土木工程拓展署
Civil Engineering and Development Department

Agreement No. CE 63/2016 (EP)

Environmental Monitoring and Audit for Disposal Facility to the East of Sha Chau (2017-2020) – Investigation

Quarterly EM&A Report for Contaminated Mud Pits to the East of Sha Chau – October to December 2020

Revision 0

April 2021

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Client:	Project No:
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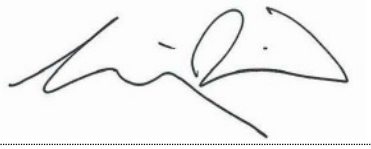
Summary: This document presents the Quarterly EM&A Report for *Environmental Monitoring and Audit for Disposal Facility to the East of Sha Chau*.	Date: 20 April 2021 Approved by:  Craig A. Reid *Partner*

Revision	Description	By	Checked	Approved	Date
v0	Quarterly EM&A Report for ESC CMPs	GS	RC	CAR	20/4/21

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Dredging, Management and Capping of Contaminated Sediment Disposal Facility at Sha Chau

Environmental Certification Sheet
EP-312/2008/A

Reference Document/Plan

Document/~~Plan~~ to be ~~Certified~~/ Verified:	Quarterly EM&A Report for Contaminated Mud Pits to the East of Sha Chau – October to December 2020
Date of Report:	20 April 2021
Date prepared by ET:	20 April 2021
Date received by IA:	20 April 2021

Reference EP Condition

Environmental Permit Condition:

Condition 3.1 of EP-312/2008/A
The EM&A programme shall be implemented in accordance with the procedures and requirements in the EM&A Manual. Any changes to the monitoring and audit requirements shall be justified by the ET leader and verified by the Independent Auditor as conforming to the requirements set out in the EM&A Manual, and shall seek the prior approval from the Director before implementation.

ET Certification

I hereby certify that the above referenced document/~~plan~~ complies with the above referenced condition of EP-312/2008/A.

Craig A. Reid,
Environmental Team Leader:  Date: 20/4/2021

IA Verification

I hereby verify that the above referenced document/~~plan~~ complies with the above referenced condition of EP-312/2008/A.

Dr Wang Wen Xiong,
Independent Auditor:  Date: 20/4/2021

CONTENTS

Agreement No. CE 63/2016 (EP)
Environmental Monitoring and Audit
for Disposal Facility to the East of Sha Chau (2017-2020) - Investigation

Quarterly Environmental Monitoring and Audit (EM&A) Report for October to December 2020

EXECUTIVE SUMMARY

Water Column Profiling, Routine Water Quality Monitoring, Pit Specific Sediment Chemistry, Cumulative Impact Sediment Chemistry and *Sediment Chemistry after a Major Storm* were carried out for the Contaminated Mud Pits (CMPs) to the East of Sha Chau (ESC) during the quarterly period of October to December 2020. This report presents the results of these monitoring activities to identify whether the disposal and capping operations at ESC CMP V are causing any unacceptable impact(s) to the surrounding aquatic environment or to those marine organisms that utilize these habitats.

Water Quality Monitoring for ESC CMPs

Water Column Profiling of ESC CMP Vb – October to December 2020

Results indicated that levels of Salinity, pH and Dissolved Oxygen (DO) complied with the Water Quality Objectives (WQOs) at both Upstream and Downstream stations. Levels of DO, Turbidity and Suspended Solids (SS) complied with the Action and Limit Levels at all stations. Overall, the results indicated that the mud disposal operation at ESC CMP Vb did not appear to cause any unacceptable impact in water quality during this quarterly period.

Routine Water Quality Monitoring of ESC CMPs – October to December 2020

Results of Routine Water Quality Monitoring conducted in October and December 2020 showed that the levels of DO, Turbidity and SS complied with the Action and Limit Levels at all stations. From the monitoring results and statistical analysis, there were no trends indicating any increase in the concentrations of contaminants with proximity to the pit or with time. Thus, it appears that mud disposal and capping operations at ESC CMPs have not caused any unacceptable impact in water quality during the reporting period.

Sediment Quality Monitoring for ESC CMPs

Pit Specific Sediment Chemistry of ESC CMP Vb – October to December 2020

Monitoring results showed that the concentrations of inorganic contaminants were generally below the Lower Chemical Exceedance Levels (LCELs) at most monitoring stations. Statistical analysis indicated that there did not appear any trend of increasing sediment contaminants' concentrations with proximity to the pit or with time. Thus, it appears that mud disposal operation at ESC CMP Vb have not caused any unacceptable impact in sediment quality during the reporting period.

Cumulative Impact Sediment Chemistry of ESC CMPs – December 2020

Monitoring results showed that the concentrations of inorganic contaminants were generally below the LCELs at all monitoring stations. Statistical analysis indicated that there did not appear to be any significant trend of increasing concentrations of contaminants with proximity to the pit or with time. Thus, it appears that mud disposal operation at ESC CMP Vb have not caused any unacceptable impact in sediment quality during the reporting period.

Sediment Chemistry after a Major Storm of ESC CMPs – October 2020

Sampling for *Sediment Chemistry after a Major Storm Event* was conducted for ESC CMPs on 16 October 2020 after the visit of tropical cyclone Nangka, which led to the issue of No. 8 Gale or Storm Signal on 13 October 2020.

Monitoring results showed that the concentrations of most inorganic contaminants were below the LCELs at most monitoring stations. Statistical analysis indicated that there did not appear to be any significant trend of increasing concentrations of contaminants with proximity to the pit. Overall, there appeared to be no evidence showing the failure of CMPs in retaining disposed mud or causing contamination of sediments after the major storm event in October 2020.

合約編號 第CE 63/2016（EP）號

沙洲以東海泥卸置設施的環境監察及審核（2017–2020）–勘查研究

環境監察及審核季度報告（二零二零年十月至十二月）

行政摘要

在2020年10月至12月的季度報告期內，環境小組在沙洲以東海泥卸置設施進行了水層質量監察、例行水質監察、指定污泥坑沉積物化學監察、沉積物化學累積性影響監察及強颱風後的沉積物質素監察。本報告詳述以上的環境監察結果，從而分析在沙洲以東海泥卸置設施CMP V的卸置及覆蓋作業有否對鄰近水體環境及利用這水體為棲身地的海洋生物造成不可接受的環境影響。

沙洲以東海泥卸置設施 (ESC CMPs)之水質監察

水層質量監察–2020年10月至12月

監察結果顯示上游及下游監測站的鹽度、酸鹼值及溶解氧含量均符合海水水質指標。上游及下游監測站的溶解氧含量、混濁度及懸浮固體含量也符合行動及極限水平。總體而言，水層質量監察結果表明報告期內沙洲以東海泥卸置設施CMP Vb 的污泥卸置活動沒有引致任何不可接受的水質影響。

例行水質監察–2020年10月至12月

2020年10月至12月的例行水質監察結果顯示所有監測站的溶解氧含量、混濁度及懸浮固體含量也符合行動及極限水平。從監察數據和統計結果顯示，海水的污染物濃度沒有因越接近泥坑而趨向增加，亦沒有隨著時間而增加。總體而言，沒有證據顯示在報告期內沙洲以東海泥卸置及覆蓋運作對周邊水體環境產生任何不可接受的水質影響。

沙洲以東海泥卸置設施 (ESC CMPs)之沉積物監察

指定污泥坑沉積物化學監察–2020年10月至12月

監察結果顯示，大部分監測站的無機污染物含量均大致低於化學物質低量值。從統計結果顯示，沉積物的污染物濃度沒有因越接近泥坑而趨向增加，亦沒有隨著時間而增加。總體而言，沒有證據顯示在報告期內沙洲以東海泥卸置運作對沉積物質素造成任何不可接受的影響。

沉積物化學累積性影響監察–2020年12月

監察結果顯示，所有監測站的無機污染物含量均大致低於化學物質低量值。從統計結果顯示，沉積物的污染物濃度沒有因越接近泥坑而趨向增加，亦沒有隨著時間而增加。總體而言，沒有證據顯示在報告期內沙洲以東海泥卸置運作對沉積物質素造成任何不可接受的影響。

強颱風後的沉積物質素監察– 2020年10月

熱帶風暴浪卡在2020年10月13日吹襲香港，並在同日發出八號烈風或暴風信號。在強颱風過後，環境小組在2020年10月16日在沙洲以東海泥卸置設施附近範圍採集沉積物樣本作分析。監察結果顯示監測站錄得的無機污染物含量均大致低於化學物質低量值。從統計結果顯示，沉積物的污染物濃度沒有因越接近泥坑而趨向增加。總體而言，沒有證據顯示2020年10月的強颱風導致污泥從泥坑擴散或引起沉積物污染。

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

1.1.1 The Civil Engineering and Development Department (CEDD) is managing a number of marine disposal facilities in Hong Kong waters, including the Contaminated Mud Pits (CMPs) to the South of The Brothers (SB) and to the East of Sha Chau (ESC) for the disposal of contaminated sediment, and open-sea disposal grounds located to the South of Cheung Chau (SCC), East of Tung Lung Chau (ETLC) and East of Ninepins (ENP) for the disposal of uncontaminated sediment. Two Environmental Permits (EPs), EP-312/2008/A and EP-427/2011/A, were issued by the Environmental Protection Department (EPD) to the CEDD, the Permit Holder, on 28 November 2008 and 23 December 2011 for the Dredging, Management and Capping of Contaminated Sediment Disposal Facilities at ESC CMP V and SB CMPs, respectively.

1.1.2 Under the requirements of the two EPs for ESC CMP V and SB CMPs, Environmental Monitoring and Audit (EM&A) programmes which encompass water and sediment chemistry, fisheries assessment, tissue and whole body analysis, sediment toxicity and benthic recolonisation studies as set out in the EM&A Manuals are required to be implemented. EM&A programmes have been continuously carried out during the operation of the CMPs at ESC and SB. A review of the collection and analysis of such environmental data from the monitoring programme demonstrated that there had not been any adverse environmental impacts resulting from disposal activities [1][2]. The current programme will assess the impacts resulting from dredging, disposal and capping operations of CMP V as well as capping operations of SB CMPs.

1.1.3 A proposal on the change of number of sample replication of water quality & sediment monitoring and combination of routine water quality monitoring and water quality monitoring during capping operation was submitted to EPD and agreed by EPD on 3 December 2020. The proposed changes have been effective for the EM&A activities since December 2020.

1.1.4 The present EM&A programme under *Agreement No. CE 63/2016 (EP)* ("the Study") covers the dredging, disposal and capping operations of the ESC CMP V as well as the capping operations of the SB CMPs (see *Annex A* for the EM&A programme). The scheduled EM&A programme for SB CMPs was completed in December 2018.

(1) ERM (2013). Environmental Monitoring and Audit for Contaminated Mud Pit V at East of Sha Chau. Final Report. For CEDD.

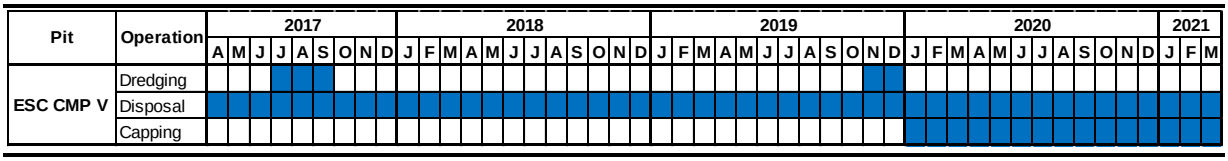
(2) ERM (2017). Environmental Monitoring and Audit for Contaminated Mud Pit V at East of Sha Chau (2012 - 2017). Final Report. For CEDD.

1.2 ACTIVITIES CONDUCTED DURING THE REPORTING PERIOD

1.2.1 Detailed works schedule for ESC CMP V and SB CMPs is shown in *Figure 1.1*. During the reporting period of October to December 2020, the following works were being undertaken at the CMPs:

- Disposal of contaminated mud at ESC CMP Vb; and
- Capping operations at ESC CMP Vd.

Figure 1.1 Works Schedule for ESC CMPs



1.2.2 The record for contaminated mud disposal at ESC CMP Vb during the reporting period are presented in *Annex B1*, and the record for capping operation at ESC CMP Vd during the reporting period is presented in *Annex B2*.

1.3 OBJECTIVES OF THE MONITORING AND AUDIT PROGRAMME

1.3.1 The objectives of the EM&A programme are as follows:

1) To monitor and report on the environmental impacts of the dredging operations associated with the construction of the disposal pits;
2) To monitor and report on the environmental impacts due to capping operations of the exhausted pits;
3) To monitor and report on the environmental impacts of the disposal of contaminated marine sediments in the active pits and specifically to determine:
    a. changes/trends caused by disposal activities in the concentrations of contaminants in sediments adjacent to the pits;
    b. changes/trends caused by disposal activities in the toxicity of sediment adjacent to the pits;
    c. changes/trends caused by disposal activities in the concentrations of contaminants in tissues of demersal marine life adjacent to and remote from the pits;
    d. impacts on water quality and benthic ecology caused by the disposal activities; and
    e. the risks to human health and dolphin of eating seafood taken in the marine area around the active pits.

4) To monitor and report on the environmental impacts of the disposal operation and specifically to determine whether the methods of disposal are effective in reducing the risks of unacceptable environmental impacts.

5) To monitor and report on the benthic recolonisation of the capped pits and specifically to determine the difference in infauna between the capped pits and adjacent sites.

6) To assess the impact of a major storm (Typhoon Signal No. 8 or above) on the containment of any uncapped or partially capped pits.

7) To design and continually review the operation and monitoring programme and:

   a. to make recommendations for changes to the operation that will rectify any unacceptable environmental impacts; and

   b. to make recommendations for changes to the monitoring programme that will improve the ability to cost effectively detect environmental changes caused by the disposal activities.

8) To establish numerical decision criteria for defining impacts for each monitoring component.

9) To provide supervision on the field works and laboratory works to be carried out by contractors/laboratories.

1.3.2 The purpose of this *Quarterly EM&A Report for October to December 2020* is to provide information regarding the findings in the quarterly reporting period of October to December 2020 on the environmental impacts resulting from backfilling operation at ESC CMP Vb and capping operation at ESC CMP Vd. Although the EM&A programme has been conducted since 1997, this report presents the analytical and statistical results of the quarterly reporting period. Results from previous monitoring will be presented and discussed in the Annual Review Report. Readers are referred to the *Monthly EM&A Reports* for this Study for graphical and tabular presentations of the monitoring results.

1.3.3 The objectives of this report are to:

- Confirm that all activities, tests, analyses, assessments etc. have been carried out as stated in the *EM&A Manual*; and,

- Report on any trend resulting from dredging, backfilling and capping operations at the CMPs.

2 ENVIRONMENTAL MONITORING & AUDITING PROGRAMME

2.1 ENVIRONMENTAL MONITORING & AUDITING TASKS

2.1.1 Six key elements were designed for the EM&A Programme for assessing whether key environmental parameters are being affected by dredging, backfilling and capping operations at the CMPs. Key tasks are as follows:

- Sediment Quality Monitoring;
- Sediment Toxicity Testing;
- Trawling & Tissue/ Whole Body Contaminant Testing;
- Water Quality Monitoring;
- Human Health and Ecological Risk Assessment; and
- Benthic Recolonisation.

2.2 EM&A SAMPLING AND ANALYSES

2.2.1 Details regarding the methodologies for the field sampling and laboratory analyses of the monitoring tasks listed in *Section 2.1* are presented in the *EM&A Manual* (1) as well as in *Contract No. CV/2017/04 (Sediment Disposal Facilities to the East of Sha Chau and East of Tung Lung Chau – Sampling (2018-2022))* and *Contract No. CV/2017/05 (Sediment Disposal Facilities to the East of Sha Chau and East of Tung Lung Chau – Testing (2018-2022)).* Lam Geotechnics Limited and Wellab Limited were responsible for sampling under *Contract No. CV/2017/04* and laboratory analyses under *Contract No. CV/2017/05*, respectively, during the quarterly period.

(1) ERM (2017). Updated EM&A Manual for ESC CMP V. Environmental Monitoring and Audit for Disposal Facility to the East of Sha Chau (2017-2020) – Investigation. Agreement No. CE 63/2016 (EP).

3 MONITORING & AUDITING RESULTS

3.1 OVERVIEW OF THE MONITORING & AUDITING ACTIVITIES

3.1.1 Sampling & Laboratory Analysis

3.1.2 Schedules of the EM&A programme are presented in *Annex A*. The samplings, *in-situ* measurements and analyses of samples were conducted in accordance with the *EM&A Manual* during this reporting period. The samplings conducted as well as the monitoring results received from the Contractors for this reporting period are shown in *Table 3.1*.

Table 3.1 Samplings Conducted and Monitoring Results Received from the Contractors for the Reporting Period of October to December 2020

Key Task	Date of Sampling & *in-situ* Measurement	Date of Results Received from the Contractors
ESC CMPs		
Water Column Profiling of ESC CMP Vb	6 October 2020 3 November 2020 3 December 2020	29 October 2020 30 November 2020 11 January 2021
Routine Water Quality Monitoring of ESC CMPs	8 October 2020 5 November 2020 4 December 2020	29 October 2020 30 November 2020 11 January 2021
Pit Specific Sediment Chemistry of ESC CMP Vb	7 October 2020 4 November 2020 7 December 2020	29 October 2020 30 November 2020 11 January 2021
Cumulative Impact Sediment Chemistry of ESC CMPs	8 & 9 December 2020	11 January 2021
Sediment Chemistry After a Major Storm	16 October 2020	29 October 2020

3.1.3 The monitoring results of the above environmental monitoring components for ESC CMPs have been presented in the respective *Monthly EM&A Reports* for this Study. The statistical analyses of these environmental monitoring components, where applicable, are presented in the following sections to report any trends caused by disposal activities at ESC CMPs during the reporting period. It should be noted that statistical analysis was not conducted for *Water Column Profiling for ESC CMP Vb* as the monitoring stations were mobile depending on the location of backfilling operation during the monitoring event.

3.2 SUMMARY OF MONITORING RESULTS AND STATISTICAL ANALYSES FOR ESC CMPS

3.2.1 Water Column Profiling of ESC CMP Vb

3.2.2 *Water Column Profiling* for ESC CMP Vb was conducted once every month from October to December 2020 as presented in *Table 3.1*. A total of two (2) stations were sampled, one located 100 m Upstream and one located 100 m Downstream of the disposal area. The monitoring results indicated that levels of Salinity, pH and Dissolved Oxygen (DO) complied with the Water Quality Objectives (WQOs) at both Upstream and Downstream stations in October, November and December 2020. Levels of DO, Turbidity and Suspended Solids (SS) also complied with the Action and Limit Levels at all stations during the quarterly period.

3.2.3 Overall, the results indicated that the mud disposal operation at ESC CMP Vb did not appear to cause any unacceptable deterioration in water quality during this quarterly period.

3.2.4 Routine Water Quality Monitoring of ESC CMPs

Background

3.2.5 *Routine Water Quality Monitoring* for ESC CMPs was conducted once every month from October to December 2020 as presented in *Table 3.1*. A total of ten (10) stations were sampled in October, November and December 2020 with locations of the monitoring stations presented ***in*** **Figure 3.1.** The disposal volume during the reporting period is detailed in *Annex B1*. The monitoring results showed that levels of DO, Salinity and pH complied with the WQOs at all stations. The levels of DO, Turbidity and SS complied with the Action and Limit Levels at all stations during the monitoring period.

Summary of Statistical Analyses

3.2.6 The aim of the statistical analysis is to reveal any trends of increasing concentration of contaminants with proximity to the pit or with time. Data obtained during this reporting period were statistically compared with data obtained since monitoring began at CMP V in February 2012. For most parameters, only low concentrations were measured from February 2012 to December 2020 and some parameters have majority of their recorded values below the limit of reporting. Statistical analysis was performed on parameters for which at least 60% of data were above the limit of reporting since monitoring of CMP V began in February 2012. Spatio-temporal differences in *in-situ* parameters, dissolved metal, inorganic and organic contaminant contents were then tested by three-factor partially-nested Analysis of Variance (ANOVA). Area, Period and Station were treated as fixed factors under investigation with Station nested within Area.

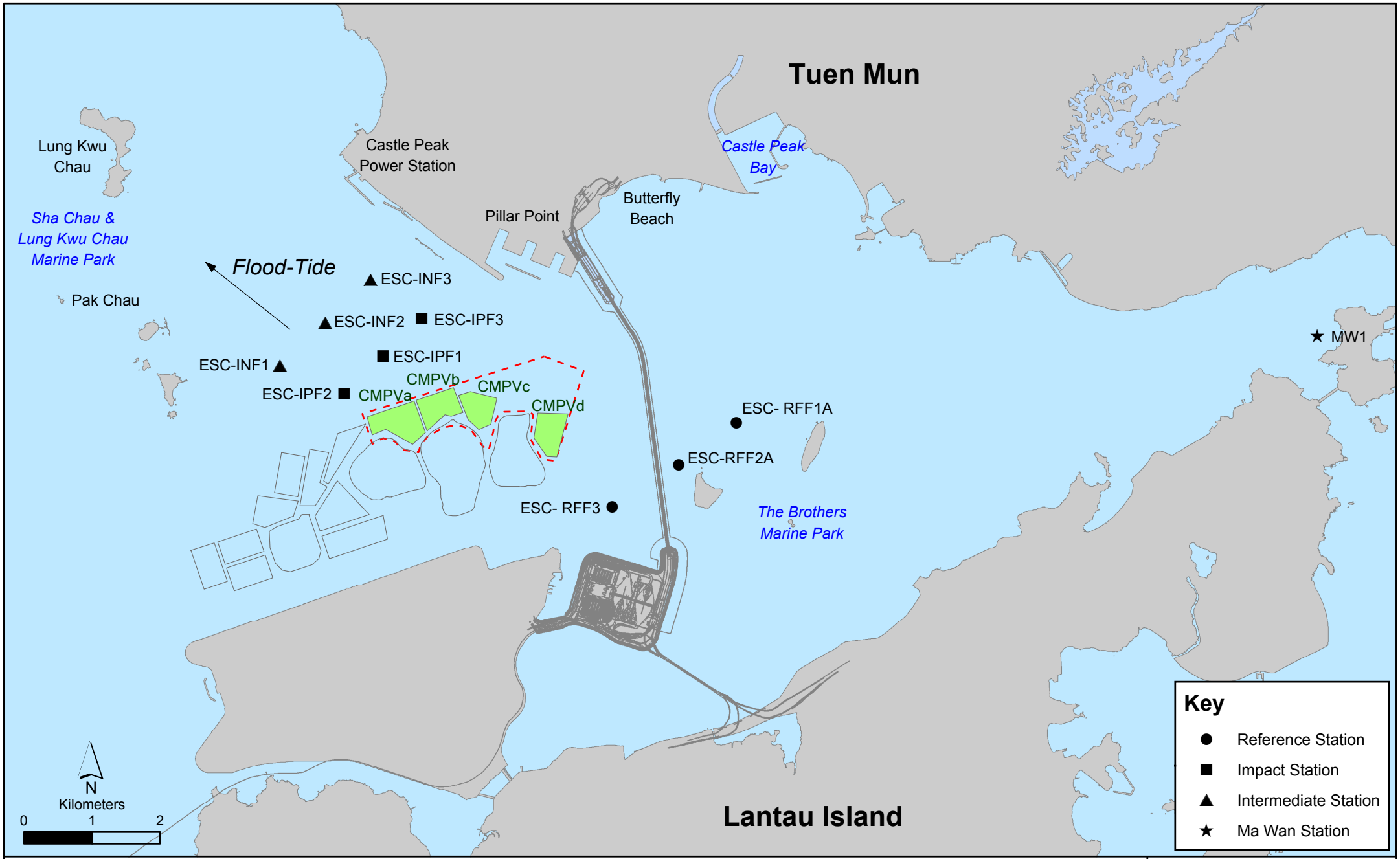


Figure 3.1

Routine & Capping Water Quality Sampling Stations (Flood-Tide) for ESC CMPs

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Date: 25/4/2017

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3.2.7 Should spatial or temporal trend of potential concern (i.e. increasing contaminant concentration with proximity to the pit or over time) be detected by ANOVA, linear regression analyses would be performed to examine the significance of the trend. Linear regression analysis makes assumptions of equal variance and normal distribution of data. Therefore, the significance level of the test was set at 1 % (i.e. $p = 0.01$) to reduce the chance of committing a Type 1 error. If a significant regression relationship was found between contaminant concentration and time (i.e. $p < 0.01$), r^2 value from the analysis would be further assessed. This value represents the proportion of the total variation in the dependent variable (i.e. contaminant concentration) that is accounted for by the fitted regression line and is referred to as the coefficient of determination. An r^2 value of 1 indicates a perfect relationship (or fit) whereas a value of 0 indicates that there is no relationship (or no fit) between the dependent and independent variables.

3.2.8 As there are no specific criteria to indicate how meaningful an r^2 value is, for the purposes of this EM&A programme a value of 0.60 was adopted to indicate a meaningful regression. If $r^2 < 0.60$ then it was considered that there was a weak relationship between contaminant concentration and time or proximity to the pit, or none at all. If the regression analysis indicated $r^2 > 0.60$ then it had been interpreted that there was in fact a strong relationship between the dependent and independent variables (i.e. a strong temporal trend of increasing contaminant concentration with time or strong spatial trend of increasing contaminant concentration with proximity to the pit). Details regarding the statistical analyses results are presented in *Annex C*.

In-situ Measurement

Dissolved Oxygen (DO)

3.2.9 DO levels varied significantly with sampling periods and areas. There was no consistent spatial trend of decreasing concentrations of DO with proximity to the pit or consistent temporal trend of decreasing concentrations of DO over time. DO levels were the highest in February 2017 and were the lowest in July 2013, August 2016 and July 2019. DO levels were the highest at Intermediate and Impact stations.

Turbidity

3.2.10 Turbidity levels varied significantly with sampling periods and areas. There was no consistent spatial trend of increasing concentrations of Turbidity with proximity to the pit or consistent temporal trend of increasing concentrations of Turbidity over time. Turbidity levels were the highest in April 2020 and November 2017 and were the lowest in February 2017. Turbidity was the highest at Impact and Reference stations.

Metals and Metalloid

3.2.11 The majority of dissolved metals had high percentage of their values below the limit of reporting (i.e. > 60% of values were below the limit of reporting during February 2012 to December 2020). Copper, Nickel and Zinc were the exceptions, and all varied significantly over area and time as indicated by results of the ANOVA tests (*Annex C*), but without any consistent spatial or temporal trends. The concentration of Copper was the highest in August 2013 when compared to all other sampling periods. The concentration of Nickel was significantly higher in April 2012, August 2013 and May 2013. The concentration of Zinc was the highest in November 2017 when compared to all other sampling periods. The concentrations of Copper were the highest at Reference stations. The concentrations of Nickel were the highest at Reference stations. The concentrations of Zinc were the highest at Ma Wan station.

Inorganic Contaminants

Ammonia Nitrogen (NH_3-N)

3.2.12 NH_3-N concentrations varied significantly with sampling periods and areas. There was no consistent spatial trend of increasing concentrations of NH_3-N with proximity to the pit or consistent temporal trend of increasing concentrations of NH_3-N over time. Concentrations of NH_3-N were the highest in April 2012. Concentrations of NH_3-N were the highest at Reference and Ma Wan station.

Total Inorganic Nitrogen (TIN)

3.2.13 TIN concentrations varied significantly with sampling periods and stations. There was no consistent spatial trend of increasing concentrations of TIN with proximity to the pit or consistent temporal trend of increasing concentrations of TIN over time. Concentrations of TIN were the highest in April 2012 and May 2018. Concentrations of TIN were the highest at Reference and Impact stations.

5-Day Biochemical Oxygen Demand (BOD_5)

3.2.14 Levels of BOD_5 varied significantly with sampling area and periods. There was no consistent spatial trend of increasing concentrations of BOD_5 with proximity to the pit or consistent temporal trend of increasing concentrations of BOD_5 over time. Levels of BOD_5 were the highest in August 2016. Levels of BOD_5 were the highest at Reference stations.

Suspended Solids (SS)

3.2.15 SS levels varied significantly with sampling areas and periods. There was no consistent temporal trend of increasing concentrations of SS over time. SS levels were the highest in April 2020 and November 2017. SS levels were the highest at Impact stations, then at Intermediate stations and in turn higher than at Reference stations. Subsequent regression analysis between SS levels and proximity to the pit (i.e. Area) indicated that there was significant spatial trend of increasing SS level with proximity to the pit ($p < 0.01$), but there was a weak relationship between SS level and proximity to the pit ($r^2 < 0.60$).

3.2.16 Overall, results of statistical analyses for the water quality data did not appear to provide any evidence of unacceptable water quality impacts caused by the mud disposal and capping operations at CMP Vb of the ESC area.

3.2.17 ***Pit Specific Sediment Chemistry of ESC CMP Vb***

Background

3.2.18 *Pit Specific Sediment Chemistry of ESC CMP Vb* was conducted once every month from October to December 2020 as presented in *Table 3.1*. A total of six (6) monitoring stations for ESC CMP Vb were sampled in each monitoring event and the monitoring locations are shown in *Figure 3.2*. The monitoring results showed that the concentrations of most inorganic contaminants were below the Lower Chemical Exceedance Levels (LCELs) at most stations from October to December 2020, except the concentrations of Arsenic were higher than LCEL at Active Pit stations ESC-NPCA and ESC-NPCB, Pit-Edge station ESC-NECA and Near-Pit station ESC-NNCA during the period; and the concentrations of Copper were higher than LCEL at Active Pit station ESC-NPCB in October 2020.

Summary of Statistical Analyses

3.2.19 Statistical analyses were performed for data obtained from *Pit Specific Sediment Chemistry of ESC CMP Vb* since February 2020. Statistical tests were run to examine the difference in contaminant concentrations amongst Active-Pit, Pit-Edge and Near-Pit stations and amongst sampling periods. ANOVA was employed as the statistical test, with Area, Period and Station as fixed factors and Station nested within Area.

3.2.20 Should spatial or temporal trend of potential concern (i.e. increasing contaminant concentration with proximity to the pit or over time) be detected by ANOVA, linear regression analyses would be performed to examine the significance of the trend. The assumptions of the linear regression analyses are discussed in *Sections 3.2.7* and *3.2.8*. Detailed results of statistical analyses are presented in *Annex C*.

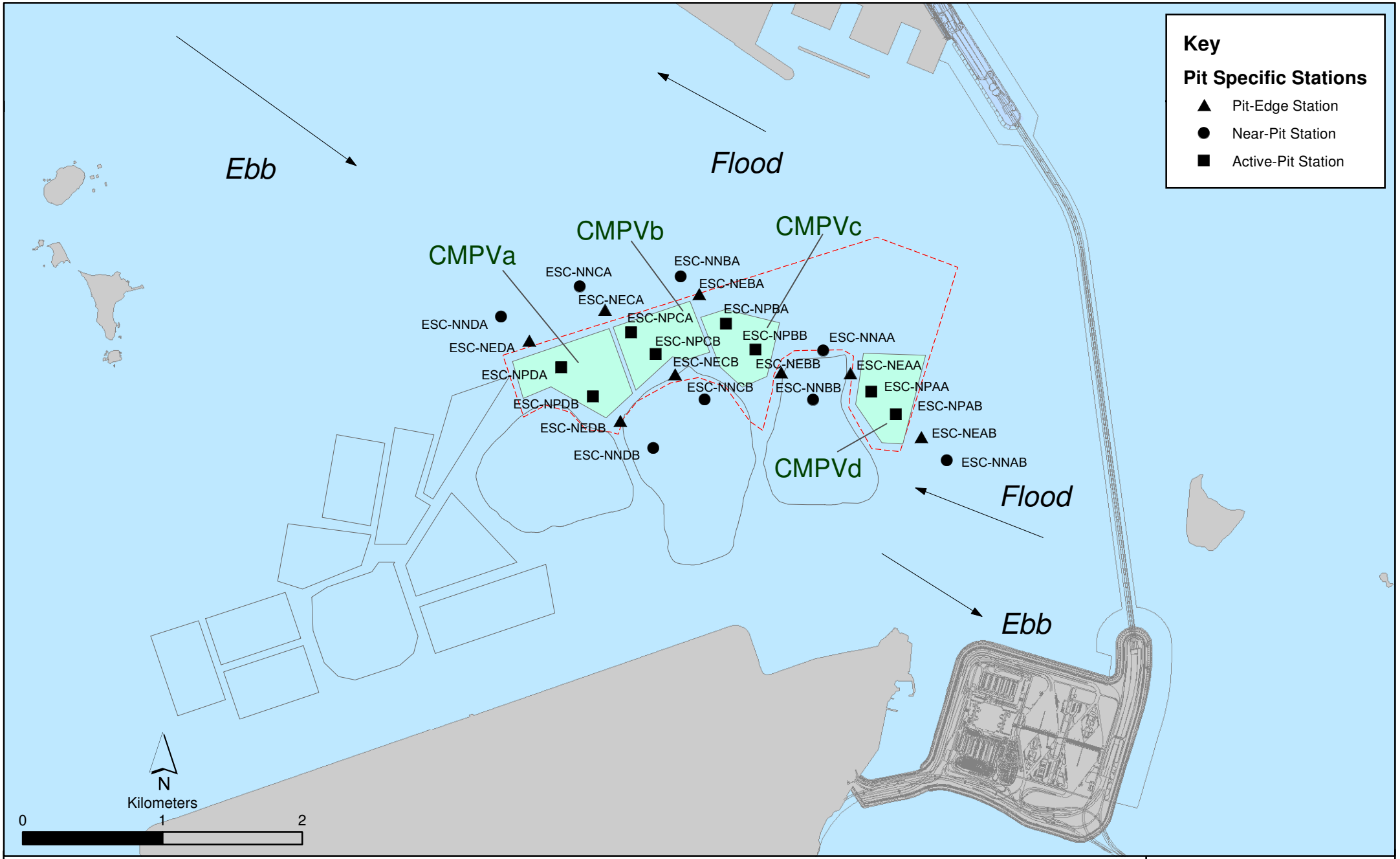

Figure 3.2

Pit Specific Sediment Quality Monitoring Stations for CMPV

File: T:\GIS\CONTRACT\0400720\Mxd\0400720_SQMS_pit specific.mxd
Date: 9/5/2017

Environmental Resources Management

ERM

Metals and Metalloids

3.2.21 There were significant spatial and temporal variations in the concentrations of all metal and metalloid contaminants (Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Mercury, Silver and Zinc). The concentrations of all measured metals and metalloids did not appear to increase over time. Subsequent linear regression analysis for Cadmium, Chromium, Lead, Mercury and Nickel levels and proximity to the pit (i.e. Area) indicated that there were significant spatial trends ($p < 0.01$), but there was a weak relationship between Cadmium, Chromium, Lead, Mercury and Nickel levels and proximity to the pit ($r^2 < 0.60$).

Organic Contaminants

3.2.22 Concentrations of majority of organic contaminants were below their limits of reporting. Statistical analyses were only performed for contaminants for which 60% of data were over their limits of reporting.

3.2.23 In this reporting period, only Total Organic Carbon (TOC) concentrations were statistically analysed. Levels of TOC varied significantly with sampling area and time, but the concentrations of TOC did not appear to increase over time or increase with proximity to the pit.

3.2.24 From the results of the above statistical analyses, there did not appear to be any significant trend of increasing sediment contaminants' concentrations with proximity to the pit or with time. Therefore, there is no evidence indicating any unacceptable environmental impacts to sediment quality as a result of the contaminated mud disposal operations at ESC CMP Vb.

3.2.25 ***Cumulative Impact Sediment Chemistry of ESC CMPs***

Background

3.2.26 *Cumulative Impact Sediment Chemistry of ESC CMPs* was conducted in December 2020 as presented in *Table 3.1*. A total of nine (9) monitoring stations were sampled and the monitoring locations are shown in *Figure 3.3*. The monitoring results showed that the concentrations of most inorganic contaminants were generally below the LCELs at most monitoring stations in December 2020, except concentrations of Arsenic were higher than the LCEL at Mid-field stations ESC-RMA, ESC-RMB, Near-field station ESC-RNB1, Capped Pit stations ESC-RCA1, ESC-RCB1 and Ma Wan station.

Summary of Statistical Analysis

3.2.27 Data obtained during this reporting period were statistically compared with previous data obtained since monitoring began for ESC CMPs in June 2016. Statistical tests were run to examine the difference in contaminant concentrations amongst Near-Field, Mid-Field, Far-Field stations. ANOVA was employed as the statistical test, with Area and Station as fixed factors and Station nested within Area.

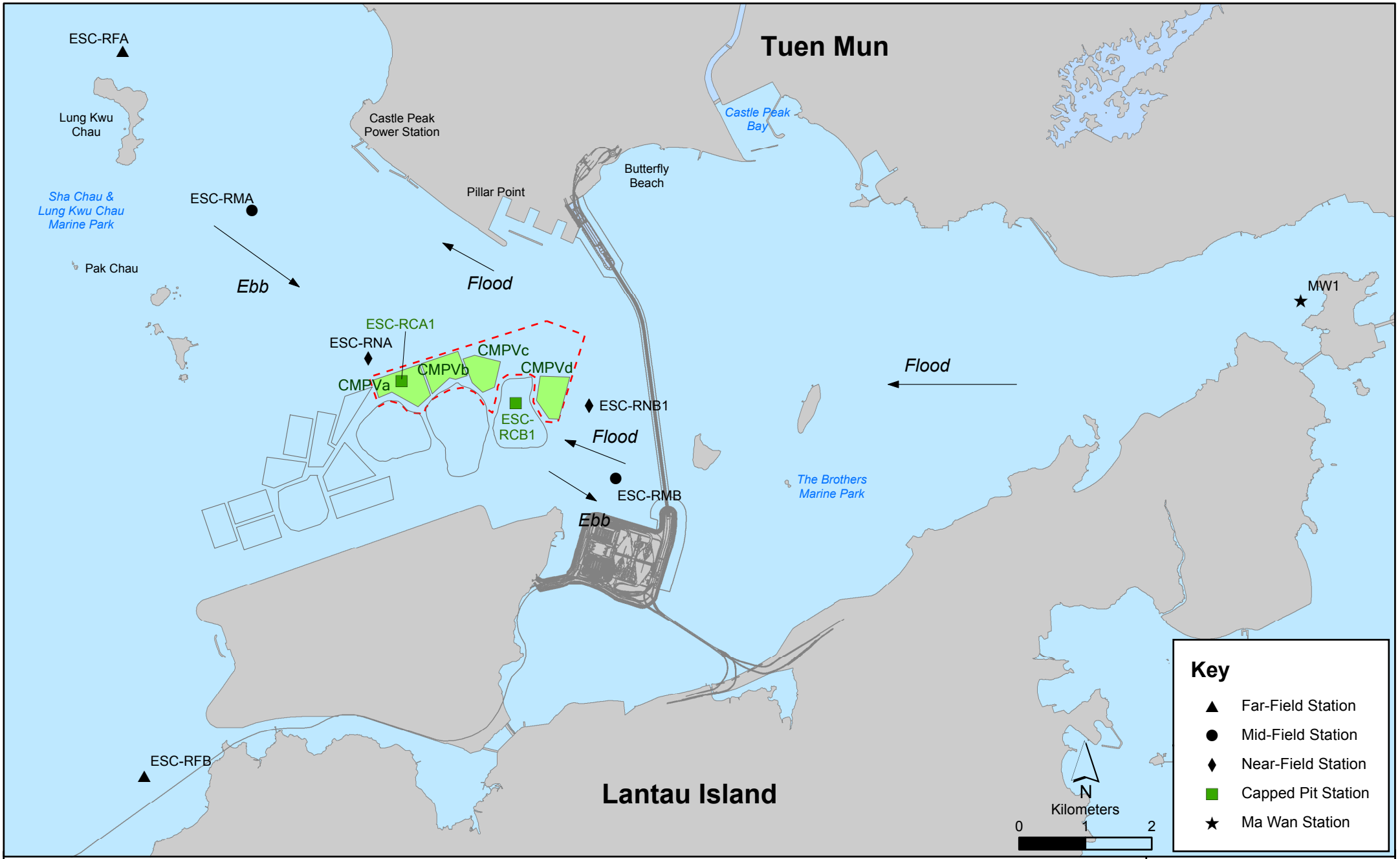

Figure 3.3

Cumulative Impacts Sediment Quality Monitoring Stations for ESC CMPs

File: T:\GIS\CONTRACT\0175086\Mxd\updated_20170419\0175086_SQMS_cum_impact.mxd
Date: 19/4/2017

Environmental Resources Management

ERM

3.2.28 Should spatial or temporal trend of potential concern (i.e. increasing contaminant concentration with proximity to the pit or over time) be detected by ANOVA, linear regression analyses would be performed to examine the significance of the trend. The assumptions of the linear regression analyses are discussed in *Sections 3.2.7* and *3.2.8*. Detailed results of statistical analyses are presented in *Annex C*.

Metals and Metalloid

3.2.29 There were significant spatial variations in the concentrations of all metal and metalloid contaminants (Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Mercury, Silver and Zinc), but no consistent trend (i.e. Near-Field > Mid-Field > Far-Field) was observed. In most cases, metal concentrations were highest at Mid-Field or Ma Wan stations. The concentrations of all measured metals and metalloids varied significantly with sampling time, but did not appear to increase over time.

Organic Contaminants

3.2.30 Concentrations of majority of organic contaminants were below their limits of reporting. Statistical analyses were only performed for contaminants for which 60% of data were over their limits of reporting.

3.2.31 In this reporting period, only TOC and Tributyltin (TBT) concentrations were statistically analysed. Levels of TOC and TBT varied significantly with sampling area and time and were the highest at Ma Wan station. There was no consistent spatial trend of increasing concentrations of TOC/TBT with proximity to the pit or consistent temporal trend of increasing concentrations of TOC/TBT over time.

3.2.32 From the results of the above statistical analyses, there did not appear to be any significant trend of increasing sediment contaminants' concentrations with proximity to the pit or over time. Therefore, there is no evidence indicating any unacceptable environmental impacts to sediment quality as a result of the contaminated mud disposal operations at ESC CMP Vb during the quarterly period.

3.2.33 ***Sediment Chemistry after a Major Storm of ESC CMPs – October 2020***

Background

3.2.34 Samplings for *Sediment Chemistry after a Major Storm of ESC CMPs* were conducted at nine (9) monitoring stations (see *Figure 3.3* for the monitoring locations) on 16 October 2020 after the visit of tropical cyclone Nangka, which led to the issue of No. 8 Gale or Storm Signal on 13 October 2020. The tracks of Nangka are shown in *Figure 3.4*. The monitoring results showed that the concentrations of most inorganic contaminants were below the LCEL, except concentrations of Arsenic at Mid-field station ESC-RMA, Far-field station ESC-RFB, Capped Pit Station ESC-RCA1 and Ma Wan Station.

Figure 3.4 ***Track of Tropical Cyclone Nangka*** *(Source: Hong Kong Observatory)*

Summary of Statistical Analyses

3.2.35 The data obtained were examined using statistical analyses. Statistical tests were run on inorganic contaminants, including Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Mercury, Silver and Zinc to examine differences in their sediment concentrations between Near-Field, Mid-Field, Far-Field, Capped-Pit and Ma Wan stations. A Two Factor Nested Analyses of Variance was employed as the statistical test, with Area as fixed factor and Station nested within Area.

3.2.36 Should spatial trend of potential concern (i.e. increasing contaminant concentration with proximity to the pit) be detected by ANOVA, linear regression analyses would be performed to examine the significance of the trend. The assumptions of the linear regression analyses are discussed in *Sections 3.2.7* and *3.2.8*. Detailed results of statistical analyses are presented in *Annex C*.

3.2.37 Results of the statistical analyses indicated that concentrations of all contaminants showed significant differences amongst sampling areas. However, there did not appear to be any trend of increasing contaminant's concentrations with proximity to the pit (i.e. Near-field > Mid-field > Far-field). Therefore, results of statistical analyses do not provide any evidence of the failure of ESC CMP Vb in retaining disposed mud or causing contamination of sediments after the major storm event in October 2020.

4 FINDINGS OF THE FIELD EVENTS AND LABORATORY TESTS AND ANALYSES BY THE INDEPENDENT AUDITOR

4.1.1 During the reporting period, the Independent Auditor (IA) conducted an inspection at the laboratory facility on 27 October 2020. The procedures of laboratory testing and measurement of inorganic contaminants in water and sediments were inspected. The IA was generally satisfied with the laboratory facilities and the whole procedures of sample analysis and measurements. Overall, the IA satisfied with the monitoring procedures and confirmed that the requirements as stated in the EM&A Manual were followed.

5 ACTIVITIES SCHEDULED FOR THE NEXT REPORTING PERIOD

5.1.1 The monitoring activities to be conducted in the next quarterly period of January to March 2021 for ESC CMPs include:

- *Water Column Profiling of ESC CMP Vb* in January, February and March 2021;
- *Routine Water Quality Monitoring of ESC CMPs* in January, February and March 2021;
- *Pit Specific Sediment Chemistry of ESC CMP Vb* in January, February and March 2021;
- *Cumulative Impact Sediment Chemistry of ESC CMPs* in February 2021;
- *Demersal Trawling for ESC CMPs* in January and February 2021; and
- *Sediment Toxicity Test of ESC CMPs* in February 2021.

5.1.2 The sampling schedule for ESC CMPs is presented in *Annex A*.

Annex A

Sampling Schedule

Annex A1 - East of Sha Chau Environmental Monitoring and Audit Sampling Schedule for CMP (April 2017 - March 2021)

			2017				2018												2019												2020												2021		
Pit Specific Sediment Chemistry *	**Code**	**Frequency**	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Active-Pit																																													
	ESC-NPAA	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	6	6
	ESC-NPAB	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	6	6
Pit-Edge																																													
	ESC-NEAA	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	6	6
	ESC-NEAB	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	6	6
Near-Pit																																													
	ESC-NNAA	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	6	6
	ESC-NNAB	Monthly	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	6	6
Cumulative Impact Sediment Chemistry *			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Near-field Stations																																													
	ESC-RNA	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
	ESC-RNB1	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
Mid-field Stations																																													
	ESC-RMA	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
	ESC-RMB	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
Capped Pit Stations																																													
	ESC-RCA1	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
	ESC-RCB1	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
Far-Field Stations																																													
	ESC-RFA	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
	ESC-RFB	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
Ma Wan Station																																													
	MW1	4 times per year				12		12				12		12				12		12				12		12				12		12				12		12				6		6	
Sediment Toxicity Tests			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Near-Pit Stations																																													
	ESC-TDA	2 times per year						5						5						5						5						5						5						5	
	ESC-TDB1	2 times per year						5						5						5						5						5						5						5	
Reference Stations																																													
	ESC-TRA	2 times per year						5						5						5						5						5						5						5	
	ESC-TRB	2 times per year						5						5						5						5						5						5						5	
Ma Wan Station																																													
	MW1	2 times per year						5						5						5						5						5						5						5	
Tissue/ Whole Body Sampling			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Near-Pit Stations																																													
	ESC-INA	2 times per year						*						*						*						*						*						*						*	
	ESC-INB	2 times per year						*						*						*						*						*						*						*	
Reference North																																													
	TNA	2 times per year						*						*						*						*						*						*						*	
	TNB	2 times per year						*						*						*						*						*						*						*	
Reference South																																													
	TSA	2 times per year						*						*						*						*						*						*						*	
	TSB	2 times per year						*						*						*						*						*						*						*	
Demersal Trawling			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Near Pit Stations																																													
	ESC-INA	4 times per year					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
	ESC-INB	4 times per year					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
Reference North																																													
	TNA	4 times per year					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
	TNB	4 times per year					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
Reference South																																													
	TSA	4 times per year					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
	TSB	4 times per year					5	5					5	5					5	5					5	5					5	5					5	5					5	5	
Capping *			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Ebb Tide																																													
Impact Station Downcurrent																																													
	ESC-IPE1A	4 times per year *																														3				3		3							
	ESC-IPE2A	4 times per year *																														3				3		3							
	ESC-IPE3	4 times per year *																														3				3		3							
	ESC-IPE4	4 times per year *																														3				3		3							
	ESC-IPE5	4 times per year *																														3				3		3							
Intermediate Station Downcurrent																																													
	ESC-INE1A	4 times per year *																														3				3		3							
	ESC-INE2A	4 times per year *																														3				3		3							
	ESC-INE3A	4 times per year *																														3				3		3							
	ESC-INE4A	4 times per year *																														3				3		3							
	ESC-INE5A	4 times per year *																														3				3		3							
Reference Station Upcurrent																																													
	ESC-RFE1	4 times per year *																														3				3		3							
	ESC-RFE2	4 times per year *																														3				3		3							
	ESC-RFE3	4 times per year *																														3				3		3							
	ESC-RFE4	4 times per year *																														3				3		3							
	ESC-RFE5	4 times per year *																														3				3		3							
Ma Wan Station																																													
	MW1	4 times per year *																														3				3		3							
Flood Tide																																													
Impact Station Downcurrent																																													
	ESC-IPF1	4 times per year *																														3				3		3							
	ESC-IPF2	4 times per year *																														3				3		3							
	ESC-IPF3	4 times per year *																														3				3		3							
Intermediate Station Downcurrent																																													
	ESC-INF1	4 times per year *																														3				3		3							
	ESC-INF2	4 times per year *																														3				3		3							
	ESC-INF3	4 times per year *																														3				3		3							
Reference Station Upcurrent																																													
	ESC-RFF1A	4 times per year *																														3				3		3							
	ESC-RFF2A	4 times per year *																														3				3		3							
	ESC-RFF3	4 times per year *																														3				3		3							
Ma Wan Station																																													
	MW1	4 times per year *																														3				3		3							
Routine Water Quality Monitoring *			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Ebb Tide																																													
Impact Station Downcurrent																																													
	ESC-IPE1A	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-IPE2A	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-IPE3	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-IPE4	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-IPE5	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
Intermediate Station Downcurrent																																													
	ESC-INE1A	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-INE2A	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-INE3A	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-INE4A	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-INE5A	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
Reference Station Upcurrent																																													
	ESC-RFE1	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-RFE2	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-RFE3	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-RFE4	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-RFE5	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
Ma Wan Station																																													
	MW1	Monthly *		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
Flood Tide																																													
Impact Station Downcurrent																																													
	ESC-IPF1	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-IPF2	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-IPF3	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
Intermediate Station Downcurrent																																													
	ESC-INF1	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-INF2	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-INF3	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
Reference Station Upcurrent																																													
	ESC-RFF1A	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-RFF2A	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
	ESC-RFF3	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
Ma Wan Station																																													
	MW1	Monthly *		8	8					8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8		8	8	4	4	4	4
Water Column Profiling *			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Plume Stations	WCP1	Monthly	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2
	WCP2	Monthly	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2
Benthic Recolonisation Studies			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Capped Stations at CMPV																																													
	ESCV-CPA	2 times per year																																											
	ESCV-CPB	2 times per year																																											
	ESCV-CPC	2 times per year																																											
	ESCV-CPD	2 times per year																																											
Reference Stations																																													
	RBA	2 times per year																																											
	RBB	2 times per year																																											
	RBC1	2 times per year																																											
Impact Monitoring for Dredging			S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Upstream Stations																																													
	US1	3 times per week	2																										2	2															
	US2	3 times per week	2																										2	2															
Downstream Stations																																													
	DS1	3 times per week	2																										2	2															
	DS2	3 times per week	2																										2	2															
	DS3	3 times per week	2																										2	2															
	DS4	3 times per week	2																										2	2															
	DS5	3 times per week	2																										2	2															
Ma Wan Station																																													
	MW1	3 times per week	2																										2	2															

Notes:
The number shown in each cell represents the numbers of replicates per monitoring station
Impact Monitoring for Dredging will be scheduled when dredging operations commence.
Benthic Recolonisation Studies for CMP V will be scheduled when capping operation for CMP V is completed.

* A proposal on the change of number of sample replication of water quality & sediment monitoring and combination of routine water quality monitoring and water quality monitoring during capping operation was submitted to EPD and agreed by EPD on 3 December 2020. The proposed changes will be effective for the EM&A activities since December 2020. Water Quality Monitoring during Capping Operation and Routine Water Quality Monitoring are combined such that Routine Water Quality Monitoring will be conducted monthly starting in December 2020.

Annex B

Disposal & Capping Records

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
1-Oct-2020	0	220496
2-Oct-2020	0	220496
3-Oct-2020	1442	221938
4-Oct-2020	0	221938
5-Oct-2020	2457	224395
6-Oct-2020	1457	225852
7-Oct-2020	967	226819
8-Oct-2020	2051	228870
9-Oct-2020	1694	230564
10-Oct-2020	976	231540
11-Oct-2020	543	232083
12-Oct-2020	0	232083
13-Oct-2020	0	232083
14-Oct-2020	0	232083
15-Oct-2020	0	232083
16-Oct-2020	907	232990
17-Oct-2020	970	233960
18-Oct-2020	328	234288
19-Oct-2020	1500	235788
20-Oct-2020	1500	237288
21-Oct-2020	1000	238288
22-Oct-2020	419	238707
23-Oct-2020	0	238707
24-Oct-2020	0	238707
25-Oct-2020	184	238891
26-Oct-2020	0	238891
27-Oct-2020	1000	239891
28-Oct-2020	1500	241391
29-Oct-2020	1000	242391
30-Oct-2020	500	242891
31-Oct-2020	500	243391
1-Nov-2020	0	243391
2-Nov-2020	0	243391
3-Nov-2020	500	243891
4-Nov-2020	500	244391
5-Nov-2020	500	244891
6-Nov-2020	500	245391
7-Nov-2020	0	245391
8-Nov-2020	0	245391
9-Nov-2020	500	245891
10-Nov-2020	1500	247391
11-Nov-2020	1900	249291
12-Nov-2020	1500	250791
13-Nov-2020	1500	252291
14-Nov-2020	1500	253791
15-Nov-2020	0	253791
16-Nov-2020	1500	255291
17-Nov-2020	1500	256791
18-Nov-2020	1400	258191
19-Nov-2020	2200	260391
20-Nov-2020	900	261291
21-Nov-2020	500	261791
22-Nov-2020	0	261791
23-Nov-2020	0	261791
24-Nov-2020	1100	262891
25-Nov-2020	1400	264291
26-Nov-2020	2300	266591

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
27-Nov-2020	1900	268491
28-Nov-2020	1500	269991
29-Nov-2020	500	270491
30-Nov-2020	2000	272491
1-Dec-2020	1500	273991
2-Dec-2020	1500	275491
3-Dec-2020	1500	276991
4-Dec-2020	1900	278891
5-Dec-2020	2800	281691
6-Dec-2020	0	281691
7-Dec-2020	1000	282691
8-Dec-2020	2500	285191
9-Dec-2020	3000	288191
10-Dec-2020	2500	290691
11-Dec-2020	2500	293191
12-Dec-2020	3300	296491
13-Dec-2020	400	296891
14-Dec-2020	1300	298191
15-Dec-2020	0	298191
16-Dec-2020	0	298191
17-Dec-2020	0	298191
18-Dec-2020	0	298191
19-Dec-2020	2500	300691
20-Dec-2020	3000	303691
21-Dec-2020	2000	305691
22-Dec-2020	2000	307691
23-Dec-2020	1985	309676
24-Dec-2020	500	310176
25-Dec-2020	2000	312176
26-Dec-2020	3000	315176
27-Dec-2020	1000	316176
28-Dec-2020	1500	317676
29-Dec-2020	3000	320676
30-Dec-2020	2465	323141
31-Dec-2020	3485	326626

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
1-Oct-2020	0	165300
2-Oct-2020	0	165300
3-Oct-2020	0	165300
4-Oct-2020	0	165300
5-Oct-2020	0	165300
6-Oct-2020	0	165300
7-Oct-2020	0	165300
8-Oct-2020	0	165300
9-Oct-2020	0	165300
10-Oct-2020	0	165300
11-Oct-2020	0	165300
12-Oct-2020	0	165300
13-Oct-2020	0	165300
14-Oct-2020	0	165300
15-Oct-2020	0	165300
16-Oct-2020	0	165300
17-Oct-2020	0	165300
18-Oct-2020	0	165300
19-Oct-2020	0	165300
20-Oct-2020	0	165300
21-Oct-2020	0	165300
22-Oct-2020	0	165300
23-Oct-2020	0	165300
24-Oct-2020	0	165300
25-Oct-2020	0	165300
26-Oct-2020	0	165300
27-Oct-2020	0	165300
28-Oct-2020	0	165300
29-Oct-2020	0	165300
30-Oct-2020	0	165300
31-Oct-2020	0	165300
1-Nov-2020	0	165300
2-Nov-2020	0	165300
3-Nov-2020	0	165300
4-Nov-2020	0	165300
5-Nov-2020	0	165300
6-Nov-2020	0	165300
7-Nov-2020	0	165300
8-Nov-2020	0	165300
9-Nov-2020	0	165300
10-Nov-2020	0	165300
11-Nov-2020	0	165300
12-Nov-2020	0	165300
13-Nov-2020	0	165300
14-Nov-2020	0	165300
15-Nov-2020	0	165300
16-Nov-2020	0	165300
17-Nov-2020	0	165300
18-Nov-2020	0	165300
19-Nov-2020	0	165300
20-Nov-2020	0	165300
21-Nov-2020	0	165300
22-Nov-2020	0	165300
23-Nov-2020	0	165300
24-Nov-2020	0	165300
25-Nov-2020	0	165300

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
26-Nov-2020	0	165300
27-Nov-2020	0	165300
28-Nov-2020	0	165300
29-Nov-2020	0	165300
30-Nov-2020	0	165300
1-Dec-2020	0	165300
2-Dec-2020	0	165300
3-Dec-2020	0	165300
4-Dec-2020	0	165300
5-Dec-2020	0	165300
6-Dec-2020	0	165300
7-Dec-2020	0	165300
8-Dec-2020	0	165300
9-Dec-2020	0	165300
10-Dec-2020	0	165300
11-Dec-2020	0	165300
12-Dec-2020	0	165300
13-Dec-2020	0	165300
14-Dec-2020	0	165300
15-Dec-2020	0	165300
16-Dec-2020	0	165300
17-Dec-2020	0	165300
18-Dec-2020	0	165300
19-Dec-2020	0	165300
20-Dec-2020	0	165300
21-Dec-2020	0	165300
22-Dec-2020	0	165300
23-Dec-2020	0	165300
24-Dec-2020	0	165300
25-Dec-2020	0	165300
26-Dec-2020	0	165300
27-Dec-2020	0	165300
28-Dec-2020	0	165300
29-Dec-2020	0	165300
30-Dec-2020	0	165300
31-Dec-2020	0	165300

Annex C

Statistical Analysis

Routine Water Quality Monitoring for ESC CMPs – Analysis of Variance and Linear Regression Analysis up to December 2020

Dissolved Oxygen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	13868655.3	3	4622885.099	54.222	**
Period	4646227289	51	91102495.86	1068.538	**
Area * Period	239865718.1	153	1567749.792	18.388	**
Error	360730993.7	4231	85259.039		
Total	29166187941	4439			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Feb 17 ≥ Feb 13 ≥ Apr 16 = Jan 17 > Feb 18 = Jan 13 > Jan 18 ≥ Feb 12 = Feb 19 ≥ Nov 18 ≥ Feb 20 > Jan 19 > Apr 13 > Apr 17 > Jan 20 = **Dec 20** > **Nov 20** ≥ Apr 18 ≥ Nov 16 ≥ Apr 19 > Apr 20 > Nov 17 = Nov 19 > Apr 12 = May 13 ≥ May 20 ≥ Nov 12 ≥ May 19 = May 18 = May 16 > Oct 16 = Oct 12 = Jul 12 > Jul 20 ≥ Aug 20 ≥ May 12 = May 17 = **Oct 20** ≥ Jul 18 > Oct 19 > Jul 16 = Aug 17 = Oct 18 = Oct 17 > Aug 12 > Aug 13 ≥ Aug 18 = Aug 19 = Jul 17 ≥ Aug 16 = Jul 13 = Jul 19
- Impact = Intermediate > Reference > Ma Wan Station

Turbidity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	201739247.7	3	67246416	192.08	**
Period	3290421187	51	64518062	184.286	**
Area * Period	628914302.7	153	4110551	11.741	**
Error	1481258962	4231	350096.7		
Total	29165969912	4439			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Apr 20 = Nov 17 > May 20 > Oct 17 = **Dec 20** = Aug 13 ≥ Jan 19 ≥ Apr 17 = Apr 12 = Aug 18 = Aug 12 = May 19 = Nov 18 = Nov 16 ≥ Oct 16 ≥ Jul 18 = Nov 12 = Jul 16 ≥ Jul 17 ≥ May 16 = Oct 18 = Aug 19 ≥ Apr 13 ≥ Feb 12 ≥ Oct 19 ≥ Apr 16 > Jul 19 = Jan 17 ≥ May 18 = **Oct 20** = Aug 20 ≥ Oct 12 ≥ Apr 19 = Jul 12 ≥ Aug 17 = Jan 18 ≥ Jul 20 ≥ Aug 16 ≥ Feb 13 ≥ Feb 18 = May 12 ≥ Jan 13 = **Nov 20** = Jan 20 ≥ Feb 19 = Apr 18 ≥ Jul 13 ≥ Nov 19 = Feb 20 = May 17 = May 13 > Feb 17
- Impact > Reference > Intermediate > Ma Wan Station

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	6985574824	50	139711496.5	624.242	**
Area	32000760.98	3	10666920.33	47.661	**
Station(Area)	93796496.65	24	3908187.36	17.462	**
Period * Area	1078501837	147	7336747.192	32.781	**
Period * Station(Area)	1492550105	438	3407648.642	15.226	**
Error	1040268711	4648	223809.964		
Total	50103552604	5318			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Aug 13 > Aug 20 = May 18 > Feb 12 = Jul 20 > Nov 18 = Jul 18 = Aug 19 = May 20 ≥ Nov 19 ≥ Jul 13 ≥ Apr 12 = Feb 20 ≥ **Oct 20** = Oct 19 = **Nov 20** ≥ Feb 19 ≥ Oct 18 = Aug 18 = Jan 13 > Jan 19 = Jan 20 = Apr 13 = May 16 ≥ Apr 18 = May 19 = Nov 12 ≥ Apr 17 > May 12 > Apr 16 = Oct 12 > Jan 18 = May 13 = Jul 16 = May 17 ≥ Apr 19 ≥ Apr 20 = Aug 16 > **Dec 20** > Aug 12 = Jul 19 = Jul 12 = Nov 17 ≥ Feb 13 ≥ Feb 18 ≥ Aug 17 = Oct 17 > Jul 17 = Oct 16 = Jan 17 ≥ Feb 17 ≥ Nov 16
- Reference > Ma Wan Station > Impact > Intermediate

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	6760250105	50	135205002.1	397.028	**
Area	52315632.58	3	17438544.19	51.208	**
Station(Area)	141529606.7	24	5897066.947	17.317	**
Period * Area	1218647864	147	8290121.524	24.344	**
Period * Station(Area)	876283701.7	438	2000647.721	5.875	**
Error	1582840893	4648	340542.361		
Total	49953679218	5318			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Apr 12 = Aug 13 = May 13 > May 12 ≥ Apr 13 = Aug 16 = Jul 13 ≥ Oct 12 = Jan 13 ≥ May 20 = Aug 12 = Feb 12 = Nov 12 > Jul 17 = Jul 12 = Apr 18 > Aug 17 = Feb 17 > Apr 20 = May 18 = Apr 17 = Jan 20 = Nov 18 = Jul 18 = Feb 18 > Oct 18 ≥ Aug 18 = Jan 18 = May 19 = Oct 19 = Feb 13 ≥ Apr 19 ≥ Aug 20 ≥ Oct 17 = Aug 19 > May 17 ≥ Oct 16 ≥ Jul 16 ≥ Nov 17 ≥ **Nov 20** = Feb 20 ≥ Nov 19 = **Dec 20** > Jul 19 = Jan 17 > Apr 16 ≥ Nov 16 = Jan 19 = Feb 19 ≥ Jul 20 = **Oct 20** = May 16
- Reference > Impact > Intermediate > Ma Wan Station

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	7420460392	50	148409207.8	417.225	**
Area	125352847.7	3	41784282.56	117.469	**
Station(Area)	127312715.6	24	5304696.482	14.913	**
Period * Area	814994787.3	147	5544182.226	15.586	**
Period * Station(Area)	1217034801	438	2778618.267	7.812	**
Error	1650828313	4641	355705.303		
Total	49947827839	5311			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Nov 17 ≥ Jul 17 = **Dec 20** = Oct 17 ≥ Feb 17 = **Nov 20** = **Oct 20** = Apr 17 = Aug 17 = Feb 18 ≥ Jan 18 = May 17 = Nov 18 = Jul 18 ≥ Aug 20 = Apr 18 > Aug 19 > Nov 19 ≥ May 18 ≥ May 20 > Apr 12 ≥ Feb 12 = Aug 13 ≥ Oct 19 ≥ Oct 18 = Aug 18 ≥ Jul 20 ≥ Apr 20 = Jul 12 ≥ Nov 12 ≥ Apr 19 ≥ Jul 13 = Feb 20 = Jan 20 = Feb 19 ≥ May 16 ≥ May 12 = Jan 19 ≥ Jan 17 ≥ Jan 13 ≥ Apr 13 = Apr 16 = Oct 16 = Oct 12 = May 19 > Jul 16 = Nov 16 > Jul 19 > May 13 ≥ Aug 12 ≥ Aug 16 ≥ Feb 13
- Ma Wan Station > Reference > Impact > Intermediate

Ammonia Nitrogen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	8285763279	50	165715265.6	551.259	**
Area	11072438.87	3	3690812.958	12.278	**
Station(Area)	46212344.81	24	1925514.367	6.405	**
Period * Area	537496797.3	147	3656440.798	12.163	**
Period * Station(Area)	473687053.1	438	1081477.29	3.598	**
Error	1397848306	4650	300612.539		
Total	50180245456	5320			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Apr 12 > Apr 13 = Jan 20 = Apr 16 > May 13 = May 20 = Feb 19 = Jan 18 = Apr 17 > Apr 20 = May 19 ≥ **Oct 20** = Feb 17 = **Dec 20** = May 17 ≥ Feb 12 ≥ Apr 19 ≥ Apr 18 > Feb 18 = Aug 20 = **Nov 20** = May 16 ≥ Jan 13 ≥ Jan 17 ≥ Nov 17 = Jul 16 > Jul 20 = Jul 18 = May 18 > Oct 17 = Jan 19 > Oct 19 ≥ Jul 13 ≥ Nov 16 ≥ Aug 19 = Feb 20 = Nov 19 = Aug 16 ≥ Jul 19 ≥ Aug 12 ≥ Aug 17 ≥ May 12 > Oct 16 = Jul 17 ≥ Aug 18 > Oct 12 = Oct 18 ≥ Aug 13 ≥ Nov 12 > Jul 12 = Feb 13 > Nov 18
- Ma Wan Station > Reference > Impact > Intermediate

Total Inorganic Nitrogen

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	8036114857	50	160722297.1	1044.92	**
Area	137978217	3	45992739.01	299.017	**
Station(Area)	173665445.6	24	7236060.233	47.045	**
Period * Area	673767176.6	147	4583450.181	29.799	**
Period * Station(Area)	654032872.6	438	1493225.737	9.708	**
Error	715230313.3	4650	153812.971		
Total	50201568386	5320			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Apr 12 = May 18 > Aug 13 > Apr 17 > Jul 16 = Aug 19 = May 13 > Jul 12 ≥ Nov 18 ≥ Aug 17 ≥ Jul 17 > May 12 = Aug 16 > Jul 20 > May 17 =Jul 19 = Aug 12 = Apr 18 = Jul 18 > Jul 13 = May 16 = Jan 20 > Apr 20 = May 19 > Aug 18 = May 20 = Oct 17 > Apr 13 > Feb 17 = Apr 16 = Jan 18 > Oct 12 = Apr 19 ≥ Feb 19 ≥ Feb 12 = Aug 20 > Nov 16 > Oct 18 = Jan 17 = Oct 16 = Oct 19 > **Nov 20** = Nov 12 = **Oct 20** > Feb 18 > Jan 19 = Nov 19 > Nov 17 ≥ Jan 13 ≥ **Dec 20** > Feb 13 = Feb 20
- Reference = Impact > Intermediate > Ma Wan Station

BOD_5

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	5180137715	50	103602754.3	230.813	**
Area	149712922.4	3	49904307.47	111.18	**
Station(Area)	84142456.84	24	3505935.702	7.811	**
Period * Area	1909613006	147	12990564.67	28.941	**
Period * Station(Area)	1643879710	438	3753150.023	8.362	**
Error	2086748771	4649	448859.706		
Total	50139209502	5319			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Aug 16 > Jul 20 = Aug 19 = Nov 16 = Apr 16 > Jan 17 ≥ Apr 19 = May 12 ≥ Oct 19 ≥ Jan 20 ≥ Aug 18 = Jan 13 = May 20 ≥ May 18 ≥ Jul 17 = Nov 17 = May 17 = May 16 ≥ Feb 20 ≥ Apr 18 = Oct 18 = Jul 19 ≥ Feb 12 = Nov 18 = Jul 18 = May 19 = Feb 18 = Apr 17 = Oct 16 > Nov 19 ≥ Oct 17 = Feb 19 ≥ Apr 13 = Aug 20 ≥ Nov 12 ≥ Jan 19 = Apr 12 ≥ Jul 12 ≥ Feb 13 = Oct 12 = **Oct 20** > Feb 17 = **Nov 20** ≥ May 13 ≥ Aug 17 = Jul 16 > Aug 12 ≥ Jan 18 ≥ **Dec 20** ≥ Aug 13 ≥ Apr 20 > Jul 13
- Reference > Ma Wan Station > Impact > Intermediate

Suspended Solids

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	6693513197	50	133870263.9	1244.525	**
Area	50010204.89	3	16670068.3	154.973	**
Station(Area)	309783953.8	24	12907664.74	119.996	**
Period * Area	1210427164	147	8234198.395	76.549	**
Period * Station(Area)	2417138885	438	5518581.93	51.304	**
Error	500188090.8	4650	107567.331		
Total	50201207133	5320			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Apr 20 = Nov 17 > **Dec 20** = May 20 > Jul 12 > Nov 12 = Jan 19 > Nov 16 = Jul 16 = Oct 16 = Aug 12 > Apr 12 = Apr 17 ≥ Oct 17 ≥ May 16 ≥ Oct 12 ≥ May 19 > Aug 13 = **Nov 20** > Aug 20 ≥ Jan 17 = Nov 18 = Jul 18 ≥ Aug 18 = Apr 16 ≥ Jul 17 = Oct 18 ≥ Apr 13 > **Oct 20** > Aug 19 = Feb 12 > Jan 18 > Oct 19 = Aug 16 > Jul 20 > May 18 ≥ Feb 13 ≥ Jan 20 > Apr 19 = Feb 18 = Feb 20 = Apr 18 = Jan 13 > Aug 17 > Nov 19 = Feb 19 = May 13 = Jul 19 ≥ Jul 13 ≥ May 12 > May 17 > Feb 17
- Impact > Intermediate > Reference > Ma Wan Station

Linear Regression Analysis

Source	df	Slope	r	r^2	P
Area	1	-194.452	0.120	0.014	**

Note: Linear regression analysis on spatial changes of contaminant concentrations.

Pit Specific Sediment Chemistry for ESC CMP Vb – Analysis of Variance up to December 2020

Arsenic

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	900149.049	10	90014.91	8.229	**
Area	3048532.139	2	1524266	139.349	**
Station(Area)	12907764.46	3	4302588	393.344	**
Period * Area	6000524.051	20	300026.2	27.429	**
Period * Station(Area)	4709917.446	30	156997.2	14.353	**
Error	7547548.458	690	10938.48		
Total	144306934	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Mar 20 ≥ **Dec 20** ≥ Jul 20 ≥ Feb 20 ≥ **Nov 20** = **Oct 20** ≥ Sep 20 ≥ Apr 20 ≥ May 20 = Aug 20 ≥ Jun 20
- Pit Edge > Active Pit > Near Pit

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	4226361.92	10	422636.2	34.539	**
Area	13885852.78	2	6942926	567.4	**
Station(Area)	2591863.091	3	863954.4	70.605	**
Period * Area	3654131.553	20	182706.6	14.931	**
Period * Station(Area)	3096353.826	30	103211.8	8.435	**
Error	8443105.896	690	12236.39		
Total	144107744.5	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Mar 20 > Apr 20 ≥ **Oct 20** = Sep 20 = Feb 20 ≥ Jun 20 = **Nov 20** > Aug 20 = **Dec 20** = May 20 = Jul 20
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-160.582	0.603	0.363	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	2253475.313	10	225347.5	24.044	**
Area	11518142.75	2	5759071	614.468	**
Station(Area)	11615617.7	3	3871873	413.112	**
Period * Area	1744881.009	20	87244.05	9.309	**
Period * Station(Area)	1940621.994	30	64687.4	6.902	**
Error	6466995.125	690	9372.457		
Total	144312876.5	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 20 > Mar 20 = **Oct 20** = **Nov 20** > **Dec 20** = Sep 20 = May 20 ≥ Aug 20 = Jun 20 = Apr 20 ≥ Jul 20
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-139.842	0.523	0.274	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1762323.795	10	176232.4	39.689	**
Area	17316756.97	2	8658378	1949.962	**
Station(Area)	8071550.869	3	2690517	605.934	**
Period * Area	2078556.963	20	103927.8	23.406	**
Period * Station(Area)	3264142.856	30	108804.8	24.504	**
Error	3063793.938	690	4440.281		
Total	144312907.5	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 20 = Mar 20 > Sep 20 = **Oct 20** = **Nov 20** = Aug 20 ≥ Jun20 ≥ Jul 20 = Apr 20 = **Dec 20** > May 20
- Active Pit > Near Pit > Pit Edge

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1491466.156	10	149146.6	15.953	**
Area	15042452.95	2	7521226	804.493	**
Station(Area)	7049597.76	3	2349866	251.349	**
Period * Area	3744592.909	20	187229.6	20.027	**
Period * Station(Area)	1978837.89	30	65961.26	7.055	**
Error	6450826.854	690	9349.024		
Total	144312907	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 20 > Mar 20 ≥ Sep 20 = Jun 20 = **Oct 20** ≥ **Nov 20** ≥ Apr 20 ≥ Jul 20 = **Dec 20** = Aug 20 ≥ May 20
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-161.880	0.606	0.367	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Mercury

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	3001442.382	10	300144.2	22.699	**
Area	8121485.851	2	4060743	307.104	**
Station(Area)	9188037.613	3	3062679	231.623	**
Period * Area	2839330.399	20	141966.5	10.737	**
Period * Station(Area)	2851789.961	30	95059.67	7.189	**
Error	9123663.167	690	13222.7		
Total	144141036	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 20 ≥ Aug 20 = Jul 20 ≥ Sep 20 ≥ Mar 20 = Apr 20 ≥ **Oct 20** = May 20 ≥ Jun 20 = **Dec 20** > **Nov 20**
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-124.079	0.465	0.217	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	3084365.948	10	308436.6	42.883	**
Area	10233411.06	2	5116706	711.4	**
Station(Area)	13023956.31	3	4341319	603.595	**
Period * Area	2080346.979	20	104017.3	14.462	**
Period * Station(Area)	2060912.151	30	68697.07	9.551	**
Error	4962784.771	690	7192.442		
Total	144312829.5	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 20 > **Oct 20** = Mar 20 = **Nov 20** > Sep 20 = Aug 20 = Jun 20 = **Dec 20** = May 20 = Jul 20 > Apr 20
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-130.568	0.488	0.239	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Silver

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1152664.708	10	115266.5	15.076	**
Area	17700932.16	2	8850466	1157.591	**
Station(Area)	3994542.019	3	1331514	174.154	**
Period * Area	2986169.965	20	149308.5	19.529	**
Period * Station(Area)	4474390.275	30	149146.3	19.507	**
Error	5275458.417	690	7645.592		
Total	144258061.5	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Sep 20 = Mar 20 = **Oct 20** = **Nov 20** = Aug 20 = Jul 20 > Feb 20 = May 20 = Apr 20 =Jun 20 > **Dec 20**
- Active Pit > Near Pit > Pit Edge

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	2970926.705	10	297092.7	35.741	**
Area	16964842.42	2	8482421	1020.46	**
Station(Area)	4672206.588	3	1557402	187.36	**
Period * Area	3617984.17	20	180899.2	21.763	**
Period * Station(Area)	2251297.621	30	75043.25	9.028	**
Error	5735519.688	690	8312.347		
Total	144312593.5	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 20 > Mar 20 = **Oct 20** > **Nov 20** > Sep 20 ≥ Jun 20 = **Dec 20** > Jul 20 = Aug 20 ≥ Apr 20 = May 20
- Active Pit > Near Pit > Pit Edge

Total Organic Carbon

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	11719344.24	10	1171934	178.463	**
Area	12571981.59	2	6285991	957.237	**
Station(Area)	3266694.606	3	1088898	165.818	**
Period * Area	1307116.056	20	65355.8	9.952	**
Period * Station(Area)	2596035.868	30	86534.53	13.178	**
Error	4531099.167	690	6566.81		
Total	144300235	756			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- **Oct 20** = **Nov 20** = Mar 20 > Sep 20 > **Dec 20** > Feb 20 = May 20 ≥ Jul 20 ≥ Aug 20 > Apr 20 > Jun 20
- Active Pit > Near Pit > Pit Edge

Cumulative Impact Sediment Chemistry for ESC CMPs – Analysis of Variance up to December 2020

Arsenic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	164047723.6	18	9113762	405.775	**
Area	100942314.8	4	25235579	1123.571	**
Area * Station	12106939.83	4	3026735	134.76	**
Period * Area	300581643.2	71	4233544	188.491	**
Period * Area * Station	29406525.85	72	408424	18.184	**
Error	41034719.42	1827	22460.16		
Total	2660621000	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Dec 19 ≥ **Dec 20** = Jun 19 = Aug 19 ≥ Jun 20 > Jun 18 = Aug 20 = Feb 20 > Dec 18 = Feb 19 = Dec 17 = Feb 18 > Aug 18 = Jun 17 > Jun 16 = Aug 17 > Dec 16 > Feb 17 = Aug 16
- Mid-Field > Ma Wan > Near-Field > Far-Field > Capped-Pit

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	101203544.4	18	5622419	54.566	**
Area	52897649.16	4	13224412	128.345	**
Area * Station	85547166.66	4	21386792	207.562	**
Period * Area	136872174	71	1927777	18.709	**
Period * Area * Station	82095378.29	72	1140214	11.066	**
Error	187941913.5	1824	103038.3		
Total	2642536291	1995			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 ≥ Aug 16 ≥ Feb 20 = Aug 19 = Aug 17 = Jun 18 = Feb 18 ≥ Dec 17 ≥ Dec 19 = Dec 18 > Jun 17 = Aug 18 ≥ Feb 19 ≥ Aug 20 ≥ Jun 20 = Feb 17 = Jun 19 > Dec 16 > **Dec 20**
- Mid-Field > Ma Wan > Far-Field ≥ Capped-Pit ≥ Near-Field

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	26886686.25	18	1493705	52.086	**
Area	276709785.7	4	69177446	2412.224	**
Area * Station	38357944.59	4	9589486	334.386	**
Period * Area	195450658.8	71	2752826	95.991	**
Period * Area * Station	58514973.6	72	812708	28.339	**
Error	52394464.67	1827	28677.87		
Total	2660670551	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 > Aug 16 ≥ Feb 20 = Dec 19 ≥ Aug 19 = Aug 17 ≥ Dec 17 ≥ Jun 18 ≥ Jun 17 ≥ Jun 19 ≥ **Dec 20** = Aug 20 = Feb 19 = Feb 18 ≥ Dec 16 ≥ Jun 20 > Dec 18 = Feb 17 > Aug 18
- Ma Wan > Mid-Field > Near-Field > Capped-Pit > Far-Field

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	26744665.83	18	1485815	46.865	**
Area	214944440.4	4	53736110	1694.939	**
Area * Station	165953124.8	4	41488281	1308.619	**
Period * Area	147660983.4	71	2079732	65.599	**
Period * Area * Station	33396629.24	72	463842.1	14.63	**
Error	57922956.31	1827	31703.86		
Total	2660670646	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 20 = Dec 17 > Dec 19 > Aug 17 ≥ Jun 18 = Feb 19 = Jun 16 = Jun 19 = Aug 16 = Aug 19 = Jun 17 ≥ Jun 20 ≥ Dec 18 ≥ **Dec 20** ≥ Aug 20 ≥ Aug 18 = Dec 16 = Feb 18 ≥ Feb 17
- Ma Wan > Mid-Field > Near-Field > Far-Field > Capped-Pit

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	140023773.5	18	7779098.527	220.402	**
Area	184646382.7	4	46161595.68	1307.879	**
Area * Station	32410524.22	4	8102631.054	229.569	**
Period * Area	185232263.9	71	2608905.125	73.917	**
Period * Area * Station	49744431.06	72	690894.876	19.575	**
Error	64483977.5	1827	35295.007		
Total	2660670535	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Aug 18 > Dec 18 > Aug 16 > Aug 19 = Dec 19 = Feb 19 = Aug 17 = Jun 18 > Jun 16 = Jun 19 = Feb 20 = Jun 20 ≥ **Dec 20** = Feb 18 ≥ Aug 20 = Dec 17 > Dec 16 > Jun 17 > Feb 17
- Ma Wan > Mid-Field > Near-Field > Far-Field > Capped-Pit

Mercury

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	247562625.4	18	13753479	133.462	**
Area	39666055.93	4	9916514	96.229	**
Area * Station	22516907.73	4	5629227	54.625	**
Period * Area	94783395.22	71	1334977	12.954	**
Period * Area * Station	35809679.06	72	497356.7	4.826	**
Error	187759815.3	1822	103051.5		
Total	2632534390	1993			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 > Aug 16 > Feb 20 ≥ Aug 20 ≥ Dec 18 = Aug 18 ≥ Dec 19 = Dec 16 > Feb 19 ≥ Feb 17 = Jun 20 ≥ Aug 17 = Jun 19 = Jun 17 ≥ Dec 17 ≥ Jun 18 = Aug 19 ≥ **Dec 20** > Feb 18
- Ma Wan > Capped-Pit ≥ Mid-Field = Far-Field ≥ Near-Field

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	27881509.31	18	1548973	54	**
Area	241618347.8	4	60404587	2105.802	**
Area * Station	47710092.46	4	11927523	415.813	**
Period * Area	217763456.9	71	3067091	106.924	**
Period * Area * Station	64361172.42	72	893905.2	31.163	**
Error	52407209.42	1827	28684.84		
Total	2660670137	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 > Aug 18 > Dec 18 ≥ Dec 19 = Aug 17 = Feb 20 = Dec 17 ≥ Aug 19 ≥ Dec 16 ≥ Jun 18 ≥ Dec 20 ≥ Jun 19 = Aug 20 = Jun 17 = Feb 18 ≥ Jun 20 = Feb 19 ≥ Aug 16 > Feb 17
- Ma Wan > Mid-Field > Near-Field = Far-Field > Capped-Pit

Silver

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	87284310.83	18	4849128	111.422	**
Area	210359841.3	4	52589960	1208.393	**
Area * Station	159360512.3	4	39840128	915.432	**
Period * Area	57703162.33	71	812720.6	18.674	**
Period * Area * Station	56708930.31	72	787624	18.098	**
Error	79512066.08	1827	43520.56		
Total	2659855364	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Aug 18 > Dec 18 > Dec 17 = Aug 16 = Feb 18 = Aug 17 > Feb 19 = Feb 17 = Feb 20 = Aug 19 = Dec 16 = Dec 19 = Jun 17 > Jun 19 = Jun 20 = Aug 20 > Jun 16 = **Dec 20** > Jun 18
- Ma Wan > Mid-Field > Near-Field > Far-Field > Capped-Pit

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	38271911.77	18	2126217	81.763	**
Area	214425771.4	4	53606443	2061.425	**
Area * Station	105243688.4	4	26310922	1011.781	**
Period * Area	202302357.1	71	2849329	109.57	**
Period * Area * Station	37790315.41	72	524865.5	20.184	**
Error	47510328	1827	26004.56		
Total	2660668085	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 20 = Dec 19 > Aug 16 ≥ Aug 19 ≥ Jun 19 = Jun 18 ≥ Jun 16 = Aug 17 ≥ Dec 17 ≥ Jun 17 = Feb 19 ≥ Feb 18 = **Dec 20** = Dec 16 ≥ Aug 20 ≥ Jun 20 = Feb 17 > Dec 18 > Aug 18
- Ma Wan > Mid-Field > Near-Field > Capped-Pit > Far-Field

TOC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	111864711.8	18	6214706	131.599	**
Area	144585240.6	4	36146310	765.413	**
Area * Station	18664023.75	4	4666006	98.805	**
Period * Area	200402250.7	71	2822567	59.769	**
Period * Area * Station	80356985.14	72	1116069	23.633	**
Error	86279303.23	1827	47224.58		
Total	2660465056	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Jun 16 > Dec 19 = Feb 20 > Dec 16 = **Dec 20** = Aug 19 = Aug 16 > Dec 17 = Feb 19 ≥ Jun 18 = Jun 17 = Jun 19 ≥ Feb 18 = Dec 18 > Aug 17 ≥ Aug 18 ≥ Jun 20 = Feb 17 > Aug 20
- Ma Wan > Mid-Field > Far-Field > Capped-Pit > Near-Field

TBT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	152469366.1	18	8470520	89.745	**
Area	126006787.1	4	31501697	333.759	**
Area * Station	8771174.512	4	2192794	23.233	**
Period * Area	62367509.01	71	878415.6	9.307	**
Period * Area * Station	34644687.06	72	481176.2	5.098	**
Error	172440410.5	1827	94384.46		
Total	2566213395	1998			

Note:
1. Data are rank-transformed;
2. NS: No significant difference;
3. **: Significant difference

SNK Results:

- Feb 17 = Dec 16 = Aug 17 = Jun 17 = Aug 18 > Jun 16 ≥ **Dec 20** ≥ Feb 18 = Dec 18 ≥ Aug 20 = Feb 19 = Aug 16 ≥ Dec 19 ≥ Dec 17 ≥ Aug 19 = Jun 19 = Jun 20 > Jun 18 = Feb 20
- Ma Wan > Capped-Pit = Near-Field = Far-Field > Mid Field

Sediment Chemistry after a Major Storm Event (13 October 2020) of ESC CMPs – Analysis of Variance

Arsenic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	47052.469	4	11763.12	80.431	**
Station(Area)	43385.615	4	10846.4	74.163	**
Error	14478.917	99	146.252		
Total	425704	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Far-field > Ma Wan = Mid-field > Capped Pit > Near-field

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	23949.844	4	5987.461	15.558	**
Station(Area)	41948.031	4	10487.01	27.249	**
Error	38100.625	99	384.855		
Total	424785.5	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Ma Wan > Mid-field = Far-field > Capped Pit = Near-field

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	43985.354	4	10996.34	71.544	**
Station(Area)	45764.354	4	11441.09	74.438	**
Error	15216.292	99	153.7		
Total	425753	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Ma Wan > Far-field = Mid-field > Capped Pit > Near-field

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	53384.313	4	13346.08	165.651	**
Station(Area)	43605.521	4	10901.38	135.308	**
Error	7976.167	99	80.567		
Total	425753	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Ma Wan > Far-field = Mid-field > Near-field > Capped Pit

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	44799.938	4	11199.98	159.303	**
Station(Area)	53205.271	4	13301.32	189.192	**
Error	6960.292	99	70.306		
Total	425752.5	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Ma Wan > Far-field = Mid-field > Near-field = Capped Pit

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	2931.702	4	732.926	200.523	**
Station(Area)	2951.924	4	737.981	201.906	**
Error	361.852	99	3.655		
Total	92257.216	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Ma Wan > Far-field = Mid-field > Near-field = Capped Pit

Mercury

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.039	4	0.01	11.786	**
Station(Area)	0.024	4	0.006	7.229	**
Error	0.082	99	0.001		
Total	0.744	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Mid-field ≥ Near-field ≥ Far-field = Ma Wan > Capped Pit

Silver

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	55839.646	4	13959.91	122.785	**
Station(Area)	37532.188	4	9383.047	82.529	**
Error	11255.667	99	113.694		
Total	425414.5	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Ma Wan > Far-field = Mid-field > Near-field > Capped Pit

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	61320.365	4	15330.09	179.457	**
Station(Area)	35183.594	4	8795.898	102.967	**
Error	8457.042	99	85.425		
Total	425748	108			

Note:
1. Data are rank-transformed;
2. NS: No significant different;
3. **: Significant difference

SNK Results:

- Ma Wan > Mid-field > Far-field > Near-field > Capped Pit