Environmental Sampling Report

Geraldton

Western Australia

February 2011

Department of Health

Executive Summary

The Department of Health coordinated an environmental sampling program of the Geraldton Port and nearby communities in response to concerns about fugitive lead, copper and zinc dust emissions from the Geraldton Port. The purpose of the sampling program was to assess whether high levels of these dusts were present in the community. The purpose of this report is to interpret the data in the context of public health.

One hundred and twenty two environmental samples were taken from within a 3.5 km radius of the Geraldton Port between 17 and 21 January 2011. The findings were compared to findings from environmental samples undertaken in 2007 by the Department of Environment and Conservation as part of their Port Emission Assessment Program.

Key Findings and Recommendations

- The level of heavy metals detected in the community was well below respective health guidelines and does not pose a health risk to the residents.
- The levels of lead at the Port boundary were under the reference level in 2011 compared with 2007. It could be inferred that improved hygiene practises at the Port have contributed to this improvement.
- It can be inferred from the pattern of exceedances for lead, copper and zinc at the Port in 2011compared with 2007 that the Berth 4 ship loading infrastructure continues to play a major role in the exceedances.
- Air monitoring data during ship loading have indicated that dust levels up to 430 $\mu g/m^3$ TSP and 150 $\mu g/m^3$ PM_{10} have been detected within the Port. If ship loading is allowed to occur during on-shore winds then there is potential for dust to reach nearby residences.
- Air quality monitoring for metals outside the Port in community areas is recommended to monitor and manage community exposure.
- A ship loading protocol for not loading metal concentrates during onshore and high winds should be considered as a management action to reduce the potential for dust to reach nearby residences.
- Improved dust suppression on the conveyor system and during ship loading is indicated.
- Further sampling within the residential areas is not recommended at this stage.

Introduction

The Department of Health (DOH) coordinated an environmental sampling program of the Geraldton Port (the Port) and nearby communities in response to concerns about fugitive lead, copper and zinc dust emissions from the Port. The purpose of the sampling program was to assess whether high levels of these dusts were present in the community. The purpose of this report is to interpret the data in the context of public health and make recommendations as deemed necessary.

Officers experienced in environmental sampling from the Esperance Clean-Up and Recovery Project (ECRP) of the Department of Transport (DoT) and the Pollution Response Unit (PRU) of the Department of Environment & Conservation (DEC) collected soil, dust and rainwater samples from strategic locations in the Geraldton Port and in the community. Samples were collected between 17 January and 21 January 2011. The findings were compared to findings from environmental samples undertaken in 2007 by the Department of Environment and Conservation as part of their Port Emission Assessment Program to investigate the impact of metal dust emissions from the Port on Geraldton.

Background

The Geraldton Port Authority commissioned four new monitoring stations in August of 2010 for a more sensitive analysis of metals in dust required to comply with the Ports operating licence. Three monitoring stations were commissioned on the Port boundary; north, east and south on the town side and one monitoring station was commissioned to the far west of the port on the seaward side. Each monitoring station comprises three monitors; a TEOM[1], a High-Volume[2] dust sampler with a selective PM_{10} inlet and a High-Volume dust sampler with a TSP[3] inlet for total dust. A condition of the Ports licence is to report to the regulators (DEC) exceedances of lead and copper.

During the bulk loading of ore concentrate rich in lead sulphide between October 22 and 23 2010 the Port reported an average TSP lead dust concentration level of 4.2 ug/m^3 (micrograms per cubic metres). This level was recorded at the monitoring station located on the seaward extremity of the Port and was approximately eight times the lead dust concentration limit for TSP of 0.5 $\mu g/m^3$ over 24 hours permitted by the Port licence.

The lead dust concentration levels were below the permitted concentration at two of the other three monitoring stations on the town side for the same period. The filter paper from the fourth monitoring station on the town side was damaged and could not be analysed.

Bulk copper and zinc concentrates and other concentrates with low lead concentrations are also exported from the Port. The copper concentration in dust did not exceed the health based guideline of 1.0 $\mu g/m^3$ in PM_{10} for the same period. There is no currently available ambient air guideline for zinc since breathing zinc dust is not typically a significant exposure pathway for the general public.

[1] TEOM – *tapered element isolating microbalance* – configured for continuous monitoring of particles 10 microns in aerodynamic diameter or smaller (PM10).
[2] Monitors configured to capture dust particles on to filter paper for chemical analysis.
[3] TSP – *total suspended particles* – dust particles 50 microns in aerodynamic diameter or smaller.

Air monitoring data during ship loading have indicated that dust levels up to 430 µg/m^3 TSP and 150 µg/m^3 PM_{10} have been seen within the Port. It can be inferred that some dust comes from ship loading and transport activities and some from major construction work at the Port.

A Port representative and a representative from the only company that exports lead out of Geraldton; the Minerals & Metal Group (MMG) met with the DOH and DEC separately to discuss the lead exceedance. DOH expressed concern at the possibility that high levels of lead dust had escaped from the Port during previous ship loading and before the new monitors were installed. The evidence presented to DOH was not sufficient to conclude that a public health risk had occurred but [DOH] later agreed to co-ordinate a sampling program to investigate if lead dust levels were high in the community.

Minerals & Metal Group (MMG) has been exporting lead out of the Port consistently for the past decade. The ore is a high precious metal ore composed of 30 – 40% lead sulphide. The ship loading process of this ore contributed to the high lead reading on the seaward TSP monitor. MMG also export copper and zinc concentrates with a low lead content. No lead exceedances have been reported during loading of these concentrates.

DOH was aware that the Port had a long history of exporting lead in some form spanning 100 years or so. In 2007 DOH participated in a DEC led state wide emissions assessment program and review of all Ports in Western Australia[4] prompted by the lead contamination issue in Esperance[5]. This investigation found lead, copper and zinc levels below health guideline and served as a useful baseline study against which to compare the 2011 results.

In 2007 DEC screened the Port and targeted locations in Geraldton for the presence of lead, copper and zinc. The screening and sampling program incorporated an investigation phase that could be escalated should an assessment uncover an unacceptable risk to public health. Hand-held x-ray fluorescence spectrometry (XRF)[6] and chemical analysis were used for qualitative and quantitative analysis of soil and surface dust samples. As part of the Geraldton program, officers from the City of Geraldton-Greenough (CoGG) also sampled rainwater from domestic rain water tanks on behalf of DOH.

The 2007 Port samples revealed high levels of lead, copper and zinc at locations associated with storage, handling and ship loading of the ore concentrates. The majority of the samples including those from the Port perimeter were not elevated for copper and zinc but were elevated for lead when compared to the current reference guidelines. The pattern of the highest contamination appeared to be well defined and contained within the Port boundary and ship loading area.

The elevated Port levels triggered an assessment of the Port infrastructure to better define the source of the exceedances. Management systems were also reviewed including a subsequent licence amendment that introduced air guideline limits for lead and copper; designed to manage fugitive dusts more effectively. Since 2007 significant infrastructural improvements have been completed at the Port and work is progressing towards covering the conveyor mechanism which was not designed for containment of heavy metal ores and remains a significant source of fugitive dust.

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[4] DEC 2007 Geraldton Port Authority – Emission Assessment Program – Internal Reports.
[5] Public Health Website – Esperance recovery
http://www.public.health.wa.gov.au/3/893/2/esperance_recovery.pm
[6] XRF - *x-ray fluorescence spectrometer* – in-the-field tool for non-destructive, fast qualitative and quantitative elemental analysis of environmental samples.

Setting

The City of Geraldton-Greenough is located on the coast of Western Australia approximately 450 km north of Perth. Geraldton is the administrative centre for the Mid-West with a growing population of 37,000. It supports a diverse range of industries from fisheries to mining. The Geraldton Port Authority is a major supporter of a booming mining sector in the Mid-West that exports iron ore, mineral sands, and heavy metal concentrates to China and other international destinations[7]. The Port is located to the south, close to the town centre and residential areas. The closest residences are within 500m south-east of the ship loading berths.

Geraldton experiences a Mediterranean-type climate, characterised by hot, dry summers and mild, wet winters. South to south-easterly and easterly winds dominate the yearly wind patterns across the area and summer winds tend to be stronger than the lighter winter winds. The Port is well located in relation to the dominant winds in so much as they tend to blow across the Port and off-shore rather than on-shore[8] in contrast to Esperance where the reverse is true. Wind is an excellent dust distributor and disperser and an understanding of the dominant wind patterns across the Port is used to guide air quality planning and dust mitigation strategies.

Methods

DOH developed a sampling and analysis plan (SAP) and reviewed by DoT and DEC officers undertaking the sampling. The SAP borrowed heavily from proven ECRP Site Sampling Methodology[9] validated by the ECRP. The SAP did not preclude sampling according to the standards that underpinned the ECRP methodology thereby allowing the PRU some flexibility in sampling. The SAP and modifications to the SAP were thoroughly discussed by the officers undertaking the sampling at pre and post sampling meetings in Geraldton. Rather than reproduce the sampling methods here the SAP is provided as attachment A.

The 2007 program sampled extensively in terms of distance from the Port. A decision was made not to resample some of the outer most locations but to contain the sampling to within 3.5 km radius of the Port berths. The rationale being that the population was concentrated in this area and air borne metal particulates tend to fall-out within 2 km of a source[10].

Part of the SAP required screening of the sampling sites with XRF. The rationale being that a XRF provides a quick qualitative measure of metal dust on a surface. The XRF detects metals locked in the substrate of the surface being scanned as well as the surface dust. In this context using XRF alone for assessing lead dust on surfaces can result in a false positive assessment of contamination from dust fall-out if the underlying substrate contains lead paint. Bearing this in mind the utility of XRF in this investigation was 1) to provide quick

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[7] Geraldton Port Authority 2009-2010 Annual Report – Geraldton Port Authority website http://www.gpa.wa.gov.au/annual_reports.aspx

[8] Climate of Geraldton – Australian Bureau of Meteorology website. http://www.bom.gov.au/wa/geraldton/climate.shtml

[9] Esperance Clean-up and Recovery Project Site Sampling Methodology

[10] Establishing an Air Guideline Value for Nickel Compounds in Ambient Air for the Western Australian Department of Health – M Goetzmann MSc Thesis –RMIT University

validation of a clean-up method if the investigation escalated to the next stage of the SAP and 2) to screen additional surfaces suspected of contamination. The XRF values have not been included in this report except where relevant to the discussion because quantitative analytical results were available for all the sites sampled.

The ChemCentre of Western Australia (CCWA) analysed the Geraldton samples due to their familiarity and experience with analysing similar environmental samples from Esperance. To ensure consistency information on the type, size and number of samples to be taken and the analysis methods employed was discussed in advance with the CCWA.

Although the SAP focused on lead, copper and zinc, information on a suite of metals was collected where the standard method of analysis allowed for such analysis. Analytical results are provided in attachment B.

Table 1 summarises the environmental samples collected during January 17 and January 21 2011. The complete list of locations can be found in the SAP. Sampling sites were tagged with GIS coordinates and photographed. The location of the sampling sites in the community are provided in Figure 1 in appendix A. GIS co-ordinates, photographic records of the 2007 sampling sites as well as other CoGG and DEC historical information were used successfully to identify sites for resampling.

Table 1. Environmental Samples collected between January 17 and 21

Media	Location	Number of Locations	Number of Samples Collected
Soil	Port	11	11
Soil	Community	23	30
Dust	Community	21	21
Water	Community	27	30 (x2)*
Total			**122**

*(x2) denotes duplicates

Since the amount of lead, copper and zinc commonly found in housing and tank construction materials vary over time, house age, and construction materials and so on these were recorded where possible. Householders were surveyed, wherever possible for hobbies where lead may be used. The presence of these metals in the sampling environment can lead to false judgements about the source meaning that if an elevated level is found it could be attributed to the wrong source. Bearing this in mind the sampling program also provided a small opportunity for other sources of high lead, copper and zinc in the environment to be uncovered and followed-up if necessary.

Rainwater tank cleaning was also recorded where possible because metals adsorb to organic matter to a varying degree and accumulate as sediments in the tank and pipe and provide an opportunity for on-going exposure if the tank water is used for drinking.

Assessment Criteria

The DOH and National reference criteria that have been used in this assessment are summarised in Table 2.

Soil
Health-based investigation levels (HIL) for metals in soil provide a useful screening measure against which to assess contaminated soils. An exceedance of a HIL is a trigger that further investigation may be needed however when interpreting the results of a soil analysis the context of the location is important to avoid unnecessary remediation and community concern. Four HILs (HIL A - F) have been developed to accommodate different exposure scenarios ranging from the most conservative (HIL-A Residential) for use in residential areas to the least conservative for use in industrial areas (HIL-F Commercial/Industrial).

In this investigation HIL-A is used for lead as the reference for all locations (including inside the Port boundary). This is because experience has shown that in principle when a Port premises is widely contaminated with a contaminant of concern such as lead and communities are in close proximity, then the risk that nearby residences will also become contaminated is increased significantly. For this reason the lead values for parks, recreational open areas and industrial areas, namely HIL-E and HIL-F, are not given in Table 2.

Surface Dust
The amount of lead dust deposited on surfaces can be used to determine the likelihood of lead exposure. Good correlation between blood lead levels and surface dust has been reported particularly in young children. DOH developed various surface dust criteria for lead for Esperance for this purpose. The Port Emissions Assessment Program undertaken by the DEC in 2007 required a dust guideline for surfaces that would be sampled that were not readily accessible to the public. The DOH established a lead dust guideline of 4.0 $\mu g/cm^2$ for external surfaces that are not readily/regularly accessible to the public. This was the most appropriate criterion applicable to Geraldton based on the surfaces that were sampled. Since surface dust is not a significant pathway for copper and zinc exposure, surface dust criteria are not available.

Water
The Australian Drinking Water Guidelines (ADWG) provides a measure of how ‘safe’ water is to drink. The guidelines also consider aesthetic qualities in terms of appearance and taste. Values based on aesthetic qualities may be more conservative than health based values e.g. copper and zinc. Rainwater analysis from domestic tanks provides very good correlation with dust deposition on rooves. A domestic roof serves as an excellent catchment for air-borne fall out to collect in rainwater therefore; metal analysis of the water can be used to identify population exposure when rainwater tanks are common in a community.

Table 2: Summary of Reference Criteria used in this Assessment

Media	Guideline	Value & Units			Reference
		Copper	**Lead**	**Zinc**	
Soil	HIL-A Residential	1000 mg/kg	300 mg/kg	7000 mg/kg	DEC 2010
	HIL-E Parks, recreational open areas.	2000 mg/kg	NA for this assessment	14000 mg/kg	
	HIL-F Commercial Industrial	5000 mg/kg	NA for this assessment	35000 mg/kg	
Surface Dust	DOH GLV*	NA	4 µg/cm^2	NA	DOH 2007
Water	ADWG health based	2 mg/L	0.01 mg/L	-	NHMRC 2004
	ADWG aesthetic based	1 mg/L	NA	3mg/L	

*GLV – Guideline Value

DEC 2010 – Contaminated Sites Management Series – Assessment levels for Soil, Sediment and Water. WA Department of Environment and Conservation.

DOH 2007 – Internal guideline developed for Port Emissions Assessment Program. WA Department of Health.

NHMRC 2004 – Australian Drinking Water Guidelines. National Health & Medical Research Council.

RESULTS

Simple statistical variables were sufficient to assess the data for public health purposes. There was no need to assess individual differences between the 2007 & 2011 data except in some instances where exceedances were evident.

Community samples

Soil Data

Thirty soil samples were collected from 23 locations within Geraldton. All data were included in the analysis. The 2007 values have been supplied for comparison. A statistical summary is provided in Table 3.

Table 3: Statistical Summary of Soil Data from the Community

Statistical Variable	Soil Concentration mg/kg					
	Copper		Lead		Zinc	
Year	**2011**	**2007**	**2011**	**2007**	**2011**	**2007**
N	30	41	30	41	30	41
min	1.4	1	1.6	2.1	6	7
max	230	160	140	240	740	700
median	18.5	7.5	12.5	9.9	78	39
HIL A	**1000**		**300**		**7000**	

LOD – Cu 0.1 mg/kg, Pb 0.5 mg/kg, Zn 5 mg/kg

None of the concentrations were below the limit of detection (LOD).

None of the data are above the reference values. The comparative maximum values for 2011 / 2007 are from the verge outside the boundary of St Johns Primary school. It is tempting to attribute these values to the influence of traffic emissions given the proximity of the sampling site to the road however the observation of the data from other road side sites is highly variable. The lead concentration decreased from 2007 to 2011. More likely the data reflects typical variability due to the effect of physical and chemical characteristics of the soil on metal adsorption. Clearly evident is that none of the data reflect accumulation of heavy metals above the reference values in the soil over time.

Water Data

Thirty duplicate (60) rainwater samples were collected from 27 domestic tanks. Eighteen of these tanks had been sampled in 2007. Some residences had 2 or more tanks that required sampling. Householders were recruited on a voluntary basis and represented a good physical spread of tank locations relative to the Port. Figure 2 appendix A shows the locations of the rainwater tanks.

All data were included in the analysis. For statistical purposes the values that were reported as <LOD were divided by 2. Eight copper, 1 lead and 1 zinc value was below the LOD and did not significantly affect the statistical variables. A statistical summary is provided in tables 4 & 5.

Table 4: Statistical Summary of Water Data from the Community

Statistical Variable	**Water Concentration mg/L**					
	Copper		**Lead**		**Zinc**	
Year	**2011**	**2007**	**2011**	**2007**	**2011**	**2007**
N	60	22	60	22	60	22
min	0.001	0.006	<LOD	0.0002	0.003	0.01
max	0.011	0.028	**0.022**	**0.016**	**5.50**	**6.1**
median	0.006	0.008	0.0007	0.0009	0.30	0.37
average	0.009	0.012	0.0012	0.002	1.17	1.23
ADWG	**2**		**0.01**		**3**	

LOD – Cu 0.002 mg/L, Pb 0.0001 mg/L, Zn 0.005 mg/L

CCWA noted that one sample pair (GW015 117 & 118) returned significantly different concentrations for lead in contrast to the rest of the data set where the duplicates were more evenly matched. Subsequent investigation revealed a sediment deposit in sample 118. Lead concentration was above the reference value in sample 118 and the highest value in the dataset. Both samples 118 & 117 were filtered and reanalysed. The original unfiltered samples returned a lead level of 0.022 mg/L (118) and 0.0012 mg/L (117) in contrast to the filtered samples which returned 0.004 mg/L (118) and 0.0007 mg/L (117) respectively.

The original values were kept in the dataset because they better reflect the exposure potential of the water if the tank water is used for drinking and cooking. XRF readings of the PVC tank and plastic feed pipes revealed traces of copper and zinc but not lead suggesting that the source of the lead in this tank could not be attributed to tank material or feed pipes.

The exceeded lead concentration in this single tank cannot be attributed to dust fall-out from the Port given that seven different tanks in close proximity were not affected. Nevertheless the lead concentration in this tank presents a source of on-going exposure for the residents and will be followed-up with the residents.

Table 5: Number of rainwater tanks with ADWG exceedances.

Year	Number of tanks sampled	Number of tanks with exceedances		
		Copper	Lead	Zinc
2007	22	0	1	2
2011	30	0	1	5

The tanks returning the exceedances were not the same tanks. In 2007 a different tank returned the maximum lead concentration of 0.016 mg/L. This tank was resampled in 2011 and returned a value of 0.0003 mg/L. One of the tanks returning an exceedance for zinc in 2007 had been subsequently removed while the other returned a normal value in 2011. For consistency, where a tank returned an exceedance for a metal other than copper, lead or zinc in 2007, it was investigated for the same exceedance in 2011. One tank had returned a nickel exceedance in 2007 but had subsequently been removed.

Five tanks returned zinc levels above the ADGW (aesthetic) guideline in 2011. Two tanks (one connected) were located in the same premises 4km to the south of the Port, one tank was located 4 km to the north of the port, two other tanks were within 200m of the port to the SW and SE. Other tanks were not affected although one tank 1.5 km to the south-east returned a level (2.85 µg/L) close to the reference level. Given their locations relative to the Port and the direction of dominant winds the exceeded zinc levels cannot be attributed to dust fall-out from the Port. The level of exceedance does not present a health concern nevertheless householders will be notified that the levels may affect taste.

Surface Dust Data

Twenty one samples were collected from 21 locations; in 2007 64 samples were collected (i.e. the front & back of a sign) from 32 locations. In 2011 only surfaces facing towards the Port were sampled.

Concentration of metal dust in air, deposition rate and surface composition are three important factors that play a significant role in the persistence of metals in the environment[10]. Put simply the more metal dusts in the air the more falls-out, the greater the concentration of metals in surface dust soils, water and so on. Metals like lead bind tightly to many types of surfaces meaning that over time the lead concentration would gradually increase. This also means that the more tightly the metal is bound the less is available for recirculation into the environment, but may present a continual source of exposure when accessible to children in particular.

In assessing exposure the most valuable information is obtained from horizontal surfaces however as a general screening exercise vertical surfaces can be used when the limitations are understood. The 2007 investigation sampled vertical surfaces and hence a decision was made by DOH to resample these surfaces with the understanding that the data should not be used to assess exposure but rather to provide evidence for lead, copper and zinc accumulation in the environment over time. The DOH GLV was used as a trigger for further investigation in the event of a lead exceedance.

As shown in table 6 there is no evidence of accumulation over time. In making this judgment the assumption was that the vertical surfaces were not regularly cleaned. Since the surfaces sampled were a mostly metal street, traffic and place signs this assumption was not unreasonable. Another assumption was that dust did not simply slide off the surface, this assumption can be rationalised when taken in context with the soil samples. In so much as the soil samples that were collected from the same location as signs were not above or close to the reference levels.

Table 6: Statistical Summary of Surface Dust Data from the Community

Statistical Variable	Surface Dust µg/cm^2					
	Copper		Lead		Zinc	
Year	**2011**	**2007**	**2011**	**2007**	**2011**	**2007**
N	21	64	21	64	21	64
min	0.013	0.002	0.003	<LOD	0.36	0.016
max	0.1	0.27	0.095	1.4	3.4	3.7
median	0.018	0.011	0.005	0.006	0.55	0.22
average	0.03	0.98	0.012	0.061	0.81	0.42
DOH GLV	**NA**		**4**		**NA**	

Port Samples

Sampling sites were located using 2007 GIS co-ordinates. The Port began a program of improvement in response to the 2007 findings and some sampling sites that had been bare earth in 2007 had since been sealed. Part of the improvement program included a program of improved Port hygiene so that spills during ship loading were cleaned up immediately. This program was operating during the sampling period thus in some areas there was insufficient loose material to collect for sampling whereas in 2007 there was.

Soil Data

Eleven samples were collected from eleven locations. Locations were selected based on the 2007 data to ensure that the most affected areas were tested including the Port boundary. A statistical summary is provided in Tables 7 & 8.

In 2007 only 3 soil samples were collected for analysis although 31 different locations were sampled with XRF. There was little value in directly comparing the 2007/2011 XRF data given that the cleanliness of the Port would be better assessed against the 2011 laboratory data. Also XRF results are not presented as µg/cm^2 and hence direct comparison to swab results cannot be made. The XRF is best used as a screening tool with analytical results the empirical method of determining relevant metal concentrations in soil.

Table 7: Statistical Summary of Soil Data from the Port

Statistical Variable	Soil Samples mg/kg					
	Copper		Lead		Zinc	
Year	**2011**	**2007**	**2011**	**2007**	**2011**	**2007**
N	11	3	11	3	11	3
min	64	380	6.8	300	68	4300
max	**9400**	610	**2700**	590	**61000**	22000
median	2000	-	580	-	8800	-
average	3042	463	955	413	18240	10767
HIL	**HIL F 5000**		**HIL A 300**		**HIL F 35000**	

The comparison of the 2007 soil samples with the 2011 soil samples is limited due to a change in methodology in collecting the soil samples between 2007 and 2011. In 2011 soil samples were collected where the XRF readings exceeded 300 mg/kg for lead which led to sampling areas of the Port which had not been sampled in 2007.

Table 8: Number of exceedances above the HILs

Number of Samples	Exceedances		
	Copper	Lead	Zinc
11	3	6	3

Exceedances for copper, lead and zinc were returned from the ship loading areas but not the berths where the hygiene program was operating. The highest exceedances occurred under the open conveyor and between storage sheds south of the berths. One location (D4) between sheds also returned a small exceedance for cadmium. If cadmium is found naturally with lead ores then this finding is not unusual.

No exceedances were returned from the Port perimeter in 2011 in contrast to 2007 when each of the 3 soil samples returned an exceedance.

Conclusions and Recommendations

Conclusions

- The levels of heavy metals detected in the community are well below respective health guideline values and do not pose a health risk to the residents.
- The levels of lead at the Port boundary were under the reference level in 2011 compared with 2007. It could be inferred that improved hygiene practises at the Port have contributed to this.
- It can be inferred from the pattern of exceedances for lead, copper and zinc at the Port in 2011compared with 2007 that the Berth 4 ship loading infrastructure continues to play a major role in the exceedances.
- Air monitoring data during ship loading have indicated that dust levels up to 430 $\mu g/m^3$ TSP and 150 $\mu g/m^3$ PM_{10} have been seen within the Port. If ship loading is allowed to occur during on-shore winds then there is potential for dust to reach nearby residences.

Recommendations

- Air quality monitoring for metals outside the Port in community areas is recommended to monitor and manage community exposure.
- A ship loading protocol for not loading metal concentrates during onshore and high winds should be considered as a management action to reduce the potential for dust to reach nearby residences.
- Improved dust suppression on the conveyor system and during ship loading is indicated.
- Further sampling within the residential areas is not recommended at this stage.

Appendix A

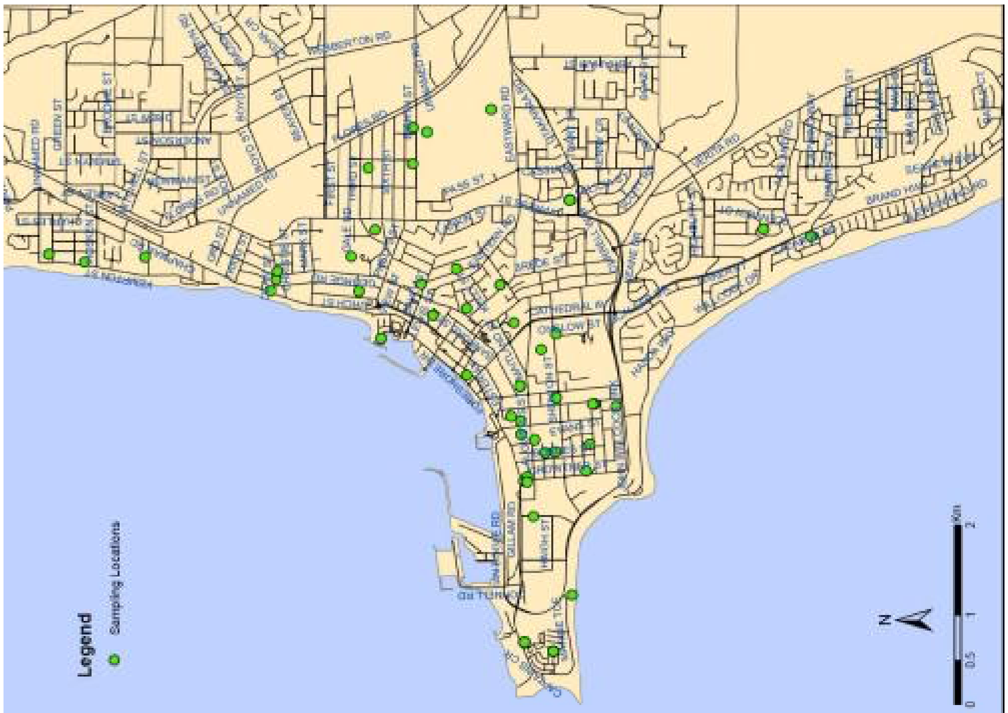

Figure 1 : All Sampling Locations

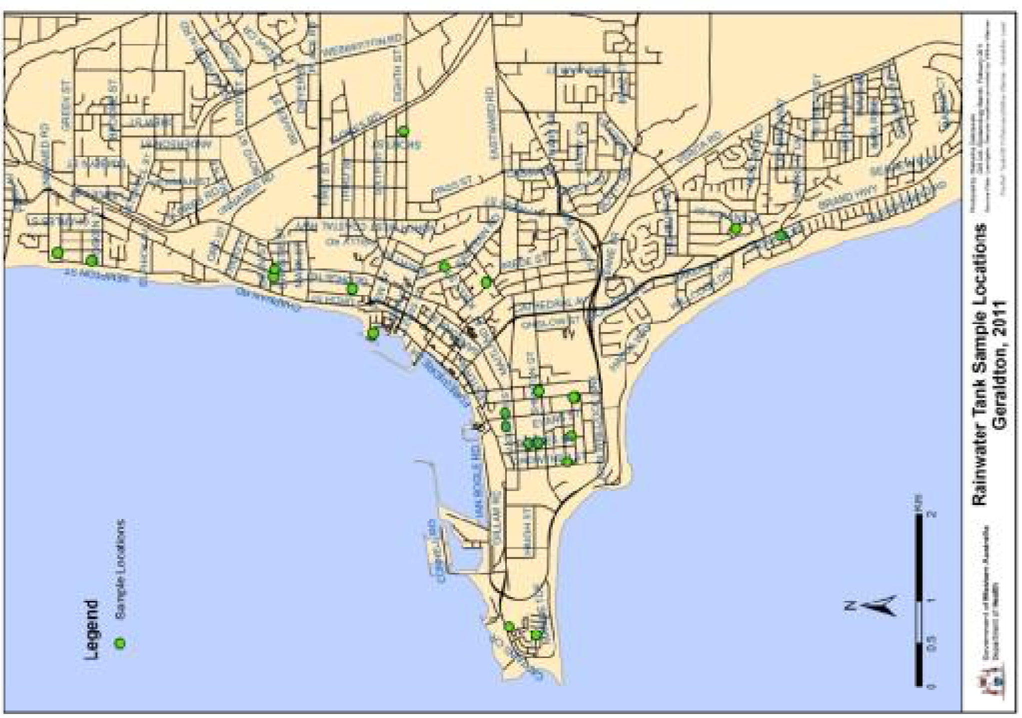

Figure 2 : Rainwater Tank Locations