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 – January to March 2019

Revision 0

May 2019

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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: 14 May 2019 Approved by:  Craig A. Reid *Partner*

Revision	Description	By	Checked	Approved	Date
v0	Quarterly EM&A Report for ESC CMPs	EL	RC	CAR	14/5/19

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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 ~~E~~east of Sha Chau – January to March 2019
Date of Report:	14 May 2019
Date prepared by ET:	14 May 2019
Date received by IA:	14 May 2019

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: 14/5/2019

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: 14/5/2019

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 January to March 2019

EXECUTIVE SUMMARY

Water Column Profiling, Routine Water Quality Monitoring, Pit Specific Sediment Chemistry and *Cumulative Impact Sediment Chemistry, Sediment Toxicity Test and Demersal Trawling* were carried out for the Contaminated Mud Pits (CMPs) to the East of Sha Chau (ESC) during the quarterly period of January to March 2019. This report presents the results of these monitoring activities to identify whether the disposal 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 Vd – January to March 2019

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 Vd did not appear to cause any unacceptable impact in water quality during this quarterly period.

Routine Water Quality Monitoring of ESC CMPs – January and February 2019

Results of Routine Water Quality Monitoring conducted in January and February 2019 showed that levels of DO, Salinity and pH complied with the WQOs at all stations. 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 operations at CMP Vd 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 Vd – January to March 2019

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 did not cause any unacceptable impact in sediment quality of ESC CMP Vd during the reporting period.

Cumulative Impact Sediment Chemistry of ESC CMPs – February 2019

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 is considered that mud disposal operations at ESC CMP Vd have not caused any unacceptable impact in sediment quality during the reporting period.

Sediment Toxicity Test of ESC CMPs – February 2019

Statistical analysis showed that there were no significant differences between Impact and Reference stations in the toxicity tests of all tested marine benthos. Therefore, there did not appear to be any evidence of unacceptable impacts to sediment toxicity due to the mud disposal operations at ESC CMPs.

Demersal Trawling for ESC CMPs

During the sampling period in January and February 2019, the mean number of faunal species caught was generally lower at Impact stations in January and February 2019. Biotic abundance, biomass, Catch per Unit Effort (CPUE) and Yield per Unit Effort (YPUE) were lower at Impact stations ESC-INA and ESC-INB in January and February 2019.

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（二零一九年一月至三月）

行政摘要

在2019年1月至3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、沉積物毒性測試及底棲漁業資源監察。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－2019年1月至3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 Vd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 － 2019年1月和2月

2019年1月和2月的例行水質監察結果顯示受影響監測站、中距離監測站及參考監測站的溶解氧含量、鹽度及酸鹼值均符合海水水質指標。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－2019年1月至3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－2019年2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。

從統計結果顯示，所有已測試的海洋底棲生物在受影響監測站及參考監測站的沉積物毒性測試沒有明顯分別。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毒性造成任何不可接受的影響。

沙洲以東污泥坑之底棲漁業資源監察

監察結果顯示，2019年1月和2月的底棲漁業資源在受影響監測站普遍錄得較低的品種數量。而在2019年1月及2月受影響監測站ESC-INA及ESC-INB的生物量、生物重量、單位努力漁獲量及單位努力生產量均錄得較低的數值。

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 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.

1.2 ACTIVITIES CONDUCTED DURING THE REPORTING PERIOD

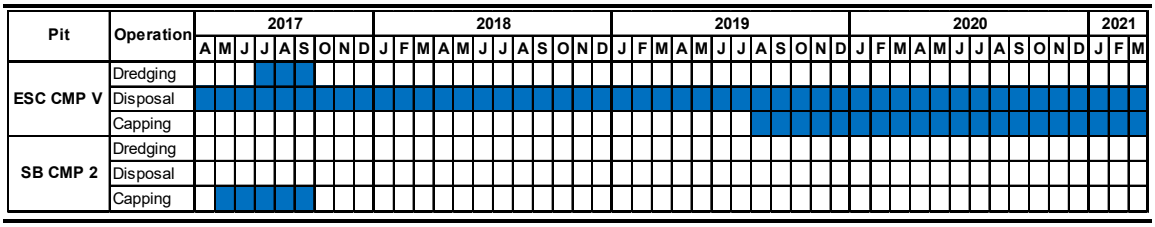
1.2.1 Detailed works schedule for ESC CMP V and SB CMPs is shown in *Figure 1.1*. During the reporting period of January to March 2019, the following works were being undertaken at the CMPs:

- Disposal of contaminated mud at ESC CMP Vd

(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.

Figure 1.1 Works Schedule for ESC CMPs



1.2.2 The records for contaminated mud disposal at ESC CMP Vd during the reporting period are presented in *Annex B* respectively.

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 January to March 2019* is to provide information regarding the findings in the quarterly reporting period of January to March 2019 on the environmental impacts resulting from backfilling 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 January to March 2019

Key Task	Date of Sampling & *in-situ* Measurement	Date of Results Received from the Contractors
ESC CMPs		
Water Column Profiling of ESC CMP Vd	4 January 2019 14 February 2019 5 March 2019	12 February 2019 6 March 2019 25 March 2019
Routine Water Quality Monitoring of ESC CMPs	9 January 2019 19 February 2019	12 February 2019 6 March 2019
Pit Specific Sediment Chemistry of ESC CMP Vd	3 January 2019 11 February 2019 4 March 2019	12 February 2019 6 March 2019 25 March 2019
Cumulative Impact Sediment Chemistry of ESC CMPs	12 & 13 February 2019	6 March 2019
Sediment Toxicity Test of ESC CMPs	12 & 13 February 2019	25 March 2019
Demersal Trawling of ESC CMPs	7 & 8 January 2019 20 & 21 February 2019	6 March 2019 10 April 2019

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 Vd* 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 Vd

3.2.2 *Water Column Profiling* for ESC CMP Vd was conducted once every month from January to March 2019 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 January, February and March 2019. 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 Vd 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 in January and February 2019 as presented in *Table 3.1*. A total of ten (10) and sixteen (16) stations were sampled in January and February 2019 respectively, and locations of the monitoring stations are presented in *Figures 3.1* and *3.2*. The disposal volume during the reporting period is detailed in *Annex B*. The monitoring results showed that levels of DO, Salinity and pH complied with the WQOs and the levels of DO, Turbidity and SS also complied with the Action and Limit Levels at all stations in January and February 2019.

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 February 2019 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.

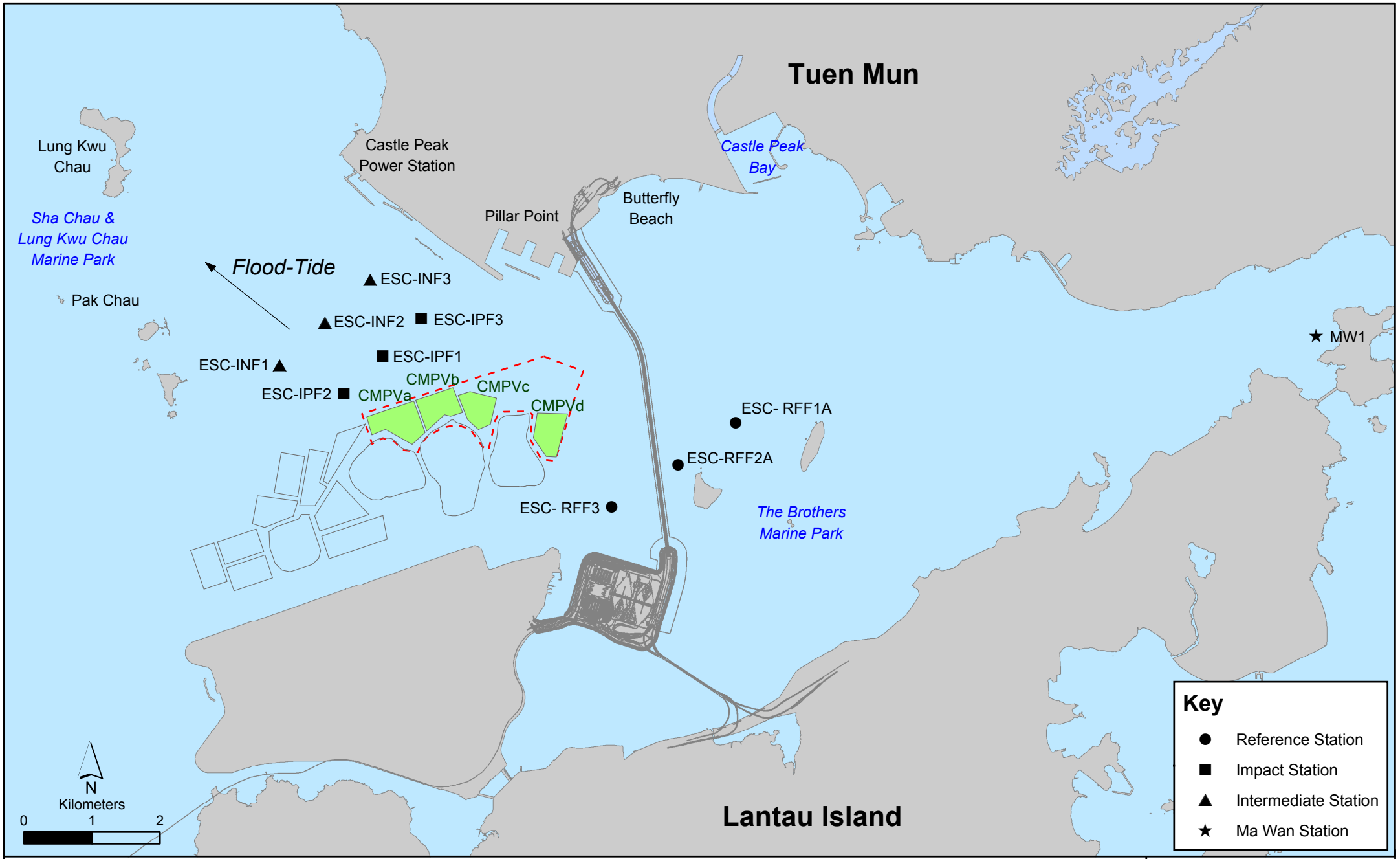


Figure 3.1

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

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Date: 25/4/2017

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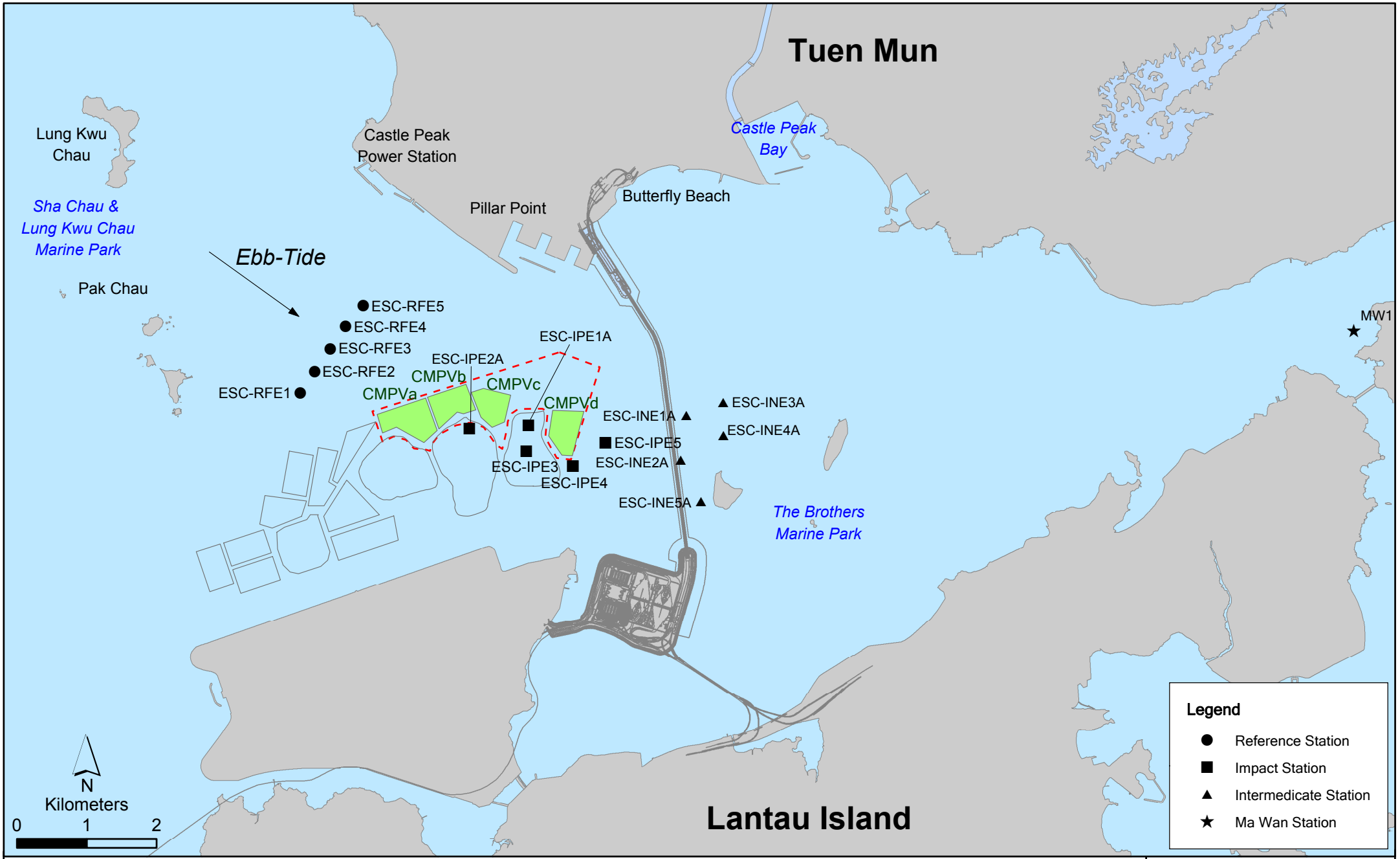

Figure 3.2

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

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Date: 19/4/2017

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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 significantly higher in February 2017 and were the lowest in July 2013, August 2016, July 2017 and August 2018. DO levels were significantly higher at Intermediate stations than at other 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 significantly higher in November 2017 than in other sampling periods. Ma Wan station had the significantly lowest Turbidity than at other 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 February 2019). 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 significantly higher in August 2013 when compared to all other sampling periods. The concentration of Nickel was significantly higher in April 2012 and August 2013. The concentration of Zinc was significantly higher in November 2017 when compared to all other sampling periods. Concentrations of Copper and Zinc were significantly lower at Intermediate stations than at other stations while concentrations of Nickel were significantly higher at Reference stations than other stations.

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 significantly higher in April 2012. Concentrations of NH_3-N were significantly lower at Intermediate stations than at other stations.

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 significantly higher in April 2012 and May 2018. Concentrations of TIN were significantly lower at Ma Wan station than at other 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 significantly higher in August 2016. Levels of BOD_5 were significantly lower at the Impact and Intermediate stations than at other 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 significantly higher in November 2017. SS levels were significantly higher 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 operations at CMP Vd of the ESC area.

3.2.17 *Pit Specific Sediment Chemistry of ESC CMP Vd*

Background

3.2.18 *Pit Specific Sediment Chemistry of ESC CMP Vd* was conducted once every month from January to March 2019 as presented in *Table 3.1*. A total of six (6) monitoring stations for ESC CMP Vd were sampled in each monitoring event and the monitoring locations are shown in *Figure 3.3*. The monitoring results showed that the concentrations of all inorganic contaminants were below the Lower Chemical Exceedance Levels (LCELs) at Pit-Edge and Near-Pit stations from January to March 2019, whilst the concentrations of some inorganic contaminants (e.g. Arsenic, Chromium, Copper, Lead, Mercury, Nickel, Silver and Zinc) were higher than LCEL / Upper Chemical Exceedance Level (UCEL) at Active Pit stations from January to March 2019.

Summary of Statistical Analyses

3.2.19 Statistical analyses were performed for data obtained from *Pit Specific Sediment Chemistry of ESC CMP Vd* since March 2016. 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*.

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. The concentrations of Cadmium, Chromium, Lead, Mercury and Zinc were significantly higher at the Active Pit stations than at the Pit Edge stations than at Near Pit stations. Subsequent linear regression analysis for Cadmium, Chromium, Copper, Lead, Mercury, Nickel and Zinc 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, Copper, Lead, Mercury, Nickel and Zinc 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.

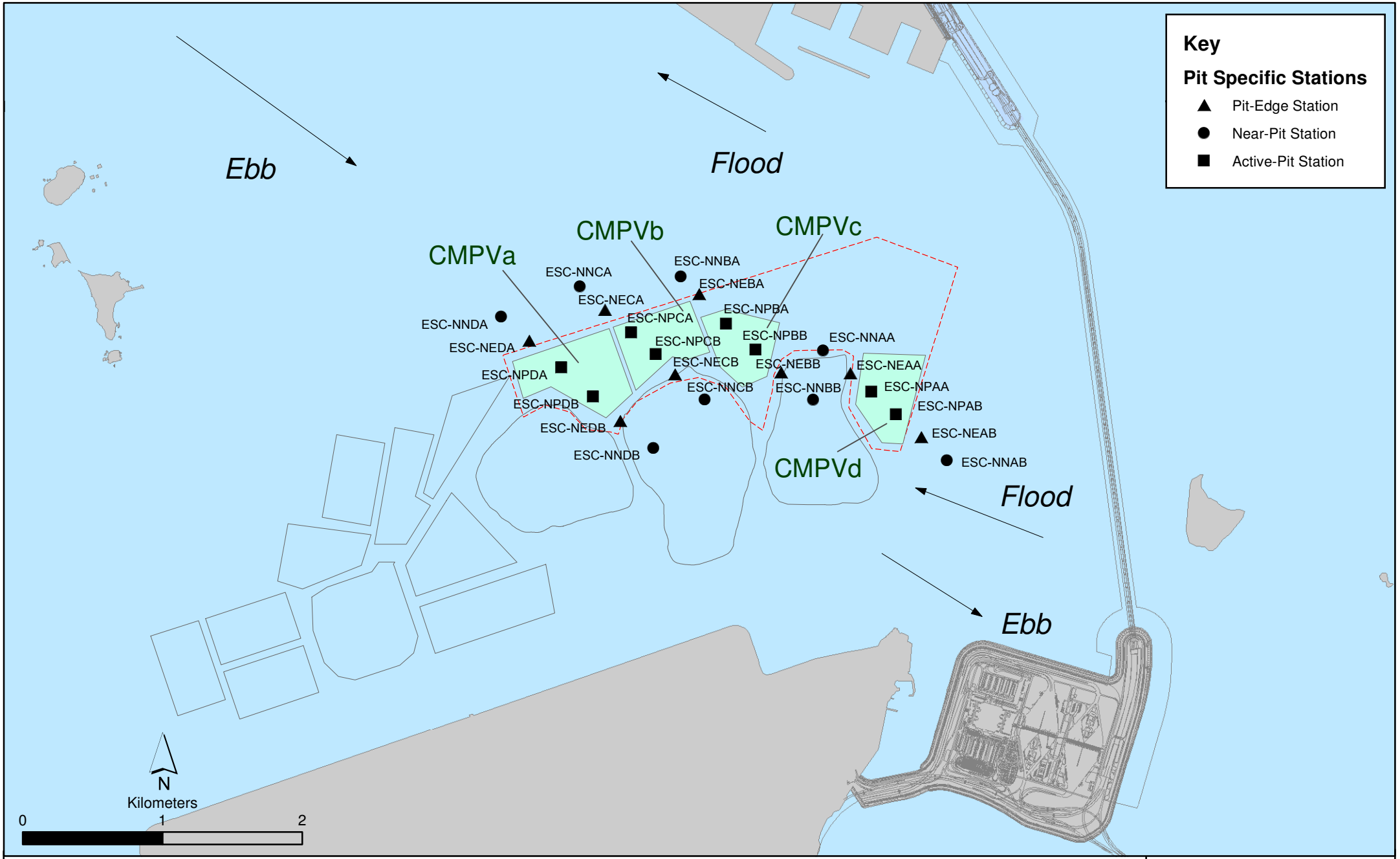

Figure 3.3

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

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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. It was significantly higher at the Active Pit stations than at the Pit Edge stations than at Near Pit stations. Subsequent linear regression analysis for TOC 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 TOC levels and proximity to the pit ($r^2 < 0.60$). There was no consistent temporal trend of increasing concentrations of TOC over time.

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 Vd.

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

Background

3.2.26 *Cumulative Impact Sediment Chemistry of ESC CMPs* was conducted in February 2019 as presented in *Table 3.1*. A total of nine (9) monitoring stations were sampled and the monitoring locations are shown in *Figure 3.4*. The monitoring results showed that the concentrations of all inorganic contaminants were generally below the LCELs at all monitoring stations in February 2019, except concentrations of Arsenic were higher than the LCEL at Mid-field stations ESC-RMA and ESC-RMB and Near-filed station ESC-RNA.

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.

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*.

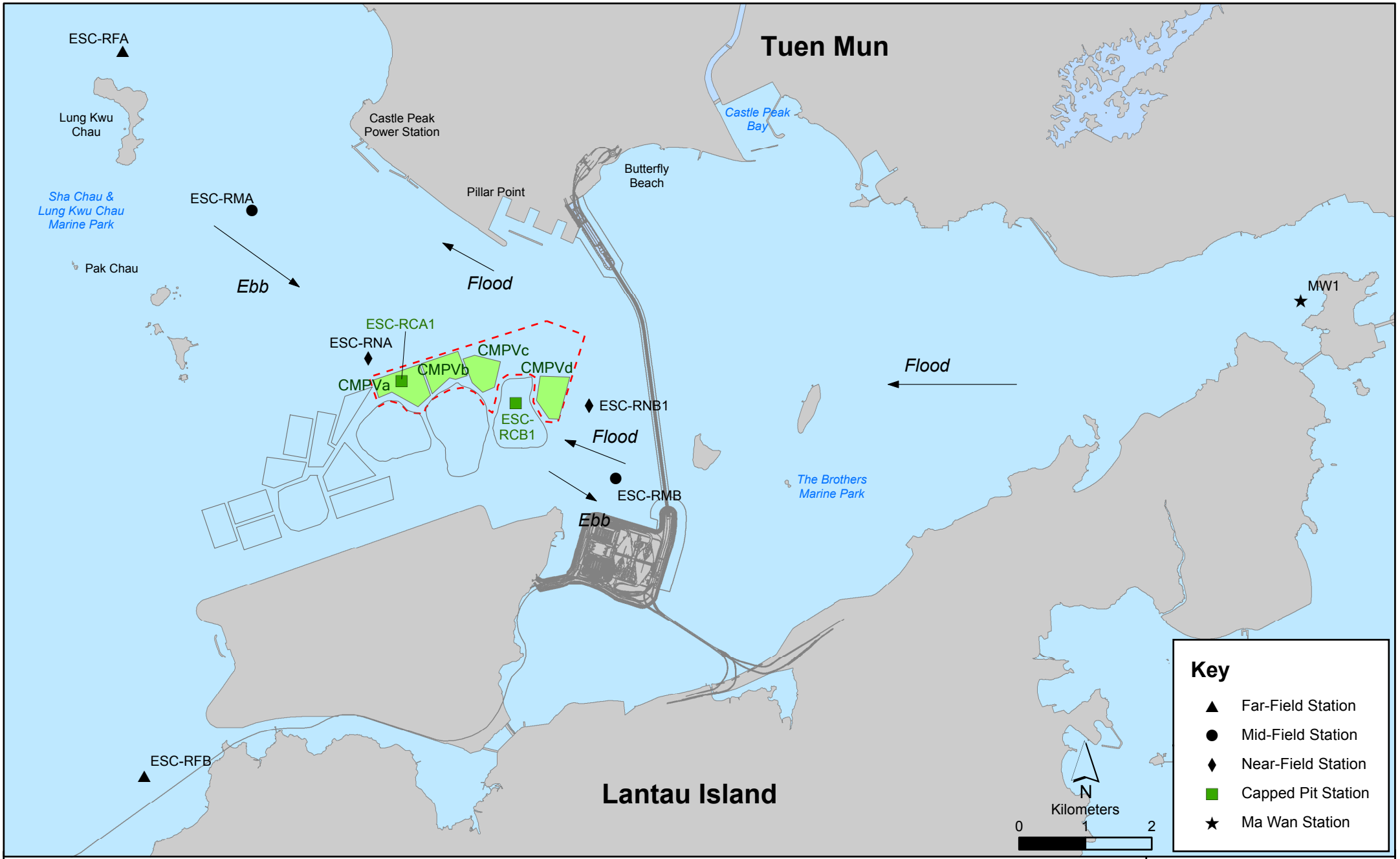

Figure 3.4

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

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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 significantly higher at Mid-Field or Ma Wan stations. The concentrations of all measured metals and metalloids 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. They were significantly higher at Ma Wan station than at other stations. 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 Vd during the quarterly period.

3.2.33 ***Sediment Toxicity Test – February 2019***

3.2.34 Sediment Toxicity Tests were undertaken for sediments collected from the Impact (Near Pit), Reference and Ma Wan stations (see *Figure 3.5* for the sampling locations) in February 2019 using three international species (burrowing amphipod *Leptocheirus plumulosus*, marine benthic polychaete *Neanthes arenaceodentata* and marine bivalve *Crassostrea gigas*) and two local species (barnacles *Balanus amphitrite* and shrimp *Penaeus vannaamei*).

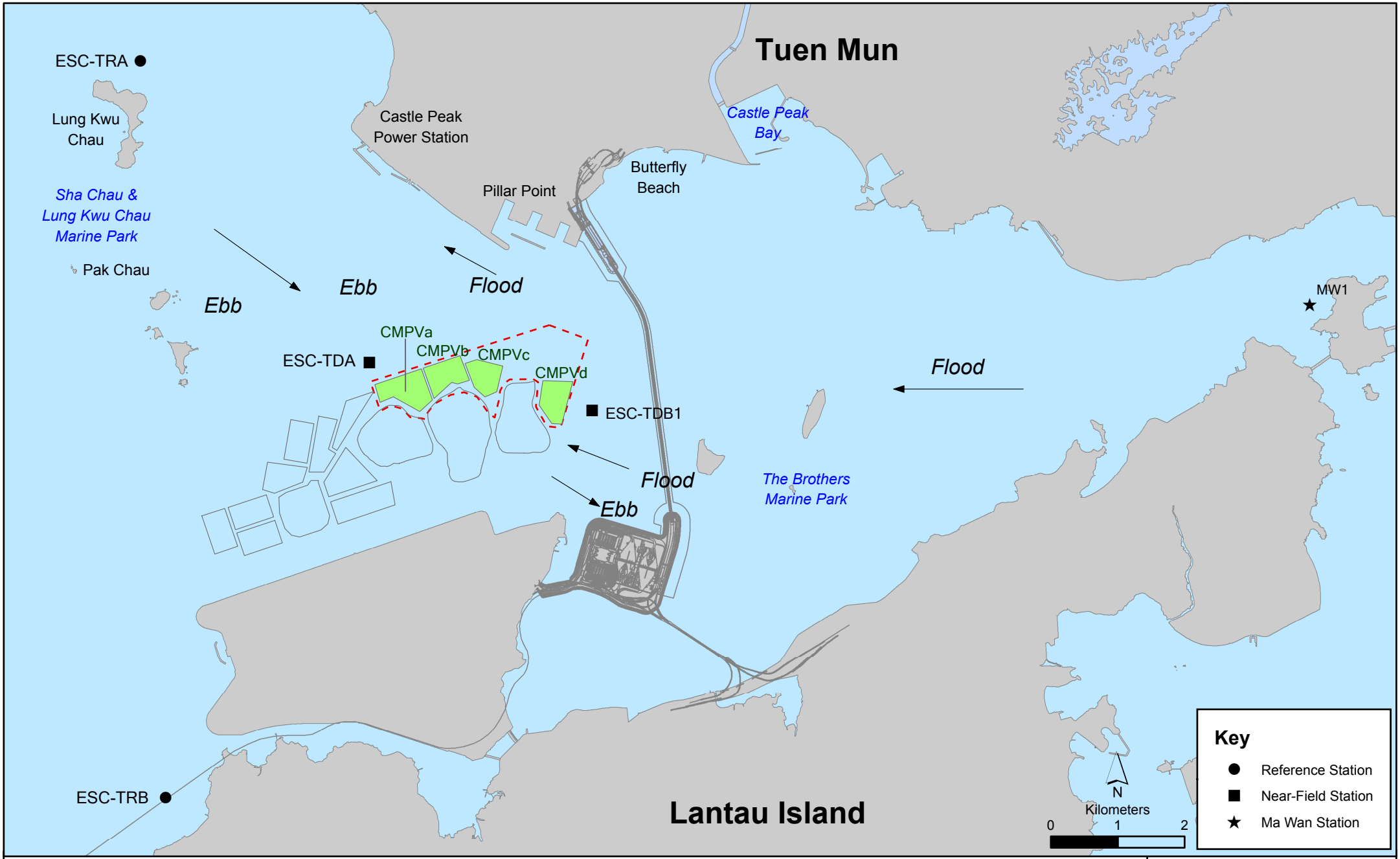

Figure 3.5

Sediment Toxicity Monitoring Stations for ESC CMPs

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

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3.2.35 Appropriate statistical test, i.e. ANOVA, was applied for comparing and determining the level of significance in the results in February 2019. For all of the ANOVA techniques, initial analyses were performed to ensure that the data are independent of each other, normally distributed and homogeneous. Should the data not comply with these assumptions then the appropriate transformation would be applied to the data. Data transformation (e.g. natural logarithm of chemical concentrations, square-root of a count and arcsine square-root of a proportion or percentage) would be used to reduce the within class heterogeneity of variance. If, after transformation, the data are still non-compliant (i.e. the residual errors are not normally distributed or variances are still heterogeneous) then rank transformed data would be applied to parametric or non-parametric equivalents to ANOVA such as Kruskal-Wallis tests. When significant difference are detected then multiple comparison procedures would be used (e.g. Student Newman Keuls Test or Turkey's HSD or Dunn's Test) to isolate where the differences is occurring.

3.2.36 Results of the Sediment Toxicity Tests in February 2019 showed that there were no significant differences between Impact and Reference stations in the toxicity tests of all marine benthos. Therefore, there did not appear to be any evidence of unacceptable impacts to sediment toxicity due to the mud disposal operations at ESC CMP Vd.

3.2.37 ***Demersal Trawling – January and February 2019***

3.2.38 Fishery resources monitoring by demersal trawling was carried out at two (2) impact and four (4) reference stations (see *Figure 3.6* for locations) in January and February 2019. Monitoring results are presented in the following sections.

Abundance and Biomass

3.2.39 The average number of species collected in the period of January and February 2019 is presented in *Table 3.2*. Mean number of faunal species caught at Impact stations was generally lower than at Reference stations in January and February 2019.

3.2.40 Biotic abundance, Biomass, Catch per Unit Effort (CPUE) and Yield per Unit Effort (YPUE) were lower at Impact stations ESC-INA and ESC-INB in January and February 2019 (*Table 3.3*). Annual trend and statistical analyses will be conducted in the Annual EM&A Review Report to determine whether there is any evidence of unacceptable impact to fishery resources caused by the mud disposal operations at ESC CMP Vd.

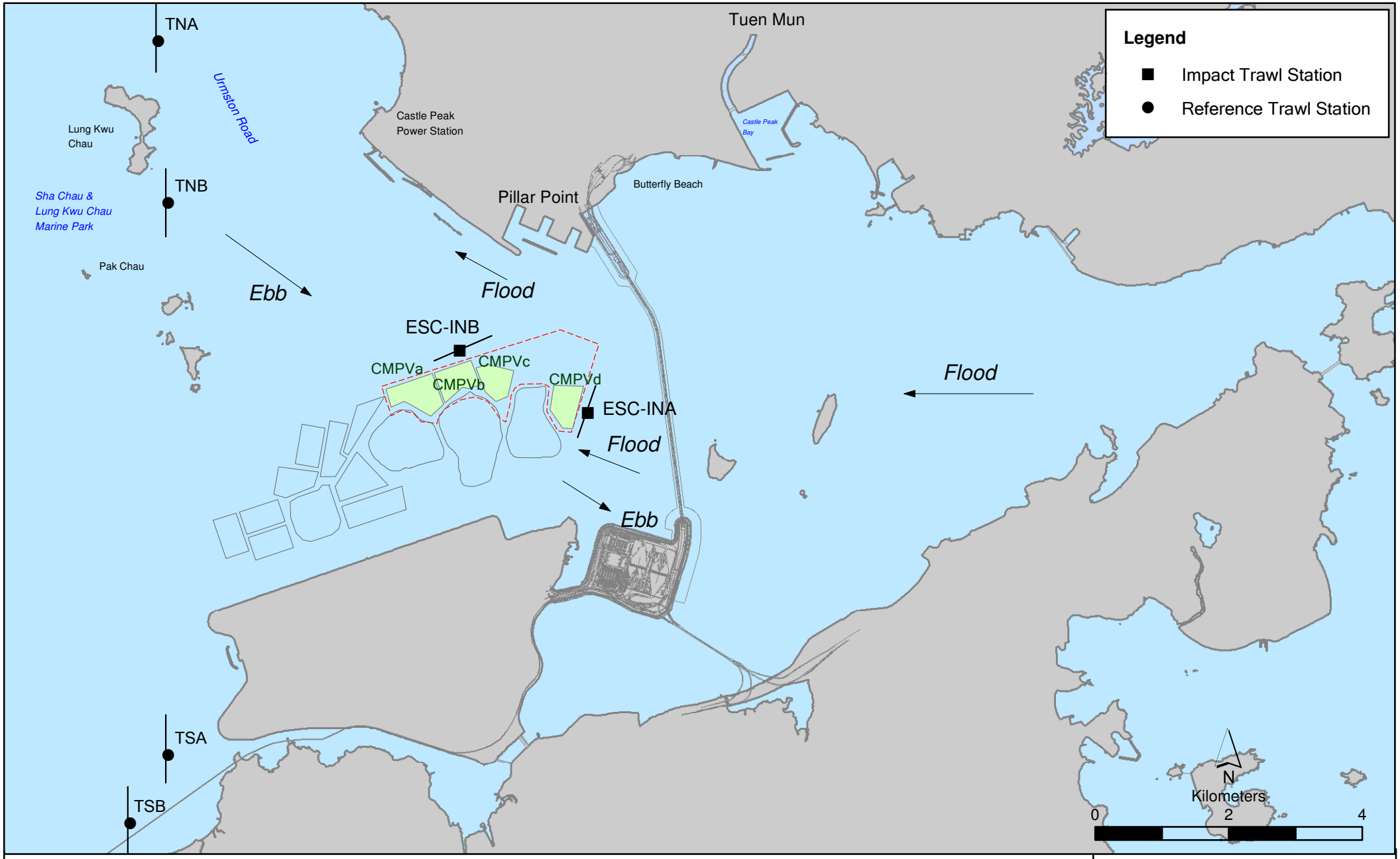

Figure 3.6

Marine Biota Monitoring Stations for CMPV

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Date: 2/6/2017

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Table 3.2 ***Summary of the Mean Number of Faunal Species Caught during January and February 2019 Monitoring***

Mean Number of Faunal Species	Impact Stations		Reference Stations			
	ESC-INA	ESC-INB	TNA	TNB	TSA	TSB
January 2019	28.8	21.2	27.2	36.4	47.4	44.0
February 2019	30.8	27.8	30.2	41.6	54.8	48.8

Table 3.3 **Summary of CPUE and YPUE during January and February 2019 Monitoring**

Date	Stations	Stations	No. of Individuals per Station	Total Biomass per Station (g)	Mean CPUE[#1] per Tow (No. / hr / net)	Mean YPUE[#2] per Tow (g / hr / net)
Jan 2019	ESC-INA	Impact	2,658	34,682	532	6,937
Jan 2019	ESC-INB	Impact	2,012	22,807	402	4,561
Jan 2019	TNA	Reference	2,706	40,696	541	8,139
Jan 2019	TNB	Reference	4,608	70,967	922	14,193
Jan 2019	TSA	Reference	19,176	329,255	3,835	65,851
Jan 2019	TSB	Reference	2,624	51,454	525	10,291
Feb 2019	ESC-INA	Impact	1,280	17,771	256	3,554
Feb 2019	ESC-INB	Impact	946	11,211	189	2,242
Feb 2019	TNA	Reference	1,680	16,789	336	3,358
Feb 2019	TNB	Reference	3,109	46,251	622	9,250
Feb 2019	TSA	Reference	2,131	61,523	426	12,305
Feb 2019	TSB	Reference	1,531	35,316	306	7,063

Notes:

#1 CPUE is calculated by dividing the number of individuals with the trawling time and number of nets (in hour and number of nets)

#2 YPUE is calculated by dividing the weight (g) of fish with trawling effort (in hour and number of nets)

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 of demersal trawling monitoring on 21 February 2019. Three monitoring stations were sampled, each had 5 replicate trawl with at least 6 nets. The samples were then sorted on site and non-target species were released to the sea after sorting. The target species were then collected for further measurement and tissue / wholebody sample preparation in the laboratory. The IA was satisfied with the sample collection 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 April to June 2019 for ESC CMPs include:

- *Water Column Profiling of ESC CMP Vd* in April, May and June 2019;
- *Routine Water Quality Monitoring of ESC CMPs* in April and May 2019;
- *Pit Specific Sediment Chemistry of ESC CMP Vd* in April, May and June 2019; and
- *Cumulative Impact Sediment Chemistry of ESC CMPs* in June 2019.

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

Annex A

Sampling Schedule

Annex A - 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**	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	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	12	12	12	12	12	12	12	12	12
	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	12	12	12	12	12	12	12	12	12
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	12	12	12	12	12	12	12	12	12
	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	12	12	12	12	12	12	12	12	12
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	12	12	12	12	12	12	12	12	12
	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	12	12	12	12	12	12	12	12	12

Cumulative Impact Sediment Chemistry			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	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				12		12				12		12	
	ESC-RNB1	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
Mid-field Stations																																																	
	ESC-RMA	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
	ESC-RMB	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
Capped Pit Stations																																																	
	ESC-RCA1	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
	ESC-RCB1	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
Far-Field Stations																																																	
	ESC-RFA	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
	ESC-RFB	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	
Ma Wan Station																																																	
	MW1	4 times per year			12		12				12		12				12		12				12		12				12		12				12		12				12		12				12		12	

Sediment Toxicity Tests			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	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						5	
	ESC-TDB1	2 times per year					5						5						5						5						5						5						5						5	
Reference Stations																																																	
	ESC-TRA	2 times per year					5						5						5						5						5						5						5						5	
	ESC-TRB	2 times per year					5						5						5						5						5						5						5						5	
Ma Wan Station																																																	
	MW1	2 times per year					5						5						5						5						5						5						5						5	

Tissue/ Whole Body Sampling			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	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			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	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					5	5	
	ESC-INB	4 times per year				5	5					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					5	5	
	TNB	4 times per year				5	5					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					5	5	
	TSB	4 times per year				5	5					5	5					5	5					5	5					5	5					5	5					5	5					5	5	

Capping			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	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				3		3				3		3				3		3	
	ESC-IPE2A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPE3	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPE4	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPE5	4 times per year																							3				3		3				3		3				3		3				3		3	
Intermediate Station Downcurrent																																																	
	ESC-INE1A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INE2A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INE3A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INE4A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INE5A	4 times per year																							3				3		3				3		3				3		3				3		3	
Reference Station Upcurrent																																																	
	ESC-RFE1	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFE2	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFE3	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFE4	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFE5	4 times per year																							3				3		3				3		3				3		3				3		3	
Ma Wan Station																																																	
	MW1	4 times per year																							3				3		3				3		3				3		3				3		3	
Flood Tide																																																	
Impact Station Downcurrent																																																	
	ESC-IPF1	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPF2	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-IPF3	4 times per year																							3				3		3				3		3				3		3				3		3	
Intermediate Station Downcurrent																																																	
	ESC-INF1	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INF2	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-INF3	4 times per year																							3				3		3				3		3				3		3				3		3	
Reference Station Upcurrent																																																	
	ESC-RFF1A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFF2A	4 times per year																							3				3		3				3		3				3		3				3		3	
	ESC-RFF3	4 times per year																							3				3		3				3		3				3		3				3		3	
Ma Wan Station																																																	
	MW1	4 times per year																							3				3		3				3		3				3		3				3		3	

Routine Water Quality Monitoring			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	A	M	J	J	A	S	O	N	D	J	F	M
Ebb Tide																																																	
Impact Station Downcurrent																																																	
	ESC-IPE1A	8 times per year	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		8	8		8	8		8	8	
	ESC-IPE2A	8 times per year	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		8	8		8	8		8	8	
	ESC-IPE3	8 times per year	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		8	8		8	8		8	8	
	ESC-IPE4	8 times per year	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		8	8		8	8		8	8	
	ESC-IPE5	8 times per year	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		8	8		8	8		8	8	
Intermediate Station Downcurrent																																																	
	ESC-INE1A	8 times per year	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		8	8		8	8		8	8	
	ESC-INE2A	8 times per year	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		8	8		8	8		8	8	
	ESC-INE3A	8 times per year	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		8	8		8	8		8	8	
	ESC-INE4A	8 times per year	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		8	8		8	8		8	8	
	ESC-INE5A	8 times per year	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		8	8		8	8		8	8	
Reference Station Upcurrent																																																	
	ESC-RFE1	8 times per year	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		8	8		8	8		8	8	
	ESC-RFE2	8 times per year	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		8	8		8	8		8	8	
	ESC-RFE3	8 times per year	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		8	8		8	8		8	8	
	ESC-RFE4	8 times per year	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		8	8		8	8		8	8	
	ESC-RFE5	8 times per year	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		8	8		8	8		8	8	
Ma Wan Station																																																	
	MW1	8 times per year	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		8	8		8	8		8	8	
Flood Tide																																																	
Impact Station Downcurrent																																																	
	ESC-IPF1	8 times per year	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		8	8		8	8	
	ESC-IPF2	8 times per year	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		8	8		8	8	
	ESC-IPF3	8 times per year	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		8	8		8	8	
Intermediate Station Downcurrent																																																	
	ESC-INF1	8 times per year	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		8	8		8	8	
	ESC-INF2	8 times per year	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		8	8		8	8	
	ESC-INF3	8 times per year	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		8	8		8	8	
Reference Station Upcurrent																																																	
	ESC-RFF1A	8 times per year	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		8	8		8	8	
	ESC-RFF2A	8 times per year	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		8	8		8	8	
	ESC-RFF3	8 times per year	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		8	8		8	8	
Ma Wan Station																																																	
	MW1	8 times per year	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		8	8		8	8	

Water Column Profiling			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	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	4	4	4	4	4	4	4	4	4
	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	4	4	4	4	4	4	4	4	4

Benthic Recolonisation Studies			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	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			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	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.

Annex B

Disposal Records

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
1-Jan-2019	0	1,260,842
2-Jan-2019	500	1,261,342
3-Jan-2019	500	1,261,842
4-Jan-2019	500	1,262,342
5-Jan-2019	1,000	1,263,342
6-Jan-2019	0	1,263,342
7-Jan-2019	1,134	1,264,476
8-Jan-2019	1,000	1,265,476
9-Jan-2019	500	1,265,976
10-Jan-2019	1,000	1,266,976
11-Jan-2019	1,130	1,268,106
12-Jan-2019	1,000	1,269,106
13-Jan-2019	0	1,269,106
14-Jan-2019	852	1,269,958
15-Jan-2019	1,000	1,270,958
16-Jan-2019	500	1,271,458
17-Jan-2019	2,040	1,273,498
18-Jan-2019	1,863	1,275,361
19-Jan-2019	1,716	1,277,077
20-Jan-2019	521	1,277,598
21-Jan-2019	620	1,278,218
22-Jan-2019	664	1,278,882
23-Jan-2019	1,700	1,280,582
24-Jan-2019	2,200	1,282,782
25-Jan-2019	1,100	1,283,882
26-Jan-2019	1,600	1,285,482
27-Jan-2019	0	1,285,482
28-Jan-2019	1,100	1,286,582
29-Jan-2019	1,400	1,287,982
30-Jan-2019	500	1,288,482
31-Jan-2019	1,000	1,289,482
1-Feb-2019	500	1,289,982
2-Feb-2019	500	1,290,482
3-Feb-2019	0	1,290,482
4-Feb-2019	0	1,290,482
5-Feb-2019	0	1,290,482
6-Feb-2019	0	1,290,482
7-Feb-2019	0	1,290,482
8-Feb-2019	0	1,290,482
9-Feb-2019	1,500	1,291,982
10-Feb-2019	3,000	1,294,982
11-Feb-2019	3,200	1,298,182
12-Feb-2019	4,600	1,302,782
13-Feb-2019	4,600	1,307,382
14-Feb-2019	3,000	1,310,382
15-Feb-2019	2,000	1,312,382

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
16-Feb-2019	1,644	1,314,026
17-Feb-2019	500	1,314,526
18-Feb-2019	600	1,315,126
19-Feb-2019	600	1,315,726
20-Feb-2019	600	1,316,326
21-Feb-2019	1,108	1,317,434
22-Feb-2019	2,247	1,319,681
23-Feb-2019	1,100	1,320,781
24-Feb-2019	0	1,320,781
25-Feb-2019	1,062	1,321,843
26-Feb-2019	2,200	1,324,043
27-Feb-2019	2,089	1,326,132
28-Feb-2019	1,600	1,327,732
1-Mar-2019	1,600	1,329,332
2-Mar-2019	1,000	1,330,332
3-Mar-2019	500	1,330,832
4-Mar-2019	1,100	1,331,932
5-Mar-2019	1,684	1,333,616
6-Mar-2019	1,835	1,335,451
7-Mar-2019	500	1,335,951
8-Mar-2019	1,713	1,337,664
9-Mar-2019	2,336	1,340,000
10-Mar-2019	709	1,340,709
11-Mar-2019	1,741	1,342,450
12-Mar-2019	2,052	1,344,502
13-Mar-2019	3,568	1,348,070
14-Mar-2019	2,199	1,350,269
15-Mar-2019	3,348	1,353,617
16-Mar-2019	4,154	1,357,771
17-Mar-2019	0	1,357,771
18-Mar-2019	2,793	1,360,564
19-Mar-2019	3,457	1,364,021
20-Mar-2019	1,852	1,365,873
21-Mar-2019	5,458	1,371,331
22-Mar-2019	1,823	1,373,154
23-Mar-2019	1,537	1,374,691
24-Mar-2019	625	1,375,316
25-Mar-2019	1,231	1,376,547
26-Mar-2019	1,232	1,377,779
27-Mar-2019	1,227	1,379,006
28-Mar-2019	3,502	1,382,508
29-Mar-2019	2,465	1,384,973
30-Mar-2019	641	1,385,614
31-Mar-2019	0	1,385,614

Annex C

Statistical Analysis

Routine Water Quality Monitoring for ESC CMPs – Analysis of Variance and Linear Regression Analysis up to February 2019

Dissolved Oxygen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	1138221.485	3	379407.162	11.588	**
Period	1200041642.857	36	33334490.079	1018.076	**
Area * Period	64468584.942	108	596931.342	18.231	**
Error	87422864.099	2670	32742.646		
Total	7463313199.500	2818			

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

Turbidity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	53090692.256	3	17696897.419	103.150	**
Period	758786374.081	36	21077399.280	122.854	**
Area * Period	189540845.017	108	1755007.824	10.229	**
Error	458075929.238	2670	171564.018		
Total	7463244271.000	2818			

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

SNK Results:

- Nov 17 > Oct 17 = Aug 13 ≥ **Jan 19** > Apr 17 ≥ Aug 18 = Apr 12 = Aug 12 = Nov 18 = Nov 16 ≥ Oct 16 ≥ Jul 18 = Nov 12 ≥ Jul 16 ≥ Jul 17 = May 16 = Oct 18 ≥ Apr 13 = Feb 12 ≥ Apr 16 ≥ Jan 17 = May 18 = Oct 12 ≥ Jul 12 ≥ Jan 18 = Aug 17 = Aug 16 ≥ Feb 13 ≥ Feb 18 = May 12 = Jan 13 = **Feb 19** = Apr 18 ≥ Jul 13 = 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	2422750229.391	35	69221435.125	747.855	**
Area	18525626.697	3	6175208.899	66.716	**
Station(Area)	33951607.791	24	1414650.325	15.284	**
Period * Area	401386524.606	102	3935162.006	42.515	**
Period * Station(Area)	503498648.471	300	1678328.828	18.132	**
Error	305818043.438	3304	92559.941		
Total	17914332424.500	3776			

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

SNK Results:

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

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	2400877385.182	35	68596496.719	445.767	**
Area	29019607.178	3	9673202.393	62.860	**
Station(Area)	71898465.649	24	2995769.402	19.468	**
Period * Area	440007387.997	102	4313797.922	28.033	**
Period * Station(Area)	301814432.493	300	1006048.108	6.538	**
Error	508432876.875	3304	153884.043		
Total	17879901583.000	3776			

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

SNK Results:

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

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	2824255356.842	35	80693010.195	709.803	**
Area	50576802.974	3	16858934.325	148.297	**
Station(Area)	59040748.044	24	2460031.168	21.639	**
Period * Area	293472753.267	102	2877183.856	25.309	**
Period * Station(Area)	475012904.615	300	1583376.349	13.928	**
Error	375610767.688	3304	113683.646		
Total	17952156673.000	3776			

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

SNK Results:

- Nov 17 > Jul 17 ≥ Oct 17 ≥ Feb 17 ≥ Apr 17 = Aug 17 = Feb 18 = Jan 18 = May 17 = Nov 18 = Jul 18 > Apr 18 > May 18 > Apr 12 > Feb 12 = Aug 13 > Oct 18 = Aug 18 ≥ Jul 12 = Nov 12 > Jul 13 ≥ **Feb 19** = May 16 = May 12 = **Jan 19** > Jan 17 = Jan 13 = Apr 13 = Oct 16 = Apr 16 = Oct 12 > Jul 16 = Nov 16 > 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	3095581433.787	35	88445183.822	760.190	**
Area	6159717.952	3	2053239.317	17.648	**
Station(Area)	19230823.406	24	801284.309	6.887	**
Period * Area	154435137.783	102	1514069.978	13.013	**
Period * Station(Area)	150797128.902	300	502657.096	4.320	**
Error	384407900.687	3304	116346.217		
Total	17944746796.000	3776			

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

SNK Results:

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

Total Inorganic Nitrogen

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	2836048491.220	35	81029956.892	1199.903	**
Area	63067150.559	3	21022383.520	311.302	**
Station(Area)	78391126.701	24	3266296.946	48.368	**
Period * Area	212044993.849	102	2078872.489	30.784	**
Period * Station(Area)	216203274.328	300	720677.581	10.672	**
Error	223120579.313	3304	67530.442		
Total	17952161245.500	3776			

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

BOD_5

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1579530873.948	35	45129453.541	176.090	**
Area	58160335.536	3	19386778.512	75.645	**
Station(Area)	39195474.298	24	1633144.762	6.372	**
Period * Area	738808985.685	102	7243225.350	28.262	**
Period * Station(Area)	608235917.377	300	2027453.058	7.911	**
Error	846770426.500	3304	256286.449		
Total	17938192957.500	3776			

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

SNK Results:

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

Suspended Solids

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	2250534345.641	35	64300981.304	1445.876	**
Area	19786688.255	3	6595562.752	148.308	**
Station(Area)	200465621.846	24	8352734.244	187.820	**
Period * Area	472297105.441	102	4630363.779	104.119	**
Period * Station(Area)	935129912.129	300	3117099.707	70.091	**
Error	146935492.500	3304	44472.001		
Total	17951674404.000	3776			

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

SNK Results:

- Nov 17 > Jul 12 > Nov 12 > **Jan 19** > Nov 16 = Jul 16 = Oct 16 = Aug 12 > Apr 12 ≥ Apr 17 = Oct 17 ≥ May 16 = Oct 12 > Aug 13 > Jan 17 = Nov 18 = Aug 18 = Jul 18 = Apr 16 ≥ Jul 17 = Oct 18 = Apr 13 > Feb 12 > Jan 18 > Aug 16 > May 18 = Feb 13 > Feb 18 = Jan 13 = Apr 18 > Aug 17 > **Feb 19** = May 13 > 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	-0.181	0.104	0.011	**

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

Pit Specific Sediment Chemistry for ESC CMP Vd – Analysis of Variance (up to March 2019)

Arsenic

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	893222736.373	36	24811742.677	337.021	**
Area	7380996.248	2	3690498.124	50.129	**
Station(Area)	137239293.031	3	45746431.010	621.380	**
Period * Area	187570292.388	72	2605142.950	35.386	**
Period * Station(Area)	143061673.577	107	1337024.987	18.161	**
Error	178751015.334	2428	73620.682		
Total	6199596472.000	2649			

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

SNK Results:

- Oct 17 = Jul 18 = Jun 18 = Oct 18 = Nov 18 = **Feb 19** ≥ **Jan 19** ≥ **Mar 19** = May 18 = Jul 17 = Nov 17 = Mar 18 > Sep 18 = Aug 18 ≥ Aug 16 = Sep 17 = Aug 17 ≥ Dec 18 ≥ Apr 18 = Dec 17 = Feb 18 = Jan 18 = Mar 16 > May 17 ≥ Jun 17 ≥ Jul 16 ≥ Apr 16 = Feb 17 = Apr 17 > Oct 16 = May 16 = Nov 16 > Mar 17 = Jun 16 = Jan 17 = Sep 16 > Dec 16
- Active Pit ≥ Pit Edge = Near Pit

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	466713264.911	36	12964257.359	103.647	**
Area	352680638.454	2	176340319.227	1409.809	**
Station(Area)	31612715.767	3	10537571.922	84.246	**
Period * Area	151971772.592	72	2110719.064	16.875	**
Period * Station(Area)	219566196.521	107	2052020.528	16.406	**
Error	303321443.849	2425	125081.008		
Total	6169117953.000	2646			

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

SNK Results:

- Oct 18 = Jun 18 > Jun 16 = May 17 ≥ Dec 17 = Mar 18 = Jul 17 ≥ May 18 ≥ Nov 17 = Oct 17 ≥ Sep 17 = Aug 17 = Apr 16 ≥ Apr 18 ≥ May 16 ≥ Sep 16 = Nov 18 = Aug 16 = Feb 17 ≥ Jun 17 = Feb 18 = Jan 18 = Dec 16 ≥ Sep 18 ≥ Aug 18 = Mar 17 ≥ Nov 16 = Mar 16 = Apr 17 = Jan 17 = Jul 16 ≥ **Jan 19** = Feb 19 ≥ Dec 18 = **Mar 19** = Jul 18 > Oct 16
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-0.049	0.296	0.087	**

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

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	506144507.336	36	14059569.648	101.060	**
Area	90020159.701	2	45010079.851	323.533	**
Station(Area)	66099037.813	3	22033012.604	158.374	**
Period * Area	300706133.753	72	4176474.080	30.021	**
Period * Station(Area)	246524320.170	107	2303965.609	16.561	**
Error	337784329.401	2428	139120.399		
Total	6199696542.000	2649			

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

SNK Results:

- Jul 17 > Oct 17 > Mar 16 ≥ Oct 18 = Jun 18 ≥ Nov 17 ≥ **Mar 19** ≥ **Jan 19** = **Feb 19** = Jul 18 = Nov 18 = Sep 17 = Aug 17 = Jun 16 = Mar 18 = Apr 16 ≥ May 18 ≥ Aug 16 ≥ Feb 18 ≥ Jan 18 ≥ Jul 16 ≥ Aug 18 ≥ Sep 18 = Dec 18 = Sep 16 = Apr 18 = Nov 16 = May 16 = Dec 16 = Feb 17 = Oct 16 > May 17 = Dec 17 = Jan 17 > Mar 17 = Jun 17 > Apr 17
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-3.160	0.191	0.036	**

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

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	265724566.162	36	7381237.949	80.911	**
Area	518933212.588	2	259466606.294	2844.184	**
Station(Area)	69618652.195	3	23206217.398	254.379	**
Period * Area	227609263.237	72	3161239.767	34.652	**
Period * Station(Area)	248317948.423	107	2320728.490	25.439	**
Error	221499352.996	2428	91227.081		
Total	6199696931.500	2649			

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

SNK Results:

- Nov 18 > **Mar 19** = Oct 17 ≥ Nov 17 = Mar 18 = Oct 18 = Jun 18 ≥ May 18 = Dec 17 ≥ Aug 16 ≥ **Jan 19** = **Feb 19** = Feb 18 = Apr 18 = Sep 18 = Sep 17 = Aug 17 = Dec 18 = Aug 18 = Jul 18 = Sep 16 = Feb 17 = Jun 16 = Jan 18 > Apr 16 ≥ Jun 17 ≥ Mar 16 = Dec 16 ≥ May 16 ≥ May 17 = Mar 17 = Oct 16 = Jan 17 = Jul 17 = Nov 16 = Jul 16 > Apr 17
- Active Pit > Near Pit > Pit Edge

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-25.436	0.167	0.028	**

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

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	384161652.292	36	10671157.008	69.173	**
Area	158893224.634	2	79446612.317	514.995	**
Station(Area)	166955601.020	3	55651867.007	360.751	**
Period * Area	215163471.342	72	2988381.546	19.372	**
Period * Station(Area)	248926473.962	107	2326415.645	15.080	**
Error	374559383.158	2428	154266.632		
Total	6199696655.500	2649			

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

SNK Results:

- Mar 17 > Nov 18 = **Mar 19** = Oct 18 = Jul 17 ≥ Jun 18 = Oct 17 ≥ May 17 ≥ Jul 18 ≥ **Jan 19** = **Feb 19** = Jun 17 = Sep 17 = Aug 17 ≥ May 18 = Mar 18 = Nov 17 ≥ Apr 16 ≥ Mar 16 = Dec 18 = Jan 18 = Jul 16 = Jun 16 = Aug 16 ≥ Nov 16 = Apr 17 = Aug 18 ≥ Sep 18 = Feb 18 = May 16 = Dec 17 = Apr 18 = Oct 16 = Feb 17 > Dec 16 > Sep 16 = Jan 17
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-4.485	0.198	0.039	**

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

Mercury

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	926737510.573	36	25742708.627	222.823	**
Area	48348369.475	2	24174184.737	209.247	**
Station(Area)	4662196.109	3	1554065.370	13.452	**
Period * Area	143590504.943	72	1994312.569	17.262	**
Period * Station(Area)	97377380.625	107	910068.978	7.877	**
Error	280506043.264	2428	115529.672		
Total	6160370000.500	2649			

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

SNK Results:

- Apr 16 = Mar 16 > May 16 = Jun 16 > Sep 16 = Jul 16 = Aug 16 ≥ Oct 16 = Jun 17 = Nov 16 > Dec 16 = May 17 = May 18 = Oct 18 = Nov 17 = Jan 17 > Mar 17 = Jun 18 = Apr 17 = Feb 17 = Sep 18 = Jul 17 = Oct 17 = Jul 18 > Aug 18 ≥ Dec 17 = Sep 17 = Aug 17 = **Jan 19** = **Feb 19** = **Mar 19** = Nov 18 > Dec 18 > Mar 18 = Jan 18 = Feb 18 = Apr 18
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-0.039	0.125	0.016	**

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

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	416238452.208	36	11562179.228	138.668	**
Area	151808309.747	2	75904154.874	910.336	**
Station(Area)	186433354.520	3	62144451.507	745.313	**
Period * Area	319535985.486	72	4437999.798	53.226	**
Period * Station(Area)	270898254.308	107	2531759.386	30.364	**
Error	202447591.729	2428	83380.392		
Total	6199696053.500	2649			

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

SNK Results:

- Jul 17 = Oct 17 > Jun 18 = Oct 18 = Mar 16 = May 17 = Jun 17 ≥ Nov 18 = Nov 17 ≥ **Mar 19** ≥ Sep 17 = Aug 17 = **Jan 19** = **Feb 19** = Apr 16 = Jul 16 = Jul 18 = Jun 16 > Dec 18 = May 18 = Mar 18 = Jan 18 ≥ Nov 16 = Aug 18 = Sep 18 ≥ Feb 18 = May 16 ≥ Aug 16 ≥ Sep 16 = Apr 18 = Dec 17 = Dec 16= Feb 17 = Jan 17 = Apr 17 > Mar 17 > Oct 16
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis					
Source	Df	Slope	r	r^2	P
Area	1	-2.098	0.235	0.055	**

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

Silver

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	195698906.941	36	5436080.748	51.386	**
Area	529300745.959	2	264650372.980	2501.686	**
Station(Area)	15036987.649	3	5012329.216	47.381	**
Period * Area	278467718.723	72	3867607.204	36.560	**
Period * Station(Area)	265714979.230	107	2483317.563	23.474	**
Error	256749381.162	2427	105788.785		
Total	6190871919.500	2648			

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

SNK Results:

- Dec 17 ≥ Nov 17 ≥ May 17 ≥ **Mar 19** = Apr 17 ≥ May 18 = Aug 16 = Jun 16 = Jun 18 = Oct 18 = Mar 18 = Jun 17 ≥ Mar 17 = Feb 17 = Jul 17 = Sep 16 = Oct 17 ≥ Apr 18 ≥ Nov 18 = Feb 18 = **Feb 19** = Sep 17 = Aug 17 = Jan 18 = Mar 16 = Apr 16 = Sep 18 = May 16 = Aug 18 ≥ **Jan 19** = Dec 16 = Jul 16 ≥ Nov 16 = Dec 18 = Jan 17 = Jul 18 > Oct 16
- Active Pit > Near Pit > Pit Edge

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	524809499.995	36	14578041.667	174.690	**
Area	194778643.344	2	97389321.672	1167.022	**
Station(Area)	153029441.840	3	51009813.947	611.254	**
Period * Area	268631334.949	72	3730990.763	44.709	**
Period * Station(Area)	203438888.334	107	1901298.022	22.783	**
Error	202619338.814	2428	83451.128		
Total	6199693258.500	2649			

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

SNK Results:

- Nov 18 > Jul 17 = Oct 17 = Jun 18 = Oct 18 = **Mar 19** ≥ Nov 17 = May 18 = Mar 18 ≥ **Feb 19** ≥ Jul 18 = Apr 18 = Mar 16 = Feb 18 ≥ **Jan 19** ≥ Sep 17 = Aug 17 = Apr 16 = Jan 18 = Aug 16 = Dec 17 ≥ Jun 16 = Sep 18 = Aug 18 ≥ Dec 18 = Jul 16 > Nov 16 ≥ May 16 = Oct 16 = May 17 > Feb 17 = Dec 16 > Mar 17 = Jan 17 > Jun 17 = Sep 16 = Apr 17
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-18.386	0.261	0.068	**

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

Total Organic Carbon

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	497936496.819	36	13831569.356	154.346	**
Area	91032851.281	2	45516425.641	507.918	**
Station(Area)	70992991.688	3	23664330.563	264.070	**
Period * Area	316872209.136	72	4401002.905	49.111	**
Period * Station(Area)	354842007.142	107	3316280.441	37.006	**
Error	217582314.721	2428	89613.803		
Total	6199263386.500	2649			

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

SNK Results:

- Oct 17 = Feb 18 ≥ Jun 18 ≥ Dec 18 ≥ Apr 16 ≥ Aug 18 = Nov 18 = Jul 17 = May 18 = Mar 16 = Dec 17 = Mar 18 = Jul 18 ≥ **Feb 19** ≥ Jun 16 ≥ Aug 16 = Jul 16 = **Jan 19** = Nov 17 = **Mar 19** = Nov 16 = Jan 17 > May 17 ≥ Sep 16 = Oct 16 = Dec 16 = May 16 = Apr 18 = Sep 18 = Sep 17 = Aug 17 = Oct 18 = Jun 17 > Jan 18 > Mar 17 = Apr 17 = Feb 17
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-870.503	0.229	0.053	**

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

Cumulative Impact Sediment Chemistry for ESC CMPs – Analysis of Variance (up to February 2019)

Arsenic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	48027531.273	11	4366139.207	436.352	**
Area	31937662.881	4	7984415.720	797.963	**
Area * Station	1119342.351	4	279835.588	27.967	**
Period * Area	81324591.030	43	1891269.559	189.014	**
Period * Area * Station	5251425.087	44	119350.570	11.928	**
Error	11887119.917	1188	10005.993		
Total	726417335.500	1296			

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

SNK Results:

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

Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	25464749.391	11	2314977.217	54.310	**
Area	12643319.211	4	3160829.803	74.154	**
Area * Station	40169533.280	4	10042383.320	235.598	**
Period * Area	37932330.178	43	882147.213	20.695	**
Period * Area * Station	13194394.345	44	299872.599	7.035	**
Error	50638655.250	1188	42625.131		
Total	724846050.500	1296			

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

SNK Results:

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

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	12158808.285	11	1105346.208	79.803	**
Area	56825920.343	4	14206480.086	1025.675	**
Area * Station	13779212.904	4	3444803.226	248.707	**
Period * Area	46936662.932	43	1091550.301	78.807	**
Period * Area * Station	16607179.669	44	377435.902	27.250	**
Error	16454828.500	1188	13850.866		
Total	726433978.500	1296			

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

SNK Results:

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

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	7562014.524	11	687455.866	51.278	**
Area	43063473.807	4	10765868.452	803.032	**
Area * Station	50169893.230	4	12542473.308	935.549	**
Period * Area	37739145.806	43	877654.554	65.465	**
Period * Area * Station	9022203.405	44	205050.077	15.295	**
Error	15926960.042	1188	13406.532		
Total	726434023.000	1296			

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

SNK Results:

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

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	57240440.878	11	5203676.443	373.229	**
Area	37877949.721	4	9469487.430	679.190	**
Area * Station	7381654.148	4	1845413.537	132.361	**
Period * Area	44282627.800	43	1029828.553	73.863	**
Period * Area * Station	9166238.269	44	208323.597	14.942	**
Error	16563477.042	1188	13942.321		
Total	726433986.000	1296			

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

SNK Results:

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

Mercury

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	83574183.990	11	7597653.090	181.114	**
Area	2995818.352	4	748954.588	17.854	**
Area * Station	5981841.445	4	1495460.361	35.649	**
Period * Area	23213618.676	43	539851.597	12.869	**
Period * Area * Station	7272596.225	44	165286.278	3.940	**
Error	49793999.449	1187	41949.452		
Total	721688924.500	1295			

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

SNK Results:

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

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	12947156.563	11	1177014.233	96.604	**
Area	44534602.569	4	11133650.642	913.796	**
Area * Station	17991091.234	4	4497772.808	369.155	**
Period * Area	56358988.971	43	1310674.162	107.574	**
Period * Area * Station	20746024.964	44	471500.567	38.698	**
Error	14474542.292	1188	12183.958		
Total	726433837.500	1296			

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

SNK Results:

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

Silver

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	28616863.878	11	2601533.080	140.996	**
Area	48271152.998	4	12067788.250	654.043	**
Area * Station	43264381.576	4	10816095.394	586.205	**
Period * Area	12691329.463	43	295147.197	15.996	**
Period * Area * Station	14141203.039	44	321390.978	17.419	**
Error	21919859.250	1188	18451.060		
Total	726285690.500	1296			

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

SNK Results:

- Aug 18 > Dec 18 > Dec 17 = Feb 18 = Aug 16 = Aug 17 > **Feb 19** = Feb 17 = Jun 17 = Dec 16 > Jun 16 > 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	10735002.721	11	975909.338	105.615	**
Area	40422909.786	4	10105727.446	1093.660	**
Area * Station	33384695.483	4	8346173.871	903.238	**
Period * Area	54962188.701	43	1278190.435	138.328	**
Period * Area * Station	10493481.330	44	238488.212	25.810	**
Error	10977456.167	1188	9240.283		
Total	726433279.500	1296			

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

SNK Results:

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

TOC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	22773476.529	11	2070316.048	118.819	**
Area	34559342.757	4	8639835.689	495.855	**
Area * Station	9356108.836	4	2339027.209	134.241	**
Period * Area	58650492.624	43	1363964.945	78.280	**
Period * Area * Station	22187650.674	44	504264.788	28.941	**
Error	20699831.792	1188	17424.101		
Total	726376986.000	1296			

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

SNK Results:

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

TBT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	35055344.515	11	3186849.501	70.473	**
Area	34134369.936	4	8533592.484	188.710	**
Area * Station	5032165.858	4	1258041.464	27.820	**
Period * Area	14019598.567	43	326037.176	7.210	**
Period * Area * Station	13750868.476	44	312519.738	6.911	**
Error	53722026.917	1188	45220.561		
Total	715064435.000	1296			

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

Sediment Toxicity for ESC CMP Vd – February 2019

Survival rate for burrowing amphipod Leptochirus plumulosus

	Survival
Chi-Square	0.700
Df	2
Asymp. Sig.	NS

Note:
1. NS: No significant difference;
2. **: Significant difference

Growth rate for benthic polychaete Neanthes arenaceodentata

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.002	2	.001	.136	NS
Within Groups	.719	122	.006		
Total	.721	124			

Note:
1. NS: No significant difference;
2. **: Significant difference

Survival rate for marine bivalve Crassostrea gigas

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.956	2	7.478	.394	NS
Within Groups	2313.578	122	18.964		
Total	2328.534	124			

Note:
1. NS: No significant difference;
2. **: Significant difference

Mortality rate for barnacles Balanus Amphitrite

Source	Mortality
Chi-Square	0.400
Df	2
Asymp. Sig.	NS

Note:
1. NS: No significant difference;
2. **: Significant difference

Mortality rate for shrimp Penaeus vannaamei

Source	Mortality
Chi-Square	1.000
df	2
Asymp. Sig.	NS

Note:
1. NS: No significant difference;
2. **: Significant difference