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 – April to June 2019

Revision 0

August 2019

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v0	Quarterly EM&A Report for ESC CMPs	CY	RC	CAR	12/8/19

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CEDD Civil Engineering and Development Department

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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 – April to June 2019
Date of Report:	12 August 2019
Date prepared by ET:	12 August 2019
Date received by IA:	12 August 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.

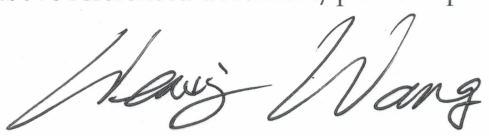
ET Certification

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: 12/8/2019

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: 12/8/2019

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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 April to June 2019

EXECUTIVE SUMMARY

Water Column Profiling, Routine Water Quality Monitoring, Pit Specific Sediment Chemistry and *Cumulative Impact Sediment Chemistry* were carried out for the Contaminated Mud Pits (CMPs) to the East of Sha Chau (ESC) during the quarterly period of April to June 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 – April to June 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 – April and May 2019

Results of Routine Water Quality Monitoring conducted in April and May 2019 showed that levels of DO, Salinity and pH generally complied with the WQOs at most 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 – April to June 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 – June 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.

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（二零一九年四月至六月）

行政摘要

在2019年4月至6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及沉積物化學累積性影響監察。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4月至6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4月和5月

2019年4月和5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、鹽度及酸鹼值大部分符合海水水質指標。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4月至6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6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。

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

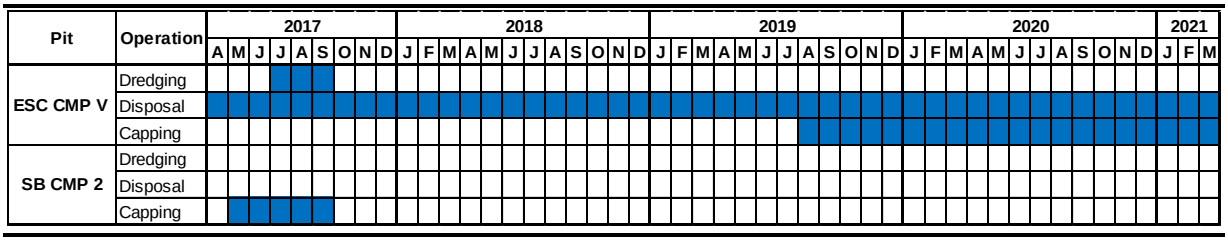
1.2.1 Detailed works schedule for ESC CMP V and SB CMPs is shown in *Figure 1.1*. During the reporting period of April to June 2019, the following works were being undertaken at the CMPs:

- 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 April to June 2019* is to provide information regarding the findings in the quarterly reporting period of April to June 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 April to June 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 April 2019 8 May 2019 5 June 2019	30 April 2019 5 June 2019 8 July 2019
Routine Water Quality Monitoring of ESC CMPs	3 April 2019 9 May 2019	30 April 2019 6 March 2019
Pit Specific Sediment Chemistry of ESC CMP Vd	2 April 2019 10 May 2019 3 June 2019	30 April 2019 5 June 2019 8 July 2019
Cumulative Impact Sediment Chemistry of ESC CMPs	3 and 4 June 2019	8 July 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 April to June 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 April, May and June 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 sixteen (16) and ten (10) stations were sampled in April and May 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 generally complied with the WQOs, except higher salinities were recorded at Ma Wan station in April and May 2019. The levels of DO, Turbidity and SS also complied with the Action and Limit Levels at all stations in April and May 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 May 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.

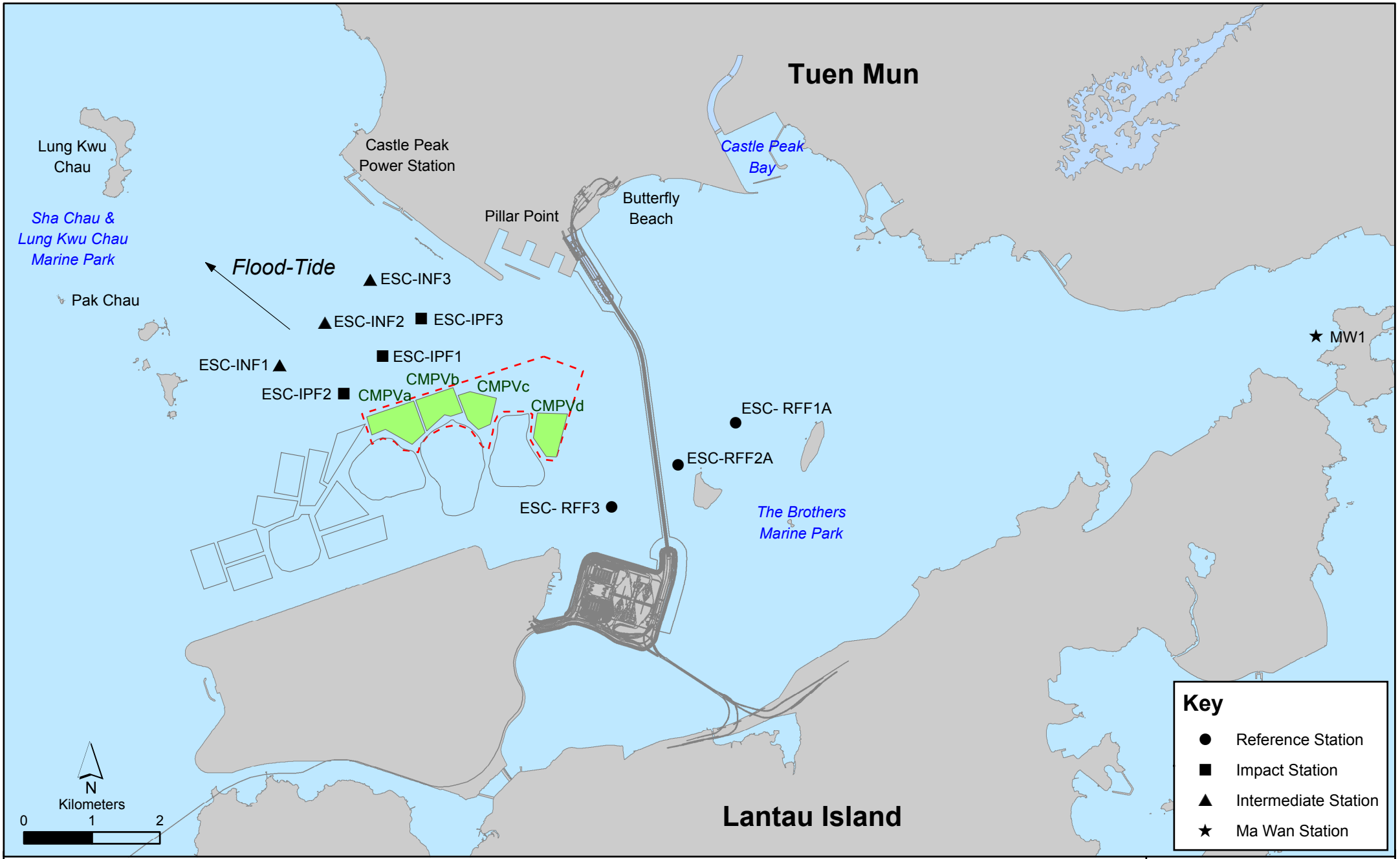


Figure 3.1

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

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Date: 25/4/2017

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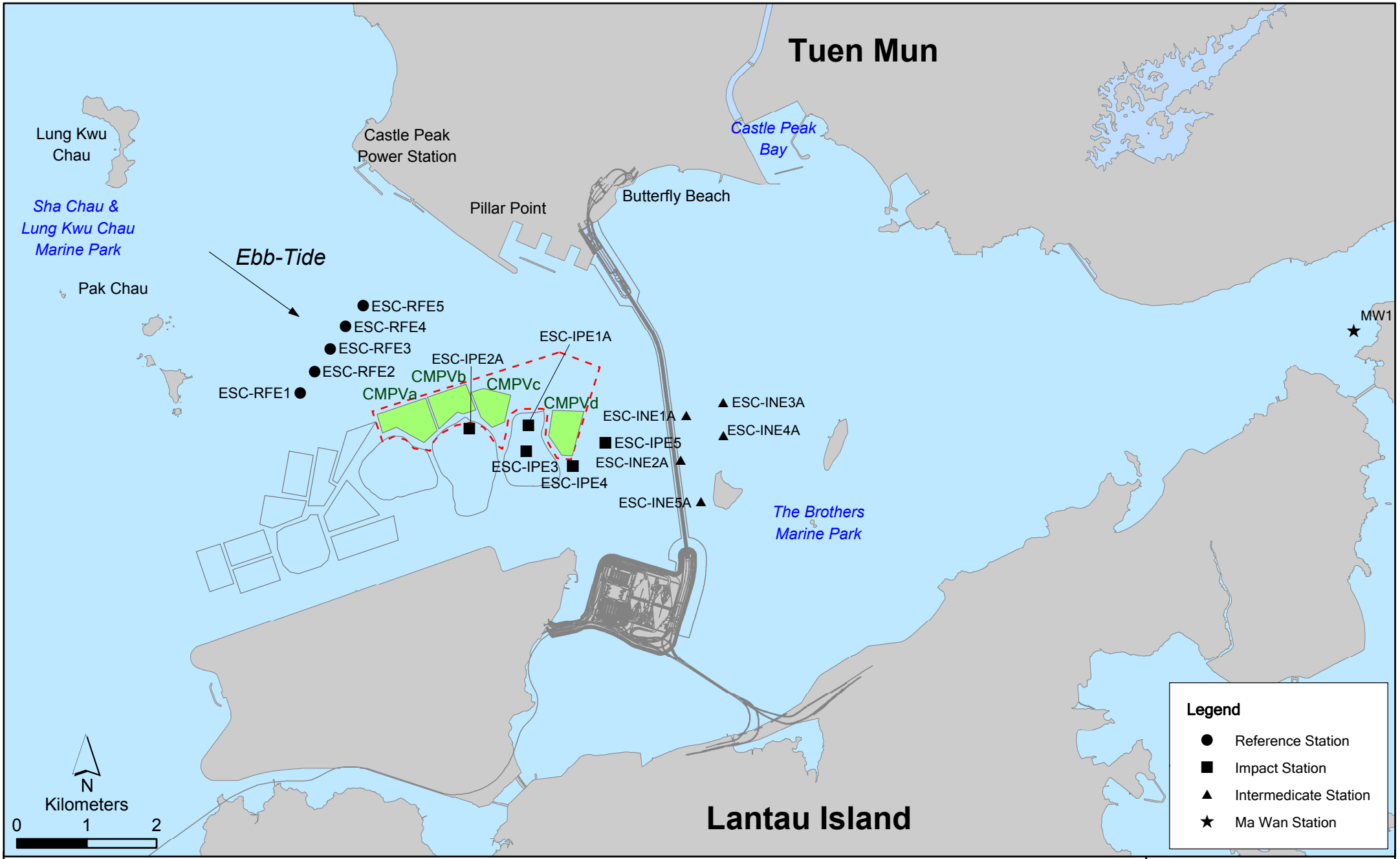

Figure 3.2

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 and July 2017. DO levels were significantly higher at Impact and 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 May 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, May 2013 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 April to June 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 Near-Pit stations April to June 2019, whilst the concentrations of some inorganic contaminants (e.g. Arsenic, Copper, Lead, Mercury and Silver) were higher than LCEL / Upper Chemical Exceedance Level (UCEL) at Active Pit and Near Pit stations from April to June 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, Copper, Lead, Mercury, Nickel 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

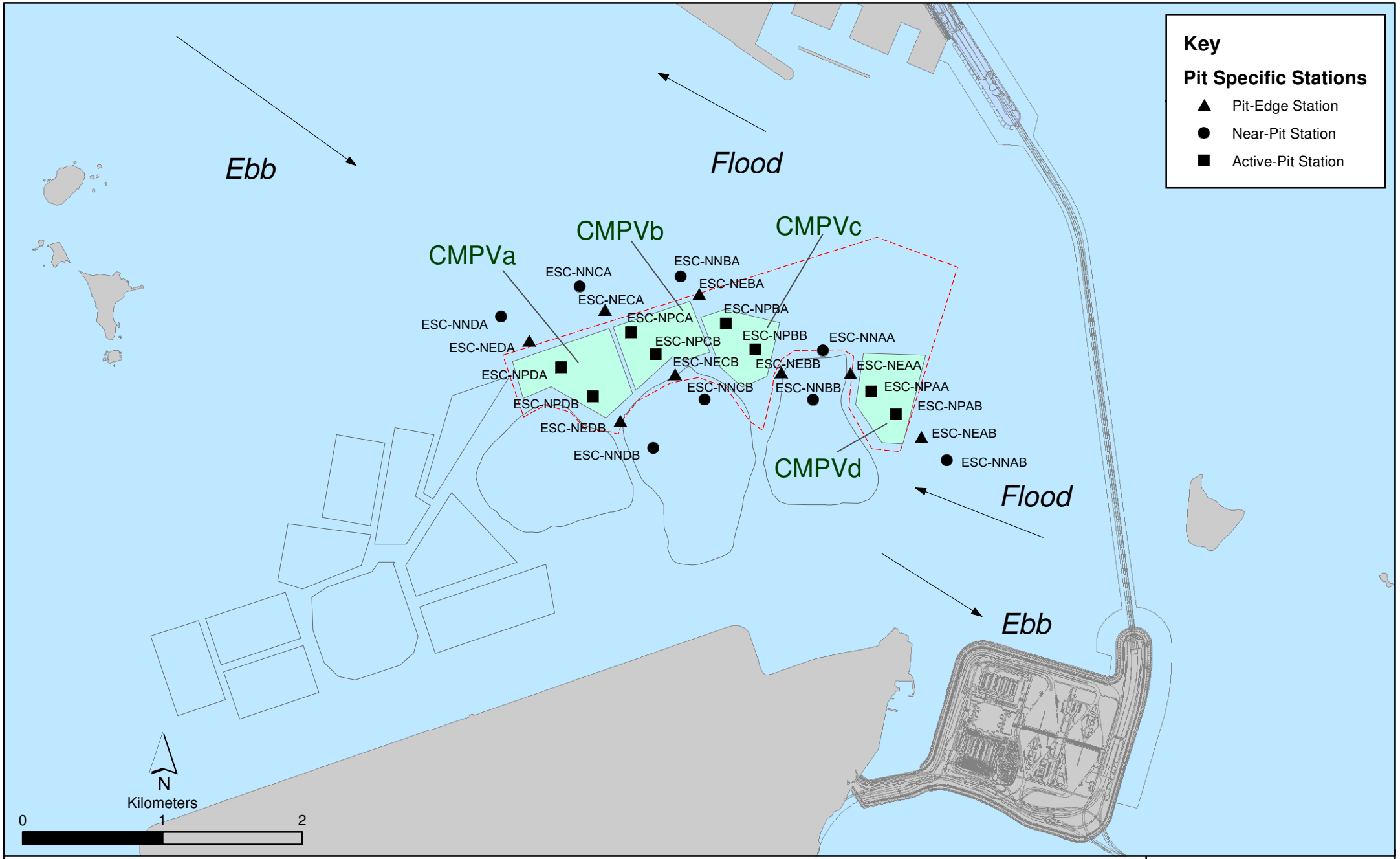

Figure 3.3

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

ERM

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. 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 June 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 June 2019, except concentrations of Arsenic were higher than the LCEL at Mid-field stations ESC-RMA and ESC-RMB, Far-field station ESC-RFB and Ma Wan station and concentrations of Copper were higher than the LCEL at 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.

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*.

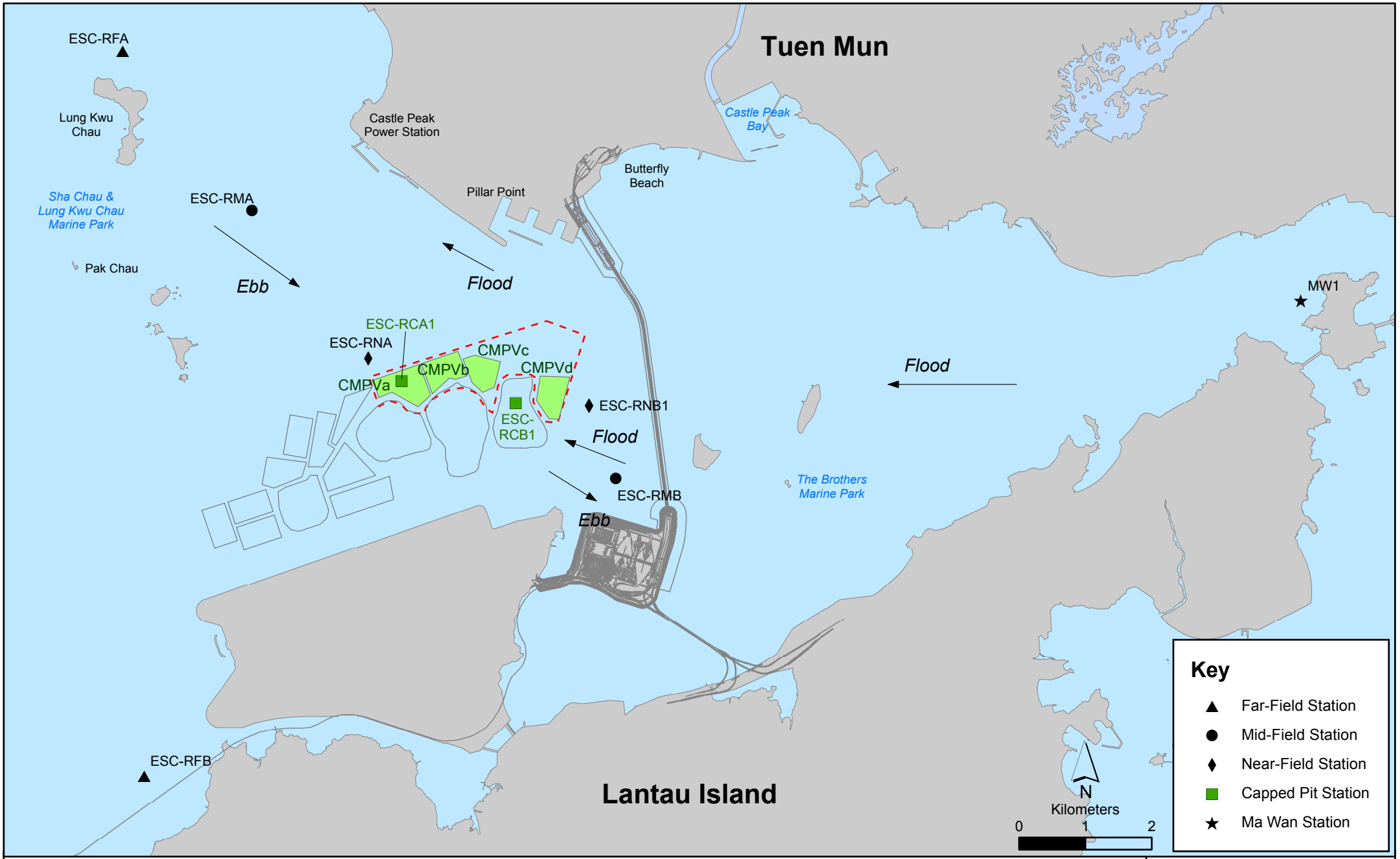

Figure 3.4

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

Environmental Resources Management

ERM

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.

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

4.1.1 During the reporting period of April to June 2019, there was no scheduled inspection conducted by the Independent Auditor (IA).

5 ACTIVITIES SCHEDULED FOR THE NEXT REPORTING PERIOD

5.1.1 The monitoring activities to be conducted in the next quarterly period of July to September 2019 for ESC CMPs include:

- *Water Column Profiling of ESC CMP Vd* in July, August and September 2019;
- *Routine Water Quality Monitoring of ESC CMPs* in July and August 2019;
- *Pit Specific Sediment Chemistry of ESC CMP Vd* in July, August and September 2019;
- *Cumulative Impact Sediment Chemistry of ESC CMPs* in August 2019;
- *Demersal Trawling for ESC CMPs* in July and August 2019; and
- *Sediment Toxicity Test of ESC CMPs* in August 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	
	ESC-IPE2A	4 times per year																													3				3		3				3		3				3		3	
	ESC-IPE3	4 times per year																													3				3		3				3		3				3		3	
	ESC-IPE4	4 times per year																													3				3		3				3		3				3		3	
	ESC-IPE5	4 times per year																													3				3		3				3		3				3		3	
Intermediate Station Downcurrent																																																		
	ESC-INE1A	4 times per year																													3				3		3				3		3				3		3	
	ESC-INE2A	4 times per year																													3				3		3				3		3				3		3	
	ESC-INE3A	4 times per year																													3				3		3				3		3				3		3	
	ESC-INE4A	4 times per year																													3				3		3				3		3				3		3	
	ESC-INE5A	4 times per year																													3				3		3				3		3				3		3	
Reference Station Upcurrent																																																		
	ESC-RFE1	4 times per year																													3				3		3				3		3				3		3	
	ESC-RFE2	4 times per year																													3				3		3				3		3				3		3	
	ESC-RFE3	4 times per year																													3				3		3				3		3				3		3	
	ESC-RFE4	4 times per year																													3				3		3				3		3				3		3	
	ESC-RFE5	4 times per year																													3				3		3				3		3				3		3	
Ma Wan Station																																																		
	MW1	4 times per year																													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	
	ESC-IPF2	4 times per year																													3				3		3				3		3				3		3	
	ESC-IPF3	4 times per year																													3				3		3				3		3				3		3	
Intermediate Station Downcurrent																																																		
	ESC-INF1	4 times per year																													3				3		3				3		3				3		3	
	ESC-INF2	4 times per year																													3				3		3				3		3				3		3	
	ESC-INF3	4 times per year																													3				3		3				3		3				3		3	
Reference Station Upcurrent																																																		
	ESC-RFF1A	4 times per year																													3				3		3				3		3				3		3	
	ESC-RFF2A	4 times per year																													3				3		3				3		3				3		3	
	ESC-RFF3	4 times per year																													3				3		3				3		3				3		3	
Ma Wan Station																																																		
	MW1	4 times per year																													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-Apr-2019	1,201	1,386,815
2-Apr-2019	1,637	1,388,452
3-Apr-2019	2,931	1,391,383
4-Apr-2019	3,602	1,394,985
5-Apr-2019	1,257	1,396,242
6-Apr-2019	0	1,396,242
7-Apr-2019	0	1,396,242
8-Apr-2019	0	1,396,242
9-Apr-2019	1,758	1,398,000
10-Apr-2019	2,596	1,400,596
11-Apr-2019	982	1,401,578
12-Apr-2019	1,224	1,402,802
13-Apr-2019	1,629	1,404,431
14-Apr-2019	0	1,404,431
15-Apr-2019	0	1,404,431
16-Apr-2019	1,161	1,405,592
17-Apr-2019	514	1,406,106
18-Apr-2019	0	1,406,106
19-Apr-2019	0	1,406,106
20-Apr-2019	0	1,406,106
21-Apr-2019	0	1,406,106
22-Apr-2019	0	1,406,106
23-Apr-2019	524	1,406,630
24-Apr-2019	0	1,406,630
25-Apr-2019	600	1,407,230
26-Apr-2019	600	1,407,830
27-Apr-2019	270	1,408,100
28-Apr-2019	0	1,408,100
29-Apr-2019	0	1,408,100
30-Apr-2019	600	1,408,700
1-May-2019	0	1,408,700
2-May-2019	620	1,409,320
3-May-2019	0	1,409,320
4-May-2019	0	1,409,320
5-May-2019	0	1,409,320
6-May-2019	0	1,409,320
7-May-2019	0	1,409,320
8-May-2019	0	1,409,320
9-May-2019	0	1,409,320
10-May-2019	0	1,409,320
11-May-2019	0	1,409,320
12-May-2019	560	1,409,880
13-May-2019	0	1,409,880
14-May-2019	0	1,409,880
15-May-2019	0	1,409,880
16-May-2019	0	1,409,880
17-May-2019	500	1,410,380
18-May-2019	0	1,410,380
19-May-2019	500	1,410,880
20-May-2019	500	1,411,380
21-May-2019	0	1,411,380
22-May-2019	500	1,411,880
23-May-2019	0	1,411,880

Date	Daily Disposal Volume (m^3)	Accumulative Disposal Volume (m^3)
24-May-2019	0	1,411,880
25-May-2019	0	1,411,880
26-May-2019	0	1,411,880
27-May-2019	0	1,411,880
28-May-2019	0	1,411,880
29-May-2019	0	1,411,880
30-May-2019	0	1,411,880
31-May-2019	0	1,411,880
1-Jun-2019	1,500	1,413,380
2-Jun-2019	2,000	1,415,380
3-Jun-2019	2,500	1,417,880
4-Jun-2019	400	1,418,280
5-Jun-2019	1,300	1,419,580
6-Jun-2019	1,600	1,421,180
7-Jun-2019	1,600	1,422,780
8-Jun-2019	1,600	1,424,380
9-Jun-2019	2,000	1,426,380
10-Jun-2019	2,000	1,428,380
11-Jun-2019	1,600	1,429,980
12-Jun-2019	800	1,430,780
13-Jun-2019	0	1,430,780
14-Jun-2019	2,500	1,433,280
15-Jun-2019	1,500	1,434,780
16-Jun-2019	0	1,434,780
17-Jun-2019	1,000	1,435,780
18-Jun-2019	700	1,436,480
19-Jun-2019	1,500	1,437,980
20-Jun-2019	1,000	1,438,980
21-Jun-2019	1,500	1,440,480
22-Jun-2019	1,200	1,441,680
23-Jun-2019	1,000	1,442,680
24-Jun-2019	3,000	1,445,680
25-Jun-2019	4,000	1,449,680
26-Jun-2019	3,500	1,453,180
27-Jun-2019	3,500	1,456,680
28-Jun-2019	3,000	1,459,680
29-Jun-2019	2,000	1,461,680
30-Jun-2019	500	1,462,180

Annex C

Statistical Analysis

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

Dissolved Oxygen

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	1345097.067	3	448365.689	12.017	**
Period	1482947395.993	38	39024931.473	1045.949	**
Area * Period	78830996.806	114	691499.972	18.534	**
Error	107081276.117	2870	37310.549		
Total	9240587823.500	3026			

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= **Apr 19** > Nov 17 > Apr 12 = May 13 > Nov 12 = **May 19** = May 18 = May 16 > 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	71032664.366	3	23677554.789	119.043	**
Period	922370226.952	38	24272900.709	122.036	**
Area * Period	240165859.434	114	2106718.065	10.592	**
Error	570840152.551	2870	198899.008		
Total	9240488713.500	3026			

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 **= May 19** =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 ≥ **Apr 19** = 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	2815937130.818	37	76106408.941	665.218	**
Area	20874884.085	3	6958294.695	60.820	**
Station(Area)	39646359.118	24	1651931.630	14.439	**
Period * Area	482706009.142	108	4469500.085	39.066	**
Period * Station(Area)	613768550.707	318	1930089.782	16.870	**
Error	398826935.688	3486	114408.186		
Total	21044601012.500	3984			

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 = **May 19** = Apr 18 = Nov 12 > Apr 17 > May 12 > Apr 16 = Oct 12 > Jul 16 = May 13 = Jan 18 ≥ **Apr 19** > May 17 = Aug 16 > 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	2805498604.951	37	75824286.620	430.469	**
Area	31628499.244	3	10542833.081	59.854	**
Station(Area)	83629082.527	24	3484545.105	19.782	**
Period * Area	529801895.161	108	4905573.103	27.850	**
Period * Station(Area)	362404313.346	318	1139636.205	6.470	**
Error	613683958.549	3484	176143.501		
Total	20978236461.500	3982			

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

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	3284010368.719	37	88757036.992	705.086	**
Area	64118758.251	3	21372919.417	169.786	**
Station(Area)	70093454.495	24	2920560.604	23.201	**
Period * Area	354113988.367	108	3278833.226	26.047	**
Period * Station(Area)	562388194.276	318	1768516.334	14.049	**
Error	438821820.750	3486	125881.188		
Total	21084940437.000	3984			

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 = **Apr 19** ≥ Jul 13 ≥ Feb 19 = May 16 = May 12 = Jan 19 > Jan 17 = Jan 13 = Apr 13 = Oct 16 = Apr 16 = **May 19** = 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	3617240481.050	37	97763256.245	725.839	**
Area	5606621.442	3	1868873.814	13.875	**
Station(Area)	20906064.019	24	871086.001	6.467	**
Period * Area	191487313.827	108	1773030.684	13.164	**
Period * Station(Area)	176893565.089	318	556269.073	4.130	**
Error	469529063.813	3486	134689.921		
Total	21076471354.000	3984			

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 > **May 19** ≥ Feb 17 = May 17 ≥ Feb 12 = **Apr 19** = 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	3353558695.741	37	90636721.507	1158.039	**
Area	74123488.105	3	24707829.368	315.685	**
Station(Area)	98268568.574	24	4094523.691	52.315	**
Period * Area	262405075.905	108	2429676.629	31.043	**
Period * Station(Area)	265932026.835	318	836264.235	10.685	**
Error	272840158.875	3486	78267.401		
Total	21084911643.500	3984			

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 > **May 19** > Aug 18 = Oct 17 > Apr 13 > Feb 17 = Apr 16 = Jan 18 > Oct 12 = **Apr 19 ≥** 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	1896704493.298	37	51262283.603	182.283	**
Area	76514500.305	3	25504833.435	90.692	**
Station(Area)	41663522.495	24	1735980.104	6.173	**
Period * Area	869857902.942	108	8054239.842	28.640	**
Period * Station(Area)	712824354.713	318	2241586.021	7.971	**
Error	980345242.563	3486	281223.535		
Total	21069273389.000	3984			

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

SNK Results:

- Aug 16 > Nov 16 = Apr 16 > Jan 17 = **Apr 19** = 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 = **May 19** = 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	2665626065.793	37	72043947.724	1434.086	**
Area	26282982.982	3	8760994.327	174.394	**
Station(Area)	213708277.873	24	8904511.578	177.251	**
Period * Area	577060914.533	108	5343156.616	106.359	**
Period * Station(Area)	1093465738.090	318	3438571.503	68.447	**
Error	175125588.750	3486	50236.830		
Total	21084401014.500	3984			

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 = **May 19** = 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 > **Apr 19** = Feb 18 = Apr 18 = Jan 13 > 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	-0.816	0.127	0.016	**

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

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

Arsenic

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Period	1124748258.798	39	28839698.944	327.312	**
Area	16161324.919	2	8080662.460	91.710	**
Station(Area)	163220203.843	3	54406734.614	617.482	**
Period * Area	229637800.929	78	2944074.371	33.413	**
Period * Station(Area)	192830596.230	116	1662332.726	18.866	**
Error	231378701.834	2626	88110.701		
Total	7842831146.500	2865			

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

SNK Results:

- **Jun 19** ≥ Oct 17 = Jul 18 ≥ Jun 18 = Oct 18 = Nov 18 = Feb 19 ≥ Jan 19 ≥ **Apr 19** ≥ Mar 19 = **May 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	560387758.350	39	14368916.881	92.520	**
Area	439466192.759	2	219733096.380	1414.835	**
Station(Area)	30150736.215	3	10050245.405	64.712	**
Period * Area	205270981.683	78	2631679.252	16.945	**
Period * Station(Area)	288399143.690	116	2486199.515	16.008	**
Error	407368857.479	2623	155306.465		
Total	7805259071.000	2862			

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 ≥ **Apr 19** ≥ May 16 = **May 19** = Sep 16 = Nov 18 = Aug 16 = Feb 17 = Jun 17 = Feb 18 = Jan 18 ≥ Dec 16 ≥ Sep 18 = **Jun 19** = Aug 18 = Mar 17 ≥ Mar 16 = Nov 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	-0.048	0.296	0.088	**

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

Chromium

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	624795753.682	39	16020403.941	96.900	**
Area	117803433.593	2	58901716.796	356.269	**
Station(Area)	68364437.915	3	22788145.972	137.835	**
Period * Area	373571720.899	78	4789381.037	28.969	**
Period * Station(Area)	338957884.061	116	2922050.725	17.674	**
Error	434154970.453	2626	165329.387		
Total	7842958250.500	2865			

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 = **Apr 19** = **Jun 19** = 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 19** = 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	-3.119	0.194	0.038	**

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

Copper

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	331801096.413	39	8507720.421	78.406	**
Area	626897268.620	2	313448634.310	2888.712	**
Station(Area)	79389805.388	3	26463268.463	243.883	**
Period * Area	289393664.673	78	3710175.188	34.193	**
Period * Station(Area)	350305475.273	116	3019874.787	27.831	**
Error	284942291.321	2626	108508.108		
Total	7842958736.500	2865			

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 = **Apr 19** = 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 > **Jun 19** ≥ Apr 16 ≥ Jun 17 ≥ Mar 16 = Dec 16 ≥ May 16 ≥ **May 19** ≥ 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	-27.175	0.177	0.031	**

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

Lead

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	504850788.443	39	12944892.011	73.874	**
Area	207459323.527	2	103729661.764	591.965	**
Station(Area)	190625607.254	3	63541869.085	362.621	**
Period * Area	267726530.113	78	3432391.412	19.588	**
Period * Station(Area)	328809359.968	116	2834563.448	16.176	**
Error	460152572.491	2626	175229.464		
Total	7842958427.500	2865			

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

SNK Results:

- Mar 17 = **May 19** > Nov 18 ≥ Mar 19 = Oct 18 = Jul 17 ≥ Jun 18 = Oct 17 ≥ May 17 ≥ **Apr 19** = Jul 18 ≥ Jan 19 = Feb 19 = **Jun 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	-4.678	0.207	0.043	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Mercury

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	1125838958.149	39	28867665.594	206.555	**
Area	63678565.950	2	31839282.975	227.817	**
Station(Area)	7115807.638	3	2371935.879	16.972	**
Period * Area	185935723.926	78	2383791.332	17.057	**
Period * Station(Area)	143394192.508	116	1236156.832	8.845	**
Error	367004337.139	2626	139757.935		
Total	7786544382.500	2865			

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 ≥ **Jun 19** ≥ Jun 18 = Mar 17 ≥ Sep 18 = Apr 17 = Feb 17 = Jul 17 = Oct 17 = Jul 18 = **Apr 19** ≥ **May 19** ≥ 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	-0.040	0.129	0.017	**
Note: Linear regression analysis on spatial changes of contaminant concentrations.					

Nickel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	498903384.017	39	12792394.462	128.691	**
Area	203524362.512	2	101762181.256	1023.722	**
Station(Area)	227576298.604	3	75858766.201	763.135	**
Period * Area	397873568.617	78	5100943.187	51.315	**
Period * Station(Area)	368991558.003	116	3180961.707	32.000	**
Error	261035158.363	2626	99404.097		
Total	7842957662.500	2865			

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 = **Apr 19** = **Jun 19** = Jan 19 = Feb 19 = Apr 16 ≥ Jul 16 = Jul 18 = Jun 16 ≥ **May 19** ≥ 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	-2.167	0.246	0.060	**

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

Silver

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	292804888.220	39	7507817.647	61.474	**
Area	629637741.673	2	314818870.836	2577.743	**
Station(Area)	13980192.056	3	4660064.019	38.157	**
Period * Area	360756165.934	78	4625079.050	37.870	**
Period * Station(Area)	333141250.456	116	2871907.332	23.515	**
Error	320590322.428	2625	122129.647		
Total	7832548499.000	2864			

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

SNK Results:

- **May 19** > 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 19** ≥ Apr 18 ≥ Feb 18 = Feb 19 = Nov 18 = 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 =**Jun 19** > Oct 16

Active Pit > Near Pit > Pit Edge

Zinc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	720219663.314	39	18467170.854	204.318	**
Area	225421031.021	2	112710515.510	1247.010	**
Station(Area)	171637029.014	3	57212343.005	632.987	**
Period * Area	326538490.195	78	4186390.900	46.318	**
Period * Station(Area)	276323215.077	116	2382096.682	26.355	**
Error	237350072.237	2626	90384.643		
Total	7842954408.500	2865			

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 = **Apr 19** = Mar 16 = Feb 18 ≥ Jan 19 = **Jun 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 > **May 19**
- Active Pit > Pit Edge > Near Pit

Linear Regression Analysis

Source	Df	Slope	r	r^2	P
Area	1	-17.862	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	5836581145.149	1	5836581145.149	54498.123	**
Area	603730498.631	39	15480269.196	144.544	**
Station(Area)	125981947.259	2	62990973.630	588.168	**
Period * Area	75586856.613	3	25195618.871	235.260	**
Period * Station(Area)	402319588.889	78	5157943.447	48.161	**
Error	470769834.136	116	4058360.639	37.894	
Total	281236511.318	2626	107096.920		

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 = **Apr 19** ≥ Feb 19 ≥ Jun 16 ≥ Aug 16 = Jul 16 = Jan 19 = **Jun 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 = **May 19** > 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	-882.504	0.238	0.056	**

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

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

Arsenic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Period	64620676.056	12	5385056.338	482.107	**
Area	45217787.621	4	11304446.905	1012.052	**
Area * Station	2138255.943	4	534563.986	47.858	**
Period * Area	95863061.977	47	2039639.617	182.603	**
Period * Area * Station	7240007.901	48	150833.498	13.504	**
Error	14375571.458	1287	11169.830		
Total	923494259.000	1404			

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

SNK Results:

- **Jun 19** > 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	30709173.477	12	2559097.790	51.566	**
Area	17059727.665	4	4264931.916	85.938	**
Area * Station	43646104.056	4	10911526.014	219.866	**
Period * Area	51272789.430	47	1090910.413	21.982	**
Period * Area * Station	20944721.715	48	436348.369	8.792	**
Error	63871281.875	1287	49628.036		
Total	921453597.500	1404			

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 = **Jun 19** > 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	13113885.727	12		1092823.811	66.649	**
Area	81773480.704	4		20443370.176	1246.791	**
Area * Station	17774402.264	4		4443600.566	271.004	**
Period * Area	58775370.696	47		1250539.802	76.267	**
Period * Area * Station	20904984.559	48		435520.512	26.561	**
Error	21102662.083	1287		16396.785		
Total	923514737.000	1404				

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 = **Jun 19 =** 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	8869484.465	12	739123.705	47.818	**
Area	63411321.620	4	15852830.405	1025.616	**
Area * Station	61198736.224	4	15299684.056	989.829	**
Period * Area	48641289.721	47	1034921.058	66.955	**
Period * Area * Station	11227895.558	48	233914.491	15.133	**
Error	19893015.750	1287	15456.889		
Total	923514790.500	1404			

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 = **Jun 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	67056744.962	12	5588062.080	334.948	**
Area	57929580.427	4	14482395.107	868.073	**
Area * Station	10393222.704	4	2598305.676	155.742	**
Period * Area	54437475.737	47	1158244.165	69.425	**
Period * Area * Station	12619902.827	48	262914.642	15.759	**
Error	21471520.000	1287	16683.388		
Total	923514756.000	1404			

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 = **Jun 19** > 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	101425841.579	12	8452153.465	174.061	**
Area	5846616.136	4	1461654.034	30.101	**
Area * Station	8252150.827	4	2063037.707	42.485	**
Period * Area	32323331.630	47	687730.460	14.163	**
Period * Area * Station	9314371.589	48	194049.408	3.996	**
Error	62446428.765	1286	48558.654		
Total	917467771.000	1403			

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 = **Jun 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	13525323.682	12	1127110.307	75.717	**
Area	67910118.111	4	16977529.528	1140.513	**
Area * Station	22297643.869	4	5574410.967	374.477	**
Period * Area	70401433.362	47	1497902.837	100.626	**
Period * Area * Station	25003559.069	48	520907.481	34.993	**
Error	19158111.583	1287	14885.868		
Total	923514576.000	1404			

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 19** = 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	34848775.532	12	2904064.628	127.568	**
Area	65440862.892	4	16360215.723	718.664	**
Area * Station	51999539.230	4	12999884.807	571.053	**
Period * Area	18115016.548	47	385425.884	16.931	**
Period * Area * Station	18588179.468	48	387253.739	17.011	**
Error	29298247.333	1287	22764.761		
Total	923304506.500	1404			

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 19** > 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	12701030.259	12	1058419.188	96.669	**
Area	60922270.173	4	15230567.543	1391.056	**
Area * Station	41197958.572	4	10299489.643	940.685	**
Period * Area	68499545.691	47	1457437.142	133.112	**
Period * Area * Station	13300778.282	48	277099.548	25.308	**
Error	14091271.125	1287	10948.929		
Total	923513890.500	1404			

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

SNK Results:

- Aug 16 > **Jun 19** = 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	26841325.017	12	2236777.085	104.358	**
Area	49742229.885	4	12435557.471	580.188	**
Area * Station	11698044.760	4	2924511.190	136.445	**
Period * Area	73932534.610	47	1573032.651	73.391	**
Period * Area * Station	26983809.740	48	562162.703	26.228	**
Error	27585108.583	1287	21433.651		
Total	923440233.000	1404			

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 = **Jun 19** = 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	43460332.985	12	3621694.415	66.047	**
Area	33401467.724	4	8350366.931	152.282	**
Area * Station	5676608.224	4	1419152.056	25.880	**
Period * Area	20829833.080	47	443187.938	8.082	**
Period * Area * Station	18581800.787	48	387120.850	7.060	**
Error	70572456.375	1287	54834.853		
Total	908906651.500	1404			

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