Environmental Monitoring Report

Final Report
January - December 2014

Papua New Guinea: Lae Port Development Project

Prepared by Korean Engineering Consultants Corporation for the Independent Public Business Corporation, the Independent State of Papua New Guinea and the Asian Development Bank.

This Environmental Monitoring Report is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature.

In preparing any country program or strategy, financing any project, or by making any designation of or reference to a particular territory or geographic area in this document, the Asian Development Bank does not intend to make any judgments as to the legal or other status of any territory or area.

LAE PORT DEVELOPMENT PROJEC

Contract Number: IPBC/LPDP 1879

中国港湾莱城港潮汐码头一期项目总经理部

Lae Port Tidal Basin Development Project Phase I
January – December 2014 Environmental Report

Prepared for

Department of Environment and Conservation, PNG

Issued February 2015

Document No: EHSR-02-15
Revision 0

Table of Contents

FIGURES

TABLES

Acronyms

ADB	Asian Development Bank
DEC	Department of Environment and Conservation
DWT	Dead Weight Tonnage
GoPNG	Government of PNG
IES	International Environmental Specialist
MSL	Mean Sea Level
NES	National Environmental Specialist
PMU	Project Management Unit
PPE	Personal protective Equipment

1 EXECUTIVE SUMMARY

1. The Lae Port Development Project – Tidal Basin Phase 1 comprises one basin 400m × 700m, one berth of length of 240m for one 50,000 tonne DWT container vessels, a 120,000m^2 container terminal yard, a link road, terminal buildings, utilities, and support facilities.

2. The tidal basin was originally dry land and has been constructed by clearing existing vegetation, dredging originally to a depth of -13 metres below MSL, although at the request of TOTAL Oil Company this has now been changed to -14 metres, constructing a wharf for berthing of ships and reclaiming the cleared land by lifting the height of the platform to form a container storage yard.

3. A permit for construction and operation of the port was issued by DEC in December 2102. It is valid for 50 years.

4. The contractor has prepared a Contractors Environmental Management Plan (CEMP) and this was approved by ADB in August 2012.

5. The contractor must enforce the CEMP and this includes issuing of PPE, training, toolbox briefings to staff on EHS issues and social aspects. These are all reported.

6. All offsite activities must have Environmental Permits issued by DEC. This has been done.

7. As part of the CEMP the contractor is required to undertake regular monitoring. This report presents the findings of the direct measurements, sampling of water column and sediment, and analysis for heavy metals.

8. The report compares the findings with previous month's results, the baseline, PNG standards and International Standards as appropriate over the period January to December 2014.

9. Water samples were taken at all points on 4 transects at a depth of 1.5 m.

10. Sediment samples were taken from the sea bed by a dropped core sampler and analysed in a manner similar to the water samples. Sediments were only taken at 4 sites along the Markham River.

11. The water sampling and analysis has demonstrated that all metal parameters are within the PNG standard except for Boron, Iron and Potassium. There are no construction site activities associated with these metals that would lead to such discharges. Also high levels are encountered at distances of 50-60kms from the site on transect 4, the "control sites". This is considered to be due to land based run off during heavy rain and is a normal occurrence.

12. River bed sediment samples did not show signs of significant contamination. Metals of concern are antimony, chromium, copper, lead, nickel and vanadium. All other metals were at low levels. There are no site activities associated with these metals.

13. It is concluded that site activities are not causing elevated levels of heavy metals adjacent to the site.

14. It should be noted that **ALL MAJOR WORKS** were completed in November 2014. As a consequence **ALL ENVIRONMENTAL MONITORING** ended in November 2014. There was no monitoring in December 2014. At completion of major works the contractor enters a Defects Liability period of 12 months duration. During this time some minor works are still ongoing if required.

15. The Lae Port Development Project had **Negligible** to **Low** environmental impact on the environment during January to December 2014.

2 Introduction

2.1 Background to the Project

16. The Lae Port Development Project – Tidal Basin Phase 1 comprises one basin 400m × 700m, one berth of length of 240m for one 50,000 tonne DWT container vessels, a 120,000m^2 container terminal yard, a link road, terminal buildings, utilities, and support facilities When finished it will look as shown in the artists impression in Figure 2-1.

Figure 2-1 Tidal Basin Phase 1, Wharf and Berthing Facilities, Cranes and Container Storage

17. The tidal basin was originally dry land and has been constructed by clearing existing vegetation, dredging originally to a depth of -13 metres below MSL, although at the request of TOTAL Oil Company this has now been changed to -14 metres, constructing a wharf for berthing of ships and reclaiming the cleared land by lifting the height of the platform to form a container storage yard. (Figure 2-2)

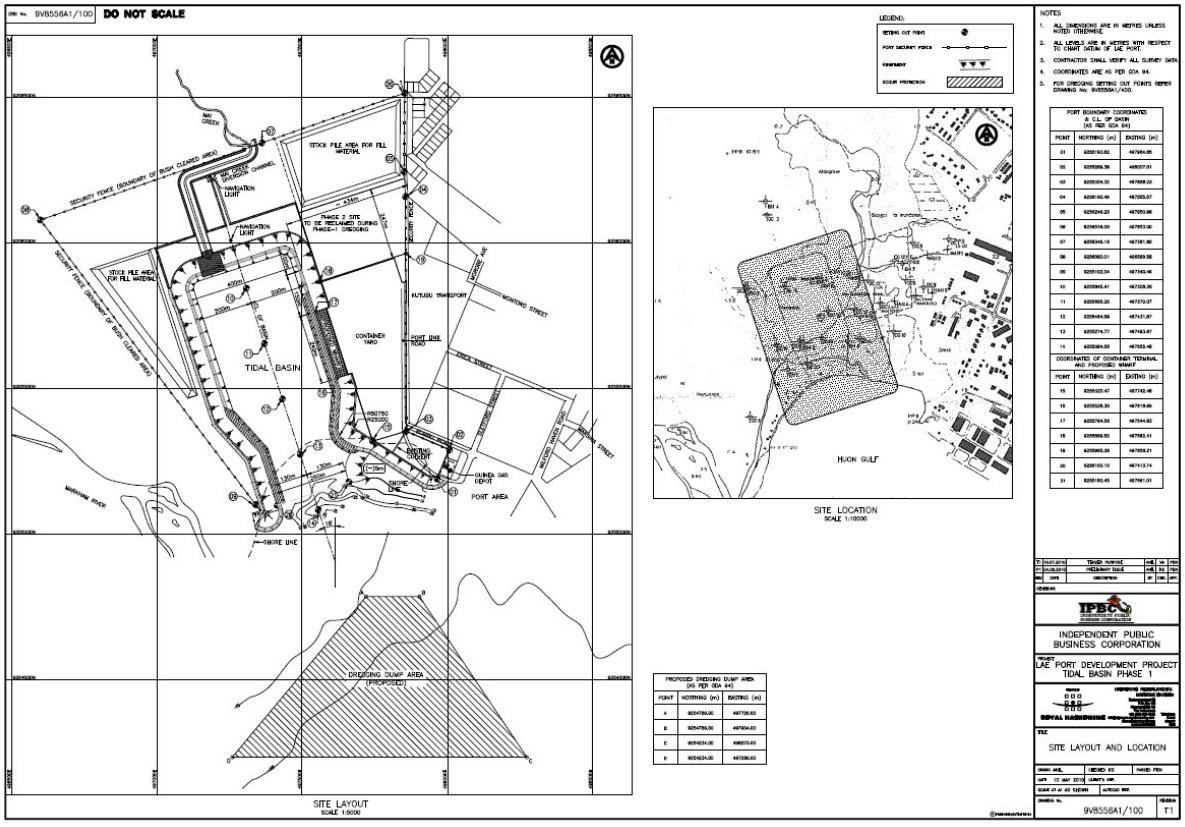


Figure 2-2 Tidal Basin Phase 1 showing location of adjacent Existing Port Facilities

18. The majority of the dredged material was suitable for reclamation and so has been excavated from the seabed and transported by floating pipeline to the reclamation area. It is then leveled and consolidated by impact hammers until flat. Some of the dredged material was unsuitable for reclamation as its soil structural properties did not match the criteria needed to support the weight of

the imposed load and this material was dumped at sea. Approval from GoPNG DEC was given for dumping and a dumping area designated which was determined by being at least at the 50 metres depth contour. All unsuitable material was dumped by bottom discharge hopper barges in the sea at depths of -50 metres or greater.

19. Construction activities on site were piling and welding. There were also off site activities such as waste disposal at a landfill, rock quarrying and obtaining gravel from nearby riverbeds. This report reviews the activities of the port construction both off and on the site since its inception. The emphasis is on activities since January to December 2014. The report relates to environment, health and safety and social issues such as relations with local villagers.

2.2 Timeline

20. The major activities as planned in the construction program are shown in Figure 1.4 below. This indicates achieved and anticipated completion dates.

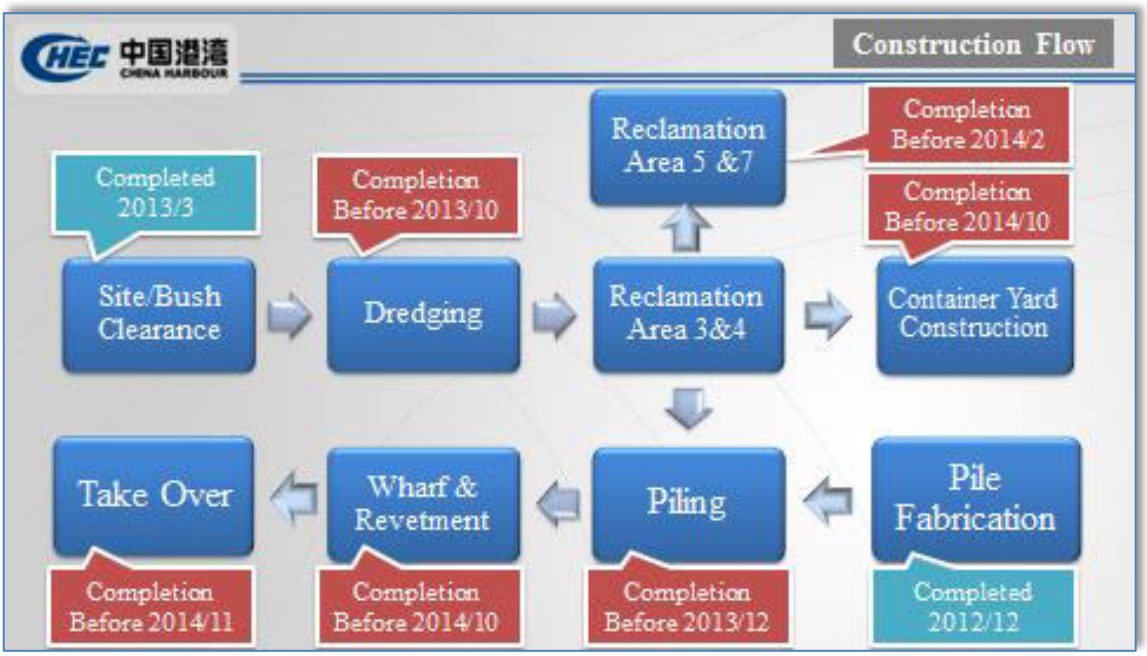


Figure 2-3 Construction Program

21. Monthly progresses of main project works was given in the Bill of Quantities (BOQ) up till 31st December 2014. In summary :

- Over-all Progress 100%
- Project is 2 months ahead of Schedule
- Construction Completion Date was November 2014
- Hand over to operator November 2014

22. The port will become operational in 2015.

3 Organization Chart Environmental Management

23. The organization chart on environmental management is shown below in Figure 3-1.

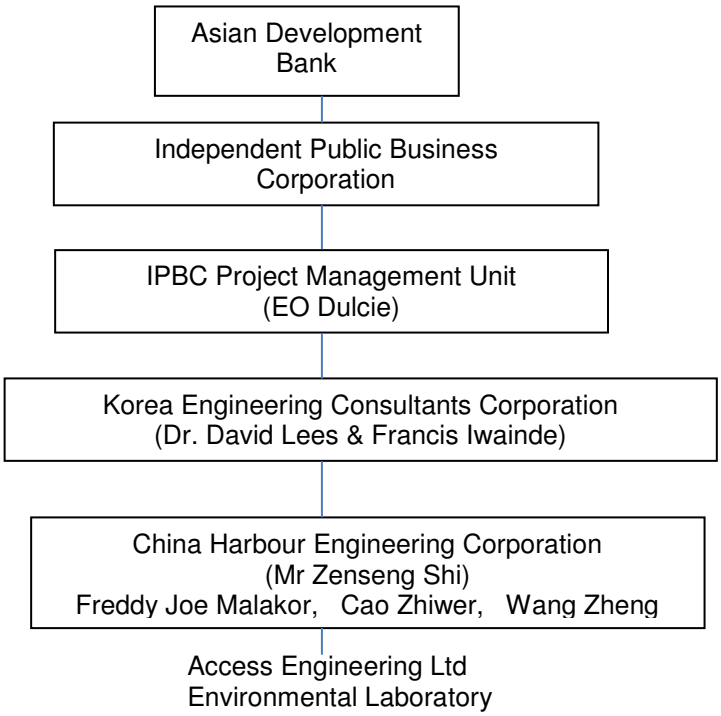


Figure 3-1 Environmental Management Organization Chart

4 Environmental Conformance

4.1 DEC Permit

24. The PNG Department of Environment and Conservation (DEC) issued a permit to PNG Ports Corporation Ltd in December 2012. It is valid for 50 years and will expire on 11th January 2062. This means the permit covers both construction and operation of the port. The permit requires compliance in general with the Environment (Water Quality Criteria) Regulation 2002 and makes specific reference to color, oil and grease, and turbidity which must be assessed at a point 50 metres from the limit of activities.

25. The permit requires the permit holder to show that they are using BAT – Best Available Technology. It also states that all environmental management and pollution control procedures, such as handling and storage of hydrocarbons, will follow Australian Standards. These standards have been obtained and given to the contractor. The full permit is given in Annex 1.

4.2 PNG Standards

26. PNG Standards for sea water are stipulated in the Environment (Water Quality Criteria) Regulation 2002 under the Environmental Act 2000. In general the project activities must comply with these standards. Specifically certain parameters have been selected for environmental sampling and analysis. The standards are given in Annex 2

4.3 ADB Requirements for CEMP Compliance Monitoring

27. The Contractor's Environmental Management Plan (CEMP) has been prepared and includes the monitoring and reporting plan of the Contractor. This Monitoring Plan is a process of observing the tasks and activities to be carried out on site (including dredging and dumping areas) after identification of environmental risks and hazard events and checking whether the actions were executed according to the codes of practice, regulations and specification requirements of the CEMP.

28. The construction works executed are observed and checked through site inspections and the results and observations recorded. Any non-conformance found is recorded and corrective actions required of the contractor. Thus, work procedures have been setup for controlling and monitoring the construction works to be implemented within the specified requirements and in compliance with the CEMP. The CEMP Revision 2 was approved by ADB in August 2012 and still applies.

29. In the first instance, it is the responsibility of the CHEC ES&H Engineer to check that the works are being carried out in conformance with the CEMP. CHEC has developed non conformance record sheets for this project. ESH issues will be recorded in a register and CHEC management will ensure these issues are addressed in a prompt and timely manner.

30. A monthly report is prepared by the Contractor to be submitted to the PMU. The monthly report contains a section on monitoring and CEMP compliance which is completed by the ES&H Engineer and contains the following information:

- A list of major forthcoming activities in the next two months which will likely have environmental impacts and nuisances to the surroundings and the control in mitigation measures that will be Implemented to mitigate or avoid the impacts.
- The training" programme for the next month and the records of training arranged / conducted in the previous month
- The updated organization chart on environmental management; and
- A summary of non-compliance issues, corrective actions specified and undertaken, defects and deficiencies identified during inspections and weekly environmental walk throughs and the follow-up actions and remedies taken to prevent recurrence.

31. The ESH Manager will prepare a quarterly ESH performance report which will be submitted to CHEC Project Manager who then reports to PMU and KECC for review by the international environmental specialist (IES) and national environmental specialist. (NES)

32. In addition, the Employer's Representative will be informed immediately if any major environmental incident occurs.

4.4 CEMP Compliance Monitoring

33. Although the CHEC ESH Engineer will be checking that the CEMP is implemented, in addition, the Employer's Representative (KECC) and the Employer's PMU will be overseeing the actions of the CHEC ESH Engineer. This is the CEMP Compliance Monitoring. This is also reviewed by ADB.

4.5 KECC Compliance Monitoring Procedures

4.5.1 National Environmental Specialist (NES)

34. KECC have appointed Mr. Francis Iwainde as National Environmental Specialist for this project. He commenced work on September 5th 2012. He will be based permanently on site for the duration of the project.

4.5.2 International Environmental Specialist (IES)

35. KECC have appointed Dr. David Lees as International Environmental Specialist for this project. The IES will make regular visits to the site. According to the original schedule his inputs were at 6 monthly intervals. However this was varied to suit the demands of the project. In addition he was allocated 1 week per month Home Office time to ensure he was in frequent contact with the project and able to supervise environmental reporting.

4.5.3 PMU National Environmental Officer

36. The PMU appointed a National Environmental Officer, Ms Dulcie Gubaila. She is full time staff of PMU. It is intended that after the construction period is finished and the port becomes operational she will continue in the role of Environmental officer. This will enhance the environmental sustainability of the project.

4.6 Schedule

37. The schedule of auditing and reporting is :

- Daily monitoring of project construction to ensure implementation of CEMP (by CHEC ESHE)
- Weekly site visit to monitor material production plants such as quarry (by CHEC ESHE, KECC

NES and PMU NEO)
- Daily site visits to oversee CHEC ESHE (by NES and PMU NEO)
- Weekly site visit to monitor material production plants such as quarry to oversee CHEC ESHE (by NES)
- Issue Non-Conformance Record by CHEC ESHE
- Monthly meetings CHEC / KECC / PMU to discuss NCR
- Ad hoc visits if any major environmental incident occurs
- Preparation of follow up reports on corrective actions taken by CHEC, as required
- Monthly reports for routine matters and immediately reporting if any major environmental incident occurs
- Three monthly reports (QPRs)
- Six monthly reports
- Annual Reports
- Project Completion Report (PCR)
- Sustainability Report (based on progress of PMU staff undergoing OT J Training)

38. In the event of a major infringement an Ad-Hoc report may be submitted at any time.

4.7 Reporting Mechanisms

39. The reporting mechanism is as follows:
- If CHEC ESHO observes an infringement he will immediately verbally notify appropriate construction manager or subcontractor
- The CHEC ESHO will follow up within 24 hours maximum with a written NCR
- The CHEC ESHO will copy the NCR to the NES
- Monthly reports will be compiled by ESHE, NES and PMU NEO detailing CARS
- Three monthly, six monthly and annual reports will be compiled by NES and IES for submission to ADB.
- A PCR will be submitted to ADB. A financial retention may apply until a satisfactory PCR is completed.

40. It is required that contractor take any requisite Corrective Action steps as soon as reasonably possible. The CHEC will file then a Corrective Action Report. The CAR will be copied to the NES

41. The NES will follow up on each CAR and report to the PMU for the item to be placed on the agenda for the next monthly meeting between CHEC/ KECC / PMU. If any CAR is not deemed satisfactory it will automatically be itemised on the agenda for the next monthly progress meeting. This does not mean the contractor has 1 month to take corrective action, he must respond as soon as practicable, but if more than a month elapses without a satisfactory CAR then sanctions may be imposed on the contractor.

42. All monitoring and other reports in respect of environmental management are subject to review and monitoring by ADB for overall compliance purposes.

5 Major Activities

5.1 Current Activities

43. The main activities, their monitoring parameters and Corrective Action are given below in Table 5-1.

Table 5-1 Activities, Monitoring Parameters and Corrective Action

Activities	Monitoring Parameter as per CEMP	Corrective Action
Dredging Works		
	Debris floating / deposits	Continuous cleaning and removal of floating debris along the shoreline.
	Solid Waste – Biodegradable. (spoil soil & logs)	Currently no more dumping at the site as site clearance is completed.
	Noise pollution from dredgers	Noise generated during construction work were all within the required and acceptable limit

	Air pollution from dredgers	Not applicable
	Water Quality	Daily monitoring of color, turbidity and oil and grease
Reclamation Works	Solid Waste – Biodegradable. (Spoil soil & logs).	Not applicable, reclamation work only
	Archaeological & cultural heritage	Not applicable
Quarry Site	Air pollution	All heavy equipment and machinery working at both quarry sites are all well serviced avoiding air pollution.
	Noise pollution	Noise from the aggregation at Bumbu & Gabensis Quarry is was within the acceptable limits.
	Waste (Solid)	Collected by Lae City Authority & taken to the landfills for Bumbu Quarry. Gabensis and Bumbu Quarries now closed.
	Waste (Water & Sewage)	Not applicable for both Bumbu & Gabenesis quarry sites
	Archaeological & cultural heritage	Not applicable
Contractor's Base Camp	Domestic wastes	Collected by Lae City Authority & taken to the landfills.
	Sewage & waste water	Connected to the main city sewage system
Contractor's Machineries Assembly and Service Area	Oil spillage & leakage	No oil / hydraulic spill. Tanks contained in secondary containments and drip trays used when refilling.
Sea Front and Community Canoe Landing area	Deposition/floating of dredging derived wood debris	Continuous cleaning and removal of floating debris along the shoreline.
Sea Water	Water quality	Daily, weekly, monthly and 3 monthly monitoring of physiochemical and heavy element water quality parameters and reporting.

5.2 Air Pollution

44. The main source of air pollution is the approach road to the site. Given that rainfall usually occurs daily this access road is more affected by mud than anything else but in dry periods extra water spraying is needed to prevent dust disturbing the roadside markets.

5.3 Noise and Vibration

45. The main source of noise was compaction of the reclaimed area whereby a 25 tonne weight is dropped to compact the dumped and levelled material. Piling is also an ongoing noise source. Weekly monitoring was conducted using a Digital Sound Level Meter TM 824 beside the Dynamic Compaction and piling works respectively. Noise levels were not causing any off site complaints from residents but were high enough for operators and nearby workers to be given ear plugs. This has been done.

5.4 Crusher Plant

46. The gravel crusher plant at Bumbu adjacent to the river was fitted with fuel oil storage containment. This site has now closed.

5.5 Waste Disposal and Landfill

47. Any waste material from the site is taken to the local municipal landfill and dumped in accordance with local environmental regulations. As site clearance of vegetation is now finished the amount of sold material to be disposed of is generally small.

5.6 Restricting Access to Villagers and Children on Site

48. Villagers walking across the site were controlled. A permanent security fence has been constructed and is patrolled by security guards to control local residents.

5.7 CEMP Environmental Compliance

49. Main component of the CEMP is Environment, Health and Safety (EHS). The Engineer

undertakes weekly validation of CEMP compliance by the contractor. In December 2014 the number of validation exercise days had being reduced due to winding down of project and most construction works had being completed. The status of CEMP compliances are discussed below by each EHS component.

50. Environmental Compliance is detailed in Table 1 below. Main environmental aspects monitored are smoke, dust, noise, marine ecology & fauna, vegetation and waste management.

Table 5-2 : Status of Environment Compliance – December 2014

Environmental Issue	Compliance (Yes / No)	NCR Issued by Engineer (Yes / No / NA)	CAR Submitted by Contractor (Yes / No / NA)	Comments or Actions Taken/Required
Noise	Yes	N/A	N/A	No complaints of excessive noise
Dust	Yes	N/A	N/A	-
Smoke	Yes	N/A	N/A	-
Marine Ecology & Fauna	Yes	N/A	N/A	No marine life stress or impacts
Spills (Fuel & Hazardous substance)	Yes	N/A	N/A	-
Truck/Traffic Impacts	Yes	N/A	N/A	No incident so far.
Cultural Remains	Yes	N/A	N/A	No cultural remains uncovered.
Vegetation Impacts	Yes	N/A	N/A	-
Community Complains	Nil	N/A	N/A	-
Waste Management	Yes	N/A	N/A	All wastes have being removed.
General Littering	Yes	N/A	N/A	Contractor's cleaners do daily cleaning of litter.

N/A – Not Applicable**; NCR –** Non-Compliance Report; **CAR** – Correction Action Report

5.8 Environment Permit WD-L3(349)

51. DEC issued Environment Permit WD-L3(349) for operation of the port facility. The following table outlines the compliance status up to December 2013. Permit conditions not listed in the table are those not applicable at this stage of project.

Table 5-3**:** Status of Environment Permit WD-L3(349) Compliance – December 2014

Environment Permit Condition	Compliance (Yes / No)	NCR Issued by Engineer (Yes / No)	CAR Submitted by Contractor (Yes / No)	Comments or Actions Taken/Required
1	Yes	N/A	N/A	Nil
4	N/A	N/A	N/A	Dredging works completed so not applicable.
5	N/A	N/A	N/A	Dredging completed, no more dumping.
6	Yes	N/A	N/A	Nil
7	Yes	N/A	N/A	Nil
8	Yes	N/A	N/A	Established before dredging
9	Yes	N/A	N/A	No vegetation clearing undertaken
10	N/A	N/A	N/A	Access road to be constructed in Phase 2
11	Yes	N/A	N/A	Facilities are adequate.
12	Yes	N/A	N/A	Most facilities constructed.
13	Yes	N/A	N/A	Nil
14	Yes	N/A	N/A	Nil
15	Yes	N/A	N/A	Nil
16	Yes	N/A	N/A	Camp buildings connected to septic tanks
17	N/A	N/A	N/A	Wastes taken to City Municipal Waste Dump.
18	N/A	N/A	N/A	Workshop is sheltered and waste oil/fuel is stored in drums. No need for drainage.
19	N/A	N/A	N/A	No oil tank installed therefore no need for drainage triple interceptor trap.
20	Yes	N/A	N/A	No leakages noticed or reported yet.
21	Yes	N/A	N/A	No leakages noticed or reported yet.
22	Yes	N/A	N/A	Nil
23	Yes	N/A	N/A	Waste management measures outlined in the CEMP are catering for this.
26	Yes	N/A	N/A	CEMP in implementation
27	Yes	Yes	No	Dusty roads sprayed with water daily

Environment Permit Condition	Compliance (Yes / No)	NCR Issued by Engineer (Yes / No)	CAR Submitted by Contractor (Yes / No)	Comments or Actions Taken/Required
28	Yes	Yes	No	Nil
29	Yes	N/A	N/A	No major noise produced.
30	Yes	N/A	N/A	Nil
31	Yes	N/A	N/A	Drainages established to divert storm water. No landfills on site.
32	Yes	N/A	N/A	Drainages established to divert storm water.
33	Yes	N/A	N/A	All wastes are managed appropriately.
34	N/A	N/A	N/A	Connected to the city's sewerage system
36	Yes	N/A	N/A	Contractor's workshop at 12 mile is operated within a shed which is kept dry.
37	N/A	N/A	N/A	No vessels in use
38	Yes	N/A	N/A	Nil
39	Yes	N/A	N/A	Using fuel drums & fuel tank vehicle with pumps
40	Yes	N/A	N/A	Nil
41	Refer to water quality report in section 5.0 of this report			
42	Yes	N/A	N/A	Monitoring done by contractor.
43	N/A	N/A	N/A	Not necessary as no domestic and industrial wastes will be discharged into the sea.
44	Yes	N/A	N/A	Daily and weekly monitoring done and monthly reports produced.
45	Yes	N/A	N/A	A Waste Management Plan has been prepared for the **operational** phase in the future.

NB: Permit Conditions not listed above are Not Applicable (N/A).

5.9 Quarries

52. CHEC obtain rock from off site quarries run by private operators. It is a condition of the CEMP that all such quarries must have obtained an environmental permit from DEC. It is the responsibility of CHEC to ensure that such a permit is obtained before accepting rock from this quarry.

5.10 Environment Permit WD-L2B(379)

53. DEC issued Environment Permit WD-L2B(379) for operation of Gabensis quarry. Full compliance was observed. There were no environmental incidents and the quarry has now ceased operations.

5.11 Health and Safety

54. The main health and safety aspects or issues of the project are excessive noise, excessive dust, excessive smoke fumes, provision and use of safety equipment, unsafe handling an use of chemicals, observance of safety signs, improper management of wastes, provision and use of safety equipments, unhygienic living, use of untreated water, and incursion into project site by locals and children. Table 2 below is outline of compliance status of these safety and health aspects of the CEMP during December 2014.

Table 5-4**:** Status of Health and Safety Compliance – December 2014

Health Issue	Compliance (Yes / No)	NCR Issued by Engineer (Yes / No / NA)	CAR Submitted by Contractor (Yes / No / NA)	Comments or Actions Taken/Required
Excessive Noise	Yes	N/A	N/A	No complaints of noise from local residents
Excessive Dust	Yes	N/A	N/A	Watering of access road to suppress dust.
Excessive Smoke	Yes	N/A	N/A	No burnings of wastes lately.
Locals access to project site	Yes	N/A	N/A	Site fenced-in & access to project site controlled.
Use of explosives	Yes	N/A	N/A	No explosives are in use.
Handling & use of chemicals	Yes	N/A	N/A	No chemicals are in use.
Safe use of gases	Yes	N/A	N/A	No gas cylinders used during the month.
Hygienic living	Yes	N/A	N/A	Nil
Use of treated water supply	Yes	N/A	N/A	Nil
Use of PPE	Yes	N/A	N/A	All workers wearing PPE.
Installation of Safety Signs & Barricades	Yes	N/A	N/A	Nil
Management of Wastes	Yes	N/A	N/A	All wastes removed from construction site.

5.12 Training Programme

55. The training" programme was “On the Job Training” with formal classroom type training also given when new staff were recruited. The Contractor conducted tool box briefings 3 times a week during 2014 but ended in December because nearly 95% of workers had being laid off due to completion of project.

5.13 Environmental Audit Lae Port Tidal Basin Phase 1

56. An environmental audit was carried out in January 2015. This comprises the Project Completion Report and has been submitted under separate cover in the Environmental Report for December 2014. No outstanding environmental issues we identified.

6 Environmental Monitoring

6.1 Choice of Laboratory

57. Sampling and analysis was undertaken by ACCESS labs of Sri Lanka. They have established a small laboratory on site in the CHEC compound. They have capability to measure D.O., temperature, salinity, conductivity, pH, and turbidity directly from a boat. They take samples and analyse these in their on-site lab for Oil and Grease, Color and Suspended Solids. This totals 9 parameters. They also measure water velocity. They take water samples and send these to NARI (National Agricultural Research Institute) in Port Moresby for more detailed analysis of heavy metals and similar parameters. “Access” have on site calibration procedures using standard solutions. NARI has not received Laboratory International Accreditation so the use of NATSL was reinstated as they have received PNGLAS accreditation.

6.2 Sampling Locations

58. As stated in the CEMP sampling takes place along 4 transects named Transects 1, 2, 3, and 4. Water samples were taken every 500m along transects 1, 2 and 3 and every 5,000 m along transect 4. The location of transect 1, 2, and 3 is indicated in Figure 6-1 below. Transect 4 runs from Labu Bay to Busama and Salamaua covering a distance of approximately 50km and samples are taken at a distance of 50m from the coastline. from the coastline. Positioning of the sampling stations was carried out by means of global positioning system device (Garmin Etrex 20). All samples were obtained at 1.5m depth below the water surface.

6.3 Timing of Water Sampling

59. In March 2013 the contractor requested a variation in the sampling and analysis regime so that faster reports could be submitted. Since then the timing has been :

- Weekly samples would be taken on Transects T1, T2 and T3 and analysed for the 9 parameters.
- Monthly samples would be taken on Transects T1, T2, T3 and T4 and analysed for the 9 parameters.
- Every 3 months the above would be repeated for all four transects and water samples sent to NARI for analysis of the other 31 parameters.

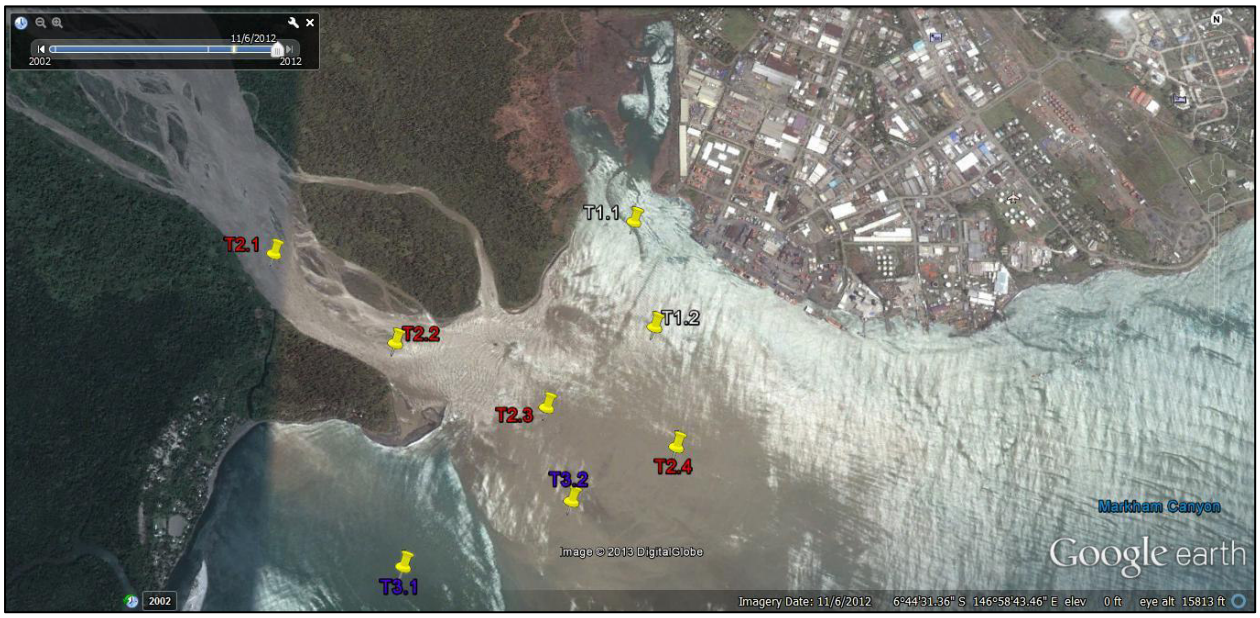


Figure 6-1 Transects 1,2 and 3

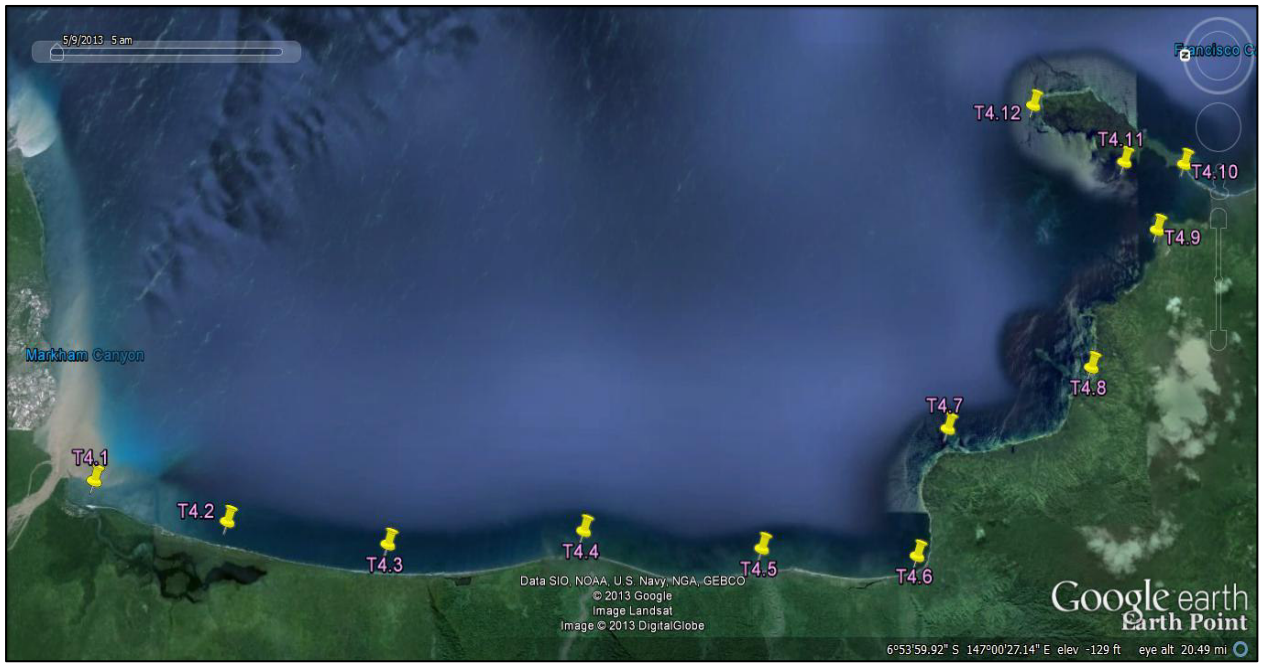


Figure 6-2 Transect 4

6.4 Parameters to be Monitored

60. The 9 parameters monitored along Transects 1, 2 and 3 are :

- Salinity
- Electrical Conductivity
- Dissolved oxygen
- Turbidity
- Colour
- pH
- Temperature
- Total suspended solids
- Grease and oil

61. The 31 parameters monitored along Transects 1,2,3 and 4 are :
01. Aluminum 02. Antimony 03. Arsenic 04. Cadmium 05. Chromium 06. Cobalt 07. Copper 08. Iron 09. Lead 10. Manganese 11. Mercury 12. Molybdenum 13. Nickel 14. Selenium 15. Silver 16. Vanadium 17. Zinc 18. Calcium 19. Magnesium 20. Potassium 21. Sodium 22. Sulfate 23. Chloride 24. Nitrogen total 25. Phosphorus total 26. Sulfur total 27. Boron total 28. Oil & Grease 29. Organic Carbon 30. Cyanide 31.Conductivity

6.5 Sampling Methodology

62. The samples were collect by operators leaning over the side of the boat and using a depth sampler to sample the 1 liter container at a depth of approximately 1.5m depth. Samples were stored in 1-L high density polyethylene (HDPE) bottles prepared by cleaning with 10% nitric soaked and rinsed with de-ionized water. All samples were stored in a chilled insulation container (Esky) with ice-packs and then transferred to the laboratory. Water samples were sent for more detailed analysis of heavy metals and similar parameters.

6.6 Analytical Methods and Instruments

63. The methods followed APHA "STANDARD METHODS for The Examination of Water & Waste Water" 21st Edition.

- pH, DO, Salinity, Conductivity, Temperature were measured in situ using a Multi parameter HACH HQ 40D with DO being measured in-situ at the correct depth using an extended probe
- Turbidity of water uses a turbidity meter HACH 2100Q
- Oil &Grease were analysed in the site lab following USEPA Method 1664A XENOSEP
- Water Velocity use GLOBAL WATER FP 211 flow probe
- TSS were analysed in the site lab following APHA method

64. All samples were analysed in accordance with APHA Standard Methods.

6.7 Certification

65. Samples were sent to NATSL of Unitech as they have obtained Accreditation to ISO Standard for their lab operation.

66. Water quality monitoring and analysis has changed from the original specification as agreed by PMU, KECC and CHEC and been reduced to 9 parameters per month and 31 parameters monitoring per quarter for Transect 1 sample 1 (Basin) through to Transect 4 sample 12 (Salamua Point), covering all four transects.

67. The results are interpreted against the Baseline Survey, the DEC Environmental Permit and criteria set by the Independent State of Papua New Guinea under the Environment ACT 2000 Water Quality criteria for Aquatic Life Protection.

7 Direct Reading Instrument Parameters

68. Parameters which are either measured directly or measured on site have been compared with previous results from earlier months, with the baseline and are shown against the PNG standard where such standards exist.

7.1 Temperature

69. Temperature ranged from 24^{o} to 30^{o} which is considered to be normal seasonal variation. There are no hot water discharges from the site.

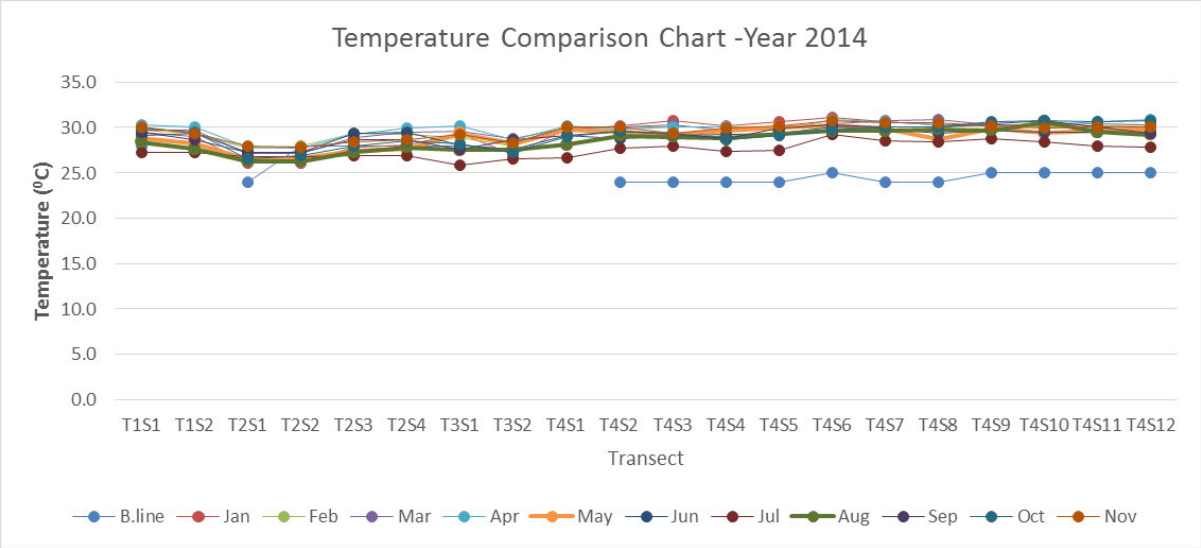


Figure 7-1 Temperature

7.2 pH

70. The values of pH were very consistent remaining around pH8There was no seasonal variation and no difference from the baseline values. It is considered that the seawater being saline has a large buffering effect on the freshwater inflows from the Markham River.

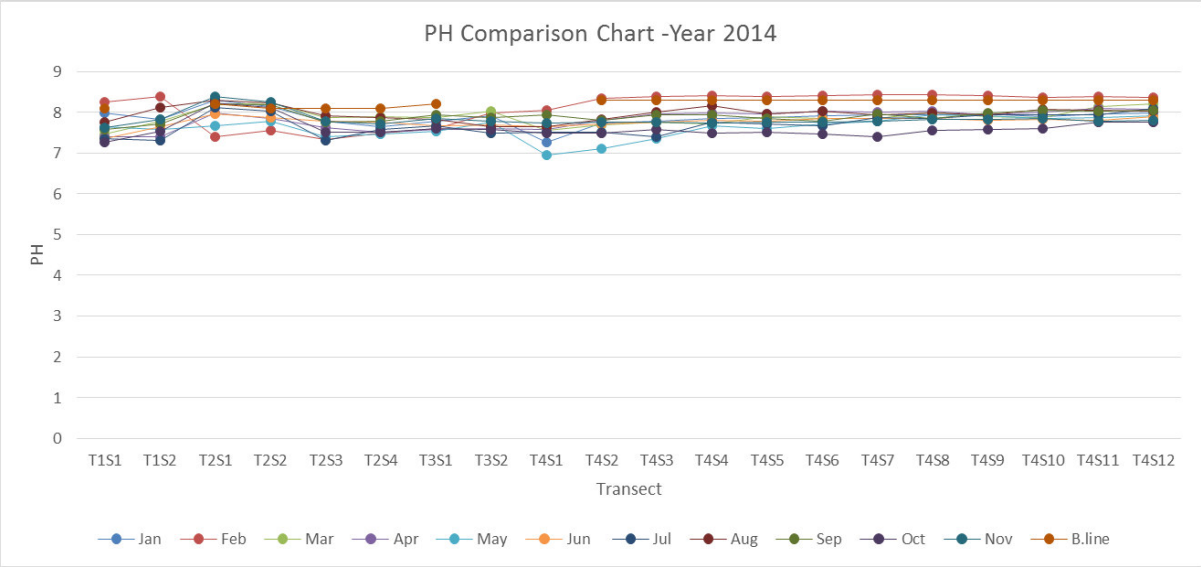


Figure 7-2 pH

7.3 Dissolved Oxygen (DO)

71. The values for D.O. varied between 6.5 to 8 mg/L indicating a healthy oxygen level. In general they remained consistently above the PNG Standard of 5 mg/L although on occasion they fell to 4 mg/L although this is not considered to be sufficiently low to give cause for concern. This was during the March period. For the rest of the year the levels indicated healthy marine waters.

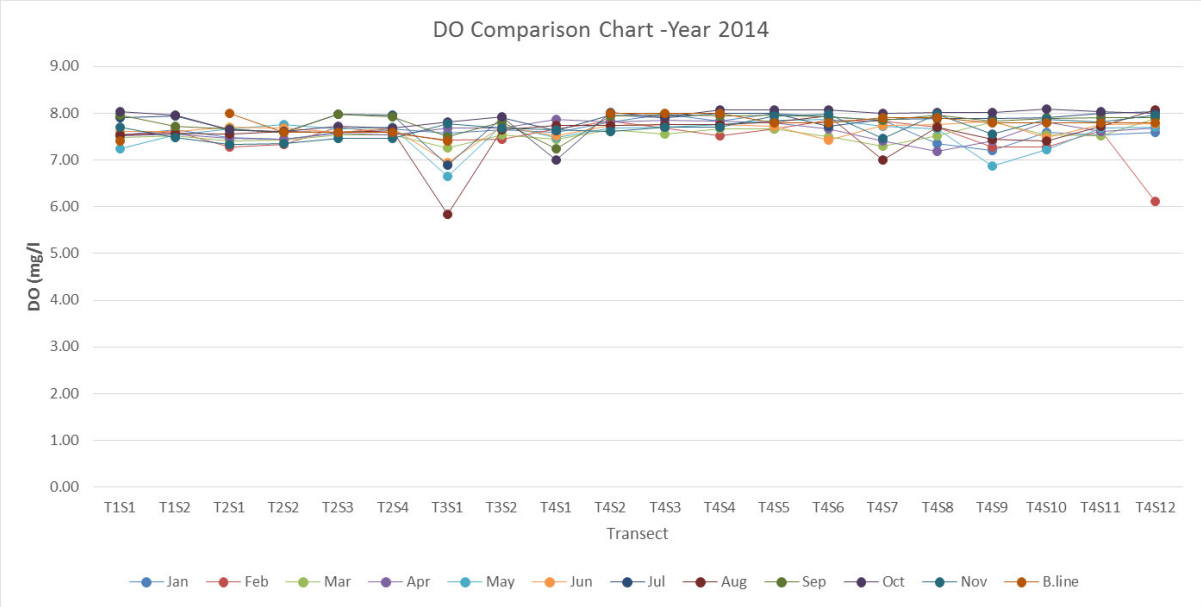


Figure 7-3 Dissolved Temperature

7.4 Salinity

72. There is no PNG standard for salinity. Levels varied considerably over the year. The lower values in Transect 2 are attributed to heavy inflows of freshwater from seasonal rain with the lowest occurring in the Markham River which is a tidal estuary, so such fluctuations are to be expected.

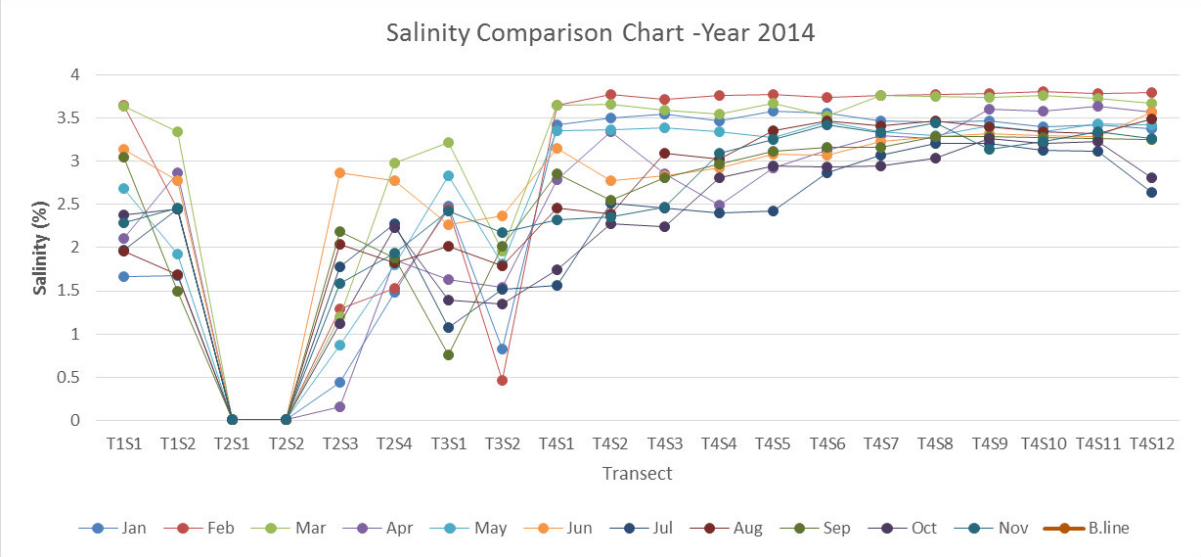


Figure 7-4 Salinity

7.5 Conductivity

73. Conductivity is the reciprocal of salinity so the comments in salinity above also apply.

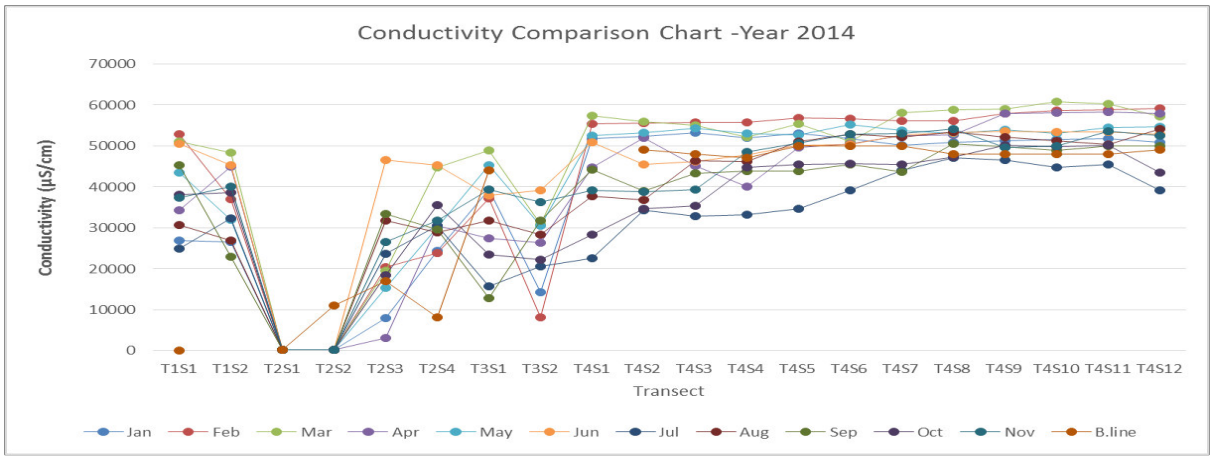


Figure 7-5 Conductivity

7.6 Turbidity

74. Turbidity levels were generally low indicating good water quality. The highest levels occurred in the Markham River which is attributed to heavy silt flows in the river from heavy inland rains. The levels in open water as shown in Transect 4 show good clarity of water.

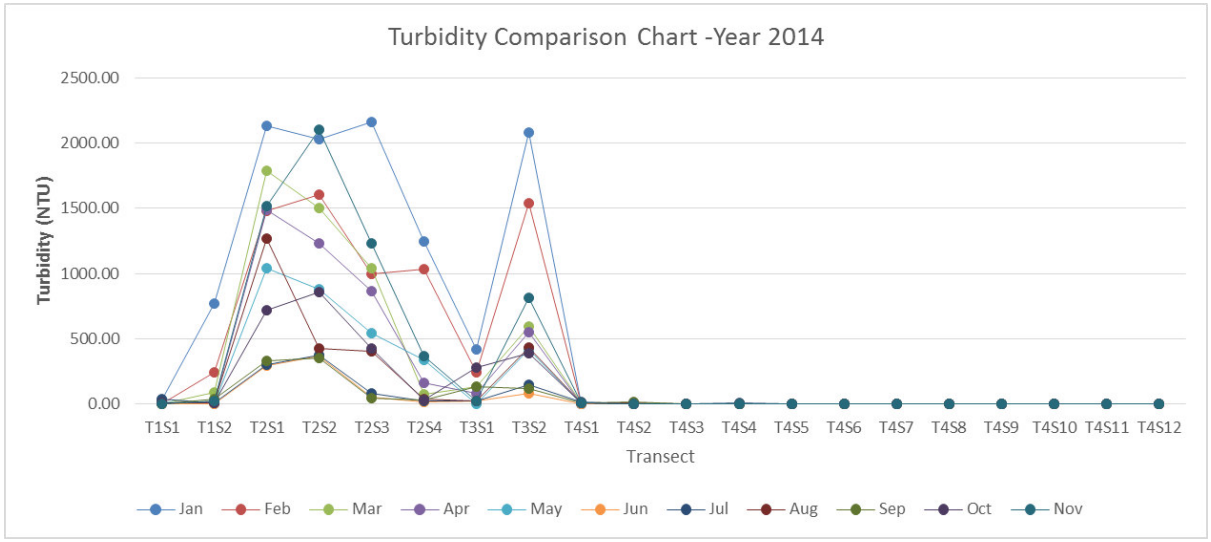


Figure 7-6 Turbidity

7.7 Oil and Grease

75. The values for oil and grease were higher in September around the site. High levels were detected along Transect 4 which is well removed from the site or the existing port. It is thought that the levels must be due to passing local marine traffic. There are no activities on the site that would cause a discharge of oil and grease.

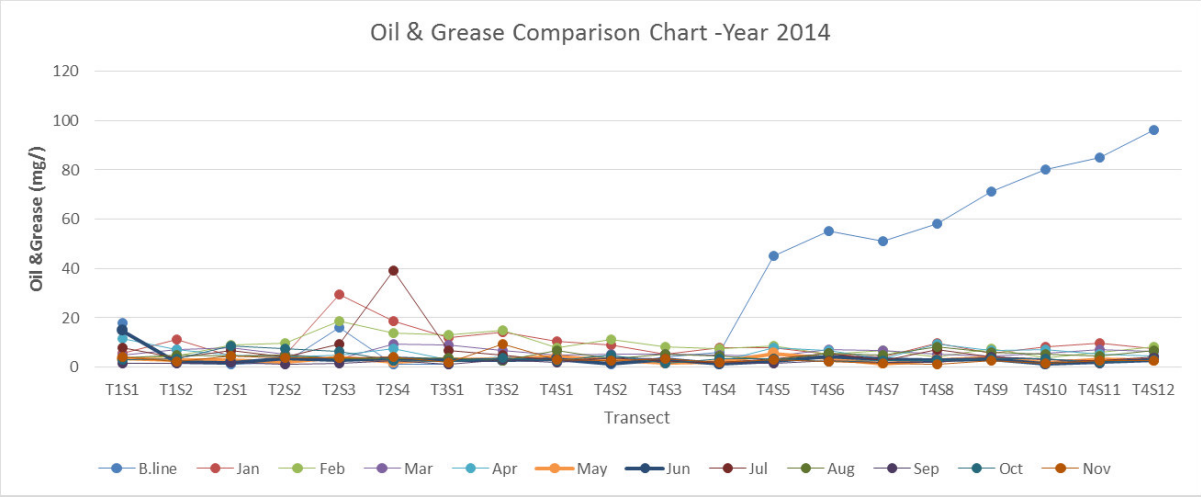


Figure 7-7 Oil and Grease

76. The PNG standard for oil and greases is “None” so all sample fail to meet the standard although the standard seems unrealistic.

7.8 Suspended Solids

77. Suspended solids are linked to turbidity although high turbidity levels may be due to coloration as well as the presence of suspended solids. The highest levels occur in the Markham River. Apart from that in general levels were similar to the baseline.

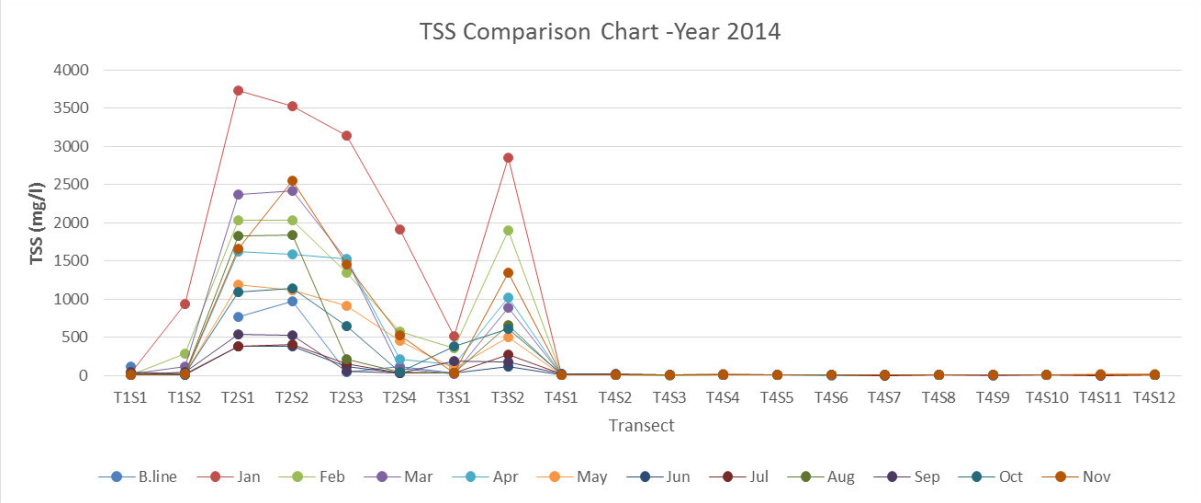


Figure 7-8 Suspended Solids

7.9 Color

78. High values were observed at T2.1 which is in the Markham River upstream of the site. These high levels cannot be due to site operations but must be due to activities upstream and inland. Slightly elevated levels were found at T 3.2 which also receives sediment flows from the Markham River.

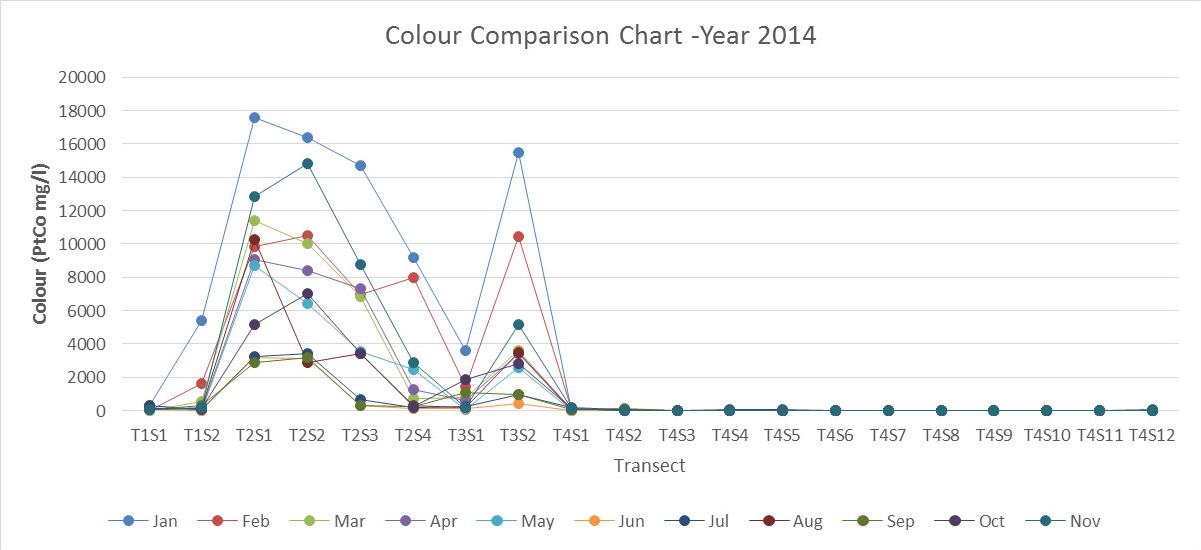


Figure 7-9 Color

8 Laboratory Instruments Results

8.1 Results for January to December 2014

79. Parameters which are either measured directly or measured on site have been compared with previous results from earlier months, with the baseline and are shown against the PNG standard where such standards exist. For reference the PNG Marine Water Quality Standards are given below. Not all parameters which are specified for measurement have corresponding PNG regulatory standards. The heavy metal analysis took place every 3 months. As work on the site ended in November 2014 the last monitoring was September 2014.

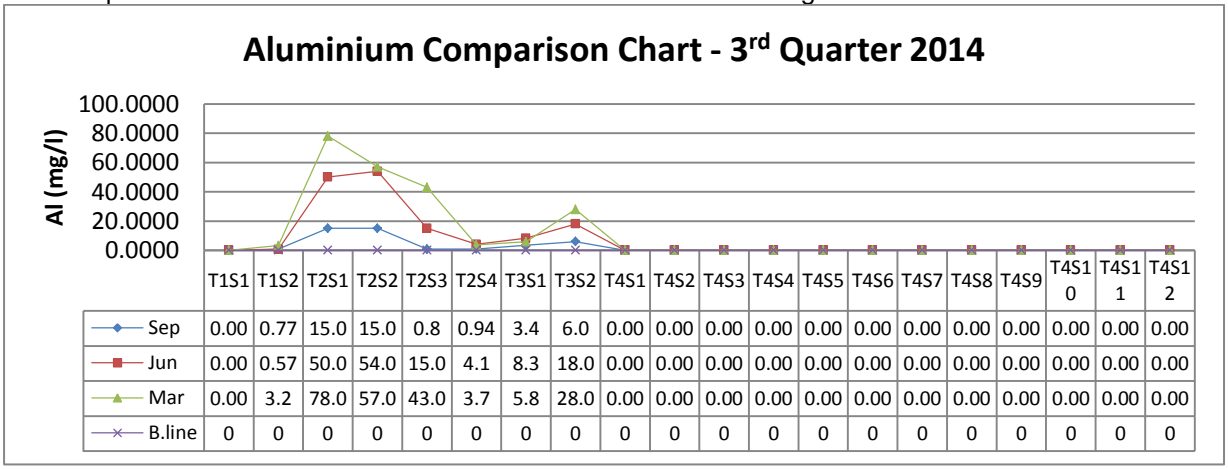
Table 8-1 Water Quality Parameters and Limits

PNG STANDARDS	
Parameters	Value
Turbidity	No alteration <25 NTU
Oil & Grease	None
Colour	No alteration to Natural colouration
Dissolved Oxygen	Not less than 5 mg/L
Salinity	No Limit
TSS	No limit
E/conductivity	No limit
Aluminium	No limit
Antimony	No limit
Arsenic	0.05 mg/L
Cadmium	0.001 mg/L
Chromium	0.01 mg/L
Cobalt	Limit of detectability
Copper	0.03mg/L
Iron	1.0 mg/L
Lead	0.004 mg/L
Manganese	2.0 mg/L
Mercury	0.0002 mg/L
Molybdenum	No Limit

Nickel	1.0 mg/L
Selenium	0.01 mg/L
Silver	0.05 mg/L
Vanadium	No Limit
Zinc	5.0 mg/L
Calcium	No Limit
Magnesium	No Limit
Potassium	450.0 mg/L
Sodium	No Limit
Sulfate	No Limit
Chloride	No Limit
Ammonia Nitrogen	0.05 mg/L
Phosphorus	No Limit
Sulfur	No Limit
Boron	2.0 mg/L
Organic Carbon	-
Cyanide	0.01 mg/L

8.2 Aluminium

80. The levels for aluminium in September were higher than the baseline but only in the Markham River (Transects 2.1 – 2.4) and were lower than previous months. This suggests sources upstream were responsible. There is no standard for aluminium in the PNG regulations.

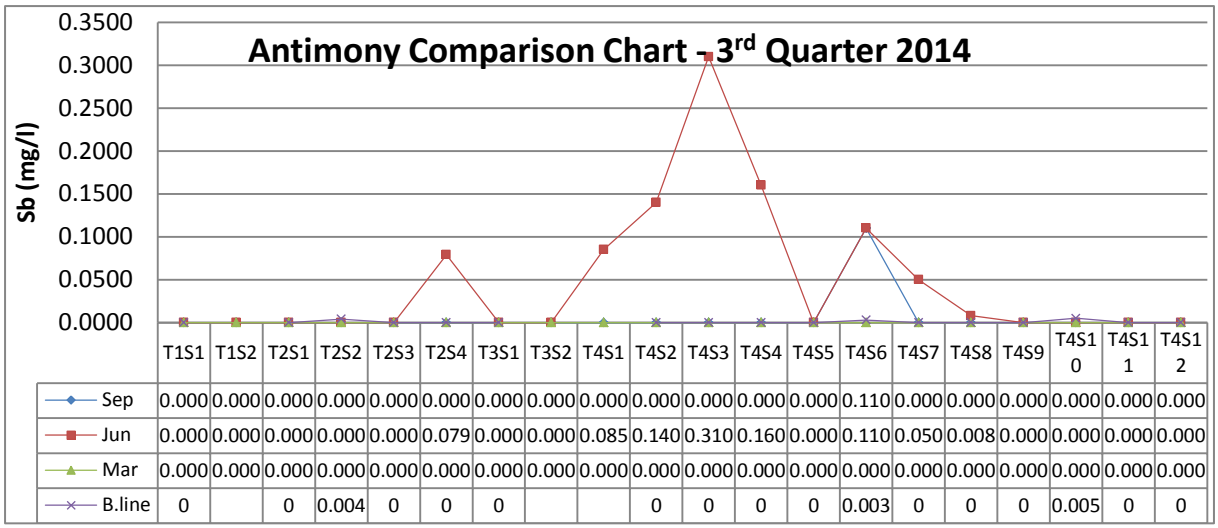


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.77	15.0	15.0	0.8	0.94	3.4	6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.57	50.0	54.0	15.0	4.1	8.3	18.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	3.2	78.0	57.0	43.0	3.7	5.8	28.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 8-1 Aluminium

8.3 Antimony

81. The levels for antimony were very low and similar to levels in the baseline. A spike in levels at T4S6 occurred as did in June 2014. There is no standard for antimony in the PNG regulations.

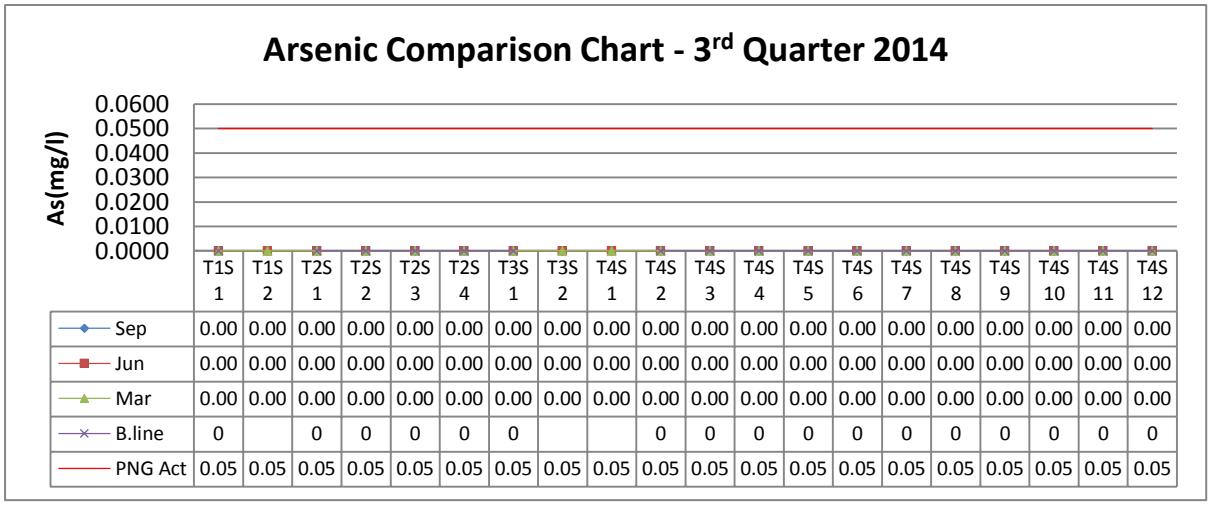


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.110	0.000	0.000	0.000	0.000	0.000	0.000
Jun	0.000	0.000	0.000	0.000	0.000	0.079	0.000	0.000	0.085	0.140	0.310	0.160	0.000	0.110	0.050	0.008	0.000	0.000	0.000	0.000
Mar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B.line	0		0	0.004	0	0	0			0	0	0	0	0.003	0	0	0	0.005	0	0

Figure 8-2 Antimony

8.4 Arsenic

82. The levels for arsenic were below the threshold of detection at 0.0002 mg/L. The standard is 0.05 mg/L in the PNG regulations.

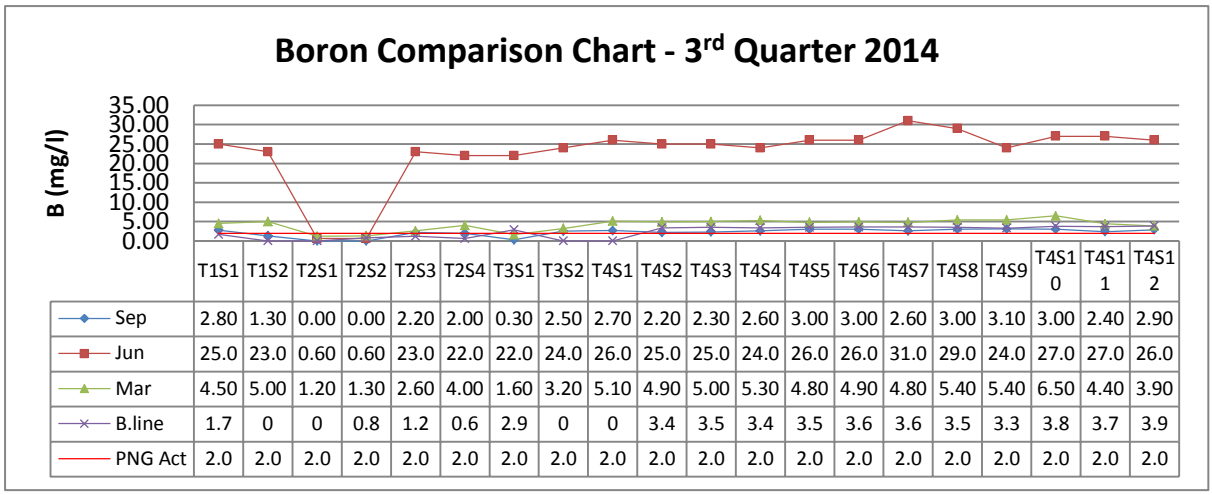


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Figure 8-3 Arsenic

8.5 Boron

83. Boron levels were around the same level as the baseline. The PNG standard for boron is 2.0 mg/L. The high levels recorded in June had dropped considerably. Adverse effects of boron are usually associated with potable water not seawater. The dilution effect of the Markham River is pronounced.

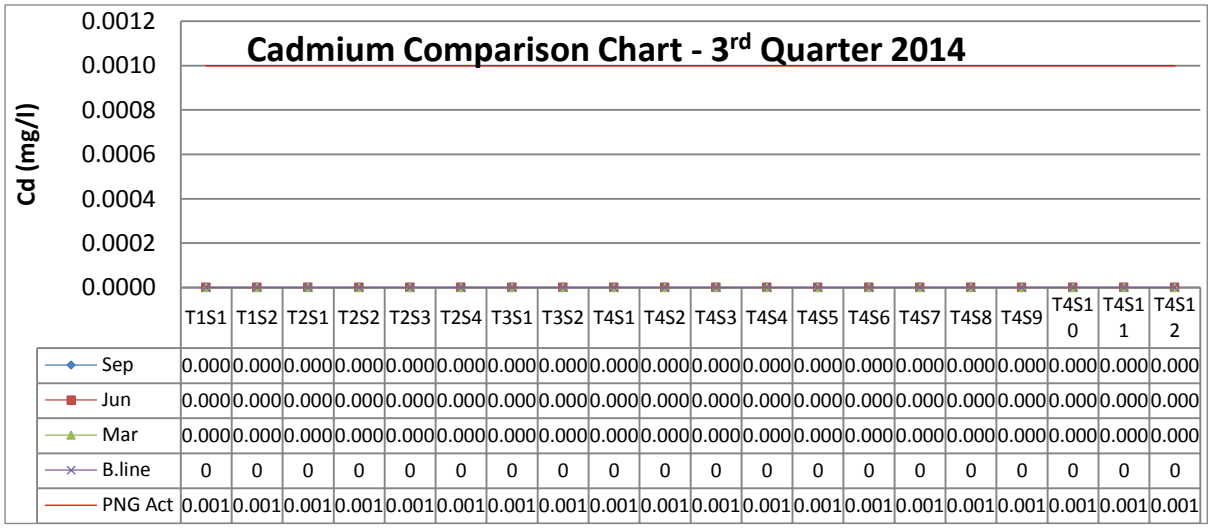


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	2.80	1.30	0.00	0.00	2.20	2.00	0.30	2.50	2.70	2.20	2.30	2.60	3.00	3.00	2.60	3.00	3.10	3.00	2.40	2.90
Jun	25.0	23.0	0.60	0.60	23.0	22.0	22.0	24.0	26.0	25.0	25.0	24.0	26.0	26.0	31.0	29.0	24.0	27.0	27.0	26.0
Mar	4.50	5.00	1.20	1.30	2.60	4.00	1.60	3.20	5.10	4.90	5.00	5.30	4.80	4.90	4.80	5.40	5.40	6.50	4.40	3.90
B.line	1.7	0	0	0.8	1.2	0.6	2.9	0	0	3.4	3.5	3.4	3.5	3.6	3.6	3.5	3.3	3.8	3.7	3.9
PNG Act	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Figure 8-4 Boron

8.6 Cadmium

84. Cadmium was not detected. The PNG standard for cadmium is 0.001 mg/L.

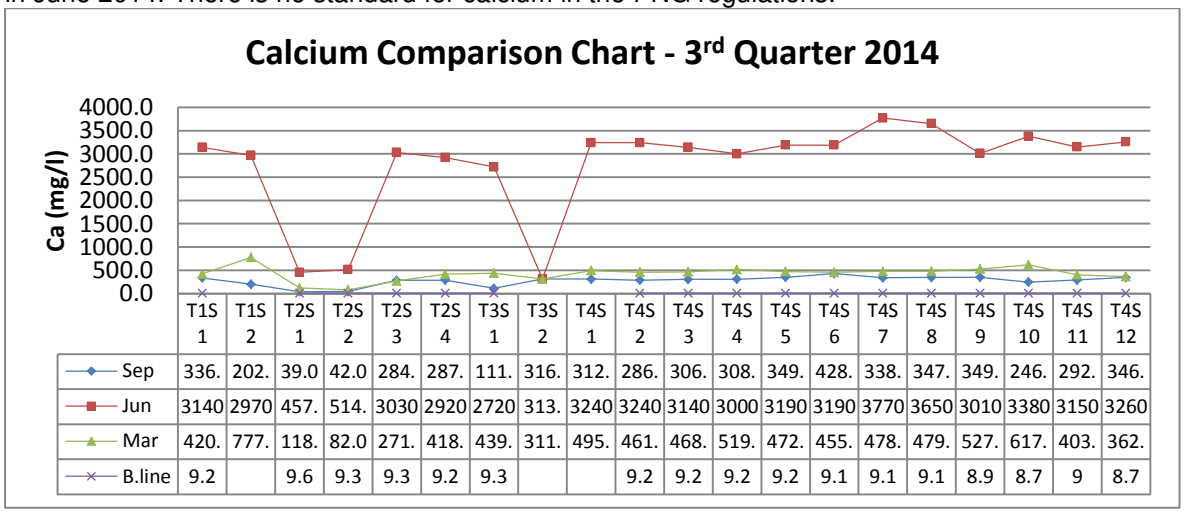


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jun	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B.line	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNG Act	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Figure 8-5 Cadmium

8.7 Calcium

85. The levels for calcium were considerably higher than the baseline but a lot lower than the levels in June 2014. There is no standard for calcium in the PNG regulations.

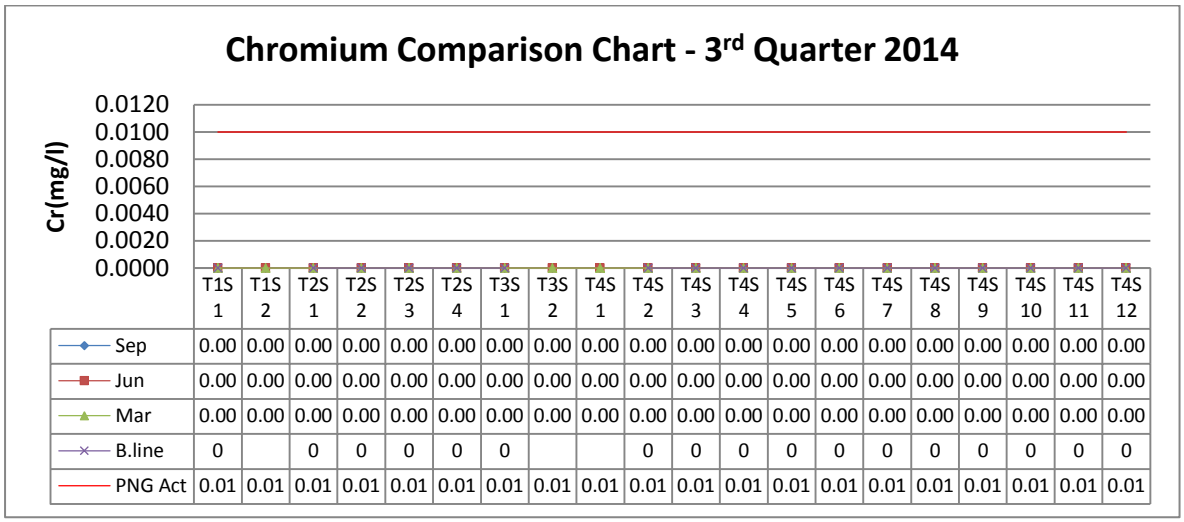


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	336.	202.	39.0	42.0	284.	287.	111.	316.	312.	286.	306.	308.	349.	428.	338.	347.	349.	246.	292.	346.
Jun	3140	2970	457.	514.	3030	2920	2720	313.	3240	3240	3140	3000	3190	3190	3770	3650	3010	3380	3150	3260
Mar	420.	777.	118.	82.0	271.	418.	439.	311.	495.	461.	468.	519.	472.	455.	478.	479.	527.	617.	403.	362.
B.line	9.2		9.6	9.3	9.3	9.2	9.3			9.2	9.2	9.2	9.2	9.1	9.1	9.1	8.9	8.7	9	8.7

Figure 8-6 Calcium

8.8 Chromium

86. Chromium was not detected. The PNG standard for chromium is 0.01 mg/L

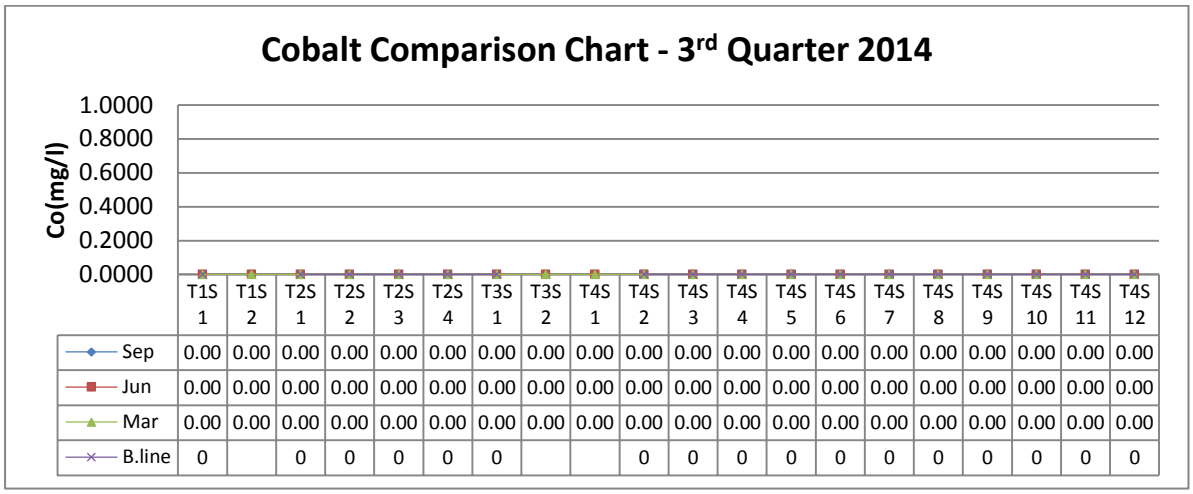


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Figure 8-7 Chromium

8.9 Cobalt

87. Cobalt was not detected. There is no PNG standard for Cobalt.

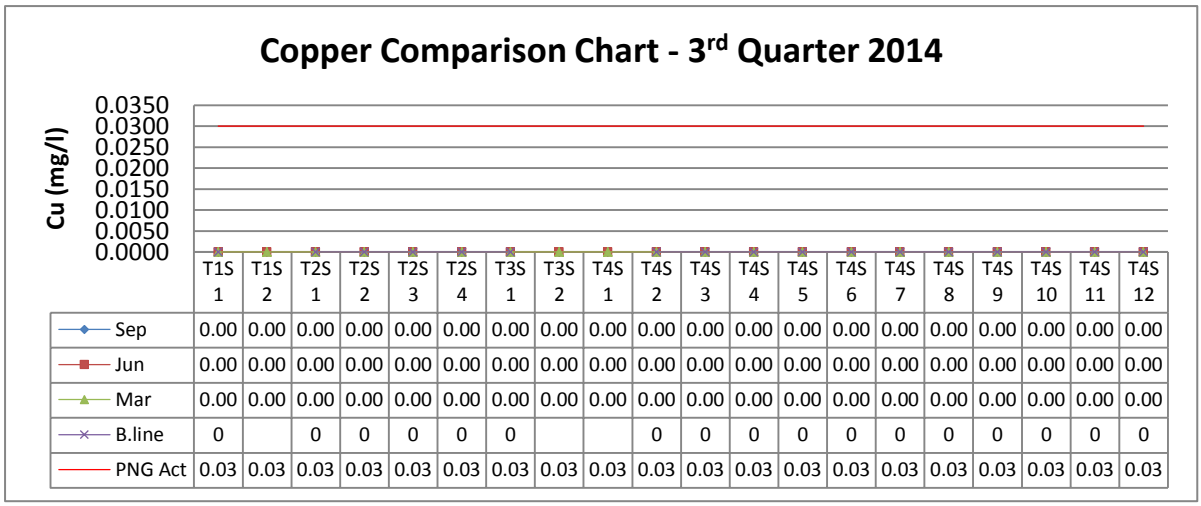


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0

Figure 8-8 Cobalt

8.10 Copper

88. Copper was not detected. The PNG standard for Copper is 0.03 mg/L

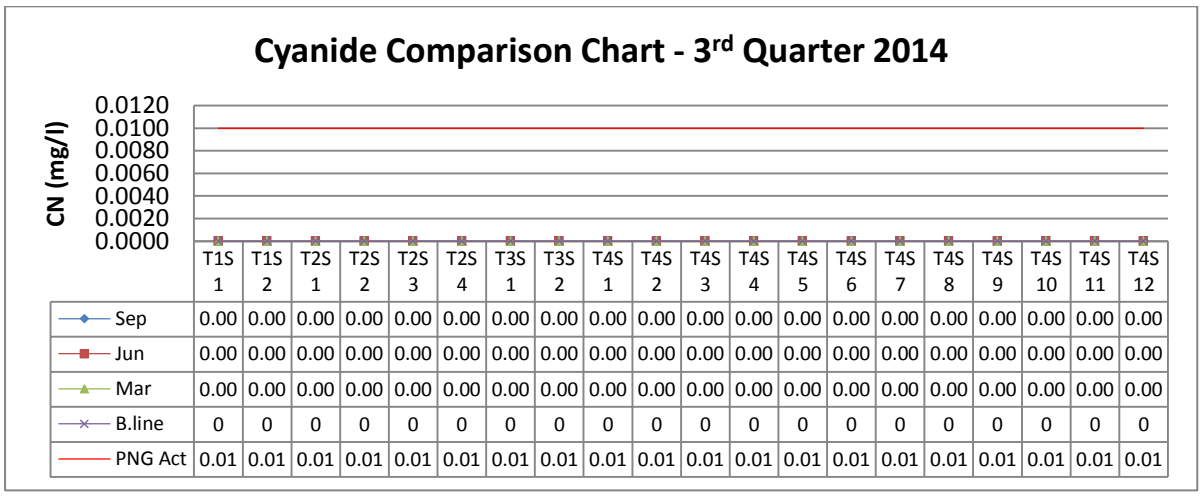


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Figure 8-9 Copper

8.11 Cyanide

89. Cyanide was not detected. The PNG standard for Cyanide is 0.01 mg/L

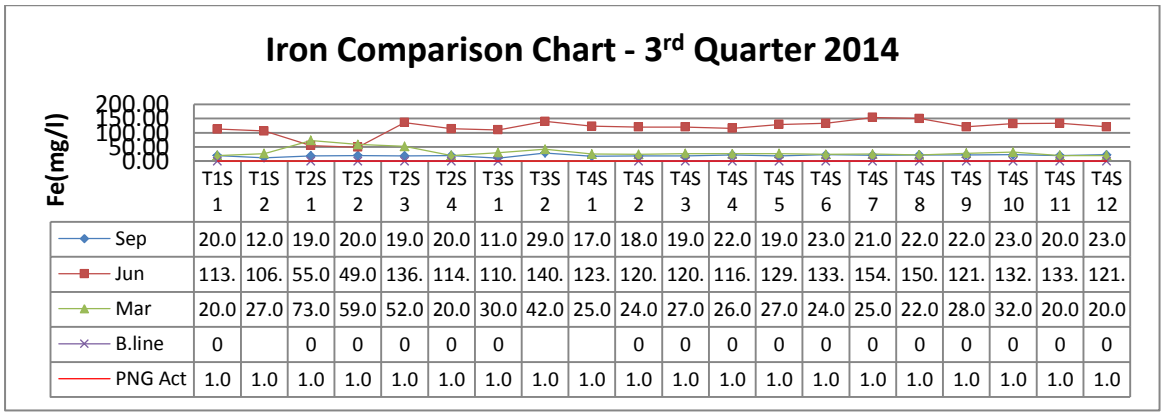


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNG Act	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Figure 8-10 Cyanide

8.12 Iron

90. The PNG standard for iron is 1.0 mg/L The levels for iron were higher than the PNG standard and higher than the baseline, yet similar to levels in March and much lower than levels in June.

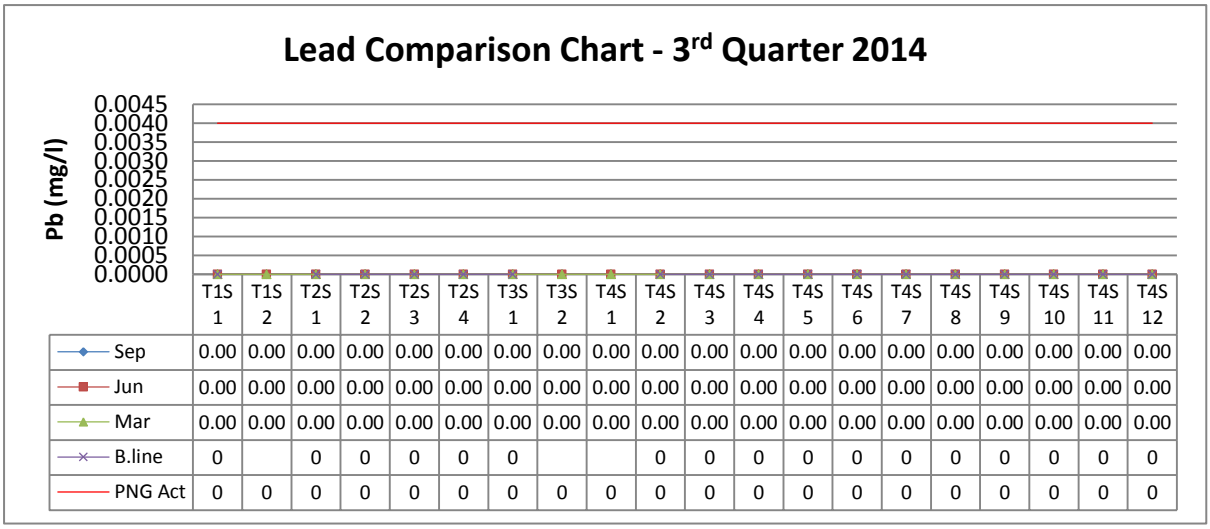


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	20.0	12.0	19.0	20.0	19.0	20.0	11.0	29.0	17.0	18.0	19.0	22.0	19.0	23.0	21.0	22.0	22.0	23.0	20.0	23.0
Jun	113.	106.	55.0	49.0	136.	114.	110.	140.	123.	120.	120.	116.	129.	133.	154.	150.	121.	132.	133.	121.
Mar	20.0	27.0	73.0	59.0	52.0	20.0	30.0	42.0	25.0	24.0	27.0	26.0	27.0	24.0	25.0	22.0	28.0	32.0	20.0	20.0
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Figure 8-11 Iron

8.13 Lead

91. Lead was not detected. The PNG standard for Lead is 0.004 mg/L

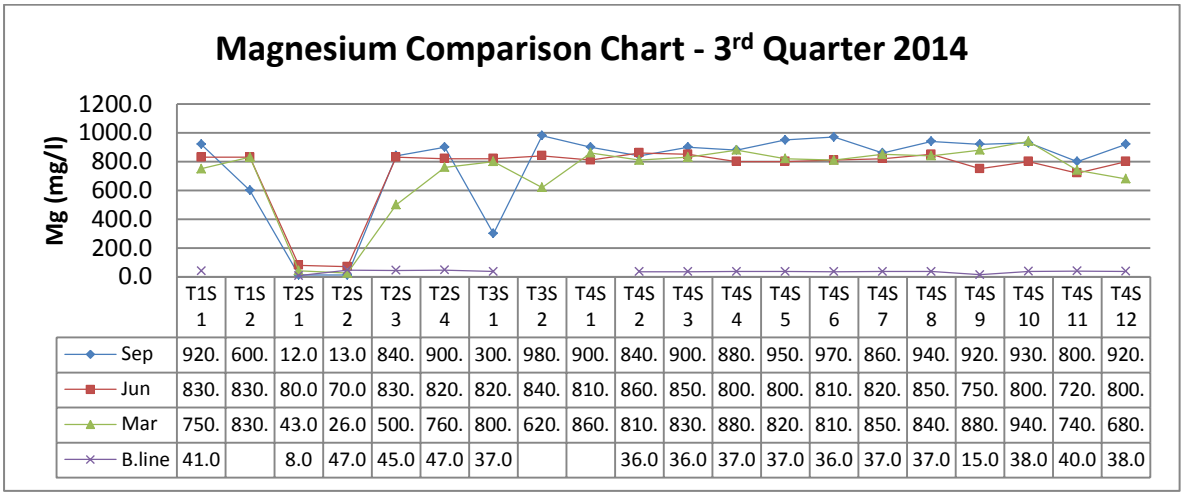


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 8-12 Lead

8.14 Magnesium

92. The levels for magnesium were much higher than the baseline and similar to levels in June and March 2014. A dip in levels in the Markham River suggests the elevated levels are marine based. There is no standard for magnesium in the PNG regulations.

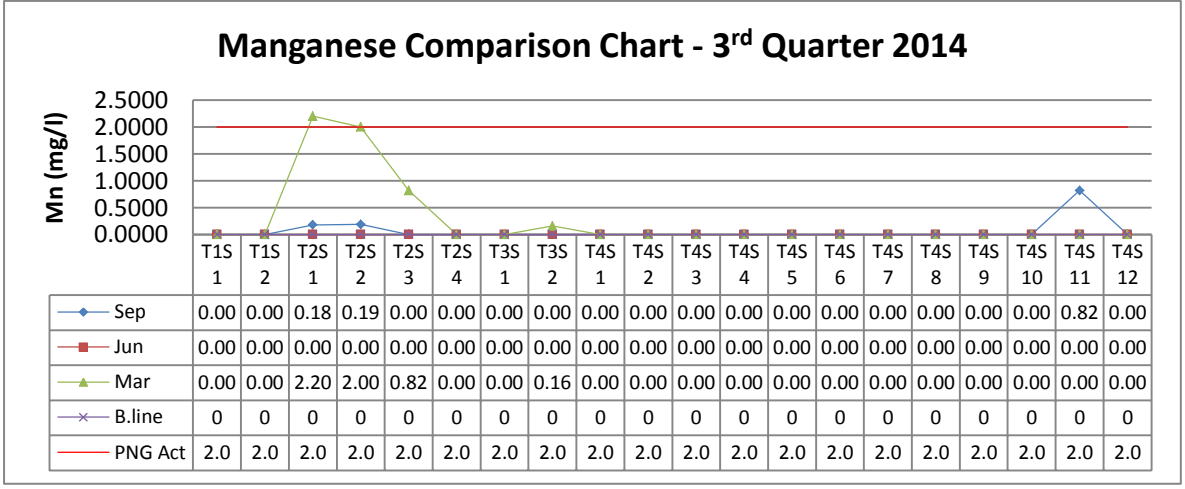


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	920.	600.	12.0	13.0	840.	900.	300.	980.	900.	840.	900.	880.	950.	970.	860.	940.	920.	930.	800.	920.
Jun	830.	830.	80.0	70.0	830.	820.	820.	840.	810.	860.	850.	800.	800.	810.	820.	850.	750.	800.	720.	800.
Mar	750.	830.	43.0	26.0	500.	760.	800.	620.	860.	810.	830.	880.	820.	810.	850.	840.	880.	940.	740.	680.
B.line	41.0		8.0	47.0	45.0	47.0	37.0			36.0	36.0	37.0	37.0	36.0	37.0	37.0	15.0	38.0	40.0	38.0

Figure 8-13 Magnesium

8.15 Manganese

93. Manganese was detected in very low concentrations. The PNG standard for manganese is 2.0 mg/L. Measured levels were much below this.

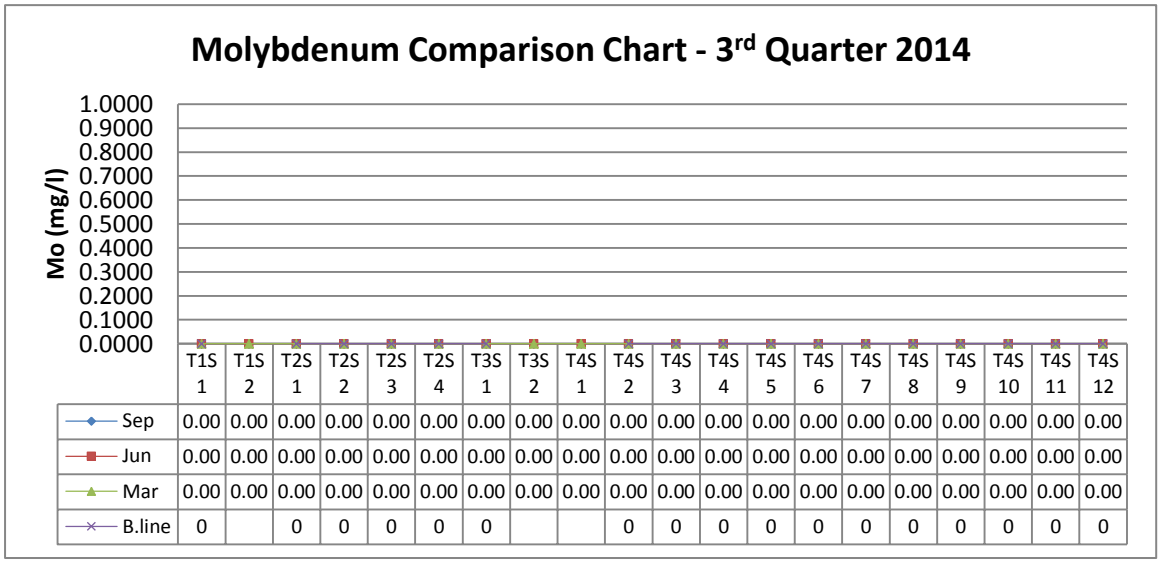


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.18	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	2.20	2.00	0.82	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PNG Act	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Figure 8-14 Manganese

8.16 Molybdenum

94. Molybdenum was not detected. There is no standard for molybdenum in the PNG regulations.

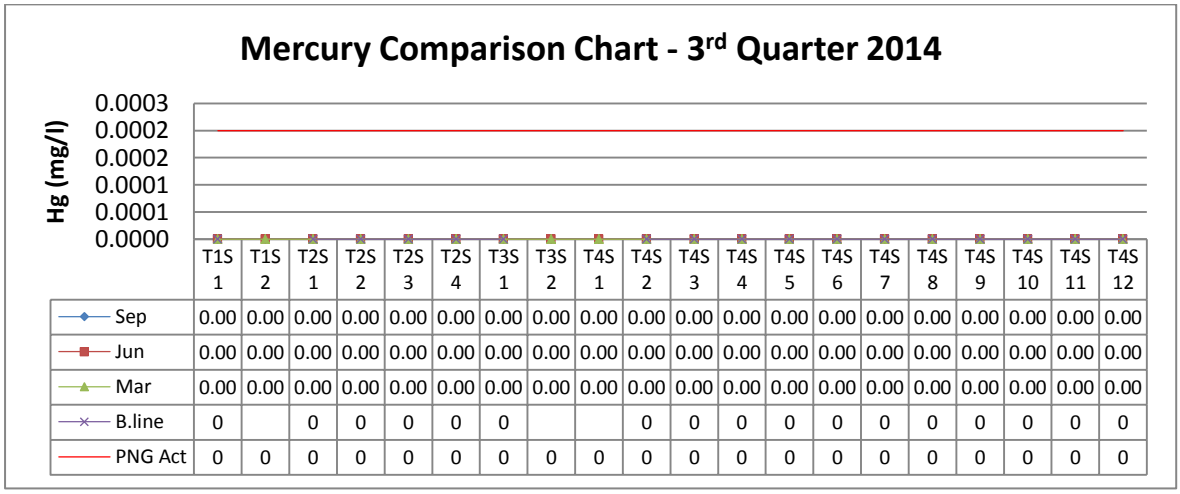


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0

Figure 8-15 Molybdenum

8.17 Mercury

95. Mercury was not detected. The PNG standard for mercury is 0.0002 mg/L

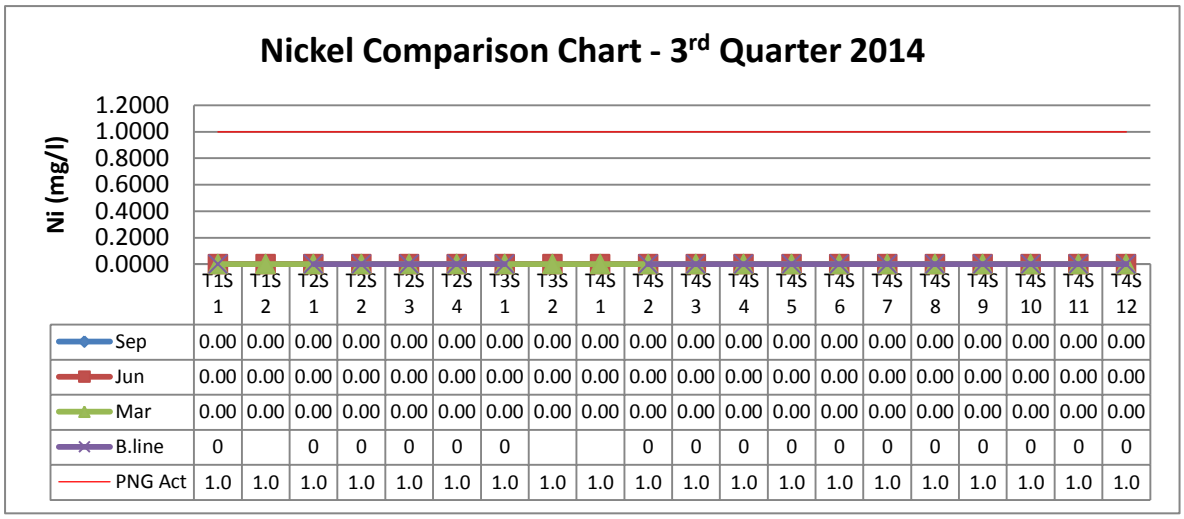


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 8-16 Mercury

8.18 Nickel

96. Nickel was not detected. The PNG standard for nickel is 1.0 mg/L.

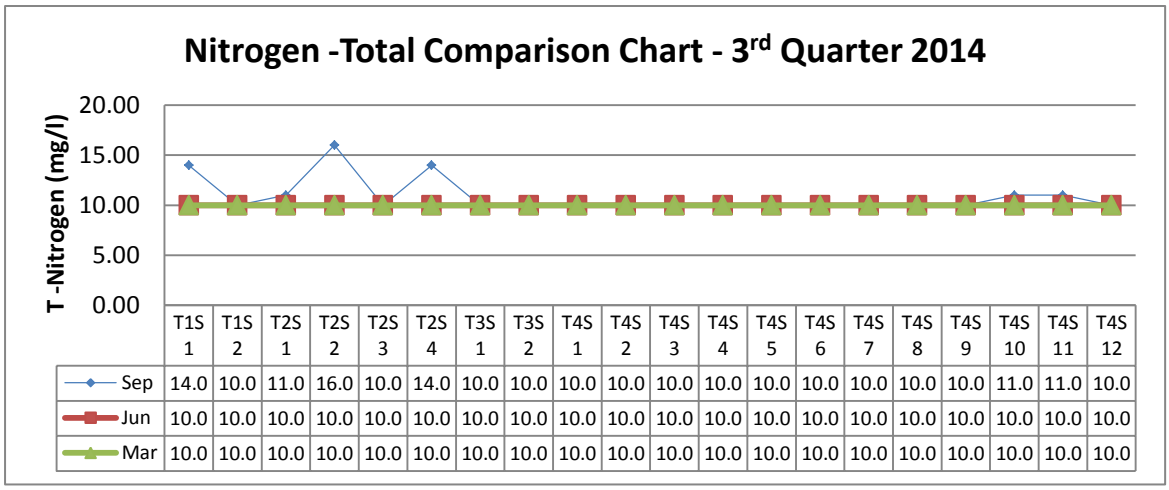


	T1S 1	T1S 2	T2S 1	T2S 2	T2S 3	T2S 4	T3S 1	T3S 2	T4S 1	T4S 2	T4S 3	T4S 4	T4S 5	T4S 6	T4S 7	T4S 8	T4S 9	T4S 10	T4S 11	T4S 12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Figure 8-17 Nickel

8.19 Nitrogen

97. Nitrogen was detected at levels similar to March and June. Levels were very consistent. There is no standard for nitrogen in seawater in PNG.

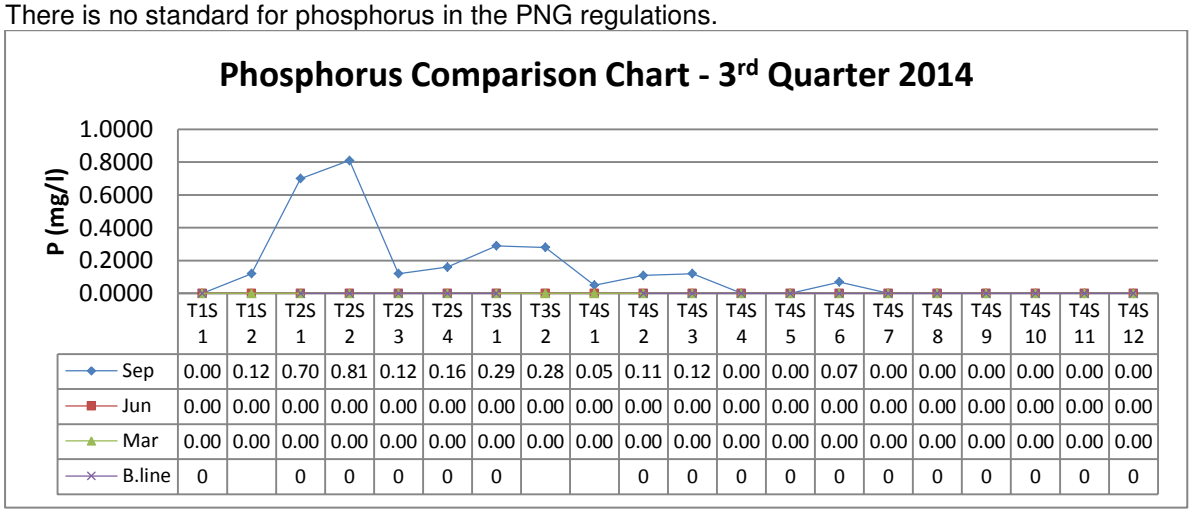


	T1S 1	T1S 2	T2S 1	T2S 2	T2S 3	T2S 4	T3S 1	T3S 2	T4S 1	T4S 2	T4S 3	T4S 4	T4S 5	T4S 6	T4S 7	T4S 8	T4S 9	T4S 10	T4S 11	T4S 12
Sep	14.0	10.0	11.0	16.0	10.0	14.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	11.0	11.0	10.0
Jun	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Mar	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Figure 8-18 Nitrogen

8.20 Phosphorus

98. Phosphorus was detected at low levels whereas in previous months it was not detected at all. There is no standard for phosphorus in the PNG regulations.

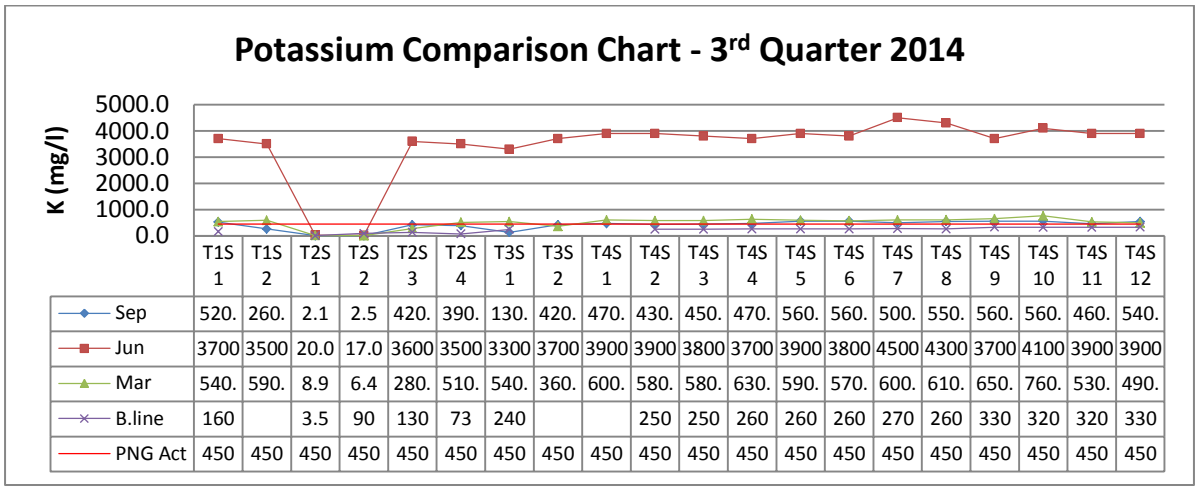


	T1S 1	T1S 2	T2S 1	T2S 2	T2S 3	T2S 4	T3S 1	T3S 2	T4S 1	T4S 2	T4S 3	T4S 4	T4S 5	T4S 6	T4S 7	T4S 8	T4S 9	T4S 10	T4S 11	T4S 12
Sep	0.00	0.12	0.70	0.81	0.12	0.16	0.29	0.28	0.05	0.11	0.12	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0

Figure 8-19 Phosphorus

8.21 Potassium

99. Levels of potassium were very low in the Markham River. Elsewhere levels were similar to March and much lower than in June. Levels were similar to the standard and the baseline. The PNG standard for Potassium is 450mg/L. There are no activities on the construction site that would generate potassium.

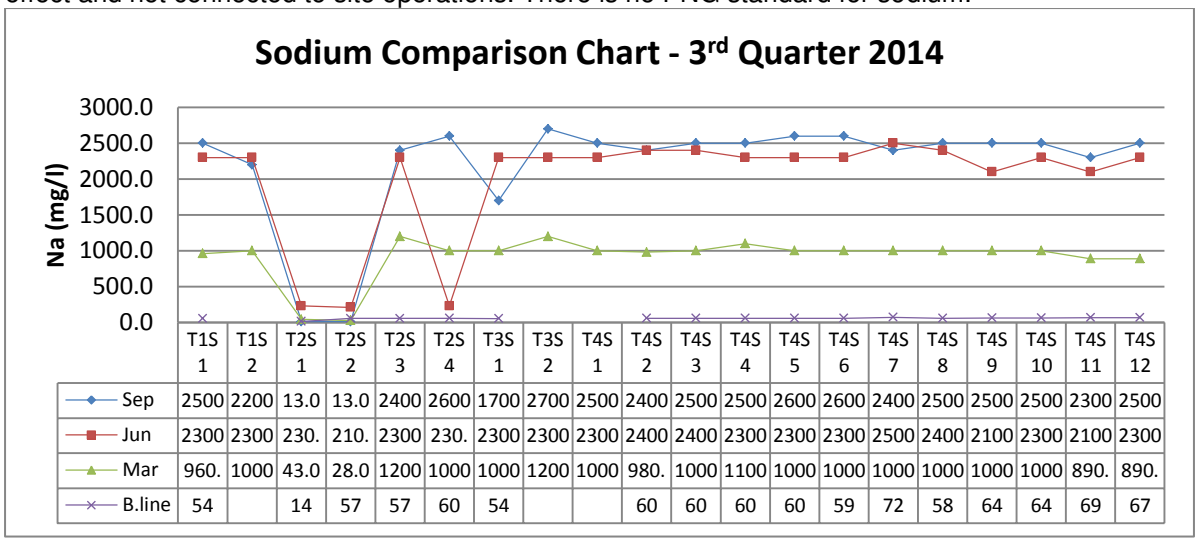


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	520.	260.	2.1	2.5	420.	390.	130.	420.	470.	430.	450.	470.	560.	560.	500.	550.	560.	560.	460.	540.
Jun	3700	3500	20.0	17.0	3600	3500	3300	3700	3900	3900	3800	3700	3900	3800	4500	4300	3700	4100	3900	3900
Mar	540.	590.	8.9	6.4	280.	510.	540.	360.	600.	580.	580.	630.	590.	570.	600.	610.	650.	760.	530.	490.
B.line	160		3.5	90	130	73	240			250	250	260	260	260	270	260	330	320	320	330
PNG Act	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450

Figure 8-20 Potassium

8.22 Sodium

100. Sodium levels were similar to the high levels recorded in June. The levels in T2S1 and T2S2 were very low. This is the upper reaches of the Markham River so the sodium discharges are not coming down the river. Sodium is associated with salinity so this is considered to be a marine based effect and not connected to site operations. There is no PNG standard for sodium.

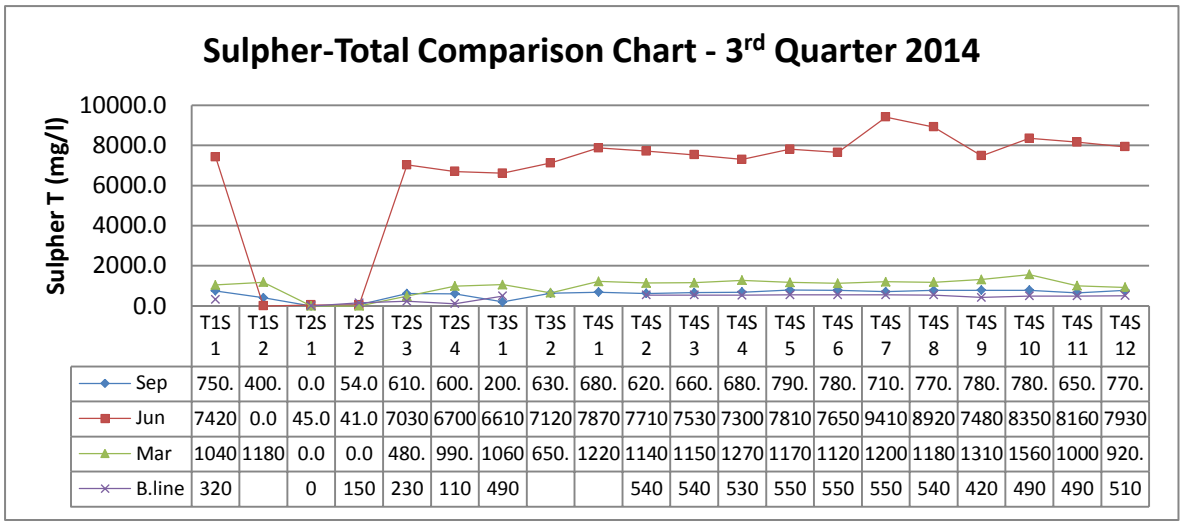


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	2500	2200	13.0	13.0	2400	2600	1700	2700	2500	2400	2500	2500	2600	2600	2400	2500	2500	2500	2300	2500
Jun	2300	2300	230.	210.	2300	230.	2300	2300	2300	2400	2400	2300	2300	2300	2500	2400	2100	2300	2100	2300
Mar	960.	1000	43.0	28.0	1200	1000	1000	1200	1000	980.	1000	1100	1000	1000	1000	1000	1000	1000	890.	890.
B.line	54		14	57	57	60	54			60	60	60	60	59	72	58	64	64	69	67

Figure 8-21 Sodium

8.23 Sulphur

101. Sulphur levels in September were much lower than in June and similar to the base line. Again levels were very low in the Markham River. This is considered to be a marine based effect and not connected to site operations. There is no PNG standard for sulphur.

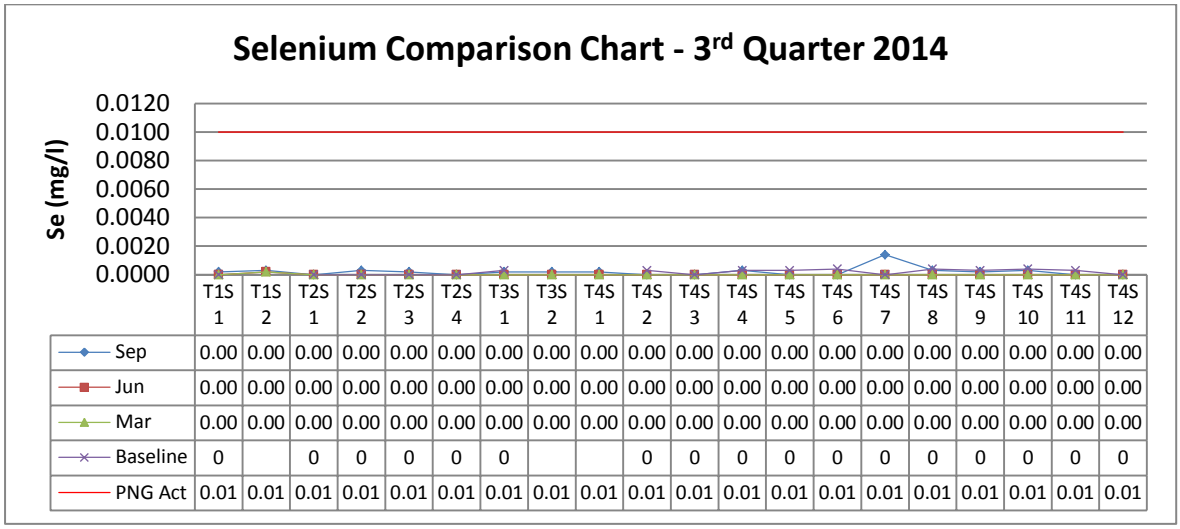


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	750.	400.	0.0	54.0	610.	600.	200.	630.	680.	620.	660.	680.	790.	780.	710.	770.	780.	780.	650.	770.
Jun	7420	0.0	45.0	41.0	7030	6700	6610	7120	7870	7710	7530	7300	7810	7650	9410	8920	7480	8350	8160	7930
Mar	1040	1180	0.0	0.0	480.	990.	1060	650.	1220	1140	1150	1270	1170	1120	1200	1180	1310	1560	1000	920.
B.line	320		0	150	230	110	490			540	540	530	550	550	550	540	420	490	490	510

Figure 8-22 Sulphur (Total)

8.24 Selenium

102. Selenium was only detected at very low levels. The PNG standard for Selenium is 0.01 mg/L. Measured levels were much below this.

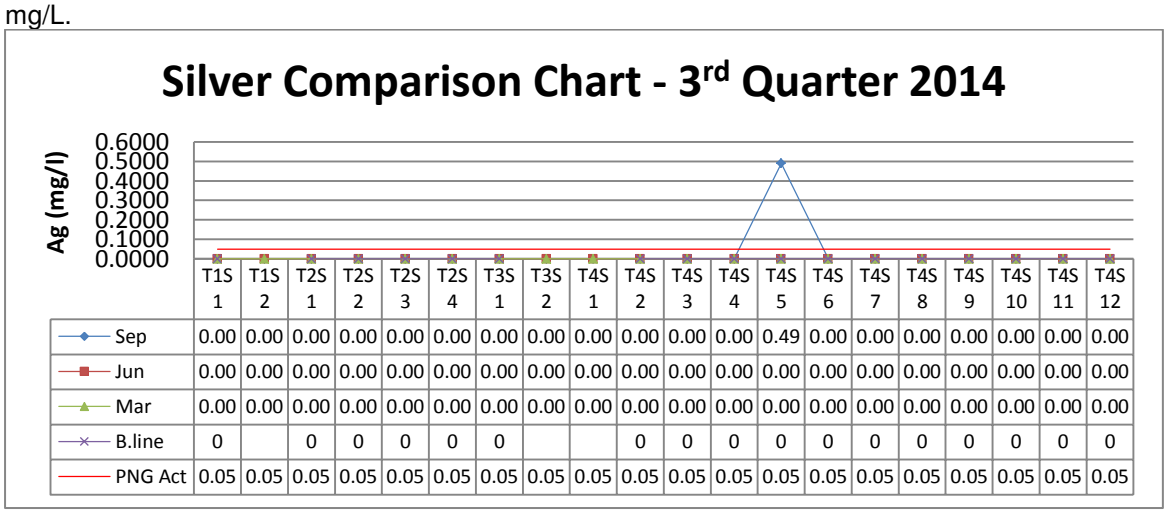


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Baseline	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Figure 8-23 Selenium

8.25 Silver

103. Silver was not detected as was the case in the baseline. The PNG standard for silver is 0.05 mg/L.

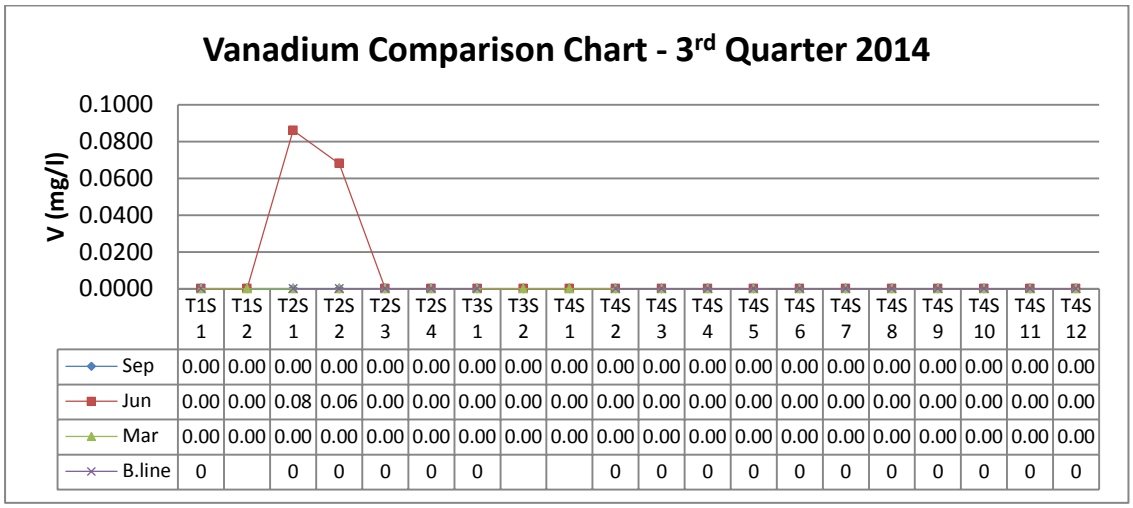


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Figure 8-24 Silver

8.26 Vanadium

104. Vanadium was not detected. There is no PNG standard for vanadium.

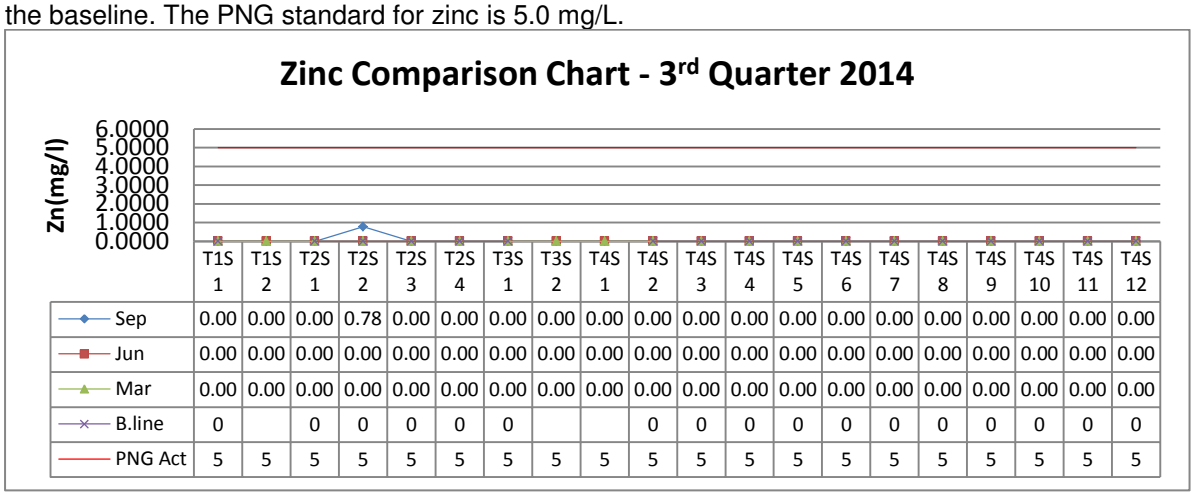


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.08	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0

Figure 8-25 Vanadium

8.27 Zinc

105. Zinc was detected in very low levels at T2S2 and not detected elsewhere. This was the case in the baseline. The PNG standard for zinc is 5.0 mg/L.

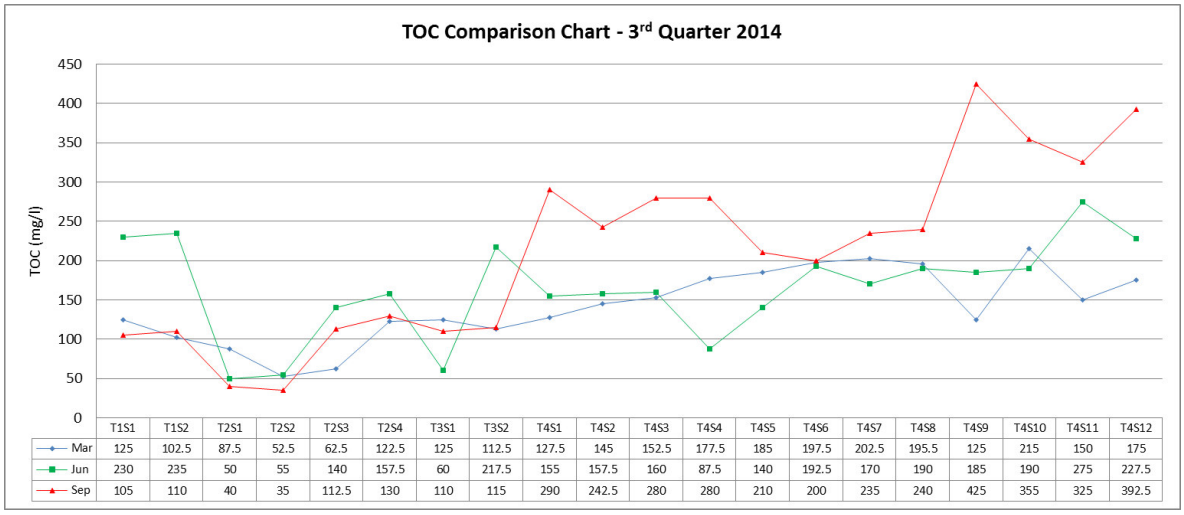


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Sep	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.line	0		0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
PNG Act	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Figure 8-26 Zinc

8.28 Organic Carbon

106. Organic Carbon levels were higher in September which is consistent with the high levels of hydrocarbons (oil and grease) found in the sea water. The higher levels were found at locations well removed from the site. There is no PNG standard for carbon.

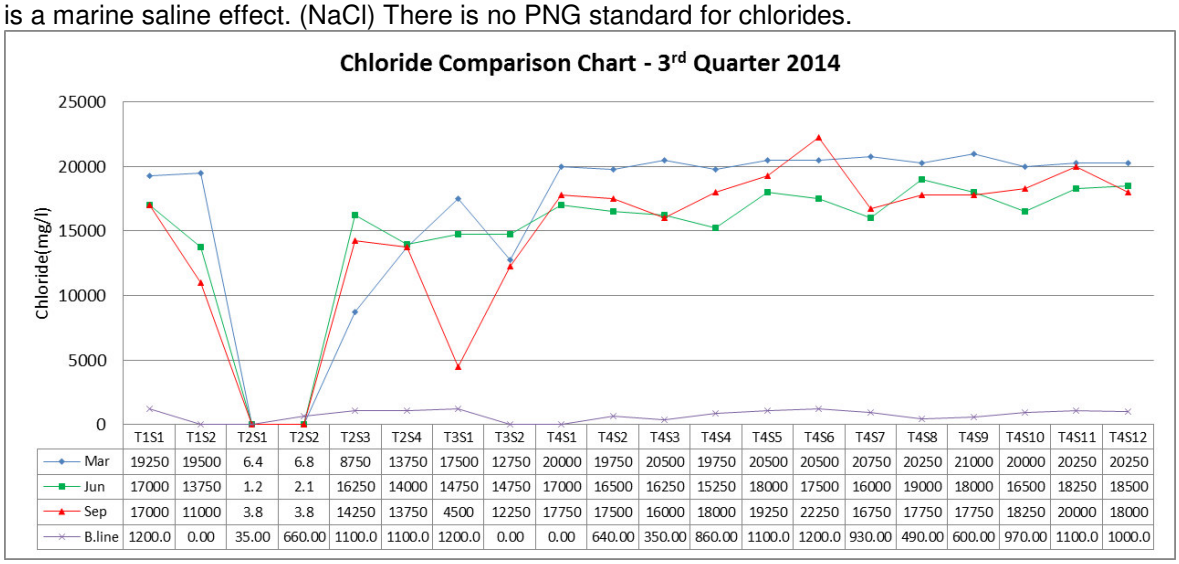


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Mar	125	102.5	87.5	52.5	62.5	122.5	125	112.5	127.5	145	152.5	177.5	185	197.5	202.5	195.5	125	215	150	175
Jun	230	235	50	55	140	157.5	60	217.5	155	157.5	160	87.5	140	192.5	170	190	185	190	275	227.5
Sep	105	110	40	35	112.5	130	110	115	290	242.5	280	280	210	200	235	240	425	355	325	392.5

Figure 8-27 Organic Carbon

8.29 Chloride

107. Chloride levels for September were similar to June and March which were all much higher than the baseline. This gives some concern over the validity of the baseline figures. The results mirror the sodium results, also being low in the freshwaters of the Markham River (T2.1, T2.2) and so confirm it is a marine saline effect. (NaCl) There is no PNG standard for chlorides.

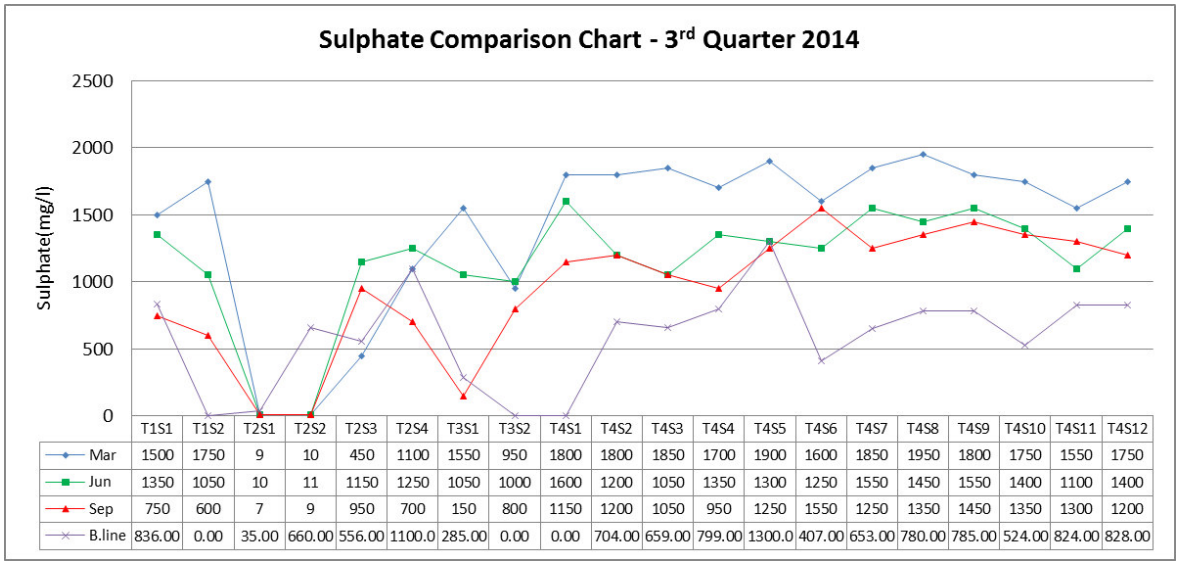


	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Mar	19250	19500	6.4	6.8	8750	13750	17500	12750	20000	19750	20500	19750	20500	20500	20750	20250	21000	20000	20250	20250
Jun	17000	13750	1.2	2.1	16250	14000	14750	14750	17000	16500	16250	15250	18000	17500	16000	19000	18000	16500	18250	18500
Sep	17000	11000	3.8	3.8	14250	13750	4500	12250	17750	17500	16000	18000	19250	22250	16750	17750	17750	18250	20000	18000
B.line	1200.0	0.00	35.00	660.00	1100.0	1100.0	1200.0	0.00	0.00	640.00	350.00	860.00	1100.0	1200.0	930.00	490.00	600.00	970.00	1100.0	1000.0

Figure 8-28 Chloride

8.30 Sulphate

108. Sulphate levels for September were lower than in March and similar to June. They were slightly higher than the baseline. Again levels were lower in the freshwaters of the Markham River indicating the variability is driven by sea conditions. There is no PNG standard for sulphate.



	T1S1	T1S2	T2S1	T2S2	T2S3	T2S4	T3S1	T3S2	T4S1	T4S2	T4S3	T4S4	T4S5	T4S6	T4S7	T4S8	T4S9	T4S10	T4S11	T4S12
Mar	1500	1750	9	10	450	1100	1550	950	1800	1800	1850	1700	1900	1600	1850	1950	1800	1750	1550	1750
Jun	1350	1050	10	11	1150	1250	1050	1000	1600	1200	1050	1350	1300	1250	1550	1450	1550	1400	1100	1400
Sep	750	600	7	9	950	700	150	800	1150	1200	1050	950	1250	1550	1250	1350	1450	1350	1300	1200
B.line	836.00	0.00	35.00	660.00	556.00	1100.0	285.00	0.00	0.00	704.00	659.00	799.00	1300.0	407.00	653.00	780.00	785.00	524.00	824.00	828.00

Figure 8-29 Sulphate

9 SEDIMENTS EXTRACTED FROM SEAWATER

109. The Terms of Reference required water samples to be filtered and the suspended sediments extracted and then analysed. This procedure was attempted but was not successful. The quantities of sediments recovered in the filtration were very low and not sufficient for analysis. Very large quantities of seawater would be needed in order to have enough sediment material for analysis. Therefore this procedure was dropped.

10 SEDIMENTS ANALYSIS

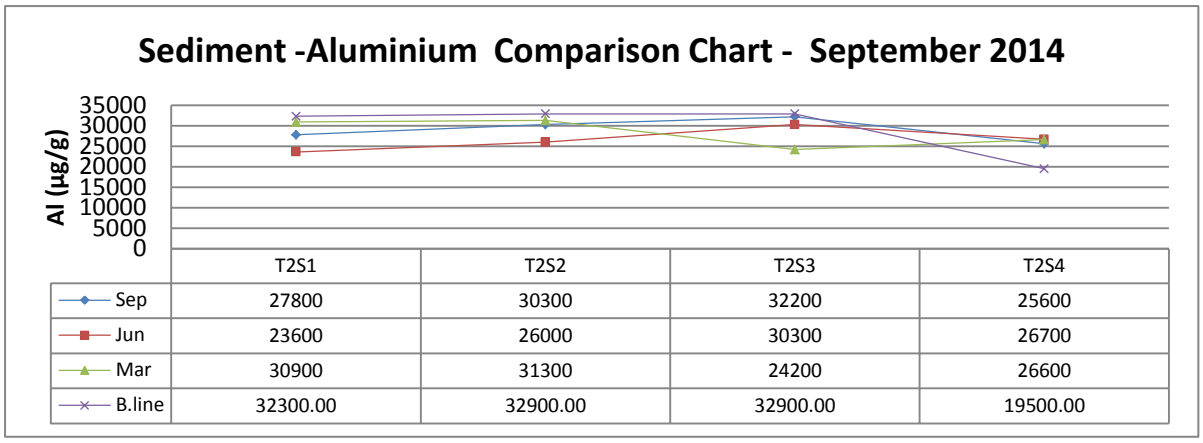
10.1 Sediment Collection

110. Sediments were collected from the seabed for the sites located in the Markham River. These are designated T2.1, T2.2, T2.3 and T2.4. (Figure 1) In the text they are referred to as T1S1, T1S2 etc.

111. The results are shown in comparison to baseline values and “Target Values”. There are no PNG standards for heavy metals in sediments and so international standards have been used. It is quite common for countries not to have standards for heavy metals in sediments, particularly marine sediments. For example the U.K. has no such standards. The “Target Values” used are taken form the Netherlands standards. These are generally accepted as the foremost standards currently available and have been adopted by countries such as Singapore and Malaysia. Even so, not all parameters have been covered but their omission generally indicates their relatively low level of concern. The most significant metals are included.

10.2 Aluminium

112. The levels for aluminium in September were lower than the baseline for the Transects 2S1 – T2S3 but higher for T2S4. There is no standard for aluminium in sediments.

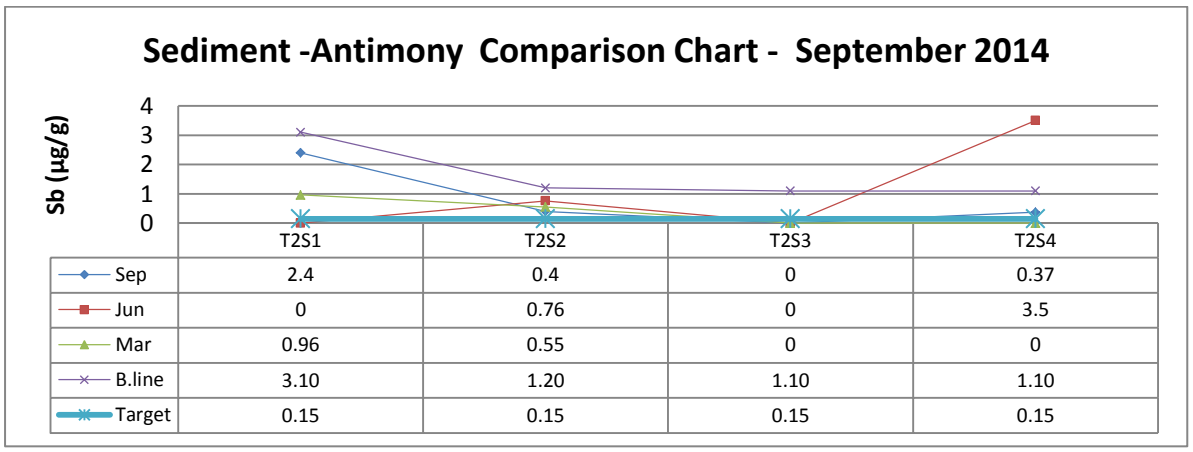


	T2S1	T2S2	T2S3	T2S4
Sep	27800	30300	32200	25600
Jun	23600	26000	30300	26700
Mar	30900	31300	24200	26600
B.line	32300.00	32900.00	32900.00	19500.00

Figure 10-1 Aluminium

10.3 Antimony

113. The levels for antimony were significantly below the baseline and above the standard in T2S1 and T2S2 but below the standards in T2S3 and above it at T2S4. The standard for antimony is 0.15 ug/gm in sediments.

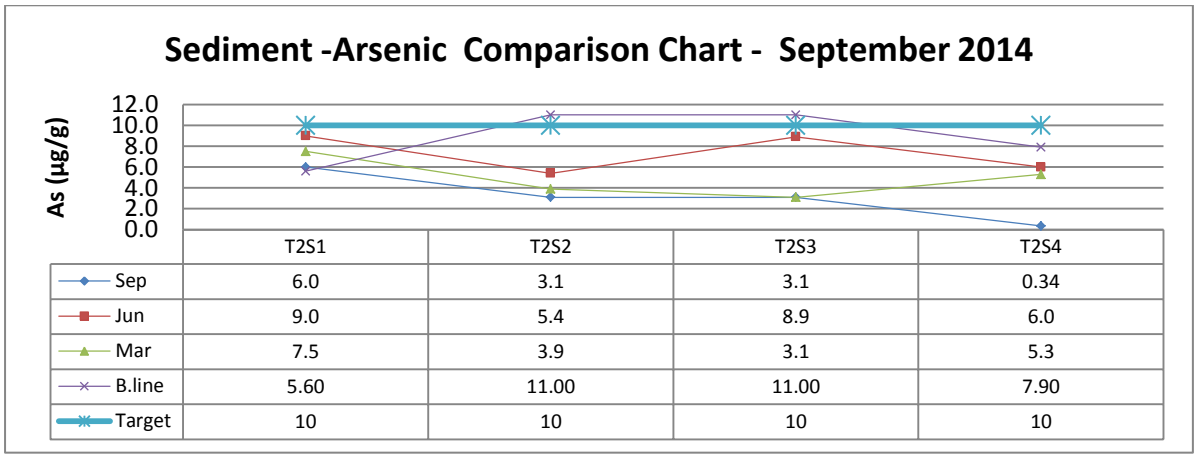


	T2S1	T2S2	T2S3	T2S4
Sep	2.4	0.4	0	0.37
Jun	0	0.76	0	3.5
Mar	0.96	0.55	0	0
B.line	3.10	1.20	1.10	1.10
Target	0.15	0.15	0.15	0.15

Figure 10-2 Antimony

10.4 Arsenic

114. The levels for arsenic were below the target level and below the baseline except for T2S1. The baseline had been similar to the target levels. The standard for arsenic is 10 ug/gm in sediments. Arsenic deposits may be due to upstream gold mining. Arsenic levels have dropped and are not of concern.



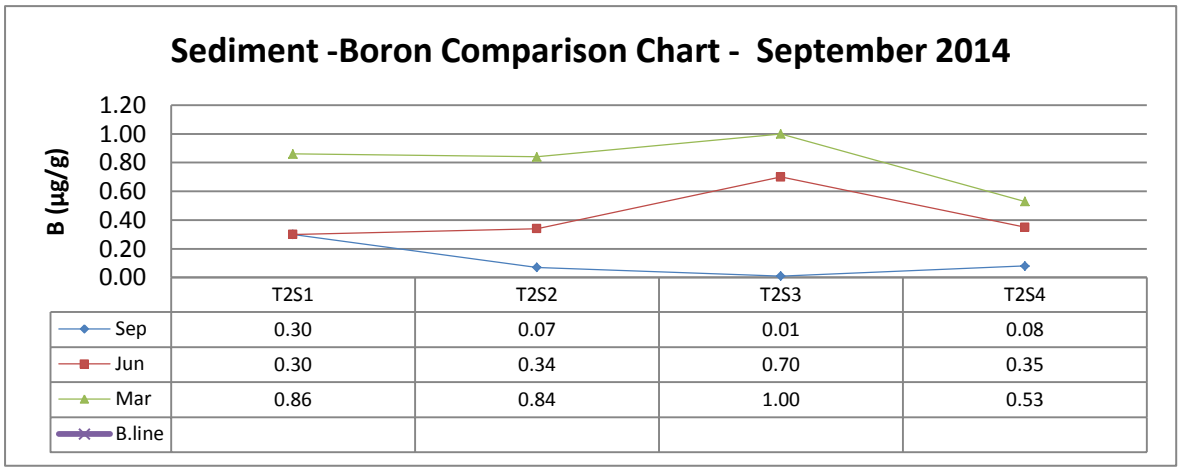
	T2S1	T2S2	T2S3	T2S4
Sep	6.0	3.1	3.1	0.34
Jun	9.0	5.4	8.9	6.0
Mar	7.5	3.9	3.1	5.3
B.line	5.60	11.00	11.00	7.90
Target	10	10	10	10

Figure 10-3 Arsenic

10.5 Boron

115. Boron levels were consistently low. There was no baseline. There is no standard for boron in

sediments. Adverse effects of boron are usually associated with potable water not seawater or sediments.

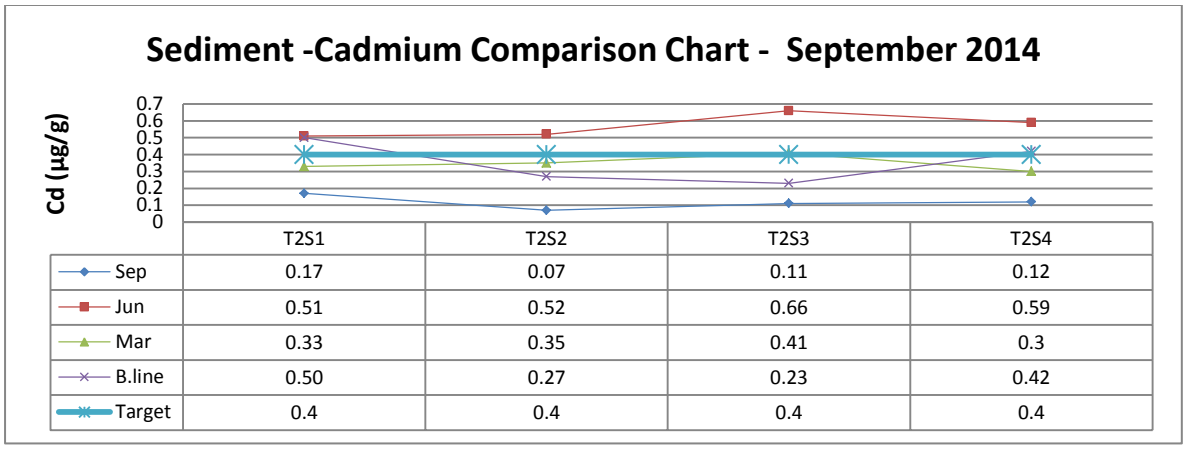


	T2S1	T2S2	T2S3	T2S4
Sep	0.30	0.07	0.01	0.08
Jun	0.30	0.34	0.70	0.35
Mar	0.86	0.84	1.00	0.53
B.line				

Figure 10-4 Boron

10.6 Cadmium

116. Cadmium levels were below the baseline and below the standard. The standard for cadmium is 0.4 ug/gm in sediments. In September all levels were within the standard.

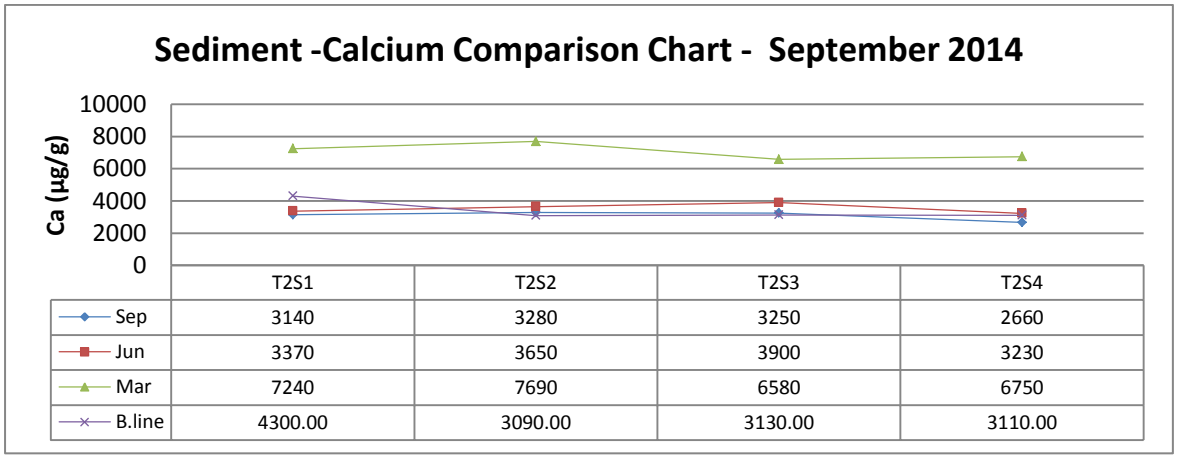


	T2S1	T2S2	T2S3	T2S4
Sep	0.17	0.07	0.11	0.12
Jun	0.51	0.52	0.66	0.59
Mar	0.33	0.35	0.41	0.3
B.line	0.50	0.27	0.23	0.42
Target	0.4	0.4	0.4	0.4

Figure 10-5 Cadmium

10.7 Calcium

117. The levels for calcium were similar to the baseline. There is no standard for calcium in sediments.

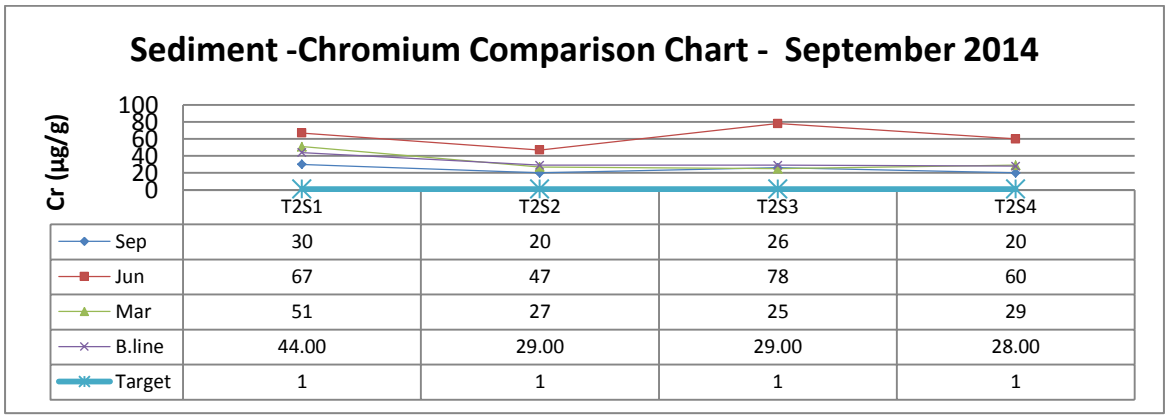


	T2S1	T2S2	T2S3	T2S4
Sep	3140	3280	3250	2660
Jun	3370	3650	3900	3230
Mar	7240	7690	6580	6750
B.line	4300.00	3090.00	3130.00	3110.00

Figure 10-6 Calcium

10.8 Chromium

118. Chromium levels in September were similar to the baseline and significantly above the standard. The standard for chromium is 1.0 ug/gm in sediments. Levels were elevated in the upper reaches of the Markham River suggesting the source is inland not coming from the site.

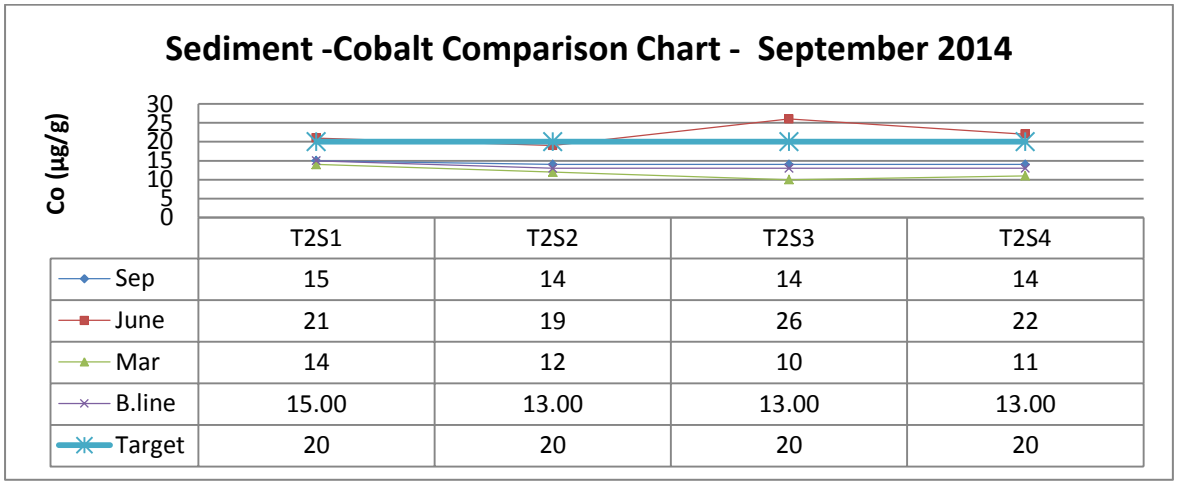


	T2S1	T2S2	T2S3	T2S4
Sep	30	20	26	20
Jun	67	47	78	60
Mar	51	27	25	29
B.line	44.00	29.00	29.00	28.00
Target	1	1	1	1

Figure 10-7 Chromium

10.9 Cobalt

119. Cobalt levels were similar although lower than the baseline and well within the standard. The standard for cobalt is 20.0 ug/gm in sediments.

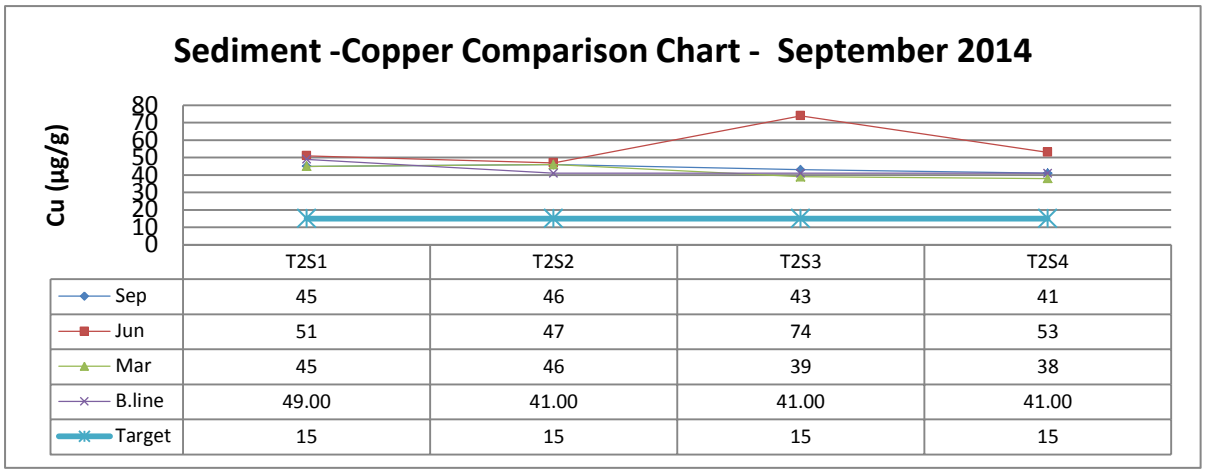


	T2S1	T2S2	T2S3	T2S4
Sep	15	14	14	14
June	21	19	26	22
Mar	14	12	10	11
B.line	15.00	13.00	13.00	13.00
Target	20	20	20	20

Figure 10-8 Cobalt

10.10 Copper

120. Copper levels in September were similar to the baseline and about 3 times the standard. The standard for copper is 15.0 ug/gm in sediments. This is of concern but there are no sources of copper on the site.

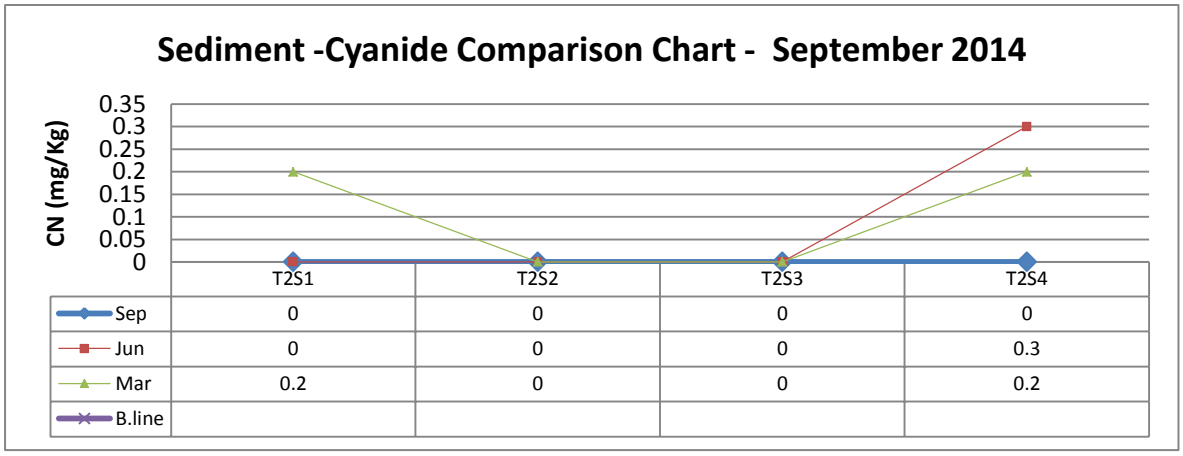


	T2S1	T2S2	T2S3	T2S4
Sep	45	46	43	41
Jun	51	47	74	53
Mar	45	46	39	38
B.line	49.00	41.00	41.00	41.00
Target	15	15	15	15

Figure 10-9 Copper

10.11 Cyanide

121. Cyanide was below the threshold of detection of 0.2 ug/g. There is no standard for cyanide in sediments and no baseline was obtained.

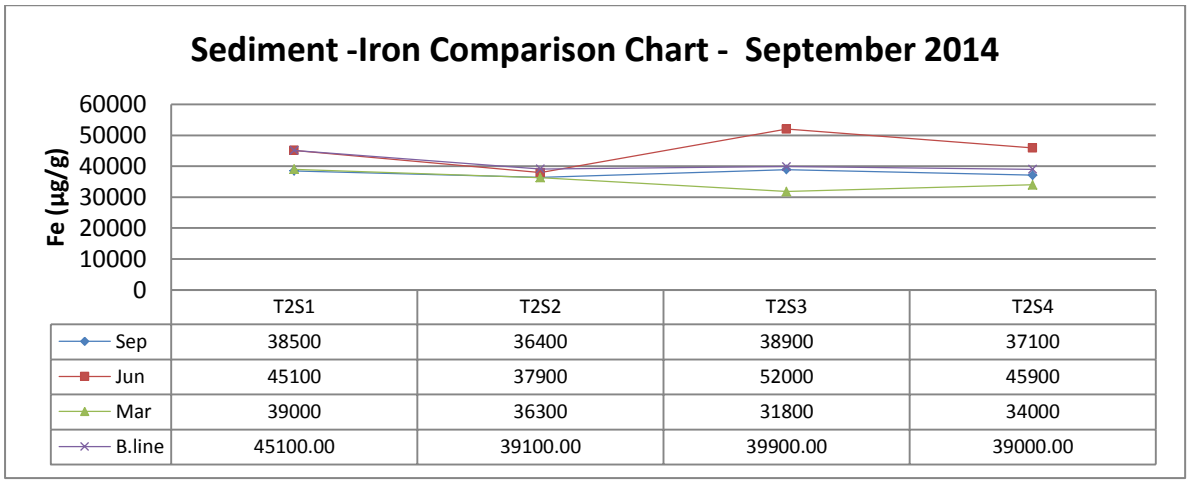


	T2S1	T2S2	T2S3	T2S4
Sep	0	0	0	0
Jun	0	0	0	0.3
Mar	0.2	0	0	0.2
B.line				

Figure 10-10 Cyanide

10.12 Iron

122. The levels for iron were high but lower than the baseline. This must be regarded as an anomaly as there are no activities on the construction site that would generate iron discharges. Industry in the port could be a source but as levels were high in the Markham River it seems more probable that heavy rain is carrying ferrous materials in sediments downstream to the sea. There is no standard for iron in sediments.

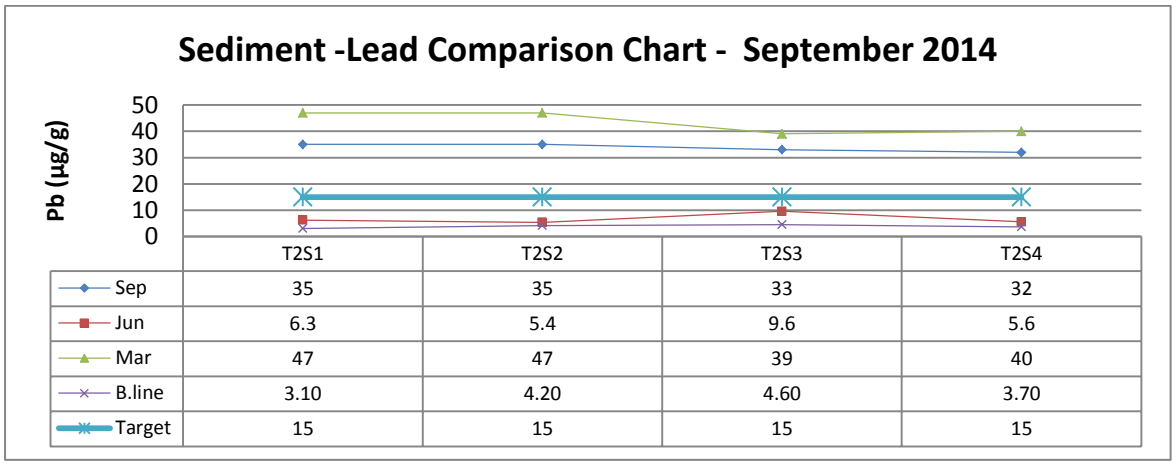


	T2S1	T2S2	T2S3	T2S4
Sep	38500	36400	38900	37100
Jun	45100	37900	52000	45900
Mar	39000	36300	31800	34000
B.line	45100.00	39100.00	39900.00	39000.00

Figure 10-11 Iron

10.13 Lead

123. Lead levels were high, up to 2 times the standard and much higher than the baseline. The standard for lead is 15.0 ug/gm in sediments. This is of concern but there are no sources of lead on the site.

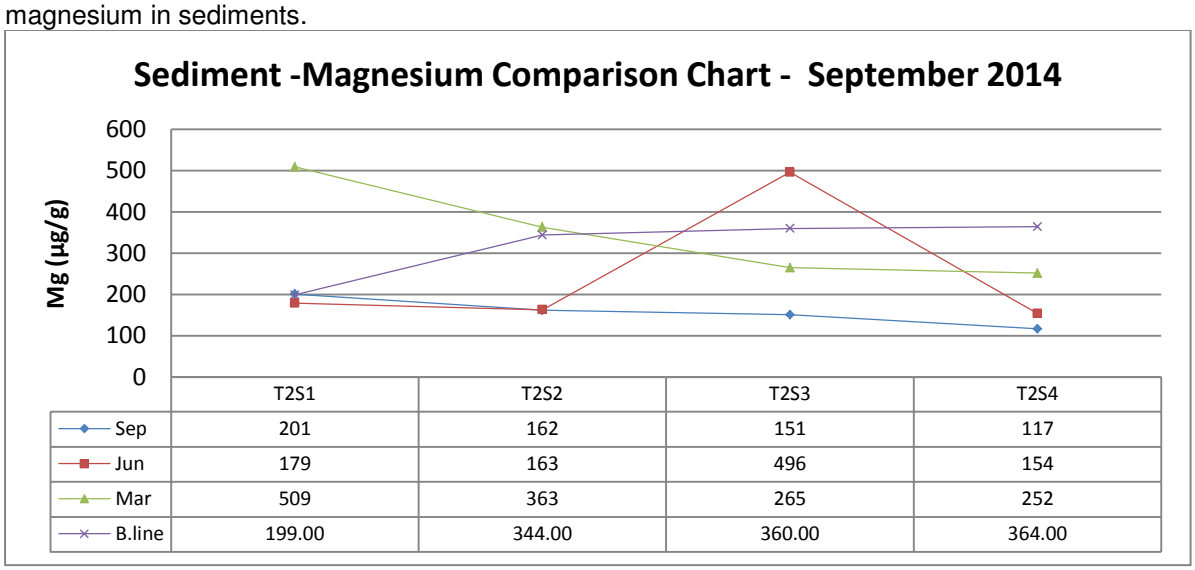


	T2S1	T2S2	T2S3	T2S4
Sep	35	35	33	32
Jun	6.3	5.4	9.6	5.6
Mar	47	47	39	40
B.line	3.10	4.20	4.60	3.70
Target	15	15	15	15

Figure 10-12 Lead

10.14 Magnesium

124. The levels for magnesium were generally lower than the baseline. There is no standard for magnesium in sediments.

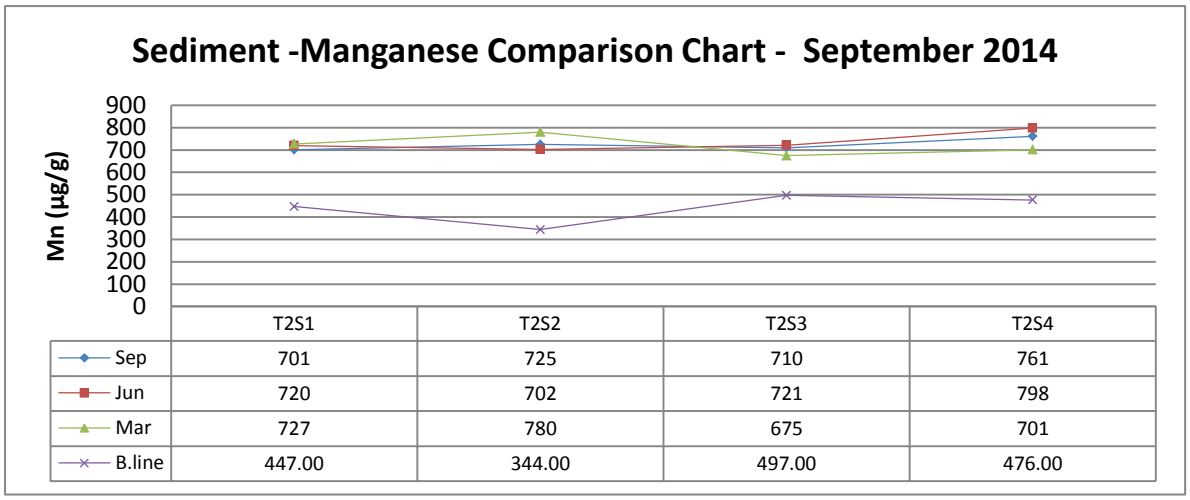


	T2S1	T2S2	T2S3	T2S4
Sep	201	162	151	117
Jun	179	163	496	154
Mar	509	363	265	252
B.line	199.00	344.00	360.00	364.00

Figure 10-13 Magnesium

10.15 Manganese

125. The levels for manganese were consistently 1.5 to 2 times higher than the baseline. There is no standard for manganese in sediments.

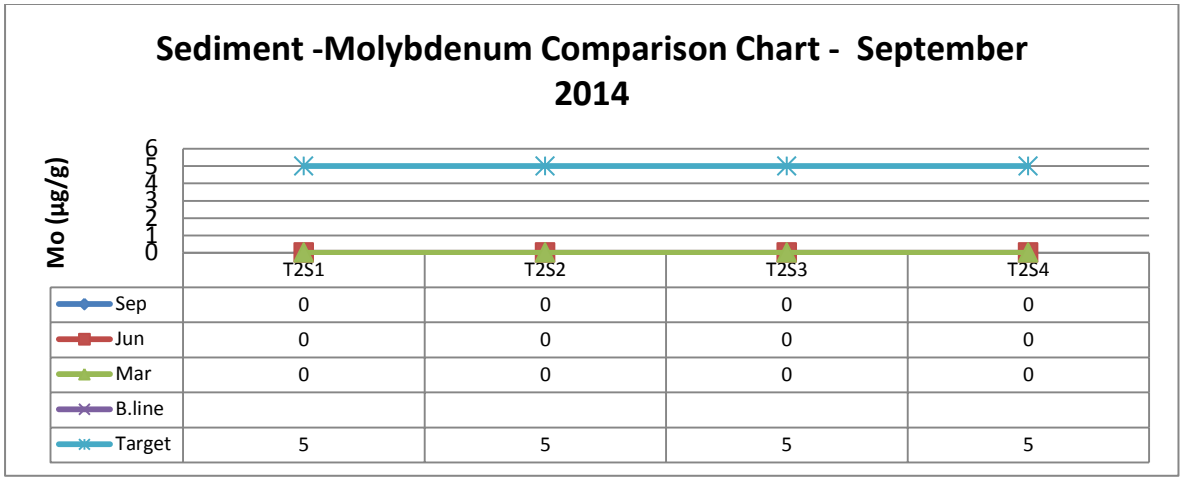


	T2S1	T2S2	T2S3	T2S4
Sep	701	725	710	761
Jun	720	702	721	798
Mar	727	780	675	701
B.line	447.00	344.00	497.00	476.00

Figure 10-14 Manganese

10.16 Molybdenum

126. Molybdenum was not detected. No baseline values were available. The standard for molybdenum is 5.0 ug/gm in sediment.

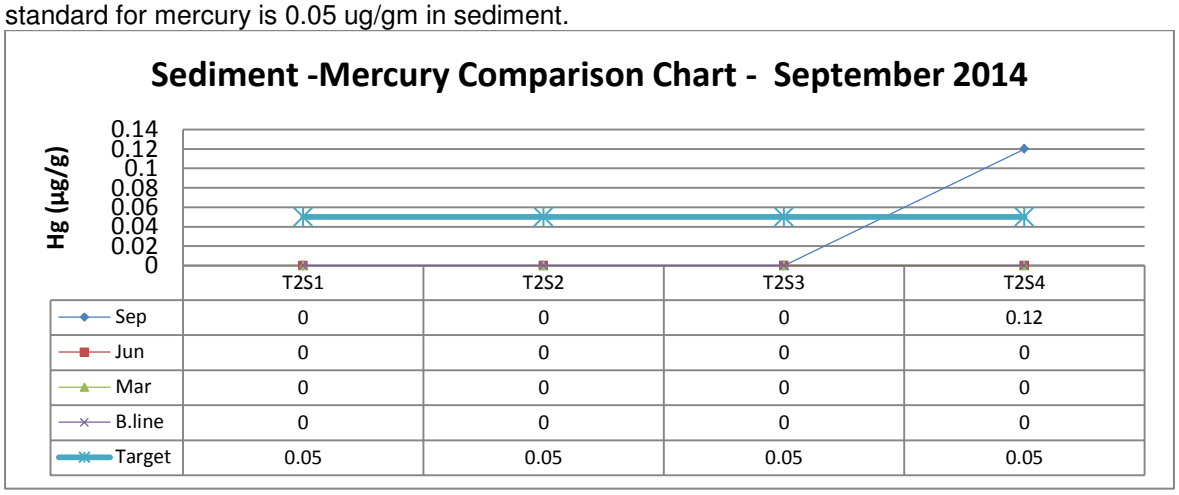


	T2S1	T2S2	T2S3	T2S4
Sep	0	0	0	0
Jun	0	0	0	0
Mar	0	0	0	0
B.line				
Target	5	5	5	5

Figure 10-15 Molybdenum

10.17 Mercury

127. Mercury was not detected in September nor in any previous months or in the baseline. The standard for mercury is 0.05 ug/gm in sediment.



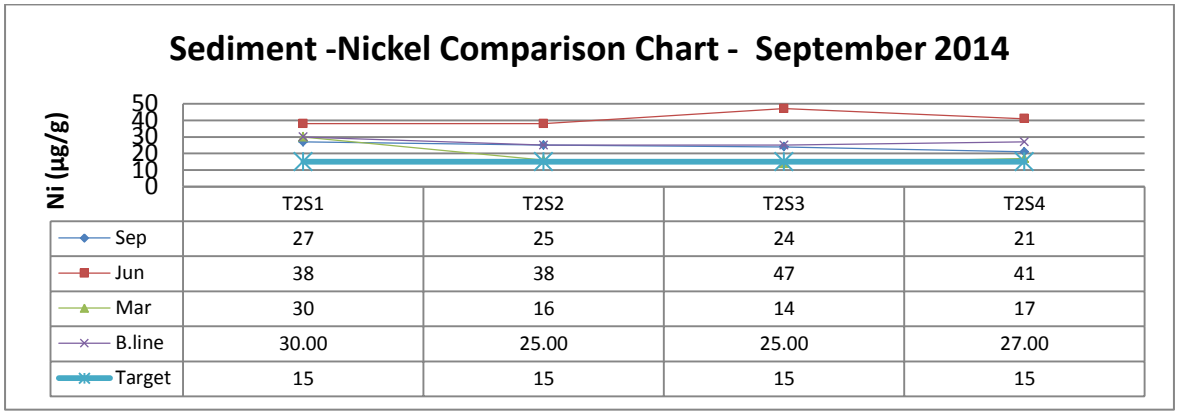
	T2S1	T2S2	T2S3	T2S4
Sep	0	0	0	0.12
Jun	0	0	0	0
Mar	0	0	0	0
B.line	0	0	0	0
Target	0.05	0.05	0.05	0.05

Figure 10-16 Mercury

10.18 Nickel

128. Nickel was below the baseline and twice the standard. The standard for nickel is 15 ug/gm in

sediment. This is of concern but there are no sources of nickel on the site.

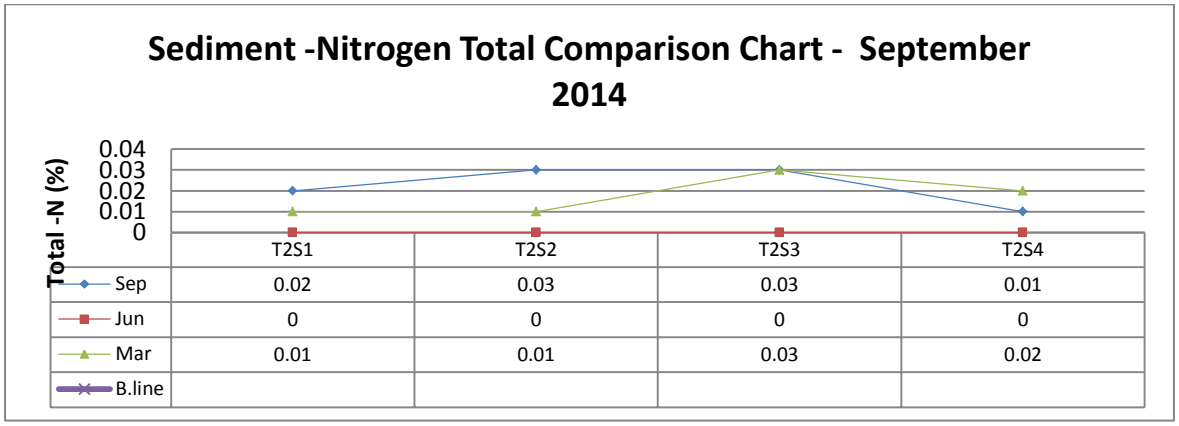


	T2S1	T2S2	T2S3	T2S4
Sep	27	25	24	21
Jun	38	38	47	41
Mar	30	16	14	17
B.line	30.00	25.00	25.00	27.00
Target	15	15	15	15

Figure 10-17 Nickel

10.19 Nitrogen

129. Nitrogen levels were low. There is no standard for nitrogen in sediments and no baseline was available.

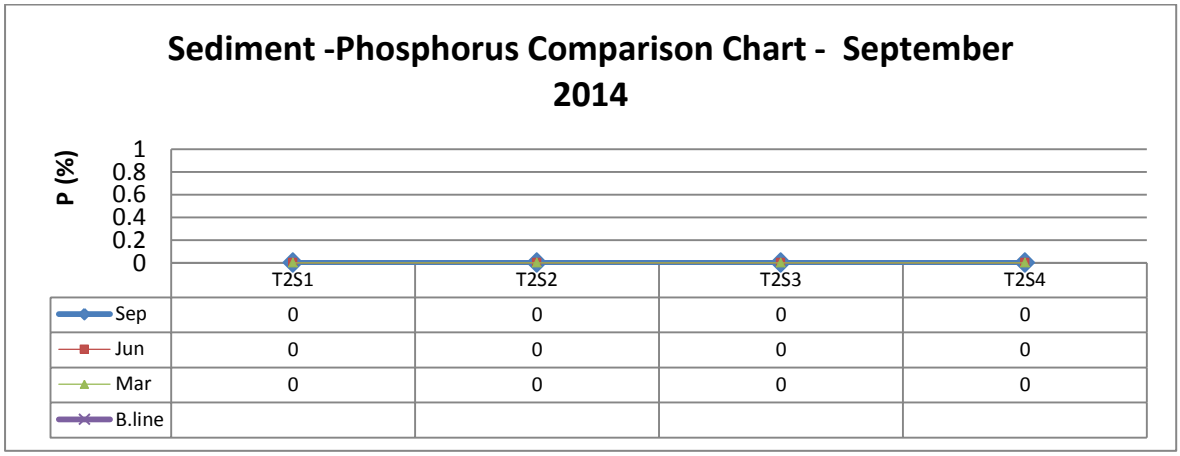


	T2S1	T2S2	T2S3	T2S4
Sep	0.02	0.03	0.03	0.01
Jun	0	0	0	0
Mar	0.01	0.01	0.03	0.02
B.line				

Figure 10-18 Nitrogen

10.20 Phosphorus

130. Phosphorus levels were low. There is no standard for phosphorus in sediments and no baseline was available.

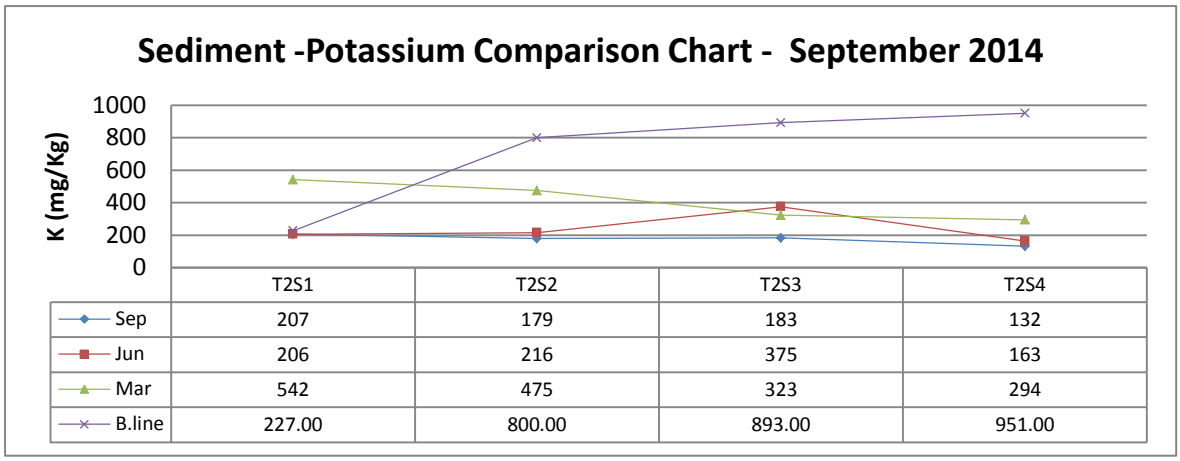


	T2S1	T2S2	T2S3	T2S4
Sep	0	0	0	0
Jun	0	0	0	0
Mar	0	0	0	0
B.line				

Figure 10-19 Phosphorus

10.21 Potassium

131. Levels of potassium were lower than the baseline. As potassium is associated with chemical fertilisers this could be land based run off from rainfall. There is no standard for potassium in sediments.

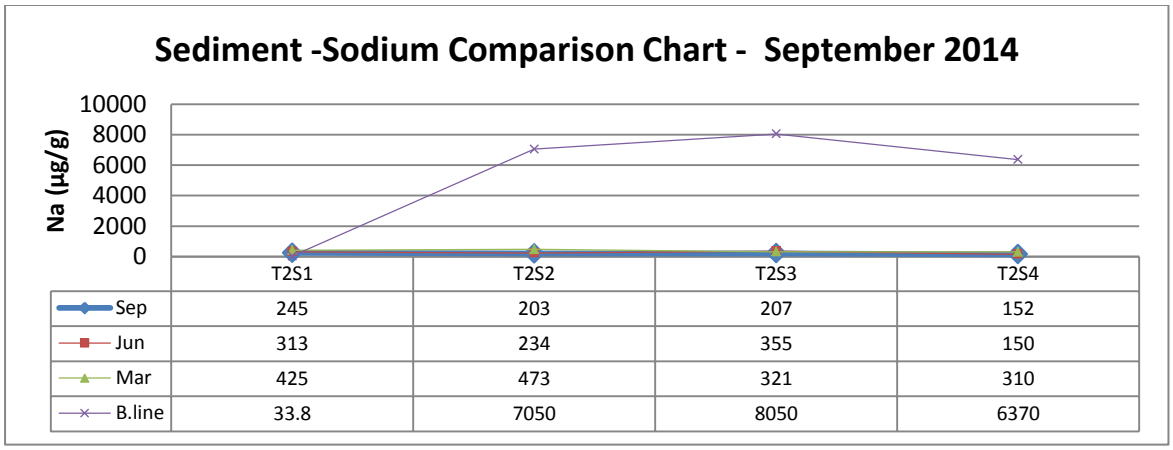


	T2S1	T2S2	T2S3	T2S4
Sep	207	179	183	132
Jun	206	216	375	163
Mar	542	475	323	294
B.line	227.00	800.00	893.00	951.00

Figure 10-20 Potassium

10.22 Sodium

132. Sodium levels were much lower than the base line. There is no standard for sodium in sediments.

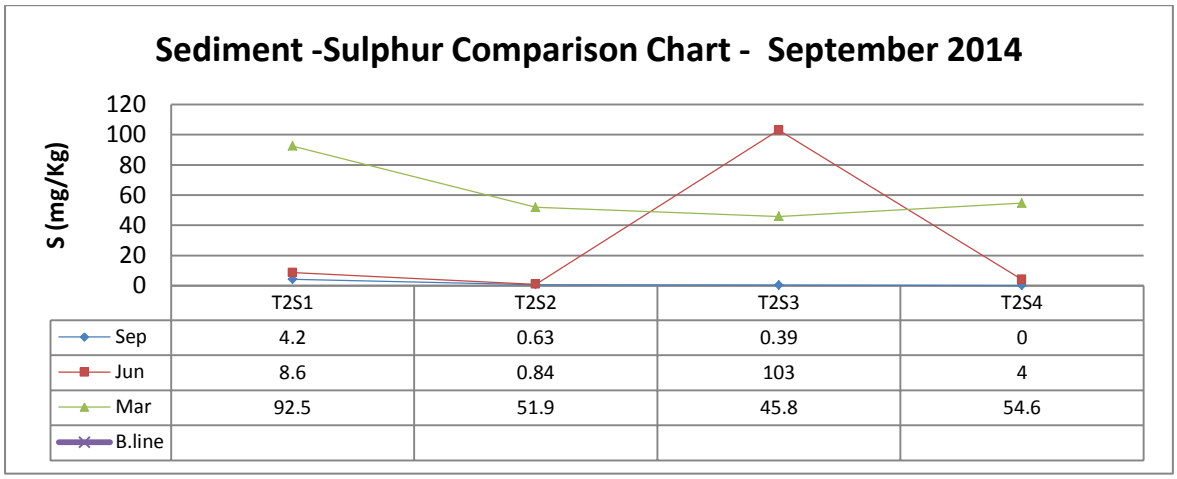


	T2S1	T2S2	T2S3	T2S4
Sep	245	203	207	152
Jun	313	234	355	150
Mar	425	473	321	310
B.line	33.8	7050	8050	6370

Figure 10-21 Sodium

10.23 Sulphur

133. Sulphur levels were low. There is no standard for sulphur in sediments and no baseline was available.



	T2S1	T2S2	T2S3	T2S4
Sep	4.2	0.63	0.39	0
Jun	8.6	0.84	103	4
Mar	92.5	51.9	45.8	54.6
B.line				

Figure 10-22 Sulphur (Total)

10.24 Selenium

134. Selenium levels were either not detected or on the limit of detection. They were similar to the baseline. The standard for selenium is 0.07 ug/gm in sediment. Levels at T2S3 were elevated. There is no apparent reason for this.

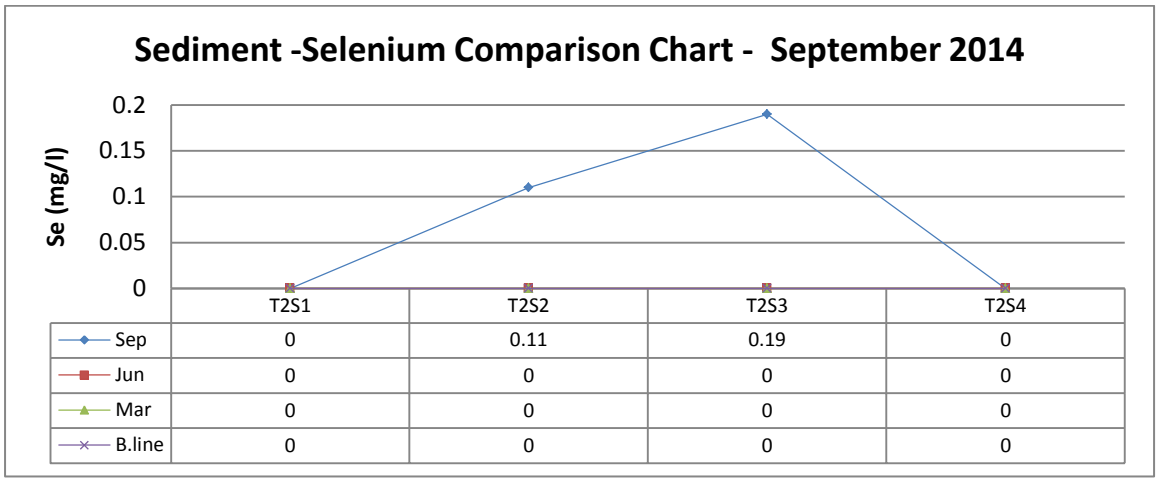


Figure 10-23 Selenium

10.25 Silver

135. Silver was not detected. There is no standard for silver in sediments and no baseline was available.

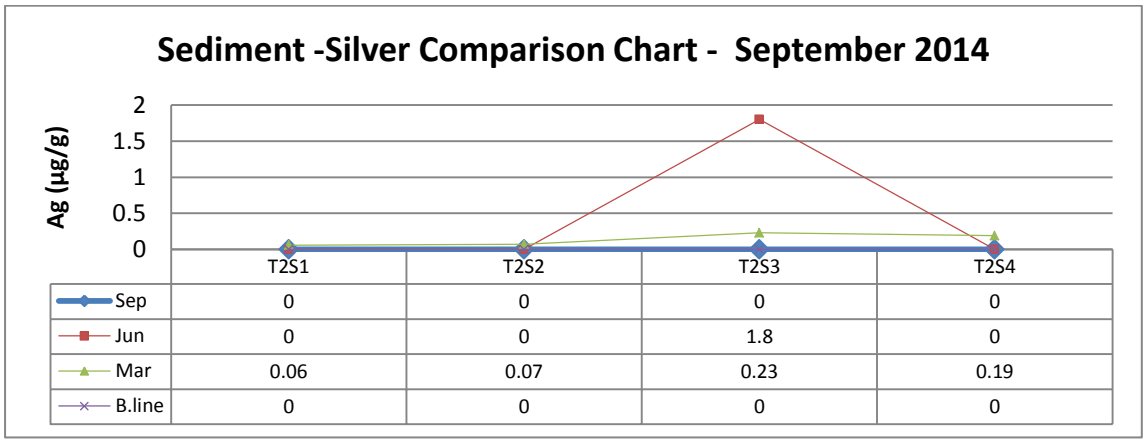


Figure 10-24 Silver

10.26 Vanadium

136. Vanadium levels in September were about 2 times higher than the baseline and significantly higher than the target value. The standard for vanadium is 0.07 ug/gm in sediment. This is of concern but there are no sources of vanadium on the site.

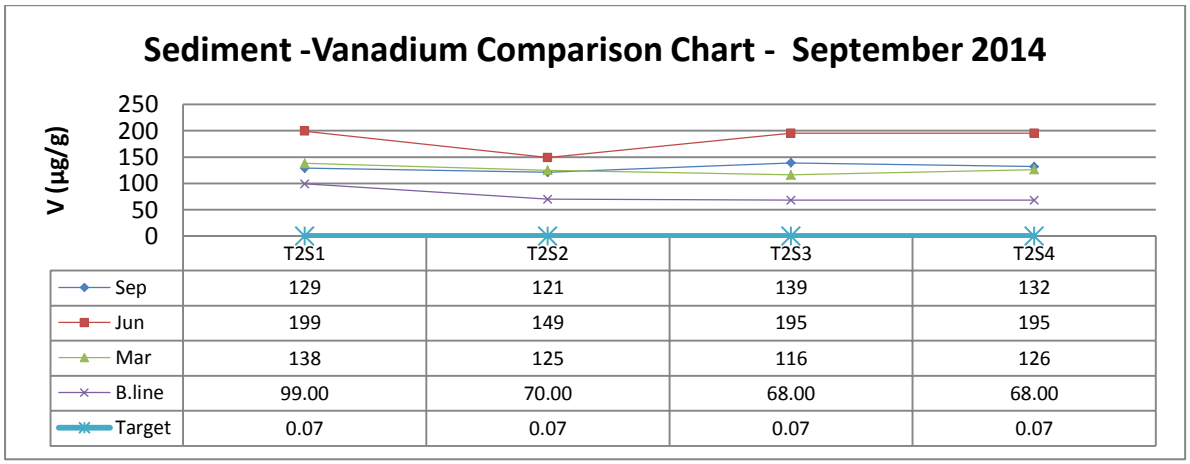
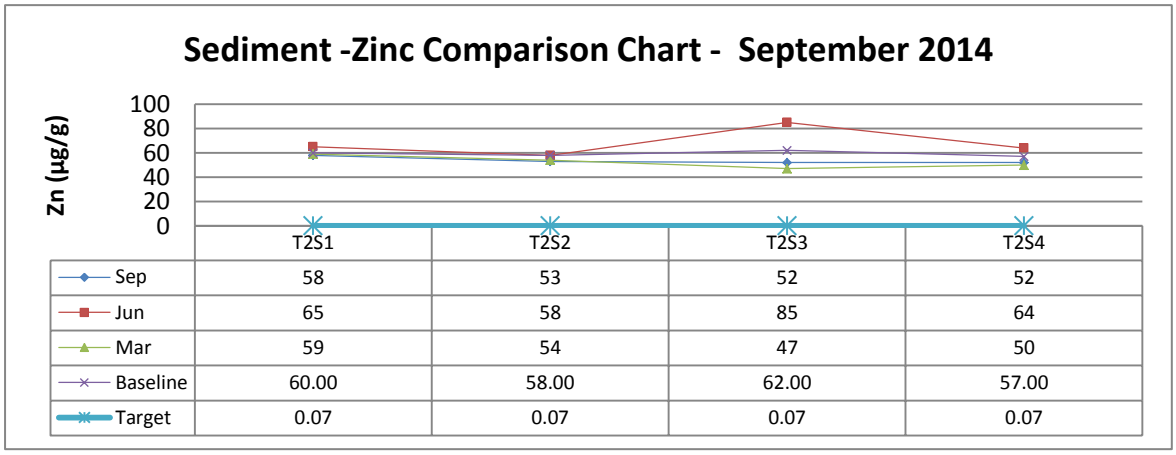


Figure 10-25 Vanadium

10.27 Zinc

137. Zinc levels in September were similar to the baseline and much higher than the standard. The standard for zinc is 0.07 ug/gm in sediment.



	T2S1	T2S2	T2S3	T2S4
Sep	58	53	52	52
Jun	65	58	85	64
Mar	59	54	47	50
Baseline	60.00	58.00	62.00	57.00
Target	0.07	0.07	0.07	0.07

Figure 10-26 Zinc

11 Dredged Material

138. The dredged materials were no longer sampled as all dredging finished in 2013.

12 Conclusions

139. The water sampling and analysis has demonstrated that all metal parameters are within the PNG standard except for Boron, Iron and Potassium. There are no construction site activities associated with these metals that would lead to such discharges. Also high levels are encountered at distances of 50-60kms from the site on transect 4, the “control sites”. This is considered to be due to land based run off during heavy rain and is a normal occurrence.

140. River bed sediment samples did not show signs of significant contamination. Metals of concern are antimony, chromium, copper, lead, nickel and vanadium. All other metals were at low levels. These metals are associated with corrosion prevention of ships and could be originating from vessels hulls. Copper could originate from the upstream gold mining as gold and copper are usually found in mineral deposits together. There are no site activities associated with these metals.

141. It is concluded that site activities are not causing elevated levels of heavy metals adjacent to the site.

142. The Lae Port Development Project has **Negligible** to **Low** environmental impact on the environment during January to December 2014.

13 Annex 1 DEC Permit for Port (Page 1)

THE INDEPENDENT STATE OF PAPUA NEW GUINEA

Environment Act 2000

Act, Section. 65 & 66-
Reg., Sec. 16(1)

ENVIRONMENT PERMIT

An Environment Permit is hereby issued under *Section 65* of the *Environment Act 2000.*

TO: PNG Ports Corporation Limited

OF: P.O. Box 671, PORT MORESBY, National Capital District

(a) to carry out works within Portion 508, Milinch: Lae, Fourmil Markham in Lae, Morobe Province, ('premises').

(a) to discharge wastes into the environment from its "premises" while carrying out a **Level 3 (Sub-category 19.2) activity** associated with the construction of sea ports and ship repair facilities serving ships of an individual tonnage of more than 500 tonnes.

The activity shall be carried out in accordance with the terms and conditions specified in this permit.

Permit Number:	WD-L3 (349)
Date of Issue:	14th December 2012
Date of Commencement:	11th January 2013
Term of Permit:	Fifty (50) years
Date of Expiry:	11th January 2062

.....
GUNTHER JOKU
Director of Environment

Page 1 of 8

14 Annex 2 PNG Standards

SCHEDULE 1

Act, Sec. 133(2)
Reg., Sec. 2

THE INDEPENDENT STATE OF
PAPUA NEW GUINEA

ENVIRONMENT ACT 2000

WATER QUALITY CRITERIA FOR AQUATIC LIFE PROTECTION

Table 1.

All values are in mg/l unless otherwise specified.

Parameters	Fresh water	Seawater
Ammonia-nitrogen	*Dependent on pH and temperature (see Table 2.)*	
Arsenic	0.05	0.05
Barium	1.0	1.0
Boron	1.0	2.0
Cadmium	0.01	0.001
Chlorine (total residual)	0.005 at pH 6	0.005
Chromium (as hexavalent form)	0.05	0.01
Colour	No alteration to natural colouration *(for both fresh and seawater)*	
Cobalt	Limit of detectability *(for both fresh and seawater)*	
Copper	1.0	0.03
Cyanide (as HCN)	0.005	0.01
Faecal Coliform Bacteria	≤200 per 100 ml *(see Note below.)*	
Fats	None	None
Fluoride	1.5	1.5
Grease	None	None
Insoluble residues	No insoluble residues or sludge formation to occur *(for both fresh and seawater)*	
Iron (in solution)	1.0	1.0
Lead	0.005	0.004
Manganese (in solution)	0.5	2.0
Mercury	0.0002	0.0002
Nickel	1.0	1.0
Nitrate (as NO_3^- + NO_2^-)	45.0	45.0
Odour	No alteration to natural odour *(for both fresh and seawater)*	
Oil	None	None
Oxygen	Not less than 6.0	Not less than 5.0
Pesticides	None	None
pH	No alteration to natural pH *(for both fresh and seawater)*	
Phenols	0.002	0.002
Potassium	5.0	450.0
Radioactivity	None	None
Selenium	0.01	0.01
Silver	0.05	0.05
Sulfate (as SO_4^{2-})	400.0	-
Sulfide (HS^-)	0.002	0.002
Tars	None	None
Taste	No alteration to natural taste *(for both fresh and seawater)*	
Temperature	No alteration greater than 2°C *(for both fresh and seawater)*	
Tin	0.5	0.5
Toxicants (miscellaneous)	None	None
Turbidity	No alteration greater than 25 N.T.U *(for both fresh and seawater)*	
Zinc	5.0	5.0

Note.
Metal concentrations are for dissolved substances (passing through a nominal 0.45µm medium).
Criteria for Faecal Coliform Bacteria is based on not fewer than five samples taken over not more than a 30 day period, in which the median value of the faecal coliform bacteria content of the waters shall not exceed 200 per 100 ml.
N.T.U. - Nephelometric Turbidity Unit.