the rubber bags one after the other in Test T, as shown in Fig. 2a. A similar procedure was adopted in Tests TT and SS, except five tunnel construction stages were simulated. Throughout each test, ground surface settlement, settlement of the pile, induced bending moment and axial force along the pile were recorded.

3. Test results

All test results presented in this paper are in prototype scale, unless stated otherwise.

3.1. Determination of the axial load carrying capacity of the pile

Prior to tunnelling, it is necessary to obtain the capacity of the pile so that the working load can be deduced. A pile load test

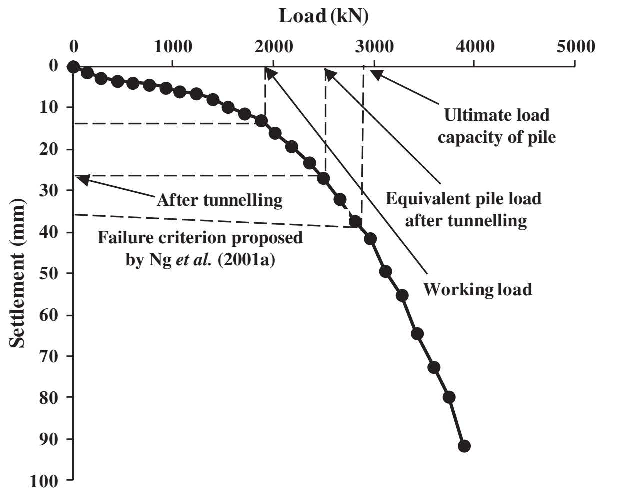

Fig. 4. Load settlement relationship obtained from load test without tunnelling (Test L).

(i.e., Test L) was carried out. Fig. 4 shows the measured load settlement relationship. The load applied to the pile cap was gradually increased to 4 MN at increments of 100 kN in each step. The ultimate axial load capacity was determined based on a displacement-based failure criterion proposed by Ng et al. (2001a). This failure criterion is expressed as follows:

$$\delta_{ph,max} \cong 0.045 d_p + \frac{1}{2}\frac{P_h L_p}{A_p E_p} \qquad (1)$$

where $\delta_{ph,max}$ is the maximum pile head movement which defines the ultimate load, P_h is the pile head load, L_p is the pile length, E_p is the elastic modulus of pile shaft, A_p is the cross-sectional area of the pile, and d_p is the pile diameter. The failure criterion proposed by Ng et al. (2001a) is a semi-empirical method for estimating an approximate interpreted failure load for pile. The method is based on a moderately conservative estimation of the movement required to mobilize toe resistance and incorporates observations of shaft shortening from actual pile loading tests. Both the 5%*D* criterion proposed by O'Neill and Reese (1999) and 10%*D* criterion proposed by Weltman (1980) do not include shortening of pile shaft and thus they may not be appropriate for long piles. Both criteria are displacement-based failure criteria. The 5%*D* and 10%*D* criterion defines the failure load of pile as the load causing a settlement of 5% and 10% of the pile diameter, respectively.

As shown in the figure, the ultimate load capacity of the pile was 2.88 MN. A working load of 1.92 MN was adopted with a factor of safety of 1.5. A pile settlement of 1.6%d_p was observed due to the applied working load.

3.2. Ground surface settlement

Fig. 5a shows the extents of ground surface settlement (*S*) measured by LVDTs 1–8 (as shown in Fig. 2) in Tests T and TT. Both the measured surface settlement and the transverse distance from the centerline of the first tunnel in Test TT and the only tunnel in Test T (*x*) were normalized by the diameter of tunnel (*D*).

In Test T, only half of the ground surface settlement trough was measured. At the end of the three stages of tunnel excavation, the measured maximum settlement was 0.27%*D* above the centerline of the tunnel. At a distance of 2*D* from the centerline of the tunnel, a surface settlement of 0.03%*D* was also measured. In Test TT, a maximum settlement of 0.24%*D* occurred at the centerline of the first tunnel after its completion. The consistency between the

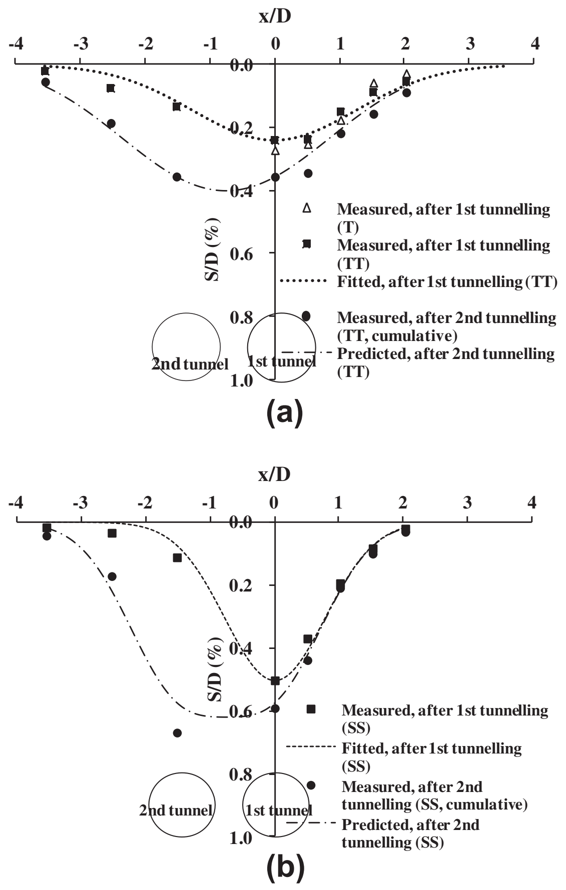

Fig. 5. Ground surface settlement induced by tunnel excavation: (a) Test T and Test TT; (b) Test SS.

two measured maximum settlement values illustrates the repeatability of the tests. After the excavation of the second tunnel in Test TT, the measured maximum surface settlement above the second tunnel was almost the same as that due to the construction of the first tunnel. The measured maximum accumulated settlement was 0.35%*D* after the excavation of the twin tunnels. Since no LVDT was installed between the centerlines of the two tunnels, the location where the maximum settlement occurred could not be identified. However, the maximum settlement was unlikely to have occurred above the centerline of the second tunnel.

The ground surface settlement profile due to tunnel construction may be represented by a Gaussian distribution (Peck, 1969). Ground surface settlement *S* is defined as

$$S = S_{max}\exp(-x^2/2i^2) \qquad (2)$$

$$S_{max} = \frac{V_s}{\sqrt{2\pi} i} \qquad (3)$$

where S_{max} is the maximum settlement at the tunnel centerline, *i* and *x* are the lateral distances from the tunnel centerline to the point of inflection and any other points on the settlement trough, respectively. V_s is the volume of settlement trough.

Eq. (2) was adopted to fit the measured values of ground surface settlement induced by excavation of the first tunnel in Test TT. As expected, the measured S_{max} was located above the centerline of the first tunnel. The best-fitted curve using an *i* of 7.5 m is shown in Fig. 5a. As proposed by O'reilly and New (1982), *i* can be represented by *KZ*, where *Z* is the vertical distance from ground surface to the center of tunnel. Following the above equation, the deduced

K value for the best-fitted curve is 0.39, which lies between the values 0.25 and 0.45 suggested by Mair and Taylor (1997) for tunnelling in sand.

Based on the design chart proposed by Peck (1969), the maximum settlement calculated using Eq. (3) is 38 mm (0.63%*D*), which is more than twice the measured data. This is consistent with the findings by Attewell and Farmer (1974), who also observed that the method proposed by Peck (1969) overestimates the maximum settlement for tunnelling in sand.

To predict the surface settlement above twin tunnels, Attewell et al. (1986) suggested summing the Gaussian curves induced by two tunnels. In this study, the best-fitted Gaussian curve is deduced from excavation of the first tunnel, as shown in Fig. 5a. Incremental settlement due to the second tunnelling is assumed the same as that during the first tunnel excavation. Superimposed curve based on the two Gaussian curves are also shown in the figure. It can be seen that the combined settlement curve fits quite well with the measured values at the end of the second excavation, except that settlement above the shoulder of the first tunnel.

Fig. 5b shows the measured surface settlement profiles in Test SS. After excavation of the first tunnel, a maximum settlement of 0.50%*D* occurred above the centerline of the first tunnel. After excavation of the second tunnel, the location of maximum surface settlement shifted to above the centerline of the second tunnel and the measured maximum value was 0.67%*D*. By fitting a Gaussian curve to the measured surface settlement profile after the construction of the first tunnel in Test SS, the fitted *K* value was found to be 0.39, consistent with that in Test TT. Similarly, by summing the two best-fitted Gaussian curves, the resulting settlement distribution is also included for comparison in Fig. 5b. The maximum settlement obtained from the summation of the two fitted curves was located above the centerline of the twin tunnels. Moreover, the measured settlement was 16% larger than the combined maximum value. It is evident that the incremental maximum settlement induced by the excavation of the second tunnel was larger than that induced by the first tunnel. Addenbrooke (1996) and Chapman et al. (2007) also found that the incremental surface settlement induced by the second tunnel is larger than that induced by the first tunnel when *C*/*D* of twin tunnels is larger than 3.0, which is higher than Test TT in this study. However, it should be noted that volume loss in each individual tunnel was not controlled in their studies. On the contrary, this study simulates tunnelling by controlling the volume loss to be 1% in all tests. This might be the reason why the magnitudes of incremental settlements induced by the twin tunnelling are close in Test TT.

Comparing the measured surface settlements in Tests TT and SS, it can be observed that the maximum surface settlement in Test TT (i.e., 0.35%*D*) was substantially smaller than that in Test SS (i.e., 0.67%*D*). This was because *C*/*D* (=1.5) the twin tunnels in Test SS was smaller than that in Test TT (*C*/*D* = 2.7). Mair et al. (1993) reported that the maximum surface settlement above one tunnel is inversely proportion to the depth of the tunnel for a given volume loss, tunnel diameter and constant value of *K*. Based on this study, it is evident that the surface settlement induced by twin tunnelling also decreases with increasing *C*/*D* ratio.

3.3. Pile settlement and apparent loss of pile capacity due to tunnelling

Fig. 6 shows the development of the normalized pile settlement (S_p) during each tunnel construction stage. Location of the tunnel at any stage is indicated by the distance between tunnel face to the centerline of the pile (*y*). Both the measured S_p and the distance from the tunnel face to the centerline of the pile (*y*) were normalized by the tunnel diameter (*D*).

In Test T, as the tunnel face advanced at a depth of *C*/*D* = 2.7 from *y*/*D* = −0.75 to −0.25, a pile settlement of 0.04%*D* was

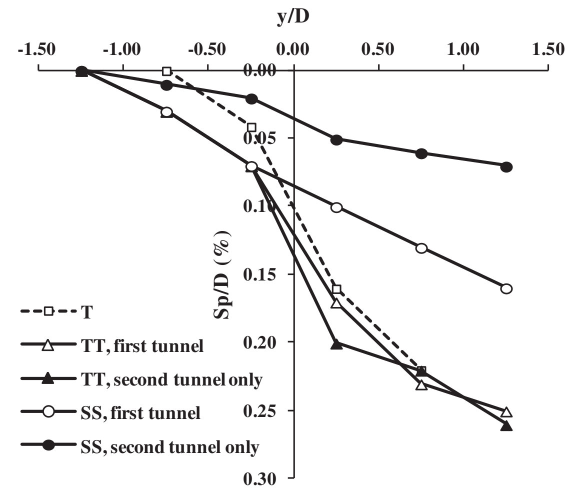

Fig. 6. Pile settlement induced by excavations of twin tunnels.

induced. A significant increase in pile settlement (0.12%*D*) occurred when the tunnel face advanced from *y*/*D* = −0.25 to 0.25. When the tunnel face reached *y*/*D* = 0.75, the pile settlement increased to 0.22%*D* (1.7% of the pile diameter). About 55% of the pile settlement was induced when the tunnel face was between *y*/*D* = −0.25 and 0.25.

In Test TT, it can be seen that the development of the pile settlement during each tunnel construction stage was very similar, in terms of the pile settlement profile and magnitude, to that observed in Test T. Significant increases in pile settlement also occurred when the tunnel face was between *y*/*D* = −0.25 and 0.25. When the face of either tunnel advanced from *y*/*D* = 0.75–1.25, the pile settlement only increased from 0.22%*D* to 0.25%*D* (1.9% of the pile diameter). About 90% of the pile settlement induced by each tunnel occurred when the face of each tunnel was between *y*/*D* = −0.75 and 0.75. Thus, the tunnelling influence zone of pile settlement was identified to be between *y*/*D* = −0.75 and 0.75. At *C*/*D* = 2.7, surprisingly the excavation of the first tunnel had almost the same effects on the pile settlement as the excavation of the second tunnel. It may suggest that each individual tunnel construction induced limited plastic strains around the pile toe. This implies that soil around the pile toe remains almost "elastic". Hence, the influence of the second tunnelling on pile settlement is almost the same as that resulted from the first tunnel.

In Test SS, the induced settlement increased almost linearly as the excavation of the first tunnel progressed at *C*/*D* = 1.5. After the excavation of the first tunnel, a pile settlement of 0.15%*D* (1.1% of the pile diameter) was measured. The induced pile settlement due to the first tunnel in this test was 40% less than that due to the first tunnel in Test TT. Based on their centrifuge tests, Lee and Chiang (2007) also reported that pile settlement induced by tunnelling near the mid-depth of pile shaft is smaller than that induced by tunnelling near the pile toe. This is because the load transfer mechanisms of the two cases are different (to be discussed in detail later). The pile settlement due to the excavation of the second tunnel in this study was 0.07%*D* (0.5% of the pile diameter), which was only about 47% of that due to the first tunnel. This may be because a significant amount of the vertical load applied to the pile was transferred downwards to the pile toe after the excavation of the first tunnel. Therefore, the effects of the construction of the second tunnel on pile settlement were smaller than those of the construction of the first tunnel. By comparing the measured results between Tests TT and SS, it is evident that the pile settlement induced by twin tunnelling is closely related to the relative location of a tunnel to the pile.

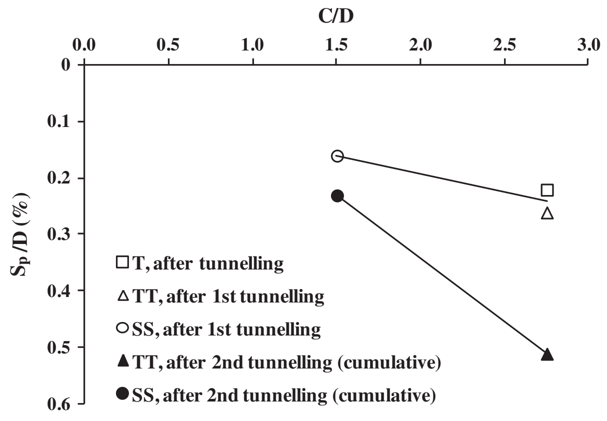

Fig. 7. Pile settlement induced by tunnelling at different *C*/*D* ratios.

Fig. 7 shows the normalized pile settlement induced by tunnelling at different *C*/*D* ratios. Open symbols denote pile settlements induced by the first tunnel, whereas solid symbols are cumulative pile settlements induced by both tunnels. After excavating the first tunnel, the pile settlement was about 0.15%*D* for *C*/*D* = 1.5 in Test SS, whereas the pile settlements were about 0.23%*D* for *C*/*D* = 2.7 in Test T and Test TT. It is clear that tunnelling near the pile toe induced 1.5 times of the pile settlement than tunnelling at the mid-depth of the pile shaft. After the excavation of the twin tunnels in Tests TT and SS, the cumulative pile settlement increased to 0.23%*D* for *C*/*D* = 1.5 in Test SS and to 0.50%*D* for *C*/*D* = 2.7 in Test TT. It is evident that twin tunnelling near the pile toe induced about 2.2 times of pile settlement than tunnelling at the mid-depth of pile shaft.

Since pile capacity is often interpreted using settlement criteria, the induced pile settlement due to tunnelling can be considered as an apparent loss of pile capacity (ALPC). Before tunnel excavation, pile settles 12 mm due to the initial applied working load (1.92 MN). An additional pile head settlement of 15 mm (0.24%*D*) is induced due to tunnelling in Test T (see Fig. 6). By using the load-settlement relationship shown in Fig. 4, a total pile settlement of 27 mm may be regarded as an equivalent load of 2.49 MN applied to the pile. Thus, the increase in equivalent pile load can be calculated to be 0.57 MN (i.e., 2.49–1.92 MN) due to the tunnel excavation. Since the ultimate load capacity of the pile was 2.88 MN as obtained from the load settlement curve using the displacement-based failure criterion proposed by Ng et al. (2001a), it can be considered that an ALPC of 20% occurred due to the tunnel excavation. The ALPC was about 21% after excavating the first tunnel in Test TT, but it increased to about 36% after the second tunnel was constructed. In Test SS, the ALPCs were about 14% and 20% after the first and second tunnels were constructed, respectively. The ALPCs suggest that the serviceability limit state of the pile after tunnelling should be considered.

3.4. Axial forces along the pile

Fig. 8a shows the measured axial force along the pile in Test T. The depth (z) was normalized by the tunnel diameter. Before the tunnel face reached the pile (i.e., $y/D = -0.25$), no significant change in axial force was recorded. As the tunnel face reached the pile toe (i.e., $y/D = 0.25$), the axial force along the pile decreased. This may imply that the shaft resistance of the pile was further mobilized when the pile settled more than the surrounding soil. This is consistent with the significant pile settlement in Fig. 6. The maximum reduction in axial force occurred at $z/D = 2.0$ and the magnitude of maximum reduction was 119.8 kN (i.e., 6.2% of the working load). Although the end bearing resistance was not measured at the pile toe directly in this study, the measured axial force at $z/D = 3.1$ (0.6 m above the toe of the 19.6 m pile, as shown in Fig. 1) may be used to deduce the variation of end bearing resistance due to tunnelling. The measured axial force at $z/D = 3.1$ decreased as the tunnel face reached the pile toe. This revealed that there was a reduction in toe resistance due to stress relief which resulted from the 1% volume loss during tunnelling.

As the tunnel face passed the pile (i.e., $y/D = 0.75$), the axial force along the pile increased. It can be observed that the maximum reduction in axial force occurred when tunnel face finally reached the piles. The magnitude of maximum reduction in axial force cannot be captured in plane strain model tests. This illustrates the importance of carrying out three-dimensional model tests.

Fig. 8b shows the measured axial forces along the pile in Test TT. The development of axial force due to the first tunnelling was consistent with that in Test T. As expected, the maximum reduction in axial force also occurred when the first tunnel finally reached the pile (i.e., $y/D = 0.25$). As the excavation of the first tunnel continued to a distance of $y/D = 1.25$ away from the pile, the axial force almost reduced to the value before tunnel excavation.

When the second tunnel was being excavated, the maximum reduction in axial force was 353.1 kN at $z/D = 1.9$. The reduction was more than 197% larger than that caused by the excavation of the first tunnel (118.6 kN). After the excavation of the second tunnel, the final reduction in axial force decreased to 75% of its maximum value. This illustrates the complex load transfer among the soil, the pile and the tunnels during tunnelling which could only be captured in three-dimensional simulations.

Fig. 8c shows the axial forces along the pile in Test SS. In contrast to the reduction in axial forces measured in Tests T and TT, the axial force in the pile increased during the first tunnelling at the mid-depth of the pile (i.e., $z/D = 2.0$). The maximum increase in axial force recorded occurred at $z/D = 1.55$ above the first tunnel when its face reached $y/D = 1.25$. When the second tunnel was being constructed, the measured axial force continued to increase but at a reduced rate until the end of tunnel construction. The final maximum recorded increase in axial force was 423.2 kN (22% of the working load), which was 32% larger than that measured at the end of the first tunnel (320.0 kN or 16.7% of the working load).

By inspecting the distributions of axial force closely, it can be seen that the axial force increased at depths above the tunnels. This suggests that there was a decrease in shaft resistance caused by downward soil movement and also by the reduction in confining stress due to the 1% volume loss from each tunnel excavation. In contrast to the induced axial force above $z/D = 1.5$, the induced axial force below $z/D = 1.5$ decreased with depth. This implies that there was an increase in shaft resistance below $z/D = 1.5$ when the pile settled during tunnel construction as shown in Fig. 6. The measured axial force at $z/D = 3.1$ (near the toe) increased by 125.7 kN (i.e., 6.5% of the working load) at the end of the construction of the first tunnel.

3.5. Shaft resistance and load transfer mechanisms

Fig. 9a shows the average shaft resistance along the pile in Test T and Test TT. Each pile shaft is divided into two parts: the upper portion of pile shaft above the depth of tunnel crown and the lower portion below tunnel crown. Based on the axial force measured using strain gauges, the average unit skin friction (f) may be calculated as follows:

$$f = \frac{\Delta Q}{pl} \tag{4}$$

where ΔQ is the difference between measured axial loads from any two consecutive strain gauges, l is the length of each portion, and p

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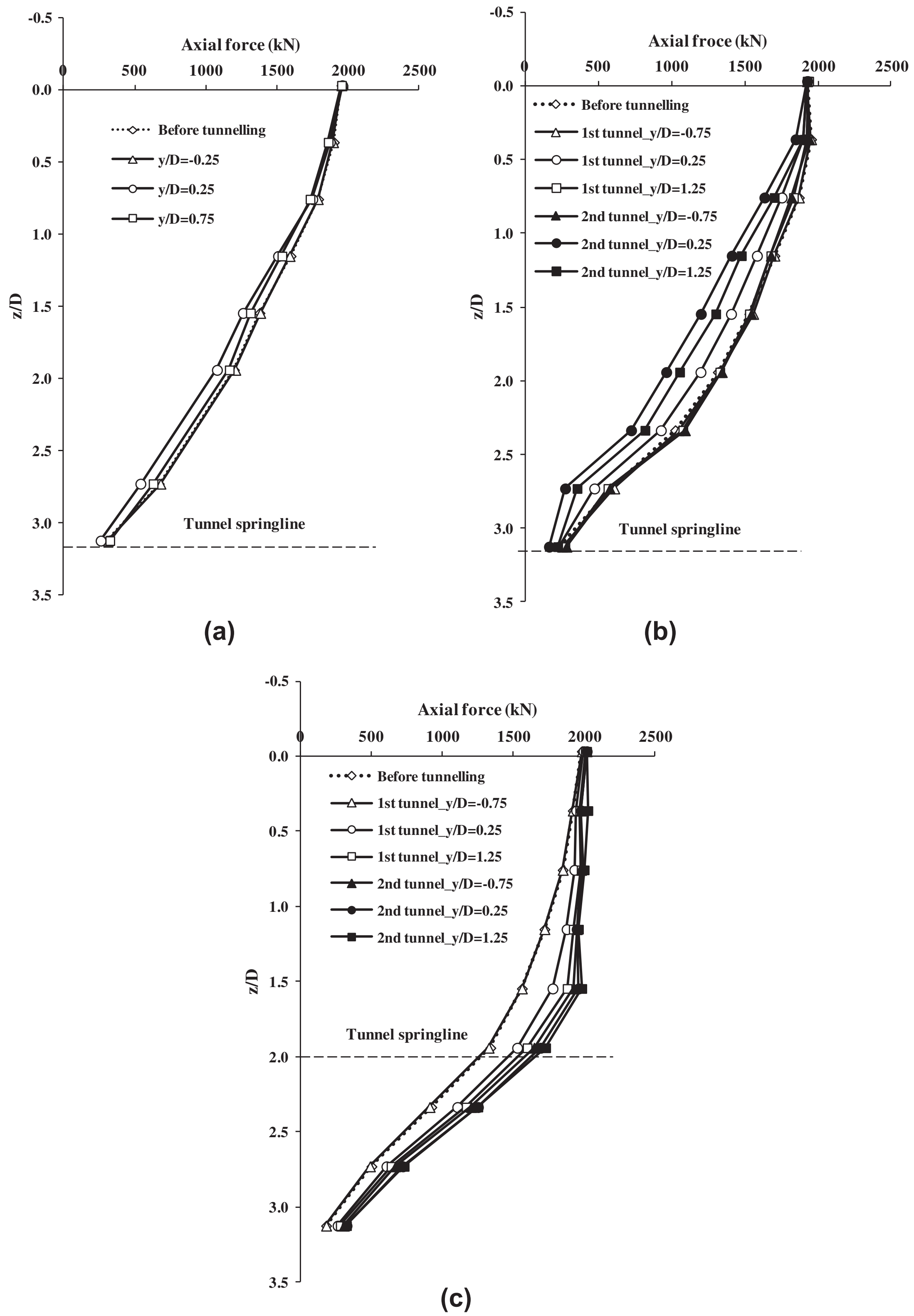

Fig. 8. Axial forces of pile at various tunnelling stages: (a) Test T; (b) Test TT; (c) Test SS.

is the perimeter of the pile. In this way, load transfer mechanism of the pile can be clearly illustrated. In Test T, as the tunnel face advanced from $y/D = -0.75$ to -0.25, no significant change in shaft resistance was observed. However, as the tunnel face further advanced from $y/D = -0.25$ to 0.25, the average shaft resistance of the pile below the tunnel crown (i.e., $z/D > 2.7$) decreased significantly and that above the tunnel crown (i.e., $z/D < 2.7$) increased significantly. Due to reduction in confining stress induced by tunnel

Please cite this article in press as: Ng, C.W.W., et al. Three-dimensional centrifuge modelling of the effects of twin tunnelling on an existing pile. Tunnel. Underg. Space Technol. (2012), http://dx.doi.org/10.1016/j.tust.2012.07.008

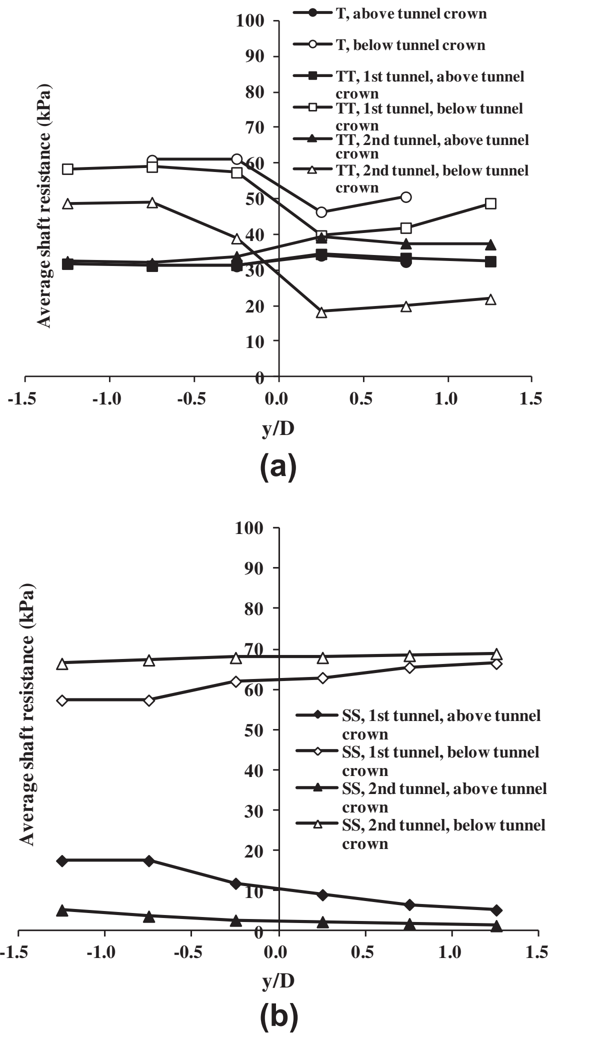

Fig. 9. Average shaft resistance along pile: (a) Test T and Test TT; (b) Test SS.

excavation, the end bearing resistance and shaft resistance of the pile at depths below the tunnel crown (i.e., $z/D > 2.7$) was reduced. In order to maintain vertical equilibrium, the pile had to settle more than the surrounding soil to mobilize shaft resistance at the upper portion of the pile shaft. This caused an increase in load taken by the upper portion and is called upward load transfer.

As the tunnel face passed the pile (i.e., as it advanced from $y/D = 0.25–0.75$), the shaft resistance of the pile above the tunnel crown (i.e., $z/D < 2.7$) decreased whereas that below the tunnel crown (i.e., $z/D > 2.7$) increased. Due to the downward soil movement and the decrease in normal stress acting on the pile induced by tunnel excavation, the shaft resistance decreased along the pile above the tunnel crown (i.e., $z/D < 2.7$). To maintain the vertical equilibrium, the shaft resistance along the pile below the tunnel crown (i.e., $z/D > 2.7$) and the end bearing resistance increased as shown in Fig. 8c. The decrease of pile load from the upward portion resulted in an increase of load in the lower portion of the pile for maintaining the vertical equilibrium. This is called downward load transfer. This is in contrast to the load transfer mechanism when tunnel face was close to the pile ($y/D = -0.25$ and 0.25). As a result, the axial force increased when the tunnel face passed the pile and advanced from $y/D = 0.25–0.75$. Therefore, the maximum reduction in axial force occurred when the tunnel face reached the pile as shown in Fig. 8. This is due to the two distinct load transfer mechanisms.

In Test TT, during the excavation of the first tunnel, the development of average shaft resistance above and below the tunnel crown was consistent with that in Test T. Two types of load transfer can again be observed. When the second tunnel was being excavated, the reduction in average resistance below the tunnel crown was larger than that in the excavation of the first tunnel. This is because part of the applied working load had been transferred to the lower part of the pile after the excavation of the first tunnel, as illustrated in Fig. 8b.

Fig. 9b shows the average shaft resistance along the pile in Test SS. Unlike in Test TT, only downward load transfer was observed in Test SS. During the excavation of the first tunnel, the average shaft resistance decreased significantly above the tunnel crown (i.e., $z/D < 1.5$) and increased below the tunnel crown (i.e., $z/D < 1.5$). Because vertical equilibrium of pile can be achieved by transferring the load taken by the upper part of the pile to the lower part of the pile, settlement of pile was relatively small compared with that when the tunnel face was near the pile toe as illustrated in Fig. 6. This is consistent with the centrifuge results reported by Lee and Chiang (2007).

When the second tunnel was being excavated, the average shaft resistance decreased above the tunnel crown (i.e., $z/D < 1.5$) and increased below the tunnel crown (i.e., $z/D < 1.5$), similar to that when the first tunnel was being excavated. At the end of the construction of the two tunnels, the mobilized shaft resistance of the pile was significantly reduced to almost zero above the crown of each tunnel. The change in average shaft resistance due to the excavation of the second tunnel was much smaller than that due to the excavation of the first tunnel. This is consistent with the measured pile settlement results shown in Fig. 6. The ALPC induced by the excavation of the second tunnel (6%) was only 43% of that induced by the first tunnelling (14%). After the excavation of the first tunnel, a significant amount of applied working load was transferred to the pile shaft below the tunnel crown and the pile toe. Thus, the effect of the second tunnel at the same depth was smaller. Clearly, the three-dimensional load transfer mechanism for twin tunnelling near the pile shaft is different from that for twin tunnelling near the pile toe. A pile suffers significant settlement when an upward load transfer is observed, but it experiences smaller settlement when the load transfer is downward. In this study, the ALPC for twin tunnelling near the pile toe (36%) was 1.8 times of that for tunnelling near the mid-depth of pile shaft (20%), as illustrated in Fig. 6.

3.6. Induced bending moments in the pile

Fig. 10a shows the measured tunnelling induced bending moment along the pile in Test T and Test TT. Bending moments were taken to be positive if tensile stress was induced at the side facing the first tunnel. In Test T, the maximum tunnelling-induced bending moment occurred near the tunnel crown (i.e., $z/D = 2.7$) with a magnitude of 61.5 kN m, which was 7.7% of the bending moment capacity of the pile ($M_{yield} = 800$ kN m). In Test TT, the maximum bending moment occurred near the crown of the first tunnel (i.e., $z/D = 2.7$) after its excavation. The maximum induced bending moment was 84.3 kN m (10.5% of M_{yield}). After the excavation of the second tunnel, the maximum bending moment decreased to 70.8 kN m (8.9% of M_{yield}). Centrifuge test results reported by Loganathan et al. (2000) are also included in the same figure for comparison. The maximum bending moment also occurred near the tunnel crown based on their test results. The bending moment at $z/D < 2.0$ in this study is different from that reported by Loganathan et al. This may be because the pile head in this study was constrained by the hydraulic jack. The general profiles of bending moment are similar though.

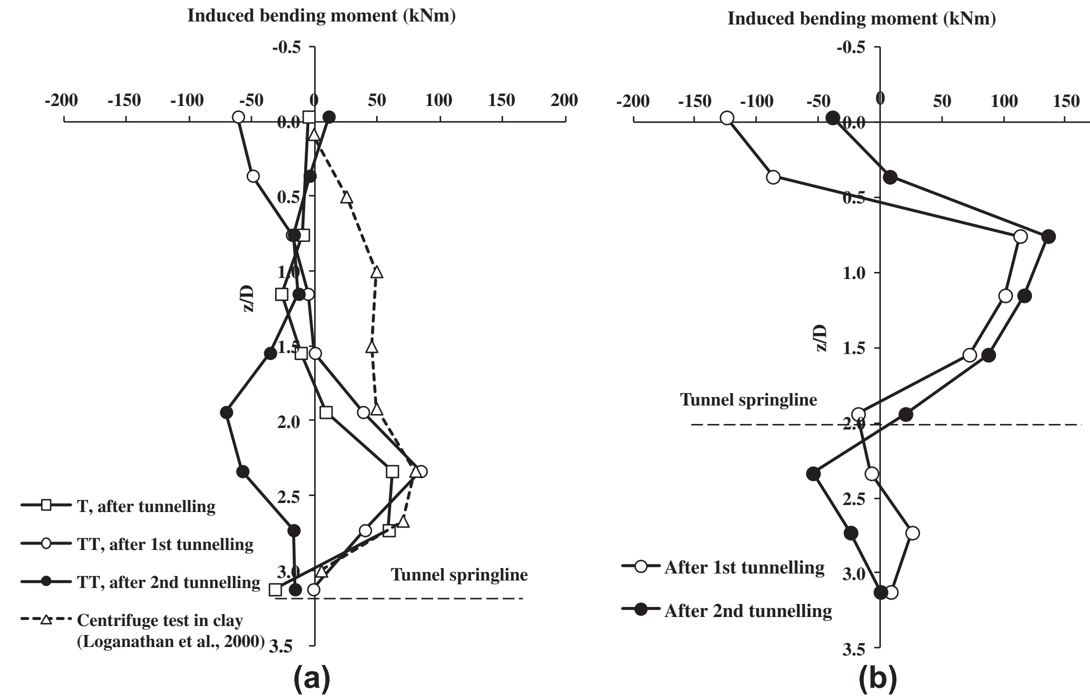

Fig. 10. Tunnelling-induced bending moment on pile: (a) Test T and Test TT; (b) Test SS.

Fig. 10b shows measured tunnelling induced bending moment along the pile in Test SS. After the first tunnel was excavated, the maximum bending moment occurred above the tunnel crown (i.e., $z/D = 0.8$). The magnitude is 113.3 kN m (14.2% of M_{yield}). A bending moment of 38.7 kN m occurred near the ground surface. This may be also due to constrain of the hydraulic jack. After the second tunnelling, the maximum bending moment was 136.0 kN m (17.0% of M_{yield}). It is the maximum value in all the three tests. Therefore, it can be concluded that the induced bending moment to the pile by twin tunnelling is relatively insignificant.

4. Summary and conclusions

A series of centrifuge model tests were carried out to investigate the effects of twin tunnel construction on an existing single pile in dry sand. In each centrifuge model test, two tunnels were simulated three-dimensionally one after the other in-flight. Based on the test results, the following conclusions may be drawn:

(a) The settlement of a pile induced by twin tunnelling is closely related to the depth of each tunnel relative to the pile. Near the pile toe (i.e., Test TT), the excavation of the first tunnel results in a pile settlement of about 1.9% of the pile diameter. The magnitude of incremental pile settlement due to the construction of the second tunnel only is about the same. Based on the displacement-failure load criterion proposed by Ng et al. (2001a), the apparent loss of pile capacity (ALPC) is about 21% after the construction of the first tunnel construction, and increases to about 36% (cumulative) after the construction of the second tunnel.

(b) For twin tunnelling near the mid-depth of the pile shaft (i.e., Test SS), the pile settlement induced by excavating the first tunnel is 1.1% of the pile diameter, which is only about 60% of that induced by the first tunnel constructed near the toe in Test TT. Due to the load transfer from the upper to lower part of the pile after the construction of the first tunnel, the construction of the second tunnel (also near the pile shaft) induces a much smaller pile settlement of only 0.5% of the pile diameter. The ALPCs are about 14% and 20% after the excavation of the first and second tunnels, respectively.

(c) The pile settlement induced by twin tunnelling is closely related to C/D ratios (cover-to-diameter ratio) of tunnels and the relative location of a tunnel to the pile. The cumulative pile settlement due to tunnelling near the toe is about 2.2 times of that due to tunnelling near the mid-depth of the pile shaft.

(d) For construction of each tunnel near the pile toe, two distinct load transfer mechanisms, i.e., an upward first and then a downward load transfer can be identified in Tests T and TT. An upward load transfer is identified when a tunnel face approaches to within 0.25D of the pile. Due to the reduction in confining stress as a result of the approaching tunnel near the toe, both the shaft resistance near the toe and the end bearing resistance of the pile decrease. As a result, a larger shaft resistance is mobilized in the upper half of the pile (or upper load transfer) while the pile settles to maintain the vertical equilibrium under the applied pile load. On the contrary, a downward load transfer is observed after the tunnel face has passed the pile by a distance of 0.25D. The shaft resistance along the upper portion of the pile decreases due to downward soil movement and stress relief induced by tunnelling, resulting in an increase in the shaft resistance along the lower portion of the pile and in the end bearing resistance so that the vertical equilibrium of the pile can be maintained. Due to the two distinct types of load transfer, the maximum reduction in axial force occurs when a tunnel face reaches the pile (in Test TT).

(e) When each tunnel is excavated near the mid-depth of the pile shaft (in Test SS), only a downward load transfer can be identified. The shaft resistance along the upper half of the pile decreases whereas the shaft resistance along the lower half of the pile increases as tunnel advances. However, there is an increase of 320 kN and 423 kN (i.e., equivalent to

17% and 22% of the working load) in the pile axial force above the crown after the construction of the first and second tunnels, respectively. At the end of the construction of the two tunnels, shaft resistance of the pile is significantly reduced to almost zero above the crowns of the tunnels.

(f) The induced bending moment due to twin tunnelling is insignificant. The maximum bending moment induced in the pile by excavation of single or twin tunnels is only about 17% of the ultimate bending moment capacity.

(g) When C/D is 1.5, the surface settlement induced by the excavation of the second tunnel is larger than that induced by the excavation of the first tunnel. Simply predicting ground surface settlement by summing the two Gaussian curves can underestimate the actual value by up to 16%.

(h) In this study only volume loss induced due to tunnelling is modelled. The effect of removal of soil inside of tunnel is not simulated. Since all the tests were carried out using the same method (by simulating volume loss), measured results obtained from different cases investigated are comparable and conclusions drawn from this study should not be affected.

Acknowledgements

The authors would like to acknowledge the financial support provided by the Research Grants Council of the HKSAR (General Research Fund Project No. 617608).

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Tunnelling and Underground Space Technology 28 (2012) 297–303

Contents lists available at SciVerse ScienceDirect

Tunnelling and Underground Space Technology

journal homepage: www.elsevier.com/locate/tust

Centrifuge and numerical investigation of passive failure of tunnel face in sand

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ARTICLE INFO

Article history:
Received 19 July 2011
Received in revised form 20 October 2011
Accepted 13 December 2011
Available online 9 January 2012

Keywords:
Tunnel face
Failure mechanism
Passive failure pressure
Surface displacement
Sand

ABSTRACT

Tunnelling is one of the major construction methods to sustain the increasing demand on development in cities. Although many studies have been carried out to investigate the active failure mechanism of tunnel face in sand, the study of passive failure of tunnel face is relatively rare and most of studies are analytical solutions based on the upper bound theorem. In this paper, centrifuge model tests and three-dimensional finite element analyses have been conducted to study the passive failure mechanisms of tunnel face in sand for tunnels located at cover over diameter (C/D) ratios equal to 2.2 and 4.3. Passive failure pressures of tunnel face as well as ground surface displacements were investigated in centrifuge tests. From both centrifuge and numerical investigations, it is found that for a tunnel located at C/D ratio equals to 2.2, the soil in front of the tunnel face is displaced by the advancing tunnel face while the soil further away from the tunnel face is forced upwards to the ground surface. A funnel-type failure mechanism is observed and the extent of the failure mechanism is narrower than a five-block failure mechanism commonly assumed in an existing upper bound solution. However, the calculated passive failure pressure by the upper bound solution is fairly consistent with the measured face pressure. It is observed that the funnel-type failure mechanism induces surface heaves. Both observed longitudinal and transverse heaves are well described by Gaussian distributions. For a tunnel located at C/D ratio equals to 4.3, the displacements of soil are confined around the vicinity of an advancing tunnel face and a localised failure mechanism associated with ground settlement is observed and computed. There is a large discrepancy between the localised failure mechanism and the five-block failure mechanism. The calculated failure face pressure is higher than the corresponding measured value by 50%. However, reasonable consistency can be found between measured and computed passive face pressures.

1. Introduction

In cities, tunnelling has become one of the major construction methods to sustain the increasing demand on development. When a tunnel is excavated, the tunnel face pressure shall be maintained within the minimum and maximum support pressures to prevent active or passive failure at the tunnel face. The failure may endanger human life and cause catastrophic damage to the structures within the influence zone.

Over the decades, numerous theoretical and experimental studies have been performed to investigate the active failure of tunnel face (Anagnostou and KovÃ¡ri, 1994, 1996; Chambon and Corte, 1994; Dias et al., 2008; Leca and Dormieux, 1990; Leca and Panet, 1988; Mollon et al., 2010; Soubra, 2002). But the study of passive failure of tunnel face is relatively rare and most of them are analytical solutions and numerical simulations (Dias et al., 2008; Leca and Dormieux, 1990; Mollon et al., 2010; Soubra, 2002; Soubra et al., 2008). Passive failure during drilling of the 2nd Heinenroord Tunnel (Bezuijen and Brassinga, 2005) imply that passive failure at tunnel face is not a theoretical risk. It is of important to know the passive failure pressure of tunnel face to prevent the passive failure.

Leca and Panet (1988) and Leca and Dormieux (1990) used lower and upper bound theorems to predict the passive failure pressure of tunnel face in sand. For upper bound solutions, they adopted a truncated cone as the failure mechanism. It is a planar on vertical plane of symmetry running longitudinally along centreline of tunnel. Soubra (2002) improved the upper bound solutions by introducing a log spiral instead of planar on the vertical plane of symmetry. The log spiral was idealised using multiple truncated rigid cones. But only an inscribed elliptical area to the entire circular tunnel face is involved in deriving the upper bound solutions, due to the conical shape of the rigid cones used in the derivation (Mollon et al., 2010).

While existing analytical and numerical analyses provide valuable information and knowledge on passive failure of tunnel face, the problem has not been studied systematically and fully understood. In view of this, centrifuge model tests were carried out to

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doi:10.1016/j.tust.2011.12.004

investigate passive failure of tunnel face in sand for tunnels located at cover over diameter, C/D ratios equal to 2.2 and 4.3. In addition, finite element analyses were conducted to back-analyse the centrifuge model tests and provide further information to understand the problem. This paper presents: (a) details of centrifuge model setup and test procedures; (b) details of the finite element analyses; (c) failure mechanisms and passive failure pressure of tunnel face obtained from the centrifuge model tests and finite element analyses as well as comparisons with the existing analytical solutions; and (d) the induced ground surface displacement due to tunnel face displacement obtained from centrifuge tests.

2. Centrifuge modelling

2.1. Experimental program

The centrifuge model tests were performed in the Geotechnical Centrifuge Facility (GCF) at the Hong Kong University of Science and Technology (HKUST). The geotechnical centrifuge at HKUST (Ng et al., 2001, 2004) has a rotating arm of approximately 8.4 m in diameter. The maximum modelling capacity of the centrifuge is 400g ton. It is capable of simulating an elevating gravity field over 150 times that of the earth's gravity (g) for static model.

Three tunnelling cases with different C/D ratios were carried out in saturated sand to study the passive failure of tunnel face. Tests S2 and S4 were designed to investigate the passive failure of tunnel face for tunnels located at C/D ratios equal to 2.2 and 4.3 respectively. The performance and reliability of load cells submerged in the water deteriorated over time due to water ingress. Tunnel located at C/D ratio equals to 2.2 was repeated in Test S2R using an internal load cell as described in Section 2.2 to obtain the variation of tunnel face pressure with tunnel face displacement. Some details of the centrifuge tests are given in Table 1.

2.2. Model setup

Fig. 1 shows the plan and elevation views of the centrifuge model setup. A rectangular model container of plan dimensions 1245 × 350 mm and depth 850 mm with a perspex viewing window in the front face was used in the centrifuge model tests. A 12.7 mm thick glass, measuring 850 mm by 714 mm, was bolted to 25.4 mm thick perspex with similar dimensions to form a composite panel. The composite panel was attached to the front face of the model container with the glass side in contact with sand. The glass served the purpose for ease of PIV control marker placement while reducing the friction between the front face and the sand. The face of the glass which was in contact with the sand formed the vertical plane of symmetry. A 25.4 mm thick aluminium plate was used to separate the sand from the loading system. The aluminium plate was braced by six aluminium struts with diameter of 41.3 mm attached to the side wall of the model container.

Fig. 2 shows the model tunnel used in the Test S2R. A tunnel lining consisted of an aluminium hollow tube, 50 mm in diameter and 200 mm long with wall thickness of 2.7 mm, which was split longitudinally along the centre plane. A hollow loading piston, 20 mm in diameter and 140 mm long was screwed to the a 60 mm long tunnel face block. A 25 mm long end block was placed at another end of the loading piston. The tunnel lining was placed on the tunnel face block and bolted to the end block.

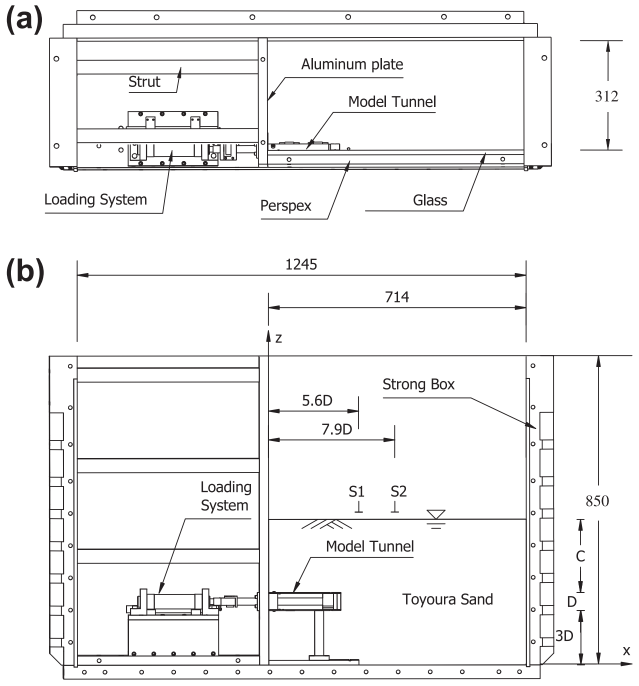

Fig. 1. Basic configuration of a centrifuge package (dimensions in mm): (a) plan view and (b) elevation view.

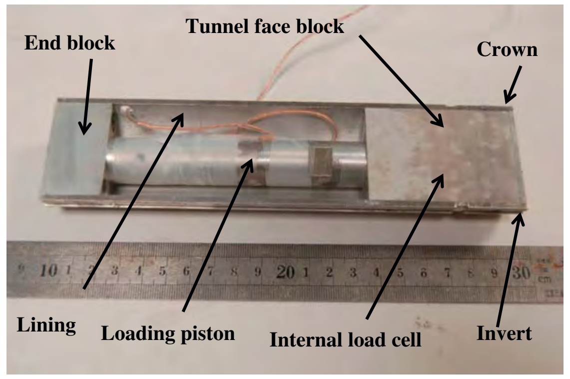

Fig. 2. Model tunnel.

The tunnel face block consisted of a tunnel face, an internal load cell and a sleeve. The internal load cell was made of hollow aluminium tube with semiconductor strain gauges bonded on the external surface. Epoxy coating was used to protect the strain gauges from abrasion. Full Wheatstone bridge strain gauges was arranged to compensate for temperature effects. The load cell was attached to the tunnel face and protected by the sleeve. There were two O-rings at both ends of the load cell in contact with the inner face of the sleeve. This minimised the friction between sleeve with lining/soil and glass to be transferred to the load cell. The O-rings also served the purpose to isolate the load cell from water ingress. There was a ring of filler to separate the sleeve from the tunnel face to ensure load from the tunnel face was measured by the load cell only. The silica gel was squeezed into the hollow section of the load cell and isolated the strain gauges from water.

Table 1
Test program.

Test	C/D	Relative density (%)	Unit weight (kN/m^3)	Remarks
S2	2.2	67	19.2	Performance of load cells submerged in water deteriorated over time
S4	4.3	56	19.0	Performance of load cells submerged in water deteriorated over time
S2R	2.2	63	19.1	–

Model tunnel used in Tests S2 and S4 was similar to that used in Test S2R except the loading piston and tunnel face block also served as load cells with full Wheatstone bridge strain gauges bonded to its external surface and protected by epoxy coating. The performance and reliability of the load cells deteriorated over time due to water ingress.

Fig. 3 shows the loading system used in the centrifuge tests. The loading system consisted of a hydraulic actuator, mounted on an actuator support by using two L-shape brackets and connected to an oil supply system through two oil supply tubes. A linear variable differential transformer (LVDT) was fastened to the actuator support and its core was bolted to a fitting cap. The fitting cap was attached to the piston of the actuator. The actuator support was made of four 12.7 mm thick aluminium plates and bolted to a 25.4 mm thick base plate, which was mounted to the bottom of the model container. A connecting piston used to connect the loading system and model tunnel was slot to the fitting cap and secured by a L-shape fitting. The connecting piston also served as an external load cell with full Wheatstone bridge strain gauges bonded to its external surface and protected by epoxy coating.

The model tunnel was supported by an aluminium column at one end and bolted to the aluminium plate via two screws at another end as shown in Fig. 1. The connecting piston of the loading system passing through the aluminium plate was connected to the loading piston of the model tunnel. The hole on aluminium plate had a groove, fit with an elastomeric O-ring, which encircled the connecting piston to ensure watertight during the movement of the piston. Perforated drainage pipes wrapped with geotextiles were used to form a drainage system. The drainage system was placed on the bottom of the model container.

2.3. Instrumentation

In Tests S2 and S4, tunnel face pressure was given by an external load cell as shown in Fig. 3. In Test S2R, tunnel face pressure was given by an internal load cell in the tunnel face block as described in the previous section. Horizontal displacement of tunnel face was measured by LVDT attached to the actuator support.

Particle image velocimetry (PIV) and close-range photogrammetry originally developed by White et al. (2003) was used to monitor the subsurface soil displacement on the vertical plane of symmetry. The precision of the measurement is 0.1 mm. Digital images were captured using in flight camera mounting on the swinging platform. Each image was divided into soil patches and each patch represented a measurement point. The movement of soil patches between two successive images was traced based on cross-correlation. PIV can only measure the displacement in the image-space coordinates. Close range photogrammetry was used to convert the image-space coordinates to object-space coordinates. Details of PIV and close-range photogrammetry can be obtained from White et al. (2003). Longitudinal surface displacements were deduced from the PIV results. The transverse surface displacements were monitored using LVDTs at Sections S1 and S2 located at 5.6D and 7.9D respectively along the x direction as indicated in Fig. 1. For Test S2, four LVDTs were placed at Section S1. Four LVDTs were placed at Section S2 for Test S4. Four LVDTs were placed at Section S1 and three LVDTs were placed at Section S2 for Test S2R.

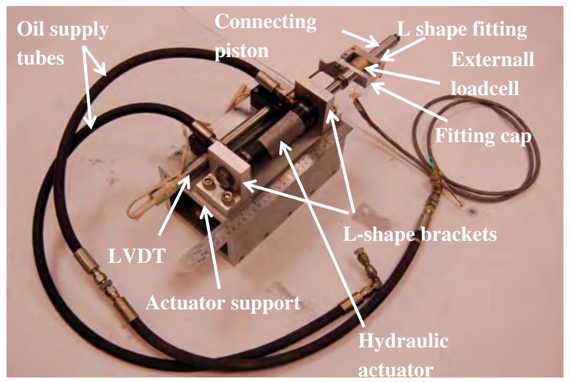

Fig. 3. Loading system.

2.4. Model preparation

Toyoura sand used in the tests has the maximum and minimum void ratios of 0.977 and 0.597 respectively. The sand has a specific gravity of 2.65 (Verdugo and Ishihara, 1996). The sand was pluviated to the strong box through a hopper and the drop height of the sand was set as 500 mm. The relative density, D_r, of the sand sample at 100g was 67%, 56% and 63% for Tests S2, S4, and S2R respectively. The relative density and corresponding saturated unit weight of the sand sample for Tests S2, S4 and S2R are listed in Table 1.

In order to saturate the sand, aluminium cover with elastomeric O-ring was placed on top of the model container. Vacuum was applied to the sand for 2 h. Then, carbon dioxide was injected through drainage system to replace the residual air. After that, the vacuum was reapplied for another 3 h. While maintaining the vacuum, deaired water from water tank was supplied through the drainage system to the soil mass. When the water level reached required level above the ground surface of the sand sample, the saturation process was terminated. The whole saturation process required around 40 h.

2.5. Test procedures

After completion of model preparation and final check, the model container was transferred to the swinging platform. The water level was maintained at around 15 mm above the ground surface after connecting the strong box to the stand pipe on the platform. Four cameras were set up to capture photographs during centrifuge testing. Three videos were installed to monitor the test. The data logger was then set to record data at 1 Hz, and upon centrifuge spinup, photographs were taken at 150 s intervals and saved to the computer.

When the acceleration of the centrifuge reached 100g and equilibrium condition was achieved, the camera settings were changed to take photographs every 30 s. The tunnel face block was pushed toward the sand in 0.2 mm per second. The speed was chosen to ensure enough time for the water to flow into the tunnel lining so that suction was not created behind tunnel face block. The tunnel face displacement was prescribed and the corresponding face pressure was measured. After pushing the tunnel face block for a maximum displacement of 35 mm, the centrifuge was spun down. It should be noted that in actual shield tunnelling, pressure controlled is normally adopted. The measured results from centrifuge tests may not be directly applicable to the actual tunnel construction. On the other hand, pressure controlled was used in the numerical simulations described later in this paper.

3. Three-dimensional numerical modelling

3.1. Finite element mesh and boundary conditions

Three-dimensional numerical modelling were performed using Plaxis finite element code (Brinkgreve and Broere, 2004). Fig. 4

shows the finite element mesh used in the numerical modelling for tunnel located at C/D ratio equals to 2.2. The finite element mesh was 700 mm long, 300 mm high and 300 mm wide. For tunnel located at C/D ratio equals to 4.3, the finite element mesh was 700 mm long, 400 mm high and 300 mm wide. This is similar to the dimensions of the soil samples in the model container.

Only half of the tunnel was modelled, taking advantage of symmetry about $y = 0$ mm. 15-noded wedge elements and 8-noded plate elements were used to model the sand and the tunnel lining respectively. On the left and right boundaries of the mesh, the movement in the y direction was restrained. The movement in the x direction on the front and rear boundaries was restrained. Pin supports were applied to the base boundary to restrict movements in the x, y and z directions. The water table was located at the ground surface, with a hydrostatic initial pore-water pressure profiles. The tunnel lining and shield was submerged under water.

3.2. Constitutive models and model parameters

The response of the sand is modelled using a non-linear hardening-soil (H-S) constitutive model employed the Mohr–Coulomb failure criterion with a non-associated flow rule. The H-S model is a non-linear elastic–plastic formulation using multiple yield loci as a function of plastic shear strain and a cap to capture volumetric hardening as described by Schanz et al. (1999). Loading and unloading within the current yield surface, which is defined by a unloading and reloading modulus, E_{ur}, are assumed to be elastic. Critical state angle of friction, ϕ_{cs} is defined by maximum angle of dilation, ψ and peak angle of friction, ϕ' according to Eq. (1a). The mobilised dilation angle, ψ_m is related to mobilised angle of friction, ϕ'_m and ϕ_{cs} as shown in Eq. (1b).

$$\sin\phi_{cs} = (\sin\phi' - \sin\psi)/(1 - \sin\phi'\sin\psi) \tag{1a}$$

$$\sin\psi_m = (\sin\phi'_m - \sin\phi_{cs})/(1 - \sin\phi'_m\sin\phi_{cs}) \tag{1b}$$

Soil dilatancy, defined by the ratio of the plastic volumetric strain rate to the plastic shear strain rate is equal to $\sin\psi_m$. A cut-off for dilation is allowed when void ratio reaches the nominated maximum void ratio. Under triaxial condition, the model predicts a hyperbolic relationship for the drained secant Young's modulus, E, as given in Eq. (2).

$$E = 2E_{50}(1 - R_f q/q_f); \quad E_{50} = E_{50}^{ref}(\sigma'_3/p_{ref})^m \tag{2}$$

where q is the deviatoric stress; E_{50}^{ref} is the E value when q is 50% of the maximum deviatoric stress, q_f at the reference confining stress, p_{ref}; R_f is the failure ratio and m controls the stress level dependence of the stiffness; σ'_3 is the confining stress. In this study, p_{ref} was taken as 100 kPa. Beside, effective oedometer modulus, E_{oed} which control the cap of the model is also stress level dependence.

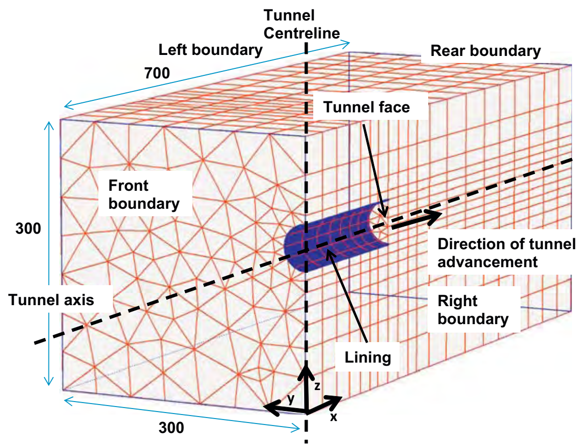

Fig. 4. Finite element mesh adopted for three-dimensional numerical modelling (dimensions in mm).

Table 2
Soil parameters used in the finite element analyses.

Parameter	Value
Saturated unit weight, γ_{sat} (kN/m^3)	19.0
Effective cohesion, c' (kPa)	1.0
Effective angle of friction, ϕ' (°)	37°
Angle of dilation, ψ (°)	7°
Effective secant modulus, E_{50} (MPa)	27
Effective unloading/reloading modulus, E_{ur} (MPa)	81
Effective oedometer modulus, E_{oed} (MPa)	27
Poisson's ratio, υ'	0.2
m	0.5
Failure ratio, R_f	0.9
At-rest earth pressure coefficient, K_o	0.5

The relative density of the sand was taken as 60%, which corresponds to a saturated unit weight, γ_{sat} of 19.0 kN/m^3. According to Verdugo and Ishihara (1996), the critical state angle of friction, ϕ_{cs} for Toyoura sand is 31° under triaxial condition. In order to obtain shear strength and stiffness parameters for numerical simulations in this study, triaxial compression tests conducted by Maeda and Miura (1999) were simulated numerically. The fitted ϕ' and ψ are 37° and 7° respectively. Small cohesion, c' of 1 kPa was assigned to the soil. In the numerical simulations, E_{50} at confining stress of 100 kPa was taken as 27 MPa. E_{oed} was set as 27 MPa (Schanz and Vermeer, 1998). The unloading and reloading modulus, E_{ur} was taken as 81 MPa, which is three times of E_{50} (Brinkgreve and Broere, 2004). The Poisson's ratio of the sand was taken as 0.2. The coefficient of earth pressure at-rest was set equal to 0.5. Soil parameters used for the numerical modelling are summarised in Table 2. The tunnel lining was modelled as linear elastic material with a Young's modulus of 70×10^6 kPa, a Poisson's ratio of 0.15, and a thickness of 2.7 mm.

3.3. Numerical modelling procedures

The analysis was started by applying an acceleration of 100g to increase the gravity of the numerical model to simulate the stress state in the centrifuge test. As tunnel was assumed to be wished-in-place and submerged under water, tunnel excavation was simulated by deactivating the soil elements within tunnel excavation zone and activated the shell elements of the lining in a single step. Such a simplified modelling approach had been adopted successfully in previous studies (Li et al., 2009). In order to ensure the sand around the vicinity of tunnel face remained at at-rest condition, a constant pressure which equal to the at-rest earth pressure at the centre of tunnel face was applied to the tunnel face. Subsequently, pressure controlled boundary was adopted at the tunnel face to investigate the passive failure of tunnel face.

4. Failure mechanism

Fig. 5a shows the measured normalised displacement vectors on the vertical plane of symmetry at normalised tunnel face displacement, S_x/D of 0.8, for tunnel located at C/D ratio equals to 2.2. The corresponding normalised tunnel face pressure, $N_{\gamma m}$ is 91. The normalised tunnel face pressure following Leca and Dormieux (1990) is given by $N_{\gamma m} = \sigma_t/\gamma D$, where σ_t = tunnel face pressure and γ = effective unit weight of sand. The displacement vectors were obtained from the centrifuge tests using PIV analyses and normalised by tunnel face displacement. The displacement vectors illustrate that the soil in front of the tunnel face is displaced by the advancing tunnel face, while the soil further away from the tunnel face is forced upwards to the ground surface and hence the soil surface heaves. The observed failure mechanism is compared to a five-block failure mechanism (dashed lines in the figure) proposed by Soubra (2002) in obtaining upper bound solutions. The five-block failure mechanism is obtained by assuming the sand obeys normality where $\psi = \phi_{cs}$, which is rarely observed during drained failure of sand. The normality assumption may be one of the reasons that the five-block failure mechanism is wider than the observed failure mechanism. Previous studies (De Borst and Vermeer, 1984; Loukidis and Salgado, 2009; White et al., 2008) also revealed that a wider failure mechanism is obtained when the soil is more dilative. When the observed failure mechanism is idealised by solid lines, a funnel-type failure mechanism may be postulated.

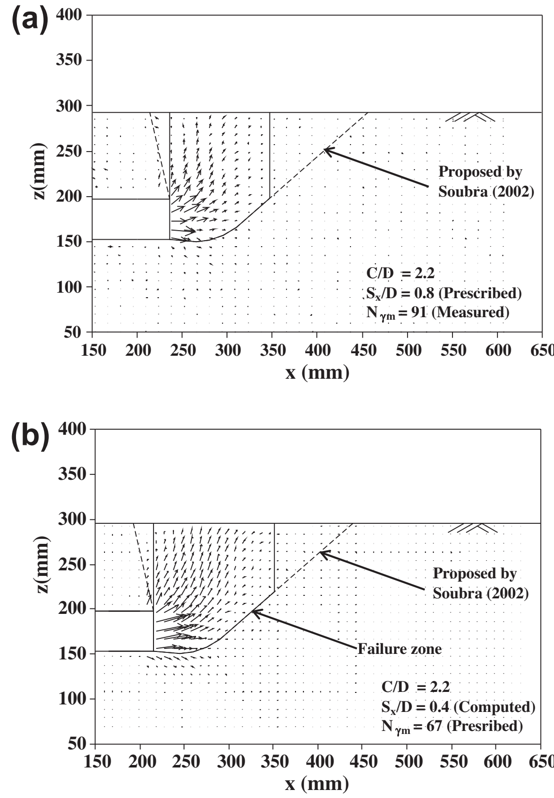

Fig. 5. Comparison of (a) measured and (b) computed normalised displacement vectors for tunnel located at C/D ratio equals to 2.2.

Fig. 5b shows the computed normalised displacement vectors at S_x/D of 0.4 and $N_{\gamma m}$ of 67. The computed displacement vectors are obtained from numerical back-analysis and normalised by tunnel face displacement. The computed displacements vectors also show a funnel-type failure mechanism. The finite element results reveal that the soil elements in front of the tunnel face and those further away from the tunnel face at which soil is forced upwards to the ground surface. The elements reached failure are indicated by the failure zone illustrated in the figure.

Fig. 6a shows the measured normalised displacement vectors are localised around the tunnel face at S_x/D of 0.8 for tunnel located at C/D ratio equals to 4.3. The corresponding $N_{\gamma m}$ is 185. The soil in front of the tunnel face is displaced forwards, whereas the soil in regions located further away from the tunnel axis is forced outwards. Obviously, the observed failure mechanism illustrated by the displacement vectors is differed from a five-block failure mechanism (dashed lines in the figure) proposed by Soubra (2002).

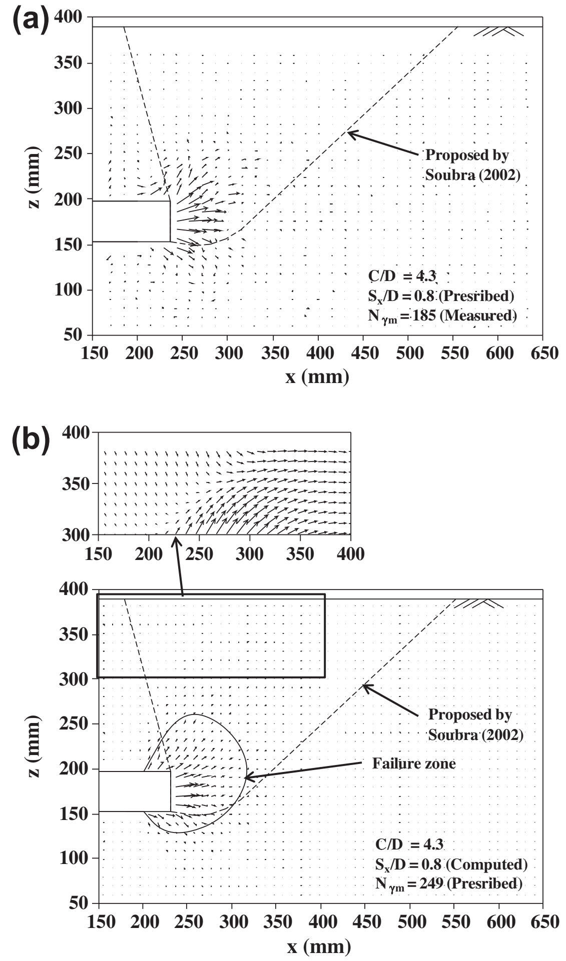

Fig. 6. Comparison of (a) measured and (b) computed normalised displacement vectors for tunnel located at C/D ratio equals to 4.3.

Fig. 6b shows the computed displacement vectors at S_x/D of 0.8 and $N_{\gamma m}$ of 249. The failure mechanism illustrated by the computed displacement vectors shows fairly close agreement with the localised failure mechanism. The finite element results reveal that the soil elements adjacent to the tunnel face reached failure. Computed failure zone is reasonably consistent with the observed displacement vectors shown in Fig. 6a. The displacement vectors at a region close to the ground surface are scaled up to 20 times for clarity. The displacement vectors illustrate surface settlements. The mobilised shear above the crown of tunnel face might drag the soil mass forwards and induce the surface settlements.

5. Passive failure pressure of tunnel face

Fig. 7 shows the variations of $N_{\gamma m}$ with S_x/D for tunnels located at C/D ratios equal to 2.2 and 4.3. For tunnels located at C/D ratio equals to 2.2, $N_{\gamma m}$ increases with S_x/D but at a reducing rate and approaches a steady state. The variation of $N_{\gamma m}$ with S_x/D for Test S2 is comparable to that obtained from Test S2R. Some of data was missing due to improper electrical gain was used in Test S2. It is observed that $N_{\gamma m}$ in Test S2 is larger than that in Test S2R. This may be reasonable as the $N_{\gamma m}$ obtained from external load cell in Test S2 was affected by the friction between tunnel face block and the lining, glass or sand. It is fortuitous that the computed pressure-displacement curve is in good agreement with the measured response. It should be noted that a displacement controlled

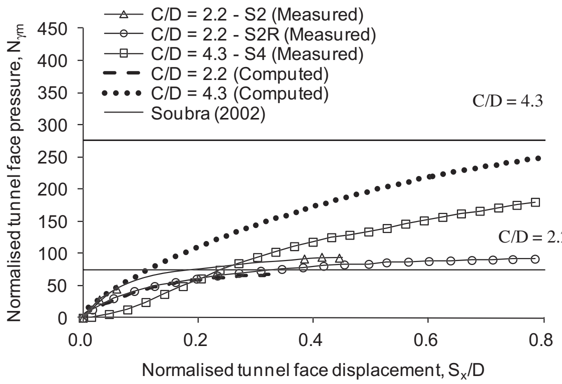

Fig. 7. Comparison of measured and computed variations of normalised tunnel face pressure with tunnel face displacement for tunnels located at C/D ratios equal to 2.2 and 4.3.

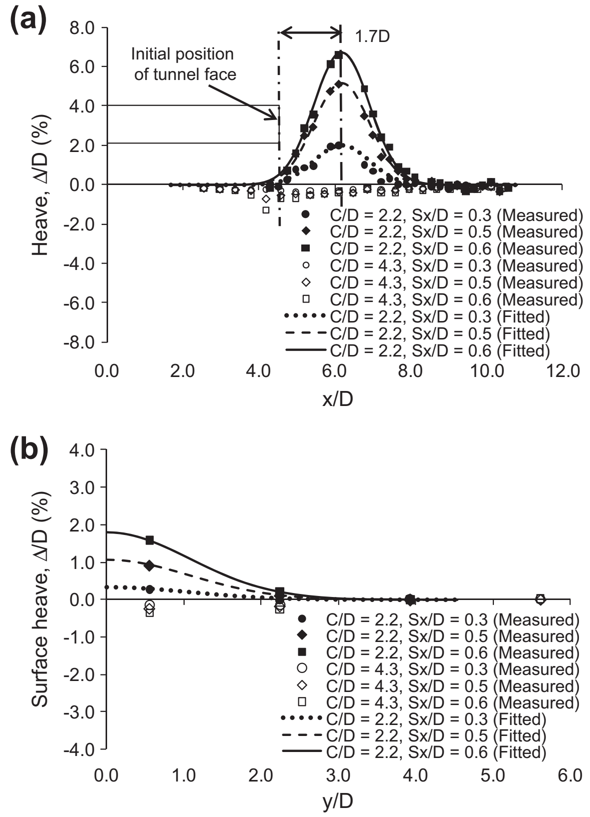

Fig. 8. Measured heaves at different tunnel face displacement for tunnels located at C/D ratios equal to 2.2 and 4.3: (a) longitudinal direction and (b) transverse direction.

boundary was used in the centrifuge test while pressure controlled was adopted in the numerical simulation. Calculated passive failure pressure by using the upper bound solution, which were derived by Soubra (2002) are included for comparison. The calculated passive failure pressure is fairly consistent with the measured face pressure.

For tunnel located at C/D ratio equals to 4.3, the measured $N_{\gamma m}$ increases slowly when S_x/D is less than 0.1. Subsequently, $N_{\gamma m}$ increases rapidly but in a reducing rate. The computed $N_{\gamma m}$ increases in a reducing rate and a steady state value was not reached at S_x/D ratio equals to 0.8. The computed $N_{\gamma m}$ is larger than the measured one. This may be due to the presence of localised loose deposit in front of tunnel face created at 1g condition. The calculated passive failure face pressure is higher than the corresponding measured value by 50%. The discrepancy may be because the measured pressure did not reach the failure one as the pressure was still increasing. This might be also attributed to the large discrepancy between the localised failure mechanism and the five-block failure mechanism.

6. Surface displacement

It is well known that measured transverse surface settlements due to tunnelling may be represented by a Gaussian distribution as suggested by Peck (1969). The Gaussian distribution can be described by:

$$\Delta = \Delta_{\max} \exp(-s^2/2i^2) \quad (3)$$

where Δ is the transverse surface settlement; $\Delta_{\max}$ is the maximum transverse surface settlement on the tunnel centreline; s is the horizontal distance from the tunnel centreline; and i is the point of inflection of the settlement trough. The point of inflection is equal to Kz_o, whereas z_o is depth of tunnel. The relation was proposed by O'Reilly and New (1982) and validated using field data by (Lake et al., 1992; Mair and Taylor, 1997). Mair and Taylor (1997) found that the K values vary from 0.25 to 0.45 for sand and gravel. Instead of fitting settlement profiles, Gaussian distribution is attempted to fit measured heaves in this study.

Fig. 8a shows the measured normalised soil displacements, Δ/D at 0.6D below the ground surface on the vertical plane of symmetry for tunnels located at C/D ratios equal to 2.2 and 4.3. The soil displacements along the longitudinal direction were obtained from the PIV analyses. Gaussian distributions are obtained by setting K equal to 0.27 and the $\Delta_{\max}$ are deduced from the measured heaves. For tunnel located at C/D ratio equals to 2.2, heaves increase with S_x/D. This is consistent with the funnel-type failure mechanism, which extends to the ground surface. The measured heaves are well described by the Gaussian distributions. The extent of the heaves and location of the maximum heave remain around 4D and 1.7D respectively from the initial position of tunnel face for different S_x/D. For tunnel located at C/D ratio equals to 4.3, instead of heaves, settlements are induced as S_x/D is increased. This is consistent with the localised failure mechanism, which induces surface settlement as shown in Fig. 6b. The maximum settlement are located near to the initial position of tunnel face.

Fig. 8b illustrates the measured normalised transverse surface heaves induced by tunnel face displacements at a section located at 3.4D in front of the initial position of the tunnel face. The surface heaves were measured by using LVDTs. For tunnel located at C/D ratio equals to 2.2, heaves increase with S_x/D and the extent of heave remains at 3D from the longitudinal tunnel axis. Gaussian distributions are fitted to the transverse surface heaves. The fitted values of Gaussian distributions are obtained by using K equal to 0.4. The transverse surface heaves are well described by the Gaussian distributions. For tunnel located at C/D ratio equals to 4.3, settlements are induced and the extent of the settlements is around 3D from the tunnel axis.

7. Conclusions

The results of centrifuge model tests and finite element back-analyses investigating the passive failure of tunnel face in sand are reported. The soil failure mechanisms and passive failure pressures of tunnel face are described and discussed. In addition, the induced ground surface displacements due to the increase in tunnel face displacement are also reported.

For both centrifuge and numerical investigations, it is found that for tunnel located at C/D ratio equals to 2.2, the soil in front of the tunnel face is displaced by the advancing tunnel face. The soil further away from the tunnel face is forced upwards to the ground surface and hence the soil surface heaves. A funnel-type failure mechanism is observed and the extent of the funnel-type failure mechanism is narrower than a five-block failure mechanism commonly assumed in the existing upper bound solution. However, the calculated passive failure pressure by the upper bound solution is fairly consistent with the measured face pressure. Besides, the computed pressure-displacement curve is in good agreement with the measured response. It is found that the extent of longitudinal surface heaves and the location of maximum heave remain around 4D and 1.7D respectively in front of the initial position of tunnel face at different S_x/D ratio. The extent of transverse surface heaves remains at 3D from longitudinal tunnel axis for different S_x/D ratio at a section, which is 3.4D in front of the initial position of tunnel face. Both observed longitudinal and transverse heaves are well described by Gaussian distributions.

For a tunnel located at C/D ratio equals to 4.3, the displacements of soil are confined around the vicinity of an advancing tunnel face and a localised failure mechanism associated with ground settlements is observed and computed. There is a large discrepancy between the localised failure mechanism and the five-block failure mechanism. The calculated failure face pressure is higher than the corresponding measured value by 50%. However, reasonable consistency can be found between measured and computed passive face pressures.

Acknowledgements

The authors would like to acknowledge the Research Grant 617608 from the Research Grants Council of HKSAR, the National Science Foundation of China for awarding the second author the Overseas and Hong Kong, Macau Young Scholars Collaborative Research Fund (No. 50629802) and financial support from the National Basic Research Program of China (Research Grant: 2007CB714001).

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