Community monitoring report: lead and arsenic in air near Exide Technologies Ltd, Petone (February to May 2008)

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Summary

Ambient air quality monitoring for lead and arsenic was undertaken near Exide Technologies Limited's (Exide) battery recycling plant in Petone from 1 February to 31 May 2008. Total suspended particulate in air was continuously sampled for 24-hour periods every second day using a high-volume sampler at two monitoring sites in the community; a commercial site on Waione Street and a residential site on Kirkcaldy Street.

Median concentrations of lead in air at both sites were approximately one third of the concentrations measured at the same locations in 1999. Arsenic concentrations in air, measured for the first time near Exide, were not at levels that warrant concern. However, a longer period of monitoring is needed for comparison with the national guideline for arsenic in air.

Average deposition velocities of lead particles were estimated using co-located measurements of lead dust deposition rates and ambient air concentrations from the community monitoring sites. Deposition velocities obtained are within the ranges used in Regional Public Health's health-risk assessment model. This model was the basis for setting emission limits at Exide's site boundary during the review of resource consent conditions in 2006.

During the monitoring period Exide undertook major maintenance work on site, including replacement of the furnace stack. On about half of the days that monitoring occurred the smelting and refining operations were shut down. Consequently emissions of lead and arsenic particulate from Exide's site during the monitoring period may be atypical and therefore these monitoring results may not be fully representative of longer term levels in air.

1. Introduction and background

1.1 Exide discharges and fugitive emissions limits

Exide operates a secondary lead smelter where used lead-acid batteries and scrap lead are refined to produce pure lead or lead alloys. The furnace waste (slag) is processed on site and after stabilisation is transported off-site for storage and subsequent landfilling.

All discharges to air from the site are authorised by resource consent WGN000128 [24363]. Mass emission limits for a range of contaminants, including lead and arsenic, apply to discharges from the 37 m furnace bag filter stack and the 12 m cartridge dust collector vent.

Fugitive emission limits for concentrations of lead in total suspended particulate (TSP) were imposed as one of the outcomes of the 2006 review of resource consent conditions. The following limits (3-month moving average, based on 7-day averages) apply to three of Exide's site boundaries:

- 1.5 $\mu g/m^3$ on the southern boundary
- 0.8 $\mu g/m^3$ on the northern boundary
- 0.55 $\mu g/m^3$ on the western boundary

Exide also undertake deposition monitoring for lead and arsenic in deposited particulate at Waione Street, Kirkcaldy Street and at Unilever.

1.2 Greater Wellington 1999 monitoring programme

Monitoring of lead concentrations in outdoor air was carried out by Greater Wellington from February to May 1999, every second day from midnight to midnight. A three-month average of 0.32 $\mu g/m^3$ and 0.10 $\mu g/m^3$ for lead in air was recorded at Waione Street and Kirkcaldy Street respectively (Davy 1999).

1.3 Lead in air at other locations

Since the phase out of the use of lead petrol additives in 1996 concentrations of lead measured in air in urban areas have declined markedly (MfE 2007). There are recent data available on lead concentrations at other sites around the country; however these measurements were collected using methods different to that used in this monitoring programme. For example, a residential location near a busy road in Auckland recorded three-month winter averages (based on 7-day TSP samples) for lead in air of 0.017 $\mu g/m^3$ (2005) and 0.018 $\mu g/m^3$ (2006) respectively (Kathleen McLeod, Watercare, pers. comm. 11/6/08). Closer to home, analysis of PM_{10} collected in the Seaview industrial area (from 2005 to 2007) shows an average 24-hour lead concentration of 0.025 $\mu g/m^3$ (Davy et al. 2008).

2. Purpose and objectives

This study was undertaken at the request of Greater Wellington's Environmental Regulation Department, the regulatory body with statutory responsibility for industrial discharges to air. The Environmental Regulation Department had agreed to undertake ambient air monitoring for lead in the community during the hearing to decide the outcome of the review of Exide's resource consent conditions. This commitment to undertake further monitoring was also specified in the subsequent Environment Court decision on the appeal of Greater Wellington's decision on the review.

Specific objectives of the 2008 monitoring were to:

- measure concentrations of lead in outdoor air at the two locations that were monitored in 1999;
- obtain information on ambient concentrations of arsenic;
- obtain co-located measurements of ambient air lead concentrations and deposition rates in order to estimate deposition velocities of lead particles; and
- compare deposition gauge results with those measured by Exide.

3. Contaminants investigated

3.1 Total suspended particulate (TSP)

Total suspended particulate (TSP) measured using a high-volume sampler includes airborne particles with an equivalent aerodynamic diameter of less than 50 μm. These particles are produced from combustion, industrial processes, motor vehicles, burning and natural sources such as wind-blown dust and sea salt. Particles 10 μm or less in aerodynamic diameter (PM_{10}) may be inhaled and are known to cause a range of adverse health effects. While a national standard for PM_{10} exists, there is no New Zealand health-based guideline for TSP which has predominantly nuisance or amenity effects such as soiling. In this study TSP is sampled in order to also capture the larger sized lead particles (above 10 μm) that may be present in airborne dust.

3.2 Lead in air

The concentration of lead in air can be calculated from the mass of lead collected in a known volume of air. The principal source of lead in air in the study area is discharges from Exide. Other potential sources of lead in the environment include dust from lead-based paint removed during renovations. Because lead is an environmentally persistent contaminant, there may be lead in soils or dust deposited from lead-smelting and refining activities and from vehicle emissions prior to the completed phase out of lead in petrol in 1996. A small fraction of this 'historical' lead may re-enter the air due to the action of wind or when soils are exposed.

Adverse health effects of lead are related to increases in the concentration of lead in blood following ingestion of deposited particulate and/or inhalation of particulate or lead fume. The national ambient air quality guideline (MfE 2002) for lead of 0.2 $\mu g/m^3$ (3-month moving average), based on 24-hour averages, is designed to protect against adverse health effects from inhalation exposure. This guideline relates only to the particulate assessed as PM_{10}. TSP was dropped as a measurement method for lead in particulate in 1994 in recognition that PM_{10} monitoring was more commonplace due to the existence of a PM_{10} guideline (MfE 1994).

The United Kingdom has an annual standard of 0.5 $\mu g/m^3$ and an air quality objective of 0.25 $\mu g/m^3$ to be achieved by the end of 2008 (both assessed as PM_{10}). The USA standard of 1.5 $\mu g/m^3$ (averaged over a calendar quarter) is assessed as TSP so that the potential contribution of re-suspended deposited lead particulate is captured. The American standard is currently going through the statutory review process with scientific advisors recommending that consideration be given to lowering the current standard (US EPA 2007).

3.3 Arsenic in air

The concentration of arsenic in air can be calculated from the mass of arsenic collected in a known volume of air. Non-industrial sources of arsenic in air include burning of timber treated with copper/chrome/arsenic preservative. Arsenic is classified as a carcinogen by US Environmental Protection Agency.

The current national guideline (MfE 2002) for arsenic is 0.0055 μg/m^3 (annual average).

3.4 Deposited particulate

Dust fallout is the combined rate of dust deposited under wet and dry conditions. It is typically measured by exposing a vessel (gauge) with a standard surface area for a specified time period. Typically these gauges collect dust particles greater than 10-20 μm (MfE 2001) with results expressed as mass per area per exposure time.

The quantity of lead in deposited dust can be used as an input to multi-pathway exposure models for determining human health risks. However, it should be noted that the deposition is a surrogate surface and lead particulate will deposit at different rates depending on the surface (e.g., vegetation, bare soils, paved etc.). Deposition gauges are a relatively unsophisticated monitoring method and can show considerable variability in results. They are, therefore, best suited for establishing long term trends rather than spot measurements for compliance assessment.

There are no standards or guidelines for lead in deposited particulate. The MfE ambient air guidelines (MfE 2002) note that where there is the likelihood of ingestion from deposited lead, this exposure pathway must be taken into account (in addition to inhalation exposure) when assessing health impacts on children.

4. Monitoring locations

4.1 Topography and surrounding land-use

The surrounding land is flat, comprising the alluvial fan of the Hutt River valley. The Hutt River is 200 m east of the monitoring sites and the Petone foreshore is 300 m to the south. The area is surrounded by light industrial and commercial premises to the south, west and east, with heavier industry to the north (Unilever) as well as high density Housing New Zealand flats. Residential dwellings are located immediately west of the Kirkcaldy Street monitoring site.

4.2 Monitoring sites

Two high-volume samplers were used to monitor ambient lead and arsenic concentrations. One sampler was located approximately 50 m south of Exide on Waione Street and the other approximately 80 m west on Kirkcaldy Street as shown on Figure 4.1. Photos of the high-volume samplers are shown in Figures 4.2 and 4.3.

Figure 4.1: Map showing location of ambient air monitors and deposition gauges

Figure 4.2: Kirkcaldy Street high-volume sampler

Figure 4.3: Waione Street high-volume sampler

4.3 Meteorology

The nearest meteorological station to the high-volume samplers is the Shandon Golf Course (NZMS 260:R27:E2669020; N5996170), approximately 750 m north-east of the monitoring sites. Winds measured at the Shandon meteorological station are predominantly from the northerly and southerly quarters. On average approximately 60 percent of wind is from between 337.5 (N-NW) and 67.4 (E-NE) degrees and 25 percent from 247.5 (W-SW) to 157.5 (S-SE). Wind roses for a three year period and for the monitoring period are presented in Appendix 1.

5. Methods

5.1 Ambient air sampling

Two high-volume samplers (Lear Siegler flow-set) fitted with TSP heads were operated in accordance with AS/NZ 3580.9.3:2003 on a one-in-two day sampling regime from midnight to midnight.

Ambient air at 70 m^3/hour was drawn through pre-conditioned and pre-weighed filters (Whatman EPM 2000). After 24-hour exposure the filters were removed, re-conditioned and reweighed. The results are expressed as TSP 24-hour average in $\mu g/m^3$ corrected to standard conditions (0^oC and 101.3 kPa).

5.2 Deposition monitoring

Deposition gauges were used at both monitoring sites to assess the monthly dust fallout rates using the horizontal deposit gauge method as outlined in the draft International Standard ISO/DIS 4222.2, with results expressed as mg/m^2/month (30 days +/- 2 days). The deposit gauge is a cylindrical, flat-bottomed vessel with an internal diameter of 200 mm and a depth of 400 mm. The deposition gauges were installed at roof height above the high volume samplers and were sited next to the deposition gauges operated by Exide.

5.3 Analytical methods

Gravimetric and chemical analyses of the filter media were carried out by Environmental Laboratory Services (ELS), Seaview, Lower Hutt. Exposed filters were quartered before undergoing hot acid digestion based on AS 2800-1985. Lead and arsenic content were determined by ICP-MS (inductively coupled plasma – mass spectroscopy). Field and laboratory blanks were included in the analyses for quality assurance purposes, with blank filter concentrations taken into account when calculating the final concentrations.

The analytical detection limits for lead and arsenic were 0.1 µg per filter (0.00005 $\mu g/m^3$) and 0.2 µg per filter (0.0005 $\mu g/m^3$) respectively. For data analysis purposes measurements reported by ELS as less than the detection limits were replaced by values one half of the detection limit. Therefore all values reported by ELS for arsenic of < 0.0005 $\mu g/m^3$ became 0.00025 $\mu g/m^3$.

The deposition gauges were analysed following the methodology outlined in the Exide Air Monitoring Manual (March 2006) to ensure comparability of results. Both soluble and insoluble particulate were collected and analysed and the results reported as total mass of lead deposited. The lead and arsenic mass were determined using ICP-MS.

5.4 Quality assurance

Both high-volume samplers were calibrated using a variable orifice flow calibrator on 29 January 2008 before sampling began and on 5 March 2008, 2 April 2008, 2 May 2008 and subsequently on 5 June 2008 once the sampling programme was completed. The calibrations confirmed that the instruments

were operating within acceptable limits and only minor corrections were made to the flow rates used to calculate the final contaminant concentrations.

5.5 Statistical analysis

The statistical analyses used in this report were undertaken using SYSTAT. Non-parametric statistical tests were used (the data were not normally distributed).

Spearman's correlation coefficient (r_s) was used to investigate the relationship between meteorology and measured contaminant concentrations. Significance testing of Spearman's r_s used critical values published by Zar (1972).

The Mann-Whitney (Wilcoxon) statistic (U) was used to compare monitoring results between sites and between different years. This test statistic is also non-parametric and is based on the ranks of data rather than actual values.

6. Results and discussion

6.1 Ambient air monitoring results

The full record of monitoring results is presented in Appendix 2.

6.1.1 Total suspended particulate (TSP)

Figure 6.1 shows the ambient concentrations of TSP for 24-hour periods measured at Waione Street and Kirkcaldy Street, with summary statistics given in Table 6.1. Median TSP concentrations measured at Kirkcaldy Street were lower than those measured at Waione Street (U = 1413, p = 0.022). The maximum recorded value at Kirkcaldy Street on 17 February 2008 was probably influenced by lawn mowing as grass clippings were noted on the sample filter.

The levels of TSP at both sites measured are probably typical of a coastal urban area, near a busy road and close to industrial and commercial premises. Recent analysis of PM_{10} samples in nearby Seaview shows that airborne particulate is dominated by sea salt and soil-derived matter (Davy et al. 2008). These two natural sources of particulate are also likely to be major contributors to TSP concentrations at the monitoring sites.

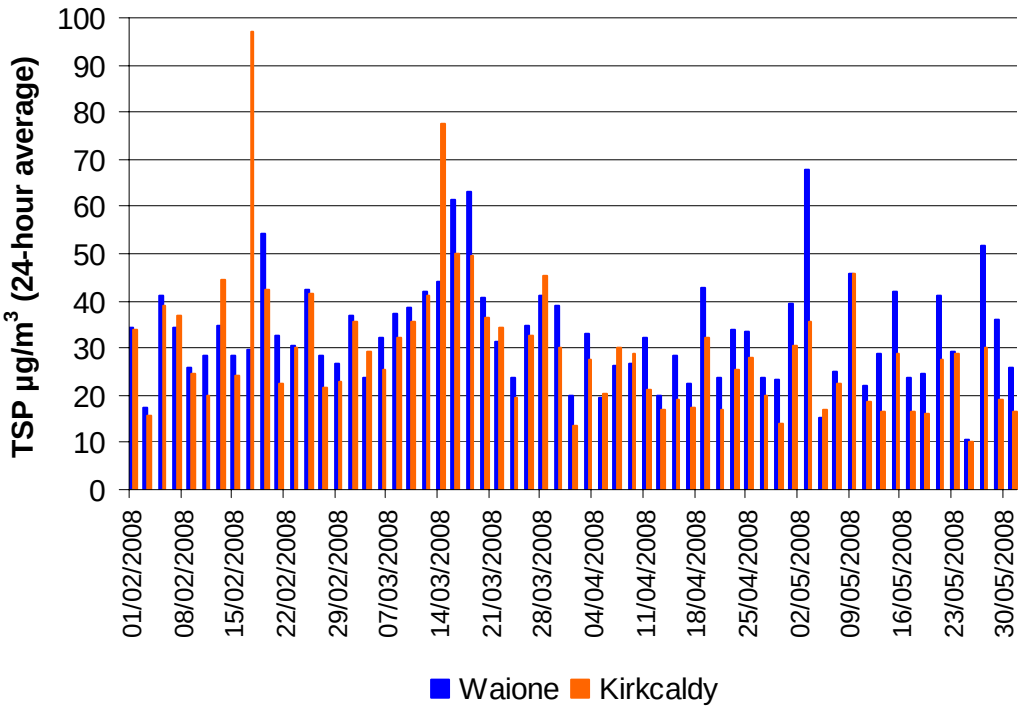

Figure 6.1: TSP concentrations (1 February to 31 May 2008)

Table 6.1: Summary statistics for TSP concentrations (1 February to 31 May 2008)

TSP (µg/m^3) 24-hour average	Waione Street	Kirkcaldy Street
Maximum	67.59	97.10
99.9 percentile	67.34	95.92
99 percentile	65.03	85.29
95 percentile	54.09	49.75
75 percentile	39.48	35.52
Mean	33.07	29.58
Median	32.06	28.06
25 percentile	25.15	19.61
Sample size	61	61

6.1.2 Lead

Figure 6.2 shows the ambient concentrations of lead for each 24-hour period measured at Waione Street and Kirkcaldy Street, while Table 6.2 provides summary statistics for these data. The median lead concentration measured at Kirkcaldy Street was lower than that recorded at Waione Street ($U = 891$, $p = 0.000$). The maximum 24-hour average recorded on 21 March 2008 at Waione Street (0.69 µg/m^3) coincides with clearing of a blockage in Exide's baghouse hopper leading to visible emissions on site[1]. Northerly wind direction and speeds during this day were conducive to elevated concentrations at the Waione Street site.

Monthly averages and three-month rolling averages are presented in Table 6.3.

[1] Comment provided with Exide boundary monitoring results, SKM

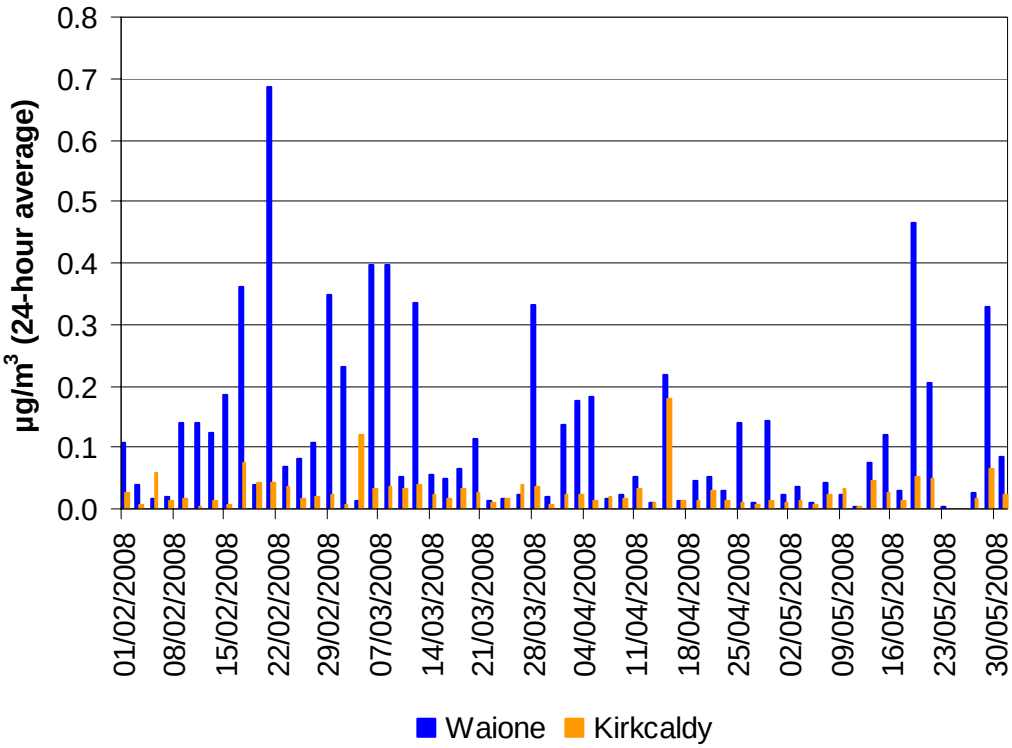

Figure 6.2: Lead concentrations (1 February to 31 May 2008)

Table 6.2: Summary statistics for lead concentrations (1 February to 31 May 2008)

Lead (µg/m^3) in TSP 24-hour average	Waione Street	Kirkcaldy Street
Maximum	0.69	0.18
99.9th percentile	0.67	0.14
99th percentile	0.55	0.06
95th percentile	0.40	0.03
75th percentile	0.14	0.01
Mean	0.12	0.03
Median	0.06	0.02
25th percentile	0.02	0.01
Sample size	61	61

Table 6.3: Monthly and three-monthly average lead concentrations

Lead (µg/m^3) in TSP	Waione Street	Kirkcaldy Street	Averaging time
February 2008	0.17	0.03	1-month
March 2008	0.14	0.03	1-month
April 2008	0.08	0.03	1-month
May 2008	0.09	0.02	1-month
February, March, April 2008	0.13	0.03	3-month
March, April, May 2008	0.11	0.03	3-month moving

During the monitoring period Exide carried out major maintenance including refurbishment of slag processing plant, replacement of the corroded furnace stack and cleaning of the baghouse stack. While these works were undertaken, slag crushing and mixing operations, and smelting and refining operations were suspended at various times. During the sampling period of 61 days, the furnace and refining activities were intermittent with the furnace operating for 28 days, and refining occurring on 25 days. From mid-April to late May both the furnace and refining operations were shut down and this appears to be reflected in the lower April and May monthly averages for Waione Street shown in Table 6.3.

The lack of day-to-day fugitive emissions associated with normal handling of battery scrap and other processing activities on site and the possibility of abnormal discharges associated with the maintenance work (e.g., cleaning of cartridge house) means the monitoring results may not be representative of local air quality compared to when Exide is operating under normal conditions.

6.1.3 Arsenic

Figure 6.3 shows the ambient concentrations of arsenic for each 24-hour period measured at Waione Street and Kirkcaldy Street, while Table 6.4 contains the summary statistics for the monitoring period.

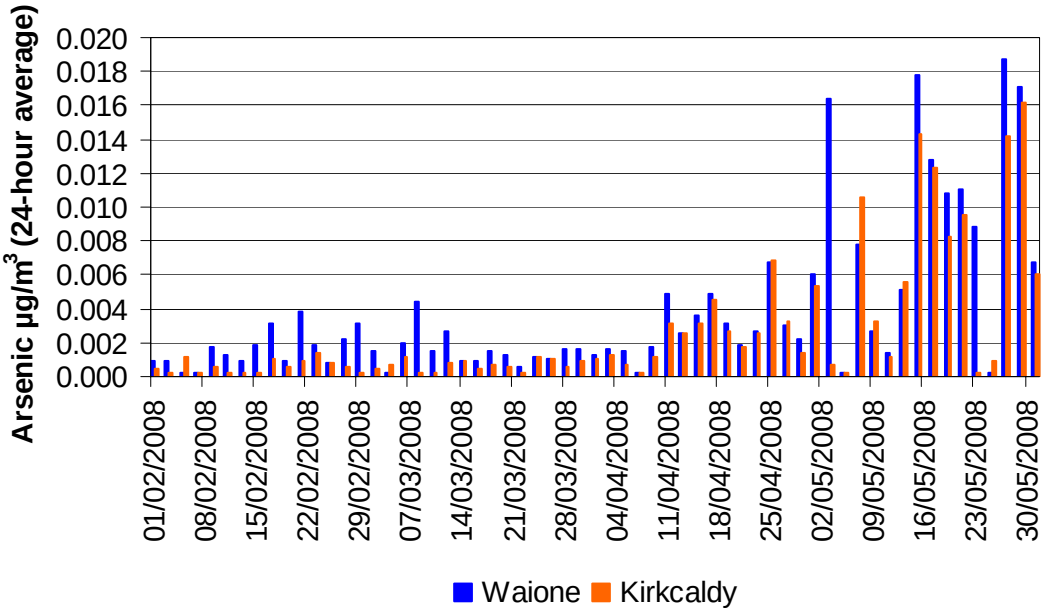

Figure 6.3: Arsenic concentrations (1 February to 31 May 2008)

Table 6.4: Summary statistics for arsenic concentrations (1 February to 31 May 2008)

Arsenic (µg/m³) in TSP 24-hour average	Waione Street	Kirkcaldy Street
Maximum	0.0187	0.0161
99.9th percentile	0.0186	0.0160
99th percentile	0.0182	0.0151
95th percentile	0.0164	0.0123
75th percentile	0.0044	0.0032
Mean	0.0038	0.0027
Median	0.0019	0.0010
25th percentile	0.0012	0.0006
Sample size	61	61

The median arsenic concentration at Kirkcaldy Street was lower than that measured at Waione Street (U = 1317, p = 0.005). During the monitoring campaign concentrations of arsenic appear higher at both sites from late April 2008 onwards. It is possible that a winter peak in arsenic concentrations is occurring due to localised domestic burning of Copper Chrome Arsenic treated timber. A longer period of monitoring and other investigations are required in order to confirm whether domestic fires are a local source of arsenic during the winter months.

The national guideline (MfE 2002) for inorganic arsenic in air to protect against health effects from inhalation exposure is an annual average of 0.0055 µg/m^3. Although, the mean arsenic concentrations shown in Table 6.4 are not

directly comparable to the annual average, the annual average can be converted to the shorter averaging time using a conservative power law relationship as recommended by Chiodo and Rolfe (2000). In this case the annual guideline converts to a 4-month average of 0.0062 µg/m^3. The mean concentrations at Waione Street and Kirkcaldy Street are both within this shorter term limit and therefore do not give any cause for concern. However, a longer period of arsenic monitoring would provide greater certainty, especially given the higher concentrations observed from late April to May 2008.

6.2 Comparison to 1999 monitoring results

Figure 6.4 shows the monthly average lead concentrations at the two sites in 1999 and in 2008. Table 6.5 shows summary statistics for lead concentrations for the two monitoring periods.

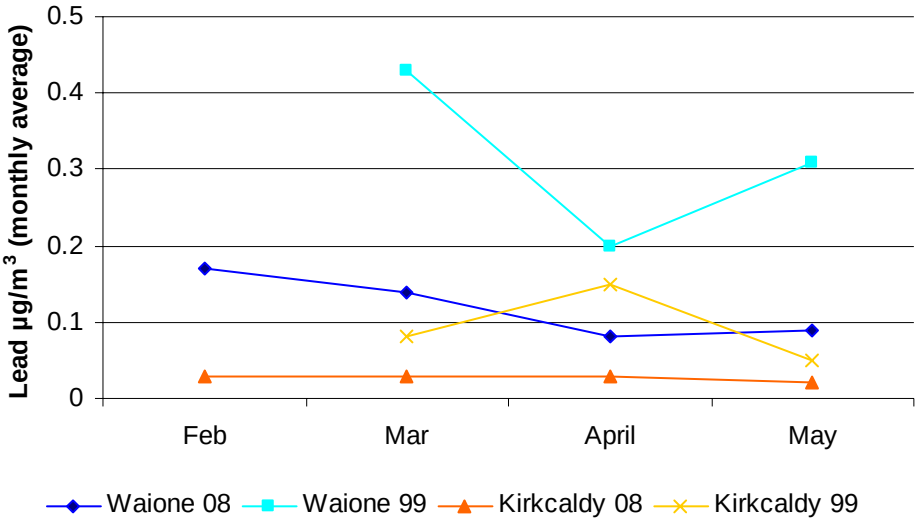

Figure 6.4: Monthly average lead concentrations in 1999 and 2008

Table 6.5: Comparison of summary statistics for lead in air 1999 and 2008

Site	Lead µg/m^3 in TSP (24-hour average)	1999 (1/2/99 to 20/5/99)	2008 (1/2/08 to 31/5/08)
Waione Street	Median	0.21	0.06
	Mean	0.31	0.12
	Maximum	1.25	0.69
	Minimum	0.010	0.001
	Sample size	43	61
Kirkcaldy Street	Median	0.06	0.02
	Mean	0.10	0.03
	Maximum	0.60	0.18
	Minimum	0.010	0.001

	Sample size	42	61

The median concentration of lead in air at Kirkcaldy Street measured in 2008 is lower than in 1999 (U = 2520, p = 0.000). Median lead concentrations were approximately three times higher in 1999. Concentrations recorded at Waione Street in 2008 show a similar magnitude reduction (U = 1865, p = 0.000) when compared to 1999 concentrations.

Since 2006 Exide has undertaken a number of plant upgrades designed to reduce and contain fugitive emissions. It is expected that these measures would contribute to lower ambient lead concentrations in air in the vicinity of their plant. However, abnormal discharges due to equipment failure, repair work on emission control equipment and dust spills still occur from time to time leading to short-term elevated ambient air lead concentrations. Process upsets were responsible for the breach of the resource consent fugitive emission limits on the southern boundary in March and November 2007.

Ambient lead concentrations measured in 2008 are lower than those measured in 1999. However, during the monitoring period Exide undertook major maintenance that involved shutting down smelting and refining activities for some of the time while the monitoring was undertaken. Consequently discharges of lead and arsenic particulate from Exide's site may be atypical and therefore these monitoring results may not be representative of longer term levels in air.

6.3 Influence of meteorology on lead and arsenic concentrations

The distribution of lead particulate from an emissions source into the environment is highly influenced by wind direction and wind speed. The Waione Street site is south of Exide and therefore under northerly wind conditions discharges from Exide will be carried towards Waione Street. The influence of winds on concentrations was examined by calculating the percentage of time during each 24-hour sample period that the wind blew from the north, east, south or west quadrant. A positive correlation was found between lead concentrations at Waione Street and the percentage of time that wind (excluding calms) was from the north (Spearman's correlation coefficient r_s = 0.675, $\alpha(1)$, $p \geq 0.001$). This relationship was also observed in the 1999 monitoring results (Davy 1999). No correlations with wind direction were observed for arsenic concentrations.

During the monitoring period, there were 11 days on which total rainfall was greater than 5 mm. It is expected that under these rainfall conditions particulate will be removed from the atmosphere and fugitive emissions will be suppressed at source. However, no correlation between rainfall and lead concentrations was found. The number of sample periods is possibly too small to detect a relationship between rainfall and ambient concentrations and is confounded by the fact that rain occurred during periods when there were no emissions from Exide.

6.4 Deposition monitoring

6.4.1 Long-term deposition monitoring results

Total deposited dust is influenced by the rate and sources of emissions, wind speed and direction, rainfall, thermal air currents and physical obstructions in the area of measurement (Bardsley 2000). Ideally, deposition surveys should run for at least 12 months to account for the effect of seasonal variability on dustfall rates and typically several years worth of data are required before statistically valid trends can be determined (West 2000).

Exide have been monitoring deposition rates at Kirkcaldy Street and Waione Street since April 2006. A preliminary review of Exide's monitoring data shows that total deposited dust rates are similar for both sites and are consistent with values reported by Rosser (1999) for other locations in the Hutt Valley. As mentioned in Section 6.1.1 of this report, much of the deposited dust will be generated from natural sources, such as sea salt and wind-blown dust from the Hutt River bed.

Figure 6.5 shows the monthly rates of lead deposition at both sites. Rates at Kirkcaldy Street are lower than at Waione Street and appear relatively stable, while deposition rates at Waione Street are higher and more variable.

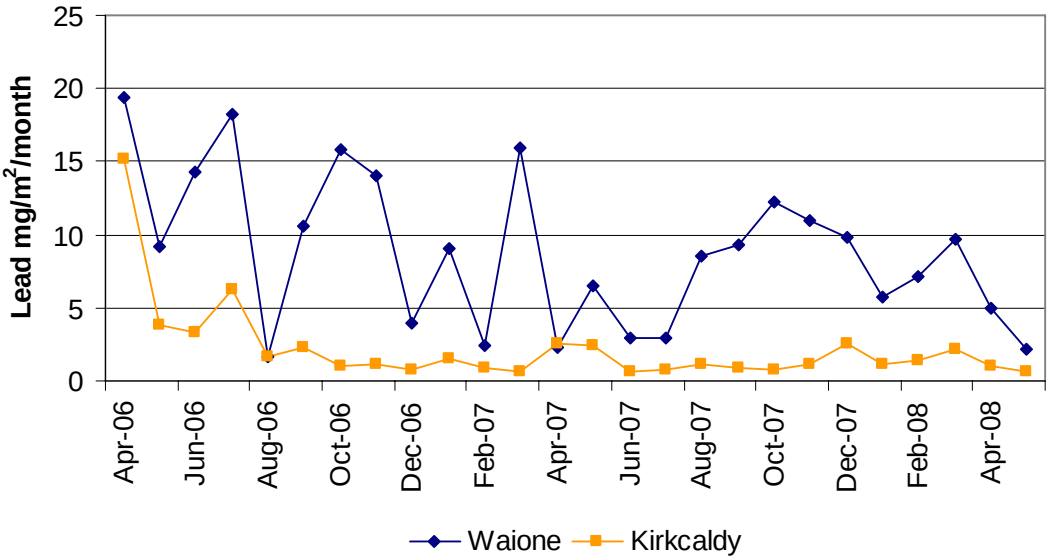

Figure 6.5: Deposition rates of lead at Waione Street and Kirkcaldy Street (April 2006 to May 2008)

Figure 6.6 shows the monthly rates of arsenic deposition at both sites measured by Exide. Both with sites appear to experience similar deposition rates. Note the outlier value measured at Kirkcaldy Street in August 2006 has been omitted.

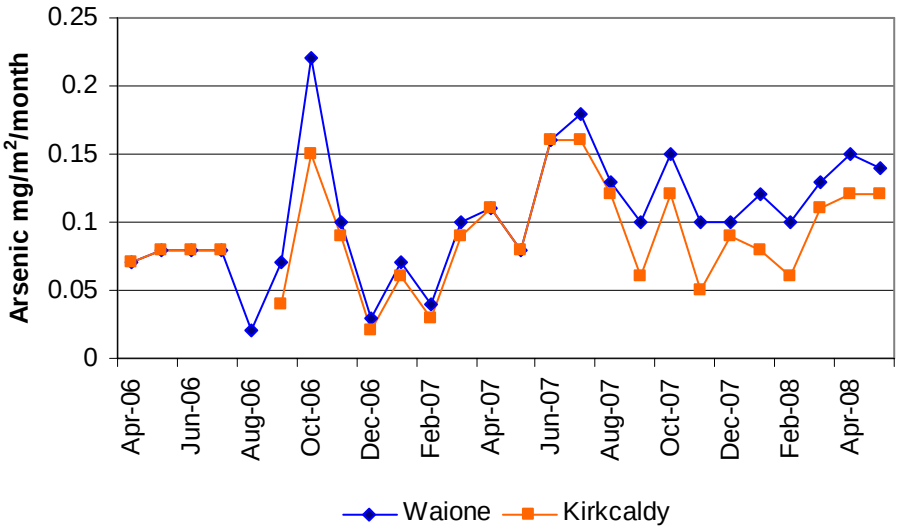

Figure 6.6: Deposition rates of arsenic at Waione Street and Kirkcaldy Street (April 2006 to May 2008)

6.4.2 Monthly deposition rates during the 2008 monitoring programme

Greater Wellington undertook deposition monitoring at the two community monitoring sites from 1 February 2008 to 31 May 2008. Unfortunately the results of this monitoring can not be used for quality assurance reasons; the exposure period is either outside that required by the monitoring method or does not match the exposure period of the samples taken by Exide. Instead the results of Exide's deposition monitoring (Table 6.6) were used in conjunction with Greater Wellington's ambient air quality monitoring to estimate deposition velocities as described in Section 6.4.3.

Table 6.6: Lead deposition rates at Waione Street and Kirkcaldy Street (February to May 2008)

2008	*n*-days	Exide deposition results mg/m²/month	
Month		Kirkcaldy St	Waione St
February	29	1.43	7.08
March	31	2.11	9.69
April	30	1.02	5.03
May	31	0.61	2.13

6.4.3 Lead deposition velocities

Deposition velocity is the rate at which particles are deposited on a surface from a reference height, reported in cm/second. The size of depositing particles is the most important factor affecting deposition velocities, i.e., larger particles fall faster.

Consideration of the deposition velocities of lead particles in the vicinity of Exide was one of the critical inputs to the Regional Public Health health-risk model used to determine lead concentration limits at Exide's site boundary that would protect public health. The boundary limits are designed to restrict the build-up of lead in outdoor dust under dry conditions because deposited lead is a potentially significant route of indirect exposure for pre-school children.

Originally, deposition velocities for both Kirkcaldy Street and Waione Street were estimated by dividing average deposition rates for 2003 and 2004 by average ambient concentrations in 1999 using the approach of Stevenson (2005a). It was noted in the Environment Court decision (W09/2006) on the appeal of Greater Wellington's decision on the review of Exide's resource consent that updated information on deposition velocities would be needed to confirm that the site boundary emission limits had been set appropriately.

In this study, co-located measurements of deposition rates and ambient air concentrations at Kirkcaldy Street and Waione Street were used to calculate the deposition velocities shown in Table 6.7.

Table 6.7: Estimated deposition velocities obtained from co-located measurements of deposition rates and ambient air concentrations in 2008

Month	*n*-days	Deposition velocity cm/second	
		Kirkcaldy	Waione
February	29	1.90	1.66
March	31	2.81	2.58
April	30	1.31	2.43
May	31	1.14	0.88
Average	121	1.70	1.91

The average deposition velocity calculated for Kirkcaldy Street is within the range of estimated deposition velocities used to set the fugitive emission limits for the southern boundary to protect the health of children (Stevenson 2005b). The average deposition velocity obtained for Waione Street is much lower than that used estimate the health risk to pregnant women (Stevenson 2005b). This means that, at least during this period of atypical operation and emissions from Exide, the fugitive emission limit at the southern boundary provides a greater level of health protection than estimated on the basis of the information available at the time when this emission limit was set.

It should be noted that the deposition rates obtained from this study used to calculate the deposition velocities included particles deposited under both wet and dry conditions. There is no standard monitoring method for measuring dry deposition rates. In theory deposition gauges could be covered and high-volume monitors switched off during rainfall periods – but this was not considered practical or possible given the monitoring resources available.

7. Conclusions

Ambient air quality monitoring for lead and arsenic in TSP was undertaken at two sites close to Exide Technologies Limited's battery recycling plant on Waione Street, Petone, Lower Hutt from February to May 2008.

Ambient monitoring to the west of Exide at Kirkcaldy Street found lead concentrations of 0.03 $\mu g/m^3$ (3-month average) and 0.03 $\mu g/m^3$ (3-month moving average). To the south of the Exide at Waione Street concentrations of 0.13 $\mu g/m^3$ (3-month average) and 0.11 $\mu g/m^3$ (3-month moving average) were measured. At both sites, the median concentrations measured during the monitoring campaign were approximately one third of the concentrations measured in 1999. Median lead concentrations at Waione Street were two thirds higher than those measured at Kirkcaldy and this is attributed to prevailing northerly winds transporting lead-containing particulate from Exide to Waione Street.

Average arsenic concentrations were 0.0038 $\mu g/m^3$ at Waione Street and 0.0027 $\mu g/m^3$ at Kirkcaldy Street. The median arsenic concentration was lower at Kirkcaldy Street than at Waione Street. Concentrations of arsenic measured in air at both sites were not at levels that indicate a health concern. However, a longer period of monitoring is required for comparison with the national guideline for arsenic in air which is expressed as an annual average.

Average lead deposition velocities were calculated using the results of co-located measurements of deposited lead and ambient air concentrations at the two monitoring sites. The results confirm that the deposition velocities used as input values to Regional Public Health's health-risk model were appropriate.

For the last two weeks of March and from mid April to near the end of May, Exide suspended furnace and refining operations while maintenance works were undertaken. The lack of day-to-day fugitive emissions associated with normal handling of battery scrap and other processing activities on site and the possibility of abnormal discharges associated with the maintenance work (e.g., cleaning of cartridge house) means the monitoring results may not be fully representative of local air quality during normal operations at Exide.

Acknowledgements

Thank you to Darren Li for installing and calibrating the high-volume samplers. We would also like to thank BBR Contech for access to their site and power supply, Mr Johnson for allowing a monitor to be sited on his property and Universal trucks for allowing their site to be used.

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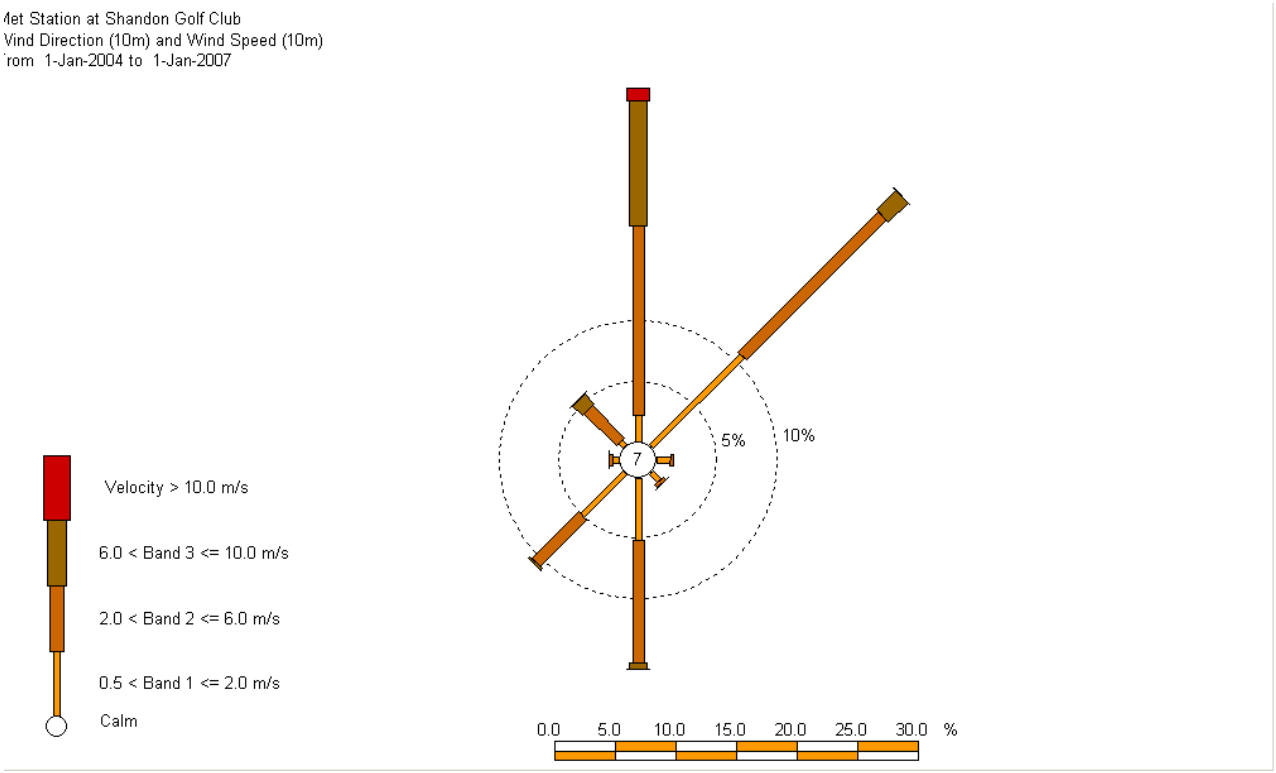
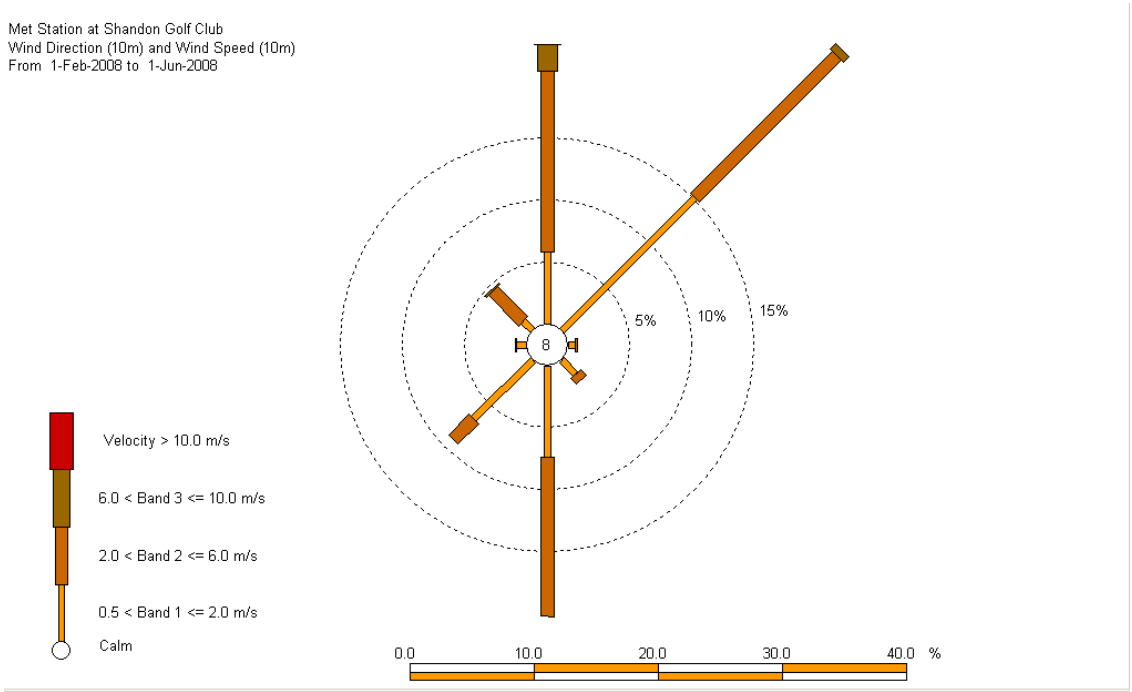
Appendix 1: Wind roses





Appendix 2: 2008 ambient air quality monitoring results

Location: Waione Street

NZMS Grid Ref: E 2668735 N 5995430
Sampling Rate: 70 m^3/hr

Filter Paper No.	Lab reference	Date On	Date Off	Flow Hrs	Flow Hrs	TSP	Lead	Arsenic
		00:00	23:59	On	Off	(µg/m³)	(µg/m³)	(µg/m³)
7954233	08/2503-02	01/02/2008	01/02/2008	17832.46	17856.5	34.52	0.108	0.00089
7954232	08/2504-02	03/02/2008	03/02/2008	17856.55	17880.54	17.39	0.038	0.00095
7954232	08/2505-02	05/02/2008	05/02/2008	17880.66	17904.64	41.28	0.015	0.00025
7954235	08/2714-02	07/02/2008	07/02/2008	17904.76	17928.74	34.42	0.020	0.00025
7954227	08/2715-02	09/02/2008	09/02/2008	17928.85	17952.84	26.03	0.141	0.00180
7954223	08/3115-02	11/02/2008	11/02/2008	17952.95	17976.93	28.33	0.140	0.00123
7954222	08/3163-02	13/02/2008	13/02/2008	17977.05	18001.04	34.65	0.123	0.00096
7954219	08/3258-02	15/02/2008	15/02/2008	18001.16	18025.14	28.29	0.185	0.00181
7954218	08/3333-02	17/02/2008	17/02/2008	18025.27	18049.25	29.67	0.362	0.00313
7954215	08/3591-02	19/02/2008	19/02/2008	18049.38	18073.36	54.09	0.039	0.00088
7954214	08/3769-02	21/02/2008	21/02/2008	18073.48	18097.46	32.68	0.685	0.00381
7954211	08/3811-02	23/02/2008	23/02/2008	18097.58	18121.57	30.66	0.067	0.00188
7954210	08/4017-02	25/02/2008	25/02/2008	18121.7	18145.68	42.47	0.083	0.00084
7954207	08/4277-02	27/02/2008	27/02/2008	18145.81	18169.79	28.38	0.106	0.00222
7954206	08/4358-02	29/02/2008	29/02/2008	18169.91	18193.9	26.67	0.346	0.00319
7954204	08/4515-02	02/03/2008	02/03/2008	18194.01	18218	36.69	0.230	0.00155
7954201	08/4875-02	04/03/2008	04/03/2008	18218.12	18242.1	23.72	0.013	0.00025
7954700	08/4983-02	06/03/2008	06/03/2008	18243.32	18267.3	32.09	0.395	0.00203
7954697	08/5011-02	08/03/2008	08/03/2008	18267.42	18291.4	37.30	0.397	0.00442
7954695	08/5319-02	10/03/2008	10/03/2008	18291.52	18315.5	38.56	0.053	0.00146
7954693	08/5447-02	12/03/2008	12/03/2008	18315.56	18339.55	41.75	0.334	0.00265
7954691	08/5492-02	14/03/2008	14/03/2008	18339.66	18363.65	44.08	0.056	0.00089
7954689	08/5782-02	16/03/2008	16/03/2008	18363.77	18387.76	61.47	0.050	0.00089
7954687	08/5885-02	18/03/2008	18/03/2008	18387.89	18411.87	63.32	0.066	0.00153
7954685	08/6000-02	20/03/2008	20/03/2008	18411.99	18435.98	40.54	0.115	0.00129
7954683	08/6053-02	22/03/2008	22/03/2008	18436.1	18460.08	31.34	0.012	0.00057
7954681	08/6148-02	24/03/2008	24/03/2008	18460.21	18484.19	23.56	0.016	0.00121
7954679	08/6463-02	26/03/2008	26/03/2008	18484.32	18508.3	34.58	0.023	0.00109
7954677	08/6529-02	28/03/2008	28/03/2008	18508.42	18532.4	41.28	0.332	0.00161
7954675	08/6628-02	30/03/2008	30/03/2008	18532.52	18556.5	38.81	0.021	0.00160
7954673	08/7167-02	01/04/2008	01/04/2008	18556.61	18581.6	20.00	0.136	0.00130
7954671	08/7168-02	03/04/2008	03/04/2008	18581.72	18605.7	32.94	0.176	0.00157

7954669	08/7169-02	05/04/2008	05/04/2008	18605.83	18629.81	19.63	0.181	0.00153
7954664	08/7456-02	07/04/2008	07/04/2008	18629.93	18653.91	26.10	0.015	0.00025
7954662	08/7633-02	09/04/2008	09/04/2008	18654.03	18678.01	26.61	0.024	0.00169
7954660	08/7634-02	11/04/2008	11/04/2008	18678.13	18702.12	32.06	0.053	0.00488
7954658	08/8117-02	13/04/2008	13/04/2008	18702.23	18726.21	20.01	0.011	0.00250
7954656	08/8118-02	15/04/2008	15/04/2008	18726.35	18750.33	28.46	0.218	0.00361
7954654	08/8119-02	17/04/2008	17/04/2008	18750.42	18774.44	22.43	0.014	0.00486
7954652	08/8288-02	19/04/2008	19/04/2008	18774.57	18798.56	42.94	0.045	0.00311
7954650	08/8507-02	21/04/2008	21/04/2008	18798.67	18822.65	23.92	0.052	0.00189
7954648	08/8508-02	23/04/2008	23/04/2008	18822.78	18846.76	34.05	0.030	0.00268
7954644	08/8582-02	25/04/2008	25/04/2008	18846.88	18870.87	33.67	0.141	0.00675
7954642	08/8753-02	27/04/2008	27/04/2008	18870.95	18894.97	23.85	0.010	0.00299
7954641	08/8990-02	29/04/2008	29/04/2008	18895.09	18919.08	23.13	0.145	0.00220
7954638	08/9099-02	01/05/2008	01/05/2008	18919.2	18943.18	39.48	0.021	0.00604
7954636	08/9321-02	03/05/2008	03/05/2008	18944.67	18968.65	67.59	0.036	0.01644
7954634	08/9518-02	05/05/2008	05/05/2008	18968.77	18992.75	15.42	0.010	0.00025
7954632	08/9792-02	07/05/2008	07/05/2008	18992.87	19016.85	25.15	0.042	0.00775
7954630	08/9901-02	09/05/2008	09/05/2008	19016.98	19040.96	45.72	0.024	0.00263
7954628	08/9980-02	11/05/2008	11/05/2008	19041.08	19065.06	21.95	0.004	0.00134
7954626	08/10291-02	13/05/2008	13/05/2008	19065.18	19089.17	28.86	0.074	0.00507
7954624	08/10292-02	15/05/2008	15/05/2008	19089.29	19113.28	41.96	0.120	0.01782
7954622	08/10467-02	17/05/2008	17/05/2008	19113.43	19137.42	23.62	0.028	0.01274
7954620	08/10736-02	19/05/2008	19/05/2008	19137.53	19161.51	24.45	0.464	0.01085
7954618	08/10844-02	21/05/2008	21/05/2008	19161.63	19185.62	41.11	0.204	0.01102
7954616	08/10991-02	23/05/2008	23/05/2008	19185.74	19209.72	29.17	0.004	0.00888
7954614	08/11263-02	25/05/2008	25/05/2008	19209.84	19233.82	10.61	0.001	0.00025
7954612	08/11414-02	27/05/2008	27/05/2008	19233.94	19271.22	51.82	0.027	0.01868
7954608	08/11457-02	29/05/2008	29/05/2008	19271.33	19295.32	36.23	0.329	0.01706
7954606	08/11689-02	31/05/2008	31/05/2008	19295.44	19319.42	25.93	0.084	0.00676

Location: Kirkcaldy Street

NZMS Grid Ref: E 2668646 N 2668646

Sampling Rate: 70 m^3/hr

Filter Paper No.	Lab Ref	Date On	Date Off	Flow Hrs	Flow Hrs	TSP	Lead	Arsenic
		00:00	23:59	On	Off	(µg/m³)	(µg/m³)	(µg/m³)
7954230	08/2503-01	01/02/2008	01/02/2008	3420.45	3444.46	33.92	0.025	0.00051
7954231	08/2504-01	03/02/2008	03/02/2008	3444.5	3468.48	15.84	0.008	0.00025
7954229	08/2505-01	05/02/2008	05/02/2008	3468.53	3492.51	39.14	0.059	0.00111
7954228	08/2714-01	07/02/2008	07/02/2008	3492.55	3516.53	37.07	0.013	0.00025
7954225	08/2715-01	09/02/2008	09/02/2008	3516.57	3540.55	24.43	0.017	0.00057
7954224	08/3115-01	11/02/2008	11/02/2008	3540.59	3564.57	20.11	0.002	0.00026
7954221	08/3163-01	13/02/2008	13/02/2008	3564.61	3588.59	44.41	0.015	0.00025
7954220	08/3258-01	15/02/2008	15/02/2008	3588.03	3612.61	24.30	0.006	0.00026
7954217	08/3333-01	17/02/2008	17/02/2008	3612.65	3636.63	97.10	0.075	0.00101
7954216	08/3591-01	19/02/2008	19/02/2008	3636.66	3660.65	42.46	0.041	0.00056
7954231	08/3769-01	21/02/2008	21/02/2008	3660.68	3684.67	22.43	0.041	0.00094
7954212	08/3811-01	23/02/2008	23/02/2008	3684.7	3708.69	29.90	0.035	0.00141
7954209	08/4017-01	25/02/2008	25/02/2008	3708.72	3732.71	41.60	0.017	0.00083
7954208	08/4277-01	27/02/2008	27/02/2008	3732.74	3756.72	21.81	0.018	0.00063
7954205	08/4358-01	29/02/2008	29/02/2008	3756.76	3780.84	22.68	0.022	0.00025
7954203	08/4515-01	02/03/2008	02/03/2008	3780.78	3804.76	35.75	0.007	0.00051
7954202	08/4875-01	04/03/2008	04/03/2008	3804.8	3828.78	29.15	0.121	0.00069
7954699	08/4983-01	06/03/2008	06/03/2008	3830.08	3854.06	25.34	0.033	0.00120
7954698	08/5011-01	08/03/2008	08/03/2008	3854.1	3878.09	32.25	0.035	0.00026
7954696	08/5319-01	10/03/2008	10/03/2008	3878.12	3902.1	35.52	0.033	0.00025
7954692	08/5447-01	12/03/2008	12/03/2008	3902.14	3926.12	41.08	0.038	0.00077
7954690	08/5492-01	14/03/2008	14/03/2008	3926.15	3950.14	77.41	0.024	0.00089
7954688	08/5782-01	16/03/2008	16/03/2008	3950.17	3974.16	50.08	0.015	0.00051
7954686	08/5885-01	18/03/2008	18/03/2008	3974.19	3998.18	49.47	0.034	0.00070
7954684	08/6000-01	20/03/2008	20/03/2008	3998.21	4022.19	36.60	0.027	0.00058
7954682	08/6053-01	22/03/2008	22/03/2008	4022.23	4046.21	34.41	0.009	0.00025
7954680	08/6148-01	24/03/2008	24/03/2008	4046.25	4070.24	19.61	0.015	0.00114
7954678	08/6463-01	26/03/2008	26/03/2008	4070.27	4094.25	32.66	0.040	0.00108
7954676	08/6529-01	28/03/2008	28/03/2008	4094.29	4118.27	45.49	0.036	0.00058
7954674	08/6628-01	30/03/2008	30/03/2008	4118.31	4141.29	30.10	0.005	0.00089
7954672	08/7167-01	01/04/2008	01/04/2008	4141.32	4166.43	13.39	0.023	0.00104

7954670	08/7168-01	03/04/2008	03/04/2008	4166.46	4190.44	27.47	0.023	0.00133
7954668	08/7169-01	05/04/2008	05/04/2008	4190.48	4214.47	20.16	0.014	0.00071
7954665	08/7456-01	07/04/2008	07/04/2008	4214.51	4238.49	30.24	0.019	0.00025
7954663	08/7633-01	09/04/2008	09/04/2008	4238.52	4262.51	28.88	0.015	0.00120
7954661	08/7634-01	11/04/2008	11/04/2008	4262.54	4286.52	21.38	0.032	0.00315
7954659	08/8117-01	13/04/2008	13/04/2008	4286.56	4310.54	16.76	0.010	0.00258
7954657	08/8118-01	15/04/2008	15/04/2008	4310.58	4334.56	19.26	0.180	0.00318
7954655	08/8119-01	17/04/2008	17/04/2008	4334.6	4358.58	17.31	0.014	0.00457
7954653	08/8288-01	19/04/2008	19/04/2008	4358.62	4382.6	32.34	0.014	0.00270
7954651	08/8507-01	21/04/2008	21/04/2008	4382.64	4406.62	16.99	0.030	0.00178
7954649	08/8508-01	23/04/2008	23/04/2008	4406.65	4430.64	25.48	0.012	0.00251
7954645	08/8582-01	25/04/2008	25/04/2008	4430.67	4454.66	28.06	0.011	0.00686
7954643	08/8753-01	27/04/2008	27/04/2008	4454.69	4478.67	20.05	0.008	0.00327
7954641	08/8990-01	29/04/2008	29/04/2008	4478.71	4502.69	14.10	0.012	0.00144
7954639	08/9099-01	01/05/2008	01/05/2008	4502.73	4526.71	30.55	0.009	0.00538
7954637	08/9321-01	03/05/2008	03/05/2008	4527.79	4551.77	35.79	0.012	0.00070
7954635	08/9518-01	05/05/2008	05/05/2008	4551.8	4575.79	16.81	0.006	0.00025
7954633	08/9792-01	07/05/2008	07/05/2008	4575.82	4599.81	22.53	0.023	0.01063
7954631	08/9901-01	09/05/2008	09/05/2008	4599.84	4623.82	45.70	0.033	0.00322
7954629	08/9980-01	11/05/2008	11/05/2008	4623.86	4647.84	18.70	0.005	0.00122
7954627	08/10291-01	13/05/2008	13/05/2008	4647.87	4671.86	16.52	0.044	0.00559
7954625	08/10292-01	15/05/2008	15/05/2008	4671.9	4695.88	28.78	0.027	0.01433
7954623	08/10467-01	17/05/2008	17/05/2008	4695.91	4719.89	16.57	0.012	0.01229
7954621	08/10736-01	19/05/2008	19/05/2008	4719.93	4743.91	16.11	0.052	0.00824
7954619	08/10844-01	21/05/2008	21/05/2008	4743.95	4767.93	27.74	0.048	0.00954
7954617	08/10991-01	23/05/2008	23/05/2008	4767.97	4791.95	28.84	0.001	0.00025
7954615	08/11263-01	25/05/2008	25/05/2008	4791.98	4815.97	10.33	0.001	0.00094
7954613	08/11414-01	27/05/2008	27/05/2008	4816	4839.98	29.96	0.016	0.01414
7954610	08/11457-01	29/05/2008	29/05/2008	4840.02	4864	18.86	0.064	0.01613
7954607	08/11689-01	31/05/2008	31/05/2008	4864.03	4888.02	16.62	0.022	0.00610

Water, air, earth and energy – elements in Greater Wellington's logo that combine to create and sustain life. Greater Wellington promotes Quality for Life by ensuring our environment is protected while meeting the economic, cultural and social needs of the community

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