SUB-COMMITTEE ON POLLUTION PREVENTION AND RESPONSE
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EVALUATION AND HARMONIZATION OF RULES AND GUIDANCE ON THE DISCHARGE OF DISCHARGE WATER FROM EGCS INTO THE AQUATIC ENVIRONMENT, INCLUDING CONDITIONS AND AREAS

Quality Assurance (QA) of the data presented in document PPR 12/7/1

Submitted by Norway

SUMMARY

Executive summary:	The dataset and the emission factors presented in document PPR 12/7/1 (Norway) have undergone a Quality Assurance (QA) by SINTEF Ocean. The annex to this document contains a project memo from SINTEF Ocean regarding the QA.
Strategic direction, if applicable:	1
Output:	1.23
Action to be taken:	Paragraph 3
Related documents:	PPR 12/7/1 and PPR 12/7/2

Background

1 In document PPR 12/7/1, Norway presented data to be used for the development of representative emission factors of discharge water from EGCS) and provided relevant information regarding the sampling and analysis of the water. In document PPR 12/7/2 (Norway), the origin of the substances detected in the samples from discharge water were considered.

2 As noted in document PPR 12/7/1, the dataset and the emission factors presented in that document have undergone a Quality Assurance (QA) by SINTEF Ocean. The annex to this document contains a project memo from SINTEF Ocean regarding the QA.

Action requested of the Sub-Committee

3 The Sub-Committee is invited to note the information contained in this document in conjunction with documents PPR 12/7/1 and PPR 12/7/2.

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SINTEF

Project memo

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EGCS emission factor evaluation

VERSION 1.1	**DATE** 26-11-2024
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PROJECT NO. 302008703	**NO. OF PAGES/APPENDICES:** 7+ Appendices

Abstract

Sintef Ocean has provided QA of analysis data summarized in an MS excel spreadsheet to enable transparent presentation and handling of data from water analysis from EGCS on ships in the Solvang fleet. The work included checking the data handling, data handling discussion and a spot check of the data. A method to handle outliers was proposed and implemented. Minor issues in spreadsheet cells were detected and corrected. Method of calculating emission factors was evaluated and agreed.
Latest version of the spreadsheet is a transparent and systematic way of calculating emissions factors from EGCS. The spreadsheet is available on Solvang home page.

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APPROVED BY Anders Valland	SIGNATURE
PROJECT MEMO NO. 302008703-NOT-2024-1	**CLASSIFICATION** Unrestricted

Document history

VERSION	DATE	Version description
1.0	2024-11-21	Final Version
1.1	2024-11-26	Updated final version. Corrected misprint in ch. 2.

Table of contents

1 Introduction

The purpose of this memo is to outline the work done in providing Quality Assurance (QA) to data handling of a data set present to us by Solvang ASA. This memo only does the check on the data handling, data handling discussion and a spot check of the data, we have not conducted any testing or further analyses of the data.

2 Solvang EGCS discharge water evaluation -Description of procedure

Appendix 3 of the 2021 Guidelines for Exhaust Gas Cleaning System (EGCS) (Resolution MEPC.340(77)) specifies that analysis should be undertaken by ISO 17025-accredited laboratories using EPA, ISO or equivalent test procedures.

The data presented to Sintef are from the following 2 points in the EGCS, see Appendix A.1. for diagram of a typical EGCS. The first sampling point (inlet water) is located on the strainer after the seawater intake (sea chest), this is used to represent seawater. The second sampling point is after the EGC (Exhaust Gas Cleaning) tower but before the water goes into the discharge water cleaning system.

In addition to the sampling points, the ship's activity is noted i.e. the ship was running main or auxiliary engines (ME and AE respectively) and if the ship was in the harbour or not. The following are the different sample conditions:

- Harbour mode: Intake seawater
- Harbour mode: After AE scrubber, but before cleaning
- Transit, full speed: Intake seawater
- Transit, full speed: After ME scrubber, but before cleaning
- Transit, full speed: After AE scrubber, but before cleaning

The samples can be grouped into 2 groups: harbour samples and during voyage (transit) samples. Solvang has taken water samples from each sampling point along the EGCS within a group within a period of time. There is an assumption that this period (within a day) between each water sample is acceptable which will allow direct comparison of the water at each sampling point, i.e. each sampling point demonstrates what is happening to the seawater as it goes through the EGCS scrubbing system (a "snapshot").

Samples from each ship were sent to an ISO 17025 accredited laboratory (ALS Limited) to analyse levels of 41 substances in each sample together with the pH and turbidity of the water sample. The data from the laboratory was compiled into one excel document for calculations and statistics.

3 QA of spreadsheet for emission analysis

The data and calculations were reviewed by: spot checks of data confirmed compliance with accredited analyses reports from ALS and checking the statistical calculations. Comments relating to the spreadsheet were noted in the document.

The following steps were performed to prepare the data for calculations:

1. Copied the raw data to a separate sheet to do calculations and to set any values of limit of detection (LOD) to half the value of the LOD
2. To detect and removed outliers, the Interquartile range (IQR) was applied: For each sampling condition ("harbour seawater intake", "harbour after scrubber before cleaning" etc.) the lower and upper quartiles (Q1 and Q3 respectively) were calculated for each substance. Subtracting Q3 from

Q1 is the IQR. To find the upper threshold, the IQR was multiplied by 1.5 and added to Q3. Any values above this threshold were dismissed as outliers

3. The data was copied again into another sheet and the above method was applied to Cadmium, Chromium, Cobalt, Copper, Lead, Molybdenum, Nickel, Vanadium and Zinc*. For these substances data above the upper threshold calculated in the previous step was removed as they are considered as outliers. The removed data is highlighted and number of removed data was noted**. All other data was kept.
4. These values are copied to the calculation sheet. Within this sheet the paired deltas were calculated
5. For the calculations, the formulae provided by Solvang were used but some of the cell references were changed for consistency of data handling

* From fuel analysis it is acknowledges that nickel and vanadium is the main elements in HFO. But those elements are also present in stainless steel together with Cadmium, Chromium, Cobalt and Molybdenum. Micro particles from scrubber body will contaminate the water samples. Abnormal levels of Copper can be found under special conditions in seawater strainer. Abnormal levels of Lead and Zinc can be caused by accumulation of these elements in the ambient seawater. These substances were chosen for removing outliers as their potential of other sources contaminating the results of the water analysis.

** Some substances had large number of data points below the LOD, this made this method less reliable with them.

4 Calculation of delta

As mentioned in the previous section (*2 Solvang EGCS discharge water evaluation -Description of procedure*), for each sample pair in a group taken on the same day can be used to allow a “snapshot” of the water contents. This assumption allows direct comparison of the water samples at each stage of the EGCS. By making this assumption, the difference between the water out and in, known as the “paired delta” in this report, can be made directly in each period making the “average paired delta” a truer representation of the system than the alternative method (“delta from averages”). The alternative method is to take the average of all samples out and subtract the average of all samples in to find the “delta from averages”.

The following steps was taken to find the “average paired delta”:

1. From the prepared data created in the calculation sheet (method outlined in previous section), for each given period and condition the delta was calculated by subtracting the values at sample point 2 from sample point 1 (Appendix A.1)
2. 4 averages (mean) and standard deviations were calculated for: paired delta at harbour, paired delta during transit with main engines, paired delta during transit with auxiliary engines, and of all the paired delta

5 Calculation of emission factor

There are discussions regarding guidelines how to calculate the emissions factors. There are two potential methods of calculating the emissions factor: “delta from averages” and “average paired delta”. Solvang’s collection method allows for both calculations of emissions factors.

Calculating emission factor from "delta from averages" method:

1. Take the averages of substances each day at the *intake* and *after the EGCS but before the cleaning system*
2. Subtract these averages
3. Multiply by the load flow (– if unknown 45 m^3/MWh can be used)

The average paired delta method is above but switching around steps 1 and 2 (see section 2 about "snapshot" assumption):

1. For each sample, subtract the intake values from the values after the EGCS but before the cleaning
2. Take the average of the paired deltas
3. Multiply by the load flow

Solvang calculated their average load flow for the three engine conditions (ME in transit, AE in transit, AE in harbour) from the data obtained on the days the samples.

1. For each date of samples, Solvang obtained the flow (m^3/h) and engine load (kW) under each condition (harbour or transit, and main or auxiliary engine)
2. For the auxiliary engine conditions the engine load is corrected by multiply by 0.95 (generator efficiency)
3. The following two methods of obtaining emissions factors in the "Overview" sheet:

   Harbour average actual waterflow AE:

   a) The sum of flow of AE at harbour was divided by the sum of the engine load AE at harbour to obtain the load flow
   b) This load flow was multiplied by the average paired delta under AE in harbour condition

   Transit average actual waterflow:

   a) The ship's engine load and load flow were recorded for each sample taken, the load flow was divided by the engine load * 1000 to get m^3/MWh for sample
   b) The above values were multiplied by the corresponding paired delta to get the emission factor from paired delta
   c) All the emission factors from ME in transit was averaged, likewise with the AE in transit
   d) To get the scenario of a typical transit use of the ship's engines, the average for ME in transit was multiplied by 0.8 and the average for AE in transit was multiplied by 0.2
   e) These two values were added together

Waterflow through system

The waterflow of seawater during each test was recorded together with the power generated, which allowed for calculation of cubic metre of seawater per mega-watt hours (m^3/MWh). This value was used together with net value on each element to calculate emission factors. The average water flow for main engine (all test included) was recorded to 56.4 m^3/MWh, (data to be available on Solvang home page[i]). The water flow corresponds to 75 % engine and scrubber load.

For the auxiliary engines, the average waterflow is ca. 96 m^3/MWh, which is more than double of design of the EGCS. This means the AE scrubber shall handle 3 auxiliary engines (plus the boiler), the full power is ~4 - 5 MW, but in real life it is difficult to produce more than 1.5-2 MW with 2 auxiliary engines at 75 % power.

The design of EGCS flow is 45m^3/MWh, which is as much as half the flow when using the auxiliary engines. By using real averaged water flow in the emission factor calculations, the obtained values are higher which are considered more accurate for the calculations in concern.

6 References

1 IMO MEPC.1/Circ.89910 June 2022. 2022 GUIDELINES FOR RISK AND IMPACT ASSESSMENTS OF THE DISCHARGE WATER FROM EXHAUST GAS CLEANING SYSTEMS

2 IMO PPR 11/7/5 December 2023. EVALUATION AND HARMONIZATION OF RULES AND GUIDANCE ON THE DISCHARGE OF DISCHARGE WATER FROM EGCS INTO THE AQUATIC ENVIRONMENT, INCLUDING CONDITIONS AND AREAS. Submitted by ICS and CLIA

3 IMO MEPC 78/9/3 April 2022. Unified and representative emission factors for environmental risk assessment of the discharge water from exhaust gas cleaning systems. Submitted by Germany

[i] https://solvangship.no/environment/scrubber-data

A Appendices

A.1 EGCS Diagram

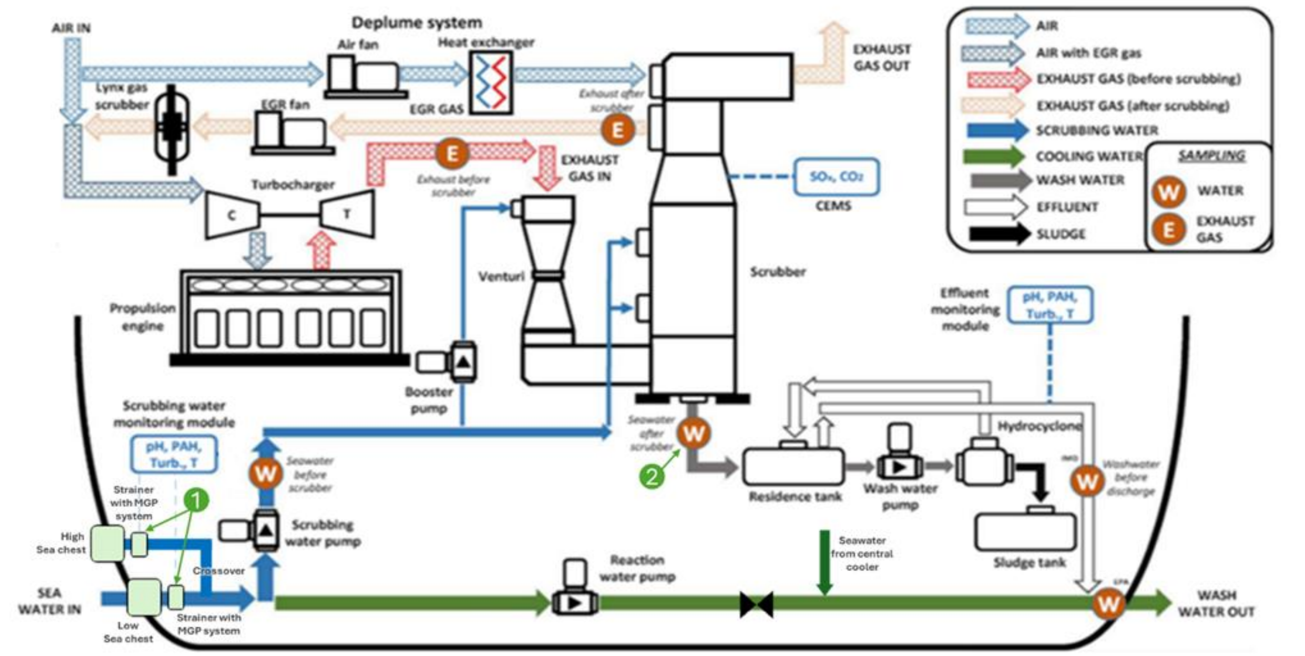

Figure 1: EGCS and Sampling Points:

1 is the sampling point of the intake seawater; 2 is the sampling point after the scrubber but before cleaning of the water.

Source: provided by Solvang

A.2 Graphs of Copper from Data Set

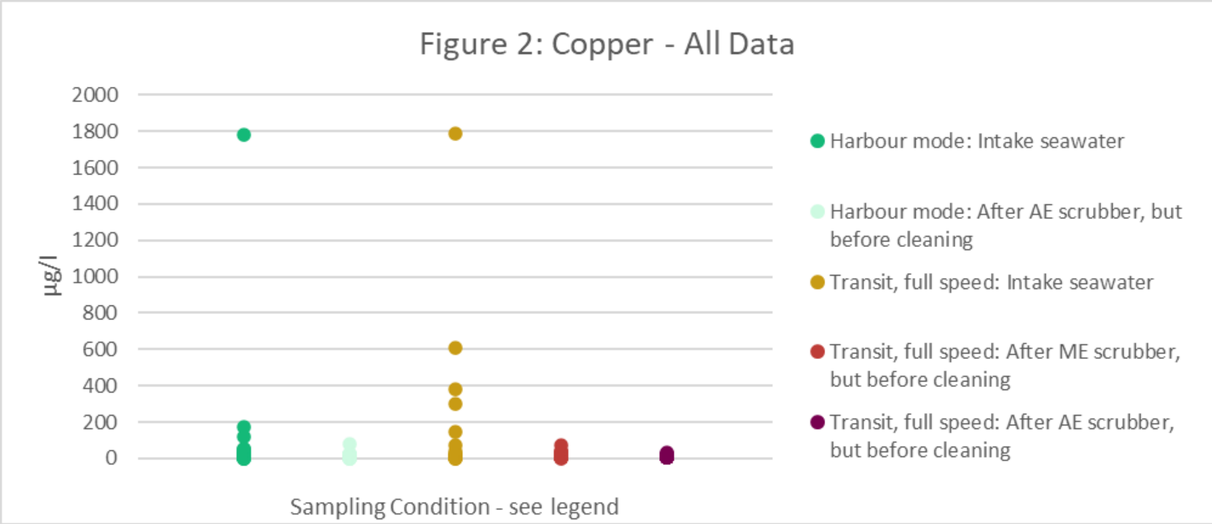

Figure 2: Copper – All Values

The graph shows all the values of copper under the different conditions

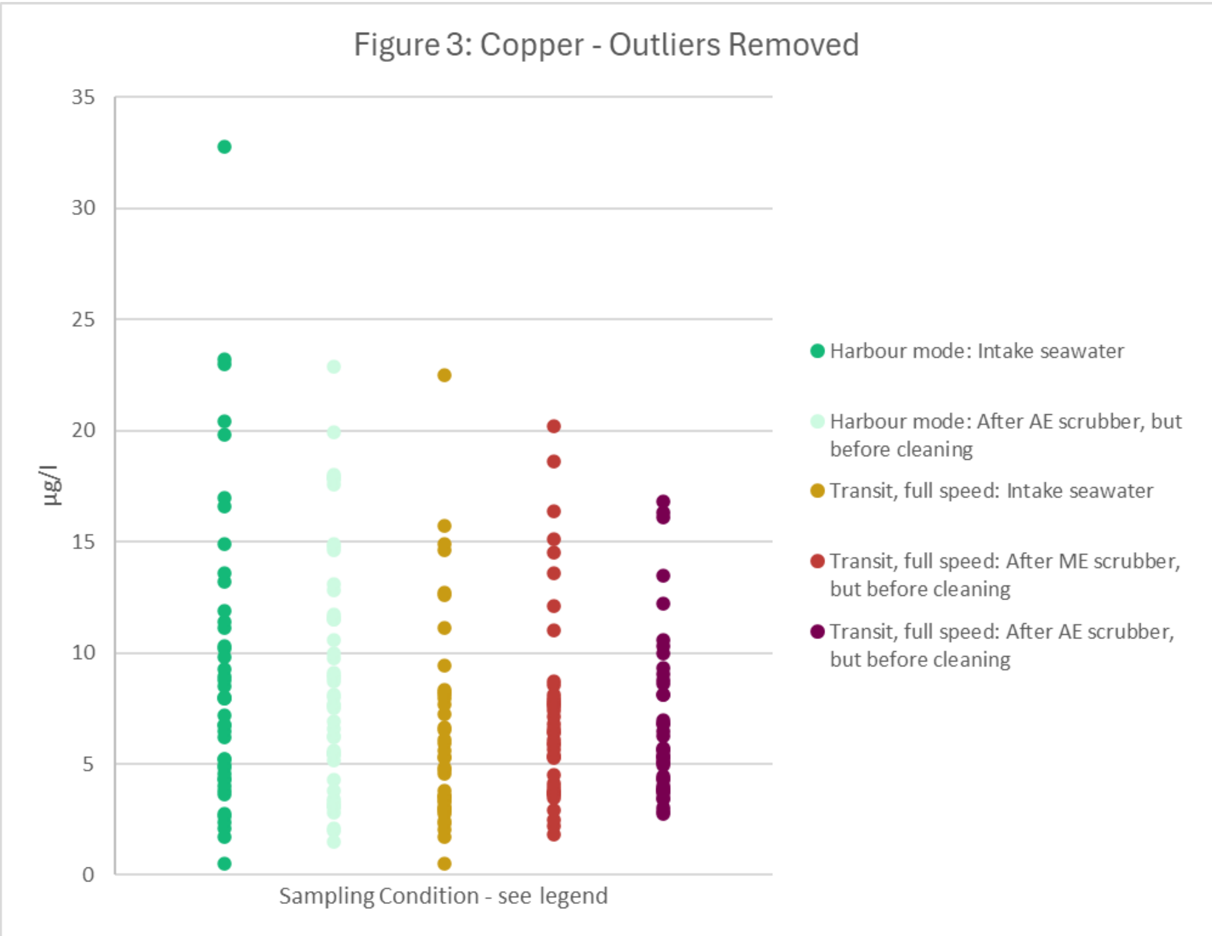

Figure 3: Copper – With the Outliers Removed using the IQR Method

The graph shows the values of copper retained after applying the IQR method for removing outliers.

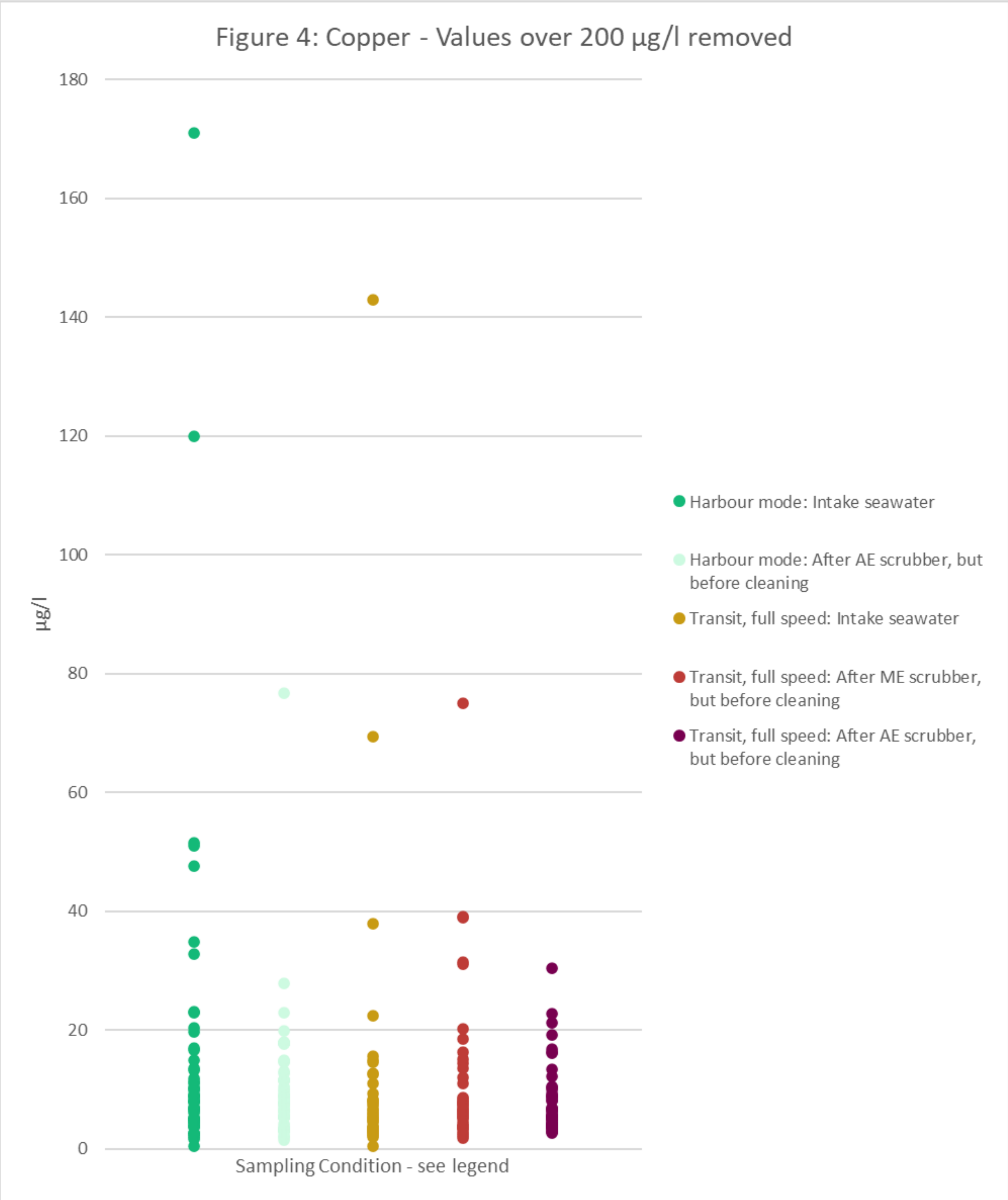

Figure 4: Copper - Values over 200 µg/l removed

Total removed data points 5. The graph shows the majority of the data is below 10µg/l, thus the outliers removed by IQR method are outliers.