觀塘區議會文件第 51/2010 號
(第十九次會議: 2.11.2010)

啓德發展計劃
啓德明渠進口道及觀塘避風塘的改善工程(第一期)

目的

1. 本文件目的，是就屬於啓德發展計劃的啓德明渠進口道及觀塘避風塘的第一期改善工程向區議會滙報最新進展，以便於明年向立法會申請撥款，進行相關工程。

背景資料

2. 啓德發展計劃是十大基建項目之一。政府正按照啓德分區計劃大綱圖制定啓德發展計劃，分階段落實。第一階段工程項目包括公共房屋、郵輪碼頭第一個泊位和相關的配套基礎設施，現在正施工中，並預計於2013年完成。啓德整項啓德發展預期在2021年大致完成。啓德發展計劃其中要處理的問題包括啓德明渠進口道及觀塘避風塘的水質和氣味的問題。

3. 由於過去幾十年來，大量有機污染物經排水系統流到啓德明渠進口道，導致明渠進口道及觀塘避風塘海床的污染沉積物大量積聚，令環境變得惡劣。因此，我們根據核准環境影響評估報告提出一系列緩解措施，以紓緩氣味問題，啓德明渠進口道及觀塘避風塘的第一期改善工程乃屬其中一項措施。

4. 本署曾於本年五月就本工程按前濱及海床（填海工程）條例（第127章）刊憲前向區議會進行諮詢，並得到各位議員普遍的支持。隨後，本署於本年七月二日至九月二日期間把相關工程刊登憲報。由於在刊憲期內，並沒有收到任何公眾意見，因此，本工程已根據該條例於本年十月十五日獲得批准。

工程簡介

5. 爲配合啓德發展，本署擬於啓德明渠進口道及觀塘避風塘進行原地生物除污法，處理在海床沉積物內釋出臭味的物質，並於淺水區域進行局部挖泥工程。本署也會進行相關水道石堤及排水口的改善工程，並拆卸連接前跑道已棄置的碼頭繫纜樁。本工程的範圍載於**附件一**。

6. 原地生物除污法是指在處理範圍內注入氧化劑，爲沉積物內含的細菌供氧，促使有臭味的硫化物化爲無臭的物質。這技術的優點在於挖泥數量可減至最少，並減低工程對環境的影響。這技術已經驗證能有效解決城門河水道和三家村避風塘的氣味問題。於2006年及2008年在啓德明渠進口道進行的實地測試，結果證實有關技術成效，並獲獨立專家於2007年認可，認可書載於**附件二**。本署更進一步邀請三位本地及國內大學獨立學者爲這技術提供意見，並於本年九至十月期間獲得他們的肯定，技術覆檢摘要及相關認可書載於**附件三**。

7. 挖出的海泥將被密封由躉船運離工地及卸置於指定的棄置區。整個運送和棄置過程將會受到嚴密監察。

8. 本署會分階段進行上述改善工程，盡量以不影響現時避風塘和公眾貨物裝卸區的運作爲目標。

環境評估

9. 本署會擬訂適當的施工安排處理沉積物。在施工期間，會使用密封式抓斗和安裝隔泥幕以減低對水質的影響。實施這些緩解措施後，預期上述改善工程可能帶來的環境影響是可以接受。除此以外，工程進行期間，本署會要求承建商做好工地管理和進行環境審查以及監控等工作。

徵收土地

10. 擬建的工程並不需要徵收土地。

諮詢意見

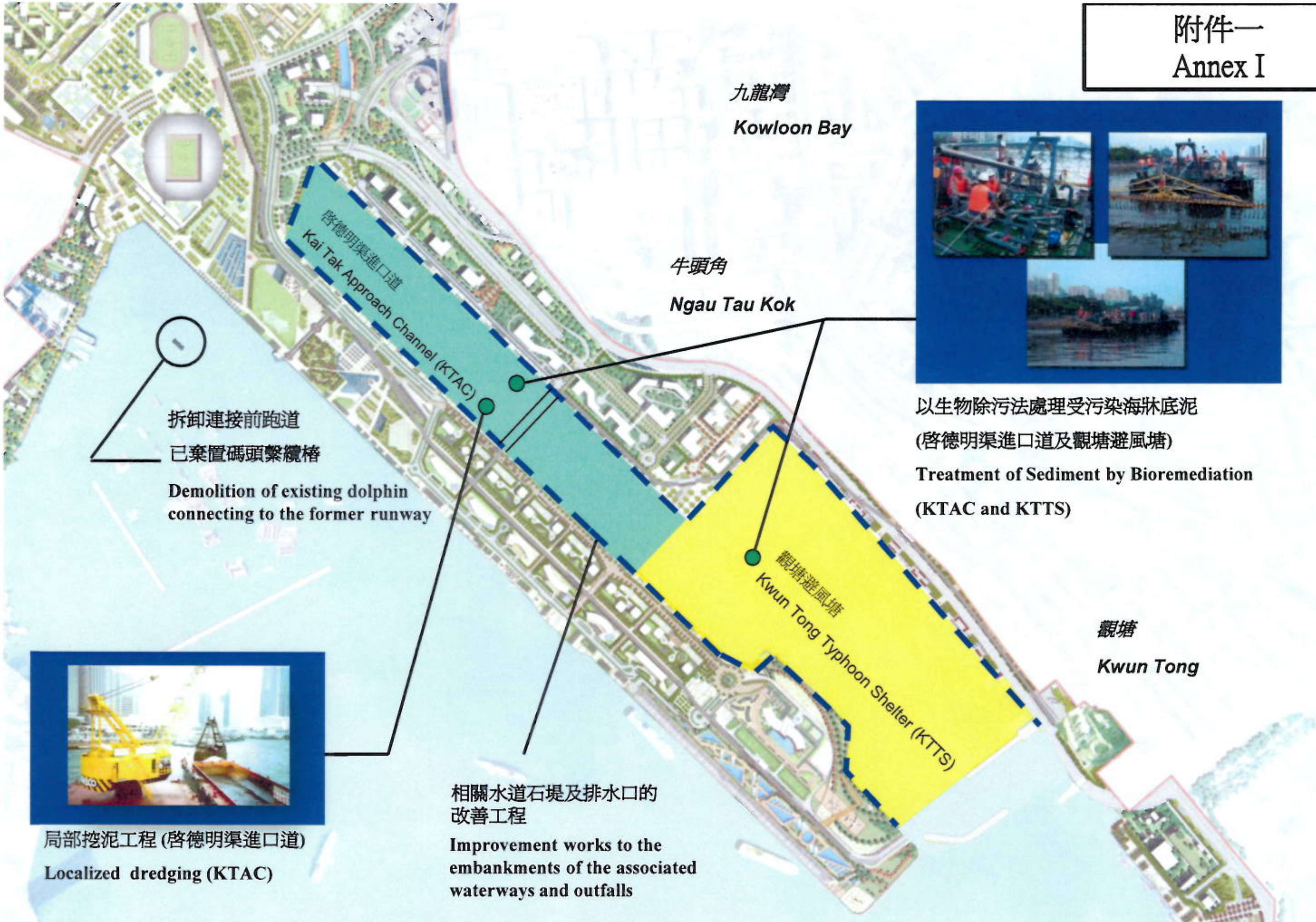
11. 本署歡迎各位議員就本工程提供寶貴意見，目標於明年向立法會提出撥款申請，爭取於明年下半年展開工程，並於2013年大致完成有關工程。

土木工程拓展署九龍拓展處
2010年10月

附件

附件一： 啓德發展計劃 - 啓德明渠進口道及觀塘避風塘的改善工程(第一期)
附件二： 獨立專家於2007年對原地生物除污法的認可書
附件三： 技術覆檢摘要及三位獨立專家於本年九至十月期間對原地生物除污法的認可書

附件一
Annex I



465CL – 啓德發展計劃 – 啓德明渠進口道及觀塘避風塘的改善工程 (第一期)

Kai Tak Development – Kai Tak approach channel and Kwun Tong typhoon shelter improvement works (Phase 1)

附件二
Annex II

THE UNIVERSITY OF HONG KONG

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Review on Pilot Trial Results of Bioremediation at Kai Tak Approach Channel

I agree in general the conclusions and recommendations in the post 12-month report on the pilot trial of bioremediation at Kai Tak Approach Channel in 2006, especially the recommendations that "Full-scale bioremediation in Kai Tak Approach Channel is recommended, in conjunction with the Kai Tak Development, to suppress the objectionable odour by replenishing the exhausting nitrate within sediment".

Professor Herbert H. P. Fang
Chair of Environment Engineering

August 15, 2007

附件三
Annex III

啟德發展計劃
啟德明渠進口道及觀塘避風塘的改善工程

處理海床沉積物技術覆檢摘要

目的

本文件是處理啟德明渠進口道及觀塘避風塘海床上沉積物的技術覆檢摘要。

背景

啟德明渠進口道是維多利亞港內一部分。過往幾十年，大量有機污染物被排放到啟德明渠進口道，加上進口道是一條封閉式長形水道，水流緩慢，導致這些污染物積聚在海床，令環境變得惡劣， 其氣味問題更一直受到社區關注。根據終審法院在2004 年年初對《保護海港條例》（第531 章）的詮釋所作出的裁決，啟德明渠進口道的任何填海工程必須符合凌駕性公眾需要， 並且必須具有力和令人信服的證據證明沒有其他合理的替代方案。

基於「不填海」原則和多階段的公眾參與而制定的啟德分區計劃大綱圖(編號S/K/22) 在2007 年11 月已根據《城市規劃條例》(第131 章)獲行政長官會同行政會議批准。相關啟德發展計劃的環境影響評估報告， 亦於2009 年3 月根據《環境影響評估條例》（第 499 章） 獲得法定核准， 確定了「不填海」的大綱圖， 包括用以解決啟德明渠進口道氣味問題的緩解方法， 在環境上是可以接受的。這表示無須採用填海方法解決啟德明渠進口道的氣味問。

解決啟德明渠進口道氣味問題的緩解方法

經過全面的研究，包括現場測量、實地試驗和實驗室分析，以及參考本地大學獨立專家的意見，啟德發展計劃的環境影響評估報告建議了多項緩解方法，主要包括堵截由周邊地區的污水排放、採用生物除污法原地處理海床上沉積物所引發的氣味，以及在前跑道打開缺口以增加進口道的水流沖刷能力。

<u>周邊地區的污水排放堵截</u>

啟德明渠進口道環境問題的癥結， 是進口道不斷受渠口排放的污水污染。要徹底消除氣味， 必須把流入進口道的污水減少。根據中九龍和東九龍污水收集整

體計劃的建議，由 2009 年起已分階段進行工程改善啟德發展計劃周邊地區的現有排水和排污系統， 以及加建污水設施以堵截和引導污水流入排污系統。海外經驗顯示，類似的堵截安排是改善河道污染首要和最有效的解決方法。

<u>海床上沉積物的處理</u>

根據 2004 年年底至 2006 年年底的啟德發展計劃的規劃檢討研究中，我們已監察啟德明渠進口道的水質和沉積物成分，以確定進口道目前的環境狀況。監察結果，在明渠進口道底部，溶解氧水平普遍約每公升1毫克，而顯示沉積物異味物質的指標—酸揮發性硫化物含量，達到最多每公斤 7 000 毫克。這表示啟德明渠進口道是一個厭氧的沿岸內灣，有機污染物含量高，極易產生有臭味的硫化氫，因而引起臭味問題。

由於啟德明渠進口道和觀塘避風塘的總面積約 90 公頃，海床上存有大量沉積物（約100 萬立方米），而現時本港棄置污泥設施的容量有限， 加上挖泥時有可能在海水中釋出污染物， 故此以挖泥方式完全清除所有受污染的沉積物並不可行。另一方面，研究亦包括多項不同的原地處理沉積物方案:

1. 生物除污處理法
2. 水泥加固及凝固法
3. 覆蓋法

有關方案的比較載於附件甲。

經詳細考慮和分析各處理方案的優劣後，生物除污法被揀選為處理現時海床上沉積物最合適和有效的方案。生物除污法是將氧化劑 （硝酸鈣溶液）注入淤泥表層，為沉積物中的細菌提供合適條件（包括氧份），將有機物分解，從而釋出無臭無害氣體，臭味便不會產生。而原先的硫化物亦會被氧化為無臭味的硫酸鹽。

為認証使用生物除污法處理啟德明渠進口道和觀塘避風塘海床上沉積物的適用性，研究並於2006 年及2008 年在進口道內進行實地測試，試驗面積共約4.5 公頃。試驗結果顯示，主要臭味指標如沉積物中的酸揮發性硫化物（AVS），經處理後剩餘不高於 5%。測試結果證實有關技術可行，並獲獨立專家香港大學環境工程學方漢平講座教授認可。實地測試數據摘要載於附件乙。為進一步確認生物除污法的效用，於本年初更邀請本地及國內共三位大學獨立學者為這技術進行覆檢，並獲得到他們的肯定。相關獨立學者的意見載於附件丙。

這技術亦曾經在城門河水道和三家村避風塘使用，並有效地解決該處的臭味問

題。有關啓德明渠進口道和城門河水道內沉積物的特點和比較載於附件4。

除採用生物除污法外，研究亦同時建議在啟德明渠進口道內淺水區域進行局部挖泥工程，以增加水深至3.5 米以上，加強緩解氣味措施的成效。

緩解措施的實施

為配合啟德發展，研究建議逐步實施啟德發展計劃環境影響評估報告內所提出的緩解措施，並在實施緩解措施前後，定期監察水質和沉積物成分，以確定措施的成效。現階段首要的工作是繼續落實在啓德腹地進行的污水截流工程堵截周邊地區的污染物排放和盡快展開啟德明渠進口道和觀塘避風塘海床上沉積物的處理工程，目標是在2013年或以前改善該水域的環境。

附件甲
Annex A

啟德明渠進口道沉積物原地處理方案比較

處理方案	完成時間	技術方面的考慮	環境影響	以往應用範圍
生物除污處理法	2 至 3 年	- 經處理後，酸揮發性硫化物的含量減少 95%以上 - 在持續缺氧環境下或污染物再出現的情況下，可重新注射硝酸溶液	- 可接受	- 經證實有效解決城門河水道和三家村避風塘的臭味問題 - 在啓德明渠進口道已進行實地測試，證實技術可行
水泥加固及凝固法	2 至 3 年	- 慣常用於處理受重金屬污染的沉積物	- 在處理沉積物的過程中，有可能在海水中釋出污染物 - 需要大量臨時保護措施，以控制對環境的影響 - 預計會對附近海洋生態系統有短期影響	- 未有在香港實地使用的經驗
覆蓋法	3 至 5 年	- 未能確保會否有效阻隔沉積物所產生氣味	- 覆蓋後令水的深度減少，進一步限制水的流量	- 較適合用於有足夠水深的開放水域，例如在東沙洲的污染淤泥坑

附件乙
Annex B

城門河和啟德明渠進口道的沉積物泥比較

參數	城門河	啟德明渠進口道
		
長度	5500 米(主流部分)	1400 米
寬度	220 米	200 米
水深	2 - 4 米	0.5 - 6 米
鹽度	~ 23 to 28 ppt	~23 to 31 ppt
沉積物主要來源	主要由過去工業，農業和生活污水排放形成	主要由過去工業和生活污水排放形成
酸揮發性硫化物沉積物（AVS）[1] （未經處理的沉積物）	~20 - 4,400 mg/kg	~ 500 - 7,000 mg/kg
AVS 處理後降低率	>75%-85%	>95% (基於現場測試結果)

[1] 主要臭味指標

附件丙
Annex C

Agreement No. CE 30/2008(CE)
Kai Tak Infrastructure – Design and Construction

<u>Review of Sediment Treatment Methods at Kai Tak Approach Channel (KTAC) and Kwun Tong Typhoon Shelter (KTTS)</u>

This is a summary of the Working Paper on Sediment Treatment Methods (April 2010) at Kai Tak Approach Channel (KTAC) and Kwun Tong Typhoon Shelter (KTTS).

A number of different sediment treatment options have been reviewed including the following:

a) *Ex-situ* treatment / disposal;
b) *In-situ* chemical oxidation (with strong oxidants);
c) *In-situ* capping;
d) *In-situ* solidification and stabilisation; and
e) *In-situ* bioremediation.

Ex-situ methods (i.e. dredge and treat / dispose the sediments) would require extensive dredging which is not preferred. Substantial amount of contaminants could be re-suspended during extensive dredging, posing significant adverse impacts to the surrounding environment.

On the other hand, *in-situ* methods (i.e. treating the sediment in place) are considered to be more acceptable as to avoid extensive dredging. However, the applicability of the treatment techniques are usually site specific and would depend on the effectiveness to suppress odour generated from the contaminated sediments, sustainability (or longevity) of odour suppression, adverse impacts pose to the surrounding environment and cost of treatment.

Some common types of *in-situ* methods (i.e. chemical oxidation, capping, solidification and stabilisation and bioremediation) have been reviewed with their limitations. For example, the chemical oxidation method using some strong oxidants (e.g. hydrogen peroxide) may generate toxic end products such as Chromium (VI) that could result in adverse ecological impacts to the surrounding water bodies. The *in-situ* capping method could result in high level of residual odour as the integrity of the underlying membrane would hinder the de-silting or treatment of the recurrent sediment deposition. Re-capping of the seabed, on the other hand, is considered not feasible as it would significantly reduce the already shallow water depth at KTAC for navigation. The *in-situ* solidification and stabilisation method would harden the seabed to concrete like material and pose permanent impacts to the local marine ecology.

On the other hand, *in-situ* bioremediation using calcium nitrate to enhance the population size and ability of microorganisms, particularly those involved in nitrogen and sulphur cycling, had been successfully applied at Shing Mun River (SMR) and Sam Ka Tsuen Typhoon Shelter, as well as the recent pilot scale field test in 2006 at the northern portion of KTAC and the advanced bioremediation near Jordan Valley Culvert Outfall in 2008. The bioremediation works carried out previously in Hong Kong are presented in **Annex I**. The bioremediation process relies on the injection of liquid calcium nitrate solution into the sediments in a controlled manner. The nitrate serves as an electron acceptor for denitrifying bacteria to utilise organic matters and organic contaminants as carbon source. The denitrifying bacteria would be stimulated which convert inorganic nitrogen (including ammonium and nitrate) to nitrogen gas. The final products of the process will mainly be odourless and harmless gases including nitrogen and carbon dioxide. The nitrate-reducing condition would also increase the reduction-oxidation (redox) potential in sediment, transforming the environment from anaerobic to anoxic, thereby suppressing the activity of sulphate reducing bacteria and odorous hydrogen sulphide generation. This approach will not create any negative effect on marine ecology as calcium nitrate is a relatively weak oxidising agent (unlike potassium permanganate) but sufficient to oxidise the organics in the sediment.

Based on the post-treatment monitoring in the pilot scale field test and advanced bioremediation, significant reduction in acid volatile sulphides (AVS) (an indicator of the odour generation) was noted from the pre-treatment conditions in the sediments. In both the pilot scale field test and advanced bioremediation, an average AVS removal of over 95% had been recorded. Considerable increase in the redox potential was also observed, indicating the sediments were under oxidising / anoxic conditions rather than the anaerobic conditions.

Previous bioremediation treatment works were intended not only to remove most of the sulphides (and subsequently odour) but to produce a reactive cap by leaving some residual nitrate in the sediment to treat any sulphide that migrate upwards from the bottom layer to the sediment surface and to further breakdown the organics in the long run. The necessity to carry out re-injection at KTAC and KTTS would depend on the results of the post-treatment monitoring. In theory there is a chance that some localised re-injection might be required from time to time due to the continuous influx of pollutants from upstream runoffs. However, the scope of the localised re-injection is expected to be very small and is likely to be restricted to areas where considerably amount of pollutants could be deposited over time (e.g. mouth of Kai Tak Nullah and Jordan Valley Culvert Outfall).

Based on the pilot scale field test and advanced bioremediation, no significant environmental impacts had been observed though it is possible that some of the undissolved metals may become oxidised and dissolved during the bioremediation process. Appropriate measures have been recommended for the proposed remediation works at KTAC and KTTS to minimise the possible impacts.

An environmental monitoring and audit (EM&A) programme according to the EM&A Manual under the Kai Tak Development Project will be implemented from commencement of bioremediation works to one year after completion of the bioremediation works. A range of water quality parameters including dissolved oxygen, turbidity, suspended solids, nitrate-nitrogen and heavy metals (i.e. chromium, cadmium, copper, zinc, silver, mercury, nickel and lead) will be monitored. In addition, ammonia-nitrogen would also be occasionally monitored prior to, during and immediately after injection when injection period coincide with neap tide (when flushing effect is relatively small). Sediment quality monitoring, including measurements of AVS, redox potential, pH, residual nitrate and Microtox®, will also be carried out during the course of bioremediation to indicate the performance and longevity of treatment.

To conclude, *in-situ* bioremediation using calcium nitrate to stimulate microbial activities is considered to be the most appropriate sediment treatment option, in terms of cost-effectiveness and long term environmental friendliness, for mitigating the odour nuisance from KTAC and KTTS.

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I have reviewed independently the Working Paper on Review of Sediment Treatment Methods (April 2010). I agree that the proposed full-scale bioremediation in Kai Tak Approach Channel and Kwun Tong Typhoon Shelter is technically feasible and effective to suppress objectionable odour generated from the sediments, providing that a careful design with a proper implementation of the EM&A programme is carried out.

Professor Irene M. C. Lo
The Hong Kong University of Science and Technology

30 September 2010

Agreement No. CE 30/2008(CE)
Kai Tak Infrastructure – Design and Construction

Review of Sediment Treatment Methods at Kai Tak Approach Channel (KTAC) and Kwun Tong Typhoon Shelter (KTTS)

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Ex-situ methods (i.e. dredge and treat / dispose the sediments) would require extensive dredging which is not preferred. Substantial amount of contaminants could be re-suspended during extensive dredging, posing significant adverse impacts to the surrounding environment.

On the other hand, *In-situ* methods (i.e. treating the sediment in place) are considered to be more acceptable as to avoid extensive dredging. However, the applicability of the treatment techniques are usually site specific and would depend on the effectiveness to suppress odour generated from the contaminated sediments, sustainability (or longevity) of odour suppression, adverse impacts pose to the surrounding environment and cost of treatment.

Some common types of *In-situ* methods (i.e. chemical oxidation, capping, solidification and stabilisation and bioremediation) have been reviewed with their limitations. For example, the chemical oxidation method using some strong oxidants (e.g. hydrogen peroxide) may generate toxic end products such as Chromium (VI) that could result in adverse ecological impacts to the surrounding water bodies. The *in-situ* capping method could result in high level of residual odour as the integrity of the underlying membrane would hinder the de-silting or treatment of the recurrent sediment deposition. Re-capping of the seabed, on the other hand, is considered not feasible as it would significantly reduce the already shallow water depth at KTAC for navigation. The *in-situ* solidification and stabilisation method would harden the seabed to concrete like material and pose permanent impacts to the local marine ecology.

On the other hand, *in-situ* bioremediation using calcium nitrate to enhance the population size and ability of microorganisms, particularly those involved in nitrogen and sulphur cycling, had been successfully applied at Shing Mun River (SMR) and Sam Ka Tsuen Typhoon Shelter, as well as the recent pilot scale field test in 2006 at the northern portion of KTAC and the advanced bioremediation near Jordan Valley Culvert Outfall in 2008. The bioremediation works carried out previously in Hong Kong are presented in **Annex I**. The bioremediation process relies on the injection of liquid calcium nitrate solution into the sediments in a controlled manner. The nitrate serves as an electron acceptor for denitrifying bacteria to utilise organic matters and organic contaminants as carbon source. The denitrifying bacteria would be stimulated which convert inorganic nitrogen (including ammonium and nitrate) to nitrogen gas. The final products of the process will mainly be odourless and harmless gases including nitrogen and carbon dioxide. The nitrate-reducing condition would also increase the reduction-oxidation (redox) potential in sediment, transforming the environment from anaerobic to anoxic, thereby suppressing the activity of sulphate reducing bacteria and odorous hydrogen sulphide generation. This approach will not create any negative effect on marine ecology as calcium nitrate is a relatively weak oxidising agent (unlike potassium permanganate) but sufficient to oxidise the organics in the sediment.

Based on the post-treatment monitoring in the pilot scale field test and advanced bioremediation, significant reduction in acid volatile sulphides (AVS) (an indicator of the odour generation) was noted from the pre-treatment conditions in the sediments. In both the pilot scale field test and advanced bioremediation, an average AVS removal of over 95% had been recorded. Considerable increase in the redox potential was also observed, indicating the sediments were under oxidising / anoxic conditions rather than the anaerobic conditions.

Previous bioremediation treatment works were intended not only to remove most of the sulphides (and subsequently odour) but to produce a reactive cap by leaving some residual nitrate in the sediment to treat any sulphide that migrate upwards from the bottom layer to the sediment surface and to further breakdown the organics in the long run. The necessity to carry out re-injection at KTAC and KTTS would depend on the results of the post-treatment monitoring. In theory there is a chance that some localised re-injection might be required from time to time due to the continuous influx of pollutants from upstream runoffs. However, the scope of the localised re-injection is expected to be very small and is likely to be restricted to areas where considerably amount of pollutants could be deposited over time (e.g. mouth of Kai Tak Nullah and Jordan Valley Culvert Outfall).

Based on the pilot scale field test and advanced bioremediation, no significant environmental impacts had been observed though it is possible that some of the undissolved metals may become oxidised and dissolved during the bioremediation process. Appropriate measures have been recommended for the proposed remediation works at KTAC and KTTS to minimise the possible impacts.

An environmental monitoring and audit (EM&A) programme according to the EM&A Manual under the Kai Tak Development Project will be implemented from commencement of bioremediation works to one year after completion of the bioremediation works. A range of water quality parameters including dissolved oxygen, turbidity, suspended solids, nitrate-nitrogen and heavy metals (i.e. chromium, cadmium, copper, zinc, silver, mercury, nickel and lead) will be monitored. In addition, ammonia-nitrogen would also be occasionally monitored prior to, during and immediately after injection when injection period coincide with neap tide (when flushing effect is relatively small). Sediment quality monitoring, including measurements of AVS, redox potential, pH, residual nitrate and Microtox®, will also be carried out during the course of bioremediation to indicate the performance and longevity of treatment.

To conclude, *in-situ* bioremediation using calcium nitrate to stimulate microbial activities is considered to be the most appropriate sediment treatment option, in terms of cost-effectiveness and long term environmental friendliness, for mitigating the odour nuisance from KTAC and KTTS.

I have reviewed independently the Working Paper on Review of Sediment Treatment Methods (April 2010) and noted that the final working paper has incorporated my previous comments. I agree the conclusions and recommendations on the sediments treatment method, especially the recommendations of the full-scale bioremediation in Kai Tak Approach Channel and Kwun Tong Typhoon Shelter to effectively suppress objectionable odour generated from the sediments.

Professor Nora F. Y. Tam
City University of Hong Kong

30 September 2010

附件丙
Annex C

Agreement No. CE 30/2008(CE)
Kai Tak Infrastructure – Design and Construction

Review of Sediment Treatment Methods at Kai Tak Approach Channel (KTAC) and Kwun Tong Typhoon Shelter (KTTS)

This is a summary of the Working Paper on Sediment Treatment Methods (April 2010) at Kai Tak Approach Channel (KTAC) and Kwun Tong Typhoon Shelter (KTTS).

A number of different sediment treatment options have been reviewed including the following:

a) *Ex-situ* treatment / disposal;
b) *In-situ* chemical oxidation (with strong oxidants);
c) *In-situ* capping;
d) *In-situ* solidification and stabilisation; and
e) *In-situ* bioremediation.

Ex-situ methods (i.e. dredge and treat / dispose the sediments) would require extensive dredging which is not preferred. Substantial amount of contaminants could be re-suspended during extensive dredging, posing significant adverse impacts to the surrounding environment.

On the other hand, *in-situ* methods (i.e. treating the sediment in place) are considered to be more acceptable as to avoid extensive dredging. However, the applicability of the treatment techniques are usually site specific and would depend on the effectiveness to suppress odour generated from the contaminated sediments, sustainability (or longevity) of odour suppression, adverse impacts pose to the surrounding environment and cost of treatment.

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Professor Zhang Xihui
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6 October 2010